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Continued Existence of Cows Disproves Central Tenets of Capitalism?

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"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)

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Abstract

We examine the returns from owning cows and buffaloes in rural India. With labor valued at market wages, households earn large, negative median returns from holding cows and buffaloes, at -304% and -75%, respectively. Making the stark assumption of labor valued at zero, median returns are then -5% for cows and +10% for buffaloes (with 52% and 46% 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, for why livestock investments may persist.

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

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I. Introduction

Despite the importance of livestock as an asset class in developing countries, we know less than we should about their economic returns. 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, it is difficult to estimate the average return for non-borrowing households without data on profitability. 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 (both formal, informal, and 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, 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]

[1] Organizations which provide livestock grants include Heifer International, BRAC, Bandhan, and Fonkoze among others.

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

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 conservative assumptions, we find that the median return on cows is -5 percent per year, and the median return on buffaloes is +10 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 52% and 46% 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? 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.

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 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.[3] 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.[4,5] All households in the survey, including the water-seller respondents, were asked the same set of questions regarding their dairying behavior.

[3] 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.

[4] 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

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.[6] 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 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.

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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.

[5] 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.

[6] 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.

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.[7] For cows, the average number of calves expected 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.[8]

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. Appendix Tables 1 and 2 present the average value of each type of fodder given to cows and buffaloes separately for when the

[7] 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 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.

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

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).

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).

Given that households are unlikely to actively buy and sell this home produced fodder, there is some concern that households may systematically over or under report its value. To get a sense of how reasonable our survey estimated fodder costs are, we manually conducted online searches for websites that describe recommended quantities 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.[9] We also collected data on the prices of fodder. For each source we estimate the cost of feeding the animal the recommended amount per day, and then take the average across all of the sources as our estimate of the average fodder cost per animal. For milking cows, the average estimate is

[9] These sources and the underlying calculations are described in the Appendix.

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" estimates of fodder costs in our baseline calculations as these are our most conservative estimates of fodder costs.

We combine this information on daily 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.

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 a clear pattern of dairy animals increasing in value at younger ages. This 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 selection will likely bias upwards our estimates of animal 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.

   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 .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.

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 that natural insemination is as expensive as artificial insemination.[10] 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

[10] 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 it is unlikely our results are driven by measurement error in insemination costs.

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.[11] 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 rupees. [12] 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). Excluding these animals

[11] 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.
[12] According to ("Indians Work 8.1 Hours a Day, More than Many Westerners" 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

from the analysis would lead to over-estimating the returns on animals actually owned by households.

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.[13] The value of milk produced by the cow/buffalo when it is dry is assumed to be zero.

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*[14]: 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.

[13] 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?"

[14] 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.

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.[15] The estimation sample is consistent through all of the results we present.

T**a**ble 1 pres**e**nts 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).

On average, the self-reported value of cows and buffaloes are 2,280 rupees and 8,800 rupees respectively. The average age of cows and buffaloes are similar at 5.5 and 5.7 years. Buffaloes produced .7 more dung cakes per day and are expected to have an additional .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.[16] Our survey respondents also report spending .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 .5 liters 9 to 12 months after birth. Further, buffalo milk is on average valued at .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

[15] 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.
[16] 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.

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.

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 -5 percent, and a median return to buffaloes of +10 percent. For buffaloes, the median return of +10 percent per month is similar to the risk-free interest rates observed in India at the time of our survey, suggesting that 50 percent of buffaloes earn returns lower than those available in risk-free savings instruments.[17] 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.[18]

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

[17] 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 (the year of our survey) was 8.5% (Campbell, Ramadorai, and Ranish 2012).

[18] Appendix Figure A3 and A4 present histograms of rates of return separately for high and low education owners and for high and low wealth owners. We find that the distribution of returns for buffalo owners is higher, although the difference is small. Otherwise, rates of return do not seem to vary systematically with education or wealth.

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. These animals have low estimated rates of return because they produced no milk revenue in the year that we observe them. 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 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 -235 percent, and the median return to buffaloes is -54 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 14,228 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).[19] 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 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.

