DRAFT, DO NOT QUOTE

ISSUES RELATED TO LIVESTOCK RETURNS IN BANGLADESH

(Why Do Bangladeshi Cattle Yield High Positive Return?)

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Abstract

This paper extends the recent debate on the rate of return of cattle rearing in India, triggered by Anagol et al (2017), Gehrke and Grimm (2018) and others, to the Bangladesh context and shows that findings of the apparent paradox of widespread cattle rearing despite negative return in India does not hold in Bangladesh. We use a representative panel data of rural Bangladesh of Bangladesh Integrated Household Survey conducted by IFPRI and find that the average (marginal) returns of cow and bullock are positive and high. We explore the sources of this high return and find that appreciation of the value of cattle is the major contributing factor for positive returns. We argue that the existence of meat market that is based on trading of cattle for slaughtering, which is missing in most states of India, is the key to high positive return in Bangladesh. Our study also sheds light on the rate of return for the poor and finds that despite lower return, the poorer are more likely to raise cattle and this finding has huge implications for the asset (livestock) transfer based antipoverty programs in developing countries.

Key words: Bangladesh, livestock, poverty, rural development

JEL Classification: C23, L25, O12, Q12.

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1 INTRODUCTION

The debate over rate of return to raising livestock was unleashed by Anagol et al. (2017) that was first published as an NBER working paper in 2014. Anagol et al. (2017) used survey data collected from Uttar Pradesh to estimate returns from raising livestock. They found that the median return to cows was -7% and a large number of Indian dairy animals generated negative returns. When labour costs were included, they found that more than half of the milking cows had negative returns. They claimed this contradicts the fundamental tenets of capitalism where activities generating negative returns would have been given up (Acemoglu and Robinson 2013). Anagol et al. (2017) discussed several factors that may explain negative returns: measurement error leading to underestimates of returns, preference for illiquid savings insurance, variation of returns over years, labour market failures, milk market failures and social, cultural, and religious values.

Two subsequent papers flagged some interesting issues by taking clue from these factors mentioned by Anagol et al. (2017). Attanasio and Augsburg (2018) argued that the data used by Anagol et al. (2017) came from a drought year characterized by scarcity of fodder and lower milk production and as such returns were low. They used a three-year panel data and found that returns were positive in normal years and negative in drought years. Gehrke and Grimm (2018) showed that returns to livestock vary by quality of the cattle and size of the stock. Those with cattle of better quality or those with larger herd size enjoyed higher returns. Household with cattle of lower quality or smaller herd size made lower profits.

These studies have bearing on two strands of literature: asset (livestock) transfer based anti-poverty programs and return of capital of microenterprises in developing countries. In the first strand, there is a growing evidence that suggest that if a livestock, generally a cow or goat, is given away to the extreme poor households along with a set of complementary inputs such as skill training, health support, consumption support, etc., they tend to increase their labor supply and as a result their income and asset increase (Bandiera et al, 2017). That is, the transfer of livestock helps the extreme poor move out of poverty and this one-off intervention tends to have long term impact. While Bandiera et al (2017) studied the Targeting Ultra Poor (TUP) program of BRAC in Bangladesh, Banerjee et al (2015) evaluated similar programs in six countries – Ethiopia, Ghana, Honduras, India, Pakistan and found that consumption, assets and food security have increased both in short and long run after the transfer of asset (livestock) and other inputs. These studies did not make any attempt to separate out the impact of livestock from other inputs as interventions were delivered as a bundle. Therefore, rate of return of livestock can be very high due to the presence of other complementary inputs in these cases. However, these studies did not shed light on the rate of return of livestock, the key element of evaluated anti-poverty programs.
Our study is also related to a strand of literature which examines the return of capital of microenterprises. De Mel, et al. (2008) provided cash and equipment grants to small firms in Sri Lanka and found high rate

of return of capital – about 6 percent per month. In a follow up study, De Mel et al (2012) found long lasting impact of one-off transfer of capital – a 10 percentage point higher rates of survival of enterprises and $8-$12 higher monthly profits for male owned business after 5 years of interventions.

The role of livestock in the development of Bangladesh has two distinct roots that can be identified with the two strands described above. The first can be found in the small-holder-based livestock development projects involving provision of credit for buying livestock, delivering veterinary services and providing training to rural households. This evolved from the poultry model initiated by BRAC and the DLS in the 1970s and culminated into several livestock development projects such as the two versions of Smallholder Livestock Development Project (SLDP I and SLDP II) in the 1990s and Participatory Livestock Development Projects (PLDP I and PLDP II) in 2000s. The second involves using livestock as the key asset to help extreme poor households come out of the poverty trap. Livestock is given to extreme poor households free of cost and they are also provided with training, veterinary services and cash benefits. In Bangladesh, these projects include TUP (Targeting Ultra Poor) and CLP (Char Livelihood Programme), among others. Public works-based transfer programs in Bangladesh (e.g., REOPA, SWAPNO) also observe that beneficiaries largely invest in livestock, which is also central to the understanding of the success of such 'poverty graduation model' (Iqbal et al. 2011). The main goal of the first approach is livestock development through supporting the smallholders through credit while that of the latter is reduction of extreme poverty through livestock transfer. Both these approaches provided multiple inputs: credit, training, veterinary services but the key role is played by livestock, mainly cattle. The experience with the first approach is mixed (Iqbal et al. 2011) while that with the second is encouraging (Bandiera et al. 2017; Banerjee et al. 2015).

Very few papers estimated rate of returns from livestock holding in Bangladesh and they have many limitations. Existing studies estimating returns from livestock rearing in Bangladesh have mostly found it profitable. Only two studies out of ten we could identify estimated negative returns (Gisby 2010 and Halim et al. 2010). When negative returns were observed the authors stopped from raising further questions that lie at the core of the current debate. Some of these studies ignored labour costs altogether, while others only considered profitability from selling livestock products (milk, manure) without considering the gain (or loss) in value of livestock as an asset. All these studies are also based on survey data that are specific to a small region or two and the sample size is small (26 to 167). Therefore, the estimates of return suffer from regional peculiarities and are not nationally representative. The methodologies used also had many drawbacks. For example, most of the studies ruled out cattle (heifer) that have not yet given birth to calves. The presence of them may affect profitability as they do not give any output other than cow dung for a considerable period of time. This is the reason why Gisby (2010) found owning a bullock less profitable than owning a milk cow. Labour costs were included in most of these studies except for in Gisby (2010). Finally, the studies on Bangladesh livestock are generally done from a technical perspective by livestock experts and issues related to livestock development did not get much attention.

Thus, the debate over returns to investment in livestock has generated a wide range of issues that are extremely relevant to livestock development in Bangladesh. It is important to examine the debate in the context of Bangladesh for two major reasons. First, the slow growth of the livestock sector in Bangladesh has been a serious concern. Though the livestock sector has grown by 3.2% in 2016, its contribution to GDP has fallen from 2.2% in 2008 to 1.7% in 2016 (GOB 2016). The contribution of this sector to the agriculture sector has been almost static at around 13% during the same period. The number of bovine population[2] has increased since 1960 but their growth could not match the growth of human population (Huque and Huda 2016). As a result, per capita bovine population in Bangladesh has declined from .38 in1960 to .18 in 2009. On the other hand, the number of small ruminant per capita has been stable at .12 while poultry population has increased from .65 to 1.07 per capita. Meat consumption in Bangladesh has steadily increased from 11.6 gms/p/d[3] in 1995 to 18.6 gms/p/d in 2010 (HIES 1995 and 2010). However, beef consumption has steadily fallen, from 8.3 gms/p/d in 2000 to 6.8 gms/p/d in 2010 - a fall by more than a fifth (21.8%). Per capita milk consumption in Bangladesh is 18 kg per year which is significantly lower than other countries in the region. India and Pakistan consume 90 kg and 190 kg of milk per capita respectively[4]. Second, a firm knowledge about the rate of returns of the cattle raised by small holders is essential for designing livestock development policies as well as anti-poverty programs in Bangladesh.

