ANNALS OF ECONOMICS AND FINANCE **27-1**, 27–60 (2026)

The Service Paradox: Structural Transformation as a Growth Drag in Modern Economies

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This paper investigates how structural transformation influences long-run economic growth in the era of service-sector dominance. We develop a two-sector Solow model in which learning-by-doing enhances industrial productivity while service productivity remains stagnant. Using panel data for 183 countries from 1961 to 2019, we find that a one-percentage-point increase in the industrial share of value added raises per capita GDP growth by 0.026 percentage points. Mechanism analyses show that industrialization accelerates productivity, raises interest rates, and improves labor efficiency. The growth effects are stronger in richer economies, countries with smaller labor forces, and those with lower agricultural employment. These results indicate that industrial development remains essential for sustaining long-run growth and productivity convergence, even as economies transition toward services. The study bridges classical structural transformation theory with modern empirical evidence, offering new insights into post-industrial growth dynamics.

Key Words: Structural transformation; Economic growth; Industrialization; Service sector.

JEL Classification Numbers: O11, O14, O33, O41, O47.

1. INTRODUCTION

How does structural transformation influence long-run economic growth? This question has become increasingly important as economies shift from industrial production to service-sector dominance. Cross-country evidence shows that development typically proceeds from agriculture to industry and then to services (Clark, 1940; Fisher, 1939; Chenery, 1960; Jorgenson, 1961; Lewis et al., 1954; Rosenstein-Rodan, 1943; Ranis and Fei, 1961; Kuznets,

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1529-7373/2026

1973; Herrendorf et al., 2014). Early theories viewed this transition as both a hallmark and a driver of growth (Rostow, 1960; Chenery, 1960, 1975; Kuznets, 1973). Recent studies, however, show that the shift toward services coincides with slower productivity growth, raising concerns about whether structural change supports sustained economic performance.

Our central objective is to determine whether the global shift from industry to services systematically reduces growth and whether this pattern reflects transitional dynamics or deeper structural constraints. To address this question, we examine how and through which mechanisms structural transformation affects long-run growth, focusing on the compositional shift from industry to services that increasingly characterizes modern economies. Despite the growing importance of services, the macroeconomic consequences of this transition remain unclear. We combine a theoretical model of endogenous productivity dynamics with a comprehensive empirical analysis using a global panel of 183 countries from 1961 to 2019. We test whether the decline of industry and the expansion of services systematically reduce growth and provide a causal assessment of deindustrialization.

This paper contributes to the literature in three ways. First, we provide a unified framework that integrates Baumol's cost disease with sector-specific learning dynamics, offering a structural explanation for observed growth slowdowns. Second, we present new cross-country evidence showing that a rising services share reduces per capita GDP growth, whereas a rising industrial share raises it. Third, we highlight the implications for income convergence by linking structural transformation to divergent growth paths across development stages.

The idea that rising services shares depress growth originates in Baumol's cost disease theory (Baumol, 1986, 1967; Herrendorf et al., 2014). The theory argues that low-productivity services absorb labor and raise relative prices even as their output stagnates, thereby depressing aggregate productivity (Van Neuss, 2019). Yet this correlation may reflect income convergence rather than causality, and most existing work does not explain how sectoral shifts translate into aggregate growth outcomes. Since the growth drag is primarily a result of resource reallocation, the literature offers several explanations, including technology-driven price changes (Ngai and Pissarides, 2007), income-driven demand shifts (Kongsamut et al., 2001), capital accumulation patterns (García-Santana et al., 2021; Herrendorf et al., 2021), and trade-based comparative advantage (Matsuyama, 1992). Few, however, link these mechanisms directly to long-run growth.

Our analysis proceeds in two stages. First, we extend the Solow framework into a general equilibrium model with sector-specific learning dynamics. In particular, we introduce a learning-by-doing mechanism whereby industrial productivity rises with cumulative experience and capital accumulation. This feature allows productivity to evolve endogenously, producing non-balanced growth paths that match the observed deceleration of both sectoral and aggregate output as economies move from industry to services. Unlike models with exogenous productivity or balanced growth, our framework generates endogenous slowdowns, offering a plausible mechanism for growth plateaus in service-heavy economies.

Second, we test the model's predictions empirically. Using panel data and fixed effects as our baseline, we show that reallocation from industry to services reduces growth. A one-percentage-point increase in the industrial share is associated with a 0.026-percentage-point increase in real GDP per capita growth. These results hold across instrumental variable (IV) regressions, system GMM estimators, weighted least squares, and robustness checks. Mechanism analysis shows that industrialization is positively associated with sectoral productivity growth, interest rates, and labor productivity — consistent with capital deepening and relative price channels. We also find heterogeneity across development stages: industrialization has stronger growth effects in high-income economies, in countries with smaller labor forces, and where agriculture contributes less to value added. These results support a structural interpretation: declining growth in service-led economies reflects deeper productivity constraints shaped by sectoral composition.

Our work contributes to the debate on the relationship between structural transformation and long-run growth. We extend the classic learning-by-doing framework (Arrow, 1962) into a multi-sector model where sectoral productivity growth arises endogenously from capital accumulation and production experience. This design moves beyond two-sector models with exogenous or constant productivity growth (Baumol, 1967; Ngai and Pissarides, 2007; Boppart, 2014). By combining Baumol-type productivity differences with capital elasticity (Acemoglu and Guerrieri, 2008) in a unified dynamic model, we capture transitional dynamics and explain observed slowdowns in service economies. We test this framework with a global panel of over 100 countries from 1960 to 2019, examining mechanisms through interest rates, productivity, and relative prices.

More broadly, we contribute to the literature on structural transformation, which highlights sectoral reallocation and technical progress as key drivers of change (Herrendorf et al., 2014, 2015). We add to this by introducing heterogeneous learning-by-doing, showing that higher learning returns in industry provide a novel channel through which the expansion of services suppresses aggregate growth. Our model aligns with research on capital intensity (Acemoglu and Guerrieri, 2008), elasticity of substitution (Alvarez-Cuadrado et al., 2017) , non-homothetic preferences (Kongsamut et al., 2001; Matsuyama, 2002; Foellmi and Zweimüller, 2008; Buera and Kaboski, 2012; Alonso-Carrera et al., 2015; Hori et al., 2015; Comin et al., 2021), and trade-induced reallocation (Matsuyama, 2009; Uy et al., 2013), household service marketization (Ngai and Pissarides, 2008), factor endowments (Jin, 2012; Ju and Wei, 2007), human capital accumulation (Caselli and Coleman II, 2001; Porzio et al., 2022), and production linkages (Sposi, 2019), thereby providing a multifaceted and dynamic perspective on the causes and consequences of structural transformation.

Given our global coverage, we also extend evidence beyond advanced economies (Hartwig, 2012; Maroto-Sánchez and Cuadrado-Roura, 2009) or correlational studies (Moro, 2015) . Using dynamic panel estimators, we show that rapid industrial decline systematically slows per capita GDP growth, consistent with McMillan et al. (2014). Finally, we highlight the implications for income convergence: the rising service share in advanced economies contributes to growth slowdowns and divergent development paths, linking structural change to global income disparities (Barro and Sala-i-Martin, 1992).

The remainder of the paper is structured as follows. Section 3 develops the theoretical model. Section 4 describes the data and empirical strategy. Section 5 presents the main results, including robustness and heterogeneity analyses. Section 6 concludes.

2. THEORETICAL FRAMEWORK

We embed structural change in a standard Solow growth framework without population growth, featuring two sectors: industry and services. Industrial output, can be used for both consumption and investment, whereas services, are non-investment goods. Households derive utility from a fixed, Leontief-type basket of the two consumption goods, reflecting empirical evidence that consumers maintain relatively stable consumption shares across sectors (Baumol, 1967).

2.1. Utility function and household behavior

Individual preferences are represented by:

$$u(c_m(t), \gamma c_s(t)) = \min\{c_m(t), \gamma c_s(t)\} \tag{1}$$

where $c_m(t)$ and $c_s(t)$ denote per-capita consumption of industrial and service goods at time t, respectively, and the parameter $\gamma > 0$ captures the fixed proportion in which these goods enter utility.

Households supply one unit of labor inelastically each period and receive wage income $w(t)$ and capital income $r(t)a(t)$, where $a(t)$ denotes period-t asset holdings and $r(t)$ is the rental rate of capital. We normalize the price of industrial goods to unity and denote the relative price of services by $P_s(t)$. Following the Solow tradition, we assume a constant, exogenous saving rate $v \in (0, 1)$. The household's budget constraint can then be written as:

$$c_m(t) + P(t)c_s(t) = (1 - v)[\omega(t) + r(t)a(t)] \tag{2}$$

where $(1 - v)$ is the share of income devoted to consumption. Given that the savings rate v is exogenously determined, the individual's optimization problem at any time t can be formulated as:

$$\max_{c_m(t), c_s(t)} : u(c_m, \gamma c_s) = \min\{c_m(t), \gamma c_s(t)\}$$
$$s.t. : c_m(t) + P_s(t)c_s(t) = (1 - v)[\omega(t) + r(t)a(t)]$$

Given the Leontief specification, households optimally adjust $c_m(t)$ and $c_s(t)$ to satisfy the fixed proportion. Substituting the binding constraint $c_m(t) = \gamma c_s(t)$ into Eq. 2 and solving for consumption yields the intra-temporal condition:

$$c_m(t) = \gamma c_s(t) \tag{3}$$

Eq. 3 confirms that consumption of industrial and service goods maintains the fixed Leontief ratio γ, and that a larger value of γ raises the relative weight of industrial goods in the consumption bundle. This simple structure will facilitate our subsequent analysis of how sectoral prices and income dynamics determine sectoral output shares and aggregate growth.

2.2. Production functions and firm behavior

We assume an economy populated by two representative firms, one producing industrial goods and the other producing services. Both firms operate under perfect competition in goods and factor markets, employing labor and capital as inputs. Industrial output serves both consumption and investment purposes, while service output is exclusively consumed.