[19] 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 -304 percent, and for buffaloes we find a median negative return of -75 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 in modern times as well. 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.[22]

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.

3. 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

[22] 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.

led to the proliferation of a variety of forms of semiformal or informal savings channels, including deposit collectors,[23] 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 illiquid assets such as livestock, even if the returns to this means of saving are low, or even negative.

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

If labor markets are missing or imperfect, particularly for women[24], 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

[23] In West Africa *susu* (deposit) collectors are paid up to 40% interest for providing a means of saving for rural households (Rutherford, 2000).
[24] For about half the households analyzed, women are responsible for tending the animals.

workforce, then the opportunity cost of raising an animal is effectively zero, or at best the value of other home production opportunities.[25]

4. 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 222% and 90% 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.

5. 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.[26] 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).

[25] 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.
[26] For a general review of the debate on why cows evolved to become holy in Hinduism see Korom (2000).

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.

6. 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.[27] 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 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 (2012) 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 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.

[27] 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.

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 buffalo 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.

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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 Indian 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 Guie 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.[28] 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

[28] 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

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, .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 .7, .5, 2.1 and 1.03 rupees per kg from sources 5, 6, 1, and 2, for an average of .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 (1680.4)	8706.5 (4740.8)
Age (Years)	5.5 (2.5)	5.7 (2.7)
Dung Cakes Per Day	4.2 (1.7)	4.9 (2.0)
Calves Expected in Rest of Life	4.3 (2.0)	4.9 (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 (26.6)	38.2 (30.1)
Feeding Guide Daily Cost of Fodder When Milking (Rupees)	20.8 (0.0)	27.9 (0.0)
Survey Daily Cost of Fodder When Dry (Rupees)	28.8 (18.7)	34.3 (35.2)
Feeding Guide Daily Cost of Fodder When Dry (Rupees)	16.3 (0.0)	21.2 (0.0)
Daily Labor Hours	3.0 (1.5)	3.3 (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 (1.0)	3.5 (1.3)
Milk (liters/day): 3-6 Months After Birth	2.7 (1.0)	3.6 (1.2)
Milk (liters/day): 6-9 Months After Birth	1.9 (1.0)	2.8 (1.1)
Milk (liters/day): 9-12 Months After Birth	0.2 (0.6)	0.7 (1.0)
Milk Value (Rupees per Liter)	11.2 (1.7)	11.7 (1.9)
Months Milking After Birth	7.2 (1.4)	8.2 (1.7)
Value of Female Calf	476.9 (531.7)	933.6 (1323.9)
Value of Male Calf	418.1 (433.0)	650.0 (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

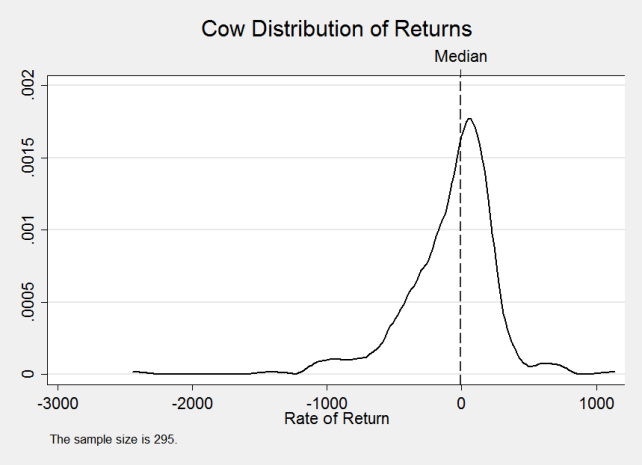
		Median Revenues				Median Costs						
Sample Frame	Animal Value	Milk	Calf	Dung	Total	Fodder	Depreciation	Insemination	Veterinary	Total	Median Profit	Median RoR
RoR in Bottom 20th Percentile	1,000	0	0	1,095	1,095	5,950	118	0	0	6,112	-4,930	-482
RoR in 20th to 40th Percentile	2,000	0	0	1,460	1,643	5,950	182	0	0	6,309	-4,572	-172
RoR in 40th to 60th Percentile	2,000	5,400	250	1,460	7,030	6,850	27	136	80	7,129	-140	-5
RoR in 60th to 80th Percentile	3,000	7,560	300	1,460	9,760	6,850	-13	136	100	7,096	2,587	90
RoR Above 80th Percentile	2,000	9,000	400	1,825	11,625	6,850	-13	136	50	7,070	4,619	222
Full Sample	2,000	5,400	125	1,460	7,030	6,850	62	68	50	7,006	-140	-5

