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Food Policy

journal homepage: www.elsevier.com/locate/foodpol

Too small to be beautiful? The farm size and productivity relationship in Bangladesh[☆]

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ARTICLE INFO

Keywords:

Bangladesh
Agricultural productivity
Stochastic frontier
Technical change

ABSTRACT

This paper examines the agricultural productivity-farm size relationship in the context of Bangladesh. Features of Bangladesh's agriculture help overcome several limitations in testing the inverse farm-size productivity relationship in other developing country settings. A Stochastic Production Frontier (SPF) model is applied using data from three rounds of a household panel survey to simultaneously estimate the production frontier and the technical inefficiency functions. The 'correlated random effects' approach is used to control for unobserved heterogeneous household effects. Methodologically, the results suggest that SPF models that ignore the inefficiency function are likely mis-specified, and may result in misleading conclusions on the farm size-productivity relationship. Empirically, the findings confirm that the farm size and productivity relationship is negative, but with the inverse relationship diminishing over time. Total factor productivity growth, driven by technical change, is found to have been robust across the sample. Across farm size groups, the relatively larger farmers experienced faster technical change, which helped them to catch up and narrow the productivity gap with the smaller farmers.

1. Introduction

One of the enduring debates in the development and agricultural economics literature is the inverse relationship (IR) between farm size and agricultural productivity. The IR continues to draw the attention of policy makers and researchers concerned with the unrelenting fall in farm sizes in much of the developing world, persistent poverty (largely concentrated in rural areas and associated with agriculture as the primary livelihood), and insufficient progress in structural transformation (see, e.g., Collier, 2008, Collier and Dercon, 2014). This paper seeks to contribute to this debate with empirical insights from Bangladesh.

Bangladesh provides a particularly interesting setting – it is one of the most densely populated and cultivated countries in the world, with farm sizes among the smallest in the world. Yet, Bangladesh's agricultural performance has been remarkable since the mid-1990s, with impressive productivity growth (appropriately defined as total factor productivity or TFP). This seemingly paradoxical coexistence of very small – and declining – farm sizes and consistent high productivity growth is itself thought provoking in the larger IR debate. Nevertheless, this casual observation raises conceptual, measurement and

methodology issues, leaving open the question on whether the IR holds in the setting of very small farms that characterize rural Bangladesh.

Several unique features of Bangladesh's agriculture make an investigation of the IR particularly interesting and important. A combination of active factor markets, the availability of household level panel dataset on agricultural production, and application of recent advances in estimation methods (specifically employing the stochastic production frontier approach to jointly estimate the production frontier and technical inefficiency for unbiased and consistent estimates) allows overcoming several of the limitations (conceptual and empirical) identified in the literature on testing the IR.

This paper has five sections. Following this introduction, the empirical context and setting for evaluating the IR is presented in Section 2. The methodology and data used for the empirical analysis are described in Section 3, followed by the results and discussion in Section 4. The paper ends with the conclusions and policy recommendations emerging from this study in Section 5.

[☆] The authors are grateful to Mahabub Hossain for providing access to the panel survey data used in this study. The authors also want to acknowledge the constructive comments and suggestions provided on an earlier draft of this paper by Keith Fuglie, Nicholas Rada, and two anonymous reviewers. The findings, interpretations, and conclusions expressed in this paper are those of the authors and do not necessarily reflect the views of the Executive Directors of The World Bank or the governments they represent. The World Bank does not guarantee the accuracy of the data included in this work.

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2. The empirical setting in the context of the IR debate

Bangladesh has made commendable progress over the past 40 years, overcoming dire predictions in the early 1970s of widespread starvation to attain its goal of self-sufficiency in rice, its main staple (Hossain and Bayes, 2009). Underlying this achievement has been impressive agricultural growth, particularly since the mid-1990s, despite a persistent macro-policy bias against agriculture and high vulnerability to exogenous weather shocks that afflict Bangladesh with regularity – primarily floods and hurricanes.¹ A combination of policy reforms, technological progress, investments in infrastructure and human capital, and the enterprise of rural Bangladeshi households have been credited with driving the trend growth rate (i.e., growth rate over rolling 10 year periods) steadily higher for the past two decades, reaching about 5% in recent years (Gautam and Faruquee, 2016).²

Available evidence indicates that Bangladesh's enviable agricultural growth has been driven primarily by TFP growth, underpinned by a combination of technical progress and efficiency gains triggered by policy reforms in the 1980s and early 1990s. Using International Food Policy Research Institute (IFPRI) estimates, Gautam and Faruquee (2016) note that agricultural TFP in Bangladesh grew at an average annual rate of about 2.7 percent between 1995 and 2011.³ During this period, Bangladesh was among the better performers in the world, comparable to China and better than the star performers in East Asia.⁴

What is remarkable about this productivity driven growth is that it has been achieved on very small farms which have continued to decline in size from what may be described as very small especially when compared to those in other countries such as the US. Table 1 shows the average farm sizes in Bangladesh for 2000 and 2008, in terms of both area owned and area operated or cultivated, calculated from the rich panel survey used in this study. It is against this dynamic backdrop that this paper investigates the farm size and productivity relationship in Bangladesh's agriculture.

