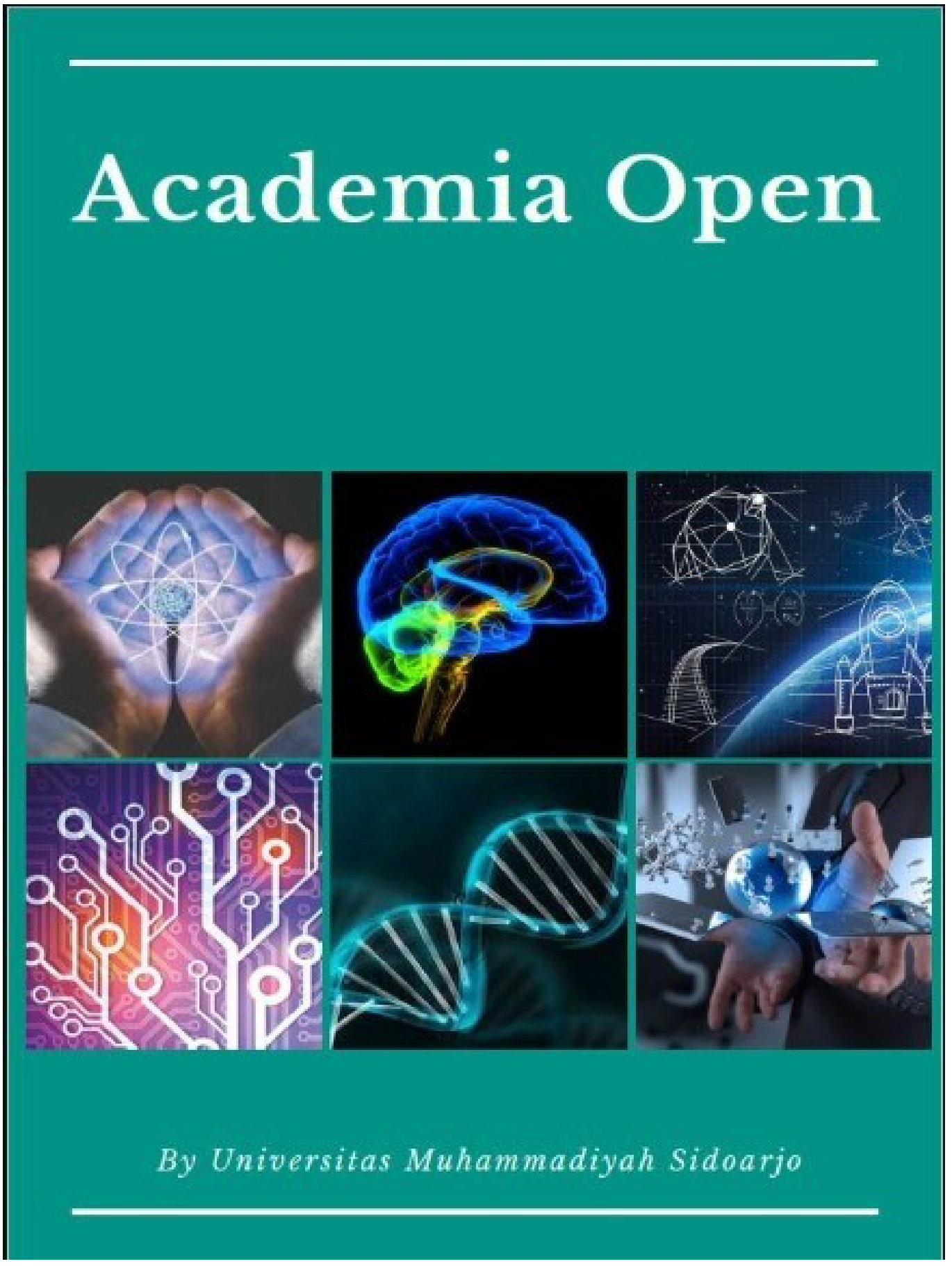
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Vol. 12 No. 1 (2027): June
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Table Of Contents

Journal Cover 1
Author[s] Statement 3
Editorial Team 4
Article information 5
Check this article update (crossmark) 5
Check this article impact 5
Cite this article 5
Title page 6
Article Title 6
Author information 6
Abstract 6
Article content 7

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Surplus Labour Persists Despite Declining Agricultural Employment and Structural Transformation

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Abstract

General Background: Structural transformation in developing economies involves labour reallocation from agriculture to modern sectors, potentially signalling the Lewis turning point. **Specific Background:** Agricultural employment in Probolinggo Regency declined from 57.7% to 42.5% between 2010 and 2025, alongside a decreasing agricultural output share. **Knowledge Gap:** Existing studies frequently interpret declining agricultural employment as structural progress without estimating nonlinear labour productivity regimes or testing whether surplus labour persists. **Aims:** This study examined agricultural growth, surplus labour, and threshold regimes using annual regional data and a theoretically derived threshold regression model. Estimation employed concentrated least squares, Newey–West standard errors, and bootstrap inference. **Results:** Agricultural labour elasticity remained statistically indistinguishable from zero (−0.05; 95% CI: −0.16 to 0.06). An estimated employment threshold of 46.32% indicated a regime shift (sup-F = 12.30; bootstrap p = 0.049–0.088), with agricultural growth 2.75 percentage points higher in the high-share regime. Investment showed a positive coefficient (0.34), whereas modern-sector growth exhibited a negative association (−0.38). **Novelty:** The study integrates Lewis dual-economy theory with an empirically estimated employment threshold, distinguishing labour withdrawal from genuine agricultural productivity transformation. **Implications:** Findings prioritize agricultural investment, farmland protection, and productivity-oriented structural policies rather than treating labour reallocation alone as evidence of economic development.

Highlights:

- Agricultural workforce contraction did not establish a transition toward positive marginal labour productivity.
- A 46.32% employment-share boundary separated two distinct growth regimes, with stronger performance in the earlier period.
- Physical investment was a robust positive predictor, while expansion of nonfarm sectors showed a negative association.

Keywords: Lewis Turning Point, Surplus Labour, Threshold Regression, Structural Transformation, Agricultural Growth

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Introduction

Agrarian economies are frequently caught in a structural paradox: labour remains concentrated in a sector whose contribution to aggregate output keeps shrinking. Probolinggo Regency in East Java illustrates the paradox with unusual clarity. Over 2010–2025 agriculture absorbed between 39 and 59 percent of the regency's workforce, yet its share of Gross Regional Domestic Product (GRDP) declined monotonically from 38.7 to 28.5 percent. A sector that employs roughly two workers in five but produces less than three-tenths of output is, almost by construction, a sector in which labour earns far less than it would elsewhere. This is the agricultural productivity gap documented across the developing world [1], [2], and it is the starting point of every dual-economy account of development.

The standard reading of such data is optimistic. In the Lewis model, the traditional sector initially holds a reservoir of labour whose marginal product is close to zero [3], [4]. As the modern sector grows, it draws this surplus away at a roughly constant wage; once the reservoir is exhausted, the economy reaches the *Lewis turning point*, beyond which agricultural labour becomes scarce, rural wages rise, mechanisation becomes profitable and the farm sector modernises [5], [6]. A falling agricultural employment share, such as Probolinggo's fifteen-point decline, is therefore commonly interpreted as evidence that the turning point is near or already behind.

