Competition and Market Power in Deregulated Fertilizers in India*

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Abstract

This paper investigates competition and market share dominance in the Indian fertilizer sector during a process of deregulation, using a newly constructed database. I present an entry model (similar to Bresnahan and Reiss 1991) for a homogenous good and symmetric firms. An additional parameter, lambda, is introduced to allow for market share dominance by the former monopoly. In the empirical application, the size of this advantage is linked to competition between the private and cooperative sectors in the credit market. I use two approaches to make inference on the effect of new firm entry on the toughness of competition in the absence of good price data. The first, borrowed from Abraham. et al 2007, is estimating a quantity equation, with a number of firms ordered probit selection rule. This provides additional information on the effect of entry on quantities, which can point to a competitive effect, but not quantify it. The second approach original to this paper is using a change in price regulation that took place during the period of analysis. By assuming the variable profits were constant with regard to the number of firms in a period of fixed prices, we can infer the entry effect on the variable profits in a period with market prices..

1 Introduction

Government monopolies are a common phenomena both in the developed and in the developing world, particularly in sectors considers vital for the economy. In recent decades we see a reverse tendency, to liberalize and/or privatize previously government controlled sectors.

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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. The Indian market for potassium fertilizer was historically controlled by a single government company, the Indian Potash Supply Agency (IPSA). This was until 1970 when it became Indian Potash Limited (IPL) and other companies were allowed to market imported potassium chloride across the country. This paper studies the patterns of firm entry and competition into this market, around a time of a further reform to the market including price deregulated. 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 of the markets, even when facing competition by an increasing number of firms.

To analyze the sources of market share concentration and the competitive effect of entry by new competitors, I present a static entry model with a homogenous product and symmetric firms (as in Bresnahan and Reiss 1991). To incorporate market share advantage for the former monopoly, I introduce the notion of captive consumers, those who will only buy from the former monopoly (modeled by an additional parameter - λ). The hypothesis is that λ is affected by the control of certain marketing channels by the historical monopoly, making competing brands unavailable for parts of the market population. Separating the competitive effect of entry in similar models has proven to be problematic. In Bressnahan and Reiss, the effect of entry on variable profits is separated from the effect on fixed costs in their specification, but it is not successfully separated by the data. In Abraham et. al 2007, using a similar model for the US hospital market but applying a log-linear specification, the competitive effect on sold quantities is derived from an additional quantity equation. This helps identify a positive competitive effect of entry (an increase in quantity is related to a drop in prices, as the product is assumed homogenous), but it is still not enough to actually quantify the effect on variable profits. In my application, I follow the idea in Abraham et al. 2007 by adding a quantity equation, but I also take advantage of the change in the price regimen which took place during the period of analysis, to actually separate the competitive effect of entry from the effect on fixed costs. The number of firms equation is used as a selection rule for the quantity equation to deal with the endogeneity of the market structures. The two equations are jointly estimated using a Maximum Likelihood procedure.

This paper also contributes to a large literature in development economics discussing different aspects of developing markets for fertilizers and other modern inputs. The availability and the usage of chemical fertilizers is generally considered a major engine of growth for agricultural productivity. It has therefor received the attention of both national policy makers and international development institutions, and is often a subject of heavy regulation and government interventions (a useful recent survey of fertilizer policies in different countries appears in Huang et al. (2017)).

The development literature has dealt with the determinants of modern input adoption among farmers in developing agricultures. Learning process and the effect of neighbor behavior were discussed in the case of fertilizers (Duflo et. al 2014, Krishan & Patnam 2014, Foster & Rosenzweig 2010, Conely & Udry 2010, Croppenstedt et. al 2003). Different methods of government support, and their effect on market outcomes, were evaluated (Barker & Hayami 1976, Gulati & 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. The new firm level data of fertilizer sales presented in this paper, provides an opportunity to address these questions.

The history and institutional details of the Indian agricultural sector also make it an interesting case for a study of market interactions. The import and marketing of fertilizers was historically controlled by a government institution. During the 70's it went through a process of liberalization and local fertilizer producers began marketing their own products and imported fertilizers. Today, many companies are active in this sector, but the historical monopoly continues to be dominant in many geographical markets. How this affects market outcomes in those locations, and what determines the level of competition and market share concentration post liberalization, these questions will be discussed in this paper.

The Indian market for fertilizers also presents an interaction between a historically strong cooperative sector, and public and private enterprises. All sectors participate in the distribution of fertilizers, but also in other related operations such as offering credit for production activities in rural areas. Several other papers discuss the effect of credit on agricultural productivity (Feder et al. (1990), Guirkinger & Boucher (2008)). In this paper, I link interactions between the different sectors: public, private and cooperative in the credit market, to market share outcomes in the product market. The rest of the paper is organized as follows: Chapter 2 presents a brief industry background of the Indian fertilizer market, Chapter 3 presents the theoretical model underlying the empirical application, Chapter 4 presents the data, Chapter 5 describes the empirical strategy, Chapter 6 presents results from regular ordered-probit and OLS estimations, Chapter 7 presents the full model results and discussion.

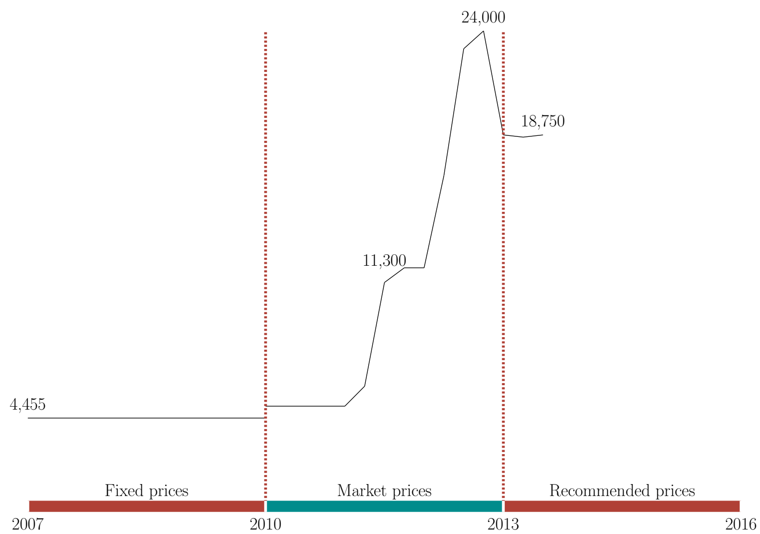
2 Industry Background

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 is dampening this effect 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 lack of local natural reserved, Potassium Chloride is imported into India from global suppliers (mainly in 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, IPSA - Indian Potash Supply Agency, 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 IPL - Indian Potash Limited. 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. But 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, potassium and phosphate fertilizer prices were deregulated to be set by the companies. The nitrogen fertilizer supply remained entirely regulated, and all prices and margins are still set by the government. Figure 1 presents average prices of potassium chloride before and after the deregulation, capturing the significant increase in prices in the after period. The two periods chosen for the empirical analysis are 2007 and 2012, where 2007 represents the fixed price period, and 2012 represents market prices.