To introduce sectoral heterogeneity in technological progress, we endogenize productivity growth in the industrial sector via a learning-by-doing mechanism(Arrow, 1962; Stokey, 1988; Romer, 1986). By contrast, we assume that the service sector experiences no endogenous technological change.[1] This study resonates with emerging theories of production-centered growth that emphasize endogenous learning, industrial autonomy,

[1]Duarte and Restuccia (2010) find that increases in industrial productivity account for approximately 50 percent of cross-country total factor productivity growth, while the persistently low productivity in services explains the observed economic stagnation in many countries. Herrendorf et al. (2014) calculate average total factor productivity growth rates for agriculture, industry, and services between 1970 and 2007 across ten European countries, Australia, Canada, and the United States, finding that agriculture exhibited the fastest growth while services grew the slowest. Using postwar U.S. data on sectoral output, capital, and labor, Herrendorf et al. (2015) further demonstrate that labor-augmenting technological progress was fastest in agriculture, followed by manufacturing, with the slowest growth occurring in services.

and the cumulative nature of national capability (Zou, 2025a). Accordingly, the industrial production function takes a Harrod-neutral Cobb-Douglas form:

$$Y_m(t) = K_m(t)^\alpha (A(t)L_m(t))^{1-\alpha} \tag{4}$$

where $Y_m(t)$ is industrial output, $K_m(t)$ and $L_m(t)$ are capital and labor inputs, $\alpha \in (0,1)$ is the capital share, and $A(t)$ denotes labor-augmenting technology. Consistent with learning-by-doing, labor efficiency A(t) evolves as a positive function of the cumulative industrial capital stock:

$$A(t) = K_m(t) \tag{5}$$

Firms in the industrial sector maximize profits $\Pi_m(t) = Y_m(t) - r(t)K_m(t) - w(t)L_m(t)$. The first-order conditions with respect to $K_m(t)$ and $L_m(t)$ yield:

$$r(t) = \alpha K_m(t)^{\alpha-1}(A(t)L_m(t))^{1-\alpha} = \alpha A(t)^{1-\alpha} k_m(t)^{\alpha-1} \tag{6}$$

$$\omega(t) = (1-\alpha)A^{1-\alpha}(t)k_m^\alpha(t) \tag{7}$$

where $k_m(t) = K_m(t)/L_m(t)$ is the industrial capital-labor ratio.

In the service sector, we posit a standard Cobb-Douglas production function without endogenous technical change[2]:

$$Y_s(t) = K_s(t)^\alpha L_s(t)^{1-\alpha} \tag{8}$$

where $Y_s(t)$, $K_s(t)$, and $L_s(t)$ represent output, capital input, and labor input in the service sector, respectively. For tractability, we assume the same capital share α in both sectors. Although allowing for sector-specific capital elasticities would increase computational complexity, it would not alter the model's core conclusions. For an analysis of structural change with heterogeneous capital elasticities, see Acemoglu and Guerrieri (2008).

Profit maximization then implies:

$$r(t) = \alpha P_s(t)K_s(t)^{\alpha-1}L_s(t)^{1-\alpha} = \alpha P_s(t)k_s(t)^{\alpha-1} \tag{9}$$

[2]To simplify the analysis, this paper assumes that both sectors share the same elasticity of output with respect to capital. Although allowing for distinct production functions across sectors would complicate the calculations substantially, it would not affect the main conclusions. Acemoglu and Guerrieri (2008) analyze structural economic changes under the assumption of heterogeneous capital-output elasticities across sectors. Indeed, differences in sectoral capital-output elasticity are not considered the major driver of structural change (Herrendorf et al., 2015). Moreover, Ngai and Pissarides (2007) study structural change in a model with only sectoral TFP growth rate differences, suggesting that our simplification is reasonable.

$$\omega(t) = (1-\alpha)P_s(t)K_s(t)^\alpha L_s^{-\alpha}(t) = (1-\alpha)P_s(t)k_s(t)^\alpha \tag{10}$$

where $k_s(t) = K_s(t)/L_s(t)$ denotes the service sector capital-labor ratio.

Finally, we assume a constant total labor supply $L(t) = 1$. This normalization simplifies aggregation of sectoral labor demands and allows focus on the dynamics of $k_m(t)$, $k_s(t)$, and $A(t)$ in determining the evolution of output shares and aggregate growth.

2.3. General equilibrium and dynamic behavior of the economy

In this section we close the model by specifying market clearing conditions and deriving the dynamics of aggregate capital, sectoral output, relative prices and factor returns. Because output of services is for consumed only, equilibrium in the service market requires:

$$Y_s(t) = c_s(t) \tag{11}$$

Industrial output is allocated between consumption and investment, so industrial market clearing implies:

$$Y_m(t) = c_m(t) + \dot{K}(t) \tag{12}$$

In the capital market, total capital supplied by households must equal the sum of sectoral capital stocks:

$$K(t) = K_s(t) + K_m(t) = a(t)L(t) = a(t) \tag{13}$$

and in the labor market the fixed labor endowment $L(t) = 1$ is allocated across the two sectors:

$$L_s(t) + L_m(t) = L(t) = 1 \tag{14}$$

Based on the optimal conditions of industrial goods producers (Eqs. 6-7) and service goods producers (Eqs. 9-10), it follows that:

$$\frac{r(t)}{\omega(t)} = \frac{\alpha k_m(t)^{\alpha-1}A(t)^{1-\alpha}}{(1-\alpha)k_m^\alpha(t)A(t)^{1-\alpha}} = \frac{\alpha}{(1-\alpha)k_m^\alpha(t)} = \frac{\alpha k_s(t)^{\alpha-1}}{(1-\alpha)k_s^\alpha(t)} = \frac{\alpha}{(1-\alpha)k_s(t)}$$

Profit maximization in both sectors (Eqs. 6-7 for industry and Eqs. 9-10 for services) together with common factor prices imply that the marginal product conditions cannot hold at different capital-labor ratios. Hence:

$$k_s(t) \equiv K_s(t)/L_s(t) = k_m(t) \equiv K_m(t)/L_m(t) = k(t) \equiv K(t)/L(t) = K(t) \tag{15}$$

We state this formally:

Property 1. At each date t, the capital-labor ratio in both sectors equals the economy-wide capital per worker.

Because $k_m(t)$ and $k_s(t)$ coincide with the aggregate ratio $k(t)$, their growth rates are identical:

$$g_{k_s}(t) = g_{k_m}(t) = g_k(t) \tag{16}$$

This result echoes Ngai and Pissarides (2007), who show that common factor markets enforce a single equilibrium ratio.

Combining the first-order conditions Eq. 6 and Eq. 9 yields an expression for the evolution of the relative price of services:

$$r(t) = \alpha k_m(t)^{\alpha-1} A(t)^{1-\alpha} = \alpha P_s(t) k_s(t)^{\alpha-1} \iff A(t)^{1-\alpha} = P_s(t) = K_m(t)^{1-\alpha} \tag{17}$$

Thus, the growth rate of P_s is pinned down by the common capital-labor growth rate:

$$(1-\alpha)g_A(t) = g_{P_s}(t) = (1-\alpha)[g_k(t) + g_{L_m}(t)] \tag{18}$$

Substituting the market-clearing conditions Eqs. 11-14 and the optimality conditions into the household budget constraint Eq. 2, and using Eq. 15 and Eq. 17, we obtain:

$$\dot{K}(t) = v[Y_m(t) + P_s(t)Y_s(t)] \tag{19}$$

that is, aggregate capital accumulates at the constant saving rate times industrial output, exactly as in the Solow model.

Substituting the production functions for the two sectors Eq. 4 and Eq. 8 into Eq. 19, and using Eq. 15 and Eq. 17 again, we obtain:

$$\begin{aligned}\dot{K}(t) =& v[Y_m(t) + P_s(t)Y_s(t)] = v[k_m(t)^\alpha A(t)^{1-\alpha} L_m(t) + P_s(t) k_s(t)^\alpha L_s(t)] \\ =& vK(t) L_m(t)^{1-\alpha}\end{aligned}$$

This equation demonstrates that total capital in the economy does not grow at a fixed growth rate. Instead, its growth rate depends on labor input in the industrial sector. As population remains constant, capital per worker and labor capital in both sectors will grow at this rate:

$$g_K(t) = g_k(t) = g_{k_s}(t) = vL_m(t)^{1-\alpha} > 0 \tag{20}$$

Additionally, from Eq. 15 and Eq. 17, the interest rate level is:

$$r(t) = \alpha L_m(t)^{1-\alpha} \tag{21}$$

The output growth rates of service products and industrial goods are given by:

$$g_{y_m}(t) = g_k + (1-\alpha)g_{l_m} = vL_m(t)^{1-\alpha} + (1-\alpha)g_{L_m},\; g_{y_s}(t) = \alpha g_k = \alpha v L_m(t)^{1-\alpha} \tag{22}$$

And the relative price increase rate of service products relative to industrial goods is:

$$g_{P_s}(t) = (1-\alpha)g_A = (1-\alpha)[g_K + g_{L_m}(t)] = (1-\alpha)[vL_m(t)^{1-\alpha} + g_{L_m}(t)] \tag{23}$$

These results lead to Property 2:

Property 2. In this model, aggregate capital per worker and sectoral capital-labor ratios grow at the same endogenous rate, determined by the industry labor share and the learning-by-doing process. Consequently, the economy does not settle on a balanced growth path. Instead, interest rates and the relative price of services evolve in line with labor reallocation and industrial-sector productivity growth.

2.4. Characteristics of structural transformation

In contrast to the traditional three-sector view, our model focuses on structural change between industry and services. We characterize transformation through three key ratios: the industrial-to-service consumption expenditure ratio, the industrial-to-service output ratio, and the industrial-to-service employment ratio.

