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Does international trade stimulate structural change in Africa?

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Abstract

While several empirical studies established a strong link between trade and growth, few studies have looked at the relationship between international trade and African structural change. This study attempts to shed empirical light on this latest relationship. It proposes a theoretical relationship between international trade and structural change through the channel of the percentage of manufactured products in total exports. Based on a panel model of 31 African countries from 1995 to 2017, empirical results show that the number of products shipped remains the catalyst for structural change in Africa. However, this factor has a marginal effect. So, yes, international trade can stimulate structural change in Africa, but it is necessary to move ahead by adding value to trading products to make progress and strength structural change.

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1. Introduction

Structural change has increasingly been at the heart of thinking in development strategies in recent years, particularly since the work of Margaret McMillan and Dani Rodrik in 2011. The transformation of economic structures is necessary for economic and social development. Thus, more successful developing countries-so-called emergent countries today-have managed to arrange fundamental changes in the structure of their economies. African countries have been aspiring to emerge since the end of the first decade of 2000. This situation implies that they can do this for sustainable, strong, and inclusive growth, but we know that foreign trade is also a source of wealth creation and a growth engine. However, Africa's trade share in the world trade remains low compared to other underdevelopment regions. Between 2015 and 2016, Africa's exports accounted for 2.4% and 2.2% of world exports. Meanwhile, imports from Africa weighed 3.4% and 3.2%, respectively.

In addition, Africa's exports to the world could be more diversified and remain dominated by commodities, mainly hydrocarbons: fuels accounted for 55% of exports in 2010-2015, and manufactured goods only 18%. Have these economies initiated the transformation of the growth pillars as described by the stylised facts of structural change? To what extent does Africa's external trade drive structural change? According to the economic literature, external trade may drive structural change. Matsuyama (2009) pointed out the role of economic openness via the specialisation schemes derived from the comparative advantages available to countries in opening and growing productivity and spending distribution. Mao and Yao (2012) recognised two effects when studying structural change in an open economy. First, the labour force migrates from the agricultural sector to the manufacturing sector because of its greater competitiveness. This situation translates into relatively higher growth in the total productivity of factors in the manufacturing sector, still known as the productivity effect. Second, there may be a labour migration to the service sector, where total factor productivity is growing faster in the agricultural and manufacturing sectors than in the services sector. In such a case, prices in the service sector increase relative to other industries. However, the inelasticity of substitution between tradable and non-tradable goods does not lead to a relative decline in demand for the services sector. Cravino and Sotelo (2019) studied how international trade affects manufacturing employment and the relative wage of unskilled workers when goods and services are traded with different intensities. They show that reductions in trade costs harmed manufacturing employment and the relative wage of unskilled workers.

Mao and Yao (2012) and Hu and Mino (2014) found that structural change results from changes in productivity between sectors but, above all, the trade structure of open economies, depending on whether the level of technology and preferences in a small open economy aligns or not with the rest of the world ones. Thus, in a similar level of technology and preferences, the tiny economy will gradually specialise from the agricultural sector to the manufacturing and services sectors. Where preferences or levels of technology diverge, the income share of the agricultural and services sectors may increase at the cost of the manufacturing industry. Analysing the link between international trade and structural change, Mesa (2023) argues that international price defines the whole process. However, the economy's capital-labour ratio depends on international trade and structural change.

Nevertheless, Foellmi and Zweimuller (2002), Comın (2005) and Inikori (2014) have shown that by specialising in the production of the goods for which countries have greater productivity or comparative advantage over relative prices, developing countries have focused on the primary sector, including export agriculture. Thus, in the face of low incomes due to the deterioration of terms of trade, developing countries, especially those in Africa and Latin America, have had a much slower structural change. Innovation and technical progress, however, increase industrial transformation and diversification of the supply of strategic sectors through the benefits of innovation generated by investments in the knowledge of trading partner countries (see Grossman and Helpman, 1991; Hakura & Jaumotte, 1999). Matsuyama (2019) shows that globalisation amplifies, rather than reduces, the power of differences in the composition of endogenous domestic demand as an engine of structural change. Neuss (2019) shows that changes in comparative advantage(s) via globalisation and trade are among the drivers of structural change. So does Comunale and Felice, (2022). Along with this result, Downes and Stoeckel (2006) and Thompson et al. (2012) demonstrate that trade contributes significantly to structural change in Australia.

