Structural Determinants of Adoption of Artificial Insemination among Livestock Farmers in Pakistan

Muhammad Imran Chaudhry & Mario Javier Miranda
Department of Agricultural, Environmental & Development Economics, Ohio State University
chaudhry.33@osu.edu & miranda.4@osu.edu

Selected Poster prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Joint Annual Meeting, San Francisco, CA, July 26-28

Structural Determinants of Adoption of Artificial Insemination among Livestock Farmers in Pakistan

Muhammad Imran Chaudhry & Mario Javier Miranda

Department of Agricultural, Environmental & Development Economics, Ohio State University

Background

•Despite being the 4th largest milk producer in the world, dairy farming in Pakistan is based on traditional, labor intensive, small scale farming methods.

•In 2010, more than 70% of dairy farmers in Pakistan had an average holding of 2-3 dairy animals and less than 2 hectares of land.

•Due to the absence of systematic breed improvement programs the milk yield of dairy cattle in Pakistan is very low compared to international standards.

•However, the genetic potential of Pakistani dairy animals can be significantly upgraded through the artificial insemination (AI) technology.

•The AI technology is primarily employed to crossbreed high yielding foreign breeds with indigenous cattle. The resulting offspring possess higher milk yields and capacity to withstand local climatic conditions.

•Based on a pilot project in rural Pakistan in 2009, offspring of local cattle inseminated with high quality AI doses produced 4,000 liters of milk/annum compared to 1,500 liters/annum by local breeds. Moreover, the crossbreds began milk production 25 months after birth compared to 42 months for local breeds (Ashraf, Ahmed & Chaudhry 2013).

•Recent, technological innovations have significantly reduced the storage and delivery of costs of AI doses.

•But despite rate of returns in access of 100%, adoption rates have remained very low and only 11% of cattle in Pakistan were artificially inseminated in 2006.

Research Objectives

•Livestock is an essential feature of rural agricultural households in Pakistan. In 2001, 47% of all rural households owned livestock and it contributed 11% towards their total income (FAO, 2009).

•Despite the potential gains, the track record of sustained poverty reduction through livestock sector interventions is weak (LID, 1999).

•Moreover**,** the existing development economics literature has focused primarily on adoption of different crop technologies e.g. fertilizer, pesticide and high-yielding seed varieties, whilst livestock technologies have been ignored.

•Therefore, this paper addresses the gap in the literature by examining the determinants of the low adoption rate of AI technology by livestock farmers in Pakistan in order to assist policy makers design better interventions for poverty alleviation.

Methodology

•Livestock serves multiple functions in the traditional, mixed-farming systems prevalent in South Asia, i.e. livestock holdings provide nutrition and off-season food security, increase farm productivity through draft power and manure, serve as an alternative source of income and an avenue for savings/investment.

•The multiple roles played by livestock in agricultural households limits the efficacy of static models and reduced form techniques.

•Therefore, we make a concerted effort to capture the essential economic features of rural agricultural households e.g. credit constraints, herd dynamics, production risk and mixed farming systems in a parsimonious structural model.

•Structural models of rural agricultural households have gained popularity in development literature over the past decade (Dercon & Christiaensen 2011 and Foster & Rosenzweig, 1993) as they allow economists to explicitly model implicit costs that are known to lower returns from technology adoption.

•To this end, we develop a dynamic, stochastic, structural model that captures the essential features of the economic environment of rural agricultural households.

Structural Model

- The model has **5 state variables:** Milk producing cross-bred cattle (F_1), calf cross-bred cattle (F_2), milk producing local cattle (**F_3**), calf local cattle (**F_4**) and liquid wealth (A).
- The model has **5 discrete decision variables:** AI technology adoption decision (I) and net purchases of cattle (X_i for i=1-4).
- The model has **3 continuous decisions variables:** Consumption (C), Mixed farming input choice (θ) and savings (A').
- The model has **18 parameters:** Household livestock capacity constraint (N), Milk yield of cross-bred cattle (Y_1), Milk yield of local cattle (Y_2), Price of crop output from mixed farming inputs (P_c), Price of milk (P_m), cost of rearing one cattle (P_r), Price of AI dose (P_{AI}), Price of mixed farming inputs (P_θ), Selling/buying price of cattle by type j (P_j for j=1-4), Mortality rate of cattle by type (Q_j where $Q_2>Q_4>Q_1>Q_3$) and production shocks ε', distributed as N (μ, σ)
- The **herd rearing cost function** is given by:

$$f\,(F_1, F_2, F_3, F_4)$$

- The **mixed farming production function** is given by:

$$g\,(\theta, F_1+F_3+X_1+X_3, \varepsilon')$$

- The **farmers' profit realization** is a function of the state variables, the decision variables, the rearing cost function and the mixed farming production function:

$$g(\theta,F_1+F_3+X_1+X_3,\varepsilon')*P_c + P_m*[(F_1+X_1)*Y_1 + (F_3+X_3)*Y_2\,]- I*P_{AI} - \theta*P_\theta - P_r* f(F_1', F_2', F_3', F_4')$$

