Financial Development, Globalization, and Structural Transformation in Developing Countries *

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Abstract

The present study develops a theoretical model to analyze the dynamics of industrialization and deindustrialization in developing countries and their integration with earlier industrialized economies. The findings suggest that financial development plays a crucial role in speeding up industrialization and easing the transition to deindustrialization. Additionally, technology adoption from developed economies fosters catch-up growth, particularly in industries that are far from the technological frontier, driving an early shift towards the services sector. The model is calibrated to South African data from 1960 to 2010 and provides empirical support for these findings.

KEYWORDS: Structural Change, Sectoral Productivity Growth, Financial Development, Technology Adoption.

JEL classification: E23, O11, O14, O31, O33, O40, O41, G28

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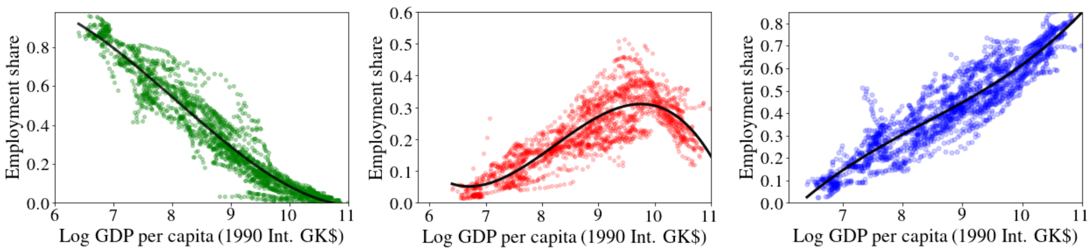
1 Introduction

The concept of structural change, defined as the reallocation of resources across broad economic sectors like agriculture, manufacturing, and services, is a key facet of economic development. This was notably included in Kuznets (1967) as one of the main stylized facts of development. Despite this common pattern, it has been documented by economists that the industrialization paths of developing economies differ substantially from those observed in developed countries. This discrepancy could potentially be influenced by the backdrop of globalization context in which these economies operate. This paper examines how the interplay of integration with earlier industrialized economies and the level of financial development influences the trajectory of industrialization in developing countries.

During the first stages of development, structural change takes place when labor moves from agriculture to other sectors, and at advanced stages of development, manufacturing shrinks when services continue to grow. Figure I shows this pattern by plotting sectoral employment shares as a function of income for several countries during the period 1950 through 2010[1]. However, the "peak" of the hump of manufacturing employment



(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE I: Worldwide employment shares of agriculture, manufacturing, and services

share has been lower at lower income levels for countries that industrialize in later years, what Rodrik (2016) called premature deindustrialization. Furthermore, in the literature, two main explanations have emerged to account for structural change: Engel's law and relative price effects. The first, and oldest mechanism, stipulates that households preferences shift from agriculture-related products to manufacturing industry and services as

[1]Using Timmer et al. (2015) and Bolt & Van Zanden (2014) database, manufacturing employment is constructed as the sum of total employment in mining, manufacturing, utilities, and construction. Services is the sum of whole sale and retail trade; hotels and restaurants; transport, storage, and communications; finance, real state, and business services; and community, social, and personal services. Income per capita is measured in 1990 international Geary-Khamis dollars. The solid black line plots the OLS fitted values from a regression of the employment share on a cubic polynomial of income per capita.

they get richer. The second mechanism, attributed to Baumol (1967), posits that asymmetric sectoral productivity growth induces structural change and accounts for different paths of deindustrialization across countries[2].

Virtually, almost all of the literature on structural change takes productivity changes as given, and effectively considers the implications of the exogenously given paths for productivity on the process of structural transformation. But if the paths of sectoral productivities differ significantly across countries, then it is important to ask what factors are responsible for these differences? Herrendorf et al. (2014) suggested to dig deeper into the factors that can explain these differences as they are more pronounced in particular sectors in particular countries. Meanwhile, recent research on endogenous economic growth emphasizes the significance of sectoral productivity in determining overall productivity through the adoption of technology.

Technological advancements primarily occur within specific industries, leading to varying rates of sector productivity growth (evidenced by studies such as Comin & Hobijn (2010), and Comin & Mestieri (2018)). Comin & Nanda (2019) and Avoumatsodo (2023) have shown that financial development differentially affects the intensity of use of adopted technologies. In this work, we first argue that financial development may have a distributional impact on productivity growth rates across various sectors. Sectors that are further from the technological frontier may experience more pronounced productivity increases as they catch up through financial development. We then conduct a cross-sectional analysis to examine the impact of financial development on structural transformation across countries. This analysis reveals a strong correlation between the level of financial development and the pace of structural shifts from agriculture to manufacturing. Specifically, countries with higher levels of financial development tend to undergo a more significant transition away from agriculture and experience more pronounced industrialization. Thus, a country's financial development can drive structural transformation by facilitating greater technology adoption within certain sectors.

The objective of this work, therefore, is to explore how financial development and globalization, through the lens of technology adoption, contribute to the phenomenon of premature deindustrialization in developing countries. To do this, we develop a three-sector endogenous growth model that considers the adoption of technology as the main driver of sectoral productivity growth. Countries can access frontier[3] technological ideas

[2] See, for example, Huneeus & Rogerson (2023) and Sposi et al. (2021)

[3] The technological frontier, in this context, refers to the group of earlier industrialized countries that have achieved advanced levels of technological development and innovation. These countries often serve as benchmarks for technological progress and are characterized by their ability to push the boundaries of knowledge and technology.

through globalization. In this framework, each final good has one intermediate good which is produced by an entrepreneur who invests in technology adoption. We introduce the assumption of financial constraints in the economy, stemming from limited financial development in developing countries. This implies that the total amount invested in technology adoption projects falls short of the optimal level due to the presence of significant financial constraints, which has been well-documented in developing countries. In the model, there is a direct cost associated with the quantity of adopted technology - the intensity of use of technology - and a sector-specific adjustment cost that reflects the expenses related to the implementation or use of the technology. These elements of the model help in capturing the nuances of technology adoption across different sectors and their impact on structural transformation.

To account for Engel's law, we follow the approach proposed by Comin et al. (2021) by introducing Constant Elasticity of Substitution (CES) nonhomothetic preferences for households. Unlike Stone-Geary preferences, CES nonhomothetic preferences maintain the elasticity of relative demand to not fall to zero as income or consumption increases, which aligns with the patterns observed in empirical data. By incorporating these elements into the model, we aim to capture the interplay between technology adoption, financial development, and household preferences in shaping economic structure. This framework facilitates a more extensive analysis of the dynamics of sectoral productivity growth and consumption patterns, providing a deeper understanding of the intricate interactions between developing and developed economies in a globalized context.

The model demonstrates that as a sector in a developing country moves further away from the technological frontier, its productivity growth rate tends to increase. This implies that sectors such as agriculture, which are typically farther from the frontier in developing countries, have the potential for higher rates of productivity growth. This finding suggests that there are opportunities for catching up and closing the productivity gap by adopting and implementing frontier technologies in sectors that are further behind.

The model also highlights an important finding regarding financial development and the processes of industrialization and deindustrialization. It shows that an increase in financial development has a dual effect on these processes. Specifically, during the phase of industrialization, higher levels of financial development accelerate the level of industrialization, leading to a more rapid transformation of the economy towards industrial sectors. This suggests that a well-developed financial system can facilitate the allocation of resources towards industrial activities, fostering economic growth and structural transformation. On the other hand, during the phase of deindustrialization, the model reveals that higher levels of financial development can actually contribute to a decrease in the level of industrialization. This implies that as a country undergoes the process of deindustrialization, a more developed financial system can facilitate the reallocation of resources away from manufacturing sectors towards other sectors or activities, such as services.

Moreover, the model examines how the process of industrialization in developing countries can be influenced when they engage with economies undergoing deindustrialization. Under certain assumptions regarding parameter values and sectoral productivity gaps at the onset of globalization, the model reveals that the level of industrialization in a country may be lower when it opens up to technologies from countries already in the deindustrialization phase. The underlying reason is that after integration, the relative productivity gap with the frontier tends to be smaller in the services sector than in manufacturing[4]. Consequently, the variation in productivity growth rates in manufacturing will be higher than that in services, leading to an early shift towards services.

We calibrate the structural parameters and time-varying processes of the model to fit South Africa's economic data from 1960 to 2010. Using sectoral expenditure and price data, we estimate key preference parameters, specifically the elasticity of substitution between goods and the income elasticity of demand for agriculture, manufacturing, and services. We find that the income elasticity of demand for agriculture is relatively lower at 0.95, indicating a lower proportional increase in agricultural consumption with increasing income. Conversely, services present a higher Engel curve, estimated at 1.26, reflecting a greater proportional rise in service consumption as income grows. Furthermore, the calculated elasticity of substitution is 0.58, which is less than one. This is aligned with the findings from Buera & Kaboski (2009) and Comin et al. (2021), and provides empirical support for the Baumol effect. This suggests that there is a prevailing tendency for resources to be reallocated away from more productive sectors.

Additionally, by using sectoral productivity data for South Africa and the technological frontier (represented here by the United States), we have calibrated the adjustment cost parameters associated with the use of new technologies. The results indicate that these costs are higher in the services sector and lower in agriculture. This suggests that, given an equivalent level of financial development and sectoral proximity to the technological frontier, the level of technology adoption will be lower in the services sector and higher in the agricultural sector. These findings illuminate the differential impacts of cost

[4]Considering that developed countries are undergoing deindustrialization, this implies that the growth rate in the manufacturing sector is higher than that in the services sector. Assuming that the growth rate in the manufacturing sector is higher than that in the services sector during the industrialization phase in the developing country, then when integration occurs, the technological frontier in the manufacturing sector will be relatively further ahead than that in the services sector.

structures and technology adoption across sectors, adding depth to our understanding of structural transformation.

To validate the model, we compared the model's predictions against empirical data. A noteworthy observation was that the model was able to capture the structural changes in the South African economy from 1960 to 2010. The model generated patterns of shifts in employment shares across the agriculture, manufacturing, and services sectors that aligned closely with the actual data. However, the model's prediction of the decline in the manufacturing labor share was not as steep as observed in the data. South African data validates, that increased financial development from 0.28 to 0.6 decreases the agricultural employment share to 8.32%, while manufacturing and services sectors see growth of 1.14% and 3% respectively. Further, when technology adjustment cost parameters across sectors are equalized, the model predicts notable shifts in employment shares: manufacturing and agriculture increase by up to 4.6% and 6.63%, while services decrease by up to 5.47%. This highlights that the higher adjustment costs in the services sector play a role in the growth dynamics of this sector as they induce lower intensity of use of new technologies and more pronounced growth in other sectors.

Related Literature. This paper is part of a recent and growing literature that seeks to understand the economic forces driving structural transformation[5], specifically the factors that explain different industrialization trajectories among countries. My work aligns closely with the research of Sposi et al. (2021) and Huneeus & Rogerson (2023), as well as the seminal work of Fujiwara & Matsuyama (2022).

Sposi et al. (2021) employed a Ricardian trade model to explore the impact of trade integration and sector-biased productivity growth on deindustrialization. Their findings concur with those from Huneeus & Rogerson (2023) indicating that sector-biased productivity growth explains the patterns of deindustrialization observed across various countries. However, their model falls short in explaining why, upon integration with other countries, the manufacturing sector might see a more substantial relative productivity growth compared to the services sector.

My model addresses this gap by explicating their concept of "importing" sector-biased productivity growth. It does this through the mechanisms of technology adoption, demonstrating that integrating with industrialized countries facilitates faster growth in the manufacturing sectors of developing countries compared to services. This is primarily because these industrialized countries also experience more significant growth in manufacturing

[5]Important contributions include Ngai & Pissarides (2007), Herrendorf et al. (2021), Duarte & Restuccia (2010), Felipe & Mehta (2016), and Świecki (2017)

relative to services[6], thereby creating a larger productivity gap in manufacturing than in services. A larger productivity gap in a sector implies a greater potential for catch-up, hence a higher growth rate in that sector. In this context, if developing countries were integrating with countries in the industrialization phase, their level of industrialization would not shift prematurely as observed.

Fujiwara & Matsuyama (2022) employ a technology catch-up model that assumes countries differ in their ability to adopt frontier technology. They demonstrate that early deindustrialization can occur if technology adoption takes longer in the services sector compared to other sectors. In contrast, my model introduces credit constraints and reveals - without making the same assumptions - that technology adoption indeed takes longer in the services sector than in manufacturing and agriculture. This is due to the higher adjustment costs in services, given that this sector is more skill-intensive in terms of technology use. Moreover, we illustrate that the reality of developed countries being in a deindustrialization phase also contributes to a slower growth rate within the service sectors. This is primarily because the growth rate is positively associated with the technology gap relative to the frontier. This gap widens more rapidly in manufacturing than in services, thus influencing the rate of growth within these respective sectors.

This paper makes a distinct contribution to the field by introducing a nuanced model that underscores the differential impacts of financial development and technology adoption on structural transformation. While previous works have investigated the impact of trade integration and technological catch-up on deindustrialization, this paper adds depth to the understanding by introducing credit constraints into the model. It provides a unique perspective on how the phase of deindustrialization in developed countries can affect the growth rate in manufacturing and services in developing economies, a dynamic that previous models do not fully address. These novel insights make this paper a significant addition to the existing body of research on structural transformation.

The remainder of this paper is structured as follows: Section 2 presents empirical evidence on structural change and financial development, providing a backdrop against which the subsequent analysis is framed. In Section 3, the theoretical model is introduced, which captures the complex relationships between various factors driving structural transformation. Section 4 expounds upon the mechanisms by which integration with advanced economies and financial development can influence structural transformation in developing countries. Section 5 lays out the calibration of the model, and discusses the qualitative and quantitative analyses conducted to examine the dynamics and implications of the model. The paper concludes with Section 6, summarizing key insights and their

[6] This is due to the fact that earlier industrialized countries are in a phase of deindustrialization

implications.

2 Facts on Structural Change and Financial Development

In this section, we present the empirical facts and motivation that underpin the theoretical model using data from GGDC (Groningen Growth and Development Centre), Bolt & Van Zanden (2014), and IMF (2014).

2.1 Structural Change and Deindustrialization Across Countries

Kuznets' model of structural transformation presents two distinctive phases. Initially, during the early stages of development, the majority of a country's resources are dedicated to the agricultural sector. As the economy advances, these resources gradually shift from

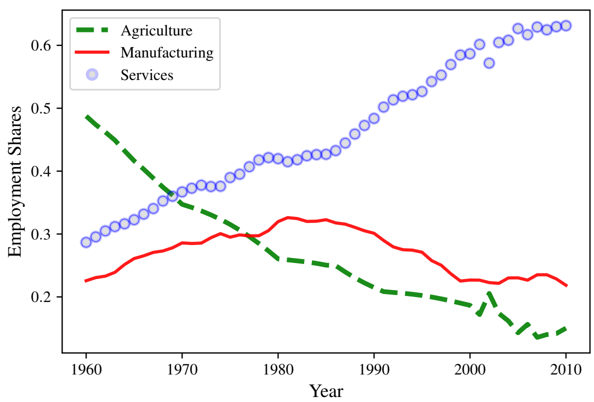


FIGURE II: Structural Transformation in South Africa.

agriculture towards industry and services, marking the first phase of structural transformation. The second phase is characterized by a reallocation of resources away from both agriculture and industry, and towards the service sector.