This study is based on household level panel data of Bangladesh Integrated Household Survey (BIHS of International Food Policy Research Institute (IFPRI) which is representative at the rural areas of all administrative divisions of the country. We have found that the average return (without valuing family labor at their market prices) from holding cattle 27.4 and 35.7 percent in 2011 and 2015 respectively. Once family labor is valued at market price, the profit reduces considerably and even becomes negative for the households with only bullocks. We found that the average returns are positive and tends to decrease with the herd size reaching a maximum for herd size of one or two. Thus, there are diseconomies of scale from livestock farming in Bangladesh. Finally, more poor households are found to raise livestock and their returns are not much different from non-poor. For example, the average rates of return are found lowest in the third food expenditure quintile in both years.

[2] Farm animals of Bangladesh consist of cattle, buffalo, goat and sheep. The former two animals are called bovine animals or large ruminants, and the latter two are called small ruminants.
Chicken and ducks are termed as poultry.

[3] Grams per person per day.

[4] Milk Money, Dhaka Tribune, June 24, 2017

The key finding of this study is the predominance of positive and high rates of returns to raising livestock in Bangladesh. We do not think Bangladeshi farmers are more "rational" than Indian farmers or they face more competitive markets. The difference lies in the cultural context that increases the market value of a cattle in Bangladesh. The current debate of the existing literature is very specific to India where the meat market for cow is absent (Gehrke and Grimm 2018). Therefore, the return of cow, both milk cow and bullock, can be higher for a country like Bangladesh where a large number of cattle are raised for meat consumption only. The existence of positive profit and the fact that the poor households are more likely to raise livestock and earn returns similar to non-poor households indicate the possibility of further development of the livestock sector in Bangladesh and further reduction of poverty through asset transfer programmes.

The rest of the paper is organized as follows: next two sections (2 and 3) describes data and present relevant descriptive statistics respectively. Profits are estimated in section 4 while average and marginal returns to raising livestock are estimated in section 5. In section 6 heterogeneity in returns are analysed and robustness checks are done in section7. We discuss the overall finding in section 8 and section 9 draws the conclusions.

2 DATA

There are several advantages of using the Bangladesh Integrated Household Survey (BIHS of International Food Policy Research Institute (IFPRI) dataset. First, the sample is statistically representative at following levels: (a) nationally representative of rural Bangladesh; (b) representative of rural areas of each of the seven administrative divisions of the country: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet. Second, BIHS conducted two rounds of survey in 2011 and 2015 on the same households. We combine them to create a household level panel data which allows us to control for household level time-invariant heterogeneity in estimating marginal returns. Second, since the objective of the survey was to study agriculture, food security, nutrition, poverty, detailed data is collected on livestock raised by the households. It contains information on livestock ownership (large/small ruminants and poultry), their current and last year's values, revenues and costs. Moreover, it has very rich socioeconomic modules including income, employment, consumption, asset, education, health, etc., allowing us to explain the variations of rate of return of livestock due to socioeconomic factors.

Number of observations (households) in the first (2011) and second round (2015) of BIHS are 6503 and 7036 respectively, of which 4423 and 4419 are nationally representative in two respective rounds. Out of the nationally representative sample, 41.2 percent (1823) and 37.6 percent (1645) of the households owned cattle in first and second rounds respectively. Farm animals of Bangladesh consist of cattle, buffalo, goat and sheep and in our study, we only consider cattle consisting of cow and bullock. As we intend to focus on the profitability of the large ruminants, we do not include small ruminants (i.e. goat and sheep) in our analysis. As buffalo is not a very common ruminant in Bangladesh, we also drop buffalo owning households from the analysis. In BIHS there are only 20 households in 2011 and 10 households in 2015 who raised buffalo.

3 DESCRITPIVE STATISTICS

The demographic and socioeconomic characteristics of the cattle-owning households are significantly different from the non-cattle owning households (Table 3-1). Cattle-owning households are more likely to be male-headed than the non-cattle owning households. About 91 percent and 92 percent of the cattle-owning households are male-headed in 2015 and 2011 respectively as opposed to 73 percent and 74 percent for non-cattle owning households. The heads of the households with cattle are older by about 3 years and the difference is statistically significant. Household size is also larger for the households with cattle. The average sizes of the households with cattle are 4.68 and 4.59 in 2015 and 2011 respectively compared to 4.12 and 3.98 for the households without cattle, with statistically significant difference. Male-female ratio is also significantly higher for the cattle-owning households.

Households who raises cattle have higher amount of land than those who do not. Average size of the land owned by the cattle owning households is more than 50 decimals higher than the non-cattle owning households in both rounds and the differences are statistically significant. It is also true for homestead land and cultivated land – households with cattle have larger homestead and cultivated land. Incidence of extreme poverty is more prevalent among cattle rearing households. Interestingly, households which raise cattle are closer to shops than the households which do not.

We also document the characteristics of the cattle farming of our sample for both rounds (Table 3-2). Mean of the total value of the stock were about 35,000 BDT in 2011 and 40,000 BDT in 2015 while the average cattle value were about 16,000 BDT and 18,000 BDT in nominal terms. Size of the herd has remained constant at about 2.3 during this time. Among the cattle sub categories, calf born households have the highest average herd size and households with only milk cow experience lowest herd size. The share of milk revenue has increased sharply during 2011 and 2015; an increase by about 65 percent. However, the contribution of manure as a source of revenue has decreased over time. Fodder and the labor (both hired and family) are the major sources of rearing costs. Average fodder cost was about 4000-4700 taka per year. Female family members worked more hours on cattle rearing than the male members. In 2015, male members allocated about 350 hours compared to 410 hours of female.

Table 3-1: Household characteristics: cattle owners vs. non-owners

	2011					2015				
	No cattle		Cattle owners			No cattle		Cattle owners		
	Mean	SD	Mean	SD	p value	Mean	SD	Mean	SD	p value
Male household head	0.74	0.43	0.92	0.26	0.000	0.73	0.44	0.91	0.27	0.000
Age of household head	42.36	14.29	45.56	13.17	0.000	44.14	14.05	47.13	12.88	0.000
Household size	3.98	1.55	4.59	1.76	0.000	4.12	1.66	4.68	1.81	0.000
Household head is literate	0.45	0.49	0.43	0.49	0.118	0.49	0.5	0.44	0.49	0.0016
Male female ratio	1.06	0.87	1.24	0.89	0.000	1.07	0.85	1.25	0.88	0.000
Per capita Food expenditure (monthly BDT)	1341	800.95	1059	653.92	0.000	1699	1150.83	1335	844.84	0.000
Per capita total expenditure (monthly BDT)	2719	2320.57	2471	2309.65	0.000	3942	4516.53	3179	3646.47	0.000
Extreme poor households (%)	21.12	0.40	34.45	0.47	0.000	24.30	0.42	40.00	0.49	0.000
Homestead land owned (decimal)	7.63	10.45	10.81	13.14	0.000	6.89	10.06	10.16	11.88	0.000
Total land owned (decimal)	35.76	84.23	89.35	154.91	0.000	38.82	98.44	95.6	170.25	0.000
Cultivated land (operated) (decimal)	34.72	81.73	148.38	195.79	0.000	39.02	92.39	142.84	195.71	0.000
Distance to local shop(km)	0.58	0.62	0.67	0.72	0.000	0.42	0.56	0.51	0.61	0.000
Observations	2,600		1,823			2,774		1,645		