- Asset accumulation is a function of profit realization, consumption level and herd buying/selling decision:

$$A_{t+1} = A_t + Profit_{t+1} - C_t - \left(\sum_{j=1}^{N} X_j^t P_j\right)$$

- In order to incorporate the herd dynamics we formulate the state transitions for each type of cattle as a linear function of the appropriate state and decision variables:

$$F_1^{t+1} = h(F_2^t + X_1^t + F_1^t, Q_1)$$
$$F_2^{t+1} = h\,(X_2^t + I, Q_2)$$
$$F_3^{t+1} = h(F_3^t + X_3^t + F_4^t, Q_3)$$
$$F_4^{t+1} = h(X_4^t + F_1 + X_1 + F_2 + X_2 - I, Q_4)$$

- The rearing cost function, the mixed farming production function and the listed parameters are calibrated using recent survey data on livestock farmers in Pakistan.

•The Bellman equation for the problem can be formulated as follows subject to the farmers profit realization and asset accumulation constraints:

$$V(F_1,F_2,F_3,F_4,A) = \max_{A',C,I,x_i,\theta}\{U(C) + BV(F_1',F_2',F_3',F_4',A')\}$$

•The farmers profit realization and the asset accumulation law of motion can be combined to substitute out consumption from the Bellman equation:

$$V(F_1,F_2,F_3,F_4,A) = \max_{A',I,x_i,\theta}\left\{U\left(A - A' + Profit - \left(\sum_{j=1}^{N} x_j^t P_j\right)\right) + BV(F'_1,F'_2,F'_3,F'_4,A')\right\}$$

•The Bellman equation is analytically intractable and is solved numerically using the method of collocation developed by Miranda & Fackler (2002), in order to compute the effects of different policy interventions on AI technology adoption rates.

Conclusion

•Our preliminary analysis suggests that in the presence of extreme poverty and in the absence of insurance markets, low rates of AI technology adoption are a direct result of households' tendency to engage in low risk production activities in order to protect assets and ensure smoother consumption.

•The literature on risk is the key to understanding the AI technology adoption problem. Even though AI technology promises significantly higher incomes in the future, absence of insurance markets and low levels of liquid wealth magnify the disutility of risks associated with new agricultural technologies like AI which entail upfront outlays and uncertain future returns.

•In the absence of insurance markets and low wealth levels dairy farmers are highly averse to risky technologies due to the importance of livestock to dairy farmers.

•As a result supply side interventions like subsidized prices for AI technology and access to subsidized credit are less likely to increase adoption rates compared to policy interventions that reduce the risk exposures of households.

•Access to credit is not as important an issue as is the risk of consumption shortfalls, therefore adoption rates due to a policy intervention of consumption insurance are higher compared to adoption rates under a policy intervention of access to subsidized credit.

•The paper calls for a paradigm shift from a supply-side focus to more demand based approach. An emphasis on the former may explain why traditional agricultural methods in developing countries have shown a remarkable resilience to a wide array of policy interventions in the past.

References

•FAO (2009).The State of Food and Agriculture. Livestock in the balance, Rome.

•Junaid Ashraf, Zeeshan Ahmad, and Imran Chaudhry (2013) Livestock Valuation in a Dairy Business. Issues in Accounting Education, Vol. 28, Issue. 4, pp. 873-883

•Livestock In Development (1999). Livestock In Poverty Focused Development. Crewkerne: Livestock In Development

•Mario J. Miranda and Paul L. Fackler (2002). Applied Computational Economics and Finance. Cambridge, MA: MIT Press.

•Mark R. Rosenzweig, and Kenneth I. Wolpin (1993). Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India. Journal of Political Economy, Vol. 101, Issue 2 pp. 223-244.

•Stefan Dercon & Luc Christiaensen (2011). Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia. Journal of Development Economics Vol. 96, Issue 2, November