Extended **Abstract**

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Paper/Poster Title	**Paper/Poster Title: Explaining Between-Farm Disparities in Labor Productivity**

Abstract prepared for presentation at the 97th Annual Conference of the Agricultural Economics Society, The University of Warwick, United Kingdom

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Abstract	***200 words max***
Understanding differences in farm labor productivity is critical to addressing rural poverty. In this study, we argue that the key elements that cause differences in labor productivity across farms in the developing countries are the underutilized family labor available to the small farms and the energy- or capital-intensity of the equipment used for plantation, reaping and water irrigation by the large farms. Using geocoded data on 5,645 farms from the 2018-19 round of the representative Household Integrated Economic Survey (HIES), we analyze the role of these factors in explaining the between-farm disparities in farm labor productivity in Pakistan. We use multiplicative factor decomposition of Mean Logarithmic Deviation or Theil's second measure to account for disparities in labor productivity and decompose it into its factor components. This relatively new method in economics decomposes the inequality in labor productivity into multiplicative input-factor components. To this end, we decompose labor productivity into land productivity, energy-intensity, energy-efficiency, capital efficiency, capital-labor ratio and farm productivity. We find that differences in energy intensity (23.9%) and capital-labor ratio (10.6%) explain the bulk of agricultural labor productivity differences across farms, whereas energy efficiency in production plays little role (2.9%). Farm productivity (-21.8%) and land productivity (-14.5%) are associated with reduction in labor productivity disparities. In addition, a substantial portion of inequality in agricultural labor productivity (13.4%) is attributed to disparities among farms of various sizes.	

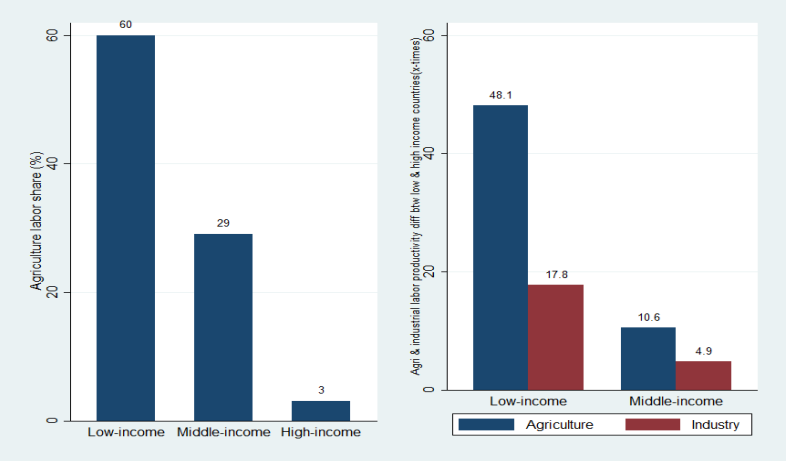
Keywords	Labor productivity, Energy efficiency, Energy intensity, Capital deepening, Decomposition.
JEL Code	J01, J31, Q12, Q40, D33, D24

Introduction	***100 – 250 words***

Agriculture is the main source of income in developing countries. It accounts for 27.6% of GDP in low-income countries. Even though the share of agricultural workers in total labor (60%) in the low-income countries is 20 times that of high-income countries (3%), agriculture contributes 5.5 times less to the national income compared to high-income countries (Figure-1). Low-income countries together produce US$ 120 billion (2015 constant) compared to US$ 656 billion that high-income countries produce. This suggests that increasing agricultural labor productivity in developing countries could help increase production and alleviate poverty.

Existing research focuses on the differences in labor productivity between developing and developed countries (Bárány & Siegel, 2021), primarily attributing these differences to the industrial and agricultural sector dichotomy between developing and developed countries (Bárány & Siegel, 2021; Chen, 2020; Blanco & Raurich, 2019).

Figure 1: Agriculture and industrial sector labor productivity



Source: *World Bank and OECD national account data 2020.*

However, recent research indicates that the disparities in labor productivity are mainly within instead of between sectors (Moussir & Chatri, 2020; Üngör, 2017; Yılmaz, 2016). Figure-1 shows that the difference in labor productivity in agriculture between low- and high-income countries is 48.1 times compared to 17.8 times for the industrial sector (Lagakos & Waugh, 2013). In this study, we demonstrate that the key elements that account for differences in labor productivity across farms in developing countries are the differences in the use of labor- and capital-intensive techniques and energy-consuming machinery across farms of various sizes i.e. production techniques. On the one hand, small holder and family farms with underutilized family labor availability mainly rely on labor-intensive techniques. On the other hand, large farms with better access to capital and credit are relatively scarce in terms of family labor, and rely mainly on capital-intensive techniques, thereby obtaining greater agricultural labor productivity (Chen,

2020; Zhang et al., 2020). Labor productivity inequality between farms increases if technology adoption is distributed asymmetrically across farms of different sizes.

Methodology

100 – 250 words

Methodology for measuring inequality

We use Mean Logarithmic Deviation (MLD) index to measure inequality in labor productivity and its constituent factors. The advantage of using MLD is that it satisfies practically all the qualities that a good inequality measure should have. The following subsections describe the MLD index and its properties to be decomposed into between-within subgroups and into its constituent factors.