This paper asks whether that inference is warranted. The question matters because the turning point is not an accounting milestone; it is a change in the *marginal* economics of farm labour. If the employment share falls but the marginal product of farm labour remains close to zero, workers have left the land without the sector crossing into the neoclassical regime in which labour is scarce and capital deepening is induced. We call this configuration *exit without take-off*. It is the regional analogue of the premature structural change and premature deindustrialisation that recent work has identified at the national level [7], [8], [9].

Three gaps in the existing literature motivate the analysis. First, most empirical work on labour and growth in Indonesia estimates linear models on national or provincial aggregates [10], [11], implicitly assuming that the marginal contribution of labour is the same before and after the turning point. This assumption contradicts the very theory that motivates the exercise. Second, where non-linearity is acknowledged, the regime split is often imposed (at the sample median or at an a priori value) rather than estimated, so the location of the threshold and the significance of the regime change are never formally tested. Third, the link between the regression coefficients and the structural parameters of the dual economy is rarely made explicit, so a negative coefficient on modern-sector growth, for example, is variously read as "crowding out", "cannibalisation" or "competition" without any statement of what the coefficient actually identifies.

We address these gaps with three contributions. First, we derive an estimable growth equation from a land-constrained agricultural production function with a Lewis-type, regime-dependent labour elasticity, so that every regression coefficient maps onto a combination of structural parameters. Second, we estimate the threshold in the agricultural employment share by concentrated least squares [12], test it against the linear alternative with a bootstrap sup-F statistic that accounts for the unidentified nuisance parameter [13], and report likelihood-ratio confidence sets for its location. Third, we subject the preferred model to a battery of small-sample checks (wild bootstrap, jackknife, alternative HAC bandwidths, a lagged threshold variable, a calendar-break alternative and exclusion of the pandemic year), which is essential when the effective sample contains fifteen annual observations.

The results overturn the optimistic reading. The marginal contribution of the agricultural labour share to agricultural growth is statistically zero throughout the sample, and the upper bound of its confidence interval implies that an additional farm worker adds at most about six percent of what the average farm worker produces. The regime break is real, but it runs in the "wrong" direction: agricultural growth was faster *above* the threshold, not below it. Physical investment is the only robust engine of farm growth, and modern-sector expansion is, on net, a drag on agriculture. Probolinggo's farm workforce has shrunk, but the economics of surplus labour have not changed.

The remainder of the paper is organised as follows. Section 2 reviews the literature and states the hypotheses. Section 3 develops the theoretical framework and derives the estimating equations. Section 4 describes the data and the econometric methods. Section 5 presents the results and Section 6 discusses them. Section 7 draws policy implications and Section 8 concludes.

Literature review and hypotheses

1. Neoclassical growth and diminishing returns

In the Solow framework, output is produced by capital, labour and technology under diminishing returns to each reproducible input [14]. Adding workers to a fixed stock of land and equipment lowers output per worker; sustained growth requires capital accumulation and technological progress. Evidence from developing economies is consistent with this prediction: physical capital, rather than the expansion of the labour force, accounts for the bulk of measured growth in Indonesia [11] and Peru [14]. In agriculture, where land is a quasi-fixed factor, the constraint is sharper still. Without investment in irrigation, storage, mechanisation and rural infrastructure, farm households remain trapped in low-productivity subsistence production [1].

2. The Lewis dual economy and the turning point

Lewis [4] divides a developing economy into a traditional sector, where labour is abundant and paid an institutional subsistence wage, and a modern sector that hires at that wage plus a premium. In the first phase, the marginal product of labour (MPL) in agriculture is close to zero, so labour can be withdrawn without reducing farm output. Ranis and Fei [6] refine the sequence into a *shortage point*, where MPL becomes positive, and a *commercialisation point*, where MPL reaches the institutional wage; between them, labour withdrawal starts to reduce farm output and to raise food prices. The turning point is therefore defined by the behaviour of MPL, not by the level of the employment share. Empirical tests in China show how contested its dating can be, even with rich wage data [15]. For Indonesia, recent studies find dualistic features persisting into the 2020s [3], [5], and regional analyses show that structural transformation has been uneven and, in places, accompanied by widening inequality [7], [10].

3. Thresholds and non-linear structural transformation

Because the Lewis model implies that the marginal contribution of labour changes discretely once the surplus is absorbed, a linear specification is misspecified by construction. Threshold regression captures this by allowing parameters to differ across regimes defined by an observable state variable crossing an unknown value γ [12], [16].

Threshold methods have been used to document non-linear effects of inflation on growth in Indonesia [17] and institutional thresholds in the effects of FDI in ASEAN [18]. Using the agricultural employment share as the state variable provides an observable proxy for the position of the economy relative to the turning point, which is otherwise latent.

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4. The modern sector: pull factor or predator?

Successful transformation requires a modern sector that absorbs surplus labour productively [2], [9]. However, modern-sector growth affects agriculture through two opposing channels. On one side are demand and input linkages, remittances and technology spillovers, which raise farm productivity. On the other side is competition for land and water, as farmland is converted to industrial, residential and commercial use. Which channel dominates is an empirical question. Where the second dominates, modern-sector growth crowds agriculture out rather than pulling it forward, a pattern associated with premature or anti-agrarian transformation [7], [8], [19].

Hypotheses

The preceding discussion yields four testable hypotheses, which Section 3 formalises:

H1 (surplus labour). The output elasticity of the agricultural labour share is zero in the surplus regime.

H2 (regime change). The relationship between agricultural growth and its determinants differs across regimes defined by a threshold in the agricultural employment share; the linear model is rejected.

H3 (capital). Physical investment raises agricultural growth.

H4 (modern sector). The net effect of modern-sector growth on agricultural growth is non-zero; its sign reveals whether land and resource competition or demand linkages dominate.

Theoretical framework and derivation of the estimating equations

This section derives the estimating equations from first principles so that each coefficient has a precise structural interpretation. The derivation also makes explicit the approximations on which the empirical work rests.

1. Technology with a Lewis surplus

Let agricultural value added Y_t be produced with capital K_t, land T_t and labour L_t according to

$$Y_t = A_t K_t^{\alpha} T_t^{\eta} [\min(L_t, \bar{L}_t)]^{\varepsilon}, \qquad \alpha, \eta, \varepsilon > 0, \qquad (1)$$

where A_t is total factor productivity (TFP) and $\bar{L}_t$ is the quantity of labour that can be productively employed given K_t and T_t. Labour beyond $\bar{L}_t$ is *surplus*: it is present on farms, shares in household income, but adds nothing to output. The marginal product of labour is

$$MPL_t \equiv \frac{\partial Y_t}{\partial L_t} = \begin{cases} \varepsilon \dfrac{Y_t}{L_t} > 0, & L_t \le \bar{L}_t, \\ 0, & L_t > \bar{L}_t. \end{cases} \qquad (2)$$

The *output elasticity of labour* is therefore regime-dependent:

$$\varepsilon_t \equiv \frac{\partial \ln Y_t}{\partial \ln L_t} = \varepsilon \cdot \mathbb{1}(L_t \le \bar{L}_t). \qquad (3)$$

Equation (3) is the formal content of the Lewis turning point: crossing $\bar{L}_t$ switches the labour elasticity from zero to a strictly positive value. The Ranis–Fei shortage point corresponds to $L_t = \bar{L}_t$.

