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Productivity by Farm Size and Food Security

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Uma Lele

Abstract

For decades, the narrative of small farms being more productive than large farms has dominated assistance strategies of international organizations. By using emerging evidence, this paper concludes that the story is more complicated, and that outcomes vary not only by continent, but within continents by individual countries, depending on public policy.

Productivity by Farm Size and Food Security

Uma Lele¹

Issues of productivity by farm size and their implications for future food security have come to the forefront once again from a strategic perspective. International organizations, such as the Food and Agriculture Organization of the United Nations (FAO), the World Bank, CGIAR, and the International Fund for Agricultural Development (IFAD) have consistently supported small farm development, for well over half a century, as the only way to address issues of food security and nutrition and facilitate structural transformation from agriculture to manufacturing. And this support has stood on the foundation of literature that suggested small farms are more productive than large farms.

The smallholder-based strategy was promoted, notably, in the writings of Johnston and Mellor (1961), who argued that, at early stages of development, a large share of the population makes a living from agriculture, and smallholders are the major source of labor supply, so that savings and investment, government revenues, effective demand for agricultural inputs and consumer goods, increase with the rise in smallholder incomes. Hence, small farm development is a major source of growth linkages between the agriculture and nonagricultural sectors.

However, in recent years, there are growing questions about the effectiveness of the smallholder strategy. Some economists have argued that governments, particularly in Africa, should support

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medium-sized and large farms as the only way to achieve food security and accelerate structural transformation. Urbanization provides additional strength to the arguments of those in favor of large- and medium-scale agriculture to meet the rapidly growing urban demand but also raises the question: who will feed the growing population, particularly in rural areas if large farm strategies do not create much income and employment for small and marginal farms?

Against this background, it is important to look at the evidence on the current role of small, medium, and large farms. Among the various estimates of farm structure, FAO estimates are, by far, the most comprehensive and documented. They suggest that more than 570 million farms in the world produce food and agricultural products and manage agroforestry and animals on rangelands. Of these, more than 500 million are “family farms,” defined as using mostly family labor and producing 80 percent of the world’s food production. Family farms are likely responsible for most of the world’s food and agricultural production.

Furthermore, according to FAO, small farms (below 2 ha)—not to be confused with family farms—operate on only about 12 percent of the world’s land. According to FAO, these small farms produce a large share of the world’s food (Graeub et al. 2016; Lowder, Scoet, and Raney 2016). Furthermore, small farms in individual countries tend to have higher yields per hectare than larger farms. The share of food produced by family farms is likely to be larger than 80 percent, although the exact share cannot be quantified (FAO (2014, 9, Footnote #13).

More than 475 million small farms of less than 2 hectares are in Asia and Africa (Lowder, Scoet, and Raney 2016, 24). Land consolidation, together with a slight increase in average farm sizes

for a small sample of low-income and middle-income countries, suggests that the average farm size has begun to increase, “for many low- and low-middle- income countries, however, average farm sizes are likely to continue to diminish for some time still” (Lowder, Skoet, and Raney 2016, 27). Evidence varies from country to country, and to complicate matters further, there is also evidence of both increase and decline in farm size in the same countries, suggesting growing dualism. Hence, the first challenge is to know with certainty what is happening to farm size.

The second issue relates to productivity by farm size. Doubts about smallholder agriculture were perhaps first raised in the writings of Collier, Dercon, and Gollin (Collier and Dercon 2014). They questioned how agricultural production and labor productivity in agriculture can be increased massively in Africa, while requiring a vast reduction in the proportion of the population engaged in agriculture and a large move out of rural areas, all with a continuing commitment to smallholder agriculture, as the main route for growth in African agriculture and for poverty reduction. The lack of productive employment elsewhere in the economies makes one wonder about the alternatives to agriculturally led growth. Collier, Dercon, and Gollin also questioned the evidence base for an exclusive focus on smallholders (for example, a long-standing assertion in the literature that small farms are more productive than large farms in terms of output per unit of land—which they argued, overlooks diseconomies of scale in marketing and processing of agriculture and the high cost of transportation incurred in transferring produce from remote rural areas to feed coastal populations. Further, they questioned the cost effectiveness of developing agriculture, compared to other sectors—for example, greater reliance on mineral resources and other strategies, such as trade, to achieve those same objectives, in view of the diversity of resource endowments of the countries. (Dercon and Gollin 2014).