Figure 2 presents the changes in market structure in the different Indian districts following the price deregulation. In 2007, high levels of competition concentrated in close proximity to international ports. The high costs of transportation in this market explains this pattern

Figure 1: Regulation Time-Line and Prices



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 proxi for a fertilizer distribution network already in place for marketing the other types of fertilizers, affecting the fixed cost encountered by new competitors entering the Potash marketing business.

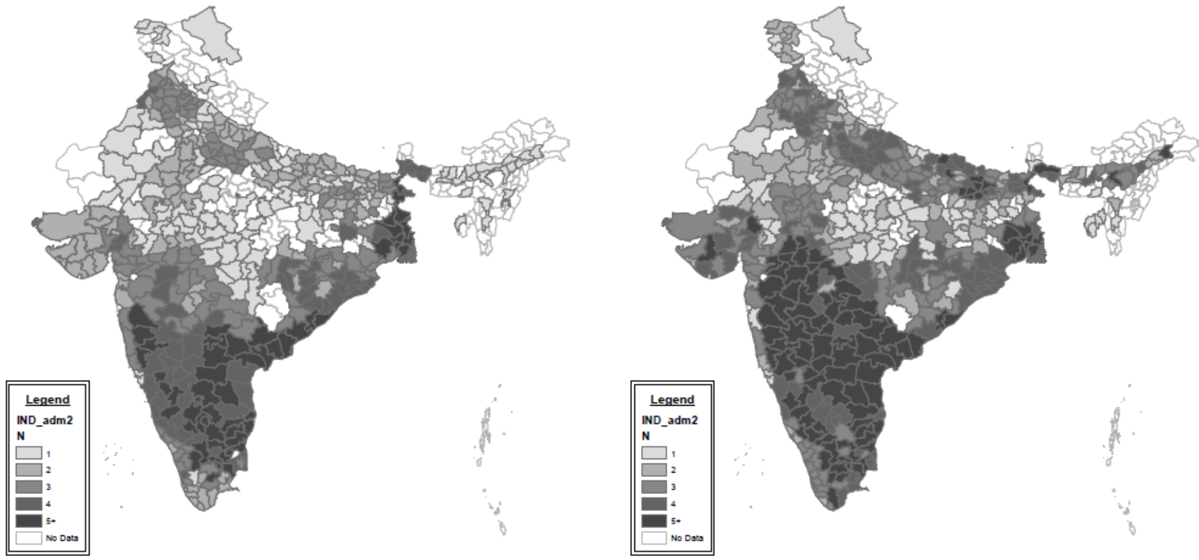
Indian fertilizer companies both produce and sell imported fertilizers [1] through their wholesale dealer networks spread across multiple districts and states. Farmers buy the products from retailers located in the rural areas. To finance agricultural inputs, farmers rely on locally available F from 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.).

The companies that are active in the potassium fertilizer market[2], besides IPL, are a mix

[1]Indian companies produce around 60% of the Nitrogen fertilizer (urea) used in India, and about 10% of Phosphate fertilizer. For Potassium India relies entirely on imports from international suppliers, due to the lack of economic deposited of Potassium in India.

[2]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)



I chose to compare these two period, because kharif 2007 is the first period in our data, still under government-set prices, kharif 2012 is the latest period post price deregulation (2010), before the government started to publish recommended prices - a softer form of price control. Source of data: *Fertilizer Monitoring System (FMS), by the Department of Fertilizers in the Ministry of Chemicals, Petrochemicals and Fertilizers, GOI.*

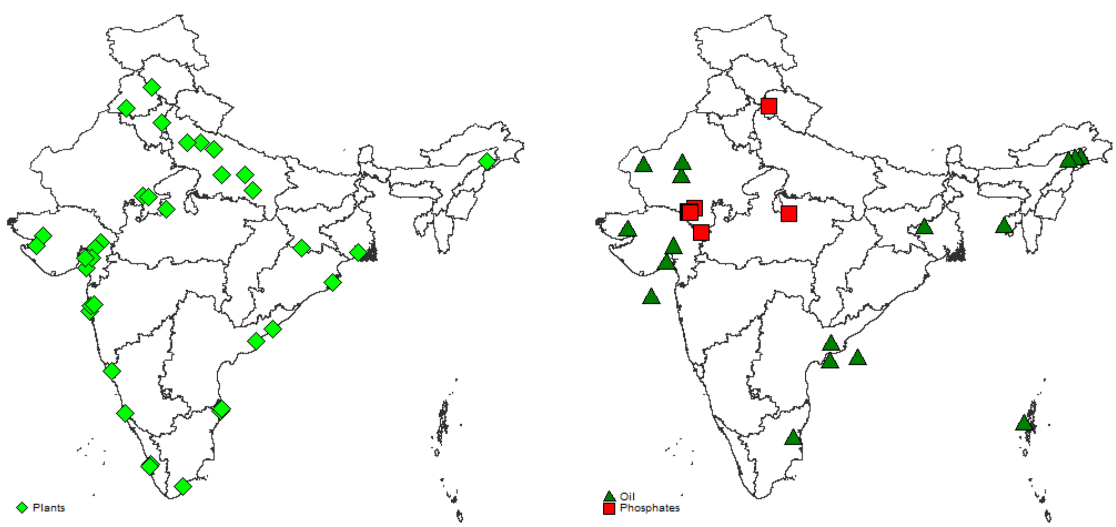
of state-government and private enterprises. Most players are also producers of other types of fertilizers, and are multi-market competitors selling potassium in many districts and even multiple states (see table 1).

