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Output per Acre and Size of Holding

A critique of Berry and Cline on the inverse relationship

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Introduction

The literature on the alleged inverse relationship between farm size and land productivity comprises a vast body of empirical and theoretical work scattered throughout many journals and studies over a long period of time. Although nowhere else has there been a debate on the Indian scale or of the Indian quality[1], the inverse relationship has been identified in a wide range of countries. This paper[2] focuses upon what has been seen as an extremely influential attempt "to consider the issues of agrarian structure and productivity at the theoretical level and to bring together recent empirical evidence on these issues from a wide range of countries" [*Berry and Cline, 1979: x*].

That attempt is the study by Albert Berry and William Cline entitled *Agrarian Structure and Productivity in Developing Countries*, published for the ILO in 1979. This collaboration grew out of earlier work by the authors on Colombia and Brazil.[3] It is cited by many writers as being the definitive study of the inverse relationship [see, for example, *Dasgupta, 1993: 525* and *Ellis, 1988: 197*].

The main focus of the study is "on differences in the productivity of existing farms by size" [*3*][4] and the factors which explain these differences. Based on a wide range of empirical evidence, the authors conclude that an inverse relationship between farm size and productivity is generally found in developing countries: "In short, it is clearly the normal relationship" [*203*]. The specific questions addressed include the impact of factor market imperfections on resource utilization, the potential of redistributive land reform to increase output and employment, the effects of the introduction of Green Revolution technology on the inverse relationship, and aspects relating to land tenure.

Various hypotheses explaining the inverse relationship are examined in their second chapter [*5-30*], and two types of empirical evidence are presented in chapters three and four. Chapter three [*31-43*] examines cross-country data on the farm size-productivity relation, while chapter four [*44-127*] and Appendix A [*141-193*] consider the evidence from various individual country case studies. Finally, chapter five [*128-140*] draws out the policy implications derived by the authors from both sets of empirical evidence.

We examine the latter first, taking the empirical evidence at face value and abstracting from the theoretical analysis. We then turn to a brief critical account of the authors' theoretical framework. Finally, we examine in some detail the empirical evidence presented by the authors, both the cross-country data and each country study individually. We shall seek to show that this empirical evidence is seriously flawed and cannot be used to test the various hypotheses proposed by the authors.

Policy implications

Berry and Cline argue that the finding of systematically higher land productivity and comparable levels of total factor productivity on small farms as opposed to large farms suggests "that the expansion of the small-farm subsector of agriculture may be a more effective way of increasing both employment and output than pro-large-farm strategies and thus warrants serious consideration in almost all developing countries" [*4*]. Their analysis of social efficiency and consideration of total factor productivity purports to show the latter falling as farm size increases where labour is abundant and where land and capital are relatively scarce, although the inverse relationship between total factor productivity and farm size is weaker than that relating to land productivity alone. Nevertheless, the authors' major claim is that in LDCs, small farms are likely to have higher total factor productivity, and so are the optimal size for output maximization, as well as for labour absorption and a more equitable income distribution [*16*].

Given their claim that small farms generate higher land productivity and total social factor productivity (the authors do admit an extremely important caveat to this statement: "except in the very smallest farms in some countries" [*128*]), the authors propose the redistribution of land to the small farmers who apply labour more intensively, and the improvement of small farm access to credit and new technology. Both strategies will improve equity and increase output levels it is claimed[*128*].

With such land redistribution, the authors claim that: "The optimal post-reform farm size, in the absence of technical returns to scale, will be merely the total agricultural area divided by the total number of families in the agricultural labour force (after adjusting for land quality). That is, since total factor productivity falls as farm size rises in the relevant range, the most productive agrarian structure will be that composed of the smallest farms possible, consistent with full allocation of the available land and labour force, i.e., total area divided by the total number of farm families" [*18*]. They add in a footnote: "An equal distribution of available land among the entire rural labour force on a family farm basis will generally result in parcels significantly larger than the smallest prereform farms" [*226, note 23*]. Berry and Cline then reason: "If the equal distribution of all available land among all families implies a labour/land ratio equal to that of the same sized farms in the existing agrarian structure, the land productivity of these latter farms can provide a rough prediction of average land productivity after redistribution..." [*18*].

Estimates of output gains after land redistribution follow a two-step procedure: first, the average farm size is computed by dividing the available land by the number of families in the rural labour force;[5] secondly, a statistical estimate of output per acre for that farm size is applied to the former result. Chapter five presents estimates of the potential gains from such equalizing land redistribution. Potential output increases range from 10% for Pakistan to 79.5% for north-eastern Brazil, including 19% for India, 23% for the Philippines, 25% for Brazil as a whole, and 28% for Colombia and the Muda river area of Malaysia [*132-3, table 5-1*].

The only caveats to this procedure given any prominence are those arising from price changes following shifts in output mix, and changes in labour input intensities [*18-19*]. However, the set of assumptions required for this astonishingly simplistic calculation to hold are both numerous and highly unlikely to occur in reality.

The first and most obvious problem with this procedure is that the estimates are not constrained by product mix or land quality. In other words, the total land available which is defined as all land currently being used for agricultural purposes including pasture and woodland, can be converted to arable cultivation. Indeed, even marginal and waste land or land unsuitable for arable purposes is assumed able to be so converted. Clearly, such a computation is inadmissible; the latter category of land would have to be excluded from the calculation, and the remainder would have to be disaggregated by type or by use, as between arable and pasture for example. Very different figures are likely to result. Indeed, where such product disaggregation has been carried out, as in Cline 1970 for Brazil, the potential output gains from land redistribution have been shown to be rather disappointing. In seven out of twelve regional crop sectors, production changes were either negative or insignificant [*Cline, 1970: 146-47, table 26*].

An equalizing distribution might well lead to a modal farm size significantly greater than the smallest currently existing farm size. An important consideration here is the question of minimum feasible size of farm, in terms of either income or employment. None of the foregoing calculations takes into account the possibility of there being a minimum efficient scale or of there being a floor determined by subsistence income. Floors might also be established with regard to employment (the size of farm that would provide full-time employment for the average number of family workers) or with regard to the full employment of farm draught animals.

Estimates of output gains after redistribution of land assume that the required inputs exist and that no losses occur due to the process of redistribution. Such estimates do not take into account the extra investment costs of providing irrigation to unirrigated land, or of providing extra inputs (seeds, fertilizers, pesticides etc.). The process of land redistribution itself may involve extra costs in terms of cadastral survey, boundary marking and the provision of access to plots.

The estimates further assume that the current input-output characteristics on existing farms of the "optimal" size would also characterise farms of that size after land reform. This question is not only related to the availability and distribution of production inputs, but also to the whole area of motivation governing labour effort. If incomes were to rise on the small farms, this may relax the subsistence income or debt obligations constraint and allow small farmers to relax labour effort with a lower application of labour per acre, and hence lower output per acre.[6] In such circumstances, while on-farm family consumption might increase, the supply of marketed surplus may well fall with serious consequences for economic activity outside agriculture.