Indeed, much of the focus on smallholders, argued Collier and Dercon (2014), may actually hinder large-scale poverty reduction: “Fast labor productivity growth is what is needed for large scale productivity reduction but smallholders and the institutions to support and sustain them are weak agents for labor productivity growth in Africa. The current policy focus ignores one key necessity for labor productivity growth: the kind of growth that will trigger successful migration out of agriculture and rural areas” (Collier and Dercon 2014, 93).

In the rest of this paper, we review the accumulated literature on productivity growth by farm size, including, particularly, the inverse relationship (IR) in Asia, Latin America, and Africa to derive implications for agricultural policy. This literature reflects considerable advancement in data and methodology to address issues of productivity and farm size, with important implications for policy. It concludes that there is evidence of high productivity among farms of all sizes, particularly along a U-shaped curve, with both small and large farms showing high degrees of productivity, compared to middle sized farms and those farm sizes that tend to be very context-specific. This means that middle-sized farms in Latin America can be large farms in Asia, and their access to technology and factors of production depends on their country-specific circumstances.

Some Evidence on Farm Size and Productivity

Evidence of higher yields per hectare on large farms is not new in Africa. In a study of smallholder and estate or large-scale production (given that definitions have been context-specific in different circumstances) of tea and coffee in Kenya and tobacco in Malawi, spanning

a period from the mid-1960s to mid-1980s, Lele, and Agarwal (1989) showed that large-scale/estate production had higher yields of production per unit of land than did smallholders. (The difference in yield was threefold.) However, this higher productivity occurred on estate farms in Malawi, because estates sold their produce in open auctions, whereas small farmers sold their produce to ADMARK (the Agricultural Development Marketing Corporation) at much lower prices. Estates used more quantities of all factors of production per unit of land, including purchased inputs and labor, than did small farmers. The reasons for the higher input use are many, and context-specific, but can generally be described as owing to their increased and easier access to credit and markets, including labor markets. And yet, careful analysis of the domestic resource costs (DRCs) of these two types of farming organizations showed clearly that large farms were not necessarily more efficient than small farms. The DRCs of the two types of farms were similar when measured per unit of production. The study outlined how public policy and delivery of information, inputs, and markets were critical to improving access of small farmers to services and overcoming diseconomies of scale.

In one of the few recent studies on farm size and productivity relationship in Africa, Muyanga and Jayne (2019) conducted an analysis in Kenya. They examined the relationship:

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...over a much wider range of farm sizes than most studies, which is particularly relevant in Africa given the recent rise of medium- and large-scale farms. Second, [they] test the inverse relationship hypothesis using three different measures of productivity including profits per hectare and total factor productivity ... [instead of] yield or gross output per hectare. [They

found] a U-shaped relationship between farm size and all three measures of farm productivity. The inverse relationship hypothesis [IR hypothesis] holds on farms between zero and 3 hectares. The relationship between farm size and productivity is relatively flat between 3 and 5 hectares. A strong positive relationship between farm size and productivity emerges within the 5-to-70-hectare range of farm sizes. Across virtually all measures of productivity, farms between 20 and 70 hectares are found to be substantially more productive than farms under 5 hectares.... the productivity advantage of relatively large farms stems at least partially from differences in technical choice related to mechanization, which substantially reduces labor input per hectare, and from input use intensity. (Muyanga and Jayne 2019, 1140)

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Based on evidence from four countries—Ghana, Kenya, Tanzania, and Zambia—Jayne et al. (2016) noted, “Medium-scale farmers [with farms between 5 to 100 hectares] may be altering the strength and location of agricultural growth and employment multipliers between rural and urban areas.... medium-scale farms are likely to soon become the dominant scale of farming in many African countries” (Jayne et al. 2016, 203).

However, using farm-level panel data from Tanzania and Uganda and a theoretical framework, Gollin and Udry (2019) came to a different conclusion. Unlike in developed countries, crop yields and input intensities vary greatly on African farms, with enormous differences in productivity across farms. This, then, leads to a conclusion that there is considerable scope to increase overall productivity by improving resource allocations across farms. The model that Gollin and Udry (2019) used allowed for the distinguishing, among various sources, of

productivity differences, such as measurement error, unobserved heterogeneity, and potential misallocation of resources. The stochastic nature of agricultural production and large shocks to production related to weather, pests, crop diseases, and so on, were not well observed in the data. A second source of variation in productivity is measurement error, despite the high quality of the data, leading to imperfect and imprecise measurement. Finally, heterogeneity in unobserved land quality was the third source of variation in productivity. The authors found that measurement error and heterogeneity together account for as much as 70 percent of the dispersion in measured productivity. They concluded that the potential for efficiency gains through reallocation of land across farms and farmers may be relatively modest (Gollin and Udry 2019).