2. From employment levels to the employment share

Agricultural employment equals the agricultural share of total employment, s_t, times total employment N_t: $L_t = s_t N_t$. Define $\bar{s}_t \equiv \bar{L}_t / N_t$. Then $L_t > \bar{L}_t \Leftrightarrow s_t > \bar{s}_t$, and the surplus condition can be written in terms of the observable share. Assuming that $\bar{s}_t$ varies slowly relative to s_t over the sample, we treat it as a constant threshold γ and define the regime indicator

$$D_t \equiv \mathbb{1}(s_t > \gamma), \qquad (4)$$

so that $D_t = 1$ marks the *high-share (surplus) regime* and $D_t = 0$ the *low-share regime*. Because the strict zero in (2) is an idealisation, the empirical model allows a general pair of elasticities, ε_S in the surplus regime and ε_N in the non-surplus regime:

$$\varepsilon_t = \varepsilon_S D_t + \varepsilon_N (1 - D_t). \qquad (5)$$

The strict Lewis prediction is $\varepsilon_S = 0 < \varepsilon_N$. The neoclassical full-employment benchmark is $\varepsilon_S = \varepsilon_N = \varepsilon > 0$, with ε typically between 0.3 and 0.6 in agricultural growth accounting.

3. Growth-rate representation

Taking logarithms of (1) within a regime and first-differencing gives

$$\Delta \ln Y_t = \Delta \ln A_t + \alpha \, \Delta \ln K_t + \eta \, \Delta \ln T_t + \varepsilon_t \, (\Delta \ln s_t + \Delta \ln N_t). \qquad (6)$$

When the economy switches regime between $t-1$ and t, the differenced term $\varepsilon_t \ln L_t - \varepsilon_{t-1} \ln L_{t-1}$ contains a level component; we absorb it, together with any regime-specific productivity drift, into a regime intercept (Section 3.5).

The data are measured as discrete percentage growth rates, $g_{X,t} \equiv 100 \, (X_t - X_{t-1}) / X_{t-1}$. A second-order Taylor expansion of $\ln(1 + x)$ around $x = 0$ gives

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$$100\,\Delta\ln X_t = 100\ln\left(1+\frac{g_{X,t}}{100}\right) = g_{X,t} - \frac{g_{X,t}^2}{200} + O\left(g_{X,t}^3\right). \qquad (7)$$

The approximation error is below 0.5 percentage points for $|g_{X,t}| \leq 10$ percent, which covers all observations of output, investment and modern-sector growth. For the employment share, whose growth rate ranges from −20.6 to +16.7 percent, the error is larger; it enters the composite disturbance and, being a function of $g_{s,t}^2$, is not systematically correlated with the sign of $g_{s,t}$. We therefore work with growth rates directly, as in the original BPS series, and note that this choice also guarantees stationarity of all regressors (Section 4.1).

4. Capital accumulation and the investment proxy

The regency does not publish an agricultural capital stock; we observe gross fixed capital formation (*Pembentukan Modal Tetap Bruto*, PMTB), I_t. Suppose a fraction θ of investment augments the capital relevant to agriculture (irrigation, roads, storage, machinery) and capital depreciates at rate d:

$$K_t = (1-d)K_{t-1} + \theta I_t. \qquad (8)$$

Iterating backward, $K_t = \theta \sum (1-d)j\ j{\geq}0\ I_{t-j}$. If investment grows at a constant rate g, so that $I_{t-j} = I_t(1+g)^{-j}$, then

$$K_t = \theta I_t \sum_{j\geq 0} \left(\frac{1-d}{1+g}\right)^j = \theta I_t \frac{1+g}{g+d}, \qquad (9)$$

which shows that K_t is proportional to I_t along a balanced path and therefore $\Delta\ln K_t = \Delta\ln I_t$. Away from the balanced path we write $\Delta\ln K_t = \Delta\ln I_t + v_t$, where v_t is a transitory deviation that enters the disturbance. The coefficient on investment growth thus identifies α, attenuated towards zero to the extent that v_t is noise.

5. Land, the modern sector and productivity

Modern-sector growth $g_{M,t}$ affects agriculture through two channels. Land and water conversion reduces the effective land input,

$$\Delta\ln T_t = \tau - \phi\, g_{M,t} + \xi_t, \qquad \phi \geq 0, \qquad (10)$$

while linkages (demand, inputs, remittances and spillovers) and regime-specific forces raise TFP,

$$\Delta\ln A_t = a + \lambda D_t + \psi\, g_{M,t} + \nu_t, \qquad \psi \geq 0. \qquad (11)$$

The parameter λ captures any productivity drift specific to the high-share regime, for instance an extensive margin of cultivation that is still open, or a younger and more able farm workforce before selective out-migration. Total employment grows at $\Delta\ln N_t = n + \omega_t$.

6. The estimable threshold equation

Substituting (5), (8)–(11) into (6) and collecting terms yields

$$\begin{aligned} g_{Y,t} = {} & \underbrace{(a + \eta\tau + \varepsilon_N n)}_{\breve{\beta}_0} + \underbrace{[\lambda + (\varepsilon_S - \varepsilon_N)\, n]}_{\breve{\delta}} D_t + \underbrace{\varepsilon_N}_{\breve{\beta}_1} g_{s,t} + \underbrace{(\varepsilon_S - \varepsilon_N)}_{\breve{\beta}_5} D_t\, g_{s,t} \\ & + \underbrace{\alpha}_{\breve{\beta}_2} g_{I,t} + \underbrace{(\psi - \eta\phi)}_{\breve{\beta}_3} g_{M,t} + u_t, \end{aligned} \qquad (12)$$

with composite disturbance $u_t = v_t + \eta\xi_t + \varepsilon_t\omega_t + \alpha v_t + r_t$, where r_t collects the approximation error in (7). Equation (12) is the general model. Three features deserve emphasis.

First, the coefficient on modern-sector growth is a *net* effect, $\beta_3 = \psi - \eta\phi$. A negative estimate does not reveal the size of either channel, but it does reveal that land and resource competition ($\eta\phi$) outweighs linkages (ψ). This gives a precise meaning to the term "crowding out".

Second, the regime intercept δ combines a pure productivity shift λ with the difference in labour elasticities scaled by employment growth. When the labour elasticity is common across regimes ($\beta_5 = 0$), $\delta = \lambda$ is the growth premium of the high-share regime that is not explained by labour, capital or the modern sector.

Third, u_t is a sum of shocks to productivity, land, employment and capital measurement, so serial correlation and heteroskedasticity are to be expected *a priori*. This motivates HAC inference regardless of the outcome of pre-tests.