One area dismissed rather cursorily by Berry and Cline is the question of the possible dynamic losses of redistributive land reform affecting negatively the rate of saving and capital accumulation, and the adoption of new technology. The authors doubt the existence of any possible dynamic losses arising from land distribution because 1) there appears to be no evidence for higher agricultural growth rates in countries with higher than average farm size, and 2) there is evidence in Green Revolution areas that small farmers adopt the new technology rapidly [*134-5*].

The first point, however, is quite irrelevant. Average farm size provides no indication of the distribution of farm size or the weight of large farms in that distribution. What needs to be compared is the relative output growth rates of a group of large capitalist farms with a group of small peasant farms in one country. Berry and Cline cite evidence of simulation experiments with rural savings data for Brazil and India by Cline and Bhalla[7] which indicate that income redistribution would have only a limited impact on rural savings rates and total savings [*28*]. However, as Sen [*1964a*] and Bharadwaj [*1974a*] have shown, the vast bulk of small farms in India are highly indebted deficit farms. It is therefore most likely that any post-reform average or marginal rate of rural saving would be very low. Indeed, as we shall see below, Bhalla disposes of this annoying problem of deficit farms by excluding them from his analysis (this reduces his NCAER sample by over 50%).

The second assertion is also highly dubious. The authors assert that small farmers adopt the Green Revolution technology very soon after the large farmers, thus reestablishing an inverse relationship in the form of an S-curve [*28*]. They claim that the association of mechanization with the adoption of new technology is erroneous, simply just another manifestation of factor market imperfections, and that the existence of the latter imply the need to channel new inputs towards the small farms [*27-8*]. However, the empirical evidence does not substantiate this assertion: Patnaik [*1987: 120-5*] has demonstrated that although some farms in all size groups have adopted the new technology, those small farms are in fact, in terms of scale and hired labour use, rich farms. It is the rich farms who both adopt the new technology thus reaping the initial benefits and who maintain that advantage. That evidence shows clearly that the inverse relation has broken down in those Green Revolution areas as large farmers adopt both the new technology and mechanize. Indeed, Berry and Cline do admit that large farms are able to capture economies of scale with the introduction of mechanized technology [*138*].

Theoretical framework

These quite erroneous assertions regarding policy prescription are of course founded on a particular conception of the factors which give rise to an inverse relationship in the first place. Berry and Cline begin by asserting that the empirical studies generally show constant returns to scale in developing country agriculture, and that there would therefore be no losses of production efficiency via land redistribution. They continue: "if returns to scale for inputs actually used are constant, then the crucial determinant of the size-productivity relationship is the behavioural pattern of resource utilization by farm size" [*6-7*].

The authors [*13-4*] are aware of the need to distinguish the inverse relationship in terms of falling physical yields of individual crops with farm size, a decreasing land use intensity or cropping intensity with farm size, and a product-mix shift to lower value crops as farm size increases. They mention the possibility that large farms might have higher output per acre but utilise a smaller proportion of their land area. Indeed, they cite evidence for higher output per acre on the large farms in Colombia with lower land use intensity. Similar evidence exists for north-eastern Brazil,[8] for China in the 1930s, and for the Philippines in the 1960s, while Pakistan also shows higher yields for some crops (see below).

The authors present the following hypothesis as the main explanation for the inverse relationship: factor prices differ between the large farms and the small farms, such that the effective prices of land and capital are low for the large farms and the effective price of labour is low for the small farms. Thus small farms have high labour/land ratios whereas large farms use labour and land less intensively. Small farms with a lower opportunity cost of labour, can exploit more marginal land, cultivate a larger proportion of their land, and achieve higher output and yields [*9-10*].

Berry and Cline take a rather eclectic position on the causes of these factor price differentials between large and small farms. The authors mention Sen's labour market dualism framework[9] where the supply price of family labour is the average product of labour and not the marginal product. The MPL on the small farms will be lower than on the large farms. The main qualification to this is where the opportunity cost of labour is high (due to the availability of off-farm employment). However, the market wage may be discounted for risk and search costs, or the family may try to hire out labour, but family preferences or unwillingness to share output with the hired-out worker will keep the MPL less than the wage [*8*].

The effective land price may be higher for the small farms because 1) small plots have higher unit costs (a greater potential market and inconvenience for landowners); and 2) land purchase needs credit and large farms have better ratings and so cheaper credit (and so the real price of land will be lower). Land price differentials reinforce labour cost differentials and lead to higher labour/land ratios and output/acre on the small farms. Imperfections in capital markets reinforce low labour use on the large farms: a low effective price of capital leads to substitution of machines for labour. The authors take a net substitutionist view of mechanization [*11*]: the main influence of mechanization is on substituting for labour rather than raising yields [see *Binswanger, 1984*]. The empirical studies in the book show markedly lower labour/land ratios on the large farms and this is taken to mean that capital and land market imperfections complement the effects of labour market dualism or are not strong enough to counteract them. The holding of land for asset price speculation or for reasons of social prestige and/or political power is also adduced as a possible explanation for lower productive activity on the large farms [*10-12*].

Let us examine these theoretical explanations for the inverse relationship presented by the authors point by point. The fact that the empirical studies in the text generally show constant returns to scale in developing country agriculture does not mean that potential economies of scale are non-existent. In the context of backward agriculture in which the forces of production are not advanced and in which large and small farms are using essentially the same techniques of production, constant or even decreasing returns are possible. However, if the potential for technical scale economies does exist, then land redistribution would not be an optimal strategy.

A major factor behind the inverse relationship relates to cropping intensity and possibly cropping pattern. The distinction between these factors and the physical yields of individual crops and the proportion of farm area actually cultivated is an important one, but these latter factors do not constitute strong evidence for redistributive land reform. Firstly, there is little evidence for falling yields of individual crops across farm size; indeed, much evidence points the other way [*Bharadwaj, 1974a* and *b*]. Secondly, lower land use in terms of area cultivated, particularly if there are higher physical yields of individual crops on the large farms, as implied above, is not an argument for land redistribution to the small farms. In this case, the appropriate policy for output maximization would appear to be to induce large farms to increase their production activity (assuming of course that the unused portion of their land is actually cultivable).

The principal thesis of differential factor prices between large and small farms, and its explanation in terms of the Sen framework, is also problematic. If indeed factor price differentials were the main explanatory mechanism at work, then we would expect to find higher capital intensities on the large farms in terms of technological innovation, both biochemical and mechanical. However, in this context the inverse relationship breaks down [*Chadha, 1978; Roy, 1981;* and *Dyer, 1991* and *1997*]. Indeed, this hypothesis would appear to be more appropriate as an explanation for the non-existence of an inverse relationship rather than its cause. Further, the supposed ability of the small farmer to exploit more marginal land (because of a lower opportunity cost of labour) is hardly conducive to higher crop yields.

