Continued Existence of Cows
Disproves Central Tenets of Capitalism?

"In theory, the market should have done away with Edible Arrangements long ago," said American Economic Association president Orley Ashenfelter, who added that one of the crucial assumptions of capitalism is the idea that businesses producing undesired goods or services will fail. "That's how it's supposed to work".

(The Onion, a satire magazine, 2011)

Santosh Anagol, Alvin Etang and Dean Karlan

December 2014

Abstract

We examine the returns from owning cows and buffaloes in rural India. With labor valued at market wages, households earn large, negative median annual returns from holding cows and buffaloes, at -293% and -65%, respectively. Making the stark assumption of labor valued at zero, median returns are then -7% for cows and +17% for buffaloes (with 51% and 45% of households earning negative returns for cows and buffaloes, respectively). Why do households continue to invest in livestock if economic returns are negative, or are these estimates wrong? We discuss potential explanations, including labor market failures and social norms, for why livestock investments may persist.

Key words: Savings, Investment, Profits, Livestock, Labor markets
JEL Classification: E21, M4, Q1, O12

Contact information: Santosh Anagol: The Wharton School, University of Pennsylvania, anagol@wharton.upenn.edu; Alvin Etang: Economic Growth Center, Yale University, alvin.ndip@yale.edu; Dean Karlan: Yale University, Innovations for Poverty Action, Jameel Poverty Action Lab and NBER, dean.karlan@yale.edu. The authors thank Ellen Degnan, Maria Dieci, Donghyuk Kim, Joe Long and Rachel Strohm for research assistance. We thank the Bill and Melinda Gates Foundation and the National Science Foundation for support for this project. All errors and opinions are our own.

I. Introduction

Despite the importance of livestock as an asset class in developing countries, we know less than we should about their economic returns. Stylized facts have circulated for years regarding low, often negative, economic returns from assets (de Janvry, Fafchamps, and Sadoulet 1991). Yet this stylized fact, to our knowledge, remains not well documented, nor well understood. Using detailed data from cows and buffalo in India, we attempt to document carefully the returns in a given year. We then discuss a myriad of reasons why observed returns may be negative, and discuss some evidence on each, including measurement error, preference for illiquid savings, insurance and variation over years (unobserved in our data), labor market failures, milk market failures, and social, cultural and religious value.

Understanding the profitability of common household investments is important for several reasons. First, if these types of investments are profitable, then it suggests that low take-up of formal financial savings products may in part be driven by profitable risk-adjusted returns to informal assets. If this is the case, then programs which encourage households to use formal sector savings are unlikely to succeed unless they provide higher, safer, or more flexible returns than those available on livestock assets.

Second, estimates of the returns to livestock can inform lenders about whether there are profitable projects for them to finance. As pointed out in de Mel, McKenzie, and Woodruff (2009a) while the (albeit limited) demand for high interest rate loans suggests that some proportion of households earn high returns on investments such as dairy animals, much heterogeneity likely exists, and evidence suggests non-borrowers may have quite low or nil returns to capital (Beaman et al. 2014).

Third, understanding the returns to livestock can help us learn more about labor market failures. Households will only choose to spend time caring for livestock if the returns on livestock are greater than their opportunity cost of labor; low returns on livestock may be masking even lower labor market opportunities (whether formal, informal, or via household production).

Fourth, to the extent that some development organizations provide grants of livestock to alleviate poverty[1], this analysis provides plausible estimates of potential impact, or at least lower bounds (many such grant programs provide services alongside the grant). Randomized trials evaluating the impact of asset transfers on income and consumption have found considerable success in several instances (Banerjee et al. 2010; Bandiera et al. 2013), but studies to date have evaluated bundled interventions which include the provision of savings accounts, health trainings, and consumption support as well as livestock grants, rendering it difficult to isolate the returns to livestock specifically.[2]

We use newly collected animal level survey data from northern India to estimate the returns to owning dairy cows and buffaloes. We are motivated to study dairy animals in India because of their importance as an asset among India's rural poor. India holds more than a sixth of the world's population and over one quarter of the world's estimated cattle population. The Rural Economic and Demographic Survey (REDS), a nationally representative survey of rural India, found that 45 percent of rural Indian households owned at least one cow or buffalo in 1999, and on average those who have a cow or buffalo have an adult female. Our survey data provides information on all the major inputs in the milk production function including the value of the animal, fodder costs, veterinary costs, and lactation periods, as well as detailed data on animal outputs including milk, calves, and dung. We estimate annual returns to owning a dairy animal based on estimates of accounting profits (excluding the opportunity cost of labor) and economic profits (including the opportunity cost of labor, but not including the opportunity cost of capital).

Our main finding is the preponderance of negative returns from investments in cows and buffaloes. We begin our analysis by calculating rates of return under two conservative (potentially upwardly biased) assumptions. First, we assume that household labor is valued at zero. And second, we use our lowest estimates of fodder costs, which come from independent sources on the prices and quantities of fodder animals eat (these independent estimates of fodder costs are substantially lower than the self-reported fodder costs in our survey). Even under these

[1] Organizations which provide livestock grants include Heifer International, and organizations which provide livestock grants alongside a holistic set of training, coaching and consumption support (often referred to as "graduate" or "ultra-poor" livelihood programs) include BRAC, TrickleUp, Bandhan, and Fonkoze among others.

[2] See http://www.poverty-action.org/ultrapoor/about for information on a set of ongoing randomized trials on this integrated intervention that includes asset transfers, typically livestock.

conservative assumptions, we find that the median return on cows is -7 percent per year, and the median return on buffaloes is +17 percent year. We show that rates of return are even lower if fodder is valued at households' self-reported values or if we value household labor at market wages. In terms of the distribution, with the conservative assumptions of zero-value for labor and lowest fodder costs, we find that 51% and 45% of households earn negative returns on cows and buffaloes, respectively.

Estimates of low or negative returns present a puzzle similar to the "Edible Arrangements" satirical quote at the opening of this paper: if cows and buffaloes earn such low, even negative, economic returns, why would rural Indian households continue to invest in them? Naturally this is not meant to be taken literally, but to make a point that we need to understand why these data generate these estimates, and likewise why we anecdotal evidence suggests similar low returns from other livelihoods and investments, such as smallholder farming (Beaman et al. 2013; Duflo, Kremer, and Robinson 2008; Karlan et al. 2013). The second part of our paper puts forward theories as to why households might persist in investing in cows and buffaloes despite their low returns. While the data at hand do not allow us to distinguish conclusively between these various explanations, we present some evidence to suggest that some explanations appear more plausible than others.

Our paper contributes to a prominent literature in anthropology that tries to understand the cultural and economic underpinnings of cattle ownership in India. One strand of this literature argues that the Indian stock of cows is too large relative to its productivity, i.e. that cows consume more societal resources than they produce. This strand explains the prevalence of these "surplus cattle" by arguing that cultural factors, such as the sanctity of cows in Hinduism, provide non-economic benefits to society that can explain the holding of unproductive animals.[3] A second strand of this literature, starting with Harris (1966), argues that a broader consideration of the benefits of cattle owning could justify the large level of cattle ownership in India on

[3] The literature focused on the fact that in Hinduism cows are considered sacred, cow slaughter is prohibited, and and eating beef is considered taboo. See Pal (1996) for a recent review of the literature on "surplus cattle" which he terms the "classical" view. There is also a literature in anthropology, mainly focused on African pastoral herders, that provides evidence that cattle play a broader role in society beyond that of economic assets. A key feature in most (though not all) African contexts is the reluctance of households to trade cattle for money, and also the special role cattle play in exchange for brides. See Comaroff and Comaroff (1990) and Hutchinson (1992) for detailed discussions. The anthropological literature on Indian cows cited above does not specifically discuss a role for cattle as a special medium of exchange (and we also have not heard of anecdotal evidence of this), so we suspect this is not an important explanation for the ownership of low return cows and buffaloes in India.

economic grounds, and that the sanctity of cows in Hinduism is a *consequence* of the economic productivity of cows.

We contribute to this debate in anthropology by focusing on individual cow rates of return and analyzing detailed animal level input and output data for a reasonably large sample of rural cow and buffalo owning households.[4] We do not see our paper as resolving this major debate, but we add some useful facts. Our results corroborate the idea that the widespread ownership of low productivity cows and buffaloes cannot be explained by the simple economic factors Harris (1966) described (i.e. benefits of milk, calves, dung); instead, there must be more subtle economic or cultural forces influencing the ownership of cows. Our data also does not wholly confirm the idea that cultural factors, such as religion, explain household cow ownership and low productivity because (1) buffaloes are not considered sacred in Hinduism, and yet we find low returns for them as well and (2) it is possible that economic factors in the form of milk or savings market failures could convey benefits to households that are difficult to measure in our setting.

The paper proceeds as follows. Section II describes the data and methods for calculating the returns to cows and buffalos. Section III presents the estimates. Section IV discusses potential explanations for why so many estimates are zero or negative, and Section V discusses further research questions and policy implications.

II. Data and Methods

Data

The data were collected from the 2007 Uttar Pradesh Household Survey, also used in Anagol (2010) and implemented by the Center for Financial Design at the Institute for Financial Management and Research in Chennai. The data were collected for a sample of households in two districts in the state of Uttar Pradesh in northern India: Lakhimpur Kheri and Sitapur.

The districts were split into two geographic regions, a smaller region called the "Ajbapur" area and a larger region called the "non-Ajbapur area". The distinction was relevant for this survey as

[4] Rao (1969) attempted to estimate cow level production functions using input data on feed and labor and output data on milk and dung. He does not report results on the profitability of cows, and also does not have information on calves born. See Dandekar (1970) for criticisms of the Rao (1969) methodology.

Ajbapur is the location of a large sugarcane mill, and the survey collected detailed data on water trading among sugarcane farmers. A complete list of villages in the two districts was obtained from the Indian census of 2000, and seventy villages were randomly selected (with probability proportional to size), including twenty from the Ajbapur area and fifty from the non-Ajbapur area. Within each village in Ajbapur, we randomly sampled 10 households from the full village, and an additional 20 households among all households that were identified as selling water in the village in a household listing survey.[5] In non-Ajbapur villages we sampled 20 households randomly from the full village and two households that were identified as jointly owning a borewell in the village.[6,7] All households in the survey, including the water-seller respondents, were asked the same set of questions regarding their dairying behavior.

The survey asked detailed questions about livestock, farming practices, land holdings, assets, household consumption and income history, savings, borrowing, and shocks. The "animal details" section of the questionnaire (Section E) focused on one randomly chosen dairy animal owned by the household, asking if the animal was a cow or buffalo and other details about the animal.[8] For an adult female dairy animal, the survey asked how many liters of milk were given at different stages of the lactation period, including immediately after giving birth to a calf, three months after giving birth, six months after giving birth and nine months after giving birth. The survey also asked about the number of insemination attempts it would take to impregnate the animal, the number and value of male and female calves born to the animal, the number of dung

---

[5] We sampled a greater number of households that traded water within the Ajbapur area because the survey was also used to study the water trading behavior of households that lived near the sugarcane mill in Ajbapur.

[6] Due to unsatisfactory performance by the initially hired data entry firm, we switched data entry firms and re-entered all of the data. In the process of transferring the hard copies of surveys from the first data entry firm to the second, 11 percent of the original surveys were lost. Among the non-Ajbapur villages, we received 967 of the expected 1100 surveys. Three villages in the original non-Ajbapur sample frame were lost. Among the Ajbapur villages, we received 546 of the expected 585 surveys. We received surveys from all of the villages that were originally included in the Ajbapur sample frame. Overall, we are missing data from eleven percent of households in the original sample frame.

[7] The survey collected a larger number of observations from water sellers in the Ajbapur to study water trading amongst those living close to a sugarcane mill. In the non-Ajbapur area, the survey collected information on two households that jointly owned borewells as baseline information for a potential field experiment on joint ownership of borewells.