Source: Authors' calculation

Table 3-2: Characteristics of cattle farming

	2011			2015		
	Mean	SD	Observation	Mean	SD	Observation
Cattle value and herd size						
Total value of stock of cattle	34910.47	30464.29	1093	40087.96	31124.72	979
Average cattle value	15702.01	7906.84	1093	18362.57	9928.11	979
Herd size: Cattle	2.32	1.48	1093	2.3	1.45	979
Herd size: Only Bullock	1.6	0.92	263	1.67	1.19	200
Herd size: Only Milk Cow	1.45	0.71	272	1.48	0.78	232
Herd size: Both Milk cow and bullock	2.82	0.95	85	2.91	1.57	86
Herd size: Calf household	3.42	1.61	333	3.22	1.43	296
Herd size: Sales household	2.46	1.57	140	2.25	1.35	165
Revenue and costs						
Milk	5936.17	18420.8	827	9229.02	19338.18	779

Manure	1911.75	2156.76	1093	1604.32	1994.68	979
Calf	8564.95	3201.99	333	10503.83	3411.61	296
Fodder	3994.41	9945.34	1093	4655.44	7447.25	979
Wage labor (taka)	176.15	2420.96	1093	32.41	479.13	979
Family labor (male, no of hours on livestock)	306.22	410.02	1093	369.07	273.66	979
Family labor (female, no of hours on livestock)	341.46	244.59	1093	410.64	274.55	979

Source: Authors' calculation

4 APPRECIATION, REVENUE, COSTS AND PROFITS

We do not have information at individual animal level except for those households having only one piece of livestock. BIHS records the total number of cattle by types (cow, bullock, buffalo, goat, etc.) at the household level. Revenue from selling milk or manure are available for all cattle taken together, so are the costs. As a result, we have to consider a number of cases separately for calculating appreciation or depreciation of cattle, costs and revenues.

BIHS has information on the value of the stock as reported by the respondents at the beginning and the end of the reference year. We can calculate appreciation/depreciation of the stock simply by taking the rate of change of value of the stock over the year for the households with constant herd size (see Appendix B for detailed methodology). We have 620 and 518 households whose herd size remained constant in years 2011 and 2015 respectively. However, we cannot do the same for households whose herd size changed during the last one year. The reasons for non-constant herd size in the beginning and the end of the year include, (i) birth of a new calf, (ii) sales of a cattle, (iii) purchase of a new cattle, (iv) giving/receiving of cattle as gift, (v) leasing in cattle, (vi) own consumption of cattle and (vii) cattle lost (i.e. stolen/burnt/spoilt/died). That is, if we take the difference of the stock value of two periods, it will reflect appreciation/depreciation and one of the contributing factors mentioned above. From these seven cases where size of the herd has changed during the one-year period, we could only consider the first two cases (i.e. calf and sales of a cattle) because the value of calf or cattle could be calculated. We have 459 and 429 households who have experienced either 'calf born' or 'cattle sales' in 2011 and 2015 respectively. We could not include households which have purchased cattle in the last one year (case iii). BIHS does not have the data on purchase price of the cattle and hence we cannot directly calculate appreciation/depreciation for these households. Due to the same reason we had to drop households which either gave or received cattle as gifts (case iv), those who received cattle through lease (case v), consumed the meat (case vi) and those who lost cattle (case vii). This left us with a working sample of 1079 households in 2011 and 947 in 2015 classified as follows (the first number is for the year 2011):

(i) Households with only bullock (263, 200)

(ii) Households with only milk cow (272, 232)

(iii) Households with both bullock and milk cow (85, 86)

(iv) Households with a calf at the end period (333, 296)

(v) Households sold cattle at the end period (126, 133)

Below we formalize the relation between appreciation, revenue and cost components.

Let the household level aggregate production function of milk cow be

$$Q = Af(K, L, X, F)$$

Where

Q= milk, calves, cattle sold, manure; K = value of cows; L= labour; X = land; F = fodder

Note that Gehrke and Grimm (2018) lumped X and F together and noted that land entered into the production function through F. Since we have data on homestead land we can treat it separately. We can think of A as household and region-specific characteristics that influence the TFP of inputs. The definition of Q demands further explanation. Note that we did not include meat as an output in the production function, rather we introduced it in the profit function in the form of appreciation/depreciation of cattle. Note that in case of bullock, the production function becomes trivial as Q includes only manure.

The profit function,

$$\pi = P.Q - cK - wL - gF - rX + \delta K$$

P = price vector of outputs; w= wage rate (both market and imputed); g= price of fodder; r= rent of land; c=other costs associated with K; δ =rate of appreciation/depreciation. Price of capital is assumed to be zero, following Gehrke and Grimm, (2018). We also set r=0.

4.1 Appreciation/Depreciation

In Anagol et al. (2017), the price of cattle a year before the current period, P (t-1), is derived from the opinion of the respondent. Anagol et al. (2017) regressed this on age of cattle and estimated the current value of the cattle, P (t), from the estimated regression. This provided an estimate of appreciation (P(t)-P(t-1)). Attanasio and Ausburg (2018) could not estimate depreciation because their data did not contain information on the age of livestock. They consider appreciation/depreciation to be a "minor source of costs, so the neglect is unlikely to introduce significant biases." They have used the depreciation rates from Anagol (2017). Gehrke and Grimm (2018) did not follow Anagol et al. (2017) for the estimation of appreciation/depreciation of cattle also because they did not have information on age of cattle. They used information from secondary sources and assumed that cow depreciates by INR 1,240 every year and the end-of-fertility value of a cow is INR 1,400 which is based on an annual depreciation of 20%.

We first notice that the rate of appreciation is very different in the two methods used by Anagol et al (2017) and Gehrke and Grimm (2018). In Anagol et al. (2017) the median appreciation for the full sample is around -3.1% of the median value of a cow. In the method used by Gehrke and Grimm (2018) cows depreciate by 20% each year.

Our method is similar to Anagol et al (2017) in the sense that we take the difference between initial and terminal values of the livestock as appreciation but these values are both reported by the respondent. The value of livestock does depend on age but it also depends on other factors incorporated by the respondent while reporting values of a cattle.

4.2 Revenue

Milk: Milk is an important source of revenue from cattle farming in Bangladesh. As expected, households having at least one calf in the herd produce more milk than other households. By taking the value of total milk produced, we account for milk that is sold in the market and that is consumed by household members. Milk price is determined by dividing total value of milk produced by amount of milk produced. One limitation of milk and manure revenue is that we cannot separate out milk and manure by categories of farm animal for households who raises both cattle and small ruminants (i.e. goat and sheep).

Calves: BIHS data provide information on number of calf born in last 12-month period, not the market price of it. We take the calf price to be 7151 BDT in 2011 and 9281 in 2015 from a secondary source (PLDP2 dataset). Once we assume calf price, we could easily separate out the net appreciation/depreciation of the remaining stock (see Appendix B for more details).

4.3 Costs

Fodder: Cost of fodder in this section does not include the collected and home-produced fodder. BIHS data only report value of purchased fodder. However, later (see section 7) we check robustness of the profit found in this section by inflating fodder cost by a certain percentage, to see how sensitive the profit with inclusion of non-purchased fodder costs is.

Labour: Cost of labor mainly comes from family labor which include both male and female labor hours (including child labor). We multiply total hours spent by male and female household members by their respective average hourly livestock wage in the market. Total cost of family labor is much higher than hired labor because only limited amount of labour is hired from outside for livestock work. This is why calculated profit and average returns are sensitive to the inclusion of family labor into the analysis

Table 4-1and Table 4-2 present the breakdown of costs and revenue for different cases of constant and non-constant herd sizes for 2011 and 2015 respectively along with appreciation and total annual profit.