Household optimization Eq. 3 implies that consumers allocate expenditure across industrial and service goods in fixed proportion. Let R_c denote the ratio of consumer expenditure on industrial goods to services, defined as $c_m/(P_s c_s)$. From the consumer optimization condition, it follows that:

$$R_c(t) = c_m(t)/(P_s(t)c_s(t)) = \gamma/P_s(t) \tag{24}$$

The corresponding growth rate of the consumption expenditure ratio is:

$$g_{R_c}(t) = -g_P = -[(1-\alpha)vL_m(t)^{1-\alpha} + (1-\alpha)g_{L_m}(t)] \tag{25}$$

Define R_Y as the ratio of industrial to service sector output $(Y_m/(P_s Y_s))$, and R_L as the ratio of industrial to service sector employment. Using the sectoral production functions Eq. 4 and Eq. 8, together with conditions Eq. 15 and Eq. 17, we obtain:

$$R_Y(t) = Y_m(t)/(P_s(t)Y_s(t)) = L_m(t)/L_s(t) = R_L(t) \tag{26}$$

Substituting the consumer optimization condition Eq. 3 and the service sector firms' optimality conditions Eqs. 9 and 10 into the individual budget constraint yields

$$\gamma c_s(t) + P_s(t)c_s(t) = (1-v)[(1-\alpha)P_s(t)k_s(t)^\alpha + \alpha P_s(t)k_s(t)^{\alpha-1}k(t)]$$

Utilizing the service sector market equilibrium condition Eq. 11 and the production function Eq. 8, and adjusting accordingly, we derive:

$$L_s(t) = (1-v)P_s(t)/(\gamma + P_s(t)) = (1-v)/(\gamma/P_s(t)+1) \qquad (27a)$$

$$L_m(t) = 1 - L_s(t) = 1 - (1-v)/(\gamma/P_s(t)+1) \qquad (27b)$$

Additionally, the price-capital relationship in Eq. 17 yields:

$$K(t)^{1-\alpha} = \frac{\gamma(1-L_m(t))}{L_m(t)^{1-\alpha}(L_m(t)-v)} \qquad (27c)$$

Since aggregate capital K grows over time, these equations imply an increasing allocation of labor to the service sector and a declining labor share in the industrial sector. Specifically, Eq. 27a indicates that the relative price of services rises with the expansion of service employment, leading to a positive growth rate in the service-to-industry relative price. Moreover, from Eq. 20, both per capita capital and sectoral labor-capital ratios decline over time. Eq. 24 and Eq. 26 together imply that the consumption expenditure ratio R_c, output ratio R_Y, and employment ratio R_L all decrease monotonically along the growth path.

As a result, the employment growth rates across sectors satisfy:

$$g_{L_s} = \left(1 - \frac{P}{\gamma+P}\right) g_P = \frac{v(L_m-v)(1-\alpha)L_m^{1-\alpha}}{(L_m-v)(1-L_m)(1-\alpha)/L_m + (1-v)} > 0 \qquad (28a)$$

$$g_{L_m} = -\frac{1-L_m}{L_m} g_{L_s} = -\frac{v(L_m-v)(1-\alpha)L_m^{1-\alpha}}{(L_m-v)(1-\alpha) + (1-v)L_m/(1-L_m)} < 0 \qquad (28b)$$

These dynamics yield the following:

Property 3: Along the growth path generated by this model, the ratios of industry-to-service consumption expenditure, output, and employment fall continuously.

2.5. Characteristics of economic growth in the model

This section examines the dynamic properties of economic growth implied by the model's structural transformation mechanism. The transition from an industry-dominated economy to a service-oriented one entails distinct patterns in productivity, output growth, interest rates, and prices. We highlight six key properties emerging from the model.

First, the growth rate of labor productivity in the industrial sector could be derived from Eq. 23:

$$g_A(t) = vL_m(t)^{1-\alpha} + g_{L_m}(t) \tag{23'}$$

This expression shows that while learning-by-doing drives endogenous productivity gains in industry, the pace of technological progress decelerates over time as the share of labor allocated to the industrial sector declines. Although the rate of slowdown diminishes, this tapering reflects the diminishing contribution of industry to aggregate productivity growth as the economy matures.

Second, from Eq. 22, the growth rate of service sector output declines as labor reallocates toward services and away from industry. Substituting Eq. 28b into Eq. 22 shows that the decline in industrial labor supply reduces output growth in both sectors, due to the centrality of industrial learning in driving aggregate technological change.

Third, the interest rate, given in Eq. 21, also responds to labor reallocation. Substituting the declining industrial labor share from Eq. 28b into Eq. 21 implies:

$$g_r(t) = (1-\alpha)g_{L_{m}(t)} < 0 \tag{21'}$$

indicating a persistent decline in the interest rate over time.

These findings yield the following result:

Property 4: During structural transformation, as the industrial-to-service output ratio declines, three trends emerge: (i) the pace of technological progress in the industrial sector slows; (ii) the real output growth rates of both industrial and service sectors decline; and (iii) the interest rate falls persistently.

In contrast to the large literature on productivity and output growth, relatively little attention has been paid to changes in the relative prices of consumption and investment goods over time. Using U.S. data, Herrendorf et al., (2021) document a sustained decline in the relative price of investment goods, especially since 1980. In our model, price dynamics arise naturally from sectoral productivity differentials.

To explore the real growth of aggregate output, let $Y(t)$ denote nominal output and PY(t) the associated price index. Define real output as:

$$P_Y(t)Y(t) = Y_m(t) + P_s(t)Y_s(t) \tag{29}$$

Fourth, the price index $P_Y(t)$ represents the cost of a fixed consumption bundle. Given the constant consumption ratio $c_m = \gamma c_s$, we normalize the bundle to one unit of services and γ units of industrial goods, yielding:

$$P_Y(t) = \gamma + P_s(t) \tag{30}$$

where $P_s(t)$ is the relative price of services. As shown in Eq. 17, $P_s(t)$ rises over time due to lower productivity growth in services. Consequently, the aggregate price level also increases, even in the absence of nominal price inflation.

Property 5: Along the structural transformation path, both the price of service goods $P_s(t)$ and the aggregate price index $P_Y(t)$ rise persistently as the service sector's output share expands.

Fifth, substituting the production functions Eq. 4 and Eq. 8 and equilibrium conditions Eqs. 14, 15, and 17 into Eq. 29, we obtain an expression for real output:

$$Y(t) = K(t)L_m(t)^{1-\alpha}/(\gamma + P_s(t)) \tag{31}$$

Differentiating Eq. 31 with respect to time yields the real output growth rate:

$$\begin{aligned} g_Y &= g_K + (1-\alpha)g_{L_m}(t) - \frac{P_s}{\gamma + P_s} g_{P_s} \\ &= vL_m(t)^{1-\alpha} + (1-\alpha)g_{L_m}(t) \\ &- (1-\alpha)(1-L_m(t))[vL_m(t)^{1-\alpha} + g_{L_m}(t)]/(1-v) \end{aligned} \tag{32}$$

As labor reallocates from industry to services, both the real output growth rate of industry and services decline due to diminishing industrial learning and low service productivity. While the growth rate of real output slows, the rate of deceleration also tapers over time, implying a smooth but non-convergent growth trajectory.

Finally, from Eq. 32, the real output growth rate is positively associated with the industrial labor share. Given the correspondence between labor allocation and the industrial output share and employment ratios, this relationship is formalized as:

$$g_Y \propto \frac{Y_m}{Y_m + P_s Y_s}, \quad \text{and} \quad L_m \tag{33}$$

Property 6: The real output growth rate is positively associated with the industrial output share.

3. EMPIRICAL STRATEGY AND DATA

3.1. Theoretical intuition

The theoretical framework above generates empirically testable predictions that guide our regression strategy. First, consistent with the model's core implications, a higher industrial value-added share and a lower service share in GDP predict faster growth, reflecting the differential capacity of these sectors to generate productivity gains. Second, as implied by Property 4, aggregate GDP growth slows in a sector-specific manner, with simultaneous deceleration in both industrial and service output. This pattern suggests that structural transformation operates through sector-specific transmission channels rather than through aggregate shocks alone. Third, Properties 4 and 5 indicate that a larger industrial share associates with higher interest rates — reflecting stronger investment demand from productivity-enhancing industrial activity — and with faster growth in output per worker, capturing improved labor efficiency and capital deepening in industry-led growth.

We test these predictions using an unbalanced panel data of 183 countries and regions from 1961 to 2019, covering diverse stages of structural transformation. The baseline empirical models are specified as follows:

$$g_{it} = \beta_0 + \beta_1 M_{it} + X_{it}\gamma' + \mu_i + \lambda_t + u_{it}$$

where i indexes countries and t indicates time. The dependent variable g_{it} is the annual growth rate of real GDP per capita. The main explanatory variables is M_{it}, the industrial share of GDP. The control vector X_{it} includes standard growth determinants. Country and time fixed effects are denoted by μ_i and λ_t, while u_{it} is idiosyncratic errors.

Coefficients β_1 capture the marginal effects of sectoral composition. We expect $\beta_1 > 0$, reflecting higher growth from industrial intensity and potential constraints from service dominance.

The empirical model includes five key control variables that capture important aspects of economic development beyond sectoral structure:

(i) Agricultural share (A): The proportion of agricultural value added in GDP. Agriculture is abstracted from the theoretical model but plays a critical role in early development stages and rural labor reallocation, particularly in low-income countries.

(ii) Agricultural growth (g_A): The annual growth rate of agricultural output, included to control for productivity improvements in agriculture that may indirectly influence overall economic growth.

(iii) Initial income ($\ln y$): The natural logarithm of real GDP per capita (constant 2010 USD) at the start of the period, serving as a proxy for conditional convergence effects, where poorer countries tend to grow faster.

(iv) Urbanization rate (U): The share of the urban population in total population, incorporated to separate the effects of sectoral shifts from broader demographic and spatial transformations that also affect growth.

(v) Inflation rate (Pi): The annual inflation rate, used to control for macroeconomic instability and to differentiate cyclical price fluctuations from structural or sector-specific changes.

These controls help isolate growth effects attributable to structural transformation while accounting for key confounding factors in economic development.

3.2. IV: the global patterns of structural transformation

Historical evidence shows that global structural transformation — marked by industrialization followed by service expansion — stems more from exogenous technological shocks than from domestic fundamentals. The First Industrial Revolution arose with the diffusion of the steam engine; the Second relied on electricity and mass production; the Third leveraged information and communication technologies; and emerging Industry 4.0 innovations, including artificial intelligence and robotics, continue to reshape global production. These innovation waves induce sectoral shifts that are largely exogenous at the national level. Technological diffusion occurs faster among countries within the same region or with similar economic structures, facilitated by shared institutions, trade linkages, and regional policy spillovers. In line with comparative advantage theory, structural change in one country also reflects developments in peer countries through global value chains and demand spillovers.