[8] The dairy section of the questionnaire (Section D) asked if the household owned any female cows/buffaloes; if so, how many cows/buffaloes the household owned. For each cow or buffalo owned, households were asked to record, beginning with the most valuable cow/buffalo and then proceeding in order of declining value, the animal's breed, and what its selling price would be if the household wanted to sell the animal. The enumerator was then instructed to administer the detailed animal questions (Section E) regarding the animal in this list whose ID number appeared first on a sticker (unique to each survey) which contained a randomized ordering of all the Animal IDs.

cakes the animal produces per day, the number of times the animal had visited the veterinarian in the 12 months preceding the survey, the costs associated with these visits, and the costs of feeding the animal (including both purchased and home-produced fodder).

Estimating the Rate of Return

Our equation for the annual rate of return on a cow or buffalo is

$$\text{Rate of return (ROR)} = \frac{(P_t - P_{t-1} + \text{Profit}_t)}{P_{t-1}}$$

where P_t is the price at end of year, P_{t-1} is the price at the beginning of the year, and Profit_t is the profit generated by the animal over the year. We estimate the term P_{t-1} from the owner's perception of its animal's value, and we measure P_t based on a regression model of the price appreciation for animals one year older. We estimate the flow profits (Profit_t) as the revenues from milk, calves and dung minus fodder, veterinary, and insemination costs.

The first calculation we need to perform to estimate the annual return to a dairy animal is how many lactations, on average, the typical animal has per year. There are two types of cows to consider in this calculation, cows that have not attained reproductive age, and cows that have attained reproductive age. Our survey asked households whether the sample dairy animal had given birth yet in its life. If the animal had not given birth yet, we count that animal's milk yield as zero for the year. 106 cows of our total of 302 cows have not given birth and thus have milk revenues of zero. 143 of our total 383 buffaloes have not given birth and thus have milk revenues of zero.

For cows that had given birth at least once before in their lives, we estimate the number of calves expected per year as follows. Our survey asked households how many calves they expected the sampled dairy animal to have in the rest of its life (having a calf is a necessary and sufficient condition for having a lactation). We take this number and divide it by an estimate of the number of years we expect the sampled animal to live.[9] For cows, the average number of calves expected

[9] We estimate a dairy's animals expected years to live as follows. We first take the observed age distribution of cows above the age of six years old in our sample, and estimate the probability of death at each age based on the proportionate decrease in the number of cows at each age level. We also assume that cows or buffaloes that reach the age of 15 will die in that year, as this is the oldest observed animal we see in our data. Using this estimate of a

per year is 0.89, and for buffaloes the average number of calves expected per year is 0.97. For simplicity, we assume that cows and buffaloes that have had at least one calf in the past will produce one calf, and thus have one lactation period, per year.[10]

The annual input and output variables used in the calculations are as follows.

Inputs

1. *Fodder costs:* Our survey asked households to report the daily value, in rupees, of 12 different types of food for the selected dairy animal. For each of these types of fodder we asked for the value that was home produced and for the value that was purchased. We also asked for these separately for when the animal was milking as well as when the animal was dry. Appendix Tables 1 and 2 present the average value of each type of fodder given to cows and buffaloes separately for when the animal is milking and when the animal is dry (dairy animals typically eat more during the time when they are giving milk). In addition our survey asked whether the animal was fed any wild grasses (which we assume are costless); more than 99 percent of the sampled dairy animals were reported to eat some wild grasses. The additional fodder costs reported should thus be interpreted as beyond the wild grasses given to these animals.

   Dairy animal fodder can be classified in to three groups: 1) roughage 2) concentrate and 3) minerals. Roughage is typically dried crop residues that are produced as a by-product of crop production. On average, the main fodder cost for both cows and buffaloes is home produced wheat straw which is the primary form of roughage in our sample area. Our respondents also report feeding their animals rice paddy and straw (puwal/paira) as additional forms of roughage. Bursin (a protein rich legume), ampicheri, maise (corn), mineral cakes, and ready-made concentrate would all fall under the concentrate type of fodder. Concentrates in general provide greater nutrients. Our households also report providing small amounts of minerals (ghur and salt).

---

mortality table for cows, we can estimate an animal's life expectancy, conditional on current age. For animals less than six years of age, we assume that they will make it to age six with probability one. We make this assumption as our data contains few observations of animals less than six years old so our estimated mortality table is not accurate for the younger ages.

[10] The assumption of one calf per year is likely an over-estimate, as even dairy cows in the US typically do not give birth to more than one calf per year on average.

Our households report that the average cost of feeding a milking cow is 35 rupees per day, and the average cost of feeding a dry cow is 29 rupees per day. For milking cows, approximately 61 percent of the daily feed cost comes from home produced fodder, and for dry cows approximately 71 percent comes from home produced fodder. The value of fodder given to buffaloes is slightly higher, but the breakdown across different fodder types is very similar to that of cows (Appendix Table 2).

An important issue is how we should interpret the values household report for home produced fodder, as it is not clear whether these values represent "buy" values or "sell" values. Households might report a high value of their home produced fodder because that is what they would buy it for; but, in reality, they may not be able to sell home produced fodder for that price because of frictions in the fodder market (such as adverse selection). Ideally we would like to know the price households could sell their home produced fodder for, and use these "ask" prices to estimate the value of home produced fodder, but this data is not available in our survey.[11]

To get a sense of such potential biases in our survey estimated fodder costs, we manually conducted online searches for websites that describe recommended quantities and market prices of fodder for Indian cows and buffaloes ("feeding guides"). We found eight sources that estimated the quantities of roughage and concentrate that should be given to cows and buffaloes in milking and dry phases.[12] For each source we estimate the cost of feeding the animal separately for the milking and dry phases, and then take the average across all of the sources as our estimate of the average fodder cost for a milking or dry animal.[13] For milking cows, the average estimate is 20.8 rupees per day. For dry cows, the average is 16.3 rupees per day. Our online sources recommend on average 21.2 rupees per day of fodder for dry buffaloes and 27.9 rupees per day for milking buffaloes. We use these "feeding guide"

[11] We are less concerned with household survey reports on the value of purchased fodder, as we suspect households based these values on the actual prices they pay in the market.

[12] A reasonable concern is that these online feeding guides might cater to richer urban households with larger and more productive cows. These feeding guides typically give recommendations for cows and buffaloes by weight. We calibrate these recommendations by proportionally reducing the amounts recommended based on the weights of rural Indian cows and buffaloes relative to the weights of the animals mentioned in the feeding guides. It is also worth noting that after our calibration, our estimated feeding guide costs are *lower* than the costs our households report themselves (see Table 1). For details on these sources and the underlying the feeding guide calculations see the Appendix.

[13] Figure 2 presents our median rate of return estimates across a range of potential fodder costs as well, to give a sense of how returns would change across different assumptions on fodder costs.

estimates of fodder costs in our baseline calculations as these are our most conservative (i.e. lowest) estimates of fodder costs.[14]

We combine this information on daily dry and milking fodder costs with previous estimates on the average amount of time Indian dairy animals spend dry versus milking per year. Dry periods for cows and buffaloes in India are estimated to be approximately 160 days per year (Anagol 2010). Since we are estimating returns over a one-year period, assuming a 365-day year implies that milking periods are 205 days per year (roughly seven months). The survey asked how many months the animal will give milk after it gives birth. The average response was seven months (but can go up to 10 months for some animals), which is consistent with the estimated 205 days we use to estimate annual fodder costs. For animals that gave milk during the survey year, we assume that each cow has daily dry fodder costs of 160 days per year and milking fodder costs for 205 days per year. For animals that have not yet given milk, we use the dry fodder costs for the 365 day period.

2. *Value of adult animal:* Our survey asked respondents "If you wanted to sell this cow, what would the price be?" We use the response to this question as our estimate of P_{t-1}.

3. *Appreciation and depreciation of dairy animal value:* We estimate the change in the capital value of each animal ($P_t - P_{t-1}$) dependent on its age as follows. We first regress the logarithm of the self-reported value of the dairy animal on age and age squared as a predictive model of dairy animal values as a function of age. Appendix Figure 1 presents scatter plots of the relationship between animal value and age separately for cows and buffaloes. Both figures show that a quadratic model in age is a reasonably good fit for the relationship between dairy animal age and value: dairy animals increase in value at younger ages and then decline in value at older ages. This positive age/value relationship at younger ages is plausible since as a young dairy animal ages it gets closer to giving milk; also, there is positive selection in our sample of older animals, as lower quality animals may die or prove to be infertile. This type of selection will likely bias upwards our estimates of animal

[14] It is interesting to note that the feeding guide estimates are similar to the survey estimates of home produced fodder on average (see Appendix Table A2 for a breakdown of our survey fodder estimates by home produced versus purchased). Our finding of low returns would thus also be similar if we estimated it using only the value of home produced fodder.

appreciation, and therefore cause us to over-estimate the returns to dairy animals. The figure also suggests that dairy animals decline in value in their older years, which is consistent with the fact that older animals have fewer future lactations to give.[15]

Given our estimated model of the relationship between the logarithm of dairy value and age, we estimate the average change in the log value of animals for each age in our data. For example, our model predicts that, on average, three year old buffaloes gain in value by 0.2 log points per year (approximately 20 percent). We apply these average changes in value, conditional on age, to each of the animals in our sample to estimate their appreciation\depreciation over the year.

One potentially important issue here is there may be a gap between the appreciation households experience, because they know their cow is high quality, versus the appreciation in market prices (where quality may be uncertain to buyers).[16] If households have private information about cow quality, and tend to keep the best animals, than the real appreciation households experience may be higher than the market price appreciation. We return to this issue when we discuss potential explanations of our finding of low returns.

4. *Veterinary costs (costs of examinations and procedures during visits to a veterinarian)*: We have a direct survey question that asks how much the household spent on veterinary costs for the animal over the past year.

5. *Cost of insemination:* This is determined by the number of insemination attempts needed to impregnate the animal multiplied by the cost for one insemination. 78 percent of animals where we collected detailed information were inseminated using a breeding bull, and 13 percent were inseminated using artificial insemination, and 9 percent were inseminated using both methods (the households tried different methods). The survey did not include a direct question on the cost of using natural insemination, so we make the conservative assumption

[15] Ideally we would have been able to estimate depreciation functions specifically by animal breed, as breed has been shown to be an important determinant of value in prior work. In our sample, however, there are very few buffaloes and cows reported as specific breeds; most animals are non-descript local varieties. More than 81 and 95 percent of the buffaloes and cows, are categorized as “Unknown Indian” breed. This leaves us with too small a sample size to estimate breed-specific depreciation, although this issue appears to be less relevant in our context where most households do not own pure-bred animals.

[16] We estimate appreciation based on households answers to the question “If you wanted to sell this cow, what would the price be?”

that natural insemination is as expensive as artificial insemination.[17] Insemination services are typically provided by either a government veterinary hospital or an NGO in our survey villages. Our village level survey suggests that the average cost of one insemination by a government hospital was 66 rupees. For an NGO, the corresponding figure was 70 rupees. As we are unable to distinguish between the services provided by the two providers, we assume the price is the average of the two, 68 rupees.

6. *Labor costs:* Our survey asked about the number of hours spent caring for dairy animals per day in the household where the sampled animal lives. Appendix Figure A2 plots the number of hours households reported taking care of their dairy animals against the number of dairy animals in the household separately for cows and buffaloes. Both plots show there appear to be strong economies of scale in taking care of dairy animals; the amount of labor hours used does not increase with the number of dairy animals owned in the household. To bias ourselves towards under-estimating the cost per animal owned, we assume that hours spent on the sampled animal is equal to the total hours spent on dairy animals divided by the number of dairy animals in the household.

   We estimate the cost per hour of this labor as follows. We observe that children and adults (both men and women) in the household are generally equally responsible for the care of the animal.[18] According to our village level survey, the daily wage rate for an adult (man or woman) is 60 rupees, and the child labor wage rate per day is 25 rupees. In our baseline estimates we thus assume that adults and children equally share the burden of taking care of the animals, yielding an average cost of taking care of the dairy animal of 42.5 rupees per day. Assuming an eight hour work day, this gives an hourly labor cost of approximately 5

[17] In reality we suspect that natural insemination is cheaper than artificial insemination, as local bulls are typically maintained in villages for insemination purposes. Nonetheless, given the low price of insemination in general (median annual cost of 70 rupees relative to a median annual value of fodder costs of 6,850 rupees) it is unlikely our results are driven by measurement error in insemination costs.