Table 4-1: Components of revenue and cost (2011)

Constant herd size (sample size=620)											
	Revenue					Cost				Profit with family L	Profit without family L
	Appreciation/ Depreciation (appreciation gross income ratio)	Milk	Manure	Value of calf	Value of the cattle sold	Wage labor	Family labor	Fodder	Medicine and other cost		
Households with only Bullock	0.68 (0.77)	0	1352	0	0	86.80	7479	2877.33	255.62	-2226	5252
Households with only Milk cow	0.71 (0.57)	3557	1541	0	0	33.80	7514	2707	339	1509	9023
Households with both Bullock and Milk cow	0.61 (0.77)	6383	2383	0	0	188	8806	5654	549	4208	13015
Non-constant herd size (sample size=459)											
Households with a calf at the end period	0.43 (0.04)	8728	2331	8564	0	360	9278	5540	518	9646	18925
Households sold cattle at the end period	0.12 (0.31)	3416	2357	0	27798	153	9580	4457	426	31953	41534

Source: Authors' calculation

Note: Figures in parentheses are appreciation as % of gross income

As evident in the tables, households who hold on to livestock asset for at least a year (i.e. constant herd size) experience much higher rate of appreciation than the households who do not (non-constant herd size). In 2011, average annual appreciation for constant herd size households varied from 61 percent (for households with both milk cow and bullock) to 71 percent (for household with only milch cow). In the same year, households with non-constant herd size experienced an average appreciation of only 12 percent (for household with cattle sales) and 43 percent (for household with a calf born). Moreover, in both years appreciation is the major source of gross income (appreciation plus revenue from annual sale of milk, manure, etc.) for constant herd size households and minor source for non-constant herd size households. For instance, in 2015, appreciation accounted for 78 percent of gross income for households with only bullock and only 4 percent for households with a calf born. Major component of gross income for non-constant herd size households came from either value of the calf (for households with calf born) or proceeds from selling livestock. We also observe that bullocks appreciated more than milk cows in 2015 but in 2011 it appreciated 3 percentage point less. Appreciation in 2015 is similar (bulls>cows) to those found by. Gisby (2010) has also found that bulls appreciated more than cows both for local variety (13% as compared to 6%) as well as for crossbred variety (21% as against 12%).

As expected, the share of milk revenue is the highest for the households with a calf. Fodder and family labor are the major cost components for all household categories. Profit from raising livestock is found positive (excluding family labor cost) in all categories. Once family labor is valued at market price, the profit reduces considerably and even becomes negative for the households with only bullock. Value of calf and the revenue from selling cattle increase the profits for households with calf and for households selling cattle respectively. Cost and revenue components and hence profits are more or less similar in year 2011 and 2015.

Table 4-2: Components of revenue and cost (2015)

Constant herd size (sample size= 518)											
	Revenue					Cost				Profit with family L	Profit without family L
	Appreciation/ Depreciation (appreciation gross income ratio)	Milk	Manure	Value of calf	Value of the cattle sold	Wage labor	Family labor	Fodder	Medicine and other cost		
Households with only Bullock	0.68 (0.78)	0	1432	0	0	0	5537	3996	305	2437	7974
Households with only Milk cow	0.42 (0.56)	6624	1226	0	0	43	5772	4298	473	4595	10368
Households with both Bullock and Milk cow	0.43 (0.56)	16198	1757	0	0	55	7080	5824	475	17612	24693
Non-constant herd size (sample size=429)											
Households with a calf at the end period	0.19 (0.04)	10052	2031	10503	0	53	6111	4019	491	18305	24417
Households sold cattle at the end period	0.15 (0.18)	7045	1487	0	32002	0	6108	6888	707	40615	46724

Source: Authors' calculation

Note: Figures in parentheses are appreciation as % of gross income

5 AVERAGE AND MARGINAL RETURNS

In this section we estimate average and marginal returns to raising livestock in Bangladesh. Average return of raising livestock is given by,

$\frac{\pi}{K} = P.\frac{Q}{K} - c - \frac{wL}{K} - \frac{gF}{K} + \delta$ ....(i)

On the other hand, we estimate marginal returns in two different ways. First, using a linear production function, where we estimate profit as a function of herd size (value of the livestock) and a number of household level characteristics after controlling for the fodder costs.

$\pi_i = \alpha_0 + \alpha_1 K_i + \alpha_2 X_i + e_i$ -------- (ii)
Where, X_i= household level characteristics.

Second, we use a CES production technology to estimate marginal return. The marginal return of this type would be-

$\pi'(K) = P.Q'(K) - c + \delta$ --------------(iii)

Therefore, the marginal return depends on the shape of the production function. If Q is a CES production function such that $Q = A.K^{\alpha_1} L^{\alpha_2} X^{\alpha_3} F^{\alpha_4}$, all parameters lie strictly between 0 and 1.

Then, the marginal return is $\pi'(K) = P.\alpha_1.\frac{Q}{K} - c + \delta$ -----------(iv)
We get the α from following regression-

$Log(PQ) = \alpha_0 + \alpha_1 logK + \alpha_2 log\, L + \alpha_3 logX + \alpha_4 logF + \alpha_5 A + \in$ --------- (v)

We then plug in the estimated value of α into the marginal return equation (i.e. $\pi'(K)$) to get marginal return from raising livestock.

The estimates of marginal return may suffer from reverse causality (Gehrke and Grimm, 2018), i.e. higher observed profit/return may lead to faster capital accumulation. We instrument the amount of capital stock (K) with a demographic variable – interaction between male and female labor hours. We explain this endogeneity issue further in section 7.2.

Estimates of average and marginal returns are presented in **Table 5-1** and **Table 5-2** for the years 2011 and 2015 respectively. (Table A1 and A2 in appendix).

Table 5-1: Average and marginal returns from raising livestock, 2011

Constant Herd Size (sample size= 620)				
	Average return		Marginal return	
	With family L	Without family L	With L	Without L
Households with only Bullock	-15.68	19.13	.73	.70
Households with only Milk cow	-4.4	28.54	.82	.82
Households with both Bullock and Milk cow	-2.13	8.8	.67	.63
Non-constant herd size (sample size=459)				
Households with a calf at the end period	12.85	37.07	.96	.96
Households sold cattle at the end period	22.48	30.37	.71	.72
All (sample size =1079)	1.38	27.43	.82	.81

Source: Authors' calculation

Table 5-2: average and marginal returns from raising livestock, 2015

Constant Herd Size (sample size=518)				
	Average return		Marginal return	
	With family L	Without family L	With L	Without L
Households with only Bullock	-0.67	21.92	.74	.73
Households with only Milk cow	6.46	27.88	.57	.57
Households with both Bullock and Milk cow	11.80	18.65	.51	.50
Non-constant herd size (sample size=429)				
Households with a calf at the end period	38.01	59.92	.73	.73
Households sold cattle at the end period	24.30	29.61	.37	.37
All (sample size =947)	17.69	35.71	.62	.62

Source: Authors' calculation

In Bangladesh, both average and marginal returns are positive for the full sample. For all household category together, the average return (without family labor) from holding cattle for a year is 27.4 and 35.7 percent in 2011 and 2015 respectively. However, average return is sensitive to the inclusion and exclusion of family labor cost. The average return drops to 1.4 and 17.7 percent in the year 2011 and 2015 respectively, when we value family labor at market price. Average return is higher in 2015 than in 2011.

The marginal return is positive and very high in Bangladesh which is more than 80 percent and 60 percent per year in 2011 and 2015 respectively. Intuitively, annual return from investing additional one dollar to the existing stock is 82 cents in 2011 and 62 cents in 2015. Unlike average return, the marginal return does not vary much with the inclusion of family labor cost. Intuitively, the marginal return depends primarily on the capital elasticity of dairy-output (measured by α), not on labor used in the production process. Labor affects marginal return only through α. Another finding is that, although the average return has increased from 2011 to 2015, marginal return has sharply decreased during this period.