Table 1: Firms in the Potash Marketing Sector (Top 15)

Company	States (mean)	Districts (mean)	Market share (mean)	Type	Produced Products
IPL	23	427	0.69	Mixed	-
CFL	9	115	0.10	Private	DAP, Complex
RCF	8	127	0.17	Public	Urea, Complex
CFCL	7	119	0.28	Private	Urea
TCL	7	98	0.31	Private	DAP, Urea, Complex
ZIL	6	89	0.21	Private	DAP, Urea, Complex
PPL	6	91	0.20	Private	DAP, Complex
MCFL	4	67	0.10	Private	DAP, Urea, Complex
SFC	4	51	0.16	Private	Urea
DFPCL	3	44	0.11	Private	Complex
FACT	3	31	0.09	Private	Complex
NFCL	3	42	0.12	Private	Urea
GNVFC	2	15	0.09	Public	Urea, Complex
TAIPL	1	6	0.15	Private	-
NFL	1	16	0.18	Private	Urea

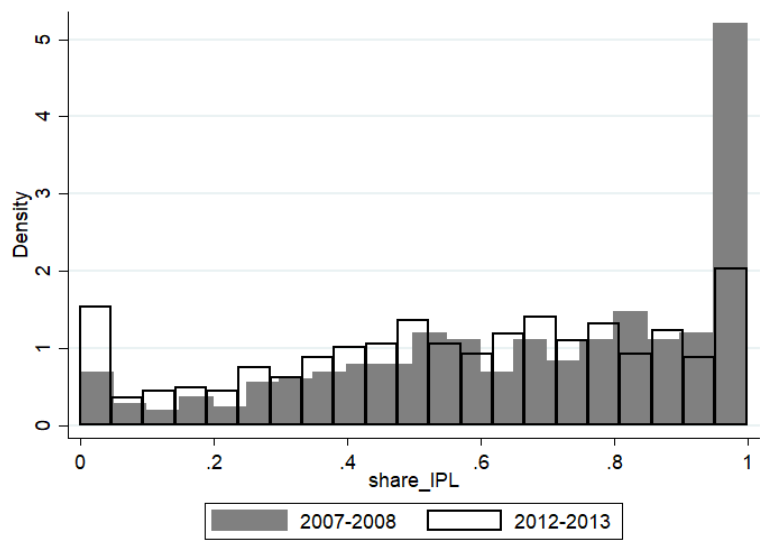
Source of production information: *Deprtment of fertilizers, GOI.*

Figure 3: Locations of Fertilizer Plants and Oil and Phosphate Deposites



IPL holds a dominant market share in a large share of the markets (69% on average) and is active in almost all of the markets (the number of markets with positive sales where IPL is not active varies between 2 and 9 markets in the different periods). 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, we 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.

Figure 4: IPL Market Share (Kharif 2007, Kharif 2012)



3 Model

I construct a static firm entry model in a market for a homogenous model. As in Bresnahan & Reiss 1991, demand is proportional to market size:

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

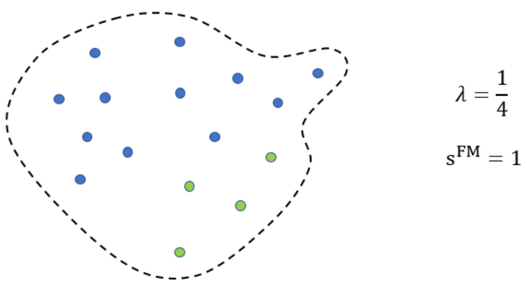
Where Q is aggregate demand, d is per-capita demand, P are prices, X are demand shifters and S is the market size. I adjust the model to allow for market power by the historical monopoly. To do this I introduce the parameter λ which will be a share of the market population who will only buy from the historical monopoly. The rest of the demand is symmetrically divided between the firms who enter the market. The market share of the former monopoly is then:

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

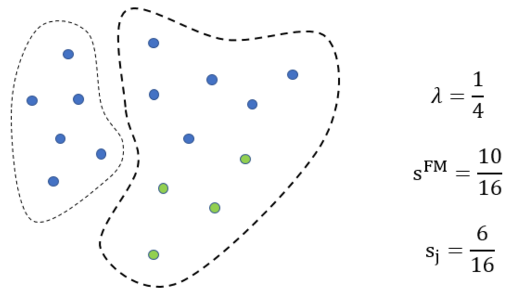
and the market share of any other firm $j \neq FM$ is:

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

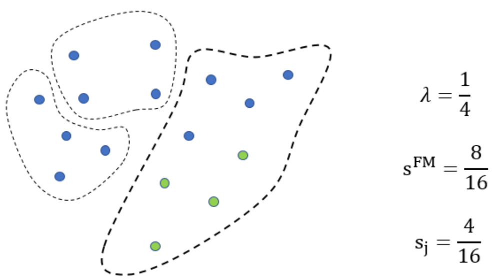
Figure 5: Model for Fixed share of Captive Consumers, Illustration



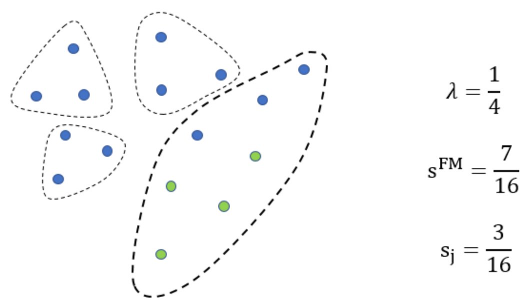
(a) N=1



(b) N=2



(c) N=3



(d) N=4

This figure demonstrates the concept of λ in our model. Assume a market with 16 consumers. If one quarter of those consumers will only buy the brand of the former monopoly (this is our λ), then in a monopoly market the former monopoly will have a market share of 1; in a duopoly the former monopoly will have the four "captive" consumers and a half of the remaining consumers, etc. As the number of firms increases, the market share of the former monopoly tends to λ and the combined market share of the competitors tends to zero.

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

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

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

$$P_N = P(X, W, \theta_N) \tag{1}$$

Prices are expected to rise with variables in X, W which increase demand or costs. We can then write the equilibrium values of total quantity sold, fixed costs and variable profits:

$$d_N = d(P_N, X) \tag{2}$$

$$F_N = F(W, N) \tag{3}$$

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

Fixed costs are allowed to vary with the number of firms, as in Bresnahan & Reiss. 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 new entrants, if local dealers show some level of loyalty to incumbent firms.[3]

3.1 Entry

A firm will enter a market if entry entails non-negative profits. Following are the profits obtained by the historical monopoly[4], 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:

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

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

[3]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]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.

λ does not enter the monopoly entry threshold, but it makes subsequent entry threshold 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 variable profits when prices are fixed, we can separate out the entry effect on variable profits by estimating the model for these two periods.

4 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 from April through October of each year. We use data from two years: 2007-2008 and 2012-2013[5]. A more dynamic approach might be of interest given the available time series data, however additional information would be necessary to separate actual sales from market presence, we don't take this rout in the current paper. Instead we focus on two years, one during the government fixed prices period, and one after the price deregulation.