[18] We do not know which household members take care of these particular animals. However, the survey asks whether a household has owned any female cows or buffaloes in the past five years and which members of this household are responsible for dairy animals. According to the data, it is common practice for household members (adult males and females as well as children) to share the responsibility of taking care of their cows and buffaloes.

rupees.[19] We multiply this average cost of labor per hour by the total number of hours spent per year on the sample animal to estimate the total cost of labor in caring for this animal. An important point to note is the possibility of multi-tasking when tending the animal. It is possible that the animal is taken out to pasture while the caretaker is doing something else (for example, working on the farm, doing something in the neighboring plot, etc.). Our survey did not ask any questions about multi-tasking so we cannot directly assess its importance. We account for the fact that multi-tasking might reduce the effective cost of labor by including return calculations where we assume the value of labor is zero (our "accounting" rates of return).

Outputs

1. *Value of milk*: For animals that had not yet given birth to a calf, the value of milk produced in the year is zero. It is important to include these animals in the analysis as our data suggests that it is common for households to own such animals (approximately 35 percent of the dairy cows and buffaloes held by our households had not yet given birth).

   For animals that had given birth to at least one calf in the past, our survey asked the following questions to determine the value of milk produced by the animal per lactation. We asked for the number of liters of milk produced during the first three months after birth, from three to six months, from six to nine months, and from nine to ten months. We asked for potentially differing amounts of milk production based on months since birthing, as cows and buffaloes typically give the most milk around four to five months after giving birth and then reduce milk production as the calf switches to solid foods. We multiply the liters per day estimate by the household's response to a survey question on the average price of milk produced by the household.[20] The value of milk produced by the cow/buffalo when it is dry is assumed to be zero.

[19] According to (*The Times Of India* 2011), the average for the OECD nations is 8 hours a day, slightly below the figure for Indians at 8.1 hours (486 minutes). Accessed online at http://articles.timesofindia.indiatimes.com/2011-04-13/india-business/29413474_1_oecd-countries-cooking-indians-work

[20] The survey did not ask for specific price per liter estimates for each animal in the household as fieldwork during piloting suggested there was not substantial variation in the price per liter of milk within households. The exact wording of the survey question was "What is the average price of this milk per liter?"

2. *Value of calves*: Given that we estimate dairy cows and buffaloes have approximately one lactation per year, this implies that they would produce one calf per year (on average). For each cow and buffalo in our sample, the survey asked the respondent to estimate what a new calf of this particular animal would be worth (separately for male and female calves) at the time of birth. Given that male and female calves are equally likely to be born, we take the average value of male and female calves as the expected value of a calf during its first year.

3. *Value of dung cakes*[21]: Our survey asked the respondent to estimate the number of dung cakes the animal produces per day. We combine this information with the estimated value of a dung cake as provided in the village survey (1 rupee per dung cake), to estimate the value of dung cakes produced per year.

III. Estimates

We collected survey data on 303 cows and 384 buffaloes. Of the 303 cows, 8 were missing data on the self-reported value of the cow, fodder costs, or labor costs, leaving us with an estimation sample of 295 cows. For buffaloes, 17 were missing the self-reported value or labor costs, so we are left with an estimation sample of 367 buffaloes.[22] The estimation sample is consistent through all of the results we present.

Table 1 presents summary statistics of the sources of value and expenditure, focusing on variables directly from our survey which were typically collected at the daily frequency (we later present summaries of annualized revenues and costs). Panel A includes variables where we have data for all animals in the sample, and Panel B includes variables only relevant for animals that have given birth to a calf (and thus have given milk before the time of the survey).

[21] Cow dung can be used in several ways. First, dung cakes are a source of domestic fuel in many rural households in India (Aggarwal and Singh 1984). Second, dung is often used as agricultural fertilizer (Aggarwal and Singh 1984). Third, due to its insect repellent properties for some types of insects (such as mosquitoes), dung is used to line the floor and walls of buildings (Mandavgane, Pattalwar, and Kalambe 2005). Dung is therefore important, allowing households to save money that would otherwise be spent on alternatives such as firewood, fertilizer and insecticides.

[22] One buffalo had a self-reported value of 20 rupees, which is too low to be reasonable. We treat this animal as having a missing self-reported value and exclude it from the estimation sample.

On average, the self-reported value of cows and buffaloes are 2,280 rupees and 8,700 rupees respectively. The average age of cows and buffaloes are similar at 5.5 and 5.7 years. Buffaloes produced 0.7 more dung cakes per day and are expected to have an additional 0.6 more calves in the rest of their life. In terms of the major costs of owning dairy animals, fodder and labor, buffaloes require approximately 3 to 7 additional rupees per day of fodder depending on whether the animal is milking or dry. The feeding guide estimates of fodder costs are typically 10 – 15 rupees lower per day relative to the survey based estimates.[23] Our survey respondents also report spending 0.3 hours (18 minutes) longer on average taking care of their buffaloes.

The milking and value of calf variables (Panel B) are means calculated for the 190 cows and 235 buffaloes that had given birth at least once at the time of the survey. Buffaloes, on average, give an additional 1 liter of milk per day between zero and nine months after giving birth, and an additional 0.5 liters 9 to 12 months after birth. Further, buffalo milk is on average valued at 0.6 rupees more than cow milk. On average, female cow and buffalo calves are worth 470 and 950 rupees respectively. Calves are worth substantially less than the average adult animal because the calf must be fed for 3 to 5 years before giving milk. Male cow and buffalo calves are worth on average 413 and 639 rupees respectively. The declining importance of male animals for farm work is likely the reason for the lower value of male versus female calves.

Table 2 presents our baseline estimates of rates of return for the full sample of cows (Panel A) and buffaloes (Panel B). To construct these tables we first calculate the rate of return earned on each animal according to equation (1) above. In this table we assume that the value of household labor used to take care of the animal is zero, and the value of fodder given is equal to the recommended amount from the feeding guides (see Appendix for full description). We then sort the animals from lowest to highest rate of return. The table presents the median for the variables indicated in the columns separately for each rate of return quintile, as well as the median values for the full sample. For example, the number 1,000 under the "Animal Value" column in the first row of the table indicates that amongst the cows in the bottom 20 percent of the rate of return distribution the median animal value is 1,000 rupees.

[23] The standard deviations on the feeding guide estimates are zero as these are imputed from the average cost based on the feeding guides. See the Appendix for details.

Our main result in Table 2 is that the median return to cows and buffaloes, even before including labor costs, is low, and that therefore there appear to be a large number Indian dairy animals that produce negative returns. We estimate a median return to cows of -7 percent, and a median return to buffaloes of +17 percent.[24] For buffaloes, the median return of +17 percent per month is slightly larger than the risk-free interest rates observed in India at the time of our survey, suggesting that a large proportion of buffaloes earn returns lower than those available in risk-free savings instruments.[25] Figure 1 presents a kernel density estimate of rates of return (excluding labor costs and valuing fodder at the feeding guide levels) for cows and buffaloes separately. The densities for both cows and buffaloes shows a large fraction of animals earning negative returns.[26]

There are a few things worth noting about the median values of the revenue and cost variables individually in Table 2. First, animals in the bottom two rate of return quintiles for cows and buffaloes have a median milk value of zero. This is because households report that more than 50 percent of the animals in this quintile had not yet given milk in their lifetime. These animals are primarily young adults ("heifers") that households hold in the expectation that they will give milk in the future. As noted above, it is important to include these animals in the analysis as they are a quantitatively important part of dairy animal holdings amongst households in India. In the absence of market failures, these animals should not necessarily have negative returns because although they currently produce no revenue, they should appreciate in value over the year as they get closer to producing milk. Our estimates suggest that these non-milking cows are particularly low return investments. Although we do include estimates of animal appreciation, one possibility

[24] We estimate mean returns of -84 percent for cows and -34 percent for buffaloes, with 95 percent confidence intervals of [-123,-43] and [-48, -20] respectively. In both cases our 95 percent confidence intervals do not include positive returns. Given the sensitivity of these mean return estimates to outliers, however, the analysis in our tables focuses on median returns as well as providing information about the full distribution of returns.

[25] The annual interest rate paid to saving accounts by many formal banks in India ranges between 4-10%. As another point of comparison, the nominal yield on ten-year Indian government bonds in 2007-2008 (the year of our survey) was 8.5% (Campbell, Ramadorai, and Ranish 2012).

[26] In the Appendix we present figures on heterogeneity in returns by education, wealth and herd size of the owner. In Appendix Figure A3 we find no significant difference in the distribution of returns across high and low education cow owners. For buffalo owners, we find that the distribution of returns for high education owners is shifted slightly higher than the returns of low education owners. Figure A4 shows little heterogeneity in returns across high and low wealth owners. In Figure A5 we explore whether there are economies of scale in cattle ownership by testing whether households with more than dairy animal have greater returns. For cows we find no difference in the distribution of returns across households with one dairy animal versus those with more than one dairy animal. For buffaloes we find that households with one dairy animal appear to have *higher* returns than those with more than 1 dairy animal, suggesting, if anything, diseconomies of scale.

is that our estimates of appreciation for these younger animals are biased downwards due to an adverse selection problem in the market for cows (Anagol, 2010). For example, households' own valuations of a cow may appreciate more than the market's value if it is difficult for a household to prove the quality of the cow on the market. We return to this issue when we discuss potential explanations for our findings.

In Appendix Table A4 we present our estimated rates of return valuing fodder at the self-reported values in the survey (labor is still valued at zero). Using household's self-reported fodder costs we find that the median return to cows is -238 percent, and the median return to buffaloes is -38 percent. The important thing to note in Table A4 is that much of the variation in median rates of return across quintiles is being driven by variation in fodder costs. For example, the median fodder costs for cows in the bottom quintile is 12,410 rupees per year, whereas the median fodder costs for those in the top quintile is 6,300 rupees per year. One possibility is that households may be over-estimating the value of home produced inputs, in particular fodder (which is the only quantitatively important input when we value labor at zero).[27] Given that between 60 and 70 percent of daily fodder costs (Appendix Tables 1 and 2) are due to home produced fodder, a small but systematic bias in the value of this home produced fodder could have large effects on our estimated rates of return. For example, households may assume that their home produced fodder is as good quality as the fodder that is traded in markets, and therefore over-estimate its value. Or, households may not have experience selling home produced fodder and therefore assume that there is a market for it when in reality it is difficult to sell.

It is also important to note that our rate of return estimates for cows will be particularly sensitive to mis-measurement of fodder costs; given that the median value of a cow is only 2,000 rupees, an upward bias in estimated fodder costs of just 5 rupees a day (or 1,825 rupees per year) would change the rate of return estimate for a cow with a true rate of return of zero percent to a negative return of -91 percent. This is less of an issue with buffaloes, as their median value is substantially larger relative to annual fodder cost cash flows.

[27] We are less concerned about households under-estimating milk revenues for the following reasons. First, the main information necessary to estimate milk revenues is the number of liters the animal gives per day. Anecdotal evidence from our conversations at markets suggest that the number of liters an animal gives per day is the most salient statistic about the animal's productivity. Also, households milk their animals themselves and are likely to notice the amount of milk the animal produces.

Given these concerns on the measurement of fodder costs, we conduct a simulation where we estimate rates of return over a range of possible annual fodder costs. Figure 2 presents the results of this simulation. The y-axis plots the median rate of return across all animals in the sample if we assume that each animal has a fodder cost equal to the value on the x-axis (we re-estimate rates of return across the sample for each fodder cost on the x-axis). The rates of return are plotted separately for cows and buffaloes. The larger negative slope for the cows rate of return line is due to the fact that cow rates of return are mechanically more sensitive to fodder costs because the capital value of cows is lower.