Following Acemoglu et al., (2019), we construct an instrumental variable (IV) to isolate plausibly exogenous variation in a country's industry-to-services output ratio. We first classify countries into five structural categories based on their industry-to-services value-added ratios. For each country i, let R_i denote the region in which country i is located.[3] Let D_{it} denote the structural group to which country i belongs in year t.[4] The reference group consists of all other countries in the same region and structural category, excluding country i. We define the IV, Z_{it} , as the average industrial value-added share among these peer countries:

$$Z_{it} = \frac{1}{N_{it} - 1} \sum_{j \in R_{it}, j \neq i} M_{jt}$$

where M_{jt} denotes the industrial value-added share in country j, and N_{it} the number of peer countries in the reference group. This peer-based measure captures variation in sectoral composition driven by global technological diffusion and regional spillovers rather than country-specific policies or shocks.

[3]Countries in the global sample are grouped into seven geographic regions: South Asia, East Asia and the Pacific, Sub-Saharan Africa, Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, and North America.

[4]To examine the role of industrial structure, we divide the full sample into quintiles based on the share of industry in total value added.

3.3. Data

Our empirical analysis uses a panel dataset from the World Bank, covering 183 countries and regions from 1961 to 2019. Key variables include industrial value-added shares in GDP, real and nominal GDP per capita, interest rates, and the GDP deflator normalized to 100 in 2010.

Additional indicators include the annual growth rate of real GDP per capita, agricultural value-added share and growth, urban population share, gross capital formation growth, and exports of goods and services as a percentage of GDP. Table 1 reports variable definitions, economic interpretations, sample sizes, means, standard deviations, minima, maxima, and medians. The average annual growth of real GDP per capita is 2.1 percent, consistent with long-run trends in advanced economies such as the United States. On average, industrial sectors account for 26.5 percent of GDP, respectively. Wide ranges in several variables indicate outliers. To ensure robustness, we exclude extreme observations from the baseline regressions.

TABLE 1.

Summary Statistics

VarName	Obs.	Mean	SD	Min	Median	Max
gpc	5857	0.021	0.038	−0.128	0.022	0.141
M	5857	0.265	0.113	0.010	0.253	0.848
A	5857	0.151	0.131	0.000	0.110	0.790
g_A	5857	0.023	0.073	−0.243	0.026	0.305
$\ln y$	5857	8.241	1.466	4.891	8.184	11.626
U	5857	0.517	0.236	0.029	0.513	1.000
Pi	5857	0.036	0.101	−0.289	0.030	0.465

Notes: This table reports the sample sizes, means, standard deviations, minima, maxima, and medians of the main variables used in the analysis. Data are sourced from the World Bank.

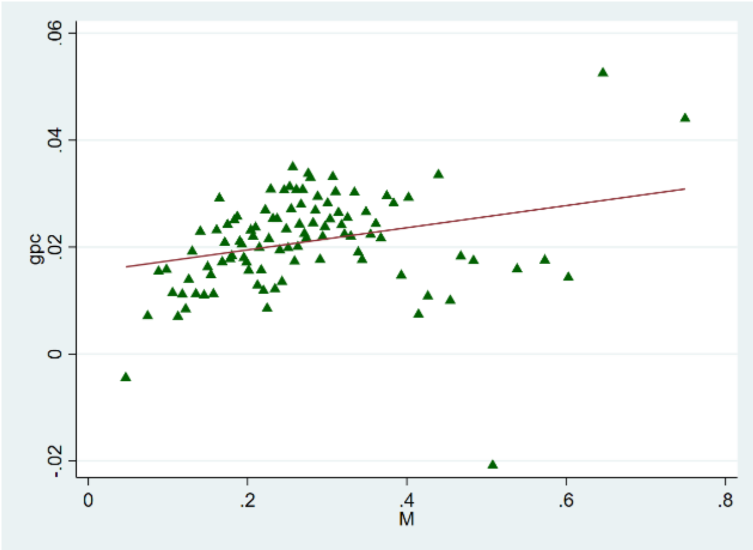
Fig. 1 plots sectoral value-added shares against long-run per capita GDP growth. Countries with larger industrial shares exhibit significantly faster growth rates, suggesting that industrialization remains a central engine of economic development. This pattern is consistent with the classic structural transformation hypothesis: the expansion of industry enhances aggregate productivity through capital deepening, scale economies, and technological spillovers from manufacturing to other sectors.

3.4. Global patterns of economic convergence

We estimate the following regression specification to test the hypothesis of absolute convergence in economic growth, following Barro and Sala-i-Martin (1992):

$$gpc_{it} = \beta_0 + \beta_1 \log(y_{i,t-5}) + \varepsilon_{it}$$

FIG. 1. Industrial Share and Per Capita GDP Growth



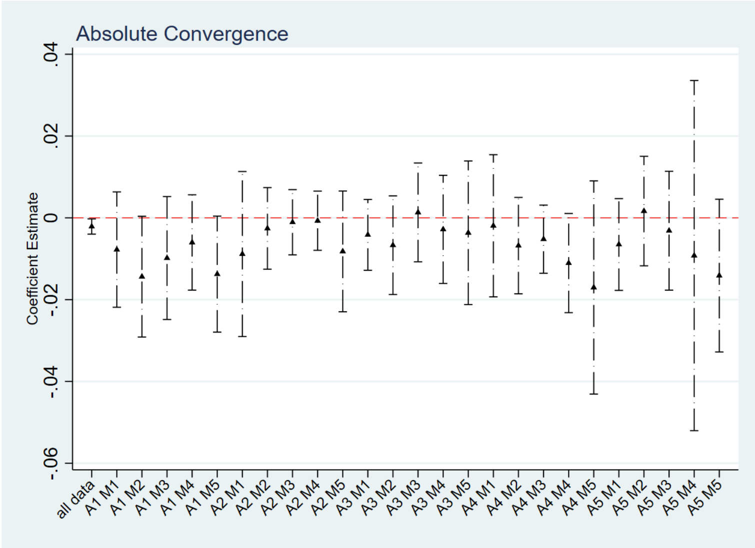
Notes: The horizontal axis shows the share of industrial value added, and the vertical axis indicates the long-run growth rate of real GDP per capita. The solid line represents the fitted regression line.

where i indexes countries, t denotes year, gpc_{it} is the annual growth rate of real GDP per capita, and $\log(y_{i,t-5})$ is the natural logarithm of GDP per capita lagged by five years. The key coefficient of interest, β_1 captures the presence of absolute convergence. A significantly negative estimate of β_1 indicates that countries with lower initial income levels grow faster than richer countries, supporting the absolute convergence hypothesis within the neoclassical growth framework.

Fig. 2 reports the estimated β_1 across different subsamples. The results show strong evidence of absolute convergence across all economies but little or no convergence within groups of countries sharing similar industrial structures. The first point ("All data") corresponds to the full sample and yields a statistically significant negative coefficient on initial income, consistent with absolute convergence.

When the sample is divided according to countries' sectoral composition — specifically, by quintiles of agricultural and industrial value-added shares — the convergence pattern changes. Here, A1 to A5 denote quintiles ranked by the share of agriculture in total value added, with A1 representing countries where agriculture accounts for the smallest share and A5 where it accounts for the largest. Similarly, M1 to M5 correspond to quintiles of industrial value-added shares, from the lowest to the highest. Within these

FIG. 2. Absolute Convergence across Sectoral Composition Groups



Notes: The figure plots the estimated coefficients on initial income (β_1) from convergence regressions across different country groups. "All data" refers to the full sample, showing a significant negative coefficient consistent with absolute convergence. A1–A5 denote quintiles ranked by the share of agriculture in total value added, where A1 represents countries with the lowest agricultural share and A5 the highest. M1–M5 represent quintiles based on industrial value-added shares, ordered from lowest to highest. Within these more homogeneous sectoral groups, the convergence coefficients become statistically insignificant, indicating that convergence weakens once differences in sectoral structure are accounted for.

more homogeneous sectoral groups, the estimated convergence coefficients become statistically insignificant, suggesting that structural composition plays a critical role in shaping growth dynamics.

4. BASELINE RESULTS

4.1. Baseline regression results

Table 2 reports the baseline regression results using an unbalanced panel of 183 countries over the period 1960–2019, with the annual growth rate of real GDP per capita as the dependent variable. The key explanatory variables is the share of industrial value added, which is introduced sequentially along with a set of control variables to test the robustness of the results.

Column (1) presents the specification without any control variables, establishing the unconditional relationship between industrialization and growth. Column (2) adds the agricultural value-added share to account for the structural composition of the economy. Column (3) further controls for the lagged level of real GDP per capita, capturing convergence effects and differences in initial development stages. Column (4) introduces additional macroeconomic controls, including the growth rate of agricultural output, urbanization rate, and inflation rate, to account for demographic and macro-stability factors.

TABLE 2.

Baseline Regression Results

	Dependent variable: Per capita GDP growth rate			
	(1)	(2)	(3)	(4)
M	0.0286^{**}	0.0216^{*}	0.0318^{**}	0.0264^{**}
	(0.0116)	(0.0128)	(0.0127)	(0.0126)
A		-0.0187	-0.0468^{***}	-0.0744^{***}
		(0.0131)	(0.0135)	(0.0131)
$l.\ln y$			-0.0184^{***}	-0.0174^{***}
			(0.00254)	(0.00243)
g_A				0.140^{***}
				(0.00758)
U				-0.0332^{***}
				(0.0117)
Pi				0.0232^{***}
				(0.00612)
Con.	0.0136^{***}	0.0182^{***}	0.171^{***}	0.182^{***}
	(0.00311)	(0.00460)	(0.0216)	(0.0207)
Country	yes	yes	yes	yes
Year	yes	yes	yes	yes
N	5,857	5,857	5,857	5,857
R^2	0.229	0.229	0.240	0.309

Notes: This table reports the effects of industrialization on long-run economic growth using an unbalanced panel of 183 countries from 1960 to 2019. The dependent variable is the annual growth rate of real GDP per capita. The key explanatory variable is the share of industrial value added. Column (1) excludes control variables; Column (2) adds the agricultural value-added share; Column (3) further controls for lagged GDP per capita; Column (4) includes additional macroeconomic controls — the growth rate of agricultural output, urbanization rate, and inflation rate. Standard errors are reported in parentheses. *** is $p < 0.01$, ** is $p < 0.05$, * is $p < 0.1$.