7. Nested specifications

Mapping g_Y = G_PDRB_AGRI, g_s = G_TK_AGRI, g_I = G_PMTB and g_M = G_PDRB_MODERN, the original three specifications and three extensions are nested in (12):

$$\text{M1 (linear):}\quad g_{Y,t} = \beta_0 + \beta_1 g_{s,t} + \beta_2 g_{I,t} + \beta_3 g_{M,t} + u_t \qquad (13)$$

$$\text{M2 (interaction):}\quad g_{Y,t} = \beta_0 + \beta_1 g_{s,t} + \beta_2 g_{I,t} + \beta_3 g_{M,t} + \beta_4 \left(g_{s,t} \times g_{I,t}\right) + u_t \qquad (14)$$

$$\text{M3, M4 (threshold):}\quad g_{Y,t} = \beta_0 + \beta_1 g_{s,t} + \beta_2 g_{I,t} + \beta_3 g_{M,t} + \delta\, \mathbb{1}(s_t > \gamma) + u_t \qquad (15)$$

$$\text{M5 (regime-specific labour slope):}\quad (15) + \beta_5\, \mathbb{1}(s_t > \gamma)\, g_{s,t} \qquad (16)$$

In M2, the interaction term arises if the capital elasticity depends on labour dynamics, $\alpha_t = \alpha_0 + \kappa\, g_{s,t}$, so that $\beta_4 = \kappa$; $\kappa > 0$ indicates complementarity and $\kappa < 0$ substitution or congestion. M3 fixes γ at the sample median (45.9 percent), as in the earlier version of this study; M4

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estimates γ. M6 re-estimates M4 excluding 2020, which is numerically identical to adding an impulse dummy for that year. Under (16), the labour elasticity is β_1 in the low-share regime and $\beta_1 + \beta_5$ in the high-share regime.

8. Testable predictions

The framework translates the hypotheses into parameter restrictions. H1 (surplus labour) implies $\varepsilon_S = 0$; under the common-slope model M4 it implies $\beta_1 = 0$, against the neoclassical benchmark $\beta_1 \geq 0.3$. H2 (regime change)

implies $\delta \neq 0$ and/or $\beta_5 \neq 0$; the strict Lewis sequence, in which leaving the surplus regime raises the return to labour,

implies $\beta_5 < 0$. H3 implies $\beta_2 = \alpha > 0$. H4 concerns the sign of $\beta_3 = \psi - \eta\phi$. Finally, (2) and the estimated elasticity give a direct bound on the marginal product relative to the average product:

$$\frac{MPL_t}{APL_t} = \frac{\partial Y_t / \partial L_t}{Y_t / L_t} = \varepsilon_t. \qquad (17)$$

An elasticity of 0.05 means that the marginal farm worker adds five percent of what the average farm worker produces.

Methods

A. Data

We use annual data for Probolinggo Regency over 2010–2025, published by Statistics Indonesia (BPS) for the regency. Agricultural and modern-sector (secondary plus tertiary) GRDP are in constant 2010 prices (billion rupiah); investment is GRDP-side gross fixed capital formation; the agricultural employment share is from the August round of the National Labour Force Survey (Sakernas). All variables enter as annual growth rates, so 2010 serves as the base year and the effective sample is $T = 15$ (2011–2025). The threshold variable s_t enters in levels. Table 1 defines the variables and Table 2 reports descriptive statistics.

Table 1. Variable definitions

Symbol	Variable in data	Definition	Unit
gY	G_PDRB_AGRI	Growth of agricultural GRDP (constant prices)	%
gs	G_TK_AGRI	Growth of the agricultural share of employment	%
gI	G_PMTB	Growth of gross fixed capital formation	%
gM	G_PDRB_MODERN	Growth of secondary + tertiary GRDP (constant prices)	%
s	TK_AGRI	Agricultural share of employment (threshold variable)	%
D	DUMMY_THR	1 if $s_t > \hat{\gamma}$ (high-share regime), 0 otherwise	0/1

Source: BPS Kabupaten Probolinggo, various years.

Table 2. Descriptive statistics, 2011–2025

Variable	Mean	Std. dev.	Min	Max	Mean, high-share regime (n = 5)	Mean, low-share regime (n = 10)
gY	2.31	2.27	−2.04	7.55	4.24	1.34
gs	−1.52	10.18	−20.62	16.74	0.30	−2.43
gI	4.33	3.83	−4.52	11.68	5.64	3.68
gM	5.48	2.50	−3.10	7.87	6.16	5.15
s	47.55	6.11	39.00	59.10	55.07	43.78

Note: Regimes defined by the estimated threshold $\hat{\gamma} = 46.32$ percent (Section 5.3). The high-share regime comprises 2011–2015.

B. Threshold estimation

For any candidate γ, model (15) is linear in its slope parameters and can be estimated by OLS. Let $S_T(\gamma)$ denote the resulting sum of squared residuals. Following Hansen [12], the threshold is estimated by concentrated least squares:

$$\hat{\gamma} = \underset{\gamma \in \Gamma}{\operatorname{argmin}}\, S_T(\gamma). \qquad (18)$$

Because $S_T(\gamma)$ is a step function that changes only when γ crosses an observed value of s_t, the minimisation is exact when performed over the sample values of s_t. The search set Γ is trimmed so that each regime contains at least three observations (20 percent of the sample), which leaves ten candidate values.

C. Testing for a threshold

The null of linearity, H_0: $\delta = 0$, is tested with

$$F_T = T\,\frac{S_0 - S_T(\hat{\gamma})}{S_T(\hat{\gamma})}, \qquad (19)$$

where S_0 is the sum of squared residuals of the linear model M1. Under H_0 the threshold γ is not identified, so F_T is a supremum statistic with a non-standard distribution [13]. We obtain p-values by a fixed-regressor bootstrap with 5,000 replications: pseudo-dependent variables are generated from the M1 residuals (by i.i.d. resampling and, alternatively, by Rademacher wild weights robust to heteroskedasticity), and F_T is recomputed with a full grid search in each replication.

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D. Confidence set for the threshold

For inference on the location of the threshold we use the likelihood-ratio statistic

$$LR_T(\gamma) = T\,\frac{S_T(\gamma) - S_T(\hat{\gamma})}{S_T(\hat{\gamma})}, \qquad (20)$$

and collect all γ with $LR_T(\gamma) \le c(\varphi)$, where $c(\varphi) = -2\ln(1-\sqrt{1-\varphi})$ is the asymptotic critical value of Hansen [12]. At $\varphi = 0.95$, $c = 7.35$.

E. Inference on the slope coefficients

Given the composite error in (12), all models are estimated by OLS with Newey–West [20] HAC covariance:

$$\widehat{\mathrm{Var}}(\hat{\boldsymbol{\beta}}) = \frac{T}{T-k}\,(X'X)^{-1}\left[\hat{\Gamma}_0 + \sum_{j=1}^{m}\left(1 - \frac{j}{m+1}\right)\left(\hat{\Gamma}_j + \hat{\Gamma}_j'\right)\right](X'X)^{-1}, \qquad \hat{\Gamma}_j$$

$$= \sum_{t=j+1}^{T} \hat{u}_t\,\hat{u}_{t-j}\,x_t x_{t-j}', \qquad (21)$$

with Bartlett kernel and bandwidth $m = \lfloor 4(T/100)^{2/9} \rfloor = 2$; inference uses Student-t critical values with $T-k$ degrees of freedom. Because HAC estimators can be unreliable in samples of this size [21], we complement them with three checks: (i) wild-bootstrap-t p-values with Rademacher weights and 9,999 replications [22]; (ii) leave-one-out (jackknife) re-estimation to detect influential years; and (iii) bandwidths $m = 1$ and $m = 3$. Conditional on $\hat{\gamma}$, the slope estimators are asymptotically normal as if γ were known [12], so standard inference applies to δ and the β's.