Among constant herd size households, those who have only milk cows, earns the highest average return in both years. Although positive, bullocks earn less returns than the milk cows. Average returns are higher for non-constant-herd-size households than constant-herd-size households. This is due to the extra sources of revenue such as revenue from calf and cattle sales. In general, the marginal return is higher for the household categories whose average return is higher and vice versa.

6 HETEROGENEITY IN AVERAGE AND MARGINAL RETURNS

In this section we discuss the heterogeneity of returns from two aspects: (i) herd size and (ii) household food expenditure. For the first aspect, we explore if there are any economies of scale in herd size and for the second we check whether rates of return change for different poverty groups as indicated by household food expenditure quintiles.

Table 6-1: Herd size and returns, 2011

Herd size	average value of total stock(BDT)	average return (with family L)	average return (without family L)	marginal return (with L)	marginal return (without L)	Observation
1	17826	-8.68	34.46	0.84	0.83	373
2	15277	7.97	33.12	0.79	0.78	349
3	13666	6.19	18.52	0.81	0.80	183
4	14667	6.80	15.50	1.03	1.03	108
>4	13679	5.46	9.97	0.56	0.56	80

Source: Authors' calculation

Table 6-2: Herd size and returns, 2015

Herd size	average value of total stock(BDT)	average return (with family L)	average return (without family L)	marginal return (with L)	marginal return (without L)	Observation
1	21158	11.42	43.98	0.73	0.73	322
2	17360	29.50	45.39	0.60	0.60	301
3	16584	15.28	22.60	0.61	0.61	176
4	17233	10.79	15.25	0.50	0.50	75
>4	15612	9.18	11.91	0.42	0.43	73

Source: Authors' calculation

Table 6-3: livestock variables and per capita food expenditure quintiles (2011)

Per capita food exp quintiles	% of HHs with livestock	Average herd size (full sample)	Average herd size (livestock sample)	Average value of total stock (BDT)	Avg. value of stock bull only (BDT)	Avg. value of stock cow only (BDT)	Average return (without family L)	Marginal return (without L)
Q1	61.81	1.5	2.5	33058	21815	29316	20.3	0.62
Q2	45.08	1.04	2.31	31315	22454	28163	22.38	0.7
Q3	36.43	0.87	2.32	32718	22202	27958	19.13	0.81

Q4	32.32	0.73	2.37	35317	21026	34858	24.9	0.88
Q5	30.43	0.75	2.44	39174	22069	35251	22.55	0.73

Source: Authors' calculation

Table 6-4: livestock variables and per capita food expenditure quintiles (2015)

Per capita food exp quintiles	% of HHs with livestock	Average herd size (full sample)	Average herd size (livestock sample)	Average value of total stock (BDT)	Avg. value of stock bull only (BDT)	Avg. value of stock cow only (BDT)	Average return (without family L)	Marginal return (without L)
Q1	52.04	1.18	2.29	35161	26139	29145	20.9	0.58
Q2	42.76	0.91	2.22	36879	25928	32537	23.8	0.6
Q3	35.52	0.79	2.14	34682	24218	31122	19.1	0.61
Q4	31.45	0.68	2.22	37476	27275	31611	31.3	0.69
Q5	24.35	0.57	2.29	44195	26684	40050	24.48	0.64

Source: Authors' calculation

We found that the average return tends to decrease with the herd size; the average rerun is maximum for herd size of one or two. When family labor is not priced, average return was as high as 45% for the herd size two in 2015. For the herd size three and above, the average return decline sharply – 23%, 15% and 11% respectively for herd size 3,4 and 5 in 2015. This trend (fall in the average revenue for herd size beyond two) is visible in 2011 data as well. Our finding of not having any economies of scale in cattle farming in Bangladesh is consistent with the finding of Anagol et al (2017) that there is no difference in the distribution of returns between households with one cow and more than one cow. Furthermore, they identified that there exist diseconomies of scale in buffalo farming in Uttar Pradesh. However, Gehrke and Grimm (2018) found an existence of economies of scale in cattle farming in their data.

In case of marginal return, we observe such pattern for 2015, but not for 2011. The marginal return is about 73% in 2015 for the herd size of one while it drops down to about 42% for the herd size above 4. In 2011, the highest marginal rate of return is observed for the herd size of 4 and then it drops to 56% for larger herd size.

Poorer households raise livestock more. Data shows that in both years, the incidence of livestock raising of the households in bottom 20th quintile is more than twice than the households in top 20th quintile[5]. Among the households who raises livestock, herd size and average value of the stock does not vary much over the food expenditure quintiles. In both years, the average rate of return is found lowest in third food expenditure quintile.

[5] We probe this issue further and regress the incidence of cattle rearing and herd size on the quintile of food consumption. The results show that the lowest quintile are more likely to raise cattle and have lower herd size, controlling for other socioeconomic variables (Table A4).

7 ROBUSTNESS CHECK

7.1 Imputed fodder cost from secondary source

We have mentioned earlier that BIHS data has information only on purchased fodder. However, literature and anecdotal evidences suggest that non-purchased fodder also constitutes a non-trivial part of fodder cost. Due to lack of data, we rely on secondary information on non-purchased fodder. Literature on the breakdown of costs of rearing cattle indicates that home produced and collected fodder is about 20% of total purchased fodder, when priced at market price (Halim et al. 2010). We use this information to inflate the fodder costs and estimate average and marginal return again. The results are reported in tables A3-1 and A3-2 in Appendix. Even if we consider non-market fodder, the average return is still very high – about 34% when we do not consider family labour in 2015. If we price family labour at market rate, this return turns out to be about 16% in 2015.

7.2 IV estimation

We noted earlier that stock value of cattle is endogenous when we estimate the marginal rate of return, regressing profit on stock value. There is a simultaneity bias as higher return can lead to higher value of cattle stock. To address this problem, we instrument cattle stock with the interaction of male hours and female hours devoted to cattle rearing. In the first stage, after controlling for male labor, female labor and household size, we regress cattle value (K) on the interaction between male and female labor hours devoted to livestock by a household as follows-

$K_i = \theta_0 + \theta_1 Z_i + \mu_i$ -------- (vi)

In the second stage, we estimate the profit function with instrumented K. We observe in the first stage regression (see Appendix A5) that there is a complementarity between male and female's work – male's hour increases the value of cattle if female works more hours and vice versa. Our identifying assumption is that this complementarity impacts profit only by increasing the value of stock of cattle which is not an implausible assumption. Our IV estimation shows (see Appendix A6) that the marginal return is about 80%.