Note that the feeding guide fodder costs are substantially lower than the fodder costs reported by the households in our survey. This result is consistent with the idea that households may be over-estimating the value of the home produced fodder they feed their animals.

It is important to note that these low estimated rates of return are calculated *before* we include the cost of any labor spent on caring for animals or adjust for the fact that livestock investments are likely more risky than formal financial products (livestock can get sick, die or have problems getting pregnant). Taking these factors in to account, the results presented so far make it seem unlikely that cows and buffaloes offer large positive returns on average.

Naturally, once we include labor costs we find large and negative returns both for cows and buffaloes. Table 3 presents these rate of return calculations where we use our feeding guide fodder costs and include our estimated value of labor. For cows, we estimate a median rate of return of -293 percent, and for buffaloes we find a median negative return of -65 percent.

IV. Potential Explanations

1. Measurement Error

The first explanation of our finding is the simplest: our data or assumptions on production of cows are wrong. We have attempted to deal with mis-measurement in fodder costs, which from Appendix Table A4 appeared to be the most noisily measured input or output in our data. We believe it is less likely that there would be a major measurement problem with the value of milk, as households milk their own animals and the number of liters an animal gives per day is anecdotally used as a summary statistic of an animal's quality. Nonetheless, it is possible that other variables are systematically mis-measured. Indeed, in Sri Lanka, de Mel, McKenzie, and Woodruff (2009a) find that firms systematically under-report revenues by about 30% and over-report costs. They conclude that simply asking firms how much profit they make provides a more accurate measure of profits than detailed questions on revenues and expenses.

Previous work in labor economics has found that workers in formal employment settings typically do over-state the amount of hours worked (Bound et al. 1994; Carstensen and Woltman 1979; Duncan and Hill 1985; Hamermesh 1990; Mellow and Sider 1983; Robinson and Bostrom 1994; Stafford and Duncan 1977). Nonetheless, the fact that we find low median returns, even when we assume that labor costs are zero, suggests that over-stating the amount of time spent on dairying is not the sole driver for our low estimated returns.

2. Preference for Home -Produced Milk

In a book published in 1900 aimed at British ex-patriots living in India entitled "Cow-keeping in India: A Simple and Practical Treatment, their Various Breeds, and The Means of Rendering them Profitable," author Isa Tweed states: "The first advantage derived from keeping one's own cows is, you get pure milk. Pure milk is very essential to health… If people do not think of their own health, …they should at least have some thought for the health of their families and friends, who may not be quite so anxious to suffer and die."

Anecdotal evidence suggests that modern Indian households also believe, and perhaps rightly so, that home produced milk is of higher quality than purchased milk. Reuters (2012) recently reported that much of the country's milk is either diluted or contaminated with chemicals, including bleach, fertilizer or detergents. A government survey also found that 68.4% of milk sold in India does not meet basic health standards (FSSAI 2011). This implies that households may value home-produced milk at a rate higher than the market value, and therefore may be willing to receive low financial returns on dairy investments in exchange for the guarantee of having high quality milk available for household consumption. Consistent with this hypothesis, we find that only 12% of our sample households actually sold milk in the past year.[30] This is also consistent with arguments about information asymmetries in the milk market in Ethiopia, in which children in households with cows (after controlling for wealth) consume more milk, and have less stunting (Hoddinott, Headey, and Dereje 2014); similarly, earlier work argued that dairy cooperatives help mitigate information asymmetries in milk markets (Staal, Delgado, and Nicholson 1997).

Figure 3 presents a simulation of the median rates of return earned on cows and buffaloes if households valued a liter of home produced milk more than their reported prices. Our survey question asked households for the average price of a liter of milk produced by their household. If there is an adverse selection problem in the milk market (say due to unobservable mixing of water with milk), then the prices our households report might be lower than the value of pure home produced milk. Note that the average price of milk for cows and buffaloes is 11.2 and 11.7 rupees per liter respectively (Table 1). The x-axis of Figure 3 is a range of possible valuations for a liter of home produced milk. We re-calculate rates of return on each animal in our sample based on all of the possible values of the x-axis, and then plot the median rate of return on the y-axis. The rates of return in this figure are calculated using the feeding guide fodder costs and assuming the value of household labor is zero.

The figure shows that if households valued home produced milk more than the price they reported in the survey (perhaps because they reported the price they could sell the milk at, but not the value to the household as pure milk), then median rates of return may be substantially higher. It is interesting to note that the price per liter of full-cream milk produced by India's largest commercial milk producer (Mother Dairy) was 23 rupees per liter at the time of the survey, suggesting it is possible that the value of trusted quality milk is higher than the prices reported by our households. Estimating household preferences for home produced versus market milk, and testing for adverse selection in the milk market, is an interesting area for future research.

[30] There are other potential explanations for why so few households sell milk. Another plausible explanation is that there is limited external demand for the milk produced in our sample villages; only 23% of our sample villages are visited by milk buyers, and only 8% have a milk cooperative.

A related explanation is that our estimates of price appreciation with age are downwardly biased because households report prices at which they could sell their cows, as opposed to how much they value their own cows. If households have private information about the quality of their cow's future milking potential, then it is plausible that the true price appreciation households experience is greater than the price appreciation as measured by prices that cows can be sold for. This bias is likely to be largest for cows that have not yet given milk, as once a cow has started milking it is easier to prove its quality on the market. If price appreciation for young animals is in reality larger due to this adverse selection problem, then cows that have not yet given milk may have higher returns, and overall returns may not be as negative.[31]

3. Buffer Stock Savings and Preference for Illiquid Savings

In developing countries, low-income individuals and small businesses are generally excluded from conventional financial institutions (Rutherford 2000). de Mel, McKenzie, and Woodruff (2009b) document that few poor households have formal savings accounts. However, as Rutherford (2000) emphasizes, low income households do typically have some savings. This has led to the proliferation of a variety of forms of semiformal or informal savings channels, including deposit collectors,[32] savings clubs, postal accounts, accumulating savings and credit associations (ASCAs), rotating savings and credit associations (ROSCAs), or saving at home. These savings channels may help to meet the needs of the poor by offering convenient services in their neighborhoods (as in the case of deposit collectors), allowing them access to loans (ASCAs and ROSCAs), and providing them with incentives to save (in the form of the social pressure present in savings clubs, ROSCAs and ASCAs).

However, there are also disadvantages associated with these types of informal savings. The use of deposit collectors entails a negative interest rate. Interpersonal conflict or lack of trust may inhibit the creation of savings clubs, ROSCAs and ASCAs, and keeping money in the home offers no shield against inflation, and may lead to temptation spending. In the face of these shortcomings, households may find it desirable to save a portion of their income close to home in

---

[31] A related possibility is that households in our sample are in the process of growing their herds, and so there are a disproportionate number of young cows which have low measured returns. While we do not have any reason to believe that cows in this sample are particularly young, nationally representative data on the age distribution of cows and buffaloes is unavailable for us to verify this.

[32] In West Africa *susu* (deposit) collectors are paid up to 40% interest for providing a means of saving for rural households (Rutherford, 2000).

illiquid assets such as livestock, even if the returns to this means of saving are low, or even negative. This is consistent, for example, with buffer stock motivation for owning bullocks, put forward in Rosenzweig and Wolpin (1993).

Evidence from Burkina Faso, however, does not support the buffer stock explanation, as even in droughts households were not likely to sell their cattle, but rather suffered extreme reductions in consumption rather than reduction in assets. This also implies a potentially very high return to owning cattle during droughts (Fafchamps, Udry, and Czukas 1998; Kazianga and Udry 2006).

4. Labor Market Failures: True Value of Marginal Time is Zero

If labor markets are missing or imperfect, particularly for women[33], then the true opportunity cost of labor may actually be zero or close to zero (Basu 1997; Dasgupta 1993; Bardhan 1984; Mammen and Paxson 2000). In many locations, the formal labor market for women is essentially non-existent (Emran and Stiglitz 2006). Mammen and Paxson (2000) note that "there may be costs associated with women working outside of the domain of the family farm or non-farm family enterprise. Custom and social norms may also limit the ability of women to accept paid employment, especially in manual jobs. Further, off-farm jobs may be less compatible with child rearing, creating fixed costs of working off-farm" (p. 143). This implies that the household optimization treats the female labor endowment as effectively non-traded. One would expect that as the costs of women's time increases as they enter the workforce, the opportunity cost of tending a cow would also rise. However, if there are no opportunities for people to enter the workforce, then the opportunity cost of raising an animal is effectively zero, or at best the value of other home production opportunities.[34]

4. Time Varying Returns

We observe returns at a single point in time; if there is significant time series variation in the returns to dairy animals then it is possible that our low returns are due to an unusually poor year for cows and buffalo ownership. In a recent paper, written in response to an earlier version of this paper, Augsburg and Attanasio (2014) find cows and buffaloes in the Anantapur district in

[33] For about half the households analyzed, women are responsible for tending the animals.
[34] Based on the traditional assumption made in the literature that the value of an individual's time spent in any activity is equal to his or her wage rate.

the Indian state of Andhra Pradesh have low returns (similar to ours) in two out of their three survey years (2009 and 2012), but positive returns in the good rainfall year 2008.

In 2007 the total rainfall in our two survey districts Sitapur and Lakhimpur Kheri was 984.4 and 1,022.9 millimeters respectively.[35] These 2007 values are quite close to the long run average rainfall values of 943 and 1,056 millimeters in our two study districts.[36] In particular, the difference between the 2007 value and the long run average value is 0.2 standard deviations for Sitapur and -0.14 standard deviations for Kheri. Appendix Figure A6 plots the distribution of annual rainfall over the period 1901 – 2002 and shows that the 2007 rainfall values are close to the center of the distribution. These results suggest that our finding of negative returns are unlikely due to extreme rainfall in our particular survey year. Nonetheless, we believe it is possible that the average returns to cows over a longer time period might be higher or lower than the returns calculated over a small number of years, and future work should attempt to estimate returns over longer periods.

5. Preference for Positive Skewness in Returns

Garrett and Sobel (1999) document theoretical and empirical evidence that positive skewness of prize distributions explains why risk averse individuals may play the lottery. Similarly, skewness of returns distributions may explain why people may hold female cows and buffaloes, given that there is a small probability of making huge profits, although on average the animals yield negative economic returns. Our estimates provide evidence for positive skewness in returns. For example, Table 2 shows that the top 20% cows and buffaloes generate 220% and 96% median returns respectively. At the same time, the bottom 60% of cows, and 40% of buffaloes, make substantial median losses. This is consistent with the model of learning and types of enterprise presented in Karlan, Knight and Udry (2012), which predicts that a majority of entrepreneurs will have low marginal returns to capital as they are not capable of running a larger business, but that a small proportion of entrepreneurs may have the skills to run large firms profitably.

[35] These district level annual rainfall estimates were downloaded from: http://www.indiawaterportal.org/articles/district-wise-monthly-rainfall-data-2004-2010-list-raingauge-stations-india-meteorological. The source of this data is the India Meteorological Department. For the Kheri district the annual total excludes November and December because these are not available in the data. These months are typically very low rainfall and including average values for them does not change the results meaningfully.

[36] Annual total rainfall values for 1901 – 2002 for Sitapur and Kheri districts were downloaded from http://www.indiawaterportal.org/met_data/. The source of this data is the India Meteorological Department.

6. Religious and Social Status Value

Hinduism may explain the results for cows, but not the results for buffalos. In Hinduism, the cow is a symbol of wealth, strength, abundance, selfless giving and a full earthly life.[37] As almost all the sampled households reported that they were Hindu, they may also derive spiritual returns from cattle ownership. The foregone returns compared to their next best investment alternative would effectively be the cost of religiosity in this context. It also requires believing that the long term social evolution of a religion could find an equilibrium in which individuals worship a loss-inducing investment; most economic models of religion predict that customs derived from religion are either beneficial or strengthen the group, and this seems to do neither (Bainbridge and Iannaccone 2010).