In line with this model, most countries witness a 'hump-shaped' progression in their manufacturing sector's share (either in employment or value-added), throughout their development process. This well-documented phenomenon, as explored by Herrendorf et al. (2014), is visible in Figure II, which illustrates the evolution of sectoral employment shares in South Africa from 1960 to 2010.

Three primary patterns of structural change are evident in the figure. Firstly, there is a persistent decline in the share of agriculture across different stages of development. Secondly, the share of the manufacturing sector follows the characteristic 'hump-shaped' curve, peaking at a certain point before declining. Lastly, there is a consistent increase in the share of the service sector, further underscoring the key phenomena that the literature on structural change seeks to explain.

In recent literature, Rodrik (2016) observed a trend in emerging economies whereby deindustrialization sets in at lower levels of income and with lower peak manufacturing shares compared to advanced economies that industrialized earlier. This phenomenon, referred to as 'premature deindustrialization', appears more prominent in certain countries or regions.

Figure III below illustrates the evolution of labor share in manufacturing across different levels of development and by region. It distinguishes between Asia (represented in blue), Latin America (in green), and Africa (in dark red). We can see that the peak manufacturing share of African countries is lower than that of Latin American countries, which, in turn, is lower than the peak share in Asian countries. Furthermore, these peaks occur at sequentially lower levels of development, underscoring the manifestations of premature deindustrialization across regions.

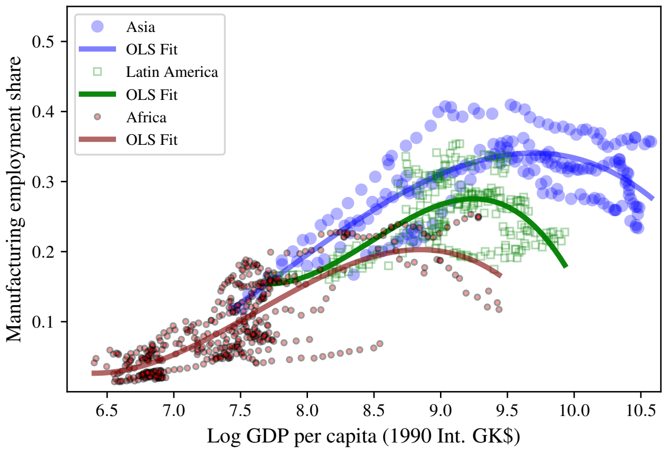


FIGURE III: Deindustrialization across regions, 1950-2010.

Note: The selection criteria dictate that the country should exhibit a well-defined hump in the manufacturing sector's employment share. Selected Asian economies include Japan, Korea, Malaysia, and Taiwan, while city-states such as Hong Kong and Singapore were excluded due to their negligible agricultural sectors despite having a pronounced hump-shape in manufacturing employment. Latin American selections encompass Argentina, Brazil, Chile, and Mexico. For Africa, South Africa and Mauritius are considered. Data sources : Timmer et al. (2015) and Bolt & Van Zanden (2014).

In a comparative analysis between Latin America and East Asia, Ungor (2017) showed that the disparities in sectoral productivity growth rates substantially elucidate the unique sectoral reallocations observed in these two regions. Notably, this accounts for the slower transition of Latin America out of agriculture. Conversely, Huneeus & Rogerson (2023) employed a benchmark model of structural change, revealing that varied rates of catch-up in sectoral productivities among nations can lead to diverse industrialization trajectories, including instances of premature deindustrialization, as observed in empirical data. Given these findings, it becomes imperative to further investigate the factors underpinning the discrepancies in the progression of sectoral productivities across countries.

2.2 Financial Development and Sector-Biased Productivity Growth

Recent research on endogenous economic growth underscores that technological advancements predominantly occur within specific industries, leading to diverse rates of sector productivity growth (See Comin & Hobijn (2010), and Comin & Mestieri (2018) for example). As a result, countries that adeptly adopt new technologies within certain sectors may witness heightened productivity growth in those sectors. Next, we test whether the levels of financial development distinctly impact sectoral productivity growth rates or not.

Figure IV illustrates the temporal evolution of the average level of financial development by regions, using data from the International Monetary Fund produced by Sahay et al. (2015). The figure reveals considerable differences in average financial development across regions or countries. While Western and Asian countries have experienced an increase over time, the African continent has not seen a substantial rise in its level of financial development. However, certain countries, such as South Africa, have seen a significant increase. For instance, South Africa's financial development level increased from 0.29 in the 1980s to 0.6 in 2010.

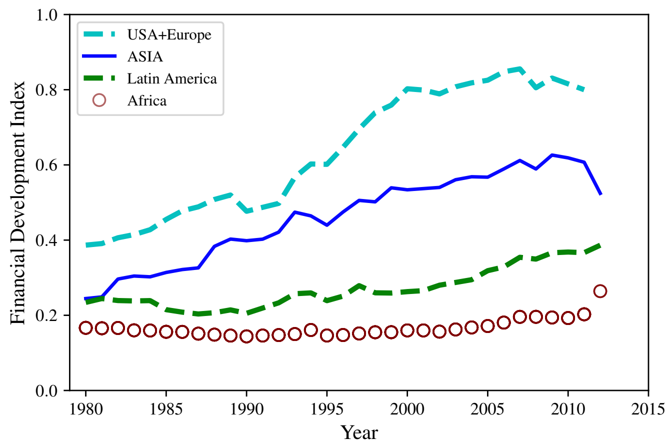


FIGURE IV: Average financial development by region over time.

Avoumatsodo (2023) and Comin & Nanda (2019) demonstrated that financial development distinctly impacts the intensity of use of various adopted technologies. In a linear regression model, we examine whether the productivity growth in a sector within a country, and across different countries, might be influenced by the productivity level at the frontier. Furthermore, we investigate whether financial development exerts the same or differing influences on productivity growth across various sectors within the same country and between different countries. To do this we interact the level of financial development in a country with the levels of proximity to the frontier technology in the sectors of agriculture (a), manufacturing (m), and services (s). We use Equation (2.1) for this investigation:

$$g_{cj} = \eta_j + \rho_c + \beta_1 FD^c_{-1} + \beta_2 dist^{jc}_{-1} + \beta_3 \left(FD^c_{-1} \times dist^{jc}_{-1} \right) + \mu_{cj} \qquad (2.1)$$

In this equation, g_{cj} signifies the average productivity growth in sector j (which can be either agriculture, manufacturing, or serces) for country c from the first decade to the last decade of the sample period, specifically between 1980-1990 and 2000-2010. For this analysis, a set of sector fixed effects, η_j, is incorporated into the regression specification to capture the unique attributes of each sector. Country-fixed effects, denoted by ρ_c, are also included to account for country-specific factors potentially influencing productivity growth.

The variable FD^c_{-1} represents the logarithm of the average measure of financial development of country c during 1980-1990. Meanwhile, $dist^{cj}_{-1}$ signifies a country's average proximity to the technological frontier in sector j during the same period. For this study, the United States serves as the benchmark for the technological frontier. The measure $dist^{cj}_{-1}$ is derived as the logarithm of the average productivity ratio between country c and the US in sector j for the 1980-1990 period, specifically $dist^{cj}_{-1} = \log(A^{cj}_{-1}) - \log(A^{usj}_{-1})$, where A^{cj}_{-1} (resp. A^{usj}_{-1})[7] indicates the average productivity of the country c (resp. US) between 1980 and 1990. This ratio offers a measure of country c's productivity in comparison to the frontier within the same sector during the 1980. And μ_{cj} is the residual or disturbance term.

Fundamentally, this regression model offers a comprehensive framework for examining whether disparities in financial development and sectoral productivity, relative to the technological frontier, might contribute to variations in sectoral productivity growth across different sectors and countries. Table I presents the coefficients from various estimations results. Columns (1) through (3) represent the results from the baseline model, treating each observation as a distinct sector within a country. Meanwhile, columns (4) through (6) provide the results of separate cross-country regression analyses for each sec-

[7]From GGDC database, we construct sectoral productivity levels in constant 2005 international US$ that are comparable across countries in the same year and over time.

tor, specifically, agriculture, manufacturing, and services.

TABLE I: Regression results of productivity growth in various sectors

	Sectoral labor productivity growth					
	Baseline			Agri.	Manu.	Serv.
	(1)	(2)	(3)	(4)	(5)	(6)
$\beta_1 : FD_{-1}$	0.192	0.235	0.013	1.003	0.060	0.294**
	(0.357)	(0.152)	(0.951)	(0.453)	(0.639)	(0.013)
$\beta_2 : dist_{-1}$	-1.810*	-1.013*	-1.890*	-3.049*	-0.884***	-0.343*
	(0.089)	(0.079)	(0.083)	(0.094)	(0.001)	(0.052)
$\beta_3 : FD_{-1} \times dist_{-1}$	-0.688	-0.391	-0.798*	-1.027	-0.380***	-0.024
	(0.104)	(0.176)	(0.095)	(0.120)	(0.006)	(0.827)
Country FE	No	Yes	No	No	No	No
Sector FE	No	No	Yes	No	No	No
Observations	63	63	63	21	21	21
R-squared	0.308	0.479	0.345	0.437	0.765	0.823

Note: Ecarts-types robustes. Robust pvalues in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The data is aggregated by periods of 10 years. The explanatory variables represent the average over the initial period from 1980 to 1990. The dependent variable is the growth rate between the averages of sectoral productivity from the initial period (1980-1990) and the final period (2000-2010).

The negative coefficient of β_2 suggests that sectors that are farther away from the technological frontier may experience greater productivity growth. This could be due to the so-called "catch-up" mechanism, where sectors that initially lag behind have more room for productivity gains by adopting existing technologies and practices from more advanced economies. The interaction coefficient β_3 is negative, indicating that the effect of financial development on productivity growth could be more pronounced for sectors that are far from the frontier. While the p-value associated with this term is slightly above conventional levels of statistical significance, it is near enough to the 10% threshold to warrant further investigation. This result might suggest that financial development could have a particularly beneficial role in enhancing growth in sectors farther from the frontier, possibly by enabling more efficient adoption and utilization of existing technologies and practices. The greater the sector's distance from the frontier (i.e., the more negative the value of $dist_{-1}$), the more positive the impact of financial development (FD_{-1}) on productivity growth, due to the negative coefficient on the interaction term.

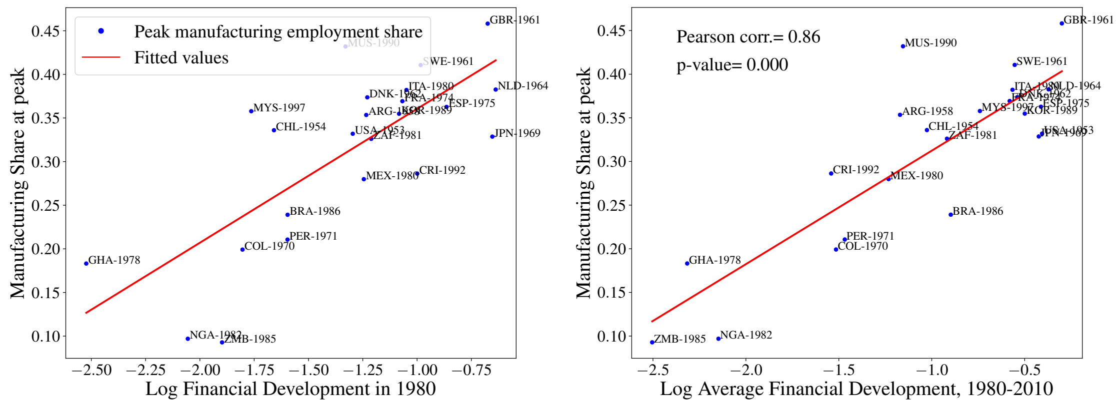
In summary, the regression models offer critical insights into how financial development and relative proximity to the technological frontier can differentially affect sectoral productivity growth across countries. Sectors further from the frontier, and thus possessing higher growth potential, may see a more pronounced productivity increase with elevated financial development. Therefore, the nation's financial development level could fuel structural transformation by expediting technology adoption and diffusion within these specific sectors. Next, we conduct a cross-sectional analysis to understand how variations in financial development levels across countries shape their structural change paths.

2.3 Financial Development and Structural Change : Cross-Country Analysis

In this subsection, we conduct a cross-country analysis to examinethe anticipated relationship between a country's level of financial development and its structural change. Indeed, the previous analysis suggest that we can expect countries with higher financial development to experience a rapid transition out of agriculture, a higher level of industrialization, and also a swifter shift towards services following the phase of industrialization, that is, after the peak in manufacturing.

Figure V–(**b**) depicts manufacturing employment share at the peak of industrialization to the average level of financial development[8] over the period 1980-2010 (in log) to establish the correlation between financial development level and the level of industrialization in cross-section. As can be seen on the graph, the Pearson correlation is positively significant and equals 0.86, indicating that countries that have achieved a higher level of industrialization are the same ones with a high level of financial development over the period from 1980 to 2010. In order to ascertain whether this correlation significantly changes depending on the year considered for the level of financial development, Figure V–(**a**) uses the level of financial development at the start of the period in 1980 rather than the average. The correlation does not appear to change significantly.

[8]Ideally, data on financial development levels preceding the manufacturing peak would be utilized, but the IMF database on financial development levels we have at our disposal only covers the period from 1980 to 2014. However, only a majority of developed countries have reached the manufacturing peak before this period.



(a) Initial financial development

(b) Average financial development

FIGURE V: Peak manufacturing employment share and financial development across countries.

In the following Table II, we present the results of the regression of the peak level of employment share in manufacturing on the average level of financial development, controlling for the average level of GDP, the population size, and the level of GDP corresponding to the peak in manufacturing. Despite the fact that we have only 23 country observations, we can still consider the statistical significance of the coefficients in light of the normality results for the error terms from the Shapiro-Wilk test.

The p-values from the Shapiro-Wilk test for skewness and kurtosis are above the 5% threshold, which leads us to conclude that we cannot reject the hypothesis of normality for the error terms. This result supports the robustness of the regression coefficients, given the assumption of normally distributed errors that underpins many statistical inferences in small sample scenarios. Consequently, we can consider the interpretation of the regression output and the substantial insights it provides regarding the relationship between the peak level of manufacturing employment share and financial development.