The literature investigating the IR hypothesis is large, with a substantial body of evidence in support of the hypothesis, but also studies that do not find empirical support for it. The traditional approach to examining the IR was to compare yields (output per unit of land) and farm size. This partial or unconditional land productivity measure was supplanted by conditional productivity, an approach that controls for other factors using a production function (see Barrett et al., 2010; Gaurav and Mishra, 2015; and Yamauchi, 2016). While conceptually superior to a partial productivity measure, a standard production function specification ignores the relationship between farm size and technical efficiency, which may or may not be in the same direction on the production frontier (Kagin et al., 2016). More worrisome is the potential bias in parameter estimates by ignoring unobserved farm heterogeneity or other variables correlated with technical efficiency, which may lead to an erroneous conclusion on the IR.

Few studies have examined the relationship between technical efficiency and farm size. These studies have either used the Data Envelopment Analysis or DEA (Townsend et al., 1998; Sharma et al., 1999) or a two-step estimation procedure (with the stochastic frontier and technical efficiency functions estimated sequentially) (Rahman,

¹ Macro-policy bias is estimated as the Relative Rate of Assistance to agriculture from the global database on agricultural incentive distortions (see Anderson and Nelgen, 2012).

² Agriculture has been identified as the main driver of poverty reduction since 2000 (World Bank, 2013). Agricultural growth has also unleashed broader and unprecedented changes in the rural economy through its linkages with the rural non-farm economy; every 10 Taka of agricultural income is estimated to stimulate an additional 6 Takas in rural non-farm incomes (Khandker and Samad, 2016).

³ See Nin-Pratt (2015) for details on IFPRI's estimation of agricultural TFP by country.

⁴ The most recent estimate from the International Agricultural Productivity database shows TFP growth in Bangladesh between 2001 and 2013 to have been 2.7% per year, which is in the top 20% of performers among the 173 countries in the database [data from USDA (2017); see Fuglie (2015) on the methodology used].

Table 1

Characteristics of Bangladesh agriculture.

Source: Authors' calculation using the 62-village panel survey.

	2000	2004	2008
<i>Household characteristics</i>			
Households with farm income (%)	79.9	80.8	87.2
Households with non-farm income (%)	83.1	89.1	77.4
HHs with both farm and non-farm income (%)	62.9	69.9	64.5
Family size	5.40	5.23	4.94
Number of earners	1.56	1.63	1.58
Number of agricultural workers	0.89	0.93	0.84
Number of non-agricultural workers	0.67	0.69	0.73
Female heads of household (%)	5.89	6.94	13.53
<i>Land</i>			
Total owned land (Ha)	0.53	0.48	0.47
Total cultivated land (Ha)	0.42	0.38	0.32
Per capita cultivated land (Ha)	0.07	0.07	0.06
Per agric. worker cultivated land (Ha)	0.42	0.37	0.35
Proportion of irrigated land	0.66	0.77	0.80
<i>Inputs and mechanization</i>			
Percent of cultivator HHs using fertilizer	96.8	96.4	97.7
Percent of cult. HHs using high-yield varieties	83.9	86.6	84.5
Percent of cultivator HHs mechanized	66.2	82.3	88.7
Percent of HHs with electricity	46.1	61.3	82.5
Agricultural capital/agric. worker (2008 BDT)	8158	8434	11,758
Non-agric. capital/non-agric. worker (2008 BDT)	15,523	11,514	12,939

Note: The averages for each characteristic are calculated across all rural households in the survey (i.e., farm and non-farm households). HH = Household; BDT = Bangladesh Taka.

2003; Salim and Hossain, 2006; Alam et al., 2014; Henderson, 2015). The results from these studies on the inverse relationship remain mixed, but the approaches used have been criticized on methodological grounds [see O'Donnell (2014) on a critique of DEA, and Wang and Schmidt (2002) on the two-step estimation]. There is only one study, to our knowledge, that simultaneously estimates the relationship of farm size with both productivity and technical efficiency (Kagin et al., 2016).⁵

Nevertheless, a number of plausible arguments for and against the IR have been suggested by researchers using different measures of productivity and across a range of empirical settings. The most common among these are factor market imperfections (typically labor); land quality; lack of adoption or constraints to the adoption of improved technology – including credit and risk (production, yield and price); farmer heterogeneity or management skills; and indivisibility of certain inputs (e.g., capital equipment).

Given the potential importance of these factors in explaining the IR, some salient features of Bangladesh's agriculture (in addition to land size) are summarized in Table 1. The dataset is described in more detail below, as are the specific variables used in the analysis. The purpose of the discussion here is to focus on the empirical context and highlight features of Bangladesh's rural economy that help address some of the confounding factors that have dogged a 'clean' explanation of the IR in other developing settings.

One striking feature of Bangladesh's agriculture is the widespread use of technology as embodied in modern inputs – almost all households use fertilizer, a vast majority have adopted high yielding varieties, and have increasingly mechanized over time. Mechanization is not necessarily with owned machinery (though, on average, farm capital has gone up). Most households hire mechanization services, the market for which has grown rapidly, allowing even the poor to cost-

⁵ Rahman and Rahman (2008) estimate the frontier and inefficiency functions of an SPF simultaneously using a sample of rice farmers in one district of Bangladesh. They include land fragmentation among the variables influencing inefficiency but do not study how the inefficiency is influenced by farm size. Moreover, their data are from a single cross-section without controlling for soil quality or land characteristics.

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