The Sen framework is itself heavily flawed: the use of a single production function to compare two very different systems of farming, points to the identification problem at the heart of the Sen model. This concerns the assumption that large farms are capitalist farms, and small farms are peasant family labour-based farms. This conceptual sleight of hand obscures the real relations at work which produce the inverse relationship. Sen focuses on two different systems of production: small peasant farms and large capitalist farms. It is not obvious therefore why these two systems are located on the same production function (the same marginal product of labour curve). The model is comparing farming methods which have fundamental differences in their organization of production and qualitative differences in their division of labour [*Roy, 1979: 19*].

The assumption of labour homogeneity is not sufficient: the use of a single MPL curve requires concomitant assumptions regarding the organization of production, homogeneity of all factors of production and equal factor intensities. It must also be assumed that different farms apply identical capital inputs per acre (both in quantity and type of capital) and that land is homogeneous regarding soil quality and irrigation. A peasant farmer may be constricted to a less efficient set of production conditions including lack of access to economies of scale, lack of technical knowledge or access to particular factors, or risk aversion to using new inputs. Note too, that the alternative use of non-homothetic production functions can result in differential factor prices even with perfect factor markets.

A further set of problems arise from the proposed behavioural calculus of the farmer internal to the farm, and to the methodology of comparison of the wage rate and marginal productivity. It is inappropriate to postulate effective leisure preference among poor peasants who are very close to subsistence; the effective limits are more likely to be biological [*Sen, 1981: 207*]. Family labour allocation is determined by objective factors like involuntary unemployment and intensity of poverty which provides a reason for a wage-gap. Poverty and unemployment, rather than leisure preference, are the main reasons why small farmers intensify family labour use [*Sen, 1981: 209*].

Furthermore, the whole exercise of comparing the marginal product and wage rates is meaningless for agricultural production. The production cycle in agriculture is prolonged and varies greatly between crops. No straightforward marginal productivity rules can be applied here as the productivity of family labour inputs prior to harvest time will depend on the timely application of the necessary amount of labour during the harvesting period.[10] Labour demand at the harvesting stage is largely determined by elements of previous stages. Labour at earlier stages thus has to be seen in the nature of fixed costs. Labour demand at harvest is a derived demand dependent on conditions earlier in the production cycle.[11] Under such conditions, the meaning of the marginal product of labour in agriculture becomes extremely hazy almost to the point of becoming operationally useless [*Roy, 1979: 20-3*].

Finally, the assertions concerning the reinforcing effects of land and capital market imperfections cannot go unchallenged. Firstly, it is not necessarily the case that small plots of land have higher unit costs because of greater demand and inconvenience to landlords. The supply side may encourage small plot size as well, particularly in the context of highly fragmented agricultural land. Secondly, on the question of mechanisation, there is a great deal of evidence that associated with mechanisation is the potential for increasing land use intensity, both in terms of cropping intensity and the utilisation of the cultivable area, thus increasing output per acre on the farms employing such technology [see *Byres, 1981*].

Empirical evidence

We have seen then that neither the policy conclusions reached by the authors nor their theoretical support are firmly grounded. Let us now turn to the empirical evidence presented by Berry and Cline. The authors present two types of empirical evidence: cross-country analysis and a number of individual country case studies. In chapter three, Berry and Cline present evidence from cross-country analysis based on 1960 FAO data for 30 LDCs. This shows:

1) the large farm sector (defined as those farms operating the top 40% of cultivated area) use land less intensively than the small farm sector (farms operating the bottom 20% of area) [33, table 3-1].

2) the ratio of large farm land use to that on small farms declines as per capita land endowment increases [33, table 3-1].[12]

3) large farms make relatively poorer use of their land where land distribution is more unequal [*38*].

4) those countries with larger average farm size do not have faster growth of agricultural output [*38-9, table 3-3*].

5) agricultural growth rates are uncorrelated with concentration in land distribution [*38-9, table 3-3*].

6) output per acre and employment per acre are higher in countries with a smaller average farm size and more equal land distribution [*41-2, table 3-5*].

However, no theoretical or policy conclusions of relevance to the inverse relationship between farm size and productivity can be drawn from these cross-country comparisons at such a high level of aggregation. Relation 6 above is clearly indicative of the macro-level inverse relationship: countries with highly fertile land have higher population density and smaller average farm size as well as higher yields. This is confirmed by the higher employment per acre ratios derived from FAO figures on agricultural population densities (in the same table) and by relation 2 above.

Relations 1-3 are quite meaningless as it is unclear what is being compared. The top 40% of farm area will include many medium sized farms as well as large capitalist and peasant farms. Large areas of farms designated as large may simply be uncultivable land. Land quality clearly needs to be considered here so that like is being compared with like. The authors themselves make the point that "Few studies have attempted to disaggregate in such a way as to allow for land quality differences, so the data do not permit strong conclusions at this point" [*225, note 21*]. In the Latin American context, as farm size increases, land is predominantly livestock pasture, but the authors fail to state whether such land is cultivable as arable land [*14*].

Let us turn now to the individual country case studies presented by the authors which may be able to provide a greater degree of disaggregation and therefore meaningfulness. The first case study presented is based on Cline's [*1970*] work which covers 8,000 farms in seven agricultural states in north-east Brazil.[13]

Brazil

Cline's earlier work found [*44-5*]: 1) constant returns to scale across farm size, 2) an inverse relation between land use and farm size, and 3) an inverse relationship between labour intensity and farm size. He then compares these findings with the data from a later 1973 study. The latter reveals a clear inverse relationship in all product sectors, with the significant exception of the rich cocoa plantation area (Bahia) which shows a positive relation [*46-7, table 4-1*]. Regression exercises reveal a significant inverse relation even when accounting for land quality (land price is used as a proxy) and where zonal dummies are included [*49, table 4-2*]. Note however, that the coefficients on the zonal dummies are not reported, and therefore there is no indication of their significance.

Note too, that these findings are derived from grouped average data by size class with no indication of group variances. The data cover very large areas, sometimes whole states and may thus merely indicate the macro-level inverse relationship. The regressions were performed on the pooled grouped data with zonal dummies. At this high level of aggregation therefore, one would expect to find such an inverse relationship.

With regard to returns to scale, a study by Scandizzo and Barbosa [*1977*] find that for north-east Brazil, the cotton and cocoa product sectors are characterised by increasing returns to scale (there is also some indication of this for the rice and sugarcane sectors).