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	847	0	0	8,640	-7,296	-197
RoR in 20th to 40th Percentile	9,000	0	0	1,460	1,460	7,738	1,524	0	0	9,480	-7,702	-90
RoR in 40th to 60th Percentile	10,000	8,100	300	1,825	10,690	9,078	529	136	100	9,973	654	9
RoR in 60th to 80th Percentile	12,000	10,800	400	1,825	13,775	9,078	368	136	100	9,788	4,332	37
RoR Above 80th Percentile	7,000	13,950	500	2,008	16,590	9,078	-40	136	100	9,398	7,186	90
Full Sample	8,000	8,100	50	1,825	10,690	9,078	625	68	50	9,426	667	10

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



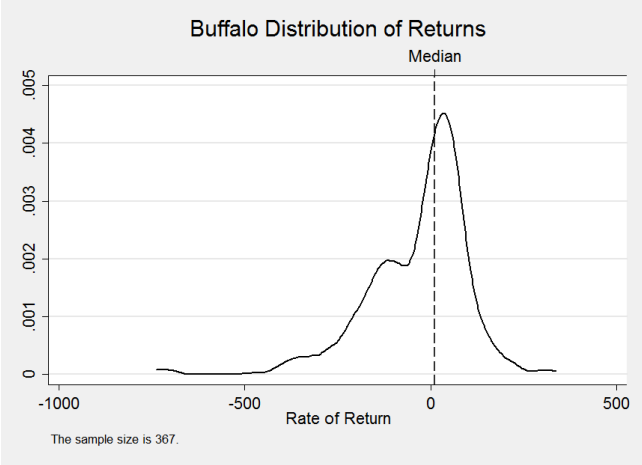
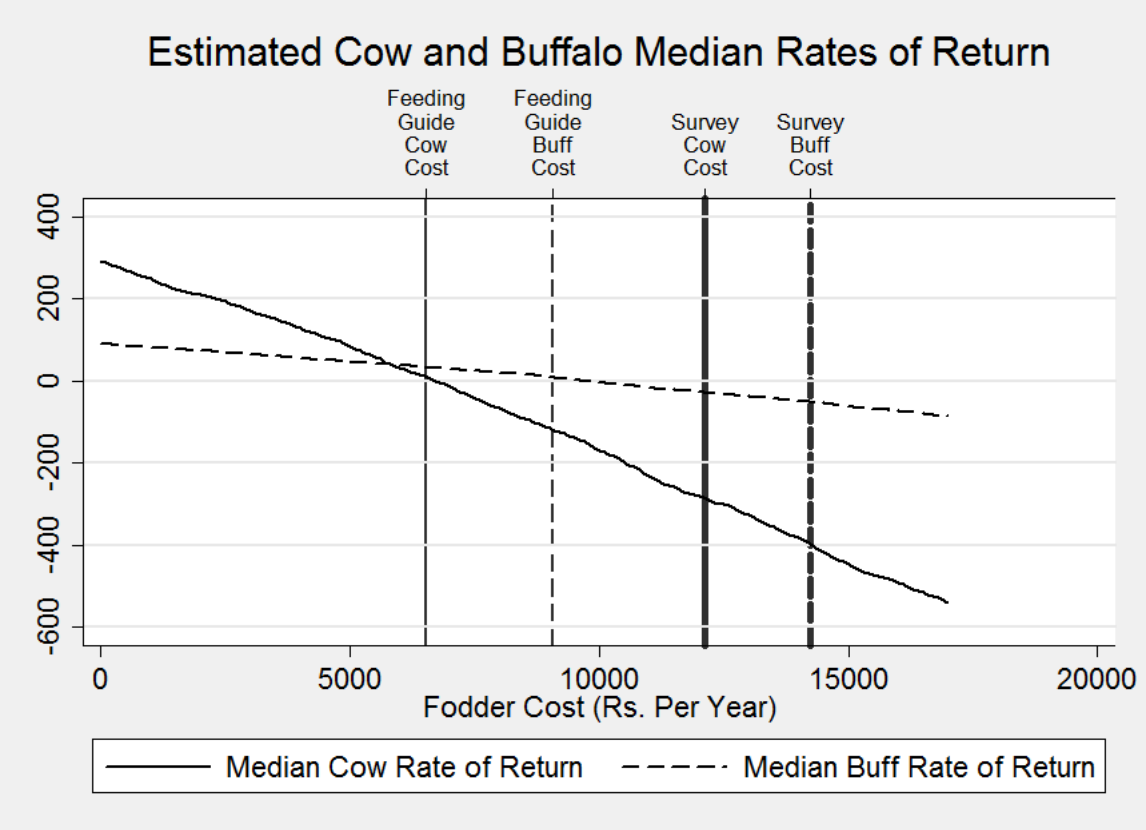