Medium-scale farms control more land than do foreign and domestic investors in the countries examined. In contrast, at least in the four countries studied, the share of land accounted for by small-scale (0–5 hectares) holdings is declining, while the number of farms between 10 and 100 hectares is growing rapidly. Jayne et al. (2016) speculated that under de facto land policies, medium-scale farms will soon account for the majority of operated farmland in many African countries. Many medium-scale farms are owned by influential rural and urban people, who purchase land in customary areas and convert it to leasehold or freehold titled land. What influence they will have on agricultural policies is an important question. The authors emphasized the need to revive the study of agrarian structure to improve our understanding of the implications of rapidly changing land distribution patterns. They also noted that existing population-based surveys are poorly designed for understanding the changes in the distribution of farm size holdings. Correcting this informational blind spot is critical for assessing what is happening in many African countries' agricultural sectors (Jayne et al. 2016).

Earlier, Mburu, Ackello-Ogutu, and Mulwa (2014, 1), in a study of the effect of farm size on economic efficiency among wheat producers, estimated “the levels of technical, allocative, and economic efficiencies among the sampled 130 large- and small-scale wheat producers in Nakuru District.” The researchers showed that the technical, allocative, and economic efficiency indices of small-scale wheat farmers were only slightly lower at 85 percent, 96 percent, and 84 percent, respectively, as compared to 91 percent, 94 percent, and 88 percent, respectively, for large-scale farmers. From a strategic point of view, their observations, that the number of years of formal education that a farmer receives, the distance the farmer must travel to obtain extension advice, and the size of the farm strongly influence the efficiency levels, has important implications. “The relatively high levels of technical efficiency among the small-scale farmers defy the notion that wheat can only be efficiently produced by the large-scale farmers” (Mburu, Ackello-Ogutu, and Mulwa 2014, 1).

Methodologically and empirically, new studies have estimated the IR hypothesis, using survey data over time, to understand the dynamics of change. A study by Deininger et al. (2015), based on three rounds of survey data in India, spanning three decades, explored the relationship between farm size and productivity. The authors noted, “While present throughout, the inverse relationship weakened significantly over time; the estimated elasticity of productivity with respect to farm size increased from 0.73 to 0.95 from 1982 to 2007. Key drivers are better functioning labor markets and a narrowing of efficiency differences between own and hired labor, possibly due to greater use of machinery. Structural transformation and a transition

towards larger farms thus did not hurt productivity and economic efficiency” (Deininger et al. 2015, 1).

Otsuka, Liu, and Yamauchi (2016) reviewed evidence of different scales of production from a number of Asian countries. They noted that increase in wage rate is typically associated with increase in farm size, and that:

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In order to reduce labor cost, farm size expansion and mechanisation must take place, as land and machinery are complements.... Also essential for farm size expansion is the migration of rural labour to urban and industrialised areas.

High income countries in Asia (for example, Japan, Taiwan, and South Korea) have retained small farms and lost their comparative advantage in agriculture, thereby massively importing grains.... If China and India, as well as other high-performing and populous Asian countries, such as Vietnam and Indonesia, become major importers of grains in the future, world grain prices will rise, and poverty will likely deepen. (Otsuka, Liu, and Yamauchi 2016, 457–8)

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The authors noted that the evidence reviewed in their study offered a warning against maintaining small farms in Asia, with a risk to global food security and argued for new policy measures to enlarge the farm size in Asia, with a need for strengthening land ownership rights and promoting land rental transactions, as well as land consolidation of parcels and the

promotion of mechanization to reach scale economies (Otsuka, Liu, and Yamauchi 2016, 457–8).

A large body of conceptual and empirical evidence, including, particularly, the earlier failed attempts at industrialization in developing countries, demonstrated that if agricultural productivity growth does not precede or at least accompany labor transfers to urban areas, wage price inflation ensues in the face of rural–urban migration and stalls industrialization (Lele and Mellor 1981; Lele and Bumb 1995). This was the case in India during the 1964–65 balance of payments crises, and subsequently in 1990–91, leading policymakers to finally focus on the development of agriculture as essential for overall development and explained the strong political support that the Green Revolution engendered (Lele and Goldsmith 1989; Lele and Bumb 1994). Notably, there was also much opposition to the Green Revolution strategy from influential economists such as T. N. Srinivasan (1991).