The results in Column (4) show a positive and statistically significant coefficient on the industrial share at the 5% level. Quantitatively, a one-percentage-point increase in the industrial share is associated with a 0.026-

percentage-point increase in real GDP per capita growth. This finding reinforces the view that industrialization remains a central engine of long-run economic growth, consistent with both theoretical and empirical studies that document the pivotal role of industry in driving productivity gains, scale economies, and technological diffusion (Herrendorf et al., 2014). Consistent with mechanisms highlighted in strategic macroeconomic models, industrial self-sufficiency and capital accumulation can reinforce long-term growth trajectories by enhancing domestic productive capacity (Zou, 2025b). In contrast, the literature emphasizes that productivity growth in the service sector tends to be slower — especially in developing economies — thereby limiting its capacity to sustain aggregate growth (Herrendorf et al., 2014; Ngai and Pissarides, 2007).

Recent evidence further supports these results. The rising share of low-productivity sectors in the second half of the twentieth century contributed to slower aggregate productivity growth in the United States (Nordhaus, 2008). Baumol's cost disease explains approximately one-third of the post-war growth slowdown (Duernecker et al., 2024). Cross-country differences in productivity increasingly stem from disparities in the service sector, as convergence in agriculture and industrial productivity accounts for about half of overall productivity growth, whereas persistently low service productivity hinders convergence in developing economies (Duarte and Restuccia, 2020). The global shift from goods to services, reflecting the lower tradability of services, has reduced welfare gains from trade integration by nearly 40 percent over the past four decades (Lewis et al., 2022).

4.2. Robustness checks

Instrumental variable estimation. To address potential endogeneity concerns arising from reverse causality or omitted variable bias in the relationship between sectoral composition and economic growth, we implement a two-stage least squares (2SLS) estimation. An exogenous instrument for sectoral composition is employed in the first stage to isolate variation in industrial share that is plausibly unrelated to contemporaneous growth shocks.

The second-stage results, reported in Table 3, Column (1), indicate that the industrial share retains a positive and statistically significant effect at the 5% level, with a coefficient of 0.15. This implies that a one-percentage-point increase in the industrial share leads to a 0.15 percentage point increase in the annual growth rate of real GDP per capita, holding other factors constant.

Weighted least squares estimation. To address potential sample selection bias arising from heterogeneity in country size and development levels, we implement a weighted least squares (WLS) estimation, using real GDP per capita as weights. By assigning greater weight to larger economies, this approach ensures that the estimated coefficients better reflect the global distribution of economic activity and improve the representativeness of the results.

The results, reported in Table 3, Column (2), indicate that the WLS estimates are very similar to the baseline OLS results in both magnitude and direction. Specifically, the coefficient on the industrial share is 0.029, statistically significant at the 5% level. This suggests that a one-percentage-point increase in the industrial share is associated with a 0.029 percentage point increase in annual per capita GDP growth, after accounting for differences in country size and development.

TABLE 3.

Robustness Checks

	Dependent variable: Per capita GDP growth rate				
	IV	WLS	SysGMM	T5%	+Controls
	(1)	(2)	(3)	(4)	(5)
M	0.150^{**}	0.0290^{**}	0.0245	0.0208^{**}	0.0252^{*}
	(0.0746)	(0.0129)	(0.0172)	(0.00905)	(0.0137)
A	−0.0164	-0.0798^{***}	-0.219^{***}	-0.0343^{***}	-0.102^{***}
	(0.0316)	(0.0134)	(0.0234)	(0.0101)	(0.0163)
g_A	0.136^{***}	0.124^{***}	0.138^{***}	0.0940^{***}	0.122^{***}
	(0.00785)	(0.00744)	(0.00512)	(0.00552)	(0.00816)
$l.\ln y$	-0.0239^{***}	-0.0199^{***}	-0.0594^{***}	-0.0101^{***}	-0.0197^{***}
	(0.00301)	(0.00240)	(0.00320)	(0.00174)	(0.00264)
U	-0.0253^{**}	-0.0305^{***}	0.245^{***}	−0.0130	-0.0443^{***}
	(0.0121)	(0.0118)	(0.0204)	(0.00906)	(0.0131)
Pi	0.0196^{***}	0.0251^{***}	2.20e-06	0.0233^{***}	0.0166^{**}
	(0.00675)	(0.00619)	(2.00e-05)	(0.00455)	(0.00687)
Con.	0.148^{***}	0.206^{***}	0.460^{***}	0.108^{***}	0.206^{***}
	(0.0241)	(0.0209)	(0.0284)	(0.0151)	(0.0237)
Country	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes
N	5,497	5,857	5,428	5,271	4,593
R^2	0.302	0.308		0.302	0.403

Notes: This table reports robustness checks for the effect of the industrial share on per capita GDP growth (183 countries, 1960?2019). Column (1) presents 2SLS estimates using an exogenous instrument for industrial share; Column (2) shows WLS results weighting by country size; Column (3) reports system GMM estimates; Column (4) excludes the top and bottom 5% of growth observations; Column (5) adds additional macro controls for trade openness and capital formation. All regressions include the baseline control variables and fixed effects. Standard errors are clustered at the country level. Standard errors are reported in parentheses. *** is $p < 0.01$, ** is $p < 0.05$, * is $p < 0.1$.

System GMM estimation. To account for the dynamic nature of economic growth and potential endogeneity of the lagged dependent variable, we implement a system generalized method of moments (GMM) estimator (Blundell and Bond, 1998). This approach allows us to capture persistence in per capita GDP growth while controlling for unobserved country-specific heterogeneity and mitigating potential simultaneity bias.

Although system GMM is known to have limitations in short panels, the results reported in Table 3, Column (3) indicate that the industrial value-added share continues to have a positive effect on growth. However, the statistical significance is somewhat reduced relative to the baseline OLS and IV estimates, likely reflecting the conservative nature of GMM standard errors in small-T panels and the additional controls for dynamics and heterogeneity.

Excluding outliers. To assess the sensitivity of our results to extreme observations, we re-estimate the baseline model after excluding the top and bottom 5 percent of GDP per capita growth rates. This trimming procedure helps mitigate potential distortions caused by idiosyncratic shocks, reporting errors, or measurement inaccuracies, which may disproportionately influence regression estimates.

The results, reported in Table 3, Column (4), indicate that the coefficient on the industrial value-added share remains very similar to the baseline, with a value of 0.02, statistically significant at the 5% level. This suggests that the positive relationship between industrialization and long-run per capita GDP growth is not driven by a few extreme growth observations, providing further robustness evidence for our main findings

Additional controls. To further test the robustness of our baseline results, we expand the model by including additional macroeconomic controls that capture differences in external exposure and capital accumulation across countries. Specifically, we incorporate trade openness, measured as the share of exports of goods and services in GDP, and investment activity, captured by the growth rate of gross capital formation. These variables account for the possibility that countries with higher industrial shares may also systematically differ in their trade integration or capital accumulation, which could influence growth outcomes.

The results, reported in Table 3, Column (5), show that the coefficients on sectoral shares remain positive, stable, and statistically significant, with the industrial share coefficient estimated at 0.025 and significant at the 10% level. This finding indicates that the positive impact of industrialization on per capita GDP growth persists even after controlling for trade and investment dynamics, reinforcing the conclusion that structural transformation exerts a systematic and robust influence on long-run economic growth.

5. HETEROGENEITY AND MECHANISM ANALYSIS

5.1. Heterogeneity analysis

The positive relationship between industrial development and economic growth is not uniform across countries. This section examines whether the growth returns to industrialization vary systematically according to structural characteristics, including income level, labor force size, and the agricultural share of GDP.

5.1.1. Heterogeneity by level of economic development

To investigate whether the growth impact of industrialization varies with a country's income level, we interact the industrial value-added share with the logarithm of per capita GDP. The results, illustrated in Fig. 3, indicate that the marginal effect of industrialization on economic growth increases with income.

In low-income countries, several binding constraints — such as limited infrastructure, low human capital endowments, and weaker institutional quality — dampen the productivity gains from industrial expansion, reducing the effectiveness of industrialization in raising per capita GDP (Gollin et al., 2014; Lewis, 1954). Conversely, higher-income countries experience larger growth returns from industrialization, consistent with endogenous growth theories emphasizing increasing returns to scale, knowledge spillovers, and technological diffusion (Acemoglu and Guerrieri, 2008; Arrow, 1962).

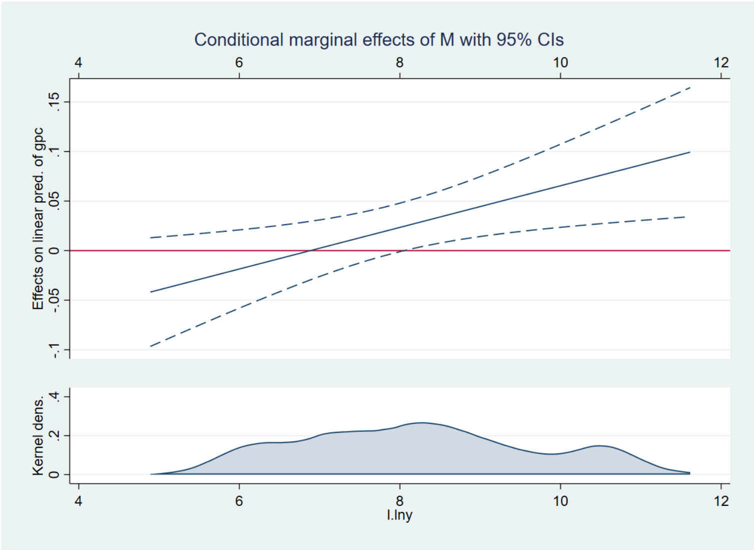
This heterogeneous pattern aligns with empirical evidence suggesting that productivity convergence and the benefits of structural transformation depend critically on institutional quality and absorptive capacity (Rodrik, 2013). In other words, the same degree of industrialization yields disproportionately higher growth in economies with greater income, stronger institutions, and better capacity to adopt and diffuse technology.