Finally, international trade may drive structural change. But according to our knowledge, a few empirical studies on the drivers of structural change has addressed the issue of the relationship between external trade and structural change in Africa[1]. So, in this paper, we set in an endogenous growth model framework with international trade as a source of productivity gains and structural change. The aim of this study is twofold. First, it aims to answer whether international trade in African countries encourages the expansion of the secondary sector. Second, is the secondary industry's evolution accompanied by a structural change in Africa? This analysis aims to conceptualise the relationship between international trade and structural change and then test this relationship for African countries. The paper is organised as follows. After this introduction, the first section describes the methodology and data. Then the following section looks at the analysis results before concluding and giving some policy implications.

2. Methodology and data

2.1. Model specification

In the theoretical model, intuitively, we assume that international trade can influence structural change through two channels: learning by doing and dynamic learning by trading, export learning). The idea behind export learning is that exporters take advantage of their buyers' knowledge base, knowledge of potential customer countries' markets, knowledge of access standards (quality standards, presentation, health, and plant health standards), the regulation of host countries, foreign buyers offering advice on improving competitiveness in these markets. This stock of knowledge will eventually lead to an improvement in the productivity and competitiveness of exporting companies. Also, those who import inputs go, from experience, to collect information to access quality inputs at the best prices. This situation will also improve their productivity in the domestic market on the one hand and the other hand in other foreign markets. Learning through practice is associated with creating knowledge on the production side and is induced by expanding international trade. The technology transfers and access to a wide range of inputs explain knowledge creation. The production growth from exploiting this knowledge stock is supposed to

[1] We find one paper on South Africa Sako, C., Maliaga, L., & Obinyeluaku, M. (2021). Trade as a driver of manufacturing structural change for sustainable development in South Africa

accelerate the economy's structural change. This structural change will be faster as trade-in manufacturing products focus on it. Therefore, the stock of knowledge favourable to structural change will depend on the percentage of manufacturing products in total exports (IX_t). Knowledge stock is assumed to increase with the percentage of manufacturing products in total exports due to technology transfer and knowledge accumulation as learning by trading with partners. Let C_t be the knowledge stock conducive to increasing productivity, driving growth and structural change (supply-side driver of structural change). We assume the following general expression:

$$C_t = G(IX_t) \qquad \textit{Equation 1}$$

Subsequently, considering the production function in which the knowledge stock is a source of the growth of the production/value-added in the secondary/industry sector, K and L, respectively, capital and labour:

$$Y_t = C_t F(K_t, L_t) \qquad \textit{Equation 2}$$

$$Y_t = G(IX_t)F(K_t, L_t) \qquad \textit{Equation 3}$$

$$Y_t = GF(IX_t, K_t, L_t) \qquad \textit{Equation 4}$$

Assuming a Cobb-Douglas specification, equation 4 becomes:

$$Y_t = A\ IX_t^{\delta}\ K_t^{\alpha}\ L_t^{\beta} \qquad \textit{Equation 5}$$

This theoretical model shows how international trade affects the dynamics of the industrial sector. As the structural change occurs more in the secondary/industry, the relationship shows that the percentage of manufacturing products in exports (vertical diversification) drives structural change through learning by trading and technological transfers. Relying on learning and knowledge accumulation by trading, this theoretical statement also considers one of the critical points in analysing structural change: productivity gains (see Ngai et Pissarides, 2007; Mao et Yao, 2012; Herrendorf et al., 2014). Equation 5 considers that productivity gains affect capital (technological transfer) and labour (knowledge via learning by trading) through the parameter δ. Then, if we emphasise the learning by exporting, TFP depends on the export experience of the manufacturing sector. The weighted average of the current and past exports of the manufacturing sector captures this effect (A). In this line, trade affects the Total Factor of Productivity;

$$TFP_t = A\ IX_t^{\delta} \qquad \textit{Equation 6}$$

Finally, trade could affect Total factor productivity, growth and structural change. After linearising equation (6), we obtain the following specification:

$$Ln\ (Y_{it}) = LnA + \delta\ Ln\ (IX_{it}) + \alpha\ Ln\ (K_{it}) + \beta\ Ln\ (L_{it}) + \varepsilon_{it} \qquad \textit{Equation 7}$$