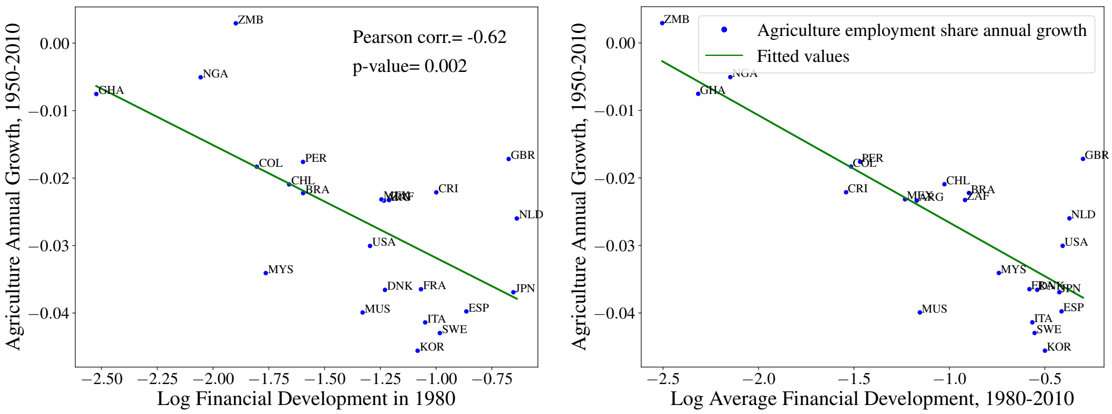
According to the estimates, the coefficient of the financial development level is both positive and significant. This lends support to the assertion that financial development intensifies structural change, particularly by promoting industrialization during the industrialization phase. We conduct the same analysis for the agricultural sector by examining the correlation between the rate of decrease in employment share in the agricultural sector and the level of financial development. Figure VI depicts the average annual growth rate over the entire period for which data are available for each country from 1950 to 2010, and the average level of financial development over the period from 1980 to 2010. We can observe a negative correlation, which means that the countries exhibiting a substantial transition out of the agricultural sector are the ones that had a higher average level of

TABLE II: Cross-country regression of peak manufacturing employment share

	Manufacturing employment share at the peak			
	(1)	(2)	(3)	(4)
Log average financial development	0.130***	0.072*	0.116***	0.095**
	(0.015)	(0.039)	(0.028)	(0.037)
Log average gdp per capita		0.049	0.024	
		(0.032)	(0.020)	
Log average population			-0.028***	-0.026***
			(0.007)	(0.006)
Log gdp per capita at the peak				0.044
				(0.026)
Nb. of countries	23	23	23	23
R-squared	0.73	0.75	0.87	0.88
Pvalue of Shapiro-Wilk test	0.13	0.16	0.47	0.28

Ecarts-types robustes. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

financial development. Table III presents the results of estimates for the average annual



(a) Initial financial development **(b)** Average financial development

FIGURE VI: Exit rate from the agricultural sector and financial development.

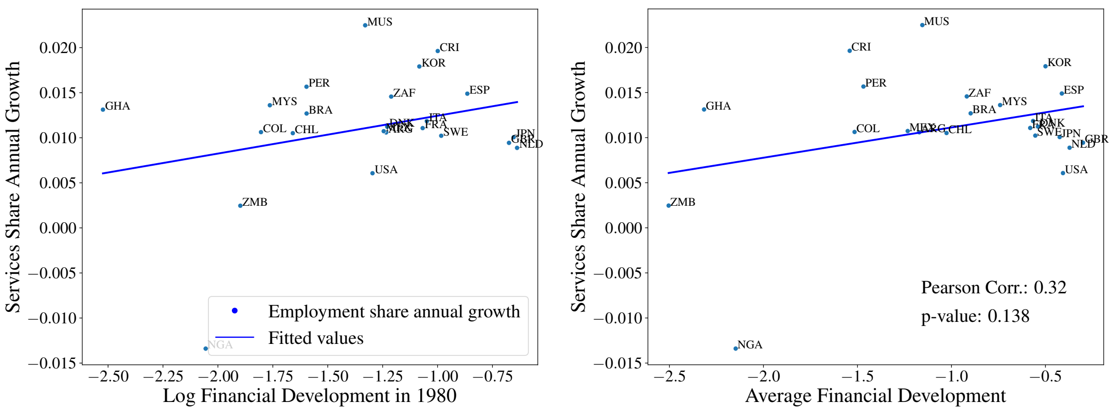
growth rate of employment in the agricultural sector in a country, relative to the country's average level of financial development. In a cross-sectional perspective, we can again observe that countries with a higher level of financial development have undergone a more substantial structural transition out of the agricultural sector. This once again supports the model's prediction, which posits that an increase in the level of financial development will impact the reduction of employment share in the agricultural sector.

TABLE III: Cross-country regression of annual growth of agriculture employment share

	Annual decrease in agriculture labor share		
	(1)	(2)	(3)
Log average financial development	-0.016***	-0.014*	-0.018***
	(0.002)	(0.007)	(0.006)
Log average gdp per capita		-0.002	0.001
		(0.005)	(0.004)
Log average population			0.003**
			(0.001)
Nb. of countries	23	23	23
R-squared	0.64	0.65	0.71
Pvalue of Shapiro-Wilk test	0.16	0.17	0.04

Ecarts-types robustes. Robust standard errors in parentheses.
** p<0.01, ** p<0.05, * p<0.1

As with the other sectors, we test whether the level of financial development will have a positive impact on the increase in services during the deindustrialization phase. For this, we consider the average annual growth rate of employment share in the services sector over the period between the peak year in manufacturing and 2010. Figure VII depicts the correlation between this average annual growth rate and the average level of financial development. Contrary to the agricultural and manufacturing sectors, even though the correlation is positiveit is not significant.



(a) Initial financial development **(b)** Average financial development

FIGURE VII: Services employment share average annual growth between 2010 and the year of peak in manufacturing.

The difference observed in services can be attributed to the early deindustrialization seen in many developing countries. Some of these countries have transitioned into the service sector without undergoing a significant manufacturing phase, leading to a shift into services even when the level of financial development is relatively low. This premature entry into the service sector is driven not by financial development, but rather by globalization, which results in higher productivity growth in manufacturing compared to services. This phenomenon is referred to by Lewis et al. (2021) as the importation of sector-biased productivity growth from other countries.

However, while their model provides valuable insights, it does not adequately explain why integration with developed countries has distinct impacts on different sectors of economic activities, or which sectors are likely to experience higher growth rates. To address this gap, the following section presents a three-sector endogenous growth model that examines the effects of financial development and globalization on a country's structural change over time, particularly through the lens of technology adoption.

3 Theoretical Framework

There are three final sectors : agricuture, manufacturing and services indexed by $k = a, m, s$. Each final sector produces competitively a single consumption good, also indexed by $k = a, m, s$ using labour and a specific intermediate input. Time is discrete, indexed by $t = 1, 2, \ldots$, and at each time there is a mass L_t of individuals. Each individual is endowed with one unit of labor that she supplies inelastically to final goods production and invests in technology adoption project as entrepreneur. Time-varying and country-specific sectoral productivity growth through intensity of using new technologies, and nonhomothetic preferences are the key drivers of structural change in the model.

3.1 Goods Production Sectors

Final goods production. Each final good is produced using labor and a specific intermediate good as input according to the Cobb-Douglas production function :

$$Y_{kt} = (A_{kt}L_{kt})^{1-\alpha} x_{kt}^{\alpha} \quad \forall k \in \{a, m, s\} \tag{3.1}$$

where $0 < \alpha < 1$ and A_{kt} is the productivity or the quality of the variety k used in sector k at time t. This productivity level will in turn be endogeneized in the subsection 3.2 as a result of technology adoption. x_{kt} is the input of the latest version of the intermediate good used in final-good k production. L_{kt} is the number of production workers in the final sector k. so that L_{kt} represents the total labor force or the hours worked in the sector k :

$$\sum_{k=a,m,s} L_{kt} = L_t \quad \forall t = 0,1,2,... \tag{3.2}$$

Since the final sector k is competitive, the representative firm takes the prices of its output P_{kt} and inputs as given, then chooses the quantity of labour L_{kt} and the quantity x_{kt} of the intermediate good to use in order to maximize its profit as follow:

$$\max_{\{L_{kt}, x_{kt}\}} P_{kt} L_{kt}^{1-\alpha} A_{kt}^{1-\alpha} x_{kt}^{\alpha} - p_t^k x_{kt} - w_t L_{kt} \tag{3.3}$$

where p_t^k is the price of the intermediate good of variety and w_t is the wage rate.

Intermediate goods production. At the beginning of each period, an individual succeeds in adopting an existing technology from the frontier and using it in the most efficient way possible to become the most productive in his sector. This entrepreneur can produce the intermediate good at a lower cost than the competitive fringe, and thus becomes the monopolistic producer of this intermediate good.

The production technology of intermediate goods consists in using a unit of the final good k to produce a unit of an intermediate good for the sector k. Given that the intermediate good producer is in a monopoly situation, it will practice the highest price that maximizes its profit given the demand function of the final sector producer for its intermediate good. It maximizes its profit as follows:

$$\max_{\{X_{kt}\}} \Pi_{kt} = p_t^k X_{kt} - P_{kt} X_{kt} \tag{3.4}$$

$$\text{s.t.} \qquad p_t^k = f_k^{-1}(X_{kt})$$

where f_k is the demand function of the final good k producer for the intermediate good in sector k, and X_{kt} is the total quantity produced by the monopoly.

3.2 Technology adoption and productivity growth

Productivity grows as the result of technology adoption that allow the monopolists to access an existing technology frontier in the sector k. At the final stage of each period t, entrepreneurs start a technology adoption project for the next period. A significant and novel aspect of this study is that it focuses not on modeling the process of technology adoption itself, but rather on examining the effective utilization of adopted technologies.

Previous research conducted by Comin & Mestieri (2018) has already investigated the diffusion of technology worldwide and found that countries have largely succeeded in adopting a wide range of technologies. However, what sets countries apart is the varying degree of intensity with which they use these adopted technologies. Let θ_{kt} be the intensity with which technologies are used in the sector k. A country's productivity in sector k at time t, denoted as A_{kt}, depends on its intensity of using new adopted technologies of the frontier in each sectors over time such that:

$$A_{kt} = \theta_{kt}\bar{A}_{kt-1} + (1-\theta_{kt})A_{kt-1};\ k = a, m, s \tag{3.5}$$

where $\bar{A}_{t-1}$ is the productivity of the frontier in sector at time $t-1$. The expansion of the frontier is a result of innovation, and the growth rate of sectoral productivity at the frontier is represented by $\bar{g}_k$[9]. If Z_{kt} units of final good k is invested in sector k at time $t-1$ for a tecnology adoption project that will take place at time t, then

$$\frac{Z_{kt}}{\bar{A}_{kt-1}} = \phi_k F_k(\theta_{kt}), \quad F_k' > 0,\ F_k'' > 0,\ F_k(0) = 0, \text{ and } \phi_k > 0 \tag{3.6}$$

where $Z_{kt}/\bar{A}_{kt-1}$ is productivity-adjusted technology adoption expenditure in the sector k. The total investment Z_{kt} in sector k is divided by $\bar{A}_{kt-1}$, the targeted productivity parameter, to take into account the "fishing-out" effect[10]. ϕ_k measures the cost-efficiency of adopting technology in sector k. It reflects how easily a sector can absorb and implement technology, given the required inputs, skills, and sectoral constraints. A higher ϕ_k indicates that technology adoption is more expensive per unit of intensity θ_{kt}, suggesting higher barriers to adoption. Conversely, a lower ϕ_k implies that technology can be adopted more efficiently and at a lower cost.

Sectors vary significantly in the level of skills, knowledge, and expertise required to implement new technologies, and this variation can impact ϕ_k. For instance, the services sector often demands a highly specialized and skilled workforce to adopt and operate technologies such as telecommunications, computer systems, and financial services infrastructure. The scarcity or high cost of such skilled labor can raise the value of ϕ_k, making technology adoption more expensive.

Meanwhile, agriculture often involves lower levels of specialization, with technology adoption typically centered around mechanization, irrigation systems, or fertilizers, which may require less technical expertise. As a result, the value of ϕ_k in agriculture

[9] In this study, unless specified otherwise, We will assume that $\bar{g}_a > \bar{g}_m > \bar{g}_s > 0$ to generate a process of structural change characterized by deindustrialization in developed countries.

[10] The further the technological frontier is, the more expensive it will be to catch up with it.

can be relatively lower, making technology adoption less costly compared to sectors with higher skill requirements. These differences imply that sectors with higher human capital requirements or greater technological complexity will face slower rates of technology adoption, leading to delayed productivity gains.

Since the function F_k is convex, the amount of investment Z_{kt} in technology adoption increases with the level of targeted intensity of using the technology θ_{kt} at time t. At equilibrium an entrepreneur chooses Z_{kt} (or chooses θ_{kt}) in order to maximize his net payoff given by :

$$\Pi_{kt} - P_{kt-1} Z_{kt} \tag{3.7}$$

The amount $P_{kt} Z_{kt}$ invested at time t in technology adoption projects is borrowed and we assume that there is a presence of credit constraints so that $P_{kt} Z_{kt}$ is constrained by a certain amount depending on the level of financial development of the country. That is, the entrepreneur cannot borrow more than a finite multiple of country's GDP per capita:

$$P_{kt-1} Z_{kt} \leq \kappa GDP_{t-1} \tag{3.8}$$

where κ is the level of financial development of the country. Entrepreneurs in less financially developed countries face more pronounced constraints, where the impact of these constraints is particularly significant for certain technologies, especially those in more productive sectors. The presence of credit constraints will tend to limit the adoption and intensity of use of these technologies.

3.3 Households

Each period a household receives instantaneous utility $\log C_t$ from its consumption bundle, where C_t is the level of aggregate consumption, which is a function of sectoral consumption C_{kt}, $k = a, m, s$. Borrowing from Comin et al. (2021), the real consumption index $\{C_t\}$ is described by an implicit function defined by the following nonhomothetic CES aggregator :

$$\sum_{k=a,m,s} \delta_k^{1/\sigma} \left(\frac{C_{kt}}{C_t^{\varepsilon_k}} \right)^{\frac{\sigma-1}{\sigma}} = 1 \tag{3.9}$$

where δ_k are constant weights for each sector in the economy[11], σ is the elasticity of substitution between goods. $\sigma < 1$ such that agricultural and manufacturing goods and services are complements. ε_k define the relative Engel curve for each sectoral output k, It represents the income elasticity of demand of sector k. C_t is a nonhomothetic index of real consumption in the country at time t.

A property of this class of preferences which is refered to as nonhomothetic constant elasticity of substitution (CES) preferences is that it generates nonhomothetic sectoral demands for all levels of income, including when income grows toward infinity. It allows for an arbitrary number of goods, includes good-specific nonhomotheticity parameters that control relative income elasticities, and features a constant elasticity of substitution. Stone-Geary preferences on the contrary are asymptotically homothetic where the nonhomotheticity is only transitional. Comin et al. (2021) show that this specification of nonhomothetic CES preferences has attractive properties for studying long-run structural change. Note that if $\varepsilon_k = 1$, $\forall k$ then equation (3.9) becomes Cobb-Douglas :

$$C_t = \left(\sum_{k \in \{a,m,s\}} \delta_k^{1/\sigma} C_{kt}^{1-\frac{1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \qquad \text{if } \varepsilon_k = 1 \quad \forall k = a, m, s \tag{3.10}$$

Equation (3.10) is the equation of the composite good when preferences are homothetic and σ is the within-period elasticity of substitution between consumption categories. Homothetic preferences are therefore a special case where all ε_k are equal to 1.