Figure 2: Rates of Return and Variation in Fodder Costs

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. 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.

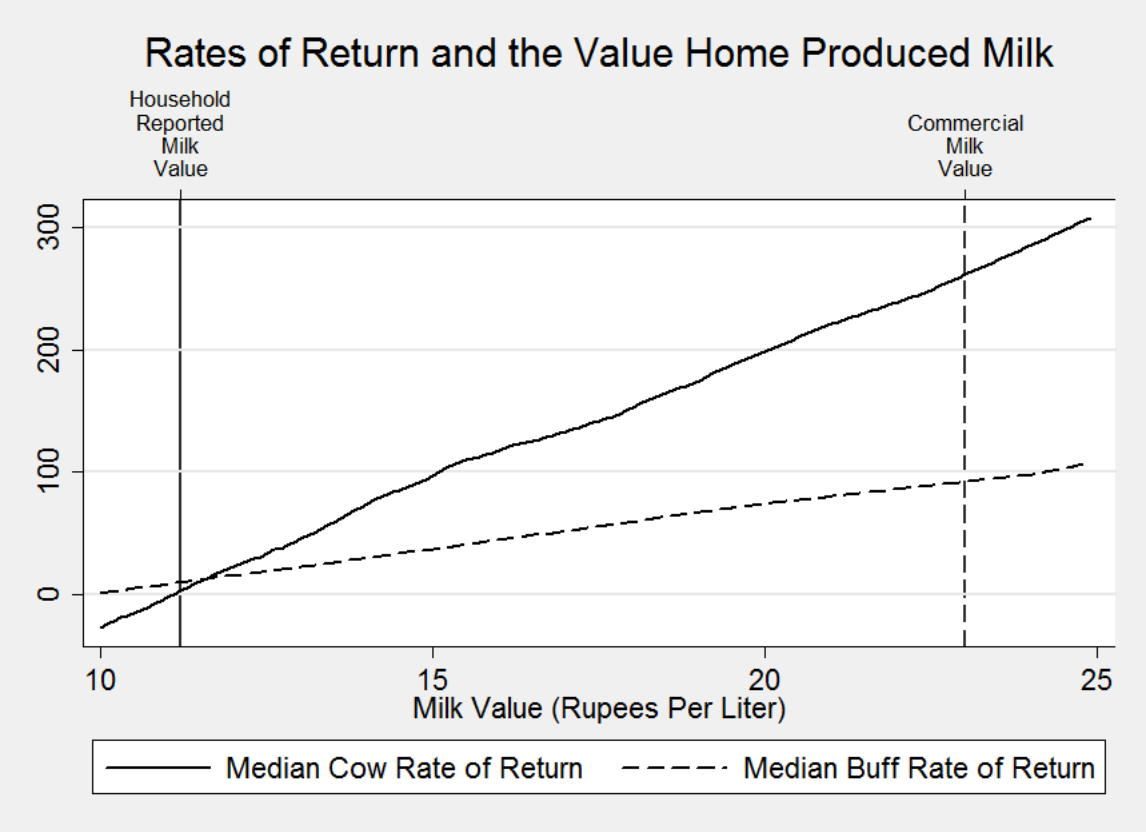
Table 3: Distribution of Rates of Return, Including Labor Costs and Valuing Fodder at Feeding Guide Values