To understand the evolution of the structural change process, we propose a simple index based on the work of Roman (1969). It is a simple clue that allows us to appreciate the process of structural change in each country based on the evolution of the agricultural and industrial sectors' value-added. It is calculated by reporting the agricultural sector's value-added and the industrial sector's added value.

$$STI_t = \frac{Value\ Added_t^{Industry}}{Value\ Added_t^{Agriculture}} \qquad \textit{Equation 8}$$

The value of the index (simple) is compared to 1. An index value below 1 reflects that the agricultural sector value-added is greater than that of the industrial sector. Hence, the process of structural change has yet to be a reality. Otherwise, the process would be ongoing. Thus, the upward trend in the index would reflect a structural change process in the economy. This indicator allows us to assess the dynamics of structural change. From the general specification (equations 5 and 7), we derive (see technical appendices for more detail) the model specification.[2]. Finally, the equation to be estimated is :

$$Ln\ (STI_{it}) = LnA + \delta\ Ln\ (IX_{it}) + \ \alpha\ Ln\ (K_{it}) + \ \beta\ Ln\ (L_{it}) + \varepsilon_{it} \qquad \textit{Equation 9}$$

We are assuming that structural change is a long-term process. As we have considered learning and knowledge accumulation by trading, we estimate equation 9 in a panel with a GLS panel-specific AR1 autocorrelation structure. By doing so, we suppose that there is a certain degree of correlation between the residuals. Also, this approach specifies that, within panels, there is AR(1) autocorrelation and that the AR(1) process coefficient is specific to each panel. Furthermore, we hold for heteroscedastic of the error terms because of heterogeneity in the sample.

2.2.Data description

The table below describes the main variables and the sources. Data covering 1995-2017 for 31 African countries from World Development Indicators,2019.

Table 1: Variables description

Variables	Sources
Industry (including construction), value added (% of GDP)	World Development Indicators, 2019
Manufacturing, value added (% of GDP)	
Structural change index	Author calculation
Gross fixed capital formation (% of GDP)	World Development Indicators, 2019
Labour force, Total	
Manufactures exports (% of merchandise exports)	

Source: The authors

Due to missing data, we kept it in the sample countries with no more than five years of missing data. Then we replace the missing data with the simple mean over the period for each country.

3. Results and discussions

3.1.Descriptive statistics

The structural change index shows that, on average, the value-added of the industrial sector is higher than that of the agricultural sector as a percentage of GDP over the period. The average value of this index is 2.46 (see appendix 1). This value is greater than 1. The average value of value-added in the agricultural sector is lower than that of the industrial sector. This idea supports the hypothesis that, on average, structural change is underway in the study sample.

Nevertheless, countries are not in the same brand in terms of the distribution of the index value (see Appendix 2 and Appendix 3). Indeed, the distribution range is 23.43 with a minimum of 0.22. The table in Appendix 5 shows that out of 31 countries in the sample, only 8 have above-average index values, and 14 countries have an index value above 1. About 50% of the country in the

[2] See the technical appendices for more explanation on deriving the final specification.

sample have initiated a structural change in their economy at different levels (see Appendix 4). The value of the coefficient of variation [3] of the index rate of 146% confirms the heterogeneous distribution of countries' performance on the path of structural change[4]. An analysis of the relationship between the structural change index and the explanatory variables (the number of products exported and the proportion of manufactured products in exports) shows a positive relationship between these variables (see appendix 5). The correlation matrix (see appendix 6) shows a positive and significant relationship between the structural change index, the number of products exported, & the proportion of manufacturing exports (% of merchandise exports). However, the correlation coefficient is relatively low. This descriptive analysis leads to suspicion of a positive relationship between the added value of the industrial sector and the number of products exported, then between the structural change index and the number of products shipped on the one hand and the structural change index and the proportion of manufactured goods in merchandise exports on the other. Finally, international trade could be a catalyst for structural change in Africa. The following section will evaluate this relationship in econometric analysis.