5.1.2. Heterogeneity by labor force size

Fig. 4 shows that the growth-enhancing effect of industrialization is stronger in countries with smaller labor forces. In economies facing labor scarcity, industrial development can compensate for limited labor availability by promoting capital deepening, mechanization, and the adoption of labor-saving technologies, thereby sustaining productivity growth (Caselli and Coleman II, 2001; Ngai and Pissarides, 2007).

These findings are consistent with dual-economy models, in which capital-intensive industrial sectors drive growth in economies constrained by demographic limitations (Lewis, 1954). Moreover, the results align with more recent empirical evidence indicating that automation and technological in-

FIG. 3. Heterogeneous Effects across Income Levels



Notes: This figure shows the interaction between the industrial value-added share and the logarithm of per capita GDP. The results indicate that the marginal effect of industrialization on economic growth increases with income, suggesting that higher-income countries experience larger growth gains from industrial expansion.

novation can mitigate the negative effects of limited labor supply on economic growth (Herrendorf et al., 2013).

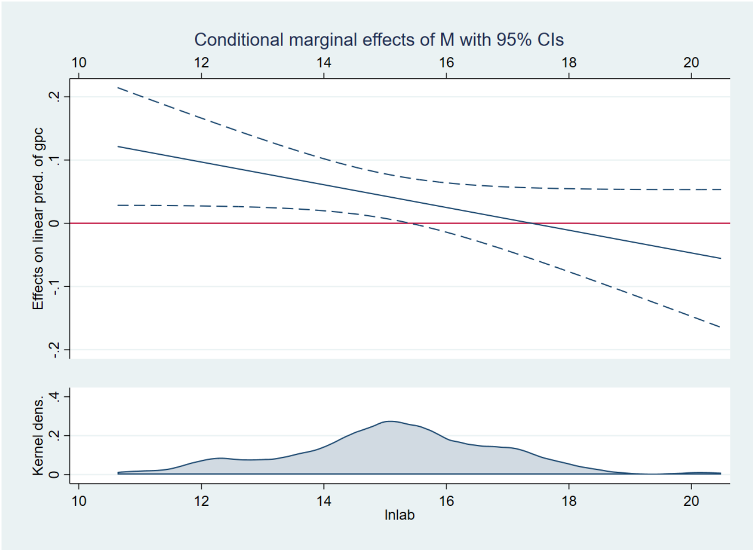
In sum, the evidence suggests that the benefits of industrialization are not uniform: countries with smaller labor forces tend to gain disproportionately from structural transformation, highlighting the complementarity between capital accumulation, technology adoption, and labor constraints in shaping long-run growth outcomes.

5.1.3. Heterogeneity by agricultural share

We investigate whether the growth benefits of industrialization vary with the size of the agricultural sector. Fig. 5 illustrates that the positive relationship between industrialization and per capita GDP growth strengthens as the agricultural share of total value added declines.

This pattern aligns with the structural transformation literature, which emphasizes that shifting labor from low-productivity agriculture to higher-productivity industrial sectors drives aggregate productivity gains. These gains are further reinforced by scale economies, capital accumulation, and

FIG. 4. Heterogeneous Effects across Labor Force Size



Notes: This figure shows the interaction between industrialization and the size of the labor force. The results indicate that the growth-enhancing effect of industrialization is stronger in countries with smaller labor forces.

the diffusion of technology across sectors (Chenery, 1975; Duarte and Restuccia, 2010; Kuznets, 1973).

As the agricultural sector contracts, industrialization becomes increasingly critical for sustaining economic growth, promoting diversification, and enhancing overall productivity. This mechanism is consistent with empirical evidence showing that countries with smaller agricultural sectors tend to derive larger growth returns from industrial expansion (Herrendorf et al., 2014).

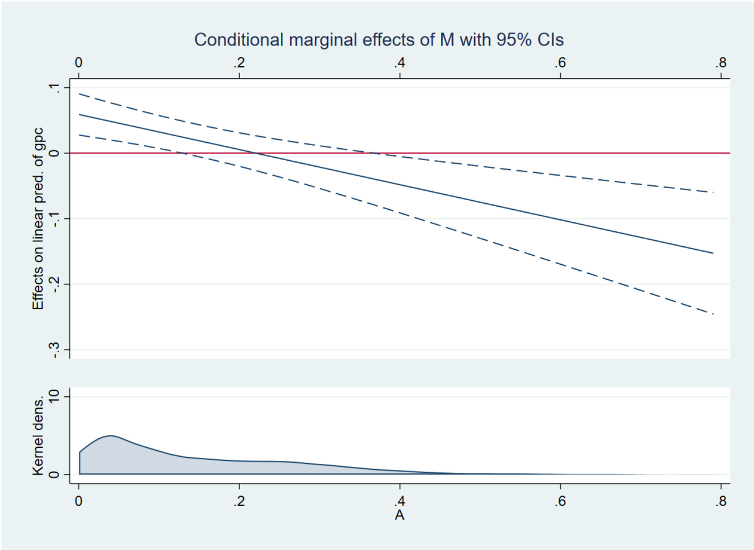
In sum, the results highlight that the marginal impact of industrialization is context-dependent, and that structural transformation is particularly effective in economies where agriculture occupies a smaller share of total value added.

5.1.4. Heterogeneity by regions

Table 4 illustrates substantial variation in the growth effects of structural transformation depending on institutional and regional context.

Columns (1) and (2) report results for OECD countries, where institutional capacity, policy effectiveness, and technological upgrading capabil-

FIG. 5. Heterogeneous Effects by Agricultural Value-Added Share



Notes: This figure shows the interaction between the industrial value-added share and the agricultural share of total value added. The results indicate that the positive effect of industrialization on per capita GDP growth is stronger in countries with smaller agricultural sectors.

ities are relatively high (Rodrik, 2013). In this context, industrialization strongly supports economic growth, reflecting the ability of firms to capitalize on scale economies, innovation, and knowledge spillovers. Conversely, the service sector exhibits a negative association with growth, consistent with market saturation and Baumol's cost disease, whereby productivity growth in services lags behind that in industry (Baumol, 1967).

Columns (3) and (4) focus on non-Arab League countries versus resource-dependent Arab economies. Here, industrial development produces larger growth gains outside the Arab League, suggesting that economies heavily reliant on natural resources may face structural and institutional constraints that limit the growth benefits of industrialization (Diop, 2012; Gelb, 1988).

Columns (5) and (6) present results for Eurozone countries, which maintain growth through coordinated industrial policies, integrated regional value chains, and strong institutional frameworks (Bugamelli et al., 2018). These mechanisms enable industrialization to generate sustained productivity improvements and economic diversification even in a highly integrated regional setting.

TABLE 4.

Regional Heterogeneity

	Dependent variable: Per capita GDP growth rate					
	OECD	Non-OECD	Arab	Non-Arab	EMU	Non-EMU
	(1)	(2)	(3)	(4)	(5)	(6)
M	0.106^{***}	0.016	0.024	0.023^{*}	0.246^{***}	0.016
	(0.035)	(0.013)	(0.042)	(0.013)	(0.079)	(0.013)
A	-0.029	-0.073^{***}	0.0015	-0.076^{***}	0.076	-0.077^{***}
	(0.053)	(0.014)	(0.07)	(0.014)	(0.209)	(0.013)
g_A	0.037^{***}	0.163^{***}	0.137^{***}	0.137^{***}	0.017	0.153^{***}
	(0.010)	(0.009)	(0.024)	(0.008)	(0.014)	(0.008)
$l.\ln y$	-0.029^{***}	-0.016^{***}	-0.031^{***}	-0.018^{***}	-0.028^{**}	-0.017^{***}
	(0.006)	(0.003)	(0.011)	(0.003)	(0.012)	(0.003)
U	0.032	-0.049^{***}	-0.124^{**}	-0.029^{**}	-0.001	-0.039^{***}
	(0.030)	(0.013)	(0.050)	(0.012)	(0.037)	(0.012)
Pi	0.063^{***}	0.016^{**}	-0.040^{*}	0.031^{***}	0.043	0.024^{***}
	(0.015)	(0.0067)	(0.022)	(0.006)	(0.040)	(0.006)
Con.	0.264^{***}	0.173^{***}	0.321^{***}	0.183^{***}	0.250^{*}	0.179^{***}
	(0.060)	(0.023)	(0.107)	(0.021)	(0.141)	(0.021)
N	1,077	4,779	533	5,321	449	5,394
R^2	0.558	0.307	0.333	0.317	0.647	0.310

Notes: This table presents regression estimates corresponding to the heterogeneous growth effects of structural transformation. The sample is divided into institutional and regional subgroups: OECD, Non-OECD, Arab League, Non-Arab, Eurozone (EMU), Non-EMU. Standard errors are reported in parentheses. *** is $p < 0.01$, ** is $p < 0.05$, * is p¡0.1.

5.2. Mechanism analysis

This section examines the channels through which structural transformation influences long-run economic growth, drawing on predictions from the theoretical model. We focus on four interrelated mechanisms: industrial output growth, service output growth, the interest rate, and GDP per worker. The corresponding regression results are presented in Table 5.

A rising industrial share in GDP is associated with higher industrial output growth, reflecting the direct expansion and dynamism of the manufacturing sector. This finding supports the view that industrialization promotes capital deepening, scale economies, and technological diffusion, which in turn enhance productivity and sustain long-term growth (Acemoglu and Guerrieri, 2008; Arrow, 1962; Kaldor, 1966; Szirmai, 2012).

Moreover, industrial growth is positively correlated with service sector expansion, highlighting income effects and production complementarities that transmit industrial dynamism to other sectors. These cross-sectoral spillovers indicate that industrialization not only increases output within manufacturing but also stimulates broader structural transformation, fostering economic diversification and raising overall productivity across the economy.