		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	13,333	-10,454	-1,076
RoR in 20th to 40th Percentile	1,500	4,320	100	1,460	5,595	6,850	7,300	67	68	50	13,510	-7,976	-529
RoR in 40th to 60th Percentile	2,000	5,400	0	1,460	6,375	6,850	5,475	53	136	0	12,516	-6,642	-304
RoR in 60th to 80th Percentile	3,000	6,480	250	1,460	8,620	6,850	5,475	46	136	100	12,365	-3,862	-149
RoR Above 80th Percentile	2,500	9,720	500	1,825	11,580	6,850	3,650	-16	136	100	10,656	1,227	41
Full Sample	2,000	5,400	125	1,460	7,030	6,850	5,475	62	68	50	11,685	-6,190	-304
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	762	0	0	14,929	-12,692	-359
RoR in 20th to 40th Percentile	7,000	0	0	1,460	1,460	7,738	5,475	1,089	0	0	14,994	-11,065	-163
RoR in 40th to 60th Percentile	10,000	8,100	200	1,825	10,118	9,078	7,300	586	136	50	17,301	-7,361	-76
RoR in 60th to 80th Percentile	12,000	10,800	500	1,825	13,465	9,078	7,300	529	136	100	16,505	-2,007	-22
RoR Above 80th Percentile	10,000	14,040	500	1,825	16,945	9,078	3,650	-65	136	100	13,717	2,790	27
Full Sample	8,000	8,100	50	1,825	10,690	9,078	7,300	625	68	50	15,659	-6,883	-75

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. 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

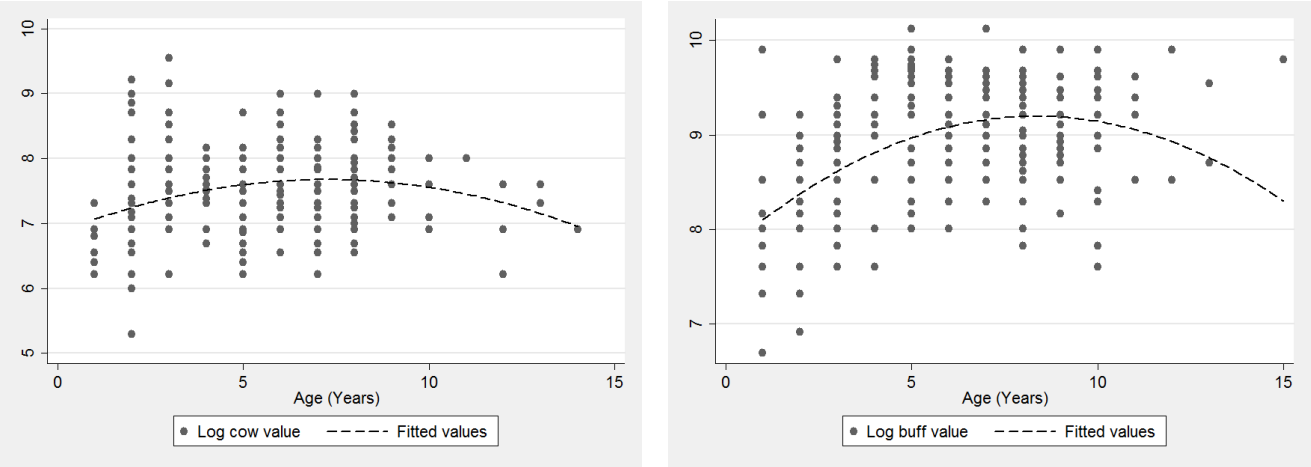
This table presents the average value, in rupees per day, of home produced and purchased fodder separately for when the cow is in the dry and milking phases.