In each period, given the nonhomothetic CES aggregator (3.9), the representative household maximizes its utility, in each period by choosing sectoral consumption levels, C_{kt}, as follow:

$$\max_{\{C_{at}, C_{mt}, C_{st}\}} \log C_t \tag{3.11}$$

$$\text{s.t.} \qquad \sum_{k \in \{a,m,s\}} P_{kt} \left(C_{kt} + Z_{kt+1} \right) \leq w_t L_t - NX_t + \sum_{k=a,m,s} \Pi_{kt}$$

where NX_t is the total net exports. Instead of deploying a trade model, we integrate the implications of trade directly into the market equilibrium conditions to regulate labor demands across sectors at time t. In an open economy framework, the domestic production for any given sector should match the domestic demand, supplemented by the net trade balance for goods in that sector.

This utility maximization problem (3.11) is equivalent to total expenditure (on con-

[11] $\sum_{k=a,m,s} \delta_k = 1$

sumption in agriculture, manufacturing and services) minimization problem subject to the implicit CES nonhomothetic aggregator.

3.4 Equilibrium

Definition 1. *The timing of the model can be summarized as follows:*

- ***Step 0*** *: Period t starts with a productivity, A_{kt}, $\forall k$, result of investment in adoption of new technologies;*
- ***Step 1*** *: The production of intermediate goods then that of final goods takes place;*
- ***Step 2*** *Entrepreneurs choose the optimal amount Z_{kt+1} to invest in adoption project in each sector $k = a, m, s$ for the next period;*
- ***Step 3*** *: Households choose the levels of consumption goods a, m and s.*

The model economy is summarized by time invariant parameters $\{\alpha, \sigma, \delta_a, \delta_m, \delta_s\}$, the initial productivities level A_{k0} $\forall k$, and time varying exogenous processes of frontier sectoral productivities, total labour force, and the country's financial development level $\{\bar{A}_{kt}, L_t, \kappa_t\}$. Let's first define and then characterize the competitive equilibrium of the model.

Definition 2. *A competitive equilibrium is a:*
– collection of wage rate and prices of final goods $\mathbf{p} = \left\{w_t, P_{kt}\right\}_{t=0\,;k=a,m,s}^{\infty}$
– consumption allocation decissions $\mathbf{c} = \left\{C_{at}, C_{mt}, C_{st}\right\}_{t=0}^{\infty}$ *for the household;*
– labor and intermediate inputs allocation decisions $\mathbf{f} = \left\{L_{kt}, x_{kt}\right\}_{t=0\,;k=a,m,s}^{\infty}$ *for firms in final sectors;*
– collection of decisions $\mathbf{i} = \{Z_{kt+1}, X_{kt}\}_{t=0\,;k=a,m,s}^{\infty}$ *for producers of intermediate varieties and collection of net exports in each sectors* $\{NX_{kt}\}_{t=0\,;k=a,m,s}^{\infty}$ *such that:*

- *Given* $\mathbf{p}$, *households maximize (3.11) ;*
- *Given* $\mathbf{p}$, *final sectors producers solve the problem (3.3);*
- *Given* $\mathbf{p}$, *varieties' producers maximize (3.4) and (3.7)*

And the following markets clearing conditions are verified:

(a) Labour market : $L_{at} + L_{mt} + L_{st} = L_t$ *for all t;*

(b) Intermediate varieties markets : $x_{kt} = X_{kt}$ *;* $\quad \forall k \in \{a, m, s\}$ $\forall t$*;*

(c) Final goods markets: $Y_{kt} = C_{kt} + X_{kt} + Z_{kt+1} + NX_{kt} \quad \forall k = a, m, s$ *and for each t.*

where NX_{kt} is net exports in sector k at time t.

3.4.1 Firms' optimization

Final good. The first order conditions for the firm in the final sector k are given by:

$$\begin{cases} p_t^k = \alpha P_{kt} x_{kt}^{\alpha-1} A_{kt}^{1-\alpha} L_{kt}^{1-\alpha} & \forall k \in [0,1] \\ w_t = (1-\alpha) P_{kt} L_{kt}^{-\alpha} A_{kt}^{1-\alpha} x_{kt}^{\alpha} \end{cases}$$

Thus, the firm of the final sector equalizes the marginal productivity of labor to the real wage and the demand function for intermediate goods of variety j_k for the firm in the final sector is given by:

$$x_{kt} = \alpha^{\frac{1}{1-\alpha}} \left(\frac{p_t^k}{P_{kt}} \right)^{-\frac{1}{1-\alpha}} A_{kt} L_{kt} \quad \forall k = a, m, s \tag{3.12}$$

Intermediate good producer. By using the demand function of the equation (3.12) in the problem (3.4), the equibrium quantity of the intermediate good in sector k is given by :

$$x_{kt} = \alpha^{\frac{2}{1-\alpha}} A_{kt} L_{kt} \tag{3.13}$$

at the price p_t^k given by : $p_t^k = \alpha^{-1} P_{kt}$. The profit made by the intermediate monopoly in the sector k is therefore given at equilibrium by:

$$\Pi_{kt} = \pi P_{kt} A_{kt} L_{kt} \tag{3.14}$$

where $\pi := (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}}$. Thus, the profits generated by each intermediate sector depend positively on the productivity, the labor share and the price of the final good of this sector. Indeed, an increase in the output price in a sector positively affects the prices of intermediate goods used in this sector. Also, the increase in labor demand in a sector will have the effect of increasing output and therefore increasing intermediate goods that are used in the same Cobb-Douglas production function.

By substituting equation (3.14) into equation (3.7) one gets a maximization problem in the intensity of using the new technologies:

$$\max_{\{0 \le \theta_{kt} \le 1\}} \pi P_{kt} \left[\theta_{kt} \bar{A}_{kt-1} + (1-\theta_{kt}) A_{kt-1} \right] L_{kt} - P_{kt-1} \phi_k F_k (\theta_{kt}) \bar{A}_{kt-1} \tag{3.15a}$$

$$s.t. \qquad \theta_{kt} \le \phi_k F_k^{-1} \left(\zeta \kappa a_{kt-1} \right) \tag{3.15b}$$

The equality (3.15b) is obtained by applying the credit constraint defined in (3.8) [12] and incorporating equation (3.6). We can define the convex cost of investment in technological adoption function F_k as follow:

$$F_k(\theta_{kt}) = \theta_{kt}^2 \tag{3.16}$$

Let us denote by $\hat{\theta}_{kt}$ the intensity of technology use in the presence of perfect credit markets in sector k at time t. Solving the problem (3.15a) yields :

$$\hat{\theta}_{kt} = \min\left\{1; \frac{\pi P_{kt}(1-a_{kt-1})L_{kt}}{2\phi_k P_{kt-1}}\right\} \tag{3.17}$$

where $a_{kt-1} := A_{kt-1}/\bar{A}_{kt-1}$ is the sectoral proximity to the frontier at time $t-1$ in sector k. The equation (3.17) shows that in presence of perfect credit markets, an increase in labor demand and the growth rate of output prices in a sector incentivizes intermediate goods producers to adopt more technologies in that sector. This is because the expected gains from adopting these technologies are expected to increase, thus providing a stronger motivation for their utilization. As $\hat{\theta}_{kt}$ decreases with the sectoral proximity to the frontier a_{kt-1}, countries that are further away from the technological frontier would, in theory, utilize existing technologies more intensively at a higher level compared to countries closer to the frontier if perfect financial markets were present. This intensified usage would enable them to bridge the gap and catch up with advanced countries. However, this scenario does not materialize due to the constraints that hinder the adoption of more advanced technologies, which limit their ability to fully capitalize on existing technological capabilities.

Assumption I. *(i) We assume a binding constraint under imperfections in credit markets. Indeed, imperfections in the credit market create a constraint that limits entrepreneurs from using technologies more intensively and this effect is well documented in the literature.*
(ii) We also consider that the parameters ϕ_k, $k = a,m,s$ are such that the intensity of use of adopted technologies is less than one : $\theta_{kt} \in [0,1]$. Under this assumption, a country's sectoral productivity is assumed to be less than the frontier productivity, which is where it sources new technological ideas.

Credit constraints are particularly prevalent in developing countries, and various authors, such as Banerjee & Duflo (2005), Aghion et al. (2005), and Cole et al. (2016) have

[12] Equation (3.23) is used to replace the expression of GDP_{t-1}.

demonstrated how this issue significantly hampers technology adoption. Then, the intensity of use of technology θ^*_{kt} at equilibrium, in the presence of imperfections in the credit market, is given by:

$$\theta^*_{kt} = \left(\frac{\zeta \kappa a_{kt-1}}{\phi_k}\right)^{1/2} \tag{3.18}$$

where ϕ_k is such that $\theta^*_{kt} \leq 1$. The intensity of technology use at equilibrium θ^*_{kt} will be higher for countries with greater financial development. Additionally, countries closer to the technological frontier will experience a higher intensity of technology use compared to countries further away contrary to the case of perfection of the financial markets, even at the same level of financial development. This is because, all else being equal, countries closer to the frontier have higher levels GDP, resulting in less severe constraints on technology adoption and utilization. The productivity growth rate g_{kt} of the sector k is determined by :

$$g_{kt} = \theta^*_{kt}\left(a^{-1}_{kt-1} - 1\right) \tag{3.19}$$

Using the expression of θ^*_{kt} in the equation (3.18), the productivity growth g_{kt} decreases with the proximity[13]. The productivity growth in sectors that are near the technological frontier is expected to be slower compared to sectors that are further away from it. This implies that the level of advancement of each sector at the frontier can influence the process of structural change in developing countries.

Aggregate behavior. The production level of the final good k at equilibrium is obtained by substituting (3.13) in (3.1) :

$$Y_{kt} = \alpha^{\frac{2\alpha}{1-\alpha}} A_{kt} L_{kt} \tag{3.20}$$

and the wage rate is given from the first order conditions of the firm in the final sector k by :

$$w_t = \omega P_{kt} A_{kt} \tag{3.21}$$

where $\omega := (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}}$. The sectoral production level depends positively and linearly on sectoral productivity and labor share and the nominal wage rate is directly proportional

[13]Note that the logarithm function is lower and increases faster than the first bisector on the intervall [0, 1] so that g_{kt} decreases with a_{kt-1}.

to the product of sectoral price and sectoral productivity level. Let's denote VA_{kt} the value added of the sector k at the period t. Then the expression of value added VA_{kt} is derived through subsequent manipulations[14], resulting in the following equation:

$$VA_{kt} = \zeta P_{kt} A_{kt} L_{kt} \tag{3.22}$$

where $\zeta := (1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}$. And the gross domestic production of the economy is given by :

$$GDP_t = \zeta P_{kt} A_{kt} L_t \,, \quad \forall k = a, m, s \tag{3.23}$$

as the wage rate w_t is constant across sectors. Note that the gross domestic production is proportional to the nominal wage of the economy and that the sectoral values added are a function of the wage rate and the level of sectoral employment.

3.4.2 Household's optimization

Given the nonhomothetic CES aggregator, the intra-temporal household's problem is equivalent[15] to the expenditure minization problem below:

$$\min_{\{C_{at}, C_{mt}, C_{st}\}} \sum_{k=a,m,s} P_{kt} C_{kt} \tag{3.24}$$

$$\text{s.t.} \qquad \sum_{k=a,m,s} \delta_k^{1/\sigma} \left(\frac{C_{kt}}{C_t^{\varepsilon_k}} \right)^{\frac{\sigma-1}{\sigma}} = 1$$

Each period the household minimizes the expenditure on consumption in agriculture, manufacturing and services subject to the implicit CES nonhomothetic aggregator.

The first order conditions[16] imply that sectoral consumption demand satisfies:

$$C_{kt} = \delta_k \left(\frac{P_{kt}}{E_t} \right)^{-\sigma} C_t^{\varepsilon_k (1-\sigma)} \tag{3.25}$$

where $E_t := \sum_{k=a,m,s} P_{kt} C_{kt}$ is the total expenditure in consumption at time t. Replacing E_t by $P_t C_t$ in the equation (3.25) where P_t is the average cost of real consumption C_t, one can

[14] See Appendix A.1.2 for more details.

[15] The expenditure minimization problem is the dual of the utility maximization problem. The relationship between the utility function and Marshallian demand in the utility maximization problem mirrors the relationship between the expenditure function and Hicksian demand in the expenditure minimization problem.

[16] See Appendix A.1.4 for calculation.

show that :

$$C_{kt} = \delta_k \left(\frac{P_{kt}}{P_t}\right)^{-\sigma} C_t^{\varepsilon_k(1-\sigma)+\sigma} \tag{3.26}$$

where the aggregate price P_t is given[17] by :

$$P_t = \left[\sum_{k=a,m,s} \delta_k P_{kt}^{1-\sigma} C_t^{(1-\sigma)(\varepsilon_k-1)}\right]^{\frac{1}{1-\sigma}} \tag{3.27}$$

Since the wage rate w_t is the same across sectors, we can deduce from the equation (3.21) a relationship between relative sectoral prices and relative sectoral productivities as expressed by the following equality :

$$\frac{P_{kt}}{P_{mt}} = \frac{A_{mt}}{A_{kt}} \quad \forall k \neq m \tag{3.28}$$

Equation (3.28) shows that $\frac{P_{kt}}{P_{mt}}$,$k \neq m$, is decreasing over time if $g_{kt} > g_{mt}$, and increasing over time if $g_{kt} < g_{mt}$, so that slower productivity growth in a sector causes its relative price to go up over time.

Combining the goods and labour market clearing conditions and demand equations with the equations for the consumption of the final goods, innovation, prices, and the global portfolio balance yields a set of conditions that fully characterize the equilibrium of the model. Table IV collects all these conditions for each period $t = 0, 1, 2, \ldots$

[17] See Appendix A.1.4 for the demonstration.