Cline then analyses farm-level, product-specific data (again using pooled data for the whole of north-east Brazil [*50, table 4-3*]. All six product sectors show an inverse relationship, but the coefficient for the cocoa sector is not statistically significant.[14] Note that again the zonal dummy coefficients are left unreported. Note too that the method of categorisation of farms is conducive to a great deal of distortion: a farm observation is located in the livestock sector if 50% of total output is derived from livestock activities.

There are major problems too concerning the data used. The productivity measure uses value added which possibly includes a bias against the large farms which have higher capital-output ratios. Regressions of value added per unit land value against land value (again using pooled farm level data and no regional dummies) also show an inverse relationship for all product sectors [*52, table 4-4*]. However, if output and land value (as a proxy for soil quality) are correlated then the regression results will be biased. The value of land may simply reflect output expectations.

The only comparison between the 1962 data and that for 1973 is for Pernambuco sugar and Ceara livestock, but as we have seen above, neither the sugar nor the livestock sectors are typical sectors from which to draw conclusions regarding an inverse relationship. Thus, there is no really strong support for a generalised inverse relationship on the basis of this data, and certainly none for the hypothesis of factor market imperfections as the main explanatory factor. Exercises testing total social factor productivity using shadow prices for labour (zero, half minimum wage and minimum wage) actually show fairly inconclusive and disappointing results from the authors' viewpoint [*56-7, table 4-7*].

Colombia

The second case study presented is based on work by Berry [*1973*] using the 1960 Colombian agricultural census and 1966 yield data. Large farms have lower labour input intensity, a lower share of land cropped and lower cropping intensity. Large farm (more than 500 hectares) yields in value-added terms are only 15% those on the small farms (2-5 hectares), or after normalisation for land value, 45% as high [*59, table 4-8*].[15] The main factor appears to be land-use intensity: land-use on the smallest farms is 87%, compared with only 6% on the large farms [*61, table4-9*].

Berry writes that the inverse relationship thus arises from greater land use on the small farms: "The obvious hypotheses are those discussed in Chapter 2. The land, labour, and capital markets all are imperfect, with the ultimate result that the opportunity costs of land and capital are higher on small farms, while that of labour is lower...Most of the differences in factor proportions are probably explained by factor price differentials"[*60*].

However, whether an inverse relationship exists or not depends on whether fallow land is included in the calculations: with fallow, large farm yields fall by 15%; with fallow land excluded, large farm yields rise by 60% because yields for many crops increase with farm size. An index of value per hectare cropped shows large farm yields some 60 per cent higher than the small farms [*61, table 4-9, column 1*]. Small farm neglect of fallow may not be optimal in the dynamic sense, leading to environmental degradation through land overuse; fallow may in the long run be optimal and therefore socially more efficient. Berry's table 4-11 [*63*] reports a higher proportion of small farms using more fertiliser, but the data says nothing about rates of application nor differing needs for fertiliser for different agricultural activities. Note that all the figures reported assume a fixed crop pattern across all size groups, whereas large farms are biased towards extensive cattle ranches.

Berry notes that although there is an inverse relationship on the basis of the 1960 data, this pattern has been modified since, although he is not clear as to direction or magnitude [*58*]. He writes that over the 1960s, an expansion in new technology, including greater use of machinery on large farms, has taken place with overall real value added per hectare increasing at 2.4% per annum [*64*]. Indeed, the 1970 agricultural census shows large farms (more than 50 ha) increasing land use intensity and small farms (less than 5 ha) decreasing land use intensity, along with a shift to crop cultivation on the part of large farms [*66, table 4-14*].

Berry cites the later evidence of a study of 3,000 farms[16] which appears to show an even stronger inverse relationship than before (yields per hectare drop tenfold between 5-10 ha and 50-100 ha farms) [*67, table 4-15*]. However, this data is an unrepresentative sample: the small farms were selected from an elite with access to credit, while the large farms were selected from colonization areas with untypically low productivity. Thus Berry is forced to admit that "the [INCORA] sample cannot be of much assistance in an attempt to judge whether size/productivity differentials changed significantly during the 1960s" [*68*]. Indeed, the same data disaggregated for crop farms alone and for livestock farms alone, shows no clear trend in land productivity over farm size (over the range from 5-100 hectares). Further, many high income farms are small farms and many low income farms are large farms [*218, table D-4*].

Philippines

The third case study is on Philippine agriculture, based on the Census of the Philippines, Agriculture, 1960. The authors present aggregate grouped estimates showing an inverse relationship: large farm (above 50 hectares) crop yields are some 32-45% below those on small farms (1-3 ha), and livestock output per hectare on the large farms only 22-39% that on the small farms [*70-1, tables 4-18* and *4-19*]. These results however, are subject to many of the deficiencies remarked on above. Many of the productivity estimates are based on crop areas rather than output figures, and the livestock figures are based on stock not current output. The regression results are based on grouped value added data and are thus not good confirmation of an inverse relationship at the micro level [*72*]. Again, a comparability problem exists in that large farms have a higher proportion of idle, pasture and forested land than the small farms.[17]

The authors also cite a 1966 study by Ruttan [*1966*] for Bulacan province in which farms are classed by size, tenurial form (share tenants/owners) and land quality (irrigated/non-irrigated; and upland/lowland). Ruttan concludes that yields per hectare bear no systematic relation to size, although they tend to be lower on the large farms above 10 hectares. Note that labour input intensities are estimated on the basis of the distribution of farm population by farm size, thus picking up the macro-level inverse relationship. This is also indicated by the 1960 data which shows the average value per hectare of farm land higher for provinces with lower average farm size [*74*].

A 1955 University of Philippines survey showed that the value per hectare of tenanted land was higher than owner cultivated land.[18] This may reflect the disproportionate share of share tenants in rich rice areas, again indicating the macro-level inverse relationship [*77*]. Ruttan also found higher yields on sharecropped rice farms, but there are serious problems with the data used in testing the productivity hypotheses: regions with good soil/climate and locational characteristics were atypical in farm size and tenure structure [*76*].

Ruttan [*1964: 104-5*], in a penetrating insight, writes: "In situations characterized by static technology, static standards and levels of living, and low literacy and income levels, both total agricultural output and total marketable surplus can be maximized by a tenure system which forces the cultivator to produce beyond the level which satisfies his family consumption requirement. In this situation, share tenancy does not limit output but rather forces agricultural output above the level that would be achieved under a system of owner-partnership." It is unfortunate that this line of reasoning is not pursued.

West Pakistan

The fourth case study is on 1960s West Pakistan as analyzed by Berry.[19] He presents evidence showing a strong inverse relationship with respect to land productivity and labour input intensity. However, the first estimate is based on the assumption of constant physical crop yields across farm size, and the second estimate on "scanty evidence" of yield differentials, showing that large farm (50-150 acres) yields are only 45% of those on the small farms (1-2.5 acres) [*81, table 4-26*]. Further evidence distinguishes between irrigated and barani regions, finding a significant inverse relation in both areas [*82, table 4-28*].[20] However, this finding is based on a very small sample of only 53 farms with none less than 7.5 acres. When region and tenurial status are taken into account, the relation is less significant.