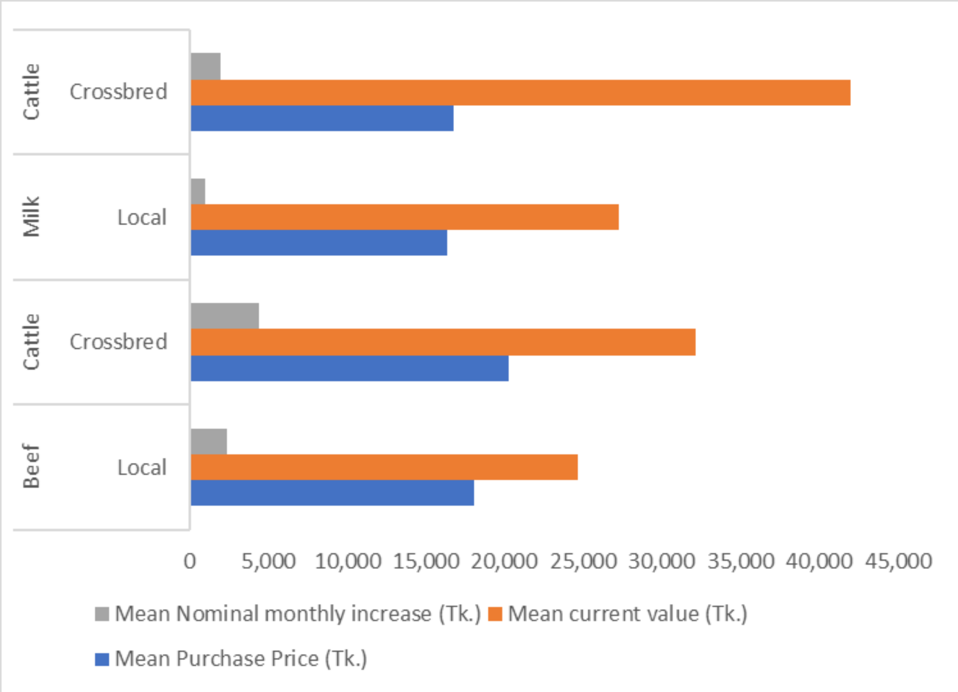
8 DISCUSSION ON THE DEBATE

This paper is motivated by the debate triggered by Anagol et al. (2017) and the existence of the (rural) nationally representative BIHS dataset that contained information on livestock holdings that allowed us to estimate rates of returns. We conducted the analysis with an open mind without any a priori bias. The existence of positive and high rates of return kept us why this is so in Bangladesh. We strongly believe that this happened due to the existence of market for buying and selling of cattle for meat consumption.

The use of age as a major determinant of value of cattle makes sense in the context of absent meat market as found in most states in India. In the states that allow cattle slaughtering, such as West Bengal, this is done in a very limited scale. The existence of a market for cattle, where they can be sold anytime, implies that the value of cattle is determined not only by the age of a cattle but also by its breed, overall health, consumer preference, condition of the market etc. When a bull/cow can be bought for slaughtering, the value of cattle includes the value of meat and this component is missing in the Indian context. Since a cattle market for meat consumption does not exist in India, the value of cattle is not maximized because the meat value is zero. Article 48 of the Constitution of India mandates the state to prohibit the slaughter of cows and calves and other milch and draught cattle. 20 out of 29 states in India currently have various regulations prohibiting either the slaughter or sale of cows (Wikipedia). India's beef industry is predominantly based on the slaughtering of water buffalo. As per existing meat export policy in India, the export of beef (meat of cow, oxen and calf) is prohibited. When cattle can be slaughtered for meat consumption and there are competitive markets for buying and selling cattle, the price of cattle as reported by the seller-farmer can be considered reliable and used as an indicator of current and past values of cattle. In most likelihood an owner of a cattle will sell it, ignoring distress sale, when the value of the cattle is the highest and this may depend on many factors. For example, in Bangladesh, cattle get the highest value before the Eid-ul-Azha when cattle are sacrificed for religious purposes. In a linear depreciation model, the value of livestock always declines as there is a finite period during which holding to it is useful (a cow gives milk or a bullock services can be used).

The BIHS dataset reported the value of cattle over a period of one year as reported by the respondents. This helped us to estimate appreciation or depreciation of cattle by taking the difference between the two. We consider these values not only incorporated the age of the cow as well as the value or meat or other factors that are relevant for the local factors. We have found appreciation to be very high. Appreciation of value of bullock was found higher than cows and rates of returns similar for 2015. This shows that the market considers many factors other than age for valuing livestock. Such high appreciation and depreciation is also reported by Gisby (2010). Gisby (2010) estimated asset gain as measured by the difference between buying and expected selling price of cattle to be very high. For bullocks, monthly asset gain is approximately 13% for local variety bull and 22% for crossbred. The corresponding figures for cows are respectively 6% and 12%. Appreciation (monthly) is higher for bulls than for cows both for local variety as well as for crossbred variety.

Figure 8-1: Appreciation of local and crossbred cattle



Source: Gisby (2010)

9 CONCLUSION

By using a nationally representative panel dataset for rural Bangladesh, this paper found that, unlike India, the rates of returns from raising cattle in Bangladesh, are high and positive. Positive rates of return in India are either explained by a good year when fodder costs are low (Attanasio and Augsburg 2018) or by the existence of economies of scale where households with larger herd size only get positive returns (Gehrke and Grimm 2018). We have argued that positive/high rates of returns in Bangladesh is explained by the existence of market for cattle in a social setup where there is no moral or religious stigma attached to meat consumption. Existence of this market adds a new dimension to the relationship between age and market value of a cattle because cattle has value beyond its property of giving milk and use as draught power. At a given age, the value of a cattle is therefore high when it can be traded for the purpose of slaughtering. This increases the extent of appreciation of cattle of Bangladesh. A market that is missing in most states of India is present in Bangladesh to increase the value of livestock held by the smallholders. Our findings have strong implications for livestock development and poverty reduction in Bangladesh. Higher rates of return for livestock rearing indicate that there is a scope for further development of the livestock sector. Since rates of return are higher for poorer households, the possibility to reduce poverty through livestock transfers still remains. There are, however, some worrying signs that should caution us. Though the returns from livestock are high but they are declining and the poorest households have reduced livestock raising more than the rest and overall the extent of households rearing livestock has been falling. These may happen for factors that could not be analysed with available data. We think that inadequate livestock services, high costs of fodder etc. could have set this trend. It should be emphasized that successful asset transfer based anti-poverty programmes in Bangladesh are bundled up with provision of livestock services and transfer of cash.

REFERENCES

Acemoglu, Daron, and James A Robinson. "Cows, Capitalism, and Social Embeddedness," http://whynationsfail.com/blog/2013/10/23/cows-capitalism-and-social-embeddedness.html.

Anagol, Santosh, Alvin Etang, and Dean Karlan. "Continued Existence of Cows Disproves Central Tenets of Capitalism?." Economic Development and Cultural Change 65.4 (2017).

Attanasio, Orazio, and Britta Augsburg. "Holy Cows or Cash Cows? The Economic Return to Livestock in Rural India." Economic Development and Cultural Change 66.2 (2018): 307-330.

Banerjee , Abhijit, Duflo, Esther, Goldberg, Nathanael, Karlan, Dean, Osei, Robert, Pariente, William, Shapiro, Jeremy, Thuysbeart, Bram, Udry, Christopher. "A multifaceted program causes lasting progress for the very poor: Evidence from six countries." Science. 15 May 2015 • Vol 348 Issue 6236.

Bandiera, Oriana, Burgess, Robin, Das, Narayan, Gulesci, Selim, Rasul, Imran and Sulaiman, Munshi. "Labor Markets and Poverty in Village Economies." The Quarterly Journal of Economics (2017), 811–870.

BBS 2011. "Household Expenditure Survey 2010." Dhaka: Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS 1995. "Household Expenditure Survey 1995." Dhaka: Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh.

De Mel, Suresh, McKenzie, David and Woodruff, Christopher. 2008"Returns to Capital in Microenterprises: Evidence from a Field Experiment." The Quarterly Journal of Economics, Oxford University Press, vol. 123(4), pages 1329-1372

De Mel, Suresh, McKenzie, David and Woodruff, Christopher. 2012, "One-Time Transfer of Cash or Capital Have Long-Lasting Effects on Microenterprises in Sri Lanka", Science, Vol. 335, Issue 6071, pp. 962-966.

Gehrke, Esther, and Michael Grimm. "Do cows have negative returns? The evidence revisited." Economic Development and Cultural Change (2018), forthcoming.

Gisby (2010) Gisby, L. Relative Profitability of Crossbred versus Local Cattle Rearing Under ATP (DRAFT) Chars Livelihoods Programme, 2010.

GOB (2016), Bangladesh Economic Review, Economic Adviser's Wing, Finance Division, Ministry of Finance, Government of Bangladesh.

Halim (2010) M. A. Halim M. A. Kashem, J. U. A. & Hossain, M. Economic analysis of Red Chittagong Cattle farming system in some selected areas of Chittagong district J. Bangladesh Agril. Univ, 2010.