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

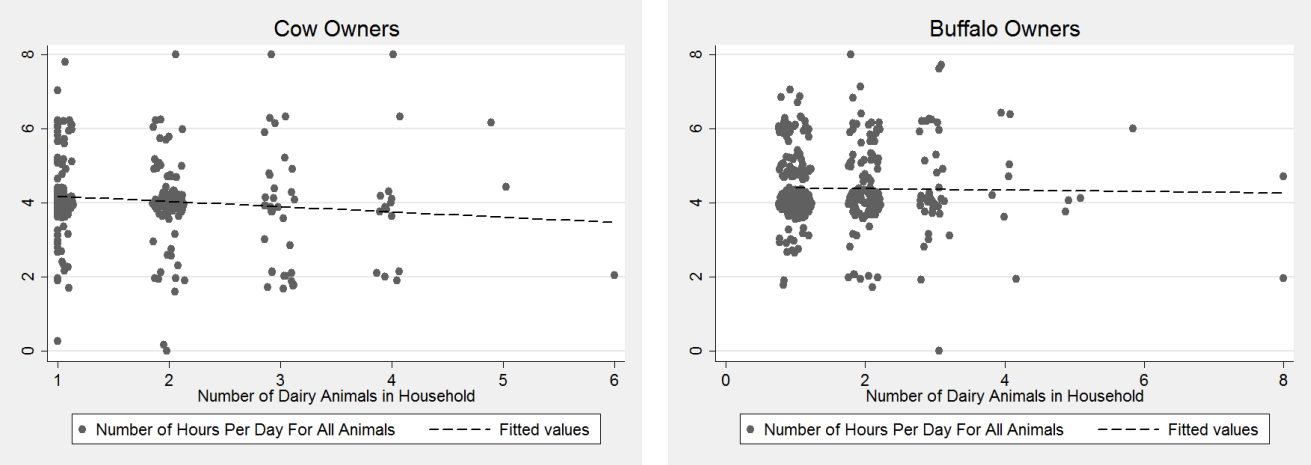
This table presents the average value, in rupees per day, of home produced and purchased fodder separately for when the buffalo is in the dry and milking phases.

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	14,228	80	0	0	14,250	-12,446	-1,079
RoR in 20th to 40th Percentile	1,500	3,600	0	1,460	5,230	12,325	91	136	30	12,617	-7,554	-440
RoR in 40th to 60th Percentile	2,000	4,500	0	1,460	5,895	11,375	89	68	0	11,594	-5,151	-235
RoR in 60th to 80th Percentile	2,500	7,200	200	1,460	8,955	9,440	68	136	50	9,683	-2,135	-82
RoR Above 80th Percentile	2,000	8,100	350	1,460	10,325	6,300	-13	136	100	6,707	3,315	140
Full Sample	2,000	5,400	125	1,460	7,030	10,230	62	68	50	10,407	-4,334	-235