[5] 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.

4.1 The product

We look at sales of Muriate of Potash (MOP), also known as Potassium Chloride or simply Potash. MOP is a straight Potassium fertilizers (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 vast majority of Potash consumed in India is through MOP, 77% in 2010 [Kinekar, 2011], so we chose to ignore the sales of potash through complex fertilizers in this analysis. Another aspect we ignore by focusing on the market for MOP, is the complex complementarity-substitution relationships in the consumption choices of the different types of nutrients. In this sense, we leave room for additional work on the demand of fertilizers.

4.2 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 countries territory, so we do not apply the isolated markets method as in Bresnahan and Reiss, to insure that there is no competition from outside the market. However, since demand in the fertilizer sector is highly localized (as farmers don't tend to travel outside their village to purchase fertilizers, let alone the district), we believe the markets as defined here are generally 'self-contained'. We leave the possibility of sub-markets existing within our defined markets (as districts can get pretty big, and also include urban populations which are not relevant for our study), and 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.

4.3 The share of captive consumers λ

In the theoretical model we introduced the parameter λ signifying a share of the market population who is captive to the former monopoly brand. This gave the following form to the market share of the former monopoly (λ plus a proportional share of the rest of the market):

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

Table 2: 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
ln_area	Ln of total area of agricultural holdings in the district	Agricultural Census, rounds 2005-06, 2010-11
ave_size	Average size of agricultural holdings	”
rice_irrig	Share of area under irrigated rice	”
rice_nirrig	Share of area under non-irrigated rice	”
wheat_irrig	Share of area under irrigated wheat	”
wheat_nirrig	Share of area under non-irrigated wheat	”
rice	Share of area under rice	”
wheat	Share of area under wheat	”
institutional	Share of area under institutional holdings	”
d_port	Distance from district centroid to nearest port	
d_plants	Distance from district centroid to nearest fertilizer plant	
d_dep	Distance from from district centroid to oil and phosphate deposits	
NB	Number of branches belonging to nationalized banks	
RRB	Number of branches belonging to Regional Rural banks	
SBI	Number of branches belonging to State Bank of India and its associates	
coop_banks	Number of villages with a cooperative bank (weighted by village population)	Village Directory in the Census of India, rounds 2005-2006, 2010-2011
ACS	Number of villages with an agricultural credit society (weighted by village population)	”
com_banks	Number of villages with a commercial bank (weighted by village population)	”
rail_fac		”
iffco_retail		FMS

In this equation two variables are directly observed: the number of firms and the market share of the former monopoly. We can then derive the empirical counterpart of λ, $\tilde{\lambda}$ which can be calculated from the observed variables:

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

In the model we defined λ for markets with at least two firms. For these values, $\tilde{\lambda}$ can be negative, if the market share of the former monopoly is smaller than the symmetrical outcome $\frac{1}{N}$. It 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 goes to infinity, the symmetrical outcome goes to zero and any positive market share is interpreted as captive consumers (λ tends to s^{FM}). In our sample, 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

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

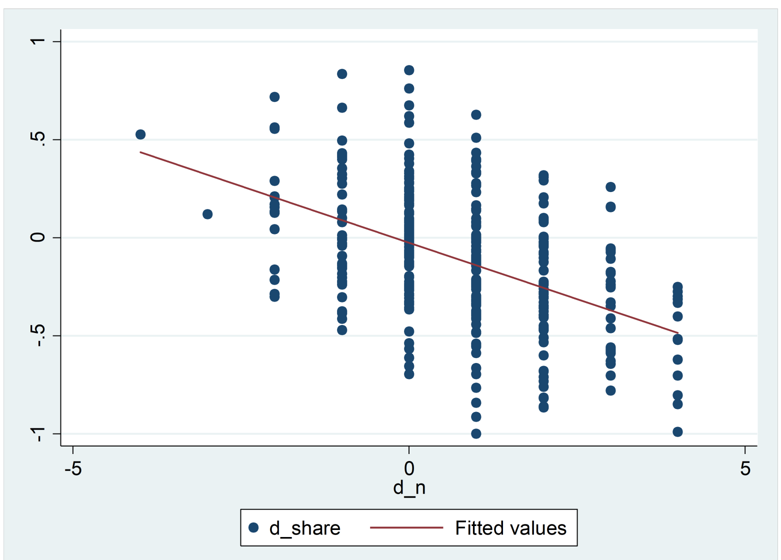
$$\Delta_i = s_i - \frac{1}{N}$$

which is the numerator of our $\tilde{\lambda}$. This measure has similar mathematical properties to our measure, it is negative when $\tilde{\lambda}$ is negative, and is also bound by the firm's market share from above. However, 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.

4.4 λ and the number of firms

In the empirical application we assume λ is determined exogenously with regard to the market structure and market outcomes. We 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 some way. 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 our data, we 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. Indeed, the market share presents a significant negative relationship with the number of firms, while λ does not.

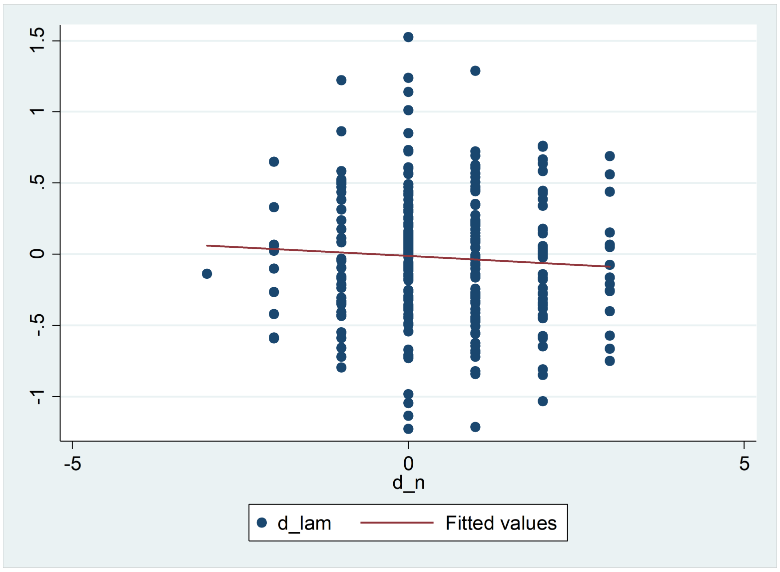
Figure 6: The change in the IPL market share on the change in N



4.5 Credit Sources

The Indian agricultural sector is characterized by a large proportion of small and budget constrained farmers. 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

Figure 7: The change in $\tilde{\lambda}$ on the change in N



production process. Narayanan (2015) 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 by helping farmers finance their input purchases, but also by making funding available to retailers for their trading activities. To consider the effect of the different credit sources available to farmers, let us briefly survey the Indian market for agricultural credit.