IFPRI (2015), Bangladesh Integrated Household Survey (BIHS) 2015,
available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/BXSYEL

IFPRI (2011), Bangladesh Integrated Household Survey (BIHS) 2011-12,
available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=hdl:1902.1/21266

Iqbal, Kazi, Toufique, Kazi, Ali and Hossain, Monzur. "Mis-targeting and Mis-using Microcredit in Livestock Development Project in Bangladesh: Some Issues, Concerns and Lessons" Bangladesh Development Studies, Vol 34 (2)., 2011

APPENDIX A

Table A1: Marginal returns to cattle: linear production function

	OLS		RE	FE
	(1)	(2)	(3)	(4)
Value of the cattle	0.584***	0.559***	0.601***	0.674***
	(0.018)	(0.028)	(0.018)	(0.035)
Value of the cattle(squared)		0.000		
		(0.000)		
Labor cost	-1.069***	-1.078***	-1.113***	-1.252***
	(0.102)	(0.102)	(0.101)	(0.197)
Homestead land owned	151.273***	154.172***	155.448***	168.174
	(40.761)	(40.836)	(44.966)	(209.049)
Fodder cost	-0.330***	-0.360***	-0.342***	-0.382**
	(0.066)	(0.071)	(0.067)	(0.161)
Distance to local shop	76.055	55.082	-215.206	-1,005.700
	(778.174)	(778.327)	(762.720)	(1,236.430)
Year	3,022.551***	3,085.597***	2,949.262***	2,504.362*
	(1,058.697)	(1,060.038)	(926.548)	(1,295.739)
Constant	-4,122.871***	-3,388.365**	-4,019.691***	-5,088.151*
	(1,289.884)	(1,439.938)	(1,303.365)	(3,082.050)
Observations	2,008	2,008	2,008	2,008
R-squared	0.388	0.388		0.512

Source: Authors' calculation

Note: Linear production function assumed. Dependent variable is profit (with labor cost). Standard errors (clustered at household level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A2: Marginal returns to cattle: CES production function

	OLS (1)	RE (2)	FE (3)
Total asset value (log)	0.784***	0.776***	0.504***
	(0.051)	(0.051)	(0.117)
Labor cost (log)	0.083	0.067	-0.113
	(0.060)	(0.060)	(0.121)
Homestead land (log)	0.090***	0.097***	0.180*
	(0.029)	(0.029)	(0.102)
Fodder cost	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Distance to local shop	0.081	0.079	0.014
	(0.050)	(0.050)	(0.097)
Year	0.235***	0.213***	0.005
	(0.070)	(0.067)	(0.110)
Constant	-1.416*	-1.266*	2.171
	(0.733)	(0.737)	(1.921)
Marginal returns to cattle at:			
Median	0.56	0.56	0.46
Mean	0.83	0.82	0.71
Observations	1,843	1,843	1,843
R-squared	0.192		0.089

Source: Authors' calculation

Note: CES production function is assumed. Dependent variable is the log of sales revenue from dairy products, calves (if any) and revenue from cattle sales (if any). Standard errors in parentheses (clustered at household level). *** p<0.01, ** p<0.05, * p<0.1

Table A3-1: average and marginal return, 2011 (with non-purchased fodder)

Constant Herd Size (sample size= 620)						
	Average return				Marginal return	
	With family L		Without family L		With L	Without L
	Cash fodder	Cash and non-cash fodder	Cash fodder	Cash and non-cash fodder		
Households with only Bullock	-15.68	-17.30	19.13	17.33	.73	.70
Households with only Milk cow	-4.4	-5.57	28.54	27.32	.82	.82
Households with both Bullock and Milk cow	-2.13	-3.40	8.8	7.52	.67	.63
Non-constant herd size (sample size=459)						
Households with a calf at the end period	12.85	10.76	37.07	34.91	.96	.96
Households sold cattle at the end period	22.48	22.49	30.37	30.42	.71	.72
All (sample size =1079)	1.38	0.07	27.43	26.06	.82	.81

Source: Authors' calculation.

Table A3-2: average and marginal return, 2015 (with non-purchased fodder)

Constant Herd Size (sample size=518)						
	Average return				Marginal return	
	With family L		Without family L		With L	Without L
	Cash fodder	Cash and non-cash fodder	Cash fodder	Cash and non-cash fodder		
Households with only Bullock	-0.67	-3.44	21.92	19.15	.74	.73
Households with only Milk cow	6.46	3.93	27.88	25.35	.57	.57
Households with both Bullock and Milk cow	11.80	10.86	18.65	17.72	.51	.50
Non-constant herd size (sample size=429)						
Households with a calf at the end period	38.01	36.51	59.92	58.35	.73	.73
Households sold cattle at the end period	24.30	22.43	29.61	26.42	.37	.37
All (sample size =947)	17.69	15.77	35.71	33.81	.62	.62

Source: Authors' calculation

The determinants of the likelihood of raising livestock: is estimated using a Linear Probability Model for years 2011 and 2015 separately.

$$Y_i = \alpha_0 + \sum_{d=1}^{4} \alpha_d Q_{di} + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \sum_{j=1}^{49} \gamma_j District_{ji} + e_i$$

Where, i= HH (household), d= expenditure quintiles and j= districts
Y=0 if HH does not raise livestock
=1 if HH raises livestock
Q= Expenditure quintile dummy[6]
District= District level dummy[7]
X_1 = share of women member in the HH, X_2 = HH size, X_3 = education of HH head, X_4 = Homestead land of the HH, X_5 = distance to local shop and e= residual of model.
We also regress herd size on the same set of regressors using OLS for both 2011 and 2015 separately. Results are presented in table A4.

Table A4: Poverty and incidence of cattle rearing and herd size

	Dep. Var = Livestock incidence	*Dep. Var = Herd size*	*Dep. Var = Livestock incidence*	*Dep. Var = Herd size*
	2011		2015	
Expenditure[8] dummy:Q1	0.077*** (0.002)	-0.465*** (0.000)	0.087*** (0.001)	-0.286*** (0.018)
Expenditure dummy:Q2	-0.005 (0.824)	-0.418*** (0.000)	0.040* (0.096)	-0.191* (0.102)

6 We take the top 20% or the fifth quintile as reference category.
7 We have total of 50 districts in BIHS data and there are 49 district dummies.
8 Monthly Per capita total (food and non-food) consumption expenditure. Reference Quintile is Q5 (top 20%).

Expenditure dummy:Q3	0.003 (0.876)	-0.339*** (0.002)	0.056*** (0.017)	-0.027 (0.807)
Expenditure dummy:Q4	-0.001 (0.957)	-0.242** (0.026)	0.019 (0.391)	-0.093 (0.405)
Female male ratio	-0.025*** (0.001)	--	-0.023*** (0.002)	--
Female labor*Male labor	--	1.79e-06*** (0.000)	--	2.23e-06*** (0.000)
HH size	0.054*** (0.000)	0.144*** (0.000)	0.041*** (0.000)	0.138*** (0.000)
Education of HH head	0.0001 (0.295)	-0.0001 (0.855)	0.0003** (0.033)	-0.0004 (0.537)
Homestead land	0.005*** (0.000)	0.012*** (0.000)	0.004*** (0.000)	0.005* (0.064)
Distance to local shop	0.012 (0.311)	-0.051 (0.307)	0.024* (0.071)	0.005 (0.930)
No. of observation R-squared	4,134 0.1499	1,773 0.1646	4,145 0.1371	1,620 0.1865

Source: Authors' calculation

Note: ***, ** and * indicate 01%, 05% and 10% level of significance respectively. Model specifications control for regional (district) effects.

