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Relationship between Farm Size and Productivity

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Abstract:
This article is an examination of the relationship between farm size and farm productivity in developing countries. The vast majority of this research supports the existence of an inverse farm size-productivity relationship, i.e., the smaller the farm the more productive it is per unit of land. Farm productivity is typically measured as yields per land unit or gross output value per land unit. Numerous studies of agriculture in developing countries have noted the existence of this Inverse Relationship (IR). A variety of causes have been proposed to explain this inverse farm size productivity relationship. These include imperfections in land, labor and capital markets, labor dualism, the effects of uncertainty on farmer decisions, and land quality differences among farms of different sizes. To conclude, the productivity is related to a variety of factors like crop mix, input use, labour employed, management of crop-related activities etc. in addition to farm size. In that case, the enquiry should be aimed at identifying the key factors and establishing the relation between a composite index of such factors and farm productivity.

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I. Introduction

A great amount of research has been done on the relationship between farm size and farm productivity in developing countries. The vast majority of this research supports the existence of an inverse farm size-productivity relationship, i.e., the smaller the farm the more productive it is per unit of land. Farm productivity is typically measured as yields per land unit or gross output value per land unit. Numerous studies of agriculture in developing countries have noted the existence of this Inverse Relationship (IR). The relationship was first observed by Chayanov in his work on Russian agriculture in the 1920s (Chayanov, 1966), and has since been observed in many other developing countries, from Brazil and Colombia to India and Malaysia. The inverse farm size productivity relationship has been observed so often that various authors refer to its existence as a "stylized fact" of agriculture in developing countries (Bardhan, 1973; Bhalla and Roy, 1988).

A size-wise analysis of productivity indicated that it is the large farms, which have higher productivity. The debate on the relationship between farm size and productivity in Asia has gone through a complete circle. In the 1960s small farms were regarded as being efficient because they could fully use their resources, particularly family labor, and they could monitor their production activities more closely. About 55% of the world's population lives in Asia, 58% of which depends on agriculture for a livelihood. However, the Asian region holds only 20% of the world's agricultural land. Moreover, the average size of holdings continues to fall in several countries of the region with the fragmentation of land holdings. Today, in most countries of Asia, the average land holding ranges from only 1 to 2 hectares, well below the world average of 3.7 hectares per person. At the same time, the number of small-size holdings has increased significantly (Pookpakdi, 1992).

Relationship between farm size and productivity in developing countries is one of the oldest issues in the academic arena for analyzing the agrarian structure. The debate on farm size and productivity relationship intensified, when Sen (1962, 1966) observed inverse relationship between farm size and output per hectare in Indian agriculture, suggesting that small farms are more productive compared to large ones. This relationship is explained by the relative advantage of using more family labour by small farms that may reduce the monitoring and supervision costs of hired labour. These findings show that equity does matter for efficiency in the agricultural sector, and raise the question of redistributive land reform in most agrarian countries. Since then, a lot of empirical studies have re-examined the problem from different angles using various statistical techniques in order to test Sen's finding, and inverse relationship (IR) has been perceived as a "stylized fact" of rural development. In favour to the IR, Sen argues that the opportunity cost of a day's labour by family members might be well below the daily wage rate of hired labour.

Feder (1985) shows that small farmers have high labour/land ratios, and could achieve higher yield per hectare. Moreover, the IR is typically explained by the failure of rural markets for credit, labour and land, as well as by the difference in labour endowments between small and large farms. Family labour has more incentives than hired labour to work intensively, because it is residual claimant of the output. This fact is analysed in relation to reduction of unequal distribution of landholdings, assuming that redistribution of land will lead to a positive effect on farm productivity.

An inverse relationship between farm size and land productivity has become part of the conventional wisdom concerning technologically backward agrarian economies. Indeed there can be little doubt about the generality of the phenomenon; it has been observed in many underdeveloped economies with widely different climatic conditions, structures of land holding and cropping patterns.

A variety of causes have been proposed to explain this inverse farm size productivity relationship. These include imperfections in land, labor and capital markets, labor dualism, the effects of uncertainty on farmer decisions, and land quality differences among farms of different sizes. There are far fewer studies which test the validity of the proposed explanations of the inverse farm-size productivity relationship than there are studies which document the existence of the relationship.