TABLE IV: Equilibrium conditions

$D_1:$	$C_{kt} = \delta_k \left(\frac{P_{kt}}{P_t}\right)^{-\sigma} C_t^{\varepsilon_k(1-\sigma)+\sigma}$	$\forall k = a,m,s$
$D_2:$	$\sum_{k\in\{a,m,s\}} P_{kt}\left(C_{kt}+Z_{kt+1}\right) = w_t L_t - NX_t + \sum_{k=a,m,s} \Pi_{kt}$	
$D_3:$	$Z_{kt} = \phi_k \theta_{kt}^2 \bar{A}_{kt-1}$	$\forall k = a,m,s$
$D_4:$	$X_{kt} = \alpha^{\frac{2}{1-\alpha}} A_{kt} L_{kt}$	$\forall k = a,m,s$
$S_1:$	$Y_{kt} = \alpha^{\frac{2\alpha}{1-\alpha}} A_{kt} L_{kt}$	$\forall k = a,m,s$
$S_2:$	$w_t = \omega P_{mt} A_{mt}$	
$S_3:$	$\frac{P_{kt}}{P_{mt}} = \frac{A_{mt}}{A_{kt}}$	$\forall k = a,,s$
$S_4:$	$\Pi_{kt} = \pi P_{kt} A_{kt} L_{kt}$	$\forall k = a,m,s$
$S_5:$	$P_t C_t = \sum_{i=a,m,s} P_{it} C_{it}$	
$S_6:$	$P_t = \left[\sum_{k=a,m,s} \delta_k P_{kt}^{1-\sigma} C_t^{(1-\sigma)(\varepsilon_k-1)}\right]^{\frac{1}{1-\sigma}}$	
$S_7:$	$g_{kt} = \theta_{kt}^* \left[a_{kt-1}^{-1} - 1\right]$	$\forall k = a,m,s$
$S_8:$	$\theta_{kt}^* = \left(\frac{\zeta \kappa a_{kt-1}}{\phi_k}\right)^{1/2}$	$\forall k = a,m,s$
$G_1:$	$L_{at} + L_{mt} + L_{st} = L_t$	
$G_2:$	$Y_{kt} = C_{kt} + X_{kt} + Z_{kt+1} + NX_{kt}$	$\forall k = a,m,s$

4 Technology Adoption and Structural Change

In this section, We will analyze the dynamics of structural by considering the effects of demand and supply and examine the impact of financial development on the shift of manufacturing share. By analyzing the relationship between financial development and changes in the manufacturing sector, We can gain a better understanding of the dynamics and implications of financial development on premature deindustrialization.

4.1 Definition of Structural Change

Let define the sectoral value added share s_{kt} and consumption expenditure share e_{kt} as :

$$s_{kt} := \frac{VA_{kt}}{GDP_t} \quad ; \quad e_{kt} := \frac{P_{kt}C_{kt}}{P_t C_t} \tag{4.1}$$

In this framework, the value added share s_{kt} and the labor share l_{kt} are identical[18] but different from the expenditure share e_{kt} and structural change is defined as the state in which some of consumption expenditure shares change over time , i.e., $g_{e_{kt}} \neq 0$ for at least some of $k = a, m, s$.

Using the equation (3.26) we can derive the following expression for the sectoral share of consumption expenditure in good k :

$$e_{kt} = \delta_k \left(\frac{P_{kt}}{P_t}\right)^{1-\sigma} C_t^{(1-\sigma)(\varepsilon_k - 1)} \qquad \forall k \tag{4.2}$$

In the rest of the work, we will study productivities and shares relative to the manufacturing sector since we are more interested in industrialization. From Equation (4.2) we can obtain the ratio of consumption expenditure shares in sector k and manufacturing sector m as follow:

$$\frac{e_{kt}}{e_{mt}} = \frac{\delta_k}{\delta_m} \left(\frac{P_{kt}}{P_{mt}}\right)^{1-\sigma} C_t^{(\varepsilon_k - \varepsilon_m)(1-\sigma)} \qquad k = a, s \tag{4.3}$$

Solving the equation (4.2) for C_t one can define the unobservable nonhomothetic index of real consumption in terms of parameters and observables :

$$C_t = \left[\left(\frac{e_{kt}}{\delta_k}\right)^{\frac{1}{1-\sigma}} \left(\frac{E_t}{P_{kt}}\right)\right]^{1/\varepsilon_k} \qquad \forall k = a, m, s \tag{4.4}$$

where E_t represents the total consumption expenditure. Combining the equation (4.4) with the (4.3) yields to the expression (4.5) of the relative sectoral share of consumption expenditure as a function of observable variables, which will be crucial in the calibration of the preferences parameters σ, ε_a, and ε_s:

$$\frac{e_{kt}}{e_{mt}} = \frac{\delta_k}{\delta_m} \left(\frac{e_{mt}}{\delta_m}\right)^{\frac{\varepsilon_k}{\varepsilon_m} - 1} \left(\frac{P_{kt}}{P_{mt}}\right)^{1-\sigma} \left(\frac{E_t}{P_{mt}}\right)^{(1-\sigma)\left(\frac{\varepsilon_k}{\varepsilon_m} - 1\right)} \qquad k = a, s \tag{4.5}$$

[18] From the equations (3.22) and (3.23), we can easily get $s_{kt} = \frac{L_{kt}}{L_t}$.

Using the equilibrium conditions D_2 and G_2, consumption expenditure share e_{kt} can be written as a function of sectoral value added and sectoral investment :

$$e_{kt} = \frac{VA_{kt} - P_{kt}Z_{kt+1} - NX_{kt}}{GDP_t - NX_t - \sum_{i=a,m,s} P_{it}Z_{it+1}} \tag{4.6}$$

By dividing the numerator and the denominator by the total GDP, one gets the following equation (4.7) that describes a relationship between the sectoral consumption expenditure share, the sectoral labor share and the share of GDP devoted to investment and net exports in the whole economy and in each sector:

$$l_{kt} = \frac{P_{kt}Z_{kt+1} + NX_{kt}}{GDP_t} + \left(1 - \frac{NX_t + \sum_{i=a,m,s} P_{it}Z_{it+1}}{GDP_t}\right) e_{kt} \tag{4.7}$$

By incorporating net exports into the model's equilibrium conditions, the labor demand in each sector now includes both a domestic and a foreign component, dictated by the net position of the trade balance. Specifically, $L_{kt} = L^D_{kt} + L^F_{kt}$, where:

$$L^D_{kt} = \frac{C_{kt} + Z_{kt+1}}{\zeta P_{kt} A_{kt}},$$
$$L^F_{kt} = \frac{NX_{kt}}{\zeta P_{kt} A_{kt}}.$$

where L^D_{kt} signifies labor demand under conditions of a closed economy or autarky, and L^F_{kt} accounts for the adjustments arising from net trade. As a consequence, if the economy is a net importer in a certain sector, labor demand in that sector would decrease, even if consumption remains unaffected. By incorporating these aspects, we can more accurately represent labor shares in each sector.

4.2 Technology Adoption and Deindustrialization

Next, we will analyze the dynamics of consumption expenditure share ratios over time by considering the influence of the Engel effect and the Baumol effect. Additionally, we will explore how sectoral proximity can impact the process of structural change through technology adoption.

Using equation (3.28), the ratio of consumption expenditure shares in the equation (4.3) can now be expressed as a function of the sectoral productivities, $\{A_{it}\}_{i=a,m,s}$ and the aggregate consumption C_t :

$$\frac{P_{kt}C_{kt}}{P_{mt}C_{mt}} = \frac{\delta_k}{\delta_m}\left(\frac{A_{mt}}{A_{kt}}\right)^{1-\sigma} C_t^{(\varepsilon_k-\varepsilon_m)(1-\sigma)} \quad \forall k = a,s \tag{4.8}$$

The equation (4.8) illustrates both the supply and demand side mechanisms for the structural change through the allocation of consumption between different sectors. To understand this, let us take the ratio of the consumption expenditure in equation (4.8) and deduce the following recurrence relation between the current and the previous ratio of consumption expenditures at time t:

$$\Psi_{kt} = \underbrace{\left(\frac{1+g_{mt}}{1+g_{kt}}\right)^{1-\sigma}}_{\text{Baumol Effect}} \times \underbrace{\left(1+g_t\right)^{(1-\sigma)(\varepsilon_k-\varepsilon_m)}}_{\text{Engel's Law}} \times \Psi_{kt-1}\,, \quad \forall k = a,s \tag{4.9}$$

where $\Psi_{kt} = \frac{P_{kt}C_{kt}}{P_{mt}C_{mt}}$ and g_t is the growth rate of the aggregate consumption between periods $t-1$ and t. The parameter σ governs the supply side mechanisms of the structural change via productivity effects and the relative compararison of income elasticities $\varepsilon_k - \varepsilon_m$ governs the relative long-run Engel curves. As $\sigma < 1$, when the relative sectoral productivity A_{kt}/A_{mt} increases then the expenditure share decreases in that sector. And when sectoral income elasticities differ, such that $\varepsilon_k - \varepsilon_m > 0$, then sector k expenditure share also rises with the aggregate consumption and vice versa.

Equation (4.9) shows that, the ratio e_{kt}/e_{mt} is decreasing if $(1+g_{kt}) > (1+g_{mt})(1+g_t)^{\varepsilon_k-\varepsilon_m}$ and increasing if $(1+g_{kt}) < (1+g_{mt})(1+g_t)^{\varepsilon_k-\varepsilon_m}$. That is, sectoral consumption expenditure shares shift from sectors with faster productivity growth to those with slower productivity growth over time.

Since the growth rate of sectoral productivity decreases with sectoral proximity to the frontier, if the frontier moves away from a country in a particular sector, the country's productivity growth becomes higher in that sector. Therefore, this country will experience a decrease in the share of the sector's consumption expenditure. Moreover, if the technology frontier is growing faster than a country relatively in a given sector k, leading to a decrease in the country' sector k productivity proximity a_{kt}, it is more likely for that sector to experience faster growth compared to other sectors. Consequently, the sectoral share of this particular sector is expected to diminish. This is the example of the agricultural sector, which is growing faster at the technological frontier than the manufacturing and service sectors. This induces a faster growth in the agricultural sector in developing countries as well since the technology gap becomes higher in agriculture. A decrease in the share of the agricultural sector in developed countries will result in a decrease in the share of the agricultural sector in developing countries through technological adoption.

Without loss of generality, we will focus on the Baumol effect in the following analysis, keeping in mind that incorporating the Engel effect would not significantly alter the results, though it would complicate the derivations.

Assumption II. *(i) We hypothesize that the growth rate at the technology frontier in manufacturing is higher than that in services ($\bar{g}_m > \bar{g}_s$) to reflect a pattern of deindustrialization at the frontier.*
(ii) Also, we assume that developing countries grow less rapidly in manufacturing than developed countries at the beginning of globalization. This assumption holds given the phase of deindustrialization at the frontier (with a higher growth rate in manufacturing than in services), as well as the industrialization in developing countries. Moreover, it is important to note that there was no significant catching up with the frontier during the early stages of globalization.

Assumption III. *Additionally, we assume that the proximity of sectoral productivities to the technological frontier a_m and a_s, as well as the growth rate of sectoral productivities g_m and g_s during the early stages of industrialization in developing countries, are such that:*

$$(1+g_s)(\phi_s a_m)^{1/2}(a_m^{-1}+1) > (1+g_m)(\phi_m a_s)^{1/2}(a_s^{-1}+1). \tag{4.10}$$

This hypothesis will be verified post-calibration. However, if the adjustment costs ϕ_s in the services sector significantly exceed those in the manufacturing sector ϕ_m, and during the industrialization phase $g_m < g_s$ in developing countries, it is intuitive to assume that the relationship posited in inequality (4.10) holds true.

If developing economies are in a phase of industrialization (assuming that the growth rate in manufacturing is lower than in services) and they adopt technologies from developed countries that are in a phase of deindustrialization (with a higher growth rate in manufacturing than services), then the relative productivity gap in manufacturing will widen further and the increase in the growth rate will be higher in manufacturing compare to services. This will lead to a decline in the slope of the curve for the manufacturing sector in developing countries as the relative growth rate in manufacturing becomes higher. Through technology adoption from previous developed countries, developing countries can experience a "premature" deindustrialization. This enables the proposal of the following proposition.

Proposition I. *Under Assumption III, when a developing country integrates (through* *technology adoption) with the technological frontier that is undergoing deindustrialization, then the consumption expenditure share of manufacturing of the country is expected to be significantly reduced.*

Proof. Let $G_s(a_m, a_s)$ denote the ratio of productivity growth rates in the manufacturing and services sectors, defined by $G_s(a_m, a_s) = (1+g_m)/(1+g_s)$. We aim to demonstrate that G_s increases when a country integrates with the technological frontier. The time subscript will be omitted for clarity, unless explicitly required.

The total variation dG_s of the function $G_s(a_m, a_s)$ following a variation in sectoral proximities to the technological frontier for productivities a_m and a_s is given by:

$$dG_s = \frac{\partial G_s}{\partial a_m} da_m + \frac{\partial G_s}{\partial a_s} da_s \tag{4.11}$$

Since the growth rate g_k of sectoral productivity A_k is decreasing with sectoral proximity a_k, $k = m, s$ then :

$$\frac{\partial G_s}{\partial a_m} < 0 \text{ and } \frac{\partial G_s}{\partial a_s} > 0 \tag{4.12}$$

As the frontier grows faster than the country in manufacturing at the integration such that $g_m < \bar{g}_m$ then a_m will decrease and da_m will be negative. If the country grows faster in services than the frontier such that $da_s > 0$ then dG_s will be positive and G_s will increase. If not, i.e. in case where $da_s < 0$, first, let us show that the growth rate of sectoral proximity to the frontier is higher in services than in manufacturing:

$$\frac{a_{st+1}}{a_{mt+1}} \Big/ \frac{a_{st}}{a_{mt}} = \frac{A_{st+1}}{\bar{A}_{st+1}} \times \frac{\bar{A}_{mt+1}}{A_{mt+1}} \times \frac{A_{mt}}{\bar{A}_{mt}} \times \frac{\bar{A}_{st}}{A_{st}} \tag{4.13}$$

By rearranging the fractions in equation (4.13) and isolating sectoral productivities at the technological frontier on one hand, and country productivities on the other hand, the following expression is derived:

$$\frac{a_{st+1}}{a_{mt+1}} \Big/ \frac{a_{st}}{a_{mt}} = \frac{1+\bar{g}_m}{1+\bar{g}_s} \Big/ \frac{1+g_m}{1+g_s} \tag{4.14}$$

Given the deindustrialization at the frontier, the numerator $(1+\bar{g}_m)/(1+\bar{g}_s)$ is greater than 1. Similarly, $(1+g_m)/(1+g_s)$ is less than 1 given that the country is undergoing industrialization. Therefore, the ratio $\frac{a_{st+1}}{a_{mt+1}} \big/ \frac{a_{st}}{a_{mt}}$ is greater than 1. Consequently, the variation rate in the sectoral proximity to the frontier will be higher in services than in manufacturing:

$$\frac{da_s}{a_s} > \frac{da_m}{a_m} \tag{4.15}$$

Let's now derive $G_s(a_m, a_s)$ with respect to its arguments. By replacing the expression of g_k, $k = m, s$, then the differential of the function $G_s(a_m, a_s)$ can be obtained as follow:

$$dG_s = \frac{(\zeta\kappa)^{1/2}}{2(1+g_s)}\left[\left(\frac{a_s}{\phi_s}\right)^{1/2}\left(a_s^{-1}+1\right)G_s(a_m,a_s)\frac{da_s}{a_s} - \left(\frac{a_m}{\phi_m}\right)^{1/2}\left(a_m^{-1}+1\right)\frac{da_m}{a_m}\right] \tag{4.16}$$

From inequality (4.15), a sign of dG can be found conditional to the values of the parameters ϕ_k, sectoral proximities a_k, and sectoral productivity growth g_k $k = m, s$:

$$dG_s > -\frac{(\zeta\kappa)^{1/2}}{2(1+g_s)^2}\left[(1+g_s)\left(\frac{a_m}{\phi_m}\right)^{1/2}\left(a_m^{-1}+1\right) - (1+g_m)\left(\frac{a_s}{\phi_s}\right)^{1/2}\left(a_s^{-1}+1\right)\right]\frac{da_s}{a_s} \tag{4.17}$$

Assuming that Assumption III holds at the beginning of integration with developed countries, then $dG_s > 0$ meaning that the relative share of services will increase over time and the slope of the curve of the manufacturing share decreasing. ■

To summarize, developing countries tend to undergo deindustrialization when they integrate with deindustrializing countries. When developing countries align their economic activities with those of deindustrializing countries, it leads to a shift away from industrialization and a decline in the manufacturing sector's relative importance. Integration with developed economies facilitates technology transfer and knowledge spillovers to developing countries. This phenomenon significantly stimulates 'catch-up' growth, especially in sectors that are farther from the technological frontier. As manufacturing tends to advance more rapidly in developed countries, a noticeable gap arises compared to the services sector in developing economies. As a result, developing countries experience higher growth rates in manufacturing relative to services. This accelerated growth in manufacturing cultivates a leapfrogging effect, thereby allowing these economies to bypass certain stages of manufacturing development and transition directly into the services sector.