F. Diagnostics

For each model we report the Jarque–Bera normality test, the Breusch–Pagan–Godfrey heteroskedasticity test, the Breusch–Godfrey LM test with two lags, the maximum variance inflation factor (VIF), and Ramsey's RESET test (squared fitted values) for functional form. Models M1–M3 were estimated in EViews 12 and replicated in Python (statsmodels); the threshold grid search, bootstrap tests and jackknife were implemented in Python.

Results and Discussion

A. Results

1. Stylised facts

Figure 1 summarises the structural setting. Panel (a) shows that the agricultural employment share fluctuated between 51 and 59 percent until 2015, then dropped sharply and has since oscillated between 39 and 46 percent. Agriculture's share of GRDP, by contrast, declined steadily throughout, so the gap between the two shares (the productivity gap) persisted across the whole period. Panel (b) shows the core fact that the econometrics must explain: agricultural growth averaged 4.24 percent per year in the high-share years and only 1.34 percent afterwards. In 2020 the employment share rebounded to 46.3 percent as workers returned from a contracting modern sector, yet agricultural output was flat (+0.02 percent).

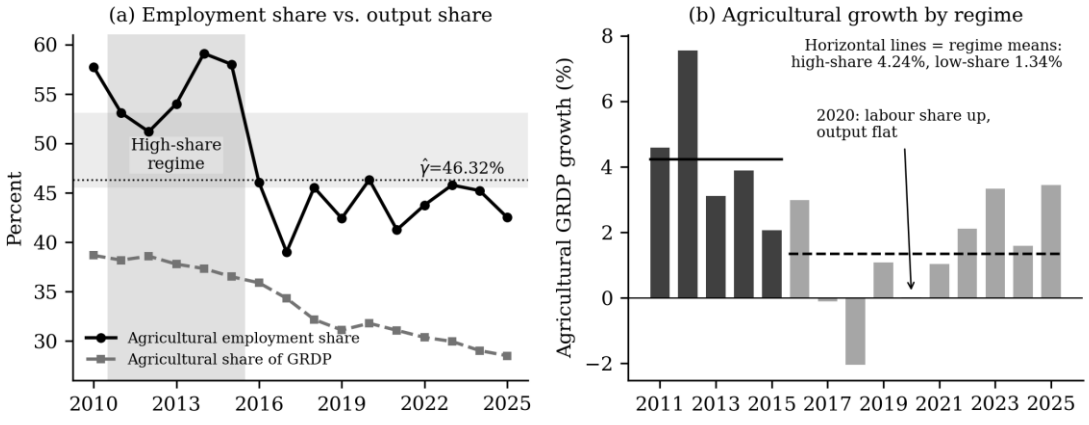


Figure 1. Employment share, output share and agricultural growth in Probolinggo, 2010–2025. Panel (a): the dotted line marks the estimated threshold and the light band its 95% likelihood-ratio confidence region; the grey column marks the high-share regime. Panel (b): dark bars are high-share years, light bars low-share years.

2. Diagnostic tests

Table 3 reports the diagnostics. Residuals are normal and homoskedastic in every specification, and no VIF exceeds 10. Two results are informative rather than routine. First, the linear model M1 fails the RESET test (p = 0.048): its functional form is rejected. Second, the residual autocorrelation detected in M1 and M2 (Breusch–Godfrey p = 0.028 and 0.027) disappears once the regime is modelled (p = 0.203 in M4). Serial correlation in the linear models is thus a symptom of an omitted regime, not an intrinsic feature of the data: the residuals of a linear fit are

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systematically positive in the early years and negative afterwards. Both findings point toward non-linearity before any threshold test is performed.

Table 3. Diagnostic tests

Test (statistic, p-value)	M1 Linear	M2 Interaction	M3 Median split	M4 Estimated threshold	M5 Regime slope	M6 Excl. 2020
Jarque–Bera	1.386 (0.500)	1.478 (0.478)	1.182 (0.554)	0.763 (0.683)	0.325 (0.850)	0.602 (0.740)
Breusch–Pagan–Godfrey	5.542 (0.136)	3.017 (0.555)	6.354 (0.174)	6.377 (0.173)	6.124 (0.294)	2.760 (0.599)
Breusch–Godfrey LM(2)	7.128 (0.028)	7.257 (0.027)	5.142 (0.076)	3.188 (0.203)	4.850 (0.089)	0.023 (0.988)
RESET, p-value	0.048	0.105	0.233	0.831	0.545	0.069
Max VIF	2.17	6.46	2.38	2.25	3.54	1.56

Note: Breusch–Pagan–Godfrey and Breusch–Godfrey statistics are $T \cdot R^2$ (χ^2). RESET uses squared fitted values (F-test).

3. Estimation results

Table 4 presents the estimates. Columns M1–M3 reproduce the original specifications; M4–M6 are the estimated-threshold models.

Table 4. OLS estimates with Newey–West HAC standard errors (dependent variable: g_Y)

Variable	M1 Linear	M2 Interaction	M3 Median split	M4 Estimated threshold	M5 Regime slope	M6 Excl. 2020
Constant	2.391**	1.461	0.617	**1.955****	2.244**	11.586***
	(0.987)	(1.694)	(1.270)	(0.859)	(0.882)	(2.280)
g_S (labour share)	−0.023	0.052	−0.022	**−0.050**	−0.068	0.006
	(0.065)	(0.122)	(0.060)	(0.050)	(0.049)	(0.021)
g_I (investment)	0.435**	0.350	0.351**	**0.339*****	0.482***	0.492***
	(0.184)	(0.268)	(0.139)	(0.091)	(0.129)	(0.128)
g_M (modern sector)	−0.365	−0.153	−0.153	**−0.384***	−0.551**	−2.034***
	(0.292)	(0.463)	(0.224)	(0.192)	(0.240)	(0.434)
$gs \times gI$		−0.016				
		(0.025)				
D (high-share regime)			2.096*	**2.754****	2.637**	2.394***
			(1.077)	(1.141)	(1.137)	(0.620)
$D \times gs$					0.174**	
					(0.069)	
Threshold γ (%)	—	—	45.91 (imposed)	**46.32** (estimated)	46.32	46.32
Observations	15	15	15	15	15	14
R^2	0.305	0.329	0.505	**0.618**	0.663	0.851
Adjusted R^2	0.115	0.061	0.307	**0.465**	0.476	0.785
Prob(F-statistic)	0.244	0.360	0.105	**0.033**	0.048	0.001
Akaike info. criterion	4.582	4.679	4.376	**4.116**	4.123	3.212
Schwarz criterion	4.770	4.915	4.612	**4.352**	4.406	3.440
SSR	50.32	48.56	35.84	**27.65**	24.36	9.96

Note: HAC standard errors (Bartlett kernel, bandwidth 2, small-sample correction) in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10 (Student-t, $T-k$ d.f.). M6 is numerically identical to M4 with an impulse dummy for 2020. In M5, the labour-share elasticity in the high-share regime is $\beta_1 + \beta_5 = 0.106$ (s.e. 0.053, p = 0.079).