II. Debate About

The debate on the subject of farm size and productivity relationship started with Sen's (1962) seminal work using India's Farm Management Survey Data. Afterwards, a significant number of studies have been completed proving or rejecting the claim of the inverse relationship between farm size and land productivity in South Asian and some other developing countries. The studies using Indian data, which found inverse relationship are Sen (1962); Mazumdar (1965); Rao (1966); Saini (1971); Bharadwaj (1974); Chaddha (1978); Ghose (1979); Bhalla (1979); among others. The studies which did not find inverse relationship or had inconclusive results are Rao (1967); Bhattacharya and Saini (1972); Khan and Tripathy (1972); Rao (1975); Dasgupta (1977); Chattopadhyay and Rudra (1976); Saini (1980); Bagi (1981); Deolalikar (1981); Rao and Chotigeat (1981); Roy (1981); among others. Studies of the type done in India are relatively scarce in other developing countries.

The relationship between farm size and productivity has been intensely debated in India. A large number of studies during the 1960s and 1970s provided convincing evidence that crop productivity per unit of land declined with an increase in farm size (Sen 1962, 1964; Mazumdar 1965; Khusro 1968; Hanumantha Rao 1966; Saini 1971; Bardhan 1973; Berry 1972) which provided strong support for land reforms, land ceiling and various other policies to support smallholders on ground of efficiency and growth. Subsequently, various analysts started exploring reasons or factors for higher productivity of smallholders (Berry and Cline 1979; Bhalla 1979; Binswanger and Rosenzweig 1986; Dong and Dow 1993; Frisvold 1994; Raghbendra et al 2000) and some of them even questioned the inverse relationship between farm size and productivity. Rudra (1968) concluded, "There is no scope for propounding a general law regarding farm size and productivity relationship".

Chadha (1978) analysing farm level data for three agro-climatic regions in Punjab for 1969-70, reported that the inverse relationship had ceased to hold in more dynamic zones. Ghose (1979) argued that an essential precondition for the existence of the inverse relationship phenomenon is technical backwardness implying that with the advances in technology the inverse relationship will vanish. Similar to this, Deolalikar (1981) observed that the inverse size-productivity relationship could not be rejected at low levels of agricultural technology in India, but can be rejected at higher levels. Chattopadhyay and Sengupta (1997) in the context of West Bengal, reported that the inverse relation between farm size and productivity was stronger in agriculturally developed regions. On the other hand, HanumanthaRao (1975) and Subbarao (1982) reported a positive relationship between farm size and productivity and attributed this to higher application of fertiliser and other cash-intensive inputs on large farms.

Dyer (1997) argued that the inverse relationship is neither a product of superior efficiency on the part of small farms nor is it due to better quality land on the small farms but arises from the desperate struggle for poor peasants for survival on below subsistence plots of land. Hence, Dyer (1997) opined that redistribution of land on the basis of the inverse relation argument, far from alleviating poverty and creating employment opportunities, will only deepen and perpetuate extreme levels of exploitation and poverty. Dyer (1997) and Havnevik and Skarstein (1997) argue that smaller farms enjoy higher land productivity in the short term, but over the long-term land productivity tends to drop. They argue that this long-term drop in land productivity results from over intensive cultivation of the land in order to maintain labour productivity, when more and more people need to survive on the same small area of farmland, and as the smaller farms are resource-poor to invest in preserving soil fertility, soil productivity eventually becomes exhausted and land productivity drops. Bhalla and Roy (1988) observed that the inverse relation between farm size and productivity weakened and disappeared when soil quality variable was included in their study.