Peter Hazell, a longtime champion of small farm development, also questioned the relevance of the small farms in Africa and Asia. The small farms are challenged by rapid urbanization, reverse farm size transition (smaller farms growing smaller), and emerging corporate farming. Hazell posits that some small farmers, with “resource endowments, good location, or sheer entrepreneurial skill” have been able to succeed as commercial farms, but face challenges of access to value chains and market opportunities. Hazell argues that “if more smallholder farms are to become commercially successful, policymakers will need to do more to support them” in terms of improving markets’ rural infrastructure and financial services, among other support (Hazell 2015, 204–5).

Dercon and Gollin (2014) went further in asserting, “there is little evidence that would support (or oppose) the claim that public investments in agriculture will generate greater improvements in social welfare than investments in other sectors” (Dercon and Gollin 2014, 6). Others question CGIAR’s rates of return studies and other studies (Ravallion and Datt 2002); or see flaws in the methodologies of studies (Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2002).

Given that it was “hard to disagree” with Collier and Dercon (2014), Hazell further stated:

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We need to move beyond the small vs. big farm debate, and think more about appropriate portfolios of small, medium, and large farms that are relevant to the resource endowments and stage of development of a country.... large numbers of small farms are not going to make it as commercial businesses, especially asset-poor farmers in backward regions. Many of these kinds of farms are already diversifying their livelihoods out of farming, but there are many instances where this is not yet possible on the scale required, or where the returns to non-farm activities remain too low for them to escape poverty. (Hazell 2015, 200)

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And yet, the demographic reality and the history of agriculture in most Asian and African countries are such that, under a business-as-usual scenario, small farms and small farmers will continue to dominate the development of food and agriculture, unless there is a drastic change in policies toward agricultural and industrial development. Hazell (2015) is right in stressing that

small farmers are getting smaller, whereas Masters et al. (2013), in a paper prepared for CGIAR and published in *Global Food Security*, observed that the process of land consolidation had begun in Asia, but China may be unique in having achieved improved land governance, compared to other Asian countries. Huang and Ding (2016) confirmed the rapid rate of land consolidation in China, despite the small farm size.

China has also undertaken reforms in extension, mechanization, water management, and finance among others. In north and northeastern China, the average size has doubled over the past decade. Huang and Ding (2016) noted the strikingly rapid emergence of medium- and large-sized farms in many regions. Bangladesh has had a stable farm size, and other Asian countries, including India, have faced declining farm sizes. According to Masters et al. (2013), rural population has peaked in Asia, [partly] “due to demographic [factors] ... but the average Asian farm size already has or will soon begin to rise, as some rural households cultivate land released by neighbors whose workers have stopped farming” (Masters et al. 2013, 157). However, we argue that this will not be achieved without India reducing its population in agriculture.

Upward of 40 percent of all small farms in the world are in India, according to FAO (2014), but reforms have been slow in coming. The number of operational holdings in India increased from 71.01 million in 1970–71 to 128.89 million in 2005–6, and operational holdings area declined from 162.18 million hectares to 156.62 million ha, resulting in reduction of the average farm size from 2.28 hectares to 1.21 hectares. In the same period, the share of small and marginal holdings in operated area doubled. Smallholders now cultivate 42 percent of operated land and constitute 83 percent of total landholdings. Making the market for farmland leasing more efficient would

be a major step forward, with a lower political cost than full ownership (Chand, Lakshmi Prasanna, and Singh 2011).

Arvind Panagariya, the first vice-chairman of the Indian think tank, NITI Aayog, between January 2015 and August 2017, noted that, although many land laws were passed soon after independence due to resistance from the landowning classes, they were not implemented; ownership rights were conferred only on 4 percent of the land; and tenancy was abolished as seemingly exploitative, with the policy having the unintended consequence of providing no protection to tenants (Bhagwati and Panagariya 2013).

Reforming tenure, a top priority of the government, has stalled because of the opposition of the political parties to change the Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act of 2013, which the Modi Government of India has considered heavy on transaction costs. Panagariya urged states to pass land bills if the national government could not get it done. He noted direct benefits of fertilizer subsidies to farmers could not be implemented without tenure reform, and access to bank credit was difficult without tenure security.

There has been little progress on clarity of land rights in India. Constitutionally, the 28 states are responsible for land, water, and forests, and they have not acted on land rights.