The non-institutional sources of credit are an important source of rural credit in India, accounting for around 40% of total credit (after gradually dropping from almost 93% in 1951). These comprise of 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. The general policy on agricultural credit has been to progress the institutionalization of the credit sources, and improve the availability of banking services to small and remote farmers. 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 Rural Development Banks.

Table 4: 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/DBIE/MOFSelectParam.jsp?option=rbi ;*

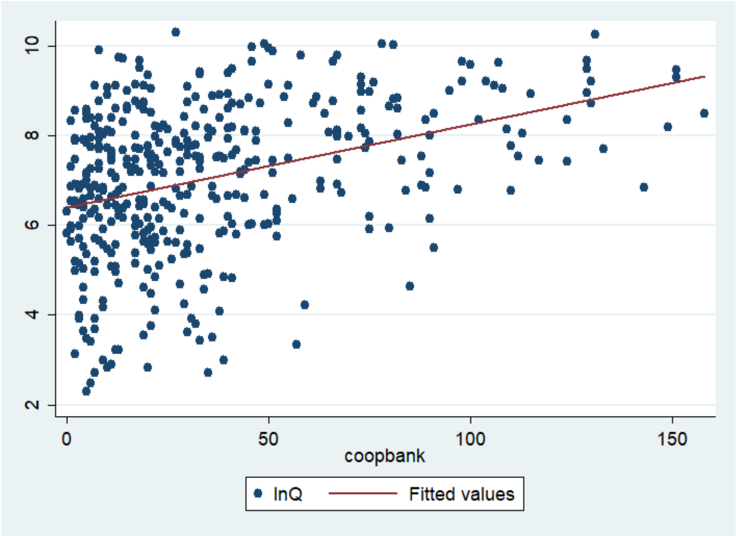
Table 5: Cooperative Credit - Number of Villages with Available Cooperative Credit

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

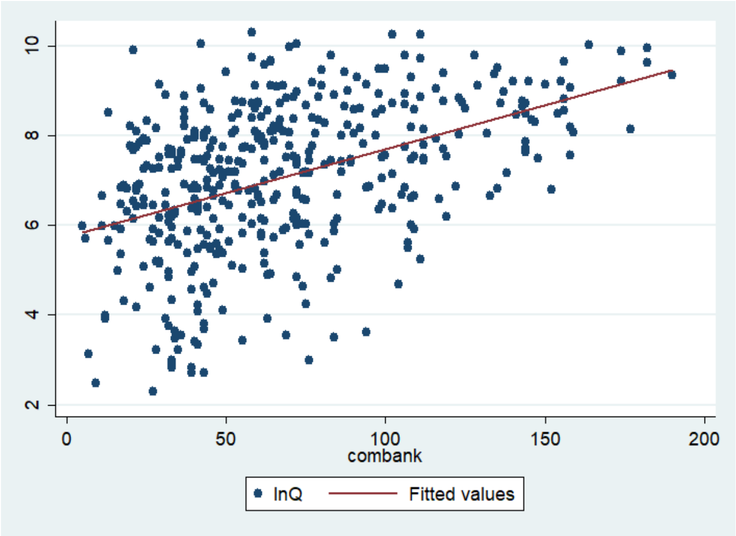
Source: *The village directory of the census rounds 2005-06, 2010-11*

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.

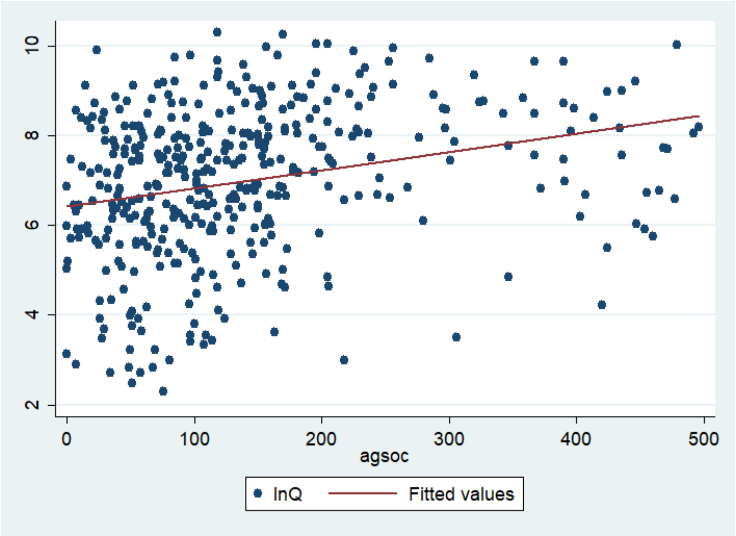
Figure 8: Ln of total sales on number of banks



(a) Cooperative banks



(b) Commercial banks

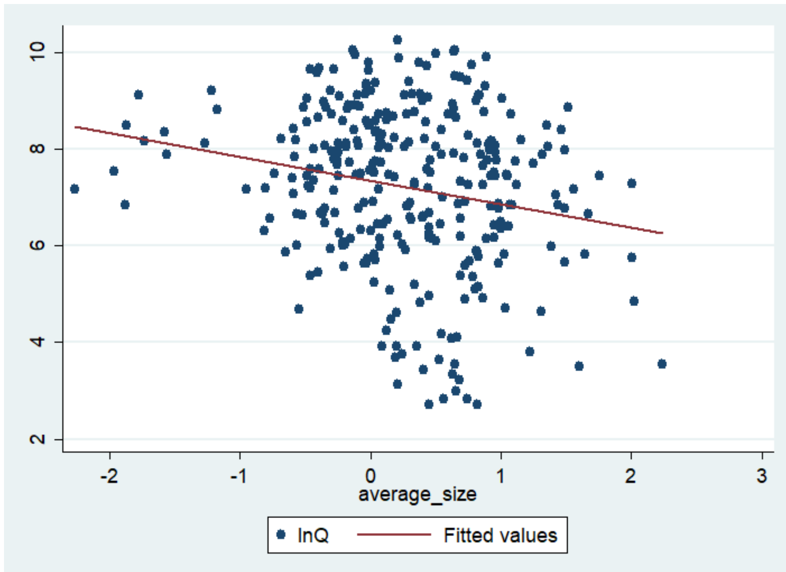


(c) Agri. credit societies

4.6 Size of Holdings

Yaron (1992) (agri-input book p 135), Land productivity inversely related to farm size.