Index decomposition by farm size

This property of MLD allows us to assign the proportionate share of labor productivity inequality T(OPL) within-between farms of various sizes (small, medium, and large) as illustrated below:

$$\mathrm{T(OPL)} = \underbrace{OPL_W}_{within\ group} + \underbrace{OPL_B}_{between\ groups} \qquad (2)$$

$$T(\mathrm{OPL}) = \underbrace{\sum_{s=1}^{S}\left(\frac{N_s}{N}\right)\mathrm{OPL}_s}_{within\ group} + \underbrace{\sum_{s=1}^{S}\left(\frac{N_s}{N}\right)\ln\left(\frac{N_s/N}{\overline{OPL_s}/\overline{OPL}}\right)}_{between\ groups} \qquad (3)$$

Where $\left(\frac{N_s}{N}\right)$ represents the population share of each $'s'$ group (farm size) in total population N and $\overline{OPL}$ is the corresponding mean.

Index decomposition by multiplicative factors

We employ Cheng and Li (2006) Theil second measure of inequality for multiplicative factor decomposition of inequality in labor productivity across farms into its constituent factors z_{if} as expressed below:

$$OPL_i = \prod_{f=1}^{k} z_{if} \qquad (4)$$

The above index can be decomposed into factors based on MLD measure as follows:

$$T(OPL) = \sum_{i=1}^{N}\frac{1}{N} ln\left(\frac{\prod_{f=1}^{k}\mu_f}{\prod_{f=1}^{k} z_{if}}\frac{\mu}{\prod_{f=1}^{k}\mu_f}\right) = \sum_{f=1}^{k} T(z_f) + ln\left(\frac{\mu}{\prod_{f=1}^{k}\mu_f}\right) \qquad (5)$$

Where $ln\left(\frac{\mu}{\prod_{f=1}^{k}\mu_f}\right) = ln\left(\frac{Cov(z_1,z_1')+\sum_{j=2}^{k-2}\prod_{f=1}^{j-1}\mu_f\, Cov(z_j,z_j')+Cov(z_{m-1},z_m)\prod_{f=1}^{m-2}\mu_f}{\prod_{f=1}^{k}\mu_f}+1\right)$ (6)

μ_f and $T(z_f)$ correspond to the factor's f mean and its inequality, while μ denotes the population mean labor productivity. Specifically, equation (5) can be described as follows:

$$\frac{Output_i}{Labor_i} = \underbrace{\frac{Output_i}{Land_i}}_{Land\ productivity} \times \underbrace{\frac{Land_i}{Energy_i} \times \frac{Inputs_i}{Energy_i}}_{Energy\ intensity\ inv} \times \underbrace{\frac{Energy_i}{Output_i}}_{Energy\ efficiency} \times \frac{Energy_i}{Capital_i} \times \underbrace{\frac{Capital_i}{Labor_i}}_{\frac{K}{L}\ ratio} \times \underbrace{\frac{Output_i}{Inputs_i}}_{Farm\ prod} \quad (8)$$

One advantage of the IDA methodology is that it produces the same result for an inverse of a factor as it does for the original factor.

Results

100 – 250 words

We find that labor productivity varies greatly between farms of varying sizes. Average labor productivity of large farms is 2.64 times higher than that of small farms (Rs.512,100 vs Rs.193,900). The highest inequality in labor productivity is found among smallholders (MLD=0.255), followed by large (0.204) and medium farms (0.20). This disparity in labor productivity is mainly attributed to small farms' intensive use of under employed family labor as opposed to large farms' intensive use of energy-based machinery. The K/L ratio (CPL) iof large farms is four times higher than that of small farms. Likewise, energy intensity is nearly double in large farms. Whereas small farms require nearly four times the amount of input per acres as compared to that of large farms.

The findings show that 13.4% of inequality in labor productivity is ascribed to differences in farm size. Besides, energy-intensity per land unit (LPE) and energy deepening (IPE) play a significant role in explaining inequality in labor productivity, accounting for 23.9% and 18.1% of the inequality, while energy-efficiency in production (EPO) has no substantial impact (2.9%). K/L ratio is another important factor that explains 10.6% of inequality in labor productivity across farms. All the constituent factors contribute to increase in labor productivity inequality, except for farm productivity (-14.5%) and land productivity (-21.8%). This is due to the fact that small farms entail relatively higher land productivity than large farms, which can offset the labor productivity differences between large and smallholders.

Discussion and Conclusion

100 – 250 words

The above findings suggest that the differences in capital- and energy-intensity in production between large and smallholders are the main factors that can explain inequality in labor productivity. Besides, marginal and smallholdings are not cost efficient to be cultivated using capital-intensive techniques. Therefore, consolidation of marginal and smallholdings to a suitable farm-size by renting in additional land and utilizing energy-based capital-intensive technology can enhance the labor productivity of medium and smallholders. Moreover, the

differences in agricultural labor productivity between small and large farms could be reduced if smallholders improve their land productivity further by fully utilizing underutilized family labor. Crop choice plays an important role in this regard. Though smallholders are more productive in producing all crops, they are particularly productive in cultivating vegetables and fruits as compared to cereals (70.9% and 155.5% respectively). This notwithstanding, 77% of smallholders still grow low productive capital-intensive crops, with 45% cultivating cereals and 32% producing fodder. Small farms can enhance their land and labor productivity by 44.4% by cultivating labor-intensive crops such as vegetables, fruits, and flowers, in which they can make better use of the under employed family labor. This can help to reduce the disparities in labor productivity from 147.4% to 20.8%.