Cows (and buffalos) may provide social prestige. Ferguson (1994), albeit from Lesotho, argues that cattle are valuable because ownership of them (and the ability to lend them out) builds the social standing of the lender. Anecdotal evidence in the Indian context is that lending milk cows and buffaloes is rare, but it is possible that cows and buffaloes confer social status in other ways that we are not capturing. Again, similar to the argument made with respect to religion, this would imply that the social evolutionary process has resulted in an equilibrium where one gains social status from taking on unprofitable investments.

7. Female Preference for Saving in Cows and Intra-household Conflict

Ferguson (1994) also argues that men of the Basotho group in Lesotho, who typically work in South African mines, choose to save in cattle back in Lesotho because cattle are viewed as male property; women do not have the right to sell cattle, although they do have the right to spend cash saved at home.[38] This creates an incentive for men in Lesotho to save in cattle, even if they earn a negative economic return. In our context women might have greater property rights over cows because they maintain the cows, and thus cows serve as a way for women to save that is

[37] For a general review of the debate on why cows evolved to become holy in Hinduism see Korom (2000).

[38] Ferguson (1994) also, in Lesotho, discusses how cattle hold special value as gifts for bride-prices. In our context, this seems to be less important, as only 7.7 percent of cows and buffaloes in our data were acquired as gifts. 36 percent of cows and buffaloes are born in to households, and 57 percent are purchased by the household.

less accessible by men. Such an explanation would be consistent with prior work that finds women use inefficient savings vehicles as a way to protect income from men. For example, Anderson and Baland (2002) explain ROSCAs in Kenya as a method for women to shield savings from men, and Schaner (2013) shows in a field experiment in rural Kenya that a woman that has a higher discount rate than her husband is more likely to use a costly individual savings account as a way to protect her savings.

V. Further Research Questions and Policy Implications

Our goal here is not to determine conclusively why Indian households invest in cows and buffaloes despite the fact that economic returns to such investments seem to be frequently negative. Our goal, rather, is to put forward a puzzle, with the aim to motivate either better data, or better understanding of these markets or behavioral decisions, in order to explain the puzzle. With a better understanding of the driving market or behavioral failures, if any, one can then focus policies on specific market problems.

Evidence suggests that the poor are often willing to earn negative interest in order to access reliable saving services (see Dupas and Robinson (2013) for evidence on savings accounts with negative interest rates in Kenya and Rutherford (2000) for deposit collectors in west Africa). If livestock ownership is seen as a form of savings, the observed negative returns to cows and buffaloes provide additional evidence of the high demand for savings, and perhaps specifically for illiquid savings in order to avoid temptation spending. The question then turns to the supply side of savings: what are the constraints on the supply side that make cows and buffalos better savings alternatives than what banks offer? With technological innovations such as mobile money, the transaction costs are plummeting for offering deposit accounts to consumers in developing countries, even in highly rural areas. Thus this is an area where improvements in ability to store cash outside of the home may lead to more efficient allocation of capital, away from risky or low return home investments. If the introduction of high quality savings accounts leads to a reduction in cow and buffalo ownership, this would be evidence for the commitment to save explanations discussed above.

If indeed, as we find, owning cows yields low or negative returns, this is of critical importance for NGO and government programs that promote investment in cows with an aim of poverty alleviation. In particular, the results here are critical for programs that engage in livestock grants to help households start or expand income generating activity from raising livestock (this is common amongst "graduation" programs, cited earlier, as well as many NGOs, such as Heifer International or other livestock grant programs). Our results suggest that merely transferring an asset alone may not be sufficient to generate higher income (beyond the value of the transferred asset). The heterogeneity in returns we observe may of course be due to heterogeneity in skills and knowledge on how to raise dairy animals profitably; this suggests potential for training and monitoring to improve the returns for households. On the other hand, Ferguson (1994) argues that World Bank programs that attempted to formalize cattle rearing among the Basotho people in Lesotho failed because the Basotho primarily used cattle as a savings device, and were not interested in upgrading their herds or reducing common grazing to improve productivity. Understanding why households choose to hold cattle at present is important for determining whether training and upgrading programs are likely to work.

Our results are also consistent with the finding in de Mel, McKenzie, and Woodruff (2009b) that female owned enterprises in Sri Lanka have a marginal return to capital equal to zero. Fafchamps et al (2013) also find that the returns to capital are equal to zero for female enterprises with less than the median level of profits prior to the capital infusion. Given that in our context the maintenance of dairy animals is managed by the women and children of the household, a similar mechanism or failure may drive the results in both our analysis and that of (de Mel, McKenzie, and Woodruff 2009b; Fafchamps et al. 2013)

Looking beyond cattle ownership, future research should analyze the returns from other assets, such as trees, tubers and small livestock (Undurragaa et al. 2013). Anecdotal evidence suggests that a variety of low-performing assets are commonly held across the developing world, but more systematic analysis across countries and asset types, and with a focus on unpacking the mechanisms driving ownership and returns of such assets, would further our understanding of household finance for the poor.

References

Aggarwal, G.C., and N.T. Singh. 1984. "Energy and Economic Returns from Cattle Dung as Manure and Fuel." *Energy* 9 (1): 87–90. doi:10.1016/0360-5442(84)90079-3.

Anagol, Santosh. 2010. *Adverse Selection in Asset Markets: Theory and Evidence from the Indian Market for Cows*. Working Paper. University of Pennsylvania Wharton School.

Anderson, Siwan, and Jean-Marie Baland. 2002. "The Economics of Roscas and Intra-Household Resource Allocation." *Quarterly Journal of Economics* 117 (3): 963–95.

Attanasio, Orazio, and Britta Augsburg. 2014. "Holy Cows or Cash Cows? The Economic Return to Livestock in Rural India." *IFS Working Paper*, April.

Bainbridge, William Sims, and Laurence R Iannaccone. 2010. "Economics of Religion." In *The Routledge Companion to the Study of Religion*, 2nd ed., 461–75.

Bandiera, Oriana, Robin Burgess, Selim Gulesci, Imran Rasul, and Munshi Sulaiman. 2013. "Can Entrepreneurship Programs Transform the Economic Lives of the Poor?" *LSE Working Paper*.

Banerjee, Abhijit, Esther Duflo, Chattopadhyay Raghabendra, and Jeremy Shapiro. 2010. "Targeting the Hard-Core Poor: An Impact Assessment." *Working Paper*, October.

Bardhan, Pranab K. 1984. *Land, Labor, and Rural Poverty: Essays in Development Economics*. Columbia University Press.

Basu, Kaushik. 1997. *Analytical Development Economics: The Less Developed Economy Revisited*. MIT Press.

Beaman, Lori, Dean Karlan, Bram Thuysbaert, and Christopher Udry. 2013. "Profitability of Fertilizer: Experimental Evidence from Female Rice Farmers in Mali." *American Economic Review Papers & Proceedings*, May.

———. 2014. "Self-Selection into Credit Markets: Evidence from Agriculture in Mali." *Working Paper*.

Bound, John, Charles Brown, Greg J. Duncan, and Willard L. Rodgers. 1994. "Evidence on the Validity of Cross-Sectional and Longitudinal Labor Market Data." *Journal of Labor Economics* 12 (3): 345–68. doi:10.2307/2535220.

Campbell, John Y., Tarun Ramadorai, and Benjamin Ranish. 2012. *How Do Regulators Influence Mortgage Risk: Evidence from an Emerging Market*. Working Paper 18394. National Bureau of Economic Research. http://www.nber.org/papers/w18394.

Carstensen, L, and H Woltman. 1979. "Comparing Earning Data from the CPS and Employer's Records." In *Proceedings of the Social Statistics Section*, 168–73.

Comaroff, L. John, and Jean Comaroff. 1990. "Goodly Beasts, Beastly Goods: Cattle and Commodities in a South African Context." *American Ethnologist* 17 (May 1990).

Dandekar, V.M. 1970. "Sacred Cattle and More Sacred Production Functions." *Economic and Political Weekly* 5 (March 21, 1970).

Dasgupta, Partha. 1993. *An Inquiry Into Well-Being and Destitution*. Clarendon Press.

De Janvry, Alain, Marcel Fafchamps, and Elisabeth Sadoulet. 1991. "Peasant Household Behaviour with Missing Markets: Some Paradoxes Explained." *The Economic Journal* 101 (409): 1400. doi:10.2307/2234892.

De Mel, Suresh, David McKenzie, and Christopher Woodruff. 2009a. "Measuring Microenterprise Profits: Must We Ask How the Sausage Is Made?" *Journal of Development Economics* 88 (1): 19–31. doi:10.1016/j.jdeveco.2008.01.007.

———. 2009b. "Are Women More Credit Constrained? Experimental Evidence on Gender and Microenterprise Returns." *American Economic Journal: Applied Economics* 1 (3): 1–32.

Duflo, Esther, Michael Kremer, and Jonathan Robinson. 2008. "How High Are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya." *American Economic Review* 98 (2): 482–88.

Duncan, Greg J., and Daniel H. Hill. 1985. "An Investigation of the Extent and Consequences of Measurement Error in Labor-Economic Survey Data." *Journal of Labor Economics* 3 (4): 508–32. doi:10.2307/2534924.

Dupas, Pascaline, and Jonathan Robinson. 2013. "Savings Constraints and Microenterprise Development: Evidence from a Field Experiment in Kenya." *American Economic Journal: Applied Economics* 5 (1): 163–92. doi:10.1257/app.5.1.163.

Emran, S., and J. Stiglitz. 2006. "Microfinance and Missing Markets." *Working Paper*. July.

Erenstein, Olaf, William Thorpe, Joginder Singh, and Arun Varma. 2007. *Crop-Livestock Interactions and Livelihoods in the Indo-Gangetic Plains, India: A Regional Synthesis*. Crop-Livestock Interactions Scoping Study, Synthesis. Mexico, D.F: International Maize and Wheat Improvement Center (CIMMYT).

Fafchamps, Marcel, David McKenzie, Simon Quinn, and Christopher Woodruff. 2013. "Microenterprise Growth and the Flypaper Effect: Evidence from a Randomized Experiment in Ghana." *Journal of Development Economics*, no. forthcoming.

Fafchamps, Marcel, Christopher Udry, and Katherine Czukas. 1998. "Drought and Saving in West Africa: Are Livestock a Buffer Stock?" *Journal of Development Economics* 55 (2): 273–305. doi:10.1016/S0304-3878(98)00037-6.

Ferguson, James. 1994. *The Anti-Politics Machine: "Development," Depoliticization, and Bureaucratic Power in Lesotho*. Minneapolis: University of Minnesota Press.

Garrett, Thomas A, and Russell S Sobel. 1999. "Gamblers Favor Skewness, Not Risk: Further Evidence from United States' Lottery Games." *Economics Letters* 63 (1): 85–90. doi:10.1016/S0165-1765(99)00012-9.

Hamermesh, Daniel S. 1990. *Shirking or Productive Schmoozing: Wages and the Allocation of Time at Work*. Working Paper 2800. National Bureau of Economic Research. http://www.nber.org/papers/w2800.

Harris, Marvin. 1966. "The Cultural Ecology of India's Sacred Cattle." *Current Anthropology* 7 (1).

Hoddinott, John, Derek Headey, and Mekdim Dereje. 2014. "Smallholder Dairying under Transactions Costs in East Africa." *Ethiopia Strategy Support Program Working Paper* 63 (February).

Hutchinson, Sharon. 1992. "The Cattle of Money and the Cattle of Girls among the Nuer, 1930-1983." *American Ethnologist* 19 (2): 294–316.

Karlan, Dean, Ryan Knight, and Christopher Udry. 2012. "Hoping to Win, Expected to Lose: Theory and Lessons on Micro Enterprise Development." *NBER Working Paper* 18325 (August). http://www.nber.org/papers/w18325.

Karlan, Dean, Isaac Osei-Akoto, Robert Darko Osei, and Christopher R. Udry. 2013. "Agricultural Decisions after Relaxing Credit and Risk Constraints." *Quarterly Journal of Economics, Forthcoming*. doi:10.2139/ssrn.2169548.