4.3 Financial Development and Structural Transformation

The main force driving structural change in the model is sector-biased productivity growth through technology adoption. This growth hinges on a sector's initial productivity relative to the technological frontier and the level of financial development. The success of sectoral technology adoption affects sectoral output which, in turn, affects the sectoral allocation of consumption expenditure and factors of production. A relative increase in productivity implies achieving the same production level with relatively fewer labor inputs. Consequently, the employment share, relative to other sectors, decreases.

Moreover, a higher sectoral productivity growth rate results in a lower relative price of output. As a result, consumers can maintain the same quantity of goods of higher productivity growth sector while spending less, allowing them to allocate the remaining income to other goods, ensuring a certain level of consumption of goods in lower productivity growth sectors. This, in turn, leads to a decrease in expenditure share in sectors with higher productivity growth rates.

In the analysis that follows, the impact of financial development on the speed of structural transformation in countries will be examined. This study specifically aims to investigate how financial development influences the dynamics of sectoral shares. In doing so, we can gain a better understanding of the role that financial development plays in the differences in industrialization paths observed between developed and developing economies.

To start, the expression for the sectoral productivity growth rate is substituted into Equation (4.9) to derive a relationship between the evolution of consumption expenditure shares and the ratio of technology use intensities between sector k and manufacturing. The outcome is represented in equation (4.18) as follows:

$$\Psi_{kt} = \left[\frac{1+\theta^*_{mt}(a^{-1}_{mt-1}-1)}{1+\theta^*_{kt}(a^{-1}_{kt-1}-1)}\right]^{1-\sigma} \times \Big(1+g_t\Big)^{(1-\sigma)(\varepsilon_k-\varepsilon_m)} \times \Psi_{kt-1} \tag{4.18}$$

where intensity of using technologies $\theta^*_{kt} = \left(\frac{\zeta\kappa a_{kt-1}}{\phi_k}\right)^{1/2}$ is increasing with the level of financial development κ. Consider that at a given date t_0 the country's level of financial development κ increases. Then, the intensity of use of new technologies, denoted as θ^*_{kt}, will increase in each sector $k = m, s$ but this increase varies across sectors due to the distinct characteristics of each sector and the differences in sectoral proximities to the technology frontier. To see this, let us differentiate the ratio of sectoral productivities in manufacturing and in sector k defined by $G_k = (1+g_m)/(1+g_k)$ with respect to κ:

$$\frac{\partial G_k}{\partial \kappa} = \frac{(\zeta/\kappa)^{1/2}\left[\frac{1}{\phi_m^{1/2}}\left(a_m^{-1/2} - a_m^{1/2}\right) - \frac{1}{\phi_k^{1/2}}\left(a_k^{-1/2} - a_k^{1/2}\right)\right]}{2(1+g_k)^2} \tag{4.19}$$

Proposition II. *Financial development drives both deindustrialization and industrialization, generating a boost in economic transformation.*

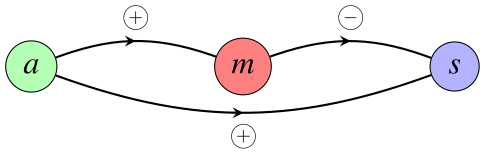
Proof. Using the equation (4.19), one can express the variation of the productivity growth in manufacturing relative to sector k, ΔG_k, as a function of sectoral productivities and the level of variation of financial development $\Delta\kappa$:

$$\Delta G_k = \frac{g_m - g_k}{2(1+g_k)^2}\frac{\Delta\kappa}{\kappa} \tag{4.20}$$

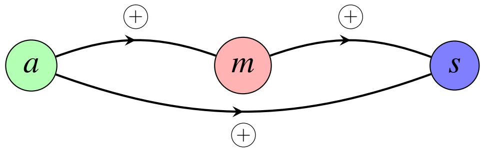
If at a given time t_0 the growth rate in manufacturing is less than services growth then ΔG_s will be negative, and the relative sectoral productivity growth $(1+g_m)/(1+g_s)$ will be lower than in the case where there was no increase in κ. Under these conditions Ψ_{st} will also be smaller than in the case where κ had not increased, which means that the manufacturing expenditure share e_{mt} will increase with κ. If, on the other hand, at a given date t_0, the productivity growth rate in the manufacturing sector g_m is higher than that in services g_s, then ΔG_s will be positive and the share of manufacturing will be lower than the case where there is not increase in κ.

Figure VIII below exemplifies these two scenarios. During the industrialization phase, where the growth rate in agriculture (g_a) is greater than that in services (g_s), which in turn is greater than that in manufacturing (g_m), resources are primarily reallocated from the agricultural and service sectors a and s to the manufacturing sector m. This reallocation is further amplified by the level of financial development, favoring higher growth in the agricultural and service sectors. Conversely, during the deindustrialization phase, where the growth rates satisfy $g_a > g_m > g_s$, resource reallocation is directed more towards the service sector. This shift is again amplified by the level of financial development. ■

As the level of financial development increases, the sector that previously exhibited a higher growth rate also experiences a proportionally greater increase. This suggests that financial development has the potential to amplify sectoral productivity growth. Sectors that had initially demonstrated higher growth rate tend to benefit the most from this advancement. Figure IX illustrates the impact of financial development level on the sectoral share of consumption expenditure in manufacturing. If an increase in financial development occurs before the peak of the manufacturing sector share curve, the impact is



(a) Industrialization phase



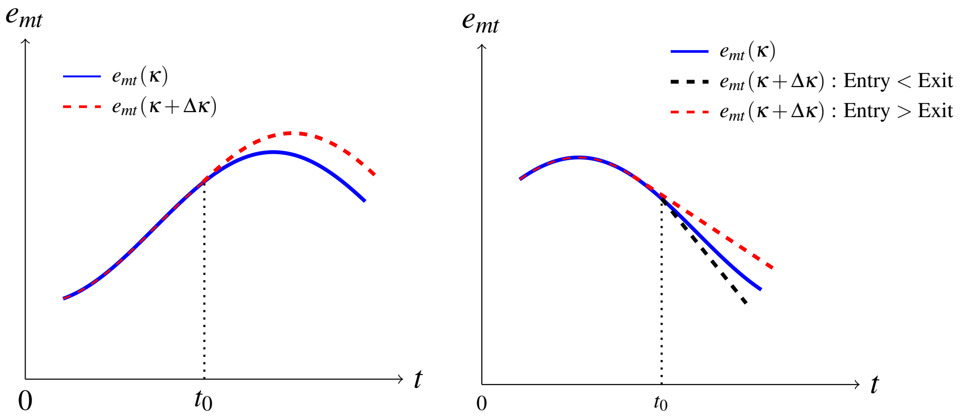
(b) Deindustrialization phase

FIGURE VIII: Impact of financial development on resource reallocation across sectors

positive. This signifies that during the industrialization phase, enhanced financial development will support a higher inflow of resources into the manufacturing sector.

However, if this increase occurs after the peak, implying a deindustrialization phase, higher levels of financial development will instead spur the reallocation of resources from manufacturing to services. At the same time, it will also cause a more significant exit from the agricultural sector, thereby leading to a considerable influx into the manufacturing sector. The overall impact will thus depend on the levels of entry and exit in the manufacturing sector, which are determined by the differences in productivity growth rates across sectors.

If $\frac{g_a - g_m}{g_m - g_s} > \left(\frac{1+g_a}{1+g_s}\right)^2$, then $|\Delta G_a| > \Delta G_s$ and the inflow into the manufacturing sector exceeds the outflow. And, if the opposite holds, the outflow dominates, leading to a reduction in the manufacturing sector's share.



(a) An increase in κ before the peak   **(b)** An increase in κ after the peak

FIGURE IX: Effect of an increase in financial development at time t_0 on manufacturing share

5 Calibration and Quantitative Analysis

In this section, we calibrate the dynamic technology adoption model, to be employed for quantitative counterfactual analysis in the subsequent section. Model parameters and exogenous processes are calibrated to align with South African[19] data spanning from 1960 to 2010. From this, the model's predictions for the employment shares across agriculture, manufacturing, and services are derived. Preference parameters, namely $\{\sigma, \delta_a, \delta_m, \delta_s, \varepsilon_a, \varepsilon_s\}$, are estimated using sectoral data on prices and expenditure shares. Frontier productivities, denoted as $\bar{A}_{kt}$, are constructed to mirror data from the United States, and technology parameters ϕ_k are constructed to match the growth rates of sectoral productivity.

In the first subsection, we discuss the primary data sources. The subsequent subsections describe the calibration procedures for the model's time-invariant parameters and time-varying processes, respectively. Once the parameters are calibrated, the baseline model is solved for each five-year interval. The final subsection assesses the model's fit by comparing non-targeted moments in the model with corresponding data points.

[19]The manufacturing employment share in South Africa exhibits a distinct hump-shape pattern in the years following World War II and comprehensive data on sectoral consumption expenditure shares is predominantly available for developed countries, hence the focus on South Africa.

5.1 Data and Sources

We rely on sectoral data[20] to drive this analysis. This includes sectoral prices (P_{kt}), employment (L_{kt}), and productivity levels ($A_{kt}, \bar{A}_{kt}$), which are sourced from the GGDC Sector Database. Furthermore, sectoral expenditure ($E_{kt} = P_{kt}C_{kt}$) and aggregate expenditure ($P_tC_t = \sum_k E_{kt}$) are drawn from the OECD dataset. Data pertaining to sectoral net exports (NX_{kt}) are sourced from the World Development Indicators (WDI). Productivity data are scaled using 2005 PPP values from the GGDC value-added per worker '2005 Benchmark' Level Database. Consumption expenditure data are available only from 1975 onwards. Given that the technology adoption process occurs at a low frequency, the data are aggregated in five-year intervals.

5.2 Time invariant parameters

The parameter α is derived from the total employment share in GDP. Using equations (3.21) and (3.23), the employment share in GDP for each country is determined as:

$$\frac{w_t L_t}{GDP_t} = \frac{1}{1+\alpha} \tag{5.1}$$

Consequently, setting $\frac{1}{1+\alpha}$ equal to the standard labor income share (2/3) allows for the calculation of the coefficient α.

The preference parameters δ_k , $k = a, m, s$ are recovered from the model-implied relationship between relative sectoral expenditure and relative productivities of equation (4.8). Without loss of generality, we adopt normalization for the nonhomothetic index of real consumption, setting $C_{1975} = 1$, reflecting its ordinal characteristics inherent in preference structure. Similarly, we normalize the baseline productivity levels in agriculture, manufacturing, and services, $\{A_{k1975} = 1\}_{k \in \{a,m,s\}}$. Consequently, each δ_k matches the sectoral expenditure share at the inception of the period.

we structurally estimate preference parameters $\{\varepsilon_a, \varepsilon_s, \sigma\}$ by minimizing the distance between the observed sectoral expenditure shares and those implied by the model given the observed prices. Specifically, the preference parameters are estimated using the equations (5.2) for $k = a, s$ below obtained from the equation (4.5) :

$$\log\left(\frac{E_{kt}}{E_{mt}}\right) = \log\left(\frac{\delta_k}{\delta_m}\right) + (1-\sigma)\log\left(\frac{P_{kt}}{P_{mt}}\right) + (\varepsilon_k - 1)\log\left(\frac{e_{mt}}{\delta_m}\right) + (1-\sigma)(\varepsilon_k - 1)\log\left(\frac{E_t}{P_{mt}}\right) \tag{5.2}$$

[20] Please refer to Appendix A.2 for detailed information on data construction.

With parameter values for each $\delta_{k\in\{a,s\}}$ obtained using the initial sectoral expenditure shares, we select from a discrete grid an arbitrary income elasticities[21] for agriculture and services, then we obtain a value of σ that minimizes the squared residual using the equation (5.3) :

$$\min_{\{\sigma\}} \sum_{t=t_0}^{T} \sum_{k=a,s} \left[\log\left(\frac{E_{kt}}{E_{mt}}\right) - \log\left(\frac{\delta_k}{\delta_m}\right) - (1-\sigma)\log\left(\frac{P_{kt}}{P_{mt}}\right) - (\varepsilon_k - 1)\log\left(\frac{e_{mt}}{\delta_m}\right) \right.$$
$$\left. -(1-\sigma)(\varepsilon_k - 1)\log\left(\frac{E_t}{P_{mt}}\right)\right]^2 \tag{5.3}$$

The process is iteratively repeated, selecting the value of σ that minimizes residuals across all observed values of ε_a and ε_s. Table V reports the estimation results. The determined parameter value for σ is 0.58, which falls below one, aligning with empirical evidence supportive of the Baumol effect which suggests that resources are reallocated away from more productive sectors. The calculated elasticity of substitution is slightly close to the value of 0.5, which was previously employed in the calibration exercises conducted by Buera & Kaboski (2009), and to the value of 0.57, as used in Comin et al. (2021).The value for Engel curves for agriculture and services, relative to manufacturing, are $\varepsilon_a = 0.95$ and $\varepsilon_s = 1.26$. The value of ε_s aligns closely with that found in Comin et al. (2021), while the computed value of ε_a appears to be slightly higher than the results presented in Comin et al. (2021). However, it's important to note that their calibration was based on sectoral employment shares, as opposed to my model, which utilizes sectoral consumption expenditure shares.

The technology parameters $\{\phi_k\}_{k\in\{a,m,s\}}$ are set to align with the observed sectoral productivity growth rates in the data. This calibration is achieved by employing equations (3.19) and (3.18), as delineated below:

$$\phi_k = \frac{1}{T}\sum_{t=1}^{T} \zeta \kappa a_{kt-1} \left(\frac{a_{kt-1}^{-1} - 1}{g_{kt}}\right)^2 \tag{5.4}$$

where g_{kt} represents the average annual growth rate over a 5-year period in sector k. To generate structural changes in the model, we have calculated the average growth rate over two periods for Manufacturing and Services sectors: the industrialization period of 1960-1980 and the deindustrialization period of 1980-2010. The calibration results reveal the following parameter values: $\phi_a = 27.81$, $\phi_m = 55.84$, and $\phi_s = 535$. These

[21]The following parametric restrictions are imposed: $\varepsilon_a < \varepsilon_m = 1 < \varepsilon_s$. These restrictions confine the parametric space to empirically relevant regions as supported by the existing literature.

figures underscore that $\phi_s > \phi_m > \phi_a$, suggesting that, for an equivalent level of financial development and sectoral proximity to the technological frontier, technology utilization will be lower in the services sector and higher in the agricultural sector.