Figure 9: Ln total sales on ln average size of holdings (2007)



4.7 Brand Preference in Agricultural Inputs

Several local surveys have been conducted to find out what affects farmers store choices and brand purchase decisions when it comes to agricultural inputs such as fertilizers and pesticides (Pingali & Kaundiya (2014) provide a useful survey). 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), Tripp & Pall (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) found that farmers preferred to shop for pesticides in town outlets even when their village had a shop offering pesticides, since town outlets promised quality, credit and 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 (if credit is available), brands are selected relying on personal experience rather than considering technical aspects of the product. Tripps & 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).

5 Empirical Strategy

5.1 Parametrization

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

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

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

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

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]:

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

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

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

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

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

For convenience, I parametrize the share of "non-captive" consumers and not λ itself. β_N, α_N, δ_N and η_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; the effect of entry on fixed costs (expected to be positive); and the effect of entry on the advantage for the historical monopoly. Z contains

[6] Bresnahan & Reiss instead employ a linear parametrization.

other variables affecting the advantage for the former monopoly, specifically cooperative credit sources, cooperative dealers, and institutional consumers. Then, the 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 markets where $N = 1$ we don't observe the "non-captive" population, and 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 distribution of the error term, the combination of the two entry equations yields a semi-ordered probit 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 endogeneity issues because of the number of firms dummy appearing on their right hand side. To deal with this, we use the number of firms equation as a selection rule for the quantity equation.

5.2 Identification

5.2.1 The entry effect on quantity

The quantity equation suffers both from selection bias, since only markets with positive sales are included, and from endogeneity of the number of firm dummies. 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 we 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. Since Potash fertilizer is entirely imported and not locally produced in India, we believe that these variables are not related to the variable costs in the marketing of Potash, so they are used as a proxy for an existing retail network in the area, affecting the fixed cost encountered when entering the business of marketing Potash.

5.2.2 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 we 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 we 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), but this effect can't be quantified. We can further obtain a measure for the combined effect of entry on variable profits and fixed cost, but we cannot separate the two.

5.2.3 The competitive effect of entry

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

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

we 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. We assume that under the fixed price regimen, $\frac{V_{N-1}}{V_N} = 1$ (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 regimens. Notice that I allow an effect of entry on the per-capita demand, even though prices are fixed, this has to do with the idea of the captive consumers, possibly introducing a Hoteling type product heterogeneity. Now we can easily derive the entry effect on variable costs under market prices, and the entry effect on fixed costs.

5.3 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 $\widehat{x\beta}$ stand for $Z\mu_Z + X\mu_X + W\mu_W$ and $\widehat{z\delta}$ stand for $X\beta_X + W\beta_W$. Then the quantity equation can be written as:

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

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

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

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, we 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, that ε_Q is normally distributed with mean 0 and variance σ^2 and be the correlation coefficient between the two terms is 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:

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

where $t_i = \left(\frac{lnQ_i - \widehat{z_i\delta} - Y_i\gamma - \beta_N}{\sigma_Q}\right)$. Summing across all of the observations will give us the total likelihood. 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. The difference is that they also 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 market with at least two firms, markets with less than two firms will have the same likelihood contribution as written above, only with $\widehat{x_i\beta} = X\beta_X + W\beta_W$.

5.4 Entry thresholds

Following an ordered Probit estimation, we can calculate the Bresnahan and Reiss entry thresholds, i.e. the minimum market size necessary to support each market structure. We 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, we will say 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.

$$\begin{aligned} Prob(\text{at least n firms}) &= Prob(\widehat{x\beta} + Y\gamma + \varepsilon_\pi > \mu_n) \\ = Prob(\varepsilon_\pi > \mu_n - \widehat{x\beta} - Y\gamma) &= 1 - \Phi(\mu_n - \widehat{x\beta} - Y\gamma) \geq 0.5 \end{aligned} \tag{27}$$

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

$$\begin{aligned} \Phi(\mu_n - \widehat{x\beta} - \gamma \cdot \ln(s)) &\leq 0.5 \\ \mu_n - \widehat{x\beta} - \gamma \ln(s) \leq 0.6915 => \ln(s) &\geq \frac{\mu_n - \widehat{x\beta} - 0.6915}{\gamma} \\ => S_n = \exp &\frac{\mu_n - \widehat{x\beta} - 0.6915}{\gamma} \\ s_n = \frac{S_n}{n} = \frac{1}{n} \exp &\frac{\mu_n - \widehat{x\beta} - 0.6915}{\gamma} \end{aligned} \tag{28}$$

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:

$$\frac{s_{n+1}}{s_n} = \frac{n}{n+1} \exp \frac{\mu_{n+1} - \mu_n}{\gamma}$$

This ratio also doesn't depend on the arbitrary 0.5 threshold on the probability.

6 Single equation results

Before turning to the full model, I present results from single equation estimations. Tables 6-8 presents the number of firms ordered-Probit. This estimation is unbiased 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 have the correct sign in all specifications. 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, it is significantly negative, 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 counterintuitive if we expect larger or richer farms to use modern and expensive inputs more often. However this result can connect to an alternative notion documented in the agricultural literature, where larger farms and holdings were found to be less productive per unit of land than small holdings. One of the explanations suggested that farmers with larger farms actually used less modern inputs and they invested their resources in the other more profitable activities of the farm (animals etc.). Our results (here and in the quantity equation) appear to stand in line with this hypothesis. The distance from deposits is significant and positive in almost all specifications. This is might result from 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 cooperative banks and credit societies do not significantly affect the number of firms in almost all specifications, while commercial banks have a significant positive effect. 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 8 presents the ordered-Probit cutoff points and the calculated per-firm entry threshold ratios. The 2007 entry thresholds are similar to those found in Bresnahan and Reiss, in the sense that they are larger than one. 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 entry thresholds 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 9-10 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. The average size of holdings is again with a significant negative sign in most specifications, consistent with the reversed productivity phenomenon. An interesting result 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 11 presents an 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 sources are the only variable 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. While cooperative banks, and agricultural credit societies have a negative effect, when significant.