The Pakistani evidence cited by Berry again reveals all the problems associated with highly aggregated and grouped data, in particular the confusion with the macro-level inverse relationship. Berry admits: "much of the negative relationship observed in [the Agricultural Census and FAFBS data] is due to large farms being found predominantly in low productivity zones, where the low productivity is mainly the result of lack of water" [*58*]. And again: "much of this inverse relationship must be attributed to a poorer soil-water combination on the larger farms" [*80*]. Large farms have poorer fodder land, while small farmers have access to common grazing land [*232, note 40*].

The census data further shows that the physical yields of sugarcane and wheat are higher on the large farms, and thus the composition of output was a highly significant factor, with those farms above 50 acres specializing in low value products [*86*]. Such differences in crop composition by size results from aggregation over regions with different crop patterns. Regional dummies will compensate for this bias only to some extent - the macro-level inverse relationship will still be present at this aggregate level. With such aggregative data, the authors' explanations based on imperfect factor markets cannot be tested.

While the 1960 census data also shows an inverse relationship between size and fertiliser application (both organic manure and chemical), there has been a massive increase in its use over the decade and especially by the large farms. This would appear to be a significant factor in the breakdown of the inverse relationship as revealed by the 1972 census [*93, table 4-34*]. However, Berry claims this may be only a temporary phenomenon. He cites Azam [*1973*] who states that water and credit are the major constraints to small farm adoption of new technology, but not enough to have reversed the inverse relationship [*95-6*].[21]

However a later study by Khan [*1975*], based on a 1972-3 survey of five districts in Punjab and four in Sind confirms the weakening of the inverse relationship, and indicates a growing gap between large and small farms in the use of modern inputs. In most regions characterised as Green Revolution areas, Khan finds a positive relation between the value of output of 5 major crops (wheat, rice, maize, cotton, and sugarcane constituting 79% of the sown area in Punjab and 77% in Sind) per cropped acre and size.[22] Of the 9 regions, 6 are characterised as being progressive, and there, large farm (above 50 acres) yields are 18% higher than those of the small farms (below 12.5acres) [*Khan, 1975: 54*].

A comparison of the agricultural censuses of 1960 and 1972 shows increasing cropping intensity on all sizes, but with the greatest increase on the large farms over 150 acres, where land use intensity more than doubled [*102, table 4-38*]. The censuses also show increased renting in of land by the large farms (their share of this category of land increased from 22.5% to 33.6% while the overall share of rented land showed a moderate decline) [*105*]. Khan also finds higher application per cropped area of fertiliser on the large farms and a significant large farm lead in the adoption of new varieties [*101*]. This process appears to be similar to that found in the Indian context, with an irreversible breakdown of the inverse relationship in Green Revolution areas.

Malaysia

The fifth case study is based on a survey of 762 double-cropping rice farms in the Muda River area of Malaysia in 1972-3. The authors use aggregate grouped data, but the area is characterised as a rice mono-cropping region, with well-functioning markets [*116*]. The evidence seems to present a strong inverse relationship in terms of value added per relong,[23] value added per unit land value, and value of farm output per relong. Value added falls by two-thirds between the large farms over 10.5 relong and the small farms below 1.5 relong. The inverse relation is still present but weaker if the smallest size-class is excluded, with small farms below 5 relong having average land productivity 32% higher than large farms over 5 relong [*117, table 4-48*].

Small farm (1.5-3.5 relong) total factor productivity is 50% higher than on the large farms (above 10.5 relong), but this is based on imputed labour costs for family labour and estimated average rates of return on land and capital [*121*]. Berry and Cline find labour productivity (based on an index of labour shadow prices) approximately constant across farm size, but this conflicts with their finding that labour input per acre declines with farm size. Barnum and Squire find labour productivity some 10% higher on farms above 5 relong [*234, notes 65 and 66*].[24]

Barnum and Squire [*1976*], working on the same survey area, but with a smaller sample of 386 farms find only a statistically insignificant difference in rice output per relong between small farms (less than 5 relong) and large farms (above 5 relong). This conflicting result possibly arises from the inclusion in the Berry and Cline data of non-padi crops, their use of farm area at the beginning of the agricultural year and not the average over the year (this produces overestimation of small farm land productivity by 8.5%). Barnum and Squire also exclude some farms with acid soils [*233-4, note 64*].

Berry and Cline make almost casual reference to the fact that yields vary little beyond the 1.5 relong size class [*121*]. They also note that when farms are classed by economic scale in terms of value of land rather than by size, the inverse relationship is much weaker (with large farms only 10% below average land productivity) and when farm output per relong is regressed on the value of land plus capital, there is no clear inverse relationship evidenced [*123-4*].[25] While fertiliser and pesticide use per relong are constant across farm size classes, machinery running costs are 65% higher on the large farms [*121*], indicating significant differences in the organisation of farm production between different size classes.

India

The major case study in Berry and Cline is given some prominence in an appendix of its own [*141-193, Appendix A*]. This is a study of farm size, productivity, and technical change in Indian agriculture by Surjit S. Bhalla using data from a National Council of Applied Economic Research (NCAER) panel survey for three years: 1968-9, 1969-70, and 1970-1. The sample includes 4,118 farms from all over India of which 1,772 are used by Bhalla. Bhalla's principal aim is to show that the inverse relationship is still strongly evidenced in India despite the Green Revolution. He refers to the expectations that the Green Revolution will have weakened somewhat the "traditional 'advantage'" of the small farmer because of better education, easier access to inputs and less risk aversion on the part of the large farmer [*236, note 1*]. This barely skims the surface of the large farm advantage in relation to modern inputs.

The main results and conclusions presented by Bhalla can be presented in summary form [*111-116*]:

1) the inverse relationship between farm size and output per acre is confirmed empirically with a highly significant negative coefficient on the log of farm size [*112, table 4-44, equation (i)*].

2) the inverse relationship holds even when land quality (proxied by average village land prices) and the irrigation factor are accounted for [*112, table 4-44, equations (iii) and (iv)*].

3) Bhalla confirms the inverse relationship at the aggregate level for individual crops, but note that the regressions assume no relation between farm size and crop mix - further, maize, jowar and sugarcane crop coefficients are not statistically significant [*155, table A-3*].

4) total social factor productivity (computed by using shadow wage rates) declines with farm size [*174, table A-13b*].

5) for the range of large farms above 30 acres, the inverse relationship is not statistically significant "suggesting that in India the dominant influence on the overall size-productivity relationship is labour-market dualism" [*114*].