Skill Intensity and Complexity: The service sector often requires highly specialized skills and human capital, which can be more challenging to train or adapt compared to the manufacturing sector, where technology can often be more standardized and automated.

Adjustment Costs: Services often face higher adjustment costs, as implementing new technology may require more significant changes in organizational processes, customer interaction, or labor practices. For instance, adopting digital tools in healthcare or finance involves complex regulatory, compliance, and training processes.

Physical Capital vs. Human Capital: Manufacturing may rely more on machinery and equipment that can be quickly upgraded, while services often rely on human capital, which adapts more slowly due to the need for retraining or acquiring new skills.

Heterogeneous Technology Needs: Services sectors (e.g., healthcare, education, and finance) have unique technology needs that may not scale or transfer easily across firms, creating a slower overall pace of adoption.

These findings can be attributed to the differential adjustment costs associated with technology adoption across various sectors. Historically, the agricultural sector, characterized by less technology-intensity, would likely encounter lower adjustment costs during technology adoption. As a result, given the same credit constraint level, the total cost of technology adoption becomes lower, leading to a significant rise in the technology utilization intensity within this sector.

In contrast, the services sector, often recognized for its reliance on human skills and interactions, may encounter higher adjustment costs when incorporating new technologies. These costs can emerge in forms such as retraining costs for employees, initial productivity losses during the transitional period, or the complicated process of integrating technology within highly personalized service delivery. Consequently, even with the same level of credit constraint, the intensity of technology use within the service sector remains lower.

To calibrate the parameters ϕ_k, $k = a,m,s$, we have imposed an average annual growth rate in sectoral productivities. It is essential to verify if the model generates productivity levels close to the data. Figure X presents the level of productivities calculated from the obtained ϕ_k, $k = a,m,s$ on the y-axis and the level of productivities in the data on the x-axis. The labor productivity suggested by the model for the manufacturing sector aligns well with the empirical data, whereas the corresponding values for the services sector tend to be lower than the fundamental productivity. The agriculture sector, on

TABLE V: Summary of Parameters

Panel A. Calibrated Outside of the Model			
Parameter	Value	Description	Source
α	0.5	Calibrated to match aggregate labour income share (2/3)	
L_t	$\{\cdot\}$	Labor endowment, numbers of persons engaged across the three broad sectors.	Timmer et al. (2014)
κ_t	$\{\cdot\}$	Financial Development Index	IMF (2014)
NX_{kt}	$\{\cdot\}$	Net exports in sector k	WDI (2022)
$A_{k,1960}$	$\{\cdot\}$	Initial levels of sectoral productivities	Timmer et al. (2015)
$\bar{A}_{kt}$	$\{\cdot\}$	US sectoral productivities	Timmer et al. (2015)

Panel B. Calibrated Using the Model Structure		
Parameter	Value	Description
σ	0.58	Elasticity of substitution between goods
ε_a	0.95	Agricultural relative to manufacturing Engel curve
ε_m	1	Homothetic preferences for manufacturing
ε_s	1.26	Services relative to manufacturing Engel curve
δ_a	0.31	Preference weight on Agriculture
δ_m	0.39	Preference weight on Manufacturing
δ_s	0.30	Preference weight on Services
ϕ_a	27.81	Calibrated to match agriculture productivity growth rates
ϕ_m	55.84	Calibrated to match manufacturing productivity growth rates
ϕ_s	535	Calibrated to match services productivity growth rates

the other hand, sees its model-implied labor productivity more closely approximating the data, particularly at the start and end of the observed period.

Using the values of productivity proximity in the manufacturing and services sectors from 1960, along with their respective growth rates, and the values of the parameters ϕ_m and ϕ_s, we are able to compute both sides of the inequality 4.10 and verify[22] Assumption III.

5.3 Time-Varying Exogenous Processes

In alignment with the extant literature[23], we consider the United States as the technological frontier across all three sectors of economic activity. Consequently, the frontier productivity parameters $\{\bar{A}_{at}, \bar{A}_{mt}, \bar{A}_{st}\}$ are calibrated as follows. By leveraging the value-added equation (3.22), the productivity level can be computed by dividing the real sectoral

[22]Between 1960 and 1965, the value for $(1+g_s)(\phi_s a_m)^{1/2}(a_m^{-1}+1)$ is 28.44 whereas $(1+g_m)(\phi_m a_s)^{1/2}(a_s^{-1}+1)$ was 6.76.

[23]Refer to Caselli & Coleman (2002), Aghion et al. (2005), and Aghion et al. (2013) for instance

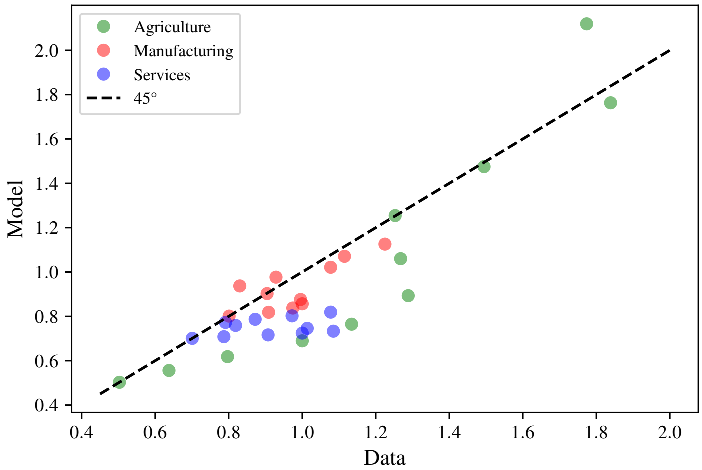


FIGURE X: Sectoral productivities: model vs data.

Note: The productivity plots for each sector are adjusted based on the 1975 value of the series for that respective sector. The data are aggregated into five-year average periods to solely focus on productivity trends, in accordance with the context of the endogenous growth of the model.

value added by the total sectoral workers, as demonstrated in the following equations:

$$\bar{A}_{kt} = \frac{VA_{kt}^{US}}{(1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}} L_{kt}^{US}}, \quad k = a, m, s \tag{5.5}$$

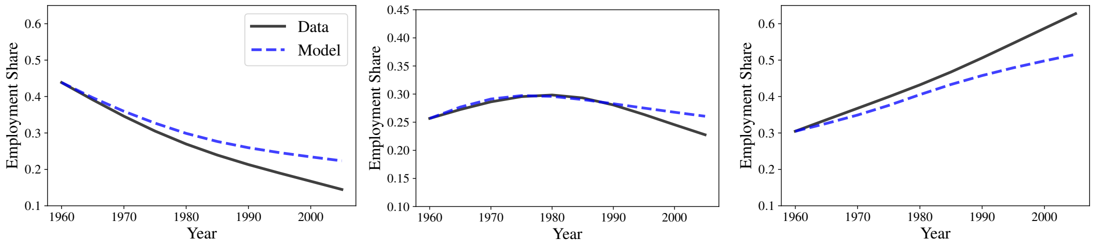
The calibration for the level of financial development, represented by κ, is derived from the financial development index provided by the International Monetary Fund (IMF)[24]. Furthermore, the level of the labor force in the country, denoted by L_t, is established using data on the number of individuals engaged across the three broad sectors. A summary of the model's parameters can be found in Table V.

5.4 Quantitative Analysis

The calibration process ensures that the model accurately aligns with data on total expenditure, sectoral expenditures, and the level of financial development. We then numerically solve the baseline model. The key step here is to identify the series of sectoral employment shares, productivities, prices, and consumption shares along the transitional path that satisfy the equilibrium conditions outlined in Table IV. Upon obtaining the equilibrium from the calibrated model, we then evaluate the model's fit relative to the data. The

[24] The available data ranges from 1980 to 2013. To compensate for missing values between 1960 and 1980, the minimum of the available data is utilized for South Africa. However, the average over the period 1980-2010 will be considered further in the cross-country analysis.

focus is on how well the model captures patterns of structural change across the three sectors over time.



(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE XI: Employment shares in South Africa, 1960-2010. Data vs. model.

Note: The employment shares are trended using a Hodrick-Prescott filter with a smoothing parameter of $\lambda = 10$.

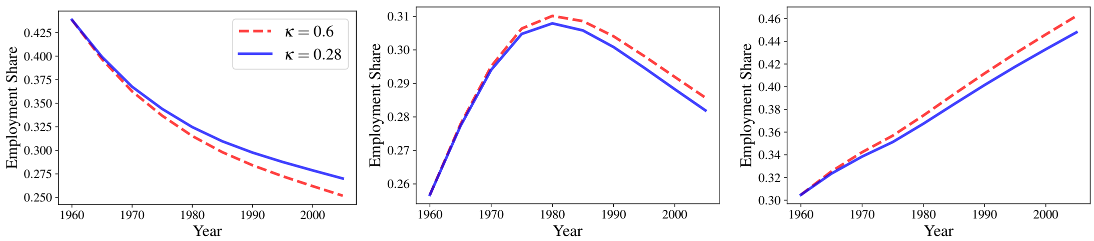
Figure XI displays both the sectoral employment shares derived from the data and those implied by the baseline model. The model's implied sectoral employment shares are represented by the blue dashed line in each panel, while the solid line indicates actual sectoral employment shares observed in the data.

The model successfully reproduces the pattern of structural change observed in South Africa from 1960 to 2010. It generates a decrease in the agriculture employment share that, while less pronounced, mirrors the actual decline. Similarly, the model generates an increase in the services employment share that, though smaller, parallels the actual rise in this sector.

Turning to the manufacturing sector, the model effectively generates the hump-shaped pattern characteristic of South Africa's manufacturing employment share. However, the model's implied decrease in the manufacturing employment share is somewhat subdued compared to the decline observed in the data.

To juxtapose the model's predictions with empirical data, we first solve the model using all the calibrated coefficients but with the financial development level held constant at $\kappa = 0.28$, its value in 1980. Subsequently, we solve the model with a different financial development level set to the 2010 value, $\kappa = 0.6$. Figure 1 below depicts the employment share dynamics across agricultural, manufacturing, and services sectors under these two scenarios. The blue solid lines represent employment shares predicted by the model for $\kappa = 0.28$, while the red dotted lines correspond to the shares predicted for $\kappa = 0.6$.

Data from South Africa substantiates the theoretical model's predictions. Indeed, increasing the financial development level over the period decreases the agricultural employment share to 8.32%, while the shares in the manufacturing and services sectors increase by 1.14% and 3%, respectively. This evidence demonstrates that financial development positively influences the structural change process in South Africa.



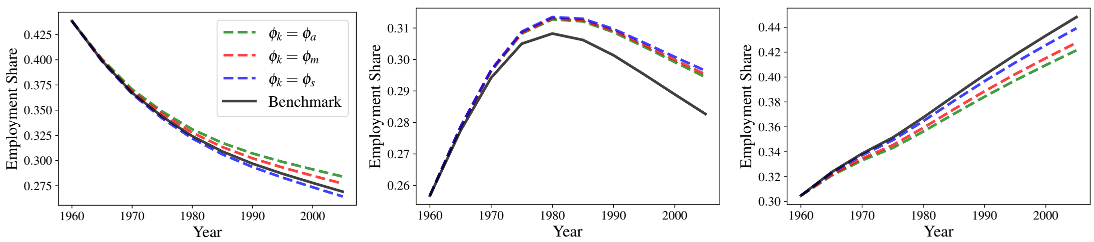
(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE XII: Impact of Financial Development on employment shares in South Africa.
Note: The employment shares are trended using a Hodrick-Prescott filter with a smoothing parameter of $\lambda = 10$.

Next, we explore how cross-sectoral variations in the adjustment cost to new technologies can influence sectoral employment shares. This is achieved by setting the levels of the parameters ϕ_k to the same value and comparing how each sector behaves relative to the benchmark. This analysis will provide insights into the impact of technology adjustment costs on the distribution of employment across different sectors. Figure XIII presents, for each sector, the benchmark model and models where all ϕ_k are set equal to ϕ_a, ϕ_m, and ϕ_s, respectively. One observation from the figure is that once all investment parameters ϕ_k are equalized, the levels of employment share in the manufacturing and agricultural sectors increase by up to 4.6% and 6.63% respectively, while services decrease by up to 5.47%. These changes suggest that disparities in the technologies used in each sector play a significant role in structural change. The closer the parameters, the less pronounced the decrease in agriculture employment share, and the less the services sector will increase. There will be less employment moving into manufacturing and also less exiting to services. Thus, the relative ease of implementing new technologies in the agricultural sector compared to other sectors confers a higher relative productivity gain to the agricultural sector, thereby facilitating structural change.

6 Conclusion

This paper offers a comprehensive exploration of the drivers of structural transformation, with a particular focus on the interplay of technology adoption, financial development, and sector-specific preferences. The developed three-sector endogenous growth model successfully embodies these aspects, providing a rich analytical platform for studying the



(a) Agriculture **(b)** Manufacturing **(c)** Services

FIGURE XIII: Impact of adjustment costs on structural change in South Africa.

Note: The employment shares are trended using a Hodrick-Prescott filter with a smoothing parameter of $\lambda = 10$.

nuanced dynamics of structural transformation.

The model yields insightful theoretical results. Particularly notable is the role of financial development during different phases of structural transformation. It is revealed to enhance industrialization during the relevant phase, yet contributes to deindustrialization during that respective period, highlighting the dual and context-dependent role of financial development in shaping a country's economic structure. The model also uncovers the potential for high productivity growth in sectors like agriculture in developing countries, typically further from the technological frontier. This result underscores the role of technology adoption in bridging productivity gaps across sectors and emphasizes the promise of 'catch-up growth'.

Furthermore, the findings of this study suggest that the level of industrialization in a country may be influenced when interacting with countries in a deindustrialization phase, due to variations in the proximity to the frontier of sectoral productivity. This has implications to shift resources to services bypassing the manufacturing sector. Additionally, a cross-country analysis suggests a robust correlation between financial development and the shift from agriculture to manufacturing, thus affirming the significant role financial development can play in enhancing industrialization. However, a transition into the service sector does not demonstrate a significant association with financial development. This prompts the consideration of other impactful factors such as global integration and technology adoption during this phase of transformation.

Finally, the accuracy of the model's predictions in capturing the actual structural changes in the South African economy, from 1960 to 2010, provides a robust validation of the model. However, the less steep decline in the manufacturing employment share, as predicted by the model compared to the empirical data, indicates areas for future refinement. In conclusion, this study provides valuable insights into the complex factors driving structural transformation and highlights the critical roles of technology adoption and financial development. Future research could be to employ a Ricardian trade model to explore not only the differential impacts on sectoral productivity growth rates due to integration with advanced economies, but also the direct effects on traded goods prices. Such an approach could provide a deeper understanding of the resulting employment shift towards the less-traded service sector.