Kazianga, Harounan, and Christopher Udry. 2006. "Consumption Smoothing? Livestock, Insurance and Drought in Rural Burkina Faso." *Journal of Development Economics* 79 (2): 413–46. doi:10.1016/j.jdeveco.2006.01.011.

Korom, Frank J. 2000. "Holy Cow! The Apotheosis of Zebu, or Why the Cow Is Sacred in Hinduism." *Asian Folklore Studies* 59 (2): 181. doi:10.2307/1178915.

Mammen, Kristin, and Christina Paxson. 2000. “Women’s Work and Economic Development.” *Journal of Economic Perspectives* 14 (4): 141–64.
Mandavgane, S A, V V Pattalwar, and A R Kalambe. 2005. “Development of Cow Dung Based Herbal Mosquito Repellent.” *Natural Product Radiance* 4 (4): 270–72.
Mellow, Wesley, and Hal Sider. 1983. “Accuracy of Response in Labor Market Surveys: Evidence and Implications.” *Journal of Labor Economics* 1 (4): 331–44. doi:10.2307/2534858.
Pal, Amar Nath. 1996. “The Sacred Cow in India: A Reappraisal.” *Indian Anthropologist*, 53–62.
Rao, Hanumantha C H. 1969. “India’s Sacred Cattle: Some Empirical Results.” *Economic and Political Weekly* 4 (December 27 1969).
Reuters. 2012. “Most Milk in India Contaminated or Diluted,” January 10. http://www.reuters.com/article/2012/01/10/us-india-milk-idUSTRE80919O20120110.
Robinson, J, and A Bostrom. 1994. “The Overestimated Workweed? What Time-Diary Measures Suggest.” *The Monthly Labor Review* 117: 11–23.
Rosenzweig, Mark R., and Kenneth I. Wolpin. 1993. “Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India.” *Journal of Political Economy* 101 (2): 223. doi:10.1086/261874.
Rutherford, Stuart. 2000. *The Poor and Their Money*. New Delhi: Oxford University Press.
Schaner, Simone. 2013. “Do Opposites Detract? Intrahousehold Preference Heterogeneity and Inefficient Strategic Savings.” Working paper. Dartmouth College, Hanover NH.
Staal, Steven, Christopher Delgado, and Charles Nicholson. 1997. “Smallholder Dairying under Transactions Costs in East Africa.” *World Development* 25 (5): 779–94. doi:10.1016/S0305-750X(96)00138-6.
Stafford, Frank, and Greg Duncan. 1977. *The Use of Time and Technology by Households in the United States.* http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED146311.
The National Survey on Milk Adulteration. 2011. Food Safety and Standards Authority of India.
The Times Of India. 2011. “Indians Work 8.1 Hours a Day, More than Many Westerners,” April 13. http://articles.timesofindia.indiatimes.com/2011-04-13/india-business/29413474_1_oecd-countries-cooking-indians-work.
Undurragaa, Eduardo, Ariela Zychermanb, Julie Yiua, TAPS Bolivia Study Team, and Ricardo Godoy. 2013. “Savings before the Arrival of Markets: Evidence from Forager-Farmers in the Bolivian Amazon.” *Tsimane’ Amazonian Panel Study Working Paper* 81.

Appendix

In this appendix we describe the "feeding guide" estimates of the cost of feeding dairy cows and buffaloes in India. We found a total of eight online sources that provided information on how much cows and buffaloes should be fed.

Source 1: Feeding guide posted to the Indian message board aaqua, Available at: http://aaqua.persistent.co.in/aaqua/forum/viewthread?thread=12082

Source 2: Feed management guide from Tamil Nadu Agricultural University, Coimbatore, available at: http://agritech.tnau.ac.in/animal_husbandry/animhus_cattle_%20feed%20management.html

Source 3: Chapter Seven of Dairy Feeding Systems by S.K. Ranjhan, available at: http://www.ilri.org/InfoServ/Webpub/fulldocs/SmHDairy/chap7.html

Source 4: Case Study 11. Hay and Crop Residues in India and Nepal. Available at: http://www.fao.org/docrep/005/x7660e/x7660e0q.htm

Source 5: Available at: http://hpagrisnet.gov.in/animal-husbandry/downloads/Project_Report_Sample.pdf

Source 6: ikisan website, a website providing farming information for Indian farmers: http://www.ikisan.com/Animal%20Husbandary/dairy/Feed%20for%20Cattle.htm

Source 7: "Low-cost feed to boost productivity of milch cows." The Hindu, December 12, 2002. Available at: http://www.hindu.com/thehindu/seta/2002/12/12/stories/2002121200140300.htm

Source 8: Buffalo Feeding Guide from Tamil Nadu Agricultural University, Coimbatore, available at: http://agritech.tnau.ac.in/animal_husbandry/animhus_buffalo%20feeding.html

These sources typically list feeding amounts of dry fodder, green fodder, and concentrate for a cow or buffalo of a specific weight. Most of the sources are guides for owners of highly productive animals that weigh substantially more than the types of dairy animals found in the rural area we study. We therefore scale the fodder amount estimates by the ratio of an estimated weight of cows and buffaloes in our data (cow weight of 250 kg and buffalo weight of 400 kg) to the weight of the animal mentioned in the feeding guide.[39] So, for example, Source 1 above recommends 7 kg of dry fodder for a 400 kg cow. We scale this by 250/400 and therefore estimate that a cow in our data would require 4.38 kg of dry fodder per day. Most sources also recommend additional amounts of dry fodder, green fodder, and concentrates per liter of milk

[39] Our survey did not collect data on the weight of animals. Source 2 provides feeding instructions for cows of different weights. We assume that the cows in our dataset have an average weight of 250 kg, which is the lowest weight level given in Source 2, and buffaloes have an average weight of 400 kg, which is the lowest reported buffalo weight.

that an animal gives. We use the average number of liters of cows and buffaloes, 2.5 and 3.5 liters per day respectively, to estimate additional amounts of fodder necessary for milking cows.

We estimate the prices of dry fodder, green fodder, and concentrates as follows. For Dry fodder, we found four estimates of prices per kg of 2.5, 1.5, 0.7 and 1.2 from Sources 1, 5, 6 and Erenstein (2007) respectively. We average these to get an average price of 1.13 rupees per kg of dry fodder. For green fodder, we found estimates of 0.7, 0.5, 2.1 and 1.03 rupees per kg from sources 5, 6, 1, and 2, for an average of 0.74 rupees per kg. For concentrates, we found estimates of 3.5, 8, 4.68 and 4.5 rupees per kg from Sources 1, 5, 7, and Erenstein (2007), for an average of 4.8 rupees per kg.

Appendix Table 1 presents the recommended amounts, by fodder type, for each of our sources, along with the total costs per day based on the prices mentioned above. The numbers presented here are already scaled based on the weight of the sample animal given in the source document.

Table 1: Summary Statistics (Mean and Standard Deviation)

Panel A: Full Sample of Dairy Animals	Cows	Buffaloes
Animal Value (Self-Reported)	2285.7	8706.5
	(1680.4)	(4740.8)
Age (Years)	5.5	5.7
	(2.5)	(2.7)
Dung Cakes Per Day	4.2	4.9
	(1.7)	(2.0)
Calves Expected in Rest of Life	4.3	4.9
	(2.0)	(2.2)
Number of Vet Trips in Past Year	0.8	0.9
	(0.9)	(1.0)
Survey Daily Cost of Fodder When Milking (Rupees)	35.2	38.2
	(26.6)	(30.1)
Feeding Guide Daily Cost of Fodder When Milking (Rupees)	20.8	27.9
	(0.0)	(0.0)
Survey Daily Cost of Fodder When Dry (Rupees)	28.8	34.3
	(18.7)	(35.2)
Feeding Guide Daily Cost of Fodder When Dry (Rupees)	16.3	21.2
	(0.0)	(0.0)
Daily Labor Hours	3.0	3.3
	(1.5)	(1.5)
Observations	295	367
Panel B: Sub-Sample of Dairy Animals That Have Produced Calf (And Thus Milk)		
Milk (liters/day): 0-3 Months After Birth	2.6	3.5
	(1.0)	(1.3)
Milk (liters/day): 3-6 Months After Birth	2.7	3.6
	(1.0)	(1.2)
Milk (liters/day): 6-9 Months After Birth	1.9	2.8
	(1.0)	(1.1)
Milk (liters/day): 9-12 Months After Birth	0.2	0.7
	(0.6)	(1.0)
Milk Value (Rupees per Liter)	11.2	11.7
	(1.7)	(1.9)
Months Milking After Birth	7.2	8.2
	(1.4)	(1.7)
Value of Female Calf	476.9	933.6
	(531.7)	(1323.9)
Value of Male Calf	418.1	650.0
	(433.0)	(744.6)
Observations (with Milk Data)	190	235

Table 2: Distribution of Rates of Return (RoR), Valuing Labor at Zero and Fodder at Feeding Guide Values

Panel A: Cows

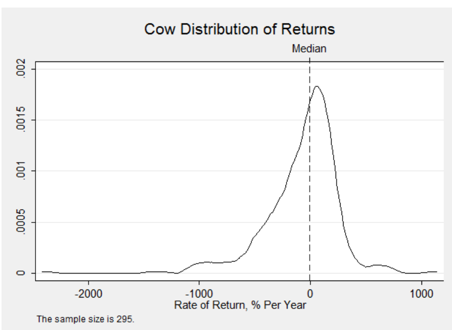
		Median Revenues				Median Costs						
Sample Frame	Animal Value	Milk	Calf	Dung	Total	Fodder	Depreciation	Insemination	Veterinary	Total	Median Profit	Median RoR
RoR in Bottom 20th Percentile	1,000	0	0	1,095	1,095	5,950	-112	0	0	5,869	-4,722	-468
RoR in 20th to 40th Percentile	2,000	0	0	1,460	1,825	5,950	-179	0	0	5,809	-3,938	-155
RoR in 40th to 60th Percentile	2,500	5,400	250	1,460	7,030	6,850	-23	136	80	7,090	-182	-7
RoR in 60th to 80th Percentile	2,500	7,560	300	1,460	9,275	6,850	13	136	100	7,117	2,141	90
RoR Above 80th Percentile	2,000	9,450	350	1,825	11,625	6,850	-27	136	40	7,040	4,627	220
Full Sample	2,000	5,400	125	1,460	7,030	6,850	-62	68	50	6,945	-182	-7

Panel B:Buffaloes

Sample Frame	Animal Value	Milk	Calf	Dung	Total	Fodder	Depreciation	Insemination	Veterinary	Total	Median Profit	Median RoR
RoR in Bottom 20th Percentile	3,500	0	0	1,460	1,460	7,738	-805	0	0	6,991	-5,667	-153
RoR in 20th to 40th Percentile	8,000	0	0	1,460	1,460	7,738	-1,524	0	0	6,432	-4,466	-53
RoR in 40th to 60th Percentile	11,500	8,100	450	1,825	10,615	9,078	-280	136	100	9,233	1,572	16
RoR in 60th to 80th Percentile	12,000	11,880	400	1,825	14,090	9,078	-459	136	100	8,855	5,354	46
RoR Above 80th Percentile	7,000	14,040	450	2,008	16,523	9,078	-247	136	100	9,086	7,352	96
Full Sample	8,000	8,100	50	1,825	10,690	9,078	-625	68	50	8,432	1,581	17

This table presents the median values of all input, output, and rate of return variables for cows and buffaloes. The data are first sorted based on the estimated rate of return for the animal, and then within each quintile we present the median value of the variable as indicated in the column headings. The sample size of cows and buffaloes is 295 and 367, respectively.