Table 6: Number of Firms Ordered Probit

	2007	2007	2007	2007	2012	2012	2012	2012
ln_area	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)
ave_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)
d_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)
d_plants	-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)
d_dep	0.189***	0.219***	0.0965*	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)
rice_irrig	1.262***	0.888***			1.539***	1.385***		
	(0.255)	(0.268)			(0.290)	(0.300)		
rice_nirrig	-0.457*	-0.807***			-1.084***	-1.033***		
	(0.255)	(0.279)			(0.288)	(0.288)		
wheat_irrig	0.566	0.548			0.34	0.197		
	(0.399)	(0.400)			(0.400)	(0.407)		
wheat_nirrig	-3.761**	-4.664***			-1.234*	-1.14		
	(1.598)	(1.589)			(0.720)	(0.726)		
rice			0.554***	0.259			0.365*	0.26
			(0.189)	(0.200)			(0.201)	(0.205)
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 7: Number of Firms Ordered Probit - cont.

	2007	2007	2007	2007	2012	2012	2012	2012
NB		0.0160***		0.0176***		0.00908**		0.0132***
		(0.004)		(0.004)		(0.004)		(0.004)
SBI		0.0250*		0.00329		-0.0406***		-0.0436***
		(0.013)		(0.012)		(0.011)		(0.011)
RRB		0.00924**		0.0114**		0.0140***		0.0182***
		(0.005)		(0.005)		(0.005)		(0.005)
coop_banks		-0.000672	-0.00103	0.000345	0.000756	0.00189	0.00254	0.00369*
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ACS	0.000666	-0.000277	0.000579	-0.000105	-0.000131	0.000262	-0.000155	0.000259
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
com_banks			0.00758***				0.00502**	
			(0.002)				(0.002)	
rail_fac	-0.00303	-0.0102*	-0.0112**	-0.0114**	0.000441	-0.00042	-0.00682*	-0.00865**
	(0.005)	(0.006)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
institutional	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	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 8: Ordered Probit cutoffs and calculated entry threshold ratios

	2007	2007	2007	2007	2012	2012	2012	2012
Constant cut1	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)
Constant cut2	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)
Constant cut3	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)
Constant cut4	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)
Constant cut5	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)
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 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9: Quantity Sold OLS

	2007	2007	2007	2007	2012	2012	2012	2012
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln_area	0.306**	0.275*	0.275*	0.270*	0.370***	0.330***	0.267**	0.234**
	(0.143)	(0.143)	(0.141)	(0.142)	(0.116)	(0.117)	(0.111)	(0.111)
ave_size	-0.301**	-0.285**	-0.265*	-0.287**	-0.251*	-0.260*	-0.148	-0.142
	(0.137)	(0.138)	(0.136)	(0.130)	(0.139)	(0.134)	(0.141)	(0.135)
d_port	-0.129***	-0.109**	-0.119***	-0.114***	-0.0609*	-0.0590*	-0.0654**	-0.0666**
	(0.044)	(0.044)	(0.043)	(0.043)	(0.032)	(0.033)	(0.032)	(0.032)
rice_irrig	0.356		0.494*		0.632**		0.463*	
	(0.289)		(0.279)		(0.277)		(0.263)	
rice_nirrig	0.0526		0.0000774		-0.31		-0.355	
	(0.321)		(0.299)		(0.281)		(0.279)	
wheat_irrig	0.838*		0.806*		0.00443		0.166	
	(0.434)		(0.434)		(0.422)		(0.412)	
wheat_nirrig	-3.571		-3.385		-0.745		-0.746	
	(2.171)		(2.169)		(0.735)		(0.731)	
rice		0.293		0.291		0.202		0.11
		(0.226)		(0.224)		(0.203)		(0.197)
wheat		0.567		0.603		0.254		0.353
		(0.421)		(0.420)		(0.363)		(0.356)
NB	0.0121**	0.0144***		0.0144***	0.00382	0.00531		
	(0.005)	(0.005)		(0.005)	(0.003)	(0.003)		
SBI	-0.0199	-0.0254*		-0.0259*	-0.00582	-0.00555		
	(0.015)	(0.014)		(0.014)	(0.011)	(0.011)		
RRB	0.000661	-0.000629		-0.00101	-0.00642	-0.00528		
	(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 10: Quantity Sold OLS - cont.

	2007	2007	2007	2007	2012	2012	2012	2012
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
coop_banks	0.00118	0.000869	0.00267		0.00490***	0.00526***	0.00554***	0.00586***
	(0.003)	(0.003)	(0.003)		(0.002)	(0.002)	(0.002)	(0.002)
ACS	0.000976	0.00133**	0.00121*	0.00136**	-0.000996**	-0.00103**	-0.00133***	-0.00139***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
com_banks			0.000798	0.000534			0.00464**	0.00520**
			(0.001)	(0.001)			(0.002)	(0.002)
d_dep		0.157**		0.153**	0.188***	0.171***	0.187***	0.166***
		(0.064)		(0.064)	(0.053)	(0.053)	(0.048)	(0.048)
rail_fac	-0.0011	0.000835	-0.000208	0.000602	0.00209	-0.000909	-0.00254	-0.00482
	(0.006)	(0.006)	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)
institutional	5.528***	5.787***	5.487***	5.822***	1.986	1.649	2.063	1.732
	(1.313)	(1.298)	(1.315)	(1.296)	(1.293)	(1.295)	(1.281)	(1.277)
iffco_retail	-0.673	-0.605	-0.65	-0.591	0.246	0.307	0.196	0.282
	(0.440)	(0.437)	(0.441)	(0.434)	(0.325)	(0.327)	(0.319)	(0.320)
N=2	0.755***	0.855***	0.770***	0.849***	0.339	0.355	0.277	0.279
	(0.213)	(0.204)	(0.213)	(0.204)	(0.248)	(0.250)	(0.247)	(0.248)
N=3	1.833***	1.931***	1.808***	1.923***	0.710***	0.820***	0.657***	0.755***
	(0.221)	(0.213)	(0.222)	(0.213)	(0.250)	(0.249)	(0.249)	(0.248)
N=4	1.960***	1.886***	2.027***	1.871***	1.204***	1.360***	1.173***	1.313***
	(0.265)	(0.269)	(0.263)	(0.269)	(0.265)	(0.262)	(0.263)	(0.259)
N=5+	2.323***	2.494***	2.336***	2.462***	2.033***	2.229***	1.924***	2.103***
	(0.295)	(0.276)	(0.283)	(0.280)	(0.279)	(0.271)	(0.277)	(0.269)
Constant	2.275	2.002	2.576	2.092	1.087	1.447	2.287*	2.613*
	(1.759)	(1.724)	(1.736)	(1.725)	(1.369)	(1.377)	(1.332)	(1.338)
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: Non-Captive Market Share ($1-\tilde{\lambda}$) OLS