In personal communication with Uma Lele, Ramesh Chand noted:

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Both ownership and operational size of holdings are declining over time. This is shown both by Census data, which is based on revenue records and National Sample Survey Office (NSSO) data based on sample households. The Census did not capture tenancy, but NSSO data is expected to capture and reveal tenancy. According to NSSO data, tenancy in India is rising and is widespread in some states. In the state of Andhra Pradesh, (before it was split in two), 37 percent of households reported land was leased in and 4.6 percent reported lease out. Obviously, marginal farmers and the landless are leasing in land on a large scale. There are also many cases of large farmers leasing in from small and marginal farmers...the increase in lease in and lease out is not resulting in an increase in operational area of farm size over time so far. Though government statistics do not reveal lease in and lease out data, it does not mean that the sizes of farms are rising due to underreporting of leasing. Farm sizes may be larger due to underreporting, but sizes are not rising over time (Ramesh Chand, personal communication, January 8, 2018).

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See also Chand, Srivastava, and Singh (2017).

As a democracy with responsibility for agricultural policy scattered in 28 states, reforming agricultural policy has been a challenge. In June 2020, the Government of India adopted three long overdue reforms relating to agricultural marketing that represented a fundamental reorientation of the existing regulatory framework. Although agriculture is a state subject, the central government took the opportunity and the initiative to use the COVID-19 crisis to push

through reforms, without the explicit involvement of the state governments. One bill relaxed restrictions governing purchase and sale of farm produce; the second bill relaxed restrictions under the Essential Commodities Act (ECA), 1955, a vestige of colonial heritage; and the third introduced dedicated legislation to enable contract farming on written agreements. Despite the consensus among economists prior to the reforms, the three bills were controversial in the farming community, particularly in the states of Punjab and Haryana, and received considerable resistance, so the government had to abandon them. With the new clout of the farmers in key states, it is too early to know the future prospects of these three forgone reforms, as they offered substantial potential to liberalize markets; contract farming could provide some security of tenure and increase overall productivity and income. For details, see Narayan (2020).

Land ownership would not change the lot of poor households much, unless they were located in peri-urban areas where the land could be developed (and would then be priced as urban land) (Hazell 2015). A part of the challenge is that the nonagricultural sectors (service and manufacturing) have not been able to generate enough productive employment, in developing countries, as we have demonstrated in Lele et al. (2021).

Furthermore, land serves as insurance. When industrial jobs are lost, workers go back to farming, as they did in Indonesia in 1997, and in China, after the 2007 financial crisis.

Africa faces a different structural problem altogether. African agriculture faces an aging and illiterate farming community and youth uninterested in agriculture; lack of formal land rights keeps land rental low; only 5.6 percent of land is irrigated; and governments are fiscally strapped

(ACET 2017). In addition, some countries are afflicted by acute governance challenges. A World Bank report documented the phenomenon of elite capture and elite competition for retaining power in the case of Malawi. (WBG 2018). A multi-stakeholder approach, involving women, youth, the private sector, foundations, and farmers of all sizes of farms, is needed—in addition to the need for leadership.

Role of Medium- and Large-Scale Farms

Those questioning the ability of small farmers to feed the world increasingly look to medium- and large-scale farms to meet that demand. Only 1 percent of all farms in the world, larger than 50 hectares, control 65 percent of the world’s agricultural land. These large farms deploy state-of-the-art biological, mechanical, and information technologies in the form of precision agriculture and enjoy economies of scale and scope. Many are becoming corporate farms (FAO 2014).

Brazil contains farms of all sizes; it has an active agricultural policy toward agribusinesses through the Ministry of Agriculture, and toward small- and medium-scale farms through the Ministry of Agrarian Development. It has ample data, and it has attracted strong analysts. So, what role has farm size played in Brazil? Helfand, Magalhães, and Rada (2015) concluded that the small and large farms are becoming more efficient faster than medium-sized farms. Their first hypothesis is that:

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Large and small farms, each through a separate and unique path, have advantageously adapted or developed size-dependent technologies or processes that have accelerated growth. The second is that Brazilian agricultural policy, through the Ministry of Agriculture and the Ministry of Agrarian Development, has respectively focused on the large and small producers and has, to a certain extent, ignored the needs of middling farm sizes. (Helfand, Magalhães, and Rada 2015, iii, 1)

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This situation may occur because the Ministry of Agriculture provides services to small farmers. Large farms have access to technology from the market, and middle-sized farmers are underserved by both. We will show evidence later that large farms increase productivity but do not generate much employment. Farm size can increase only if enough farm workers leave farming for nonfarm jobs.