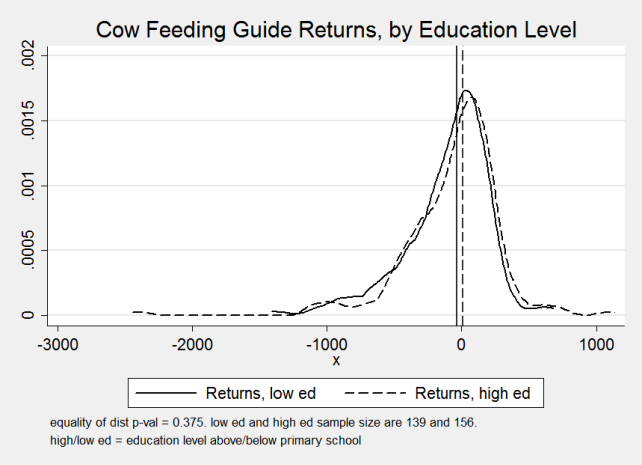
Panel B:Buffaloes

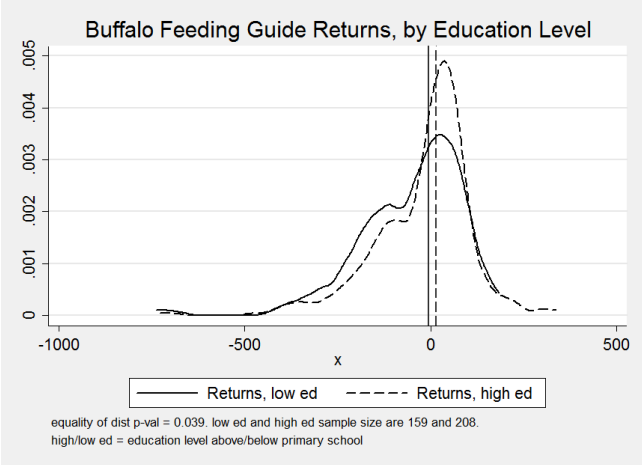
Sample Frame	Animal Value	Milk	Calf	Dung	Total	Fodder	Depreciation	Insemination	Veterinary	Total	Median Profit	Median RoR
RoR in Bottom 20th Percentile	4,000	0	0	1,460	1,460	13,775	653	0	0	14,589	-12,256	-283
RoR in 20th to 40th Percentile	8,000	0	0	1,460	1,660	11,950	1,250	0	20	13,359	-8,905	-129
RoR in 40th to 60th Percentile	9,500	7,200	25	1,460	9,150	12,033	805	68	0	13,456	-5,038	-54
RoR in 60th to 80th Percentile	12,000	10,800	500	1,825	13,340	12,743	282	136	100	13,163	191	2
RoR Above 80th Percentile	8,000	12,960	350	1,825	15,585	7,809	76	136	100	8,478	6,503	73
Full Sample	8,000	8,100	50	1,825	10,690	11,680	625	68	50	12,624	-4,200	-54

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

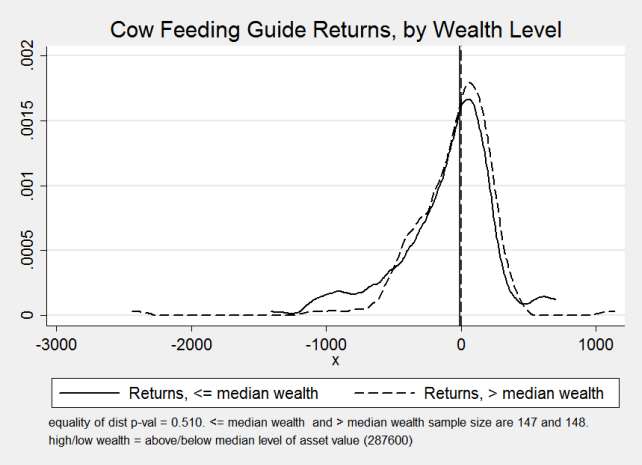


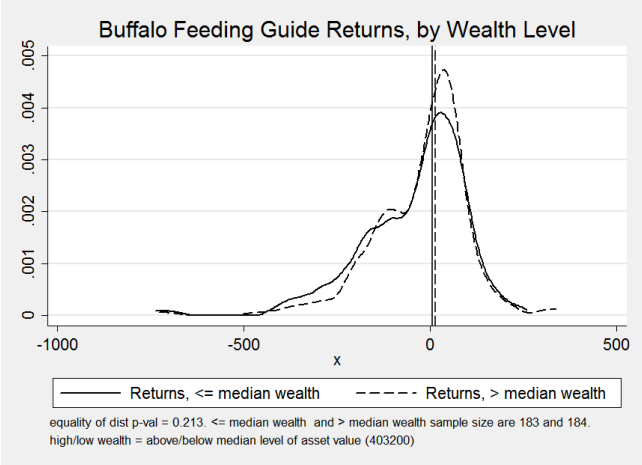


The solid and dashed vertical lines are the median returns in the low and high education groups respectively.

Figure A4: Cow 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 education groups respectively.