3.2.Estimation results

Table 2[5] (columns (1) and (2)) highlights two findings concerning the questions that motivated this research. The first result relates to the relationship between the number of products exported and the industrial sector's value-added. The second result is related to the sign of the coefficient associated with the variable "percentage of manufacturing products in exports" in the regression result. As for the first result, as we can see, the coefficient associated with the number of products exported is positive and significant (see Table 4). The exportable basket diversification in terms of the number of products exported contributes to the increase in the value-added of the industrial sector (table 2). A 1% increase in the number of exported goods leads to a rise of about 0.1359% in the Industry sector value-added in Africa.

This result confirms the idea of learning by exporting or du learning by trading. Because as we said, exporters take advantage of their buyers' knowledge base, knowledge of potential customer countries' markets, knowledge of access standards (quality standards, presentation, health, and plant health standards), the regulation of host countries, foreign buyers were offering advice on improving competitiveness in these markets.

[3] The ratio between the standard deviation and the average distribution gives the value of the coefficient of variation. i.e. 3.58/2.45=1.45 (146%), which shows a strong heterogeneity in distribution.
[4] This result supports using GLS as an estimation method, as we assume in section 2.1.
[5] Appendix 9A and Appendix 9B give more details.

Table 2: Estimation results

Dependent Variable:	: Ln (Industry (including construction), value added (% of GDP))		Ln (Structural Change Index)	
	(1)	**(2)**	**(3)**	**(4)**
Estimation methods	*GLS AR1 autocorrelation structure*	*GLS panel-specific AR1 autocorrelation structure*	*GLS AR1 autocorrelation structure*	*GLS panel-specific AR1 autocorrelation structure*
Independent Variables				
ln (Labor force, Total)	-0.0131	0.0079	-0.2195***	-0.1492***
	(0.4358)	(0.6231)	(0.0000)	(0.0000)
ln (Gross fixed capital formation (% of GDP))	0.0402**	0.0287*	0.1055**	0.0912**
	(0.0449)	(0.0978)	(0.0136)	(0.0140)
ln (Number of exported products)	0.1210***	0.1359***	*0.3925****	*0.5627****
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ln (Manufactures exports (% of merchandise exports))	0.0025	0.0025	*0.0046*	*0.0083*
	(0.5674)	(0.5403)	(0.6263)	(0.3157)
Constant	2.6021***	2.2124***	1.4045**	-0.3567
	(0.0000)	(0.0000)	(0.0110)	(0.2650)
Observations	713	713	713	713
Number of ind	31	31	31	31
Wald chi2(4)	46.03	90.73	96.90	360.30
Prob > chi2	0.0000	0.0000	0.0000	0.0000

Note: pval in parentheses, *** p<0.01, ** p<0.05, * p<0.1

We perform more than four estimations. See appendix 9A and appendix 9B for more details about the result

Source: The authors

Another regression made as a robustness check[6] with the manufacturing sector value added confirms this result (% of GDP) (see Appendix 7 and 9). This result is so small that we can explain the failure of policies settled in most underdeveloped countries: the import substitution policy without processing goods but only increasing exported goods basket in terms of the number and quantity of raw materials. Raw materials remain a significant component of the exported basket in Africa. So, increasing the number of exported goods is a marginal source of structural change in Africa. Therefore, international trade is a driver of structural change in Africa, as Downes and Stoeckel (2006); Thompson and al, (2012) and Comunale and Felice (2022) demonstrate.

Table 2 (columns (3) and (4)) describes the estimation results considering the structural change index (Appendix 6 provides robustness checks for these results). A 1% increase in exported goods leads to a 0.5627% increase in the structural change index. This result shows that the value-added of the agricultural sector remains relatively lower than the industrial sector's. This result is typical for most African countries. It shows that the process of structural change via international trade with the increase in the number of exported goods is still marginal. The second result suggests that the percentage of manufactured goods in total export has not significantly affected African structural change. This result could indicate that the current proportion of manufactured goods in exports does not allow countries to mobilise a stock of knowledge capable of improving the productivity of export-oriented industrial sectors of Wares. As argued by Yameogo and al, (2014), the African trade structure limits structural change.