Fan and Connie (2005) show that to increase labour productivity, and therefore, farmer's income, either land productivity has to increase or land to labour ratio has to improve. Given the consensus that smaller farms

have a lower land-labour ratio than large farms. Foster and Rosenzweig (2010) using plot level panel data (over the span 1999-2008), of the Rural Economic Development Survey (REDS) data of the National Centre for Agricultural Economics and Policy Research (NCAER), and using a model incorporating supervision costs, risks, credit-market imperfections and scale economies associated with mechanisations, report that small-scale farming is inefficient in India. Thapa and Gaiha (2011) using all India survey, REDS, 2006 of NCAER data, analysed the farm size crop yields relationship, using the Kernel density function, and observed that the relation varies with food commodity group. They also report that "while much lower fractions of smallholders are concentrated in lower ranges of yields compared with medium-and large-landholders, segments of smallholders also obtain very low yields".

Hazell (2011) who also maintains that many of the advantages of smallholders disappear as countries develop. The reasoning given for this is that as the per capita income rises, the economy diversifies and workers leave agriculture and the wage rate goes up. It then becomes more efficient to have progressively larger and more mechanised farms.

III. Existing Theories and Empirical Evidence

A number of theories and explanations for the inverse relationship between farm size and productivity exist. Sen (1962) attributed the inverse relationship to labor dualism, in which large and small farms are assumed to have the same technology, but small-scale farmers have lower opportunity costs of their labor than operators of large farms. Then, again Amartya Sen (1964) in his article explained three alternative lines of observation such that:

i. Technique based,
ii. Labour based, and
iii. Fertility based explanations.

Labour-Based Explanation: He found the technique-based explanation the weakest of the three, though he has not rule it out altogether. In its simplest form this can take the shape of assuming "diseconomies of large scale". In this form the argument is open to the obvious objection that diseconomies of scale can be avoided by the big farmer by splitting his big piece of land into small bits and cultivating them in these smaller units. Because of personal participation and supervision that a small business allows, a small holding may permit the use of some techniques-efficient ones-that cannot be used in larger holdings. Some techniques require not only inputs in the usual sense but also loving care, and Adam Smith had directed our attention to the "affection" that small property inspires. It may be difficult to make a paid labourer do what the owner himself would. The second line of argument is that, in a situation of wide-spread unemployment, the opportunity cost of labour to a family based farm is very low, but for reasons (mainly perhaps sociological), the wage rate does not go down below a certain level , considerably higher than the opportunity cost. As a result the family-based farmer applies labour more liberally with less restraint than the wage-based farmer, and this naturally leads to higher productivity per acre of the small farms, because these are mostly family-based farms rather than wage-based ones.

Fertility -Based Explanation: The fertility- based explanation is quite different from all this. What we could suggest here is that the smaller farms have higher output per acre because they are more fertile. Even if we start from a situation of no relation between fertility of land and the size of holdings, a positive relation between the two will be soon established through a more rapid expansion of population on the more fertile land than on less fertile ones. If two piece of land are of the same size but holding A is more fertile than holding B, the former will provide a greater opportunity of earning income, so that family size may expand faster in the former case. This will lead to quicker subdivision of A than of B, and soon a correlation may be established between smallness of the size of the holdings and fertility of soil.

The inverse relation between holding size and productivity per acre in Indian agriculture was revealed by the Farm Management Studies. N.Bhattacharya and G.R. Saini (1972), attempts to examine disaggregated data for individual farms, separately for each sample village, and to apply rigorous tests for the correlation between farm size and gross value of output per acre. The existence of the inverse has been widely accepted and attributed, among other factors, to higher intensity of cropping for the smaller holdings where the proportion of irrigated land is relatively high.

Michael R. Carter (1984) using a pooled farm level data set, the study tries to distinguish between alternative explanations of the inverse farm-size productivity relationship. Its basic conclusions are that the relationship is not a reflection of bias resulting from sample selection based on farmer literacy, nor is it a misidentification of village effects. The analysis favors what might be called a "mode of production" explanation of the inverse relationship. The data for this study are from farm management surveys taken in the Indian state of Haryana during the agricultural years 1969/70-1971/72. For each of the three years, 162 holdings were selected through a multi-stage stratified random sampling procedure. He used the regression measure to estimate the farm-size productivity. The regression relationship is assumed to be constant over time. He found very strong inverse

relationship between farm size and productivity, with per-hectare production declining nearly 40% as farm size doubles.