Foster and Rosenzweig (2017), who, in their paper, asked, “Are There Too Many Farms in the World?” showed that “the existence of labor-market transaction costs can explain why the smallest farms are most efficient, slightly larger farms least efficient and larger farms as efficient as the smallest farms.” They explained further that “the rising upper tail of the U characteristic of high-income countries requires there be economies of scale in the ability of machines to accomplish tasks at lower costs at greater operational scales.” Data from India’s village-level panel surveys conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) are consistent with these conditions. The authors also noted, “that there are too many farms, at scales insufficient to exploit locally available equipment-capacity scale-economies.”

Much of the debate on farm size and productivity has been focused on land or labor productivity, generally showing respective productivity advantages to smaller or larger sized farms. Rada and Fuglie (2019) brought together evidence from a set of rich and poor countries, using panels of farm micro data and measures of total factor productivity (TFP), as the measure of comparative performance (see Figure 1). Their case studies, in (1) Malawi, Tanzania, and Uganda; (2) Bangladesh; (3) Brazil; (4) Australia; and (5) the United States, suggest:

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There is no single economically optimal agrarian structure; rather, it appears to evolve with the stage of economic development. Certain farm sizes face relative productivity advantages, such as small farms in Africa. But with economic and market growth, that smallholder advantage will likely attenuate, moving toward constant and eventually increasing returns to size. Yet, importantly, small farms may be quite dynamic, and need not be a drag on agricultural growth [for example, in Bangladesh; see Gautam and Ahmed (2018)] until perhaps well into the development process. (Rada and Fuglie 2019, 147)

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Rada and Fuglie (2019) suggested flattened U-shaped curves on farm-level efficiency. Their findings suggest that policymakers need not favor medium and large farmers, at the cost of small farmers. By the same token, without attention to small farmers' productivity, differences in productivity growth between large and small farmers will continue to grow.

It is important to acknowledge some countervailing factors that may offset the negative impacts of increasingly concentrated farm structure. Lele and Stone (1989) explored Boserup's hypothesis that intensification is expected to occur, as a consequence of increasing relative land scarcity. However, empirical evidence for such intensification in Africa is decidedly mixed, suggesting constraints to land intensification, a conclusion that Headey and Jayne (2014) also reached a quarter century later. Researchers, with new evidence, have challenged the inverse farm size–productivity hypothesis, with the incorporation of data on larger farm sizes that are typically not observed in farm household surveys (Nkonde et al. 2015; Muyanga and Jayne 2019). The upshot of this work is that returns to scale may be an important source of intrasectoral growth. The researchers have joined in questioning the cost-effectiveness of promoting small-scale agriculture in Africa (see, for example, Collier and Dercon 2014; Dercon and Gollin 2014). Their argument would have greater validity if the literature suggested strong success in industrialization and ability of countries to absorb labor there. Unfortunately, evidence presents a dismal picture on growth in manufacturing.

Environmental Costs and Benefits of Productivity Growth

Much of the traditional economic literature did not address the environmental costs and benefits of technological change, but this is beginning to change. Modeling efforts are underway to quantify environmental impacts and implications for policy. The examples presented here are only illustrative. Taheripour, Hertel, and Ramankutty (2019) estimated the impact of rapid output expansion of palm oil output in response to rising global demand and concluded that:

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Limiting palm oil production or consumption is unlikely to halt deforestation in M&I [Malaysia and Indonesia] in the absence of active forest conservation incentives. Policies aimed at restricting palm oil production in M&I also have broader consequences for the economy, including significant impacts on consumer prices, real wages, and welfare. (Taheripour, Hertel, and Ramankutty 2019, 19193)

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Quite another kind of modeling is underway in the area of climate change. Parry, Mylonas, and Vernon (2018), in their paper, “Mitigation Policies for the Paris Agreement: An Assessment for G20 Countries,” provided an illustration of emissions pricing” and noted that “results underscore the generally strong case for (comprehensive) pricing over other instruments” (Parry, Mylonas, and Vernon 2018, 2)

Jeuland and Whittington (2014) explored water resources planning with respect to climate change under alternative scenarios, assessing the robustness of real options for the Blue Nile. They concluded that “new, improved planning methods” are needed to address deep uncertainties related to climate change and its impacts on water resource development (Jeuland and Whittington 2014, 2086).