6) land rental prices and interest rates on borrowed capital are higher for the small farms which leads to differing factor intensity patterns.[26]

7) labour input intensity declines and capital/labour ratios increase with farm size. Cropping intensity declines with size [*149, table A-1 and 171, table A-12*].

8) the inverse relationship persists in the third year although somewhat attenuated [*112, table 4-44, equations (i) and (ii)*]. In other words, the Green Revolution has weakened the size/productivity pattern, but not reversed it. The data show that the proportion of cultivated area under HYVs is relatively constant across farm size which would apparently indicate that the small farms are not lagging in the adoption of new technology [*179, table A-16*].

Bhalla makes the astonishing claim that "A unique feature of this study is that it analyzes data for all of India" [*142*]. Bhalla proudly announces that the regression exercises include "farms from all of India, with differing quality of land and growing different crops" [*146*]. He complains that previous studies are too disaggregated at the village or district level and too many have been carried out in Green Revolution areas. The "dispersion in time, space, and methodology of these studies makes them unreliable for extrapolation to conditions prevailing in agriculture in general...Thus, since local factors can be expected to average out, the general pattern can be observed by analysis of the NCAER data" [*141-2*]. Bhalla does not seem to realise that this is precisely the problem with highly aggregated data. It is precisely the problems associated with aggregation and averaging at the general level that need to be avoided. The tables present highly grouped data: only four size-classes (0-5, 5-15, 15-25, and above 25 acres), with small farms defined as those below 15 acres [*143*]. These are very wide size classes indeed, but nothing is said about category content or in-group variance.

Besides this major defect of the Bhalla study, there are a number of other deficiencies in the way the data has been handled. All farm households that invested in land in any of the three years were excluded in the final analysis. This presents the danger of excluding those progressive farmers accumulating land for expanding production. Further, farms with a gross cultivated area of less than

0.05 acre were omitted. This cut-off point is significantly above the NCAER definition of 0.01 acre for a small plot. The inclusion of these farms might have reduced small farm average productivity, especially in Green Revolution areas. Any farm which had land leased out in the third year was omitted. Again, these may have been largely composed of low productivity small farms. Finally, an upper bound of Rs 3,000 was placed on income per acre (which may exclude some rich capitalist farms with high yields) and a lower bound of zero Rupees eliminated dissavers from the analysis (as Sen [*1962*] has shown, the marginal and poor peasant households with very low yields). All these measures cut the sample from 4,118 to 1,772 [*188-9, Annex A.1*].

Bhalla posits that differential yields per acre between farm size classes are due to either a) differing technical/economic efficiency, or b) different factor prices facing small farmers and large farmers. Since both small farmers and large farmers are asserted to be equally rational, Bhalla reasons that (b) must be the main explanatory factor behind the inverse relationship [*156*]. Note however, that Bhalla (and others) assume homogeneous production functions, but if non-homothetic functions are used, differences in factor ratios will result even with perfect factor markets.

Bhalla continues: land markets will be rendered imperfect by 1) institutional factors such as tenancy regulations, 2) credit financed land purchase, and 3) lower transaction costs for large plots of land [*157*]. The observed relation between rental/acre and farm size, it is claimed, provides partial support for the contention that large farmers face lower land prices, but note that rental price may reflect tenancy arrangements - this effect needs to be removed before testing. However, the NCAER data does not provide tenancy information. Nevertheless, this does not stop Bhalla from trying [*175*]: tests of tenancy effects on productivity show no relation, supposedly reinforcing Cheung's conclusions concerning share tenancy, but note that Bhalla has defined tenancy in terms of area leased in, thus creating conceptual confusion between the different motivation and results on large and small farms.

Although the finding that labour input intensity declines with increasing farm size appears fairly robust, it does not constitute firm evidence for the thesis that the inverse relationship is caused by differential factor prices, in particular, labour market dualism. Bhalla's own data shows that 52% of small farm income is derived from off-farm employment, and some 83% of small farms use some hired labour [*165, table A9*]. The various *a priori* arguments associated with the labour market dualism thesis are however untestable, as the NCAER data that Bhalla is using provides neither information on the ratio of hired to family labour inputs nor disaggregated data on wage rates. Again, this deficiency does not prevent the author from proceeding to test this thesis. However, the way in which Bhalla has manufactured the data on farm labour input, detailed in Annex A2 [*189-93*], would tend to cast doubt on the validity of Bhalla's interpretation of the results obtained from the production function analysis.

Total farm labour input L* is computed as the sum of hired labour L1 and family labour L2. L1 is computed as H/w where H is total paid out wage costs and w is an average wage estimate. Bhalla uses average district-level wage data (and sometimes even average state-level wage data).[27] Note here that if wage rates in sparsely populated areas are higher than in densely populated areas, and the former areas have larger average farm size, then this will introduce a downward bias into large farm hired labour estimates.

L2 is defined as the sum of farm earner labour input M1 and family worker labour input M2. M1 is computed as (M-e/w)E where M is full employment (300 days), e is off-farm earnings, w is the wage rate, and E is the number of earners. Now, imputation of a constant number of work days for all farms (300) overestimates small farm on-farm employment, so Bhalla uses Punjabi data[28] to correct for this: M1 = (288.3 + 0.596 (farm size) - e/w)E, as total employment is held to increase with farm size. Note that this procedure will underestimate on-farm labour input by members who earn higher than average wages, and if there is a relation between large farms and higher off-farm wages then this adds a further downward bias to large farm labour input intensity. Further, it is questionable to assume that the

Punjabi figures are representative of other parts of India. The Punjab is a major Green Revolution area with possibly much higher levels of on-farm employment (due to HYV cultivation) thus biasing upwards the small farm employment level to 288 days for all India.

M2 is computed as (FW x cultivated area x 10 days per acre) where FW is the number of family workers. The 10 days per acre is derived from the full employment level of 300 days divided by the average size of large farm (30.6 acres), assuming that family workers work at the same rate regardless of farm size. Although Bhalla claims that: "This construction of M2 automatically imputes less total work to family workers on small farms than on large farms" [*193*], it may nevertheless overestimate small farm levels of family worker employment by assuming that full employment levels of labour input intensity on the large farms are applicable to small farms. There may be some indication of this in Bhalla's omission of 63 small farms from the analysis whose L2 estimate came to an average of 555 days. The fact that Bhalla's average L* of 82 days per acre falls well within the range of other estimates in the literature [*170*] is irrelevant, as one is not interested so much in the average level of labour intensity, but in its trend over farm size. Given the synthetic nature of the labour input data, the results of the production function analysis have to be treated very tentatively.