A measurement error in land input due to heterogeneous land could also explain an inverse relationship. For example, Bhalla and Roy (1988), and Benjamin (1995) suggest that unobserved land quality is positively related to farm productivity but inversely related to farm size. Barrett (1996) argues that the combined effects of non-degenerative land distribution and price risk could produce an inverse relationship.

According to Rasmus Hetberg (1998), the inverse relationship between farm size productivity is an important stylized fact of rural development, which has far-reaching implications for development policy and academic research. His study sought to review and clarify the controversy over the inverse relationship and to present novel empirical work based on Pakistani farm data. Three lines of criticism have been raised in the literature against the inverse relationship hypothesis, (a) that the empirical evidence is flawed due to omitted variable bias, (b) that the relationship may no longer hold after the Green Revolution, and (c) that a consistent explanation for the inverse relationship is missing.

Graham Dyer (1998) explained the inverse relation relationship between farm size and output per hectare, which seems to have been strengthened in the agriculturally developed regions of West Bengal compared to the relatively less developed regions. This, they claim, may be due to the impact of green revolution technologies on land productivity on the smaller sized farms. Given their use of disaggregated farm level data for 1998-90, sampled from six agro-climatic zones across the state of West Bengal, this is at first sight a potentially significant finding which runs against much of evidence from India and other countries which a breakdown in the inverse relationship with higher levels of capitalist development in agriculture.

Deininger and Feder (2001) suggest that a farm using only family labor is more efficient because it is free of principal-agent problems, that is, family members have a long-run interest in the success of the farm. When a farm is small and labor markets are not functioning, small-scale farms use only family labor and do not hire labor or sell labor in the nonfarm labor market. Benjamin and Brandt (2002) attribute the inverse relationship between farm productivity and size in China's agriculture to local administrative land distribution policies and uneven off-farm work opportunities. In an economy with private land ownership, family members have a strong incentive to work, because they share the farm output directly, and in the long run, they might expect to inherit the farm. He has investigated the role of measurement error in labor and land, respectively, and shows how it creates the observed relationship.

Assuncao and Ghatak (2003) present a theoretical model showing that endogenous occupational choice and heterogeneity in farming skills, coupled with credit market imperfections, can explain the inverse relationship when there is a constant return to scale and no labor market imperfection. Lamb (2003) confirms that inclusion of land quality adjustments largely explains the inverse relationship between farm size and profit.

There are few empirical studies examining the relationship between farm size and productivity at farm level in Nepal. One recent study done by Bhandari (2006) shows a positive relationship between land inequality and productivity, rejecting the argument that in Nepal, small farms appear to be more efficient than large farms. The author has well summarized the overall development of land reform in Nepal in relation to productivity and poverty reduction. However, the study is mainly focused on the districts of the southern plain area (i.e. Terai), where yield is supposed to be higher because of better soil quality and regular irrigation facility. In order to obtain this result, the author used macro level data applying a simple bivariate regression between the Gini- index of each district and land productivity. His finding is solely based on rice yield without considering any other crops or land quality in the model. Hence, this paper attempts to make a further empirical contribution in this literature, using farm level data from Nepalese mid-hills. The following article deals with the issues of the relationship between farm size and productivity taking into consideration village dummies as cluster controls, ratio of irrigated land and other socio-economic variables (i.e. caste dummies and family size) showing that the difference of inverse relationship between farm size and productivity is more likely to be negligible if farmers have better access to resources (i.e. credit, advanced technologies, irrigation and market information). The latter is explained as incomplete factor markets that lead to family owned farm and household with better access to resources being more efficient.

IV. In Pakistan

In spite of the pertinent nature of the policy debates the analysis of farm size and productivity relationship did not attract much attention of the researchers in Pakistan. However, a few studies have been conducted in the past dealing with this issue. The first is that of Khan (1979) using 732 irrigated farms in the Indus basin for the year 1974 and a production function technique incorporating a farm size dummy variable concluded that the large farmers get higher output per acre. The study further indicates that per acre use of non-traditional inputs-fertiliser, hired labour and farm machinery is higher on large farms than on small farms: The observed difference is a result of market distortions induced by public policy. The second study by Khan and Maki (1980) uses the same 1974 data set. It conducts analyses for wheat and rice crops only. It found no significant farm size-based difference in