Industrial activity also contributes to faster productivity gains at the worker level, measured by GDP per worker, confirming the central role of industry in driving efficiency improvements. These results are consistent with recent arguments that industrialization enhances both productivity and investment efficiency, further supporting sustained growth (McMillan et al., 2011; Rodrik, 2016).

Finally, the positive association between industrialization and interest rates likely reflects stronger investment demand and deeper financial intermediation, as capital-intensive sectors absorb more domestic savings and incentivize the development of financial markets (Herrendorf et al., 2013; Ngai and Pissarides, 2007). This channel underscores the role of industrialization in promoting capital accumulation and efficient allocation of resources, further reinforcing long-term growth.

In summary, the evidence demonstrates that structural transformation operates through multiple, mutually reinforcing channels, with industrialization at its core, generating productivity growth, cross-sectoral spillovers, capital deepening, and financial development, all of which contribute to sustained economic growth.

Table 6 further examines how industrial structural transformation drives regional growth through heterogeneous interaction effects across capital, labor, technology, and trade dimensions.

Columns (1) and (2) highlight the role of capital formation capacity. Regions with higher savings rates (Column 1) or higher gross capital formation (Column 2) experience stronger growth effects from industrial expansion, reflecting deeper financial intermediation, more effective asset accumulation, and efficient allocation of capital. These results are consistent with the literature emphasizing the importance of financial development and investment capacity in amplifying the productivity benefits of industrialization (Levine, 1997)

Column (3) focuses on labor market dynamics. In labor-abundant regions, diminishing returns to labor and low capital intensity per worker limit the productivity gains from industrial expansion, reducing its growth impact. Conversely, Column (4) shows that regions experiencing faster to-

TABLE 5.

Mechanism Analysis

	growth rate of industrial output (1)	growth rate of service output (2)	interest rate (3)	GDP per worker growth rate (4)
M	0.0767^{***}	0.0746^{***}	0.251^{*}	0.0541^{***}
	(0.0295)	(0.0273)	(0.135)	(0.0199)
A	-0.0694	-0.0722^{**}	0.352^{***}	-0.0734^{***}
	(0.0457)	(0.0332)	(0.118)	(0.0235)
g_A	0.0313	0.0194	-0.102^{***}	0.124^{***}
	(0.0198)	(0.0125)	(0.0388)	(0.00964)
$l.\ln y$	-0.0460^{***}	-0.0123^{***}	-0.0748^{***}	-0.0293^{***}
	(0.00816)	(0.00472)	(0.0238)	(0.00433)
U	-0.165^{***}	-0.0918^{***}	0.258^{***}	-0.0497^{**}
	(0.0380)	(0.0312)	(0.0719)	(0.0217)
Pi	0.0156	0.0329^{***}	-0.0217	0.0409^{***}
	(0.0161)	(0.0103)	(0.0931)	(0.00789)
Con.	0.491^{***}	0.182^{***}	0.527^{**}	0.282^{***}
	(0.0789)	(0.0409)	(0.215)	(0.0388)
Country	yes	yes	yes	yes
year	yes	yes	yes	yes
N	5,585	5,595	3,220	4,024
R^2	0.138	0.164	0.337	0.344

Notes: This table reports regression estimates exploring four channels through which the shares of industry and services affect economic growth: (1) industrial output growth, (2) service sector output growth, (3) interest rate, and (4) GDP per worker growth. Standard errors are reported in parentheses. *** is $p < 0.01$, ** is $p < 0.05$, * is $p < 0.1$.

tal factor productivity (TFP) growth capture larger gains from industrialization, highlighting the critical role of technological progress in sustaining industrial upgrading and amplifying regional growth differentials.

Column (5) demonstrates the importance of trade openness. Regions with higher external integration see magnified growth contributions from industrialization, as trade expands market size, facilitates technology diffusion, and attracts foreign investment, thereby strengthening the positive effects of industrial structural transformation (Frankel and Romer,1999).

In summary, the results in Table 6 indicate that the growth effects of industrial transformation are context-dependent, varying with capital formation, labor market conditions, technological progress, and trade openness. These findings imply that effective policy design must account for such interactions in order to fully harness the benefits of industrial expansion and promote sustainable regional development.

TABLE 6.

Heterogeneous Effects by Country Characteristics

	Dependent variable: Per capita GDP growth rate				
	(1)	(2)	(3)	(4)	(5)
$M \times s$	0.210^{***}				
	(0.0288)				
$M \times K$		0.0027^{***}			
		(0.0004)			
$M \times lnlab$			-0.0255^{***}		
			(0.0086)		
$M \times g_{tfp}$				0.00368^{***}	
				(0.0011)	
$M \times trade$					0.0459^{***}
					(0.0113)
M	-0.0608^{***}	-0.0569^{***}	0.421^{***}	0.0247	-0.0150
	(0.0188)	(0.0171)	(0.132)	(0.0170)	(0.0164)
A	-0.0638^{***}	-0.0674^{***}	-0.0809^{***}	-0.0795^{***}	-0.0759^{***}
	(0.0172)	(0.0138)	(0.0220)	(0.0211)	(0.0133)
g_A	0.126^{***}	0.147^{***}	0.127^{***}	0.124^{***}	0.141^{***}
	(0.0082)	(0.0079)	(0.009)	(0.0086)	(0.0078)
$l.\ln y$	-0.0341^{***}	-0.0168^{***}	-0.0308^{***}	-0.0124^{***}	-0.0177^{***}
	(0.0029)	(0.0024)	(0.0039)	(0.0031)	(0.0025)
U	-0.0208	-0.0446^{***}	-0.0248	-0.0274^{*}	-0.0371^{***}
	(0.0148)	(0.0121)	(0.0189)	(0.0150)	(0.0119)
Pi	0.0303^{***}	0.0272^{***}	0.0335^{***}	0.0283^{***}	0.0237^{***}
	(0.0072)	(0.0063)	(0.0074)	(0.0080)	(0.0064)
Con.	0.325^{***}	0.186^{***}	0.290^{***}	0.142^{***}	0.188^{***}
	(0.0276)	(0.0208)	(0.0352)	(0.0282)	(0.0212)
Country	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes
N	4,308	5,296	4,105	3,618	5,474
R^2	0.385	0.338	0.367	0.390	0.324

Notes: This table conducts a series of interaction analyses to investigate the potential mechanisms through which industrial output share influences regional economic growth. Column (2) introduces the savings rate as an interacting factor. Column (1) examines the interaction with the gross capital formation to GDP ratio. Column (3) includes labor force size. Column (4) interacts with the growth rate of total factor productivity (TFP). Column (5) interacts industrial output share with trade openness, measured by the ratio of trade volume to GDP. All regressions control for agricultural share, agricultural growth, initial income, urbanization rate, and inflation, and include country and year fixed effects. Standard errors are reported in parentheses. *** is $p < 0.01$, ** is $p < 0.05$, * is $p < 0.1$.

6. CONCLUSION

Our two-sector Solow model with learning-by-doing generates a central prediction: structural transformation produces unbalanced growth. When resources shift from manufacturing to services, aggregate capital-labor ratios decline, and the economy increasingly relies on lower-productivity sectors. This mechanism echoes Kaldor's growth laws, in which manufacturing specialization generates dynamic increasing returns and spillovers to the broader economy (Kaldor, 1981, 1966). In contrast, a shrinking industrial base reduces these spillovers and triggers Baumol's cost disease, whereby stagnant-productivity services dominate, raising relative prices and slowing aggregate growth (Baumol, 1967). These patterns reaffirm that structural transformation is a defining feature of sustained economic development (Kuznets, 1971).

Unlike balanced-growth models in which sectoral TFP differences gradually reallocate labor under constant aggregate growth (Ngai and Pissarides, 2007), our model predicts persistent deviations from balance. Learning-by-doing externalities concentrate in manufacturing. As the industrial share declines, aggregate productivity growth slows, and the economy converges to a lower-growth trajectory. Capital deepening across sectors with differing elasticities generates additional non-balanced growth (Acemoglu and Guerrieri, 2008).

Empirically, panel data from 183 countries between 1961 and 2019 support these predictions. Higher industrial shares correlates consistently with faster per capita GDP growth, whereas a rising service share slows growth. These findings indicate that structural shifts toward high-productivity sectors explain divergent growth experiences across regions (McMillan et al., 2011). They also align with the notion of premature deindustrialization, whereby developing countries lose industrial capacity early, foregoing productivity gains captured historically by advanced economies (Rodrik, 2016).

Mechanism analysis clarifies these patterns. A shrinking industrial sector lowers aggregate returns to capital and slows capital deepening. As services absorb more resources, aggregate TFP growth declines and service prices rise, consistent with Baumol's cost disease (Baumol, 1967). These outcomes reinforce the structuralist view that sectoral linkages and specialization have macroeconomic implications (Herrendorf et al., 2013).

Our findings also contribute to the literature on learning-by-doing and endogenous productivity growth. Cumulative experience in high-productivity sectors fosters faster growth (Arrow, 1962; Stokey, 1988) , and deindustrialization undermines the economy's long-run growth potential. Structural transformation is therefore not a neutral reallocation; it systematically shapes long-term productivity trajectories.

In conclusion, our study bridges early structuralist insights with modern growth models, emphasizing the centrality of structural transformation in long-run development (Herrendorf et al., 2014, 2013; Kaldor, 1966; Kuznets, 1971; McMillan et al., 2011; Ngai and Pissarides, 2007; Rodrik, 2016). Premature shifts toward services may constrain future growth, not because services are inherently unproductive, but because they lack the learning externalities, sectoral linkages, and capital-deepening effects that historically made manufacturing the engine of growth. Our results do not imply a return to heavy industrial policy but suggest that policymakers consider the long-run productivity consequences of sectoral reallocation.

REFERENCES

Acemoglu, D., and V. Guerrieri, 2008. Capital Deepening and Nonbalanced Economic Growth. *Journal of Political Economy* **116**, 467-498.

Acemoglu, D., S. Naidu, P. Restrepo, and J. A. Robinson, 2019. Democracy does Cause Growth. *Journal of Political Economy* **127**, 47-100.