Clearly, the NCAER data is a very weak basis for proving that higher labour input intensity on the small farms as compared to the large farms is the main explanatory factor behind the inverse relationship. Even though labour input intensity may be a crucial factor behind the inverse relationship at the micro level, such a relationship between labour intensity and size at the aggregative macro level may hold for spurious reasons. It certainly does not establish the validity of the Bhalla thesis that the inverse relationship is caused by factor price differentials, and in particular, labour market dualism.

Bhalla presents evidence to show that interest rates on borrowed capital decline with farm size [*160, table A-5 and 164, table A-8b*]. While the commercial banks did lend to the non-HYV sector, mostly to the large farms, institutional lending sources are biased toward HYV growers. Small farmers pay higher interest rates than the large farmers, and HYV cultivation "improves access to credit and diminishes the cost of credit", and there is less variation in the cost of credit for HYV growers [*161*].

The "imperfect market" framework however, is hardly adequate for explaining the deep structural problems associated with rural credit markets in developing countries [see *Bhaduri, 1973*]. Nevertheless, the observation that large and small farmers face different costs of borrowing capital is not an imperfect market phenomenon which can be used to explain the existence of an inverse relationship between farm size and land productivity. Rather, it is one of the important factors behind the breakdown of the inverse relationship. Relatively cheaper capital directed to those progressive farms who are adopting the new technology, both biochemical and mechanical, permits increased cropping intensity and land productivity on the large farms.

Bhalla concludes: "The data used were for the 1970-71 agricultural year - a year some six years after the introduction of the high-yielding varieties. The Green revolution has, therefore, not qualitatively affected the inverse relationship" [*172*]. However the validity of this conclusion is clearly suspect at this aggregate all-India level. Bhalla finds that the inverse relationship still holds for the Green Revolution states for Tamil Nadu rice and Punjab/Haryana wheat on the basis of the NCAER aggregate data [*176*]. Of course, the more carefully disaggregated and detailed studies by Chadha [*1978*] and Roy [*1981*] have superseded Bhalla's findings, but even the latter reveals a significant weakening of the inverse relationship over time with the coefficient on the area variable declining by some 34% over the three years 1968-71 [*177, table A-15*]. Indeed, Bhalla's data shows that while small farm earnings increased by only 9% over the period, large farm earnings increased by 42%, significantly reducing any gap in productivity. This is clearly related to the finding that large farms increased their area under HYV cultivation by 63%, significantly more than the increase of 13% on the small farms [*179, table A-16*].

Summary and conclusions

The authors provide some further tentative evidence from a number of other case studies [*194-203, Appendix B*], but these are subject to many of the criticisms noted above, in particular, their highly aggregated nature.[29] The aggregate nature of most of the empirical evidence leads to an inevitable confusion between the macro and micro level inverse relationships which are of entirely different import. This applies particularly to the cross-country data, but also to most of the individual country case studies. Certainly, such data are an inadequate basis for testing the hypotheses concerning market imperfections.

The theoretical framework chosen by the authors, that of differential factor prices and imperfect markets, is both logically flawed and not supported by the evidence. Further, where it does have some validity, however inadequate, it actually undermines its own purpose. The so-called market imperfections adduced, would seem more appropriate to explaining why the inverse relationship might be expected to disappear in the long-run rather than explaining the existence of an inverse relationship. Indeed, some of the more careful analyses, such as that for Pakistan, does indicate some of these problems quite clearly, and also points to the breakdown of the inverse relationship in the dynamic context.

The authors' policy conclusion of an equalising distribution of land towards the small farm sector, is both crude and simplistic, and requires a number of unrealistic assumptions to hold. They are further rendered baseless by inadequate theoretical and empirical support. The authors would have benefited from greater familiarity with the Indian debate.

Notes:

[1] The Indian debate on the inverse relationship has been by far the most extensive. It began in the pages of the Economic Weekly (later Economic and Political Weekly) with Amartya Sen's 1962 article. It continued over the years with Mazumdar 1963, Sen 1964, Agarwala 1964, Khusro 1964, Mazumdar 1965, Paglin 1965, A.P. Rao 1967, C.H.H. Rao 1966 and 1968, Rudra 1968a and 1968b, C.H.H. Rao 1972, Bhattacharya and Saini 1972, Patnaik 1972, Rudra 1973, Bharadwaj 1974a, Chandra 1974, Chattopadhyay and Rudra 1976 and 1977, Chadha 1978, Rudra and Sen 1980. Other major contributions are Sen 1966, Bhagwati and Chakravarty 1969, Saini 1971, Bharadwaj 1974b, Saini 1979, Roy 1981, Carter 1984, Patnaik 1987, Bhalla 1988, Bhalla and Roy 1988. A reprise of the debate took place in the pages of the Economic and Political Weekly with Chattopadhyay and Sengupta 1997 and Dyer 1998.

[2] This paper constitutes the first draft of chapter 10 of a forthcoming work being written jointly by myself and Terry Byres: The Logic of Peasant Economy.

3. See Berry [*1973*] and Cline [*1970*].

4. All subsequent page references in this chapter refer to Berry & Cline [*1979*], unless otherwise indicated.

5. In determining the number of family parcels it is assumed that each family has 2.5 workers [*1979: 130*]. Land available is defined as total farm area in the 1960 FAO World Census of Agriculture.

6. See Dharm Narain [*1961*] in the context of the effects of rising farmgate prices on peasant supply response, where peasants market a "distress surplus", rather than a true commercial surplus. Poor peasants market a relatively high proportion of their output in order to pay off various cash obligations (debt, rent, taxes). This leaves them with insufficient foodgrain for the rest of the agricultural cycle, and they are thus forced into market purchases later.

7. See Cline [*1973*] and Bhalla [*1975*] using NCAER data.

8. See Sund [*1965*].

[9] See Sen [1962].

10. See Roy [*1979: 21*]: at the final harvesting stage, the constraint on labour-hiring is NOT the MPL = w criterion, but whether these fixed costs can be covered. This means that not only will labour continue to be hired when the MPL is less than the wage rate, but also even when the wage rate is greater than the APL. The only limit to labour-hiring occurs when the gross revenue from a day's harvest is less than the cost of a day's harvesting.

11. See Roy [*1979: 22*]. The physical yield of a crop is already determined (plants per acre times yield per plant), and therefore the number of labour-hours required to harvest the crop is also predetermined (for any given technology). Whereas with Sen, higher labour input causes higher yield, there is in fact a reversal of causation: higher yields produce a greater demand for labour.

12. The authors qualify this by stating that the data measure omits multicropping (important in Asia) and extensive grazing (important in Latin America) and so the decline will be much less than indicated.

13. Cline's data comprises a 1962-3 sample survey for seven Brazilian states conducted by the Getulio Vargas Foundation,

and a second survey by GVF on sugar farms. There is also a 1973 survey by the IBRD and SUDENE (Superintendencia para o Desenvolvimento do Nordeste) of 8,000 farms in north-east Brazil.