efficiency. However, they reported the existence of increasing returns to scale. Mahmood and Haque (1981) using two sets of data-Agricultural Census and the Rural Credit Survey data for the year 1972-concluded that the smallest (<5 acres) and the largest farm size categories were the most efficient and equally productive. While the middle farmers were relatively inefficient as they used inefficient combination of inputs, which resulted in lower marginal productivity. The study by Chaudhry *et al*. (1985) finds the inverse relationship between size of farm and productivity for Pakistan. It is interesting to note that studies on this issue are old and pertain to data set, which are at least 15 years old. It is therefore important to have a fresh look into the subject. A number of studies relating to productive efficiency in Pakistan have also been conducted as of Khan and Maki (1979) discussed in the foregoing. Ali and Flinn (1989) using the profit frontier approach found an average economic efficiency of 69 percent for the Basmati rice farmers in Punjab using data application from Gujranwala district. Farmers' education, lack of credit facility, late of fertilisers, and irrigation constraints were considered to be the factors for low efficiency.

V. New Developments

Despite a number of studies favouring the IR, it has failed to reach a consensus. Some show that IR has disappeared in small regions of India (Bhalla and Roy, 1988; Newell et al., 1997). They argued that the causes of IR might be the regional variations in underlying land quality. Bhalla and Roy (1988) further concluded that the stylized fact of and IR between farm size and output per hectare might be in larger part due to the omission of soil quality variables from the estimated equations. Likewise, Cornia (1985) analysed the relationship between factor inputs, yields, and labour productivity for farms of different sizes in 15 developing countries. These results showed a positive relationship between farm size and productivity in Bangladesh, Peru and Thailand. Deolalikar (1981) also observed that the IR could be rejected at a higher level of agricultural technology. Several economists put their views that the IR remains valid for traditional agriculture. As a result, small farms in most developing countries were perceived as more efficient than large farms before the 1980s. On the other hand, rapid technological changes and the expansion of commercial farming have changed the perception of efficiency toward small farms, suggesting that the IR diminished, when the agricultural sector moved towards modernization through the adoption of more capital intensive technology. Such transformation will pay more attention on other inputs such as fertilizer and modern variety of seeds rather than the importance of farm labour. IR hypothesis argues that the earlier adoption of new technology by large farmers has reduced or even reversed the yield advantage of small farmers (Fan and Chan-Kang, (2003). Small farmers, in this regard, might be unable to compete, especially as the rapid sequence of new technological inputs requires investments that go beyond their capacity.

Shenggen Fan, Connie Chan-Kang (2003), in their article discussed that poverty remains essentially a rural phenomenon in Asia and most of the rural poor depend on farming for their livelihood. Agriculture production typically takes place on small holdings in the region. Moreover, the number of small farms has increasing over time due to land fragmentation. Therefore, small-scale agriculture plays an important role for food security and poverty alleviation.

A number of policy options have been proposed to help small-scale farmers who face increasing globalization. Reforming land policies, for example, is crucial to secure property rights to farmers and to increase farm size. Equally important is the reform of public institutions in order to help small farmers have access to credit, marketing, and technology.

According to Ramesh Chand, P A Lakshmi Prasanna, Aruna Singh (2010), this debate has assumed a renewed importance in the wake of the changes brought about by technological change, liberalisation, commercialisation and further divisions of landholdings in case of India. Further, the structural transformation of Indian economy has not helped to move sizeable population of cultivators to non-agricultural occupations. The share of agriculture and allied sectors in GDP stands at less than 20%, while more than 50% of the workforce is still engaged in agriculture. Because of this imbalance in structural changes in output and occupation, the disparity between per worker income in agriculture and non-agriculture has sharply increased. Accompanied by a slowdown in the growth rate of agriculture, this has put serious strain on smallholders' income and livelihood. Against this background, they revisit the debate on farm size and agriculture productivity to suggest policy measures to address the twin problems of raising productivity and growth of agriculture as well as improving the income and livelihood of smallholders, who constitute more than 80% of farming household, 50% of rural households and 36% of total households in India.