Four results emerge.

Labour. The coefficient on the labour share is small and insignificant in all six specifications, ranging from −0.068 to 0.052. In the preferred model M4 it is −0.050 with a 95 percent confidence interval of [−0.161, 0.061]. The neoclassical benchmark $\beta_1 = 0.3$ is rejected decisively (t = −7.01, p < 0.001), and even $\beta_1 = 0.1$ is rejected (p = 0.013). By equation (17), the upper confidence bound implies that the marginal farm worker produces at most about six percent of the output of the average farm worker. H1 is supported.

Regime. Moving from the imposed median split (M3) to the estimated threshold (M4) raises the adjusted R^2 from 0.307 to 0.465, lowers both information criteria, and makes the regression jointly significant at the 5 percent level (p = 0.033). The regime coefficient is 2.754 (p = 0.037): conditional on labour, investment and the modern sector, agricultural growth was 2.75 percentage points per year higher in the high-share regime. Against a low-regime mean growth rate of 1.34 percent, this premium is large. H2 is supported, but the direction is the reverse of the conventional reading, a point developed in Section 6.2.

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Capital. Investment growth is positive in every model and significant in all but M2, with an elasticity of 0.339 in M4 (p = 0.004). A one-standard-deviation increase in investment growth (3.83 points) raises agricultural growth by about 1.3 percentage points, more than half of the sample mean. H3 is supported.

Modern sector. The modern-sector coefficient is negative in every specification: −0.384 in M4 (p = 0.073), −0.551 in M5 (p = 0.047) and −2.034 in M6 (p = 0.001). H4 is supported in the sense that $\psi - \eta\phi < 0$: land and resource competition outweighs linkages. The jump in magnitude when 2020 is excluded is examined in Section 5.5.

The interaction model M2 adds nothing: the interaction coefficient is −0.016 (p = 0.529), the adjusted R^2 falls to 0.061, and multicollinearity inflates the standard error on investment enough to render it insignificant. There is no evidence of capital–labour complementarity at the margin, which is exactly what one expects if the marginal product of labour is near zero: additional capital cannot raise the return to workers who are not contributing to output.

4. Threshold Inference

Table 5 and Figure 2 report the threshold tests. The concentrated least-squares estimate is $\hat{\gamma} = 46.32$ percent; observations with an employment share above this value form the high-share regime (2011–2015, $s_t \geq 51.18$). The sup-F statistic is 12.30. Its i.i.d. bootstrap p-value is 0.088 and its heteroskedasticity-robust wild-bootstrap p-value is 0.049. Linearity is rejected at the 10 percent level under both schemes and at the 5 percent level under the robust scheme. Given fifteen observations and a nuisance parameter that is not identified under the null, this is strong evidence.

The location of the threshold is estimated less precisely than its existence. The 95 percent LR confidence set is [45.53,53.08] plus an isolated point at 42.42. Substantively, the data locate the regime boundary somewhere between the mid-forties and the low fifties: the high-growth regime ended when agriculture ceased to employ roughly half of the workforce. The original median split of 45.9 percent lies inside the confidence set but is not the least-squares estimate, because it places 2016 and 2020 in the high-share regime even though both were low-growth years.

Table 5. Threshold estimation and tests (model M4)

Statistic	Value
Threshold estimate $\hat{\gamma}$ (agricultural employment share)	46.32%
High-share regime ($s_t > \hat{\gamma}$)	5 obs. (2011–2015)
Low-share regime ($s_t \leq \hat{\gamma}$)	10 obs. (2016–2025)
SSR, linear model S_0 / threshold model $S_T(\hat{\gamma})$	50.32 / 27.65
sup-F statistic F_T	12.30
Bootstrap p-value, i.i.d. residuals (5,000 reps.)	0.088
Bootstrap p-value, wild Rademacher (5,000 reps.)	0.049
Bootstrap critical values, i.i.d. (10% / 5%)	11.74 / 15.30
95% LR confidence set for γ (c= 7.35)	[45.53, 53.08] ∪ {42.42}

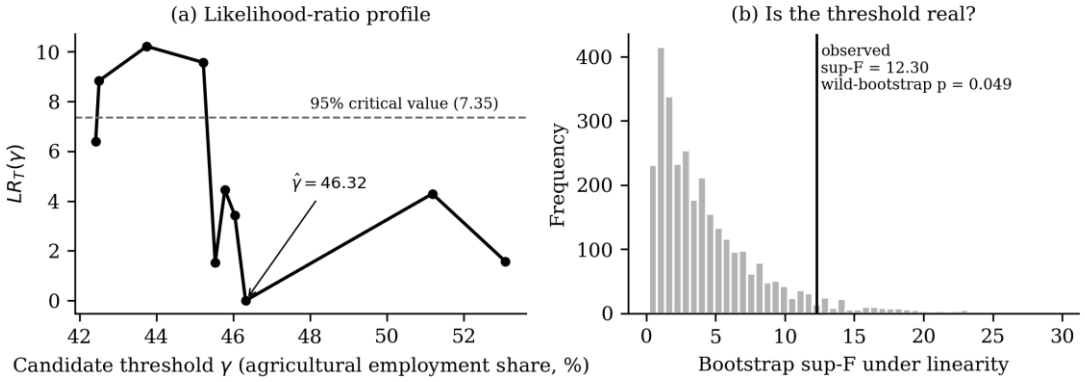


Figure 2. Threshold inference. Panel (a): likelihood-ratio profile $LR_T(\gamma)$ over candidate thresholds; values below the dashed line form the 95% confidence set. Panel (b): wild-bootstrap distribution of the sup-F statistic under linearity; the vertical line is the observed value.

5. Robustness

Table 6 and Figure 3 assess the stability of M4.

Table 6. Robustness of the preferred model (M4)

Check	g_s (labour)	g_I (investment)	g_M (modern)	D (regime)
Baseline M4, HAC p-value	0.339	0.004	0.073	0.037
Wild-bootstrap-t p-value (9,999 reps.)	0.608	0.048	0.254	0.053
HAC bandwidth m = 1, p-value	0.342	0.010	0.098	0.033
HAC bandwidth m = 3, p-value	0.334	0.004	0.062	0.031
Conventional OLS s.e., p-value	0.302	0.081	0.167	0.017
Jackknife range of coefficient	[−0.075, 0.046]	[0.162, 0.492]	[−2.034, −0.183]	[1.561, 3.208]

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Check	g_s (labour)	g_I (investment)	g_M (modern)	D (regime)
Lagged threshold variable s_{t-1} ($\hat{\gamma}$ = 42.42)	0.074 (0.166)	0.485 (0.003)	−0.635 (0.071)	4.164 (0.134)
Calendar break (D = 1 for 2011–2014)	−0.058 (0.261)	0.239 (0.120)	−0.286 (0.161)	3.140 (0.027)
Excluding 2020 (M6)	0.006 (0.787)	0.492 (0.004)	−2.034 (0.001)	2.394 (0.004)

Note: Rows 6–8 report coefficients with HAC p-values in parentheses. The jackknife row reports the minimum and maximum of each coefficient across the 15 leave-one-out samples.