There are other important issues related to the process of small farm intensification and productivity growth, which we do not address here. One issue is agricultural intensification and human health. For example, “pesticide use is strongly correlated with increased value of harvest,

but is also correlated with higher costs associated with human illness, including increased health expenditures and time lost from work due to sickness in the recent past” (Sheahan, Barrett, and Goldvle 2017, 27). At the same time, with improvements in household incomes, “the content of the food basket is changing with a gradual shift toward high-value foods such as animal products, fruits and vegetables and processed foods. Overall, this dietary transition has important implications for the food security debate and for agricultural and food policy” (Worku et al. 2017, 73). Also, there are important trade-offs between nonfarm employment and income and farm productivity growth under smallholder agriculture. In certain circumstances, agricultural productivity declines as nonfarm income increases. This is because nonfarm employment and income can increase farm hired labor and improve input intensity; but can have “a negative effect on on-farm family labor use... targeted policies are required to reduce these potential trade-offs between nonfarm employment and agricultural intensification and productivity change” (Amare and Shiferaw 2017, 59).

In the preceding pages, we reviewed disaggregated evidence on productivity growth by farm size. Below we present aggregated sectoral estimates of TFP growth at the national level.

What Does Aggregated Evidence Show about Overall Productivity Growth at the Sectoral Level?

Figure 1 shows Fuglie’s estimates of trends in TFP growth for individual countries across Asia over time, and Figure 2 shows it across regions. In Asia, all countries are dominated by smallholders, but there are huge differences in growth rates across countries within Asia. South

Korea performed the best until 2010, after which China exceeded Korea. Thailand and Vietnam exceed India.

HUGE DIFFERENCES ACROSS COUNTRIES AND REGIONS IN TFP GROWTH (1960-2018)

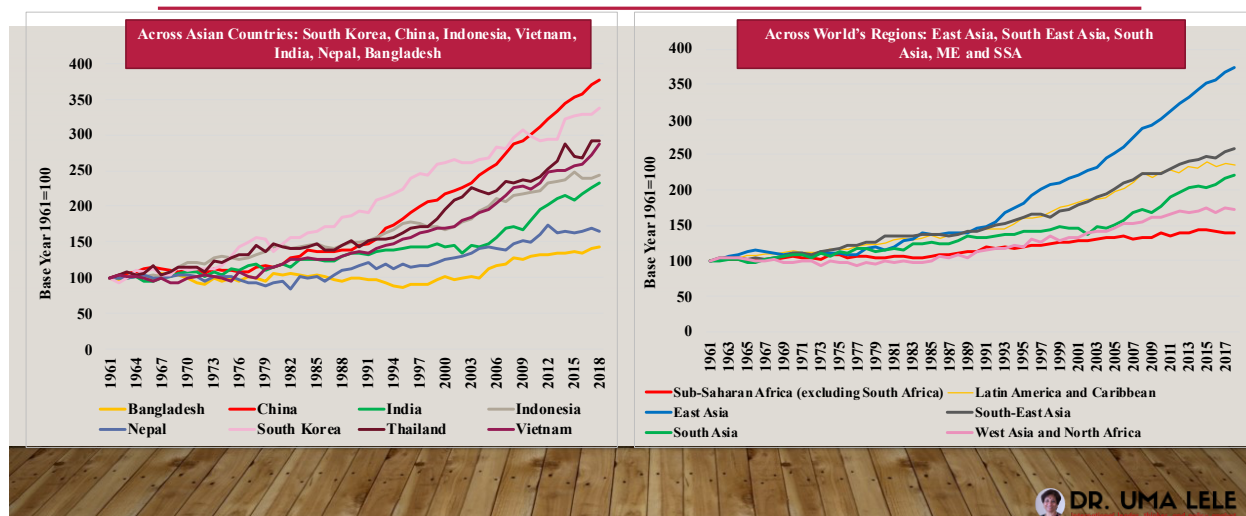


Figure 1. Huge differences across countries and regions in total factor productivity growth (1960–2018).

Source: Based on data provided by Keith O. Fuglie.

Across regions, too, East Asia shows the most rapid rates of growth, compared to Latin America where large-scale agriculture dominates. The evidence suggests that many factors other than farm size influence productivity growth, including investment in physical infrastructure, for example, irrigation and markets, and access to new technology, capital, and knowledge.

Next, Figure 2 shows that most of the growth in sub-Saharan Africa, and to a lesser extent in Latin America, has been due to area expansion, whereas in North-East Asia and South Asia, it is largely due to intensification.