It has been hypothesised in some studies by Hazell (2011) that many advantages of smallholders disappear as countries develop and it becomes more efficient to have progressively larger and more mechanised farms. This type of change has been experienced in western economies where economic transformation has been associated with an increase in the size of holdings with near obliteration of smaller farms.

China continues to have a much lower size of landholdings than India but its agricultural productivity and growth are significantly higher than India. It is thus imperative to look for ways and means to improve productivity and livelihood of smallholders without worrying too much about the size of holdings.

VI. Conclusion

After World War II, the consensus was that small farms exhibited the highest productivity while physical output and labour investment decreased with increasing farm size. This assumption corresponded with the empirical findings. It is worth mentioning that at the time landlords, large farms and smallholders employed – with only a few exceptions – traditional technology.

There are indications that this opinion no longer holds true to an increasing extent. The many technological changes and the expansion of commercial farming seem to have changed the picture. Using the same technology as employed on the large farms, the smallholder was more productive in the past because of greater labour input. During the 70s, however, progressive and commercial farmers started to employ a higher level of technology. The small farmer was frequently unable to compete, especially as the rapid sequence of new technological inputs required investments that went beyond his capacity. An indication of this process is the sequence of rapid technological inputs within the process of the so-called 'green revolution.' The new varieties required the purchasing of expensive seed at the beginning. Soon the existing irrigation facilities had to be improved by the addition of tube-wells in order to ensure the availability of a timely and adequate supply of water. The low resistance to insects and pests necessitated the use of chemicals. Once seed and water were under control, the traditional bullock plough proved to be the next bottleneck in the attempt to increase productivity, and thousands of tractors with machines were bought within a short time. This made it unnecessary to employ great numbers of tenants who owned bullocks, and very many were dismissed. This, once again, led to the substitution of herbicides for manual labour, and the introduction of mowing and threshing machines to carry out the harvest work.

It is obvious that most of the smallholders could not cope with such a large volume of investment requirements within a short time. Quite a number had to give up farming following financial losses due to failure, or because they realized that they could not cope with the new requirements.

This was at least in part due to the absence or imperfection of institutions for assisting smallholders to overcome their limitations. A more efficient cooperative system of credit, supply and marketing as well as of supporting production by group activities, the use of machinery etc., could have led to other results than those which we experienced during the 80s.

But most likely the process will go on; perhaps it will even increase on the basis of a second 'green revolution' caused by biotechnical development.

Today it appears as if middle-sized farms turn out the highest productivity, while smallholders are increasingly unable to provide their cultivating family with a decent living. Due to shrinking farm size, they have to look for additional income, thus taking labour input away from the farms. The younger generation in particular is losing interest in cultivation.

One can certainly still find traditional landlords with all of the consequences of the system, but more and more frequently they (and their sons) take up intensive commercial farming instead of extensive cultivation employing small tenants. By doing so, they increase, or at least maintain the size of their standard of living even after the size of their landed property has been reduced. At the same time, they do what governments have always asked them to do: increase the production of food in order to satisfy the needs of the urban population. As a result, an important argument in the land reform discussion – the low productivity of large farms – ceases to exist.

The well-known statement that "there exist an inverse relationship between farm size and productivity" has been increasingly debated by the scholars. With the development of technology, more detailed analysis using regression methods shows that no firm relationship exists between farm size and productivity.

The search for the causal factors of productivity remains inconclusive. Farm productivity may be related not to the size of farm but to a complex of various factors including size of farm. Choice of crops, administration of inputs at the right time, management of crop-related activities, etc. could make all the difference, irrespective of the size of the farm. In the case of perennial crops once a choice is made, productivity depends only on the management of inputs; and results begin to appear after a time lag. As Pol Barbier (1984) has remarked, if correlation of productivity is to be found it should not be with the size of land only, but with different packages.

To sum up, productivity of farms does not show any clear relationship with farm size. It is possible that the productivity is related to a variety of factors like crop mix, input use, labour employed, management of crop-related activities etc. in addition to farm size. In that case, the enquiry should be aimed at identifying the key factors and establishing the relation between a composite index of such factors and farm productivity.

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