14. Berry and Cline claim all 6 are significant [*1979: 50*].

15. The effective hectares used in the calculations are defined as hectares divided by the ratio of land price on farms in-group relative to overall average land price (i.e. highly aggregated and grouped data).

16. A study carried out by the Instituto Nacional de Colonizacion y Reforma Agraria (INCORA) of 3,000 farms, analyzed by USAID 1969.

17. As might be expected, the physical yields of individual crops either show no relation across farm size or insignificant differences [*73, table 4-20*]. Sugarcane and corn yields are higher on the large farms. Small farm rice yields (less than 0.2 ha) are not robust due to large rounding errors [*230, note 18*].

18. Citing Estanislao [*1965: 120*] in turn citing Horst et al. [*1957*].

19. Berry analyzes the 1959-60 Census of Agriculture in *'Some evidence on the economic potential of small farms in Pakistan'*, mimeo, 1976.

20. Source: Punjab Farm Accounts and Family Budget Surveys (FAFBS) 1966-67 and 1968-69.

21. According to Berry and Cline, the inverse relationship will be re-established once small farmers adopt the new technology, when technological improvement slows down, and as inputs become more evenly distributed. However, they admit that the indivisibilities associated with tubewells and mechanized cultivation may prevent this. Tractors make marginal and previously uncultivated land cultivable and machines allow a move away from labour intensive techniques of production [*105*].

22. Note however that Khan uses gross cropped area in his computations, and thus introduces a bias against finding an inverse relationship.

23. one relong = 0.7 acre.

24. The authors are somewhat confused on the topic of labour input intensity. They write: "the ratio of labour inputs/area in padi does not vary dramatically by size, being only 20 to 25 percent lower in the largest-farm category than in the smallest-farm categories" [*121*].

25. Land value increases with size, while there appears to be an inverse relationship between capital and size in the range up to 20 relong [*117-8, table 4-48*].

26. Regressing rental per acre (R) on farm area (A), price of unirrigated land (P), and percentage of area irrigated (I), Bhalla finds the following results:

$$R = 203 - 4.9\,A + 0.027\,P + 0.46\,I$$
$$(5.2)\ (1.9)\quad (1.98)\quad (0.76)$$

$$R^2 = 0.19$$

(source: Bhalla in *Berry and Cline, 1979: 113, table 4-45, equation (i)*).

The cost of borrowed capital across farm size shows the following trend:

farm size	rate
< 5 acres	17.3
5-15	13.8
15-25	12.2

> 25	11.8

(source: Bhalla in *Berry and Cline, 1979: 115, table 4-46*). See also Table 49 in Appendix A.

27. From unpublished data for 1969-70 (Mark Rosenstein at Yale). Note that the Bhalla study is for 1970-71 so he uses the growth rate for wages in Jose [1974].

28. D.P. Chaudhri, *Factors affecting productivity on different size class of farm holdings in India*, unpublished manuscript, 1974.

29. B1: Taiwanese evidence shows a strong inverse relationship with small farm productivity below 0.5 ha., twice that of the large farms above 2 ha [Source: Joint Commission on Rural Reconstruction in China, Taiwan Agricultural Statistics, 1901-1965, Economic Digest Series no. 8, Taipei, Taiwan, 1966 pp. 219-29]. However, this is based on highly aggregated and grouped data using farm income per hectare, where farm income equals farm receipts minus farm expenses. It is not clear whether family labour costs have been imputed.

B2: Bachman and Christensen [1967: 247] report data from the Japan Farm Household Survey in 1960 showing that while individual crop yields are somewhat higher on the larger farms, the multiple-cropping ratio is larger for small farms, indicating that cropped land is used more intensively on the smaller units. Total receipts per unit of cultivated area are slightly less on farms with more than 2 cho (about 5 acres) than on smaller farms. Small farms use much more labour per acre than do larger farms. However, there is some evidence that with economic development and the greater use of capital the larger farms are becoming more intensive. Ogura [*1973*] shows that while rice yields are higher on the larger farms, the reverse was true during the 1930s, apparently reflecting the influence on yields of fertilisers, pesticides, and other purchased inputs that are used in somewhat larger amounts on the larger farms. Kaneda [*1967*] notes that by the 1950s, value added per tan (1 tan = 0.1 ha or 0.245 acre) does not vary across farm size.

B3: Mexican data provides evidence for a strong inverse relationship [Eckstein et al., 1978: 9, Appendix C], but this is based on very broad size categories (undefined by Berry and Cline) at the aggregate level. Note too that comparison of 1960 with 1940 data shows a considerable weakening of the relationship, as well as important differences in output composition between large farms, small farms and ejidos. Output per peso of capital plus land was higher on the large farms in 1960 due to the shift from livestock to crops and strong government support with credit and infrastructural investment.

B4: Kenyan large farms in Trans-Nzoia District 1970-1 have a lower share of area under crops and lower output and employment per acre [*source: Ministry of Finance and Planning, Statistics Division, An Economic Survey of African-owned farms in Trans-Nzoia 1970-1, Farm Economic Survey Report no.28, 1972*]. Note however that this is compared to farms less than 250 acres, which implies rather large size classes. There are also some exceptions between 1,000 and 1,250 acres. The Report notes that a number of large farmers lack adequate capital, thus suggesting the existence of an identification problem in the data.

B5: The Kenyan settlement schemes 1967-8 show gross output (shillings) per acre falling from 635 on farms below 10 acres to 111 on farms above 70 acres [source: *Ministry of Finance and Planning Statistics Division, An Economic Appraisal of the Settlement Schemes 1964/5-1967/8, Farm Economic Survey Report no.27, 1971*].

B6: Malawi data shows increasing gross and net output per acre in densely-populated Malawi [*source: National Statistical Office, Malawi Government, National Sample Survey of Agriculture, 1968-9, Zomba province, 1970, p.42*]. Berry and Cline resort to deducting home consumption from output to get value added estimates (the consumption rates are arbitrary with large farm rates being three times small farm rates), and then conclude that "total output per acre is a decreasing function of size of holding" [*202*].

Other countries which show an inverse relationship include:
Argentina, Chile, and Guatemala [*source: Comite Interamericano de Desarrollo Agricola, Monografias Sobre Algunos Aspectos de la Tenencia de la Tierra y el Desarrollo Rural en America Latina, Organizacion de los Estados Americanos, Washington, 1970, p.34*]; pre-revolutionary China [*source: John Lossing Buck, Land Utilization in China (New York: Paragon Book Reprint Corp 1968) and Buck, Chinese Farm Economics (Chicago: University of Chicago Press 1930)*]. Note that in fact, Buck dismisses the presence of an inverse relationship in Chinese agriculture as a statistical artefact; and Korea [*source: Bank of Korea, Research Department, Economic Statistics Year Book, 1960, p.278*] all at the aggregate level.