4. Conclusion and policy implications

This analysis sheds empirical light on the relationship between international trade and African structural change. Based on a panel model of 31 African countries from 1995 to 2017, the paper presents a theoretical framework and tests this link. Results show that the number of products shipped drives structural change in Africa, even if the effect is marginal. Nevertheless, the percentage of manufactured products in total exports does not affect African structural change. This study then confirms one of the central assertions about structural change: moving from an economy based on the primary sector to an economy whose base is the secondary sector with a very dynamic tertiary industry. So, international trade can stimulate structural change in Africa. Based on these results, African economies could: (i) continue diversifying their exports by increasing the number of products offered to trade partners. This strategy should be supported upstream by a rigorous analysis of the promising markets on the one hand and, on the other hand, by identifying high-potential customers. This result will ensure opportunities for exported products and match exportable supply to foreign demand; (ii) Strengthen the processing sector of exported products to increase the share of manufactured goods in the exportable basket. This policy could be done by identifying priority sectors, driving upstream industrial dynamics, and then creating an enabling environment to attract foreign direct investment, encourage technology transfer, and invest in value-added innovation in sectors of the economy with a high export propensity; (iii) Put in place a strategy to fit into regional and even global value chains. Studies need to be undertaken by trade support institutions to identify potential regional and global niches; (iv) Develop support services: transport, communication, and banking, to accompany this strategy in a coherent and comprehensive framework of the continent's development.

[6] We compute the structural change index using Manufactured value added

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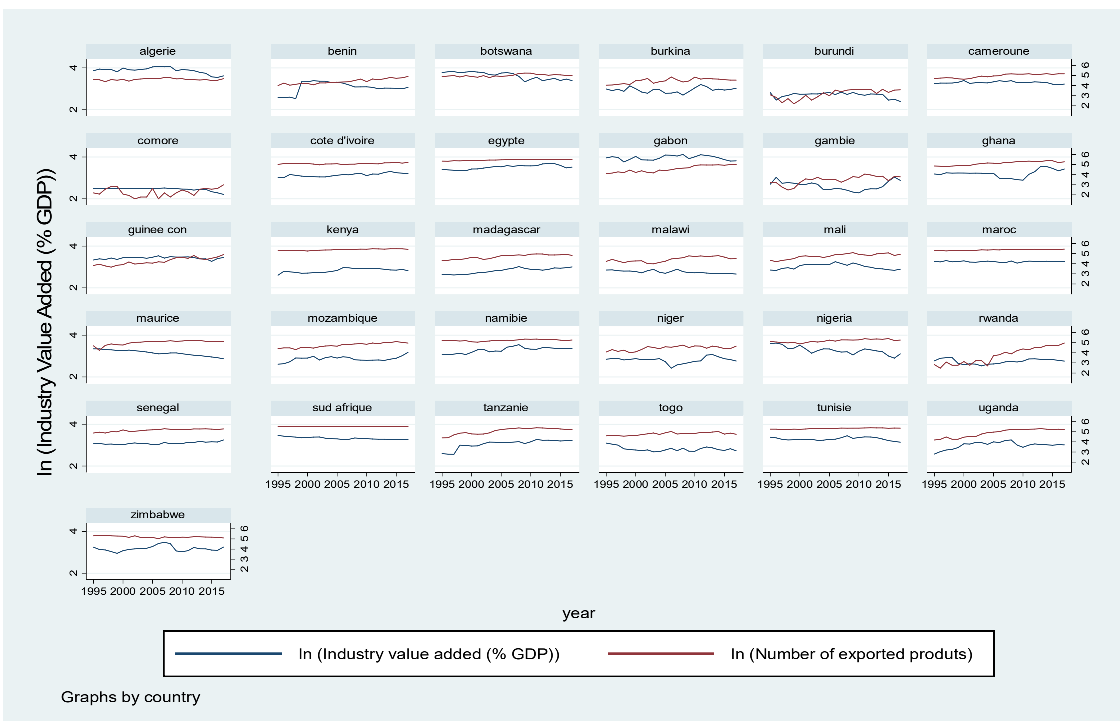
Appendices