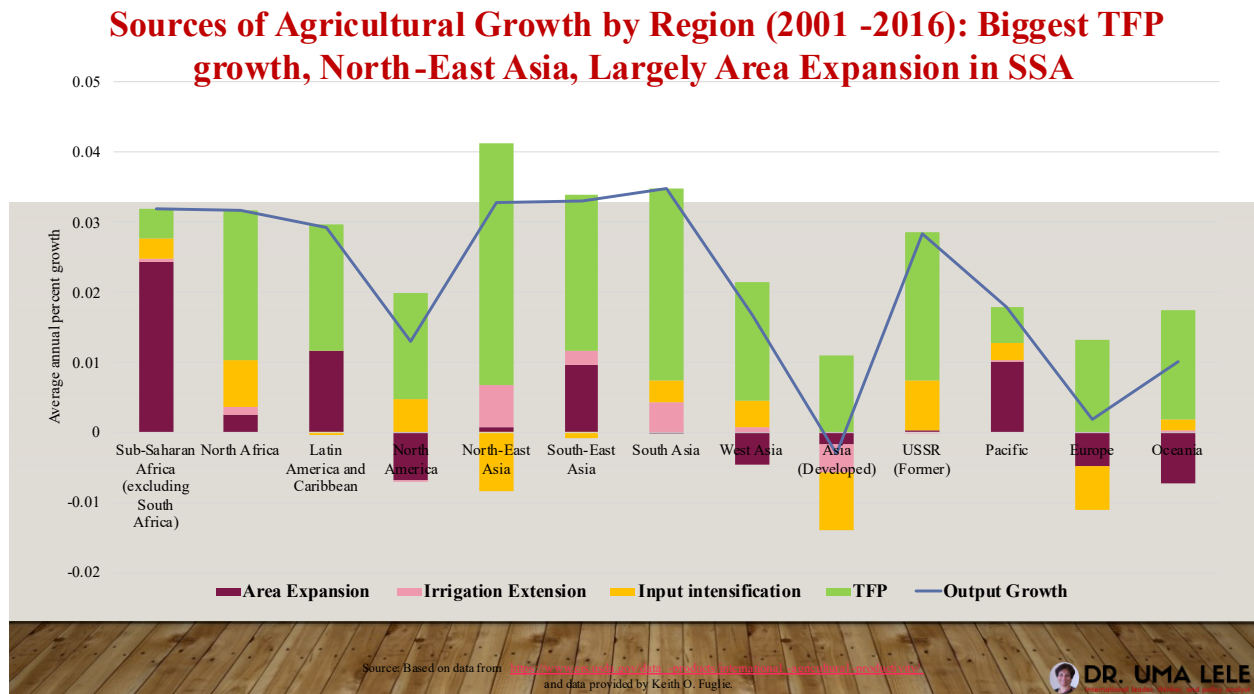


Figure 2. Sources of agricultural growth by region (2001-2016): Biggest total factor productivity growth, Northeast Asia, largely area expansion in sub-Saharan Africa.

Source: Based on data provided Keith O. Fuglie.

Important implications are that development of agriculture requires investments in factor and product markets and that farm size matters less than factors promoting intensification. Where land is scarce, as in much of Asia, intensification is the only route to productivity growth.

Fuglie's estimates suggest that farm size has not been an obstacle to productivity growth in Asian countries where they have pursued good agricultural policies. This is not the case in

Africa, however, where productivity growth is still at the lowest level. Also, due to the higher income elasticity of demand for food consumption among small farmers than their larger counterparts, food security of Asian small farmers is more directly assured by their productivity growth. Again, this is not the case in Africa. In Africa, investment in research and development and in infrastructure as well as access to input and output markets have been obstacles due to underinvestment in agriculture.

Conclusion

Small farms are more productive, when measured in terms of yields per hectare, than large farms, with a caveat that this is true when factor and product markets are nascent and small farmers depend largely on family labor. New evidence suggests that as factor and product markets develop, or as access to factors of production is de facto restricted, either through public policy or social constructs, productivity by farm size begins to become greater for large farms. Small farms are increasingly at a disadvantage, as they often lack the security of tenure and access to technology, credit, and output markets. With economies of scale in mechanization, however, large farms do not create much employment, and concentrating resources on large farms still leaves open the challenge of incomes and food security for small farmers.

Within this larger construct, country policies have a larger effect on productivity growth than the scale of farming. Small farms dominate in Asia, where China has shown remarkable productivity growth. China is experiencing land consolidation, as a natural progression in the course of structural transformation. In Japan, through public policy, the government has artificially

maintained small farms, and Japan is losing its comparative advantage in agriculture. In India policy reforms, such as security of tenure have been slow in coming, resulting in land fragmentation and too many small farms.

Evidence in Africa on productivity by farm size is mixed. Heterogeneity in farming conditions makes it difficult to arrive at firm conclusions. In Latin America—both large and small farms have been productive with a U-shaped curve observed on productivity by farm size.

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