Table A5: First stage IV regressions

Dep. Var= Value of the stock (K)	2011 (1)	2011 (2)	2015 (1)	2015 (2)	Panel (1)	Panel (2)
Male labor	8.56***	7.89***	11.37*	10.21	-0.50	0.87
	(2.86)	(2.85)	(6.51)	(6.54)	(5.81)	(5.91)
Female labor	-6.24	-5.11	-1.12	-1.00	5.26	5.89
	(5.04)	(5.02)	(5.99)	(5.98)	(6.53)	(6.55)
Male L* Female L	0.03***	0.03***	0.02*	0.02**	0.02*	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
HH size		2,022.29***		1,035.26*		1,588.92
		(554.35)		(593.27)		(1,297.22)
Observations	1,079	1,079	946	946	2,025	2,025
R-squared	0.05	0.06	0.04	0.04	0.03	0.04
Number of group					1,585	1,585

Source: Authors' calculation

Note: Linear production function assumed. Dependent variable is value of the stock (K). Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Second stage IV regressions.

	2011	2015	Panel
Value of cattle	-9.91	3.94	0.80**
	(77.74)	(7.60)	(0.40)
Labor cost	5.86	-3.76	-1.33***
	(52.05)	(7.17)	(0.31)
Homestead land owned	1,448.48	-436.65	155.27
	(10,360.33)	(1,646.11)	(216.00)
Fodder cost	15.91	-6.05	-0.44*
	(119.64)	(12.58)	(0.25)
Distance to local shop	-11,643.02	-4,039.74	-776.01
	(91,069.04)	(10,105.67)	(1,448.79)
Year			1,900.60
			(2,314.16)
Observations	1,067	941	2,008
Number of group			1,574

Source: Authors' calculation

Note: Linear production function assumed. Dependent variable is profit (with labor cost). 'Value of cattle' is instrumented by 'interaction of male hours and female hours'. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

APPENDIX B

Constant Herd Size

Case 01: Households with only Bullock (constant herd size)

This type of households satisfy two conditions: (i) HH raises only bullock, and (ii) herd size does not change during a one year period.

Case 02: Households with only Milk cow (constant herd size)

This type of households satisfy two conditions: (i) HH raises only milk cow, and (iii) herd size does not change during a one year period.

Case 03: Households with both Bullock and Milk cow (constant herd size)

This type of households satisfy three conditions: (i) HH raises bullock and milk cow, (ii) herd size is at least two in both beginning and the end of the year and (iii) herd size does not change during a one year period.

Average return for case 01, case 02 and case 03 is calculated using the following formula—

$$\boldsymbol{\pi = P.Q - cK - wL - gF + \delta K}$$

π= profit

PQ= sales revenue (revenue from selling milk[9] and manure)

c is the ratio of other costs to the value of the asset (K). We define 'other costs' as the summation of Medicine cost (K3_03) and Other cost (K3_10) in BIHS data.

cK= medicine and other costs

wL= labor cost

Labor cost has four components: (i) hired male labor cost, (ii) hired female labor cost, (iii) family labor cost (male) and (iv) family labor cost (female)

We take cost of hired labor (for both male and female) directly from BIHS data. We use average hourly hired labor cost of male as a proxy of hourly cost of all male family laborers. We use average hourly hired labor cost of female as a proxy of hourly cost of all female family laborers.

We calculate two set of average returns: (i) including both hired and family labor costs and (ii) excluding family labor costs.

gF= fodder cost (i.e. fodder that is purchased)

δK = value of appreciation/depreciation (i.e. rate of change of the stock over the year)[10]

K= value of asset at end period.

Once we calculate profit (π), we can get rate of return by using the formula:

$\boldsymbol{RoR} = \frac{\boldsymbol{\pi}}{\boldsymbol{K}}$ for each Household.

Finally, average RoR is found by the formula:

$$\boldsymbol{average\ RoR} = \frac{\boldsymbol{RoR}}{\boldsymbol{no.of\ cattle\ owned\ by\ HH}}$$ for each HH.

Finally, we drop few outlier households (i.e. HHs having unusual appreciation/depreciation, HHs having unusually high value of milk revenue etc.) For instance, in 2011 DATA, household id 4440 reports that it had two milk cows worth 18,000 taka at the beginning of the year. But at the end of the year that stock depreciates to only 2,000 taka.

In cases 01, 02 and 03, we have 5 or 6 HHs like this.

Case 04: $\boldsymbol{N_t > N_{t-1}}$ (calf)

This type of households satisfy three conditions: (i) herd size is positive in both beginning and the end of the year and (ii) herd size at the end of the year is strictly higher than the herd size at the beginning of the year, (iii) Change in herd size is due to the born of new calf only.

BIHS data has information on the number of calves not their market price. Calf price/value is included into the end period asset value (K1_03b). Therefore, a straightforward calculation of the change in stock value will be the sum of two components: 1) appreciation/depreciation of the existing stock and 2) the value of calf. In order to separate this two components, we use average price of calf (below 12 months) from a secondary source (PLDP2 database). Average price of a calf is BDT 7151 and BDT 9281 in year

[9] Milk revenue is zero for Case 01.

[10] We do not know the app/dep of a single livestock. Only the app/dep of the stock is known.

2011 and 2015 respectively[11]. Therefore, we get true app/dep of the existing stock simply by using the formula—

$$\boldsymbol{net\ deltaK = total\ change\ in\ stock - average\ calf\ price}$$

As the reported value of the asset at the end period is the value of appreciation plus calf value, we estimate actual end period value of the asset using the formula-

$$\boldsymbol{actual\ asset\ value\ at\ the\ end\ period = asset\ value\ at\ the\ initial\ period + net\ deltaK}$$

Revenue comes from milk, manure and value of calf. Average return calculation follows Equation 01.

Finally, we drop few outlier households (i.e. HHs having unusual appreciation/depreciation, HHs having unusually high value of milk revenue etc.)

For instance, in 2015 data, HH id 5074 reports that it has sold 50,180 litre milk in one year and the value of the milk cow was only 24,000 taka.

For instance, let us assume that at the beginning period a HH had 3 cattle with value 40,000 taka. During a one year period a calf born. Then at the end of the year the herd size becomes 4 and value of all 4 cattle is 50,000 taka. If this is so, the net delta would be—

Net delta= change in stock – average calf value

Net delta= (50,000-40,000)- 7151 = 2849

Actual asset value at end period= asset value at initial period + net delta

Actual asset value at end period = 40,000+2849= 42849

Case 05: $N_t < N_{t-1}$ (cattle sold)

This type of households satisfy three conditions: (i) herd size is positive in both beginning and the end of the year and (ii) herd size at the end of the year is strictly negative than the herd size at the beginning of the year, (iii) Change in herd size is due to the sales only.

We have the information on both sales price of the cattle and the change in total stock for the given year. In BIHS data, the reported asset value at the end period is lower than the actual value by the amount of the value of the asset sold. Hence, the calculation of appreciation/depreciation is based on the formula—

$$\boldsymbol{deltaK = reported\ asset\ value\ at\ end\ period - (reported\ asset\ value\ at\ beginning\ period - value\ of\ the\ asset\ sold)}$$

$$\boldsymbol{delta = \frac{deltaK}{reported\ asset\ value\ at\ beginning\ period - value\ of\ the\ asset\ sold}}$$

For example, a HH had 2 cattle of value 24,000 taka at the beginning of the year. HH sold one cattle of value 20,000 taka during a one year period. At the end of the year its herd size reduces to one and value of the herd reduces to 6,000 taka. Then based on the formula—

deltaK= 6,000-(24,000-20,000) = 2,000 taka

delta= 2,000/4,000= 1/2

Average return calculation follows Equation 01.

We calculate average return for 1093 and 979 households for year 2011 and 2015 respectively.

[11] Calf price has been adjusted for inflation.