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A Appendix

A.1 Mathematical Appendix

A.1.1 Goods production sectors

The problem of the intermediate firm in sector k is :

$$\max_{\{x_{kt}\}} \Pi_{kt} = p_t^k X_{kt} - P_{kt} X_{kt} \tag{A.1}$$

$$\text{s.t.} \qquad p_t^k = \alpha P_{kt} X_{kt}^{\alpha-1} A_{kt}^{1-\alpha} L_{kt}^{1-\alpha}$$

The first order condition is given by:

$$\alpha^2 P_{kt} X_{kt}^{\alpha-1} A_{kt}^{1-\alpha} L_{kt} - P_{kt} = 0 \Longleftrightarrow X_{kt} = \alpha^{\frac{2}{1-\alpha}} A_{kt} L_{kt}$$

Then the intermediate variety price is given from the constraint of the problem (A.1) by :

$$p_t^k = \alpha^{-1} P_{kt} \tag{A.2}$$

A.1.2 Aggregate behavior

$$\begin{aligned}
VA_{kt} = {} & \underbrace{P_{kt} Y_{kt} - p_t^k X_{kt}}_{\text{Final sector value added}} + \underbrace{\left(p_t^k x_{kt} - P_{kt} X_{kt}\right)}_{\text{Intermediate varieties value added}} \\
& = P_{kt} Y_{kt} - P_{kt} X_{kt} \\
& = \alpha^{\frac{2\alpha}{1-\alpha}} P_{kt} A_{kt} L_{kt} - \alpha^{\frac{2}{1-\alpha}} P_{kt} A_{kt} L_{kt} \\
& = (1-\alpha^2) \alpha^{\frac{2\alpha}{1-\alpha}} P_{kt} A_{kt} L_{kt}
\end{aligned}$$

❖ *Calculation of GDP by income perspective*

$$GDP_t = w_t L_t + \sum_{k=a,m,s} \Pi_{kt} \tag{A.3}$$

where Π_{kt} is the total profits made in sector k intermediate variety. By replacing w_t and Π_{kt} by their expression, the equation (A.3) becomes :

$$\begin{aligned}
GDP_t &= (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} P_{kt}A_{kt} + (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} \sum_{i=a,m,s} P_{it}A_{it}L_{it} \\
&= (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} P_{kt}A_{kt} + (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}} P_{kt}A_{kt} \sum_{i=a,m,s} L_{it} \\
&= (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} \left[1+\alpha^{\frac{1+\alpha-2\alpha}{1-\alpha}}\right] P_{kt}A_{kt}L_t \\
&= \zeta P_{kt}A_{kt}L_t \quad \forall k = a,m,s
\end{aligned} \tag{A.4}$$

where $\zeta := (1-\alpha^2)\alpha^{\frac{2\alpha}{1-\alpha}}$

❖ *Calculation of the GDP by value added perspective*

$$\begin{aligned}
GDP_t &= \sum_{i=a,m,s} VA_{it} \\
&= \sum_{i=a,m,s} \zeta P_{it}A_{it}L_{it} \\
&= \zeta P_{kt}A_{kt} \sum_{i=a,m,s} L_{it} \\
&= \zeta P_{kt}A_{kt}L_t \quad \forall k = a,m,s
\end{aligned} \tag{A.5}$$

A.1.3 Dynamics of productivity

The expected productivity growth rate $g_{A_{kt}}$ of the sector k is :

$$\begin{aligned}
g_{A_{kt}} &= \frac{A_{kt} - A_{kt-1}}{A_{kt-1}} \\
&= \theta_{kt}\left(\frac{\bar{A}_{kt-1}}{A_{kt-1}} - 1\right) \\
&= \theta_{kt}\left[a_{kt-1}^{-1} - 1\right]
\end{aligned} \tag{A.6}$$

where $a_{kt} := A_{kt}/\bar{A}_{kt}$

A.1.4 Housesolds' optimization

The lagragian of the household's problem is :

$$\mathscr{L}\left(C_{at}, C_{mt}, C_{st}; \lambda_t\right) = \sum_{k=a,m,s} P_{kt}C_{kt} + \lambda_t \left[1 - \delta_k^{1/\sigma}\left(\frac{C_{kt}}{C_t^{\varepsilon_k}}\right)^{\frac{\sigma-1}{\sigma}}\right] \tag{A.7}$$

where λ_t is the Lagrange multiplier. And the first order conditions are given by :

$$\frac{\partial \mathscr{L}}{\partial C_{kt}} = P_{kt} - \lambda_t \delta_k^{1/\sigma} \left(\frac{\sigma - 1}{\sigma} \right) \frac{C_t^{\varepsilon_k}}{C_t^{2\varepsilon_k}} \left(\frac{C_{kt}}{C_t^{\varepsilon_k}} \right)^{-1/\sigma} = 0 \quad \forall k = a, m, s \tag{A.8}$$

Then the price of the composite good in the sector k is given by :

$$P_{kt} = \lambda_t \left(\frac{\sigma - 1}{\sigma} \right) \frac{\delta_k^{1/\sigma}}{C_t^{\varepsilon_k}} \left(\frac{C_{kt}}{C_t^{\varepsilon_k}} \right)^{-\frac{1}{\sigma}} \tag{A.9}$$

And the expenditure in the consumption of the sector k final good is given by :

$$P_{kt} C_{kt} = \lambda_t \left(\frac{\sigma - 1}{\sigma} \right) \delta_k^{1/\sigma} \left(\frac{C_{kt}}{C_t^{\varepsilon_k}} \right)^{1-\frac{1}{\sigma}} \quad \forall k \tag{A.10}$$

Using the equation (A.10) and the utility function equation (3.9), the total expenditure $E_t := \sum_{k=a,m,s} P_{kt} C_{kt}$ at time t is given by :

$$E_t = \lambda_t \left(\frac{\sigma - 1}{\sigma} \right) \tag{A.11}$$

The expression (A.9) of the price of the final good of the sector k can then be rewriten as :

$$\frac{P_{kt}}{E_t} = \delta_k^{1/\sigma} C_{kt}^{-1/\sigma} C_t^{\varepsilon_k \left(\frac{1}{\sigma} - 1 \right)} \tag{A.12}$$

By rearranging, we obtain the expression for consumption in sector k as follows:

$$C_{kt} = \delta_k \left(\frac{P_{kt}}{E_t} \right)^{-\sigma} C_t^{\varepsilon_k (1-\sigma)} \quad \forall k = a, m, s \tag{A.13}$$

Next, we will derive the expression for the aggregate price. By rasing each of the equations (A.9) to the power $1 - \sigma$, then one obtains :

$$P_{kt}^{1-\sigma} = \delta_k^{\frac{1-\sigma}{\sigma}} E_t^{1-\sigma} C_t^{(\sigma-1)\varepsilon_k} \left(\frac{C_{kt}}{C_t^{\varepsilon_k}} \right)^{1-\frac{1}{\sigma}} \quad \forall k \tag{A.14}$$

So

$$\delta_k P_{kt}^{1-\sigma} C_t^{(1-\sigma)\varepsilon_k} = E_t^{1-\sigma} \delta_k^{\frac{1}{\sigma}} \left(\frac{C_{kt}}{C_t^{\varepsilon_k}} \right)^{1-\frac{1}{\sigma}} \quad \forall k = a, m, s \tag{A.15}$$

By adding the equations (A.15), we obtain :

$$\sum_k \delta_k P_{kt}^{1-\sigma} C_t^{(1-\sigma)\varepsilon_k} = E_t^{1-\sigma} \tag{A.16}$$

$$\implies C_t^{1-\sigma} \sum_k \delta_k P_{kt}^{1-\sigma} C_t^{(1-\sigma)(\varepsilon_k-1)} = E_t^{1-\sigma} \tag{A.17}$$

By defining the aggregate price P_t such that $P_t C_t = \sum_k P_{kt} C_{kt}$, We can deduce from the equation (A.17) the expression of P_t as follow:

$$P_t = \left[\sum_{i=a,m,s} \delta_i P_{it}^{1-\sigma} C_t^{(1-\sigma)(\varepsilon_i-1)} \right]^{\frac{1}{1-\sigma}} \tag{A.18}$$

From the equation (A.13) we can derive the demand for the composite good k in function of the aggregate consumption and aggregate price:

$$C_{kt} = \delta_k \left(\frac{P_{kt}}{P_t} \right)^{-\sigma} C_t^{\varepsilon_k(1-\sigma)+\sigma} \qquad \forall k = a, m, s \tag{A.19}$$

The expenditure share e_{kt} of the sector k is :

$$\begin{aligned} e_{kt} &= \frac{P_{kt} C_{kt}}{P_t C_t} \\ &= \delta_k \left(\frac{P_{kt}}{P_t} \right)^{1-\sigma} C_t^{(1-\sigma)(\varepsilon_k-1)} \qquad \forall k \end{aligned} \tag{A.20}$$

$$\begin{aligned} \implies \frac{e_{kt}}{e_{mt}} &= \frac{\delta_k}{\delta_m} \left(\frac{P_{kt}}{P_{mt}} \right)^{1-\sigma} \times \frac{C_t^{(\varepsilon_k-1)(1-\sigma)}}{C_t^{(\varepsilon_m-1)(1-\sigma)}} \\ &= \frac{\delta_k}{\delta_m} \left(\frac{P_{kt}}{P_{mt}} \right)^{1-\sigma} C_t^{(\varepsilon_k-\varepsilon_m)(1-\sigma)} \end{aligned} \tag{A.21}$$

The equation (A.20) gives :

$$\begin{aligned} e_{kt} &= \delta_k \left(\frac{P_{kt}}{E_t C_t^{-1}} \right)^{1-\sigma} C_t^{(1-\sigma)(\varepsilon_k-1)} \\ &= \delta_k \left(\frac{P_{kt}}{E_t} \right)^{1-\sigma} C_t^{(1-\sigma)\varepsilon_k} \qquad \forall k = a, m, s \end{aligned} \tag{A.22}$$

Hence,

$$C_t = \left[\left(\frac{e_{kt}}{\delta_k} \right)^{\frac{1}{1-\sigma}} \left(\frac{E_t}{P_{kt}} \right) \right]^{1/\varepsilon_k} \qquad k = a, m, s \tag{A.23}$$

Then the equation (A.21) becomes :

$$\begin{aligned} \frac{e_{kt}}{e_{mt}} &= \frac{\delta_k}{\delta_m} \left(\frac{P_{kt}}{P_{mt}} \right)^{1-\sigma} \left[\frac{E_t}{P_{mt}} \left(\frac{e_{mt}}{\delta_m} \right)^{\frac{1}{1-\sigma}} \right]^{\frac{(1-\sigma)(\varepsilon_k - \varepsilon_m)}{\varepsilon_m}} \\ &= \frac{\delta_k}{\delta_m} \left(\frac{P_{kt}}{P_{mt}} \right)^{1-\sigma} \left(\frac{e_{mt}}{\delta_m} \right)^{\frac{\varepsilon_k}{\varepsilon_m} - 1} \left(\frac{E_t}{P_{mt}} \right)^{\frac{(1-\sigma)(\varepsilon_k - \varepsilon_m)}{\varepsilon_m}} \end{aligned} \tag{A.24}$$

And the expenditure share is finally given by :

$$e_{kt} = \delta_k \left(\frac{e_{mt}}{\delta_m} \right)^{\frac{\varepsilon_k}{\varepsilon_m}} \left(\frac{P_{kt}}{P_{mt}} \right)^{1-\sigma} \left(\frac{E_t}{P_{mt}} \right)^{(1-\sigma)\left(\frac{\varepsilon_k}{\varepsilon_m} - 1 \right)} \tag{A.25}$$

A.2 Data Appendix

A.2.1 Data description

This section describes the data for the calibration.

Labor endownment by sector. We take total employment data in GGDC database as the measure of L_t. These data correspond to the total of the number of workers engaged in different economic activities. Manufacturing employment is constructed as the sum of total employment in mining, manufacturing, utilities, and construction. Services is the sum of whole sale and retail trade; hotels and restaurants; transport, storage, and communications; finance, real state, and business services; and community, social, and personal services.

Value added by sector. For value added data, we rely on the GGDC database. We take nominal goods value added in a country to be the combination of expenditure in "Agriculture, hunting, forestry, fishing" and "Mining, Manufacturing, Utilities", while services value added is expenditure in "Construction",

Sectoral prices. To estimate the preference parameters, we need gross-output sectoral prices. First, we take nominal and real value added (indexed to 2005) data in goods and services from GGDC database. We generate sectoral value added price indices as the ratio of nominal to real value added.

Sectoral Productivities. We consider the value added at 2005 constant price divided by the sesctoral employement as a proxy for labor productivity. Then, we proportionally scale South Africa and US productivities using 2005 PPP.

Sectoral expenditure. The OECD supplies comprehensive consumption expenditure data for South Africa, spanning from 1975 to 2010. The data for the three sectors are acquired as follows: agricultural expenditure consumption corresponds to "Food and non-alcoholic beverages", industrial expenditure includes "Durable goods", "Semi-durable goods", "Non-durable goods" with the subtraction of "Food and non-alcoholic beverages", while expenditure on services is denoted as "Services".

Net exports. WDI provide data from 1975 to 2010 on total exports, total imports, percentage of agriculture and manufacturing exports and imports. We then calculate the total amounts of exports, imports in each sector.

A.2.2 Solution Algorithm

This appendix details the solution algorithm for each period of the model economy. Equations that We refer to are listed in Table IV. For each time period :

- **Step 1.** Compute θ_{kt}.
- **Step 2.** Compute the sectoral productivities levels A_{kt} for each sector k using

$$A_{kt} = \theta_{kt}\bar{A}_{kt-1} + (1-\theta_{kt})A_{kt-1}$$

  and then the sectoral productivity growth g_{kt}.
- **Step 3.** Compute sectoral proximities to the frontier a_{kt} and sectoral total technology adoption investments $Z_{kt} = \phi_k \theta_{kt}^2 \bar{A}_{kt-1} L_t$ where L_t is the total employment.
- **Step 4.** Compute the relative prices $P_{kt} = \dfrac{A_{mt}}{A_{kt}}$ by taking manufacturing good as numeral ($P_{mt} = 1$).

- **Step 5.** With agregate expenditure E_t, compute the aggregate consumption level C_t from the equation below using the equation (3.25) by Newton-Raphson method:

$$E_t^{1-\sigma} = \sum_{k=a,m,s} \delta_k P_{kt}^{1-\sigma} C_t^{\varepsilon_k(1-\sigma)} \tag{A.26}$$

- **Step 6.** Compute aggregate price index using equation (3.27) and then sectoral consumption C_{kt}, $k = a, m, s$ using (D1).

- **Step 7.** Repeat steps 1 to 6 until the last period T.

- **Step 8.** Compute sectoral labor demand L_{kt} using conditions (G2), (D4) and (S1) jointly:

$$L_{kt} = \frac{C_{kt} + Z_{kt+1} + NX_{kt}}{\zeta A_{kt}}$$