Figure 1: Histogram of Rates of Return, Valuing Labor at Zero and Fodder at Feeding Guide Values



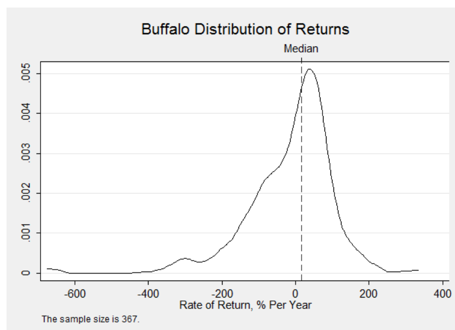
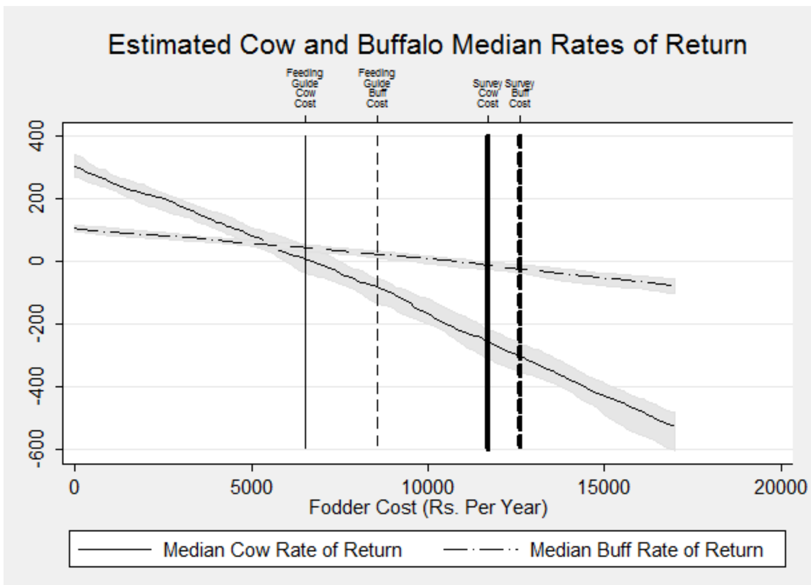


Figure 2: Rates of Return and Variation in Fodder Costs

Assumption: Labor Valued at Zero



This figure shows how rates of return change with different values of fodder costs. The figure plots the median rate of return in the sample given a per animal annual fodder cost on the x-axis (shaded regions are 95% confidence intervals). The thin solid vertical line is the cost of feeding a cow as recommended by the feeding guides. The thin dashed vertical line is the cost of feeding a buffalo as recommended by the feeding guides. The thick solid vertical line is the mean annual fodder cost for a cow in our survey data. The thick dashed vertical line is the mean annual fodder cost for a buffalo in our survey data.

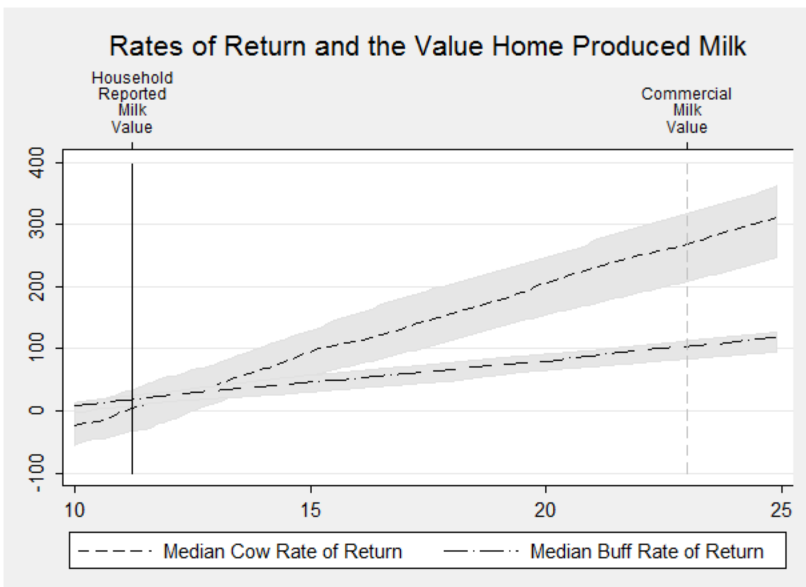
Table 3: Distribution of Rates of Return, Including Labor Costs and Valuing Fodder at Feeding Guide Values

		Median Revenues				Median Costs							
Sample Frame	Animal Value	Milk	Calf	Dung	Total	Fodder	Labor	Depreciation	Insemination	Veterinary	Total	Median Profit	Median RoR
RoR in Bottom 20th Percentile	1,000	0	0	1,095	1,095	5,950	7,300	-89	0	0	13,163	-10,083	-1,069
RoR in 20th to 40th Percentile	1,500	4,320	125	1,460	5,645	6,850	7,300	-61	68	50	13,287	-7,646	-525
RoR in 40th to 60th Percentile	2,000	4,500	0	1,460	6,130	6,850	5,475	-54	136	0	12,012	-6,471	-293
RoR in 60th to 80th Percentile	3,000	6,480	250	1,460	8,625	6,850	5,475	-46	136	100	11,512	-3,983	-140
RoR Above 80th Percentile	2,800	9,720	400	1,825	11,625	6,850	3,650	13	136	100	10,368	1,267	45
Full Sample	2,000	5,400	125	1,460	7,030	6,850	5,475	-62	68	50	11,677	-6,014	-293
Panel B:Buffaloes													
Sample Frame	Animal Value	Milk	Calf	Dung	Total	Fodder	Labor	Depreciation	Insemination	Veterinary	Total	Median Profit	Median RoR
RoR in Bottom 20th Percentile	3,000	0	0	1,460	1,460	7,738	7,300	-653	0	0	13,949	-10,964	-321
RoR in 20th to 40th Percentile	7,000	0	0	1,460	1,825	7,738	7,300	-1,089	0	0	13,261	-9,281	-126
RoR in 40th to 60th Percentile	10,000	7,560	225	1,825	10,093	9,078	7,300	-423	136	50	16,046	-6,183	-65
RoR in 60th to 80th Percentile	12,000	10,800	450	1,825	13,605	9,078	7,300	-469	136	100	15,154	-802	-10
RoR Above 80th Percentile	10,000	14,040	500	1,825	16,955	9,078	3,650	-441	136	100	13,188	2,998	31
Full Sample	8,000	8,100	50	1,825	10,690	9,078	7,300	-625	68	50	14,337	-5,704	-65

This table presents the median values of all input, output, and rate of return variables for cows and buffaloes. The data are first sorted based on the estimated rate of return for the animal, and then within each quintile we present the median value of the variable as indicated in the column headings. The sample size of cows and buffaloes is 295 and 367, respectively.

Figure 3: Rates of Return and the Value of Home Produced Milk

Assumptions: Labor Valued at Zero and Fodder Valued at Feeding Guide Values



This figure shows how rates of return change with household's valuations of home produced milk. The x-axis plots possible values of home produced milk. For each possible value on the x-axis we re-estimate the median rate of return in the cows and buffaloes sample assuming labor is valued at zero and fodder at the the feeding guide values. These median rates of return are plotted on the y-axis (shaded regions are 95% confidence intervals). For reference, the solid vertical line is the mean self-reported price of milk produced by the house in the sample (answer to the survey question "What is the average price of [home produced] milk per liter?"), and the dashed vertical line is the value of a liter of full-cream milk produced by India's largest commercial milk producer (Mother Dairy).

1 Appendix Tables and Figures

Table A1: Cows Fodder Amounts in Rupees Per Day

	Dry		Milking	
Fodder Type	Home Produced	Purchased	Home Produced	Purchased
Wild Grasses	0.00	0.00	0.00	0.00
Wheat Straw	7.78	1.19	7.64	2.10
Rice (Paddy)	1.19	0.41	1.29	0.63
Rice (Puwal/Paira)	3.54	0.40	3.43	0.58
Bursin	3.24	0.50	3.41	0.77
Ampicheri	1.59	0.23	1.79	0.42
Maise/Jawar	0.57	0.04	0.57	0.06
Mineral Cakes	0.81	1.93	0.89	3.77
Ready Made Concentrate	0.83	0.70	1.33	2.04
Ghur	0.44	0.31	0.66	1.23
Salt	0.72	2.42	0.54	2.06
Others	0.03	0.01	0.03	0.02
Total Rupees Per Day	20.71	8.12	21.56	13.65

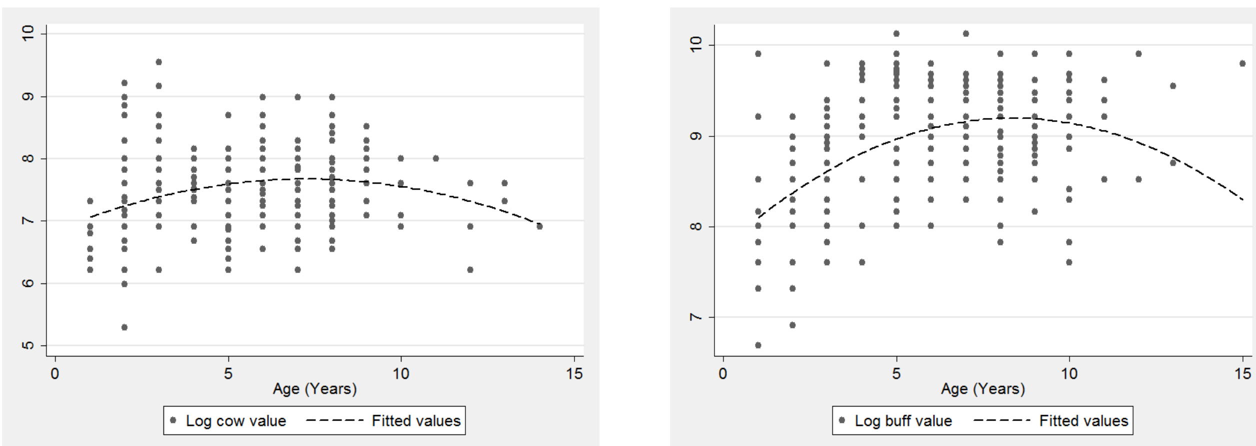
This table presents the average value, in rupees per day, of home produced and purchased fodder separately for when the cow is in the dry and milking phases.

Table A2: Buffaloes Fodder Amounts in Rupees Per Day

	Dry		Milking	
Fodder Type	Home Produced	Purchased	Home Produced	Purchased
Wild Grasses	0.00	0.00	0.00	0.00
Wheat Straw	8.77	1.14	8.20	1.42
Rice (Paddy)	1.04	0.67	1.15	0.88
Rice (Puwal/Paira)	4.12	0.46	3.90	0.48
Bursin	3.89	0.38	3.81	0.56
Ampicheri	2.08	0.42	2.10	0.49
Maise/Jawar	0.59	0.09	0.80	0.20
Mineral Cakes	0.72	2.82	0.81	4.25
Ready Made Concentrate	1.07	1.48	1.45	2.94
Ghur	0.35	0.40	0.82	1.22
Salt	0.82	3.05	1.21	1.89
Others	0.01	0.00	0.00	0.00
Total Rupees Per Day	23.45	10.90	24.24	14.34

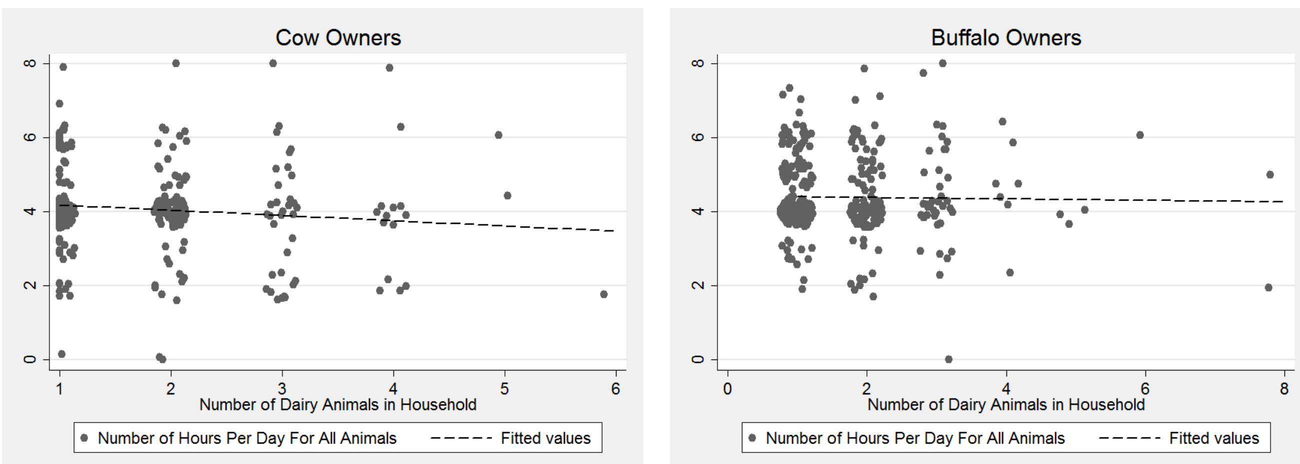
This table presents the average value, in rupees per day, of home produced and purchased fodder separately for when the buffalo is in the dry and milking phases.