Alonso-Carrera, J., J. Caballé, and X. Raurich, 2015. Consumption Composition and Macroeconomic Dynamics. B.E. *Journal of Macroeconomics* **15**, 1-42.

Alvarez-Cuadrado, F., N. Van Long, and M. Poschke, 2017. Capital-Labor Substitution, Structural Change, and Growth: Capital-Labor Substitution. *Theoretical Economics* **12**, 1229-1266.

Arrow, K. J., 1962. The Economic Implications of Learning by Doing. *Review of Economic Studies* **29**, 155-173.

Barro, R. J., and X. Sala-i-Martin, 1992. Convergence. *Journal of political Economy* **100**, 223-251.

Baumol, W. J., 1986. Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show. *American Economic Review* **76**, 1072-1085.

Baumol, W. J., 1967. Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis. *American Economic Review* **57**, 415-426.

Blundell, R., and S. Bond, 1998. Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics* **87**, 115-143.

Boppart, T., 2014. Structural Change and the Kaldor Facts in a Growth Model With Relative Price Effects and Non-Gorman Preference. *Econometrica* **82**, 2167-2196.

Buera, F. J., and J. P. Kaboski, 2012. The Rise of the Service Economy. *American Economic Review* **102**, 2540-2569.

Bugamelli, M., F. Lotti, M. Amici, E. Ciapanna, F. Colonna, F. D'Amuri, S. Giacomelli, A. Linarello, F. Manaresi, G. Palumbo, others, 2018. Productivity Growth in Italy: A Tale of a Slow-Motion Change. Bank of Italy Occasional Paper.

Caselli, F., and , W. J. Coleman II, 2001. The U.S. Structural Transformation and Regional Convergence: A Reinterpretation. *Journal of Political Economy* **109**, 584-616.

Chenery, H. B., 1975. The Structuralist Approach to Development Policy. *American Economic Review* **65**, 310-316.

Chenery, H. B., 1960. Patterns of Industrial Growth. *American Economic Review* **50**, 624-654.

Clark, C., 1940. The Conditions Of Economic Progress. Macmillan, London.

Comin, D., D. Lashkari, and M. Mestieri, 2021. Structural Change With Long?Run Income and Price Effects. *Econometrica* **89**, 311-374.

Diop, C. A., 2012. Black Africa: The Economic and Cultural Basis for A Federated State. Chicago Review Press.

Duarte, M., and D. Restuccia, 2020. Relative Prices and Sectoral Productivity. *Journal of the European Economic Association* **18**, 1400-1443.

Duarte, M., and D. Restuccia, 2010. The Role of the Structural Transformation in Aggregate Productivity. *Quarterly Journal of Economics* **125**, 129-173.

Duernecker, G., B. Herrendorf,and A. Valentinyi, 2024. Structural Change within the Services Sector and the Future of Cost Disease. *Journal of the European Economic Association* **22**, 428-473.

Fisher, A. G. B., 1939. Production, Primary, Secondary and Tertiary. *Economic Record* **15**, 24-38.

Foellmi, R., and J. Zweimüller, 2008. Structural Change, Engel's Consumption Cycles and Kaldor's Facts of Economic Growth. *Journal of Monetary Economics* **55**, 1317-1328.

Frankel, J. A. and D. Romer, 1999. Does Trade cause Growth? *American Economic Review* **89**, 379-399.

García-Santana, M., J. Pijoan-Mas, and L. Villacorta, 2021. Investment Demand and Structural Change. *Econometrica* **89**, 2751-2785.

Gelb, A. H., 1988. Oil Windfalls: Blessing or Curse? Oxford university press.

Gollin, D., D. Lagakos, and M. E. Waugh, 2014. The Agricultural Productivity Gap. *Quarterly Journal of*

Hartwig, J., 2012. Testing the Growth Effects of Structural Change. *Structural Change and Economic Dynamics* **23**, 11-24.

Herrendorf, B., C. Herrington, and Á. Valentinyi, 2015. Sectoral Technology and Structural Transformation. *American Economic Journal: Macroeconomics* **7**, 104-133.

Herrendorf, B., R. Rogerson, and Á. Valentinyi, 2021. Structural Change in Investment and Consumption — A Unified Analysis. *Review of Economic Studies* **88**, 1311-1346.

Herrendorf, B., R. Rogerson, and Á. Valentinyi, 2014. Growth and Structural Transformation, in: Aghion, P., Durlauf, S.N. (Eds.), Handbook of Economic Growth, Handbook of Economic Growth. Elsevier, pp. 855-941.

Herrendorf, B., R. Rogerson, and Á. Valentinyi, 2013. Two Perspectives on Preferences and Structural Transformation. *American Economic Review* **103**, 2752-2789.

Hori, T., M. Ikefuji, and K. Mino, 2015. Conformism and Structural Change. *International Economic Review* **56**, 939-961.

Jin, K., 2012. Industrial Structure and Capital Flows. *American Economic Review* **102**, 2111-2146.

Jorgenson, D. W., 1961. The Development of a Dual Economy. *Economic Journal* **71**, 309-334.

Ju, J., and S.-J. Wei, 2007. Current Account Adjustment: Some New Theory and Evidence (Working Paper No. 13388), Working Paper Series. National Bureau of Economic Research.

Kaldor, N., 1981. The Role of Increasing Returns, Technical Progress and Cumulative Causation in the Theory of International Trade and Economic Growth. *Economie appliquée* **34**, 593-617.

Kaldor, N., 1966. Causes of the Slow Rate of Economic Growth of the United Kingdom.

Kongsamut, P., S. Rebelo, and D. Xie, 2001. Beyond Balanced Growth. *Review of Economic Studies* **68**, 869-882.

Kuznets, S., 1973. Modern Economic Growth: Findings and Reflections. *American Economic Review* **63**, 247-258.

Kuznets, S., 1971. Economic Growth of Nations: Total Output and Production Structure. Harvard University Press.

Levine, R., 1997. Financial Development and Economic Growth: Views and Agenda. *Journal of Economic Literature* **35(2)**, 688-726.

Lewis, L. T., R. Monarch, M. Sposi, and J. Zhang, 2022. Structural Change and Global Trade. *Journal of the European Economic Association* **20**, 476-512.

Lewis, W. A., 1954. Economic Development with Unlimited Supplies of Labour.

Maroto-Sánchez, A., and J. R. Cuadrado-Roura, 2009. Is Growth of Services an Obstacle to Productivity Growth? A Comparative Analysis. *Structural Change and Economic Dynamics* **20**, 254-265.

Matsuyama, K., 2009. Structural Change in an Interdependent World: A Global View of Manufacturing Decline. *Journal of the European Economic Association* **7**, 478-486.

Matsuyama, K., 2002. The Rise of Mass Consumption Societies. *Journal of Political Economy* **110**, 1035-1070.

Matsuyama, K., 1992. Agricultural Productivity, Comparative Advantage, and Economic Growth. *Journal of Economic Theory* **58**, 317-334.

McMillan, M., D. Rodrik, M. Bacchetta, and M. Jensen, 2011. Making Globalization Socially Sustainable. ed. Marc Bacchetta and Marion Jansen, Chapter Globalization, Structural Change, and Productivity Growth. Geneva: International Labour Organization and World Trade Organization.

McMillan, M., D. Rodrik, and Í. Verduzco-Gallo, 2014. Globalization, Structural Change, and Productivity Growth, with an Update on Africa. *World Development* **63**, 11-32.

Moro, A., 2015. Structural Change, Growth, and Volatility. *American Economic Journal: Macroeconomics* **7**, 259-294.

Ngai, L. R., and C. A. Pissarides, 2008. Trends in Hours and Economic Growth. *Review of Economic Dynamics* **11**, 239-256.

Ngai, L. R., and C. A. Pissarides, 2007. Structural Change in a Multisector Model of Growth. *American Economic Review* **97**, 429-443.

Nordhaus, W. D., 2008. Baumol's Diseases: A Macroeconomic Perspective. B.E. *Journal of Macroeconomics* **8**.

Porzio, T., F. Rossi, and G. Santangelo, 2022. The Human Side of Structural Transformation. *American Economic Review* **112**, 2774-2814.

Ranis, G., and J. C. Fei, 1961. A Theory of Economic Development. *American Economic Review* 533-565.

Rodrik, D., 2016. Premature Deindustrialization. *Journal of Economic Growth* **21**, 1-33.

Rodrik, D., 2013. Unconditional Convergence in Manufacturing. *Quarterly Journal of Economics* **128**, 165-204.

Romer, P. M., 1986. Increasing Returns and Long-Run Growth. *Journal of Political Economy* **94**, 1002-1037.

Rosenstein-Rodan, P. N., 1943. Problems of Industrialisation of Eastern and South-Eastern Europe. *Economic Journal* **53**, 202-211.

Rostow, W., 1960. Industrialization and Economic Growth, in: StockholmMCMLX, First International Conference of Economic History, Mouton, París, 1960RostowIndustrialization and Economic GrowthStockholm MCMLX, First International Conference of Economic History1960.

Sposi, M., 2019. Evolving Comparative Advantage, Sectoral Linkages, and Structural Change. *Journal of Monetary Economics* **103**, 75-87.

Stokey, N. L., 1988. Learning by Doing and the Introduction of New Goods. *Journal of Political Economy* **96**, 701-717.

Szirmai, A., 2012. Industrialisation as An Engine of Growth in Developing Countries, 1950-2005. *Structural Change and Economic Dynamics* **23**, 406-420.

Uy, T., K.-M. Yi, and J. Zhang, 2013. Structural Change in An Open Economy. *Journal of Monetary Economics* **60**, 667-682.

Van Neuss, L., 2019. The Drivers of Structural Change. *Journal of Economic Surveys* **33**, 309-349.

Zou, H. F. 2025a. Reclaiming Production: A Dynamic Mercantilist Model of Trade, Capability, and National Welfare (No. 772). China Economics and Management Academy, Central University of Finance and Economics.

Zou, H. F., 2025b. Strategic Trade, Industrial Power, and Geopolitical Rivalry: A Two-Country Differential Game of the U.S.-China Conflict, CEMA Working Papers 774, China Economics and Management Academy, Central University of Finance and Economics.