	2007	2007	2012	2012
	(1)	(2)	(3)	(4)
ave_size	0.242**	0.159	-0.0181	-0.00675
	(0.097)	(0.097)	(0.071)	(0.073)
NB	0.00288		-0.00136	
	(0.004)		(0.002)	
SBI	0.0127		-0.000992	
	(0.011)		(0.007)	
RRB	0.0152***		0.0115***	
	(0.004)		(0.003)	
coop_banks	-0.0000866	-0.00137	-0.000396	-0.00237*
	(0.002)	(0.002)	(0.001)	(0.001)
ACS	-0.00185***	-0.000857**	0.000446	0.000233
	(0.0005)	(0.0004)	(0.0003)	(0.0003)
institutional	-0.559	-0.538	0.27	-0.158
	(1.223)	(1.280)	(0.885)	(0.889)
iffco_retail	0.134	0.238	-0.205	-0.215
	(0.287)	(0.298)	(0.206)	(0.204)
com_banks		0.000905*		0.00384***
		(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 for 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 12: Selection models for the two years and the full model

	Selection Model 2007	Selection Model 2012	Full Model
$\beta's$			
ln_area	0.51746***	0.9469***	0.76493***
	(0.106)	(0.110)	(0.065)
ave_size	-0.15186	-0.3708***	-0.3211***
	(0.107)	(0.118)	(0.074)
d_port	-0.30414***	-0.12901***	-0.20815***
	(0.035)	(0.030)	(0.021)
d_plants	-0.14645**	-0.071248	-0.10923***
	(0.063)	(0.055)	(0.040)
d_dep	0.14025**	0.045111	0.11091***
	(0.064)	(0.057)	(0.038)
rice	0.42184**	0.3757*	0.60196***
	(0.193)	(0.196)	(0.131)
wheat	1.5936***	0.6959**	1.1301***
	(0.360)	(0.335)	(0.234)
NB	0.01805***	0.010317***	0.010811***
	(0.004)	(0.003)	(0.003)
RRB	0.0097658**	0.016362***	0.010847***
	(0.004)	(0.005)	(0.003)
coop_banks	0.0013564	0.0025996	0.0028958***
	(0.002)	(0.002)	(0.002)
ACS	-0.00021781	0.00044806	0.00007862
	(0.001)	(0.001)	(0.000)

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

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

$\underline{\delta' s}$			
ave_size	0.70678**	0.29731	-0.56171***
	(0.302)	(0.255)	(0.090)
rice	-0.50536***	-0.56095***	0.60196***
	(0.126)	(0.132)	(0.131)
wheat	0.42184**	0.3757*	1.0177***
	(0.193)	(0.196)	(0.298)
NB	0.90591	0.6184	0.0119***
	(0.709)	(0.385)	(0.003)
RRB	0.014827**	0.0092716**	0.0038572***
	(0.007)	(0.004)	(0.004)
coop_banks	0.0035494	0.00051167	0.0028958***
	(0.006)	(0.005)	(0.002)
ACS	0.0011537	0.0055986***	0.00007862
	(0.003)	(0.002)	(0.000)
SBI	0.00063923	-0.0009459**	-0.042377***
	(0.001)	(0.000)	(0.009)
d_port	-0.025909*	-0.043402***	-0.20815***
	(0.014)	(0.012)	(0.021)
$N = 2$	-0.16057	-0.10291***	0.55107***
	(0.103)	(0.040)	(0.165)
$N = 3$	1.6122***	0.41698	0.89878***
	(0.497)	(0.291)	(0.199)
$N = 4$	1.6624**	0.56954	0.9323***
	(0.669)	(0.361)	(0.254)
$N = 5+$	1.6882*	0.89566*	0.99009***
	(1.012)	(0.487)	(0.340)
σ_Q	1.1312***	1.0891***	1.1986***
	(0.072)	(0.071)	(0.052)
ρ	0.18959	0.46335***	0.44752***
	(0.072)	(0.071)	(0.075)

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.

	Selection Model 2007	Selection Model 2012	Full Model
<u>2007 cutoffs</u>			
μ_1	4.5433***		7.859***
	(1.209)		(0.776)
μ_2	5.4524***		8.7667***
	(1.222)		(0.780)
μ_3	6.2142***		9.5135***
	(1.223)		(0.781)
μ_4	6.976***		10.245***
	(1.225)		(0.785)
μ_5	7.6951***		10.912***
	(1.233)		(0.790)
<u>2012 cutoffs</u>			
μ_1		9.6626***	7.4511***
		(1.240)	(0.748)
μ_2		10.165***	7.9317***
		(1.260)	(0.759)
μ_3		10.848***	8.5923***
		(1.274)	(0.766)
μ_4		11.703***	9.4304***
		(1.288)	(0.773)
μ_5		12.392***	10.121***
		(1.300)	(0.782)
Obs.	404	377	781
Log-Likelihood	-979.62	-845.93	-1867.4

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

Table 15: Entry threshold ratios from full model

	2007	2012
s2/s1	1.638	0.937
	(0.023)	(0.017)
s3/s2	1.770	1.581
	(0.016)	(0.018)
s4/s3	1.951	2.243
	(0.014)	(0.018)
s5/s4	1.915	1.973
	(0.013)	(0.014)

Standard errors in parentheses, calculated using delta method.

Then we show the results from the full model, where we set all parameters to be the same between the two years, except for the cutoffs in the entry equation. In the final model we 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 16: Combined entry effect on variable profits and fixed costs

	$(\alpha_N - \delta_N)^{2007}$	$(\alpha_N - \delta_N)^{2012}$
$N = 2$	8.508	7.598
	(0.931)	(0.906)
$N = 3$	9.618	8.043
	(0.967)	(0.922)
$N = 4$	10.105	8.854
	(1.009)	(0.964)
$N = 5+$	10.585	9.714
	(1.071)	(1.030)

Table 17: Calculated per-capita demand ratios

	d2/d1	d3/d2	d4/d3	d5/d4
2007	2.086	2.231	1.068	1.041
2012	1.758	1.200	1.301	1.514

Table 18: Calculated fixed cost ratios

F2/F1	F3/F2	F4/F3	F5/F4
4.190	3.908	2.089	2.044

Table 19: Calculated variable profits ratios

V2/V1	V3/V2	V4/V3	V5/V4
2.008	1.976	0.691	0.683

The figures bellow 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) beginning with the fourth entrant, and remains negative with the fifth entrant.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.

8 Conclusion

The relatively simple entry model presented here gives room to discuss some important features of the Indian Potassium fertilizer market. We 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 we related this advantage to the structure of the local credit market, commercial banks and Regional Rural Banks in particular were found to have a diminishing 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, we 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, we 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, we can 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 affect 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 to affect competition and subsequent market outcomes.

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