Figure A1: The Age Profile of Dairy Animal Values



This figure shows a scatterplot of the logarithm of dairy animal values against the age of the animal.

Figure A2: Total Dairying Hours vs. Number of Animals in Household



This figure shows a scatterplot of the household's reported total hours spent on dairying against the number of dairy animals in the household.

Table A3: Estimated Fodder Costs by Source

Source (1)	Total Fresh Green Fodder Consumed (kg) (2)	Total Dry Fodder Consumed (kg) (3)	Concentrates (kg) (4)	Total Cost of Dry Cows Per Day (Rs) (5)	Additional Concentrates (kg) (6)	Additional Dry Fodder (kg) (7)	Additional Green Fodder (kg) (8)	Total Cost of Milking Cows Per Day (Rs) (9)
Panel A: Dry and milking cows								
1	6.25	4.38	1.56	17.16	0.94	0.00	0.00	21.69
2	5.00	5.50	1.25	15.99	0.91	0.00	0.00	20.39
3	8.89	4.00	0.83	15.17	0.83	0.00	0.00	19.20
4	3.85	4.51	0.00	7.97	0.32	2.40	1.94	13.66
5	16.67	4.17	1.67	25.17	0.83	0.00	0.00	29.19
6	2.91	5.81	0.00	8.75	0.83	0.00	0.00	12.78
7	11.11	3.33	2.50	24.12	1.00	0.00	0.00	28.95
Average	7.81	4.53	1.12	16.33	0.81	0.34	0.28	20.84
Panel B: Dry and milking buffaloes								
1	10.00	7.00	3.50	23.70	1.49	0.00	0.00	30.89
3	12.22	5.50	1.50	21.65	1.75	0.00	0.00	30.11
4	3.58	7.28	0.09	15.83	0.00	0.18	-1.54	14.90
5	20.00	5.00	2.00	27.37	0.40	1.40	0.00	34.13
6	4.65	9.30	0.00	18.83	1.40	0.00	0.00	25.60
7	17.50	5.50	0.00	24.08	1.75	0.00	0.00	32.53
8	7.33	5.38	0.73	17.12	1.27	-1.00	4.01	25.11
Average	10.76	6.42	1.12	21.23	1.29	-0.41	1.24	27.93

This table presents the estimated amounts and costs necessary to feed a 250 kg cow or 400 kg buffalo. The sources listed in Column (1) are described in the Appendix, as are the average prices used to convert amounts of fodder to costs of fodder.

Table A4: Distribution of Rates of Return, Valuing Labor at Zero, Fodder at Survey Values

Panel A: Cows

		Median Revenues				Median Costs						
Sample Frame	Animal Value	Milk	Calf	Dung	Total	Fodder	Depreciation	Insemination	Veterinary	Total	Median Profit	Median RoR
RoR in Bottom 20th Percentile	1,000	0	0	1,460	1,825	12,410	-80	0	0	12,239	-9,769	-989
RoR in 20th to 40th Percentile	1,600	3,600	0	1,095	4,995	12,585	-89	136	50	12,825	-7,603	-461
RoR in 40th to 60th Percentile	2,000	4,500	100	1,460	6,295	11,375	-111	68	0	11,598	-5,528	-238
RoR in 60th to 80th Percentile	3,000	7,200	200	1,460	8,295	9,300	-68	136	50	9,562	-2,028	-72
RoR Above 80th Percentile	2,000	8,100	350	1,460	10,325	6,300	13	136	100	6,769	3,224	136
Full Sample	2,000	5,400	125	1,460	7,030	10,220	-62	68	50	10,375	-4,621	-238

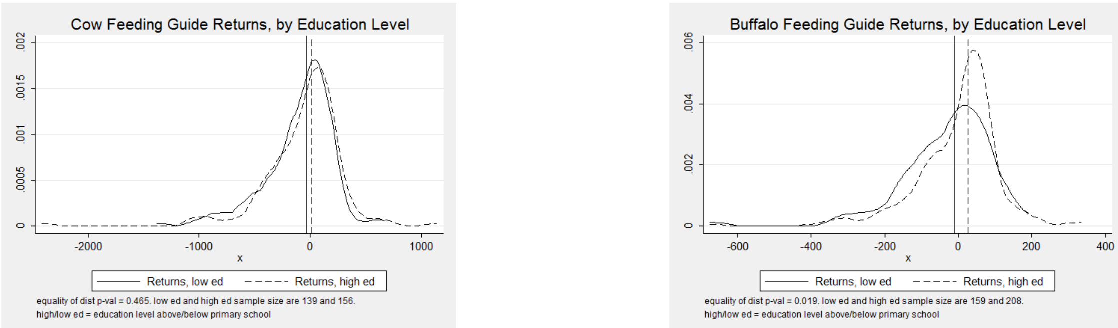
Panel B:Buffaloes

Sample Frame	Animal Value	Milk	Calf	Dung	Total	Fodder	Depreciation	Insemination	Veterinary	Total	Median Profit	Median RoR
RoR in Bottom 20th Percentile	5,000	0	0	1,460	1,825	11,687	-653	0	50	11,321	-8,719	-203
RoR in 20th to 40th Percentile	8,000	0	0	1,460	1,825	11,020	-1,089	0	0	9,646	-6,803	-91
RoR in 40th to 60th Percentile	10,000	7,560	275	1,460	10,093	13,463	-538	136	25	12,935	-3,027	-38
RoR in 60th to 80th Percentile	12,000	10,800	350	1,825	12,680	11,455	-491	136	100	11,180	1,089	10
RoR Above 80th Percentile	7,000	12,600	250	1,825	15,235	7,665	-361	136	100	7,285	6,943	83
Full Sample	8,000	8,100	50	1,825	10,690	10,855	-625	68	50	10,161	-2,862	-38

This table presents the median values of all input, output, and rate of return variables for cows and buffaloes. The data are first sorted based on the estimated rate of return on a cow, and then within each quintile we present the median value of the variable as indicated in the column headings. Panel A presents the estimates for cows, and Panel B presents the estimates for buffaloes. The estimation sample size of cows and buffaloes are 295 and 367 respectively.

Figure A3: Rates of Return: Heterogeneity by Owner Education

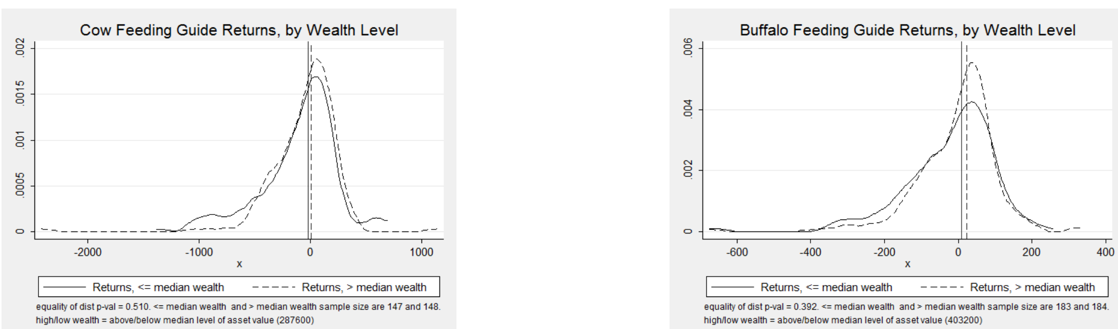
Labor Valued at Zero and Fodder Valued at Feeding Guide Values



The solid and dashed vertical lines are the median returns in the low and high education groups respectively.

Figure A4: Rates of Return and Owner Wealth

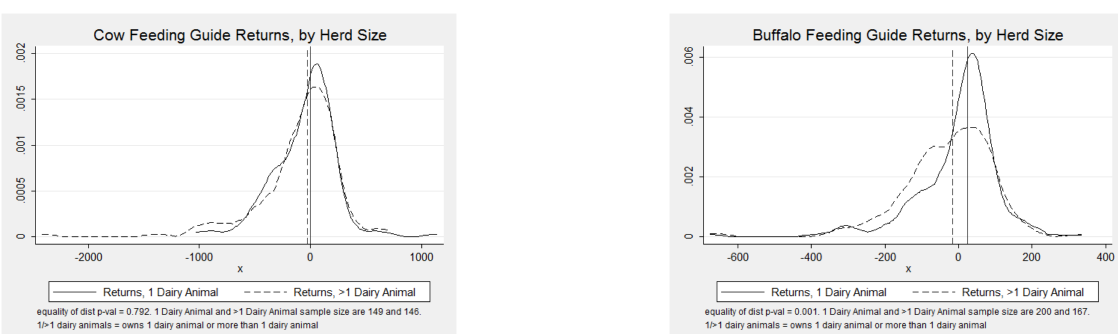
Labor Valued at Zero and Fodder Valued at Feeding Guide Values



The solid and dashed vertical lines are the median returns in the low and high wealth groups respectively.

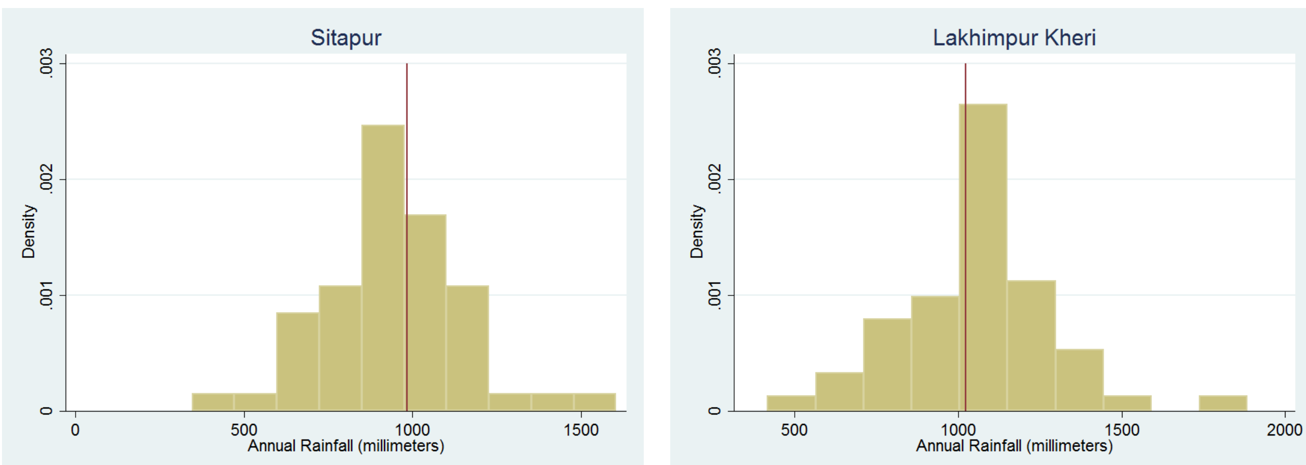
Figure A5: Rates of Return and Herd Size

Labor Valued at Zero and Fodder Valued at Feeding Guide Values



The solid and dashed vertical lines are the median returns in the low and high herd size groups respectively.

Figure A6: Long Run Distribution of Annual Rainfall in Survey Districts



The solid line indicates annual rainfall in 2007.