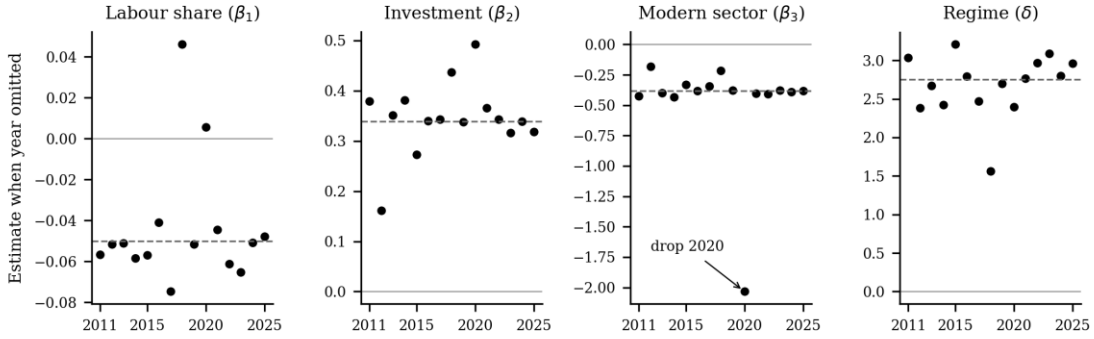


Figure 3. Jackknife stability of the M4 coefficients. Each point is the estimate obtained when the indicated year is omitted; the dashed line is the full-sample estimate.

Four patterns stand out. First, the labour coefficient never leaves a narrow band around zero; no single year can make it economically meaningful. Second, the investment and regime coefficients keep their sign in every leave-one-out sample, and their wild-bootstrap p-values (0.048 and 0.053) confirm that significance does not hinge on the HAC approximation. Third, the modern-sector coefficient is negative in every sample but its magnitude depends heavily on 2020: dropping that year moves it from −0.38 to −2.03. In 2020 the modern sector contracted by 3.1 percent because of pandemic restrictions, not because land and water were released to farming, so the year contributes an observation with low g_M and flat g_Y that flattens the estimated slope. Since the land-competition mechanism in (10) operates through the *expansion* of the modern sector, M6 arguably measures the structural effect more accurately; we nevertheless treat −0.38 as the conservative estimate. Because modern-sector growth in normal years varies only between 4.4 and 7.9 percent, the large M6 constant (11.6) is an extrapolation outside the support of the data and should not be interpreted. Fourth, the regime premium is robust in sign to a lagged threshold variable (which addresses the simultaneity of s_t and $g_{Y,t}$), though it is less precisely estimated (p = 0.134) and the threshold moves to 42.4 percent.

The calendar-break row requires a candid comment. A dummy for 2011–2014 fits slightly better than the estimated threshold (SSR 27.09 versus 27.65), and the estimated threshold regime itself coincides with 2011–2015. With fifteen annual observations, a regime indexed by the employment share and a structural break in the calendar are close to observationally equivalent. We retain the threshold specification because it is economically interpretable and nests the theory in Section 3, but we read the regime as a *structural era indexed by the labour share* rather than as a switch that can be flipped back and forth. The 2020 observation supports this reading: when the employment share returned to the threshold, the growth premium did not return with it.

B. Discussion

1. A falling labour share is not a turning point

The central finding is that the marginal contribution of the agricultural labour share to agricultural growth is zero, in both regimes and in every robustness check. In the framework of Section 3, this is the defining property of a Lewis surplus: workers enter and leave agriculture without measurable effects on output, because they are not at the productive margin. The finding holds even though the employment share fell by fifteen percentage points over the sample. The decline in the share is therefore not evidence that the turning point has been reached; it is consistent with a surplus that is being drained without being exhausted, or with a surplus that is regenerated whenever the modern sector stumbles.

The 2020 episode is a natural experiment in this respect. When pandemic restrictions caused the modern sector to contract, the agricultural employment share rose by 9.2 percent, a large inflow of labour into farming. Agricultural output growth was +0.02 percent. Labour arrived; output did not respond. This is the textbook behaviour of agriculture as a residual employer, the "sponge" that absorbs workers whom the modern sector cannot keep. It mirrors evidence from Sub-Saharan Africa that labour movements between sectors are often driven by turbulence rather than productivity [19], and Gollin's observation that a falling agricultural labour share is frequently not accompanied by commensurate productivity gains [1].

A caveat is warranted. The regency employment share is a survey estimate, and its year-to-year swings (−20.6 percent in 2016, +16.7 percent in 2018) almost certainly contain sampling noise. Classical measurement error in g_s attenuates β_1 toward zero. However, attenuation scales the true coefficient by the reliability ratio and cannot change its sign. For a true elasticity of 0.3 to be consistent with our upper confidence bound of 0.061, more than 80 percent of the variance of g_s would have to be noise. That is possible but implausible, and it would leave the qualitative conclusion unchanged: on the available evidence, there is no sign of a positive marginal product.

2. Exit without take-off

The regime result is the paper's most counter-intuitive finding and requires careful interpretation. In the textbook sequence, crossing below the threshold should mark the moment when labour becomes scarce, wages rise, mechanisation is induced and agricultural productivity accelerates. Probolinggo experienced the opposite: once the employment share fell below the threshold region, agricultural growth slowed by about 2.75 percentage points per year, conditional on investment and the modern sector.

Section 3 tells us what the regime coefficient can and cannot mean. Under the common-slope model it equals λ, a productivity drift specific to the high-share era. Three mechanisms can generate a positive λ and are consistent with near-zero marginal labour elasticities.

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The first is *selective exit*. Out-migration from agriculture is not random: younger, better-educated and more entrepreneurial workers leave first. If the regime shift coincided with this selective outflow, the remaining farm workforce became older and less adaptable. Each marginal departure has no measurable output effect, but the cumulative compositional change lowers the trend of farm productivity. This is the heterogeneity and selection mechanism emphasised by Gollin and Udry [23].

The second is the *closing of the extensive margin*. In the early 2010s, agricultural growth could still come from bringing additional land into intensive cultivation, double-cropping and expanding high-value horticulture. As this margin closes, growth must come from intensification, which requires capital and know-how that were not forthcoming at the same pace.

The third is *land conversion*. The modern sector's net drag in our estimates operates year by year through g_M, but cumulative conversion of the most productive lowland plots near urban centres can lower the productivity trend in a way that a contemporaneous growth rate does not capture.

What the evidence rules out is the optimistic interpretation that labour left because farming had become productive enough to release it. Had that been the case, the labour elasticity would have turned positive in the low-share regime. Instead it remained at zero, and M5 suggests it became, if anything, slightly negative (−0.068, p = 0.20). Probolinggo's farm workforce left without a take-off.

3. Capital is the binding constraint

Investment is the only variable that robustly raises agricultural growth, with an elasticity of 0.34 that survives every check. This accords with the Solow prediction and with Indonesian evidence that physical capital, not labour, drives growth [11], [14]. It also follows directly from the surplus-labour result. When the marginal product of labour is near zero, output can only grow through the inputs that are at the margin, namely capital and land, and through TFP.

The original version of this study interpreted the negative interaction coefficient in M2 as evidence of a skill mismatch: capital injected into a workforce that cannot operate it efficiently. The estimates do not support so strong a claim. The interaction coefficient is small (−0.016), statistically indistinguishable from zero (p = 0.53), and adding it worsens every measure of fit. What the data say is narrower: there is no detectable complementarity between capital and labour-share dynamics. The skill-mismatch hypothesis remains plausible, and is consistent with field evidence on low technology adoption [19], but testing it requires farm-level data on human capital and machinery use. We therefore present it as a hypothesis for future research rather than as a finding.

4. The modern sector: neighbour or predator?

The modern-sector coefficient is negative in every specification. By equation (12), this means that the land- and water-competition channel ($\eta\phi$) outweighs the linkage channel (ψ). In normal (non-pandemic) years, the estimates imply that each additional percentage point of modern-sector growth is associated with between 0.4 and 2.0 percentage points lower agricultural growth. The modern sector in Probolinggo, which includes power generation, manufacturing, trade and tourism along the northern coastal corridor, has expanded in ways that compete with agriculture for space and water rather than drawing it into higher-value supply chains. This is consistent with the regional evidence of Halim et al. [7] and Suparman and Muzakir [10] that Indonesian structural transformation has often been uneven and spatially extractive, and with Rodrik's [8] broader warning about transformations that bypass the agricultural sector rather than upgrading it.

Two qualifications apply. The coefficient is a net effect, so it does not show that linkages are absent, only that they are weaker than competition. And because the coefficient is sensitive to the pandemic year, its precise magnitude is uncertain; the sign is not.

5. From employer to shelter

Model M5 allows the labour elasticity to differ across regimes. The difference is statistically significant (0.174, p = 0.032). In the high-share regime the elasticity is 0.106 (p = 0.079); in the low-share regime it is −0.068 (p = 0.20). Neither is large, and with five observations in the high regime the result should be read as suggestive. Its pattern is nonetheless revealing. Before the threshold, changes in the farm labour share moved weakly *with* agricultural output, as one would expect if labour responded to farm opportunities. After the threshold, they moved weakly *against* it: labour flowed into agriculture in bad years (2018, 2020) and out in good years. The sign of the relationship changes from pro-cyclical to counter-cyclical, which is the signature of a sector that has become a shelter rather than an employer of choice.

This is the reverse of the strict Lewis prediction ($\beta_5 < 0$). Rather than leaving the surplus regime and entering a regime in which labour is productive, Probolinggo seems to have moved from a regime in which farm labour was weakly responsive to opportunity to one in which it is driven by distress. In that sense the low-share regime is not post-Lewis at all. It is a regime in which surplus labour is periodically *regenerated* by shocks to the modern sector.

6. Probolinggo in comparative perspective

The debate over whether China has passed its Lewis turning point illustrates how easily a falling agricultural labour share can be mistaken for the turning point itself [15]. Our results suggest that the same caution applies to Indonesian regions. The productivity gap literature [2] shows that the gap between agricultural and non-agricultural labour productivity narrows only when labour leaves agriculture *and* the remaining farm workforce becomes more productive. In Probolinggo the first condition has been partly met; the second has not. The regency thus resembles the pattern McMillan et al. [9] document for economies in which structural change fails to raise aggregate productivity because labour moves out of agriculture into activities, or back into agriculture, without a productivity gain.

Policy implications

The findings imply five priorities for the Probolinggo Regency Government and for regional planners more generally.

First, stop treating a falling agricultural employment share as a success indicator. The share has fallen, but the marginal economics of farm labour have not changed. Planning documents should monitor indicators that bear directly on the turning point, such as real rural wages, the farm–non-farm wage gap and labour productivity per worker, rather than the employment share alone.

Second, make capital deepening the core of agricultural policy. Investment is the only robust driver of farm growth. Priority should go to capital that raises land productivity: small reservoirs (*embung*) and irrigation rehabilitation to stabilise dry-season output, farm roads (*jalan usaha tani*) to reduce logistics costs, and post-harvest storage and processing. Mechanisation programmes should be paired with operator training and maintenance support at the farmer-group level. This is a prudent design choice given the plausibility of skill constraints, even though our data cannot test them directly.

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Third, enforce farmland protection. The modern sector's net drag on agriculture runs through land and water competition. Strict enforcement of Sustainable Food Agricultural Land (*Lahan Pertanian Pangan Berkelanjutan*, LP2B) designations, especially for irrigated lowland plots near the northern coastal corridor, and water-allocation rules that protect irrigation during the dry season would directly reduce ϕ.

Fourth, convert competition into linkages. The same equation shows that strengthening ψ is as effective as reducing ϕ. Agro-industrial clusters that process local produce (mango, shallot, grapes, fisheries and horticulture) would turn the modern sector from a competitor for land into a buyer of farm output.

Fifth, recognise agriculture's role as a shock absorber. The 2020 episode shows that farming absorbs workers displaced from the modern sector. This function has social value but it is not productive employment. Adaptive social protection and short-term employment programmes during downturns would relieve farms of the burden of acting as an informal safety net, and would prevent temporary inflows from depressing farm productivity.

Conclusion

This paper has asked whether Probolinggo's declining agricultural employment share signals that the regency has passed its Lewis turning point. By deriving the estimating equations from a land-constrained production function with a regime-dependent labour elasticity, estimating the threshold rather than imposing it, and testing the results against small-sample alternatives, we reach a clear answer: it has not.

Three findings support this conclusion. The marginal contribution of the agricultural labour share to agricultural growth is statistically zero and decisively below neoclassical values, so the defining feature of surplus labour persists. The economy did cross a threshold, located at an employment share between roughly 46 and 53 percent, but crossing it was followed by slower rather than faster agricultural growth. And the only robust engine of agricultural growth is physical investment, while modern-sector expansion competes with agriculture rather than pulling it forward. Labour has left the farm, but the farm has not taken off.

The study has limitations that also point to future research. The effective sample of fifteen annual observations limits statistical power and makes the threshold observationally close to a calendar break. The regency-level employment share is noisy, which attenuates the labour coefficient. The investment variable is regency-wide rather than sector-specific. And the mechanisms behind the regime premium (selective exit, the closing extensive margin and land conversion) are inferred rather than directly observed. A panel of East Java regencies would allow the threshold to be identified from cross-sectional as well as temporal variation and would separate the regime from the calendar. Combining such a panel with farm-level data on age, education, machinery use, land conversion and rainfall variability [24] would allow each mechanism to be tested directly. Until then, the evidence counsels against reading the shrinking farm workforce as a sign that the hardest part of structural transformation is over.

Conflict of Interest Statement

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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