Appendix 1: Table A.1: Some descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Structural change index	713	2.459	3.584	0.2207	23.43875
Agriculture. Forestry. And fishing. value added (% of GDP)	713	21.63	11.387	1.828	53.38092
Industry (including construction), value added (% of GDP)	713	24.11	9.755	9.137	61.742
Number of exported products	713	134.60	65.354	5	256
Manufactures exports (% of merchandise exports)	713	354.29	203.865	1	708

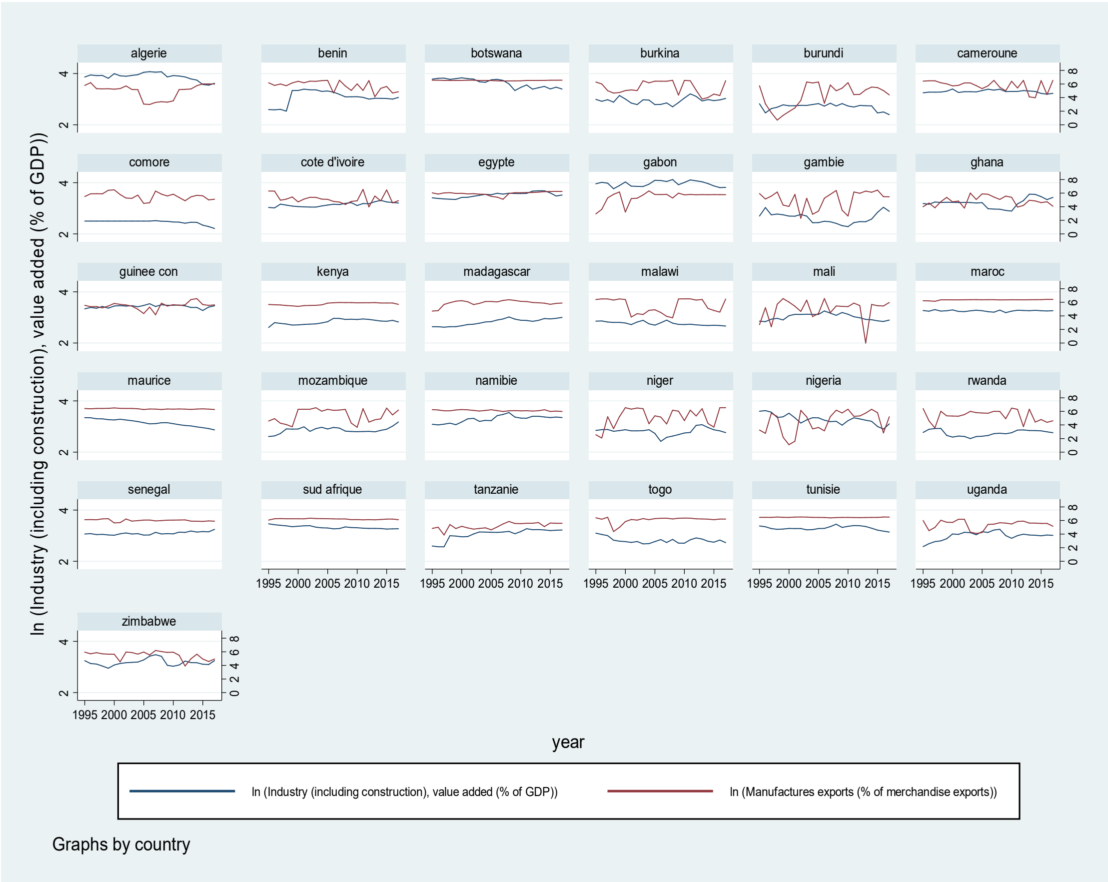
Source: The authors

Appendix 2: *Graph A 1: Evolution of Industry value added (% GDP) and the number of products exported by each country*



Source: The authors

Appendix 3*: Graph A 2: Evolution of Industry value added (% GDP) and manufacturing exports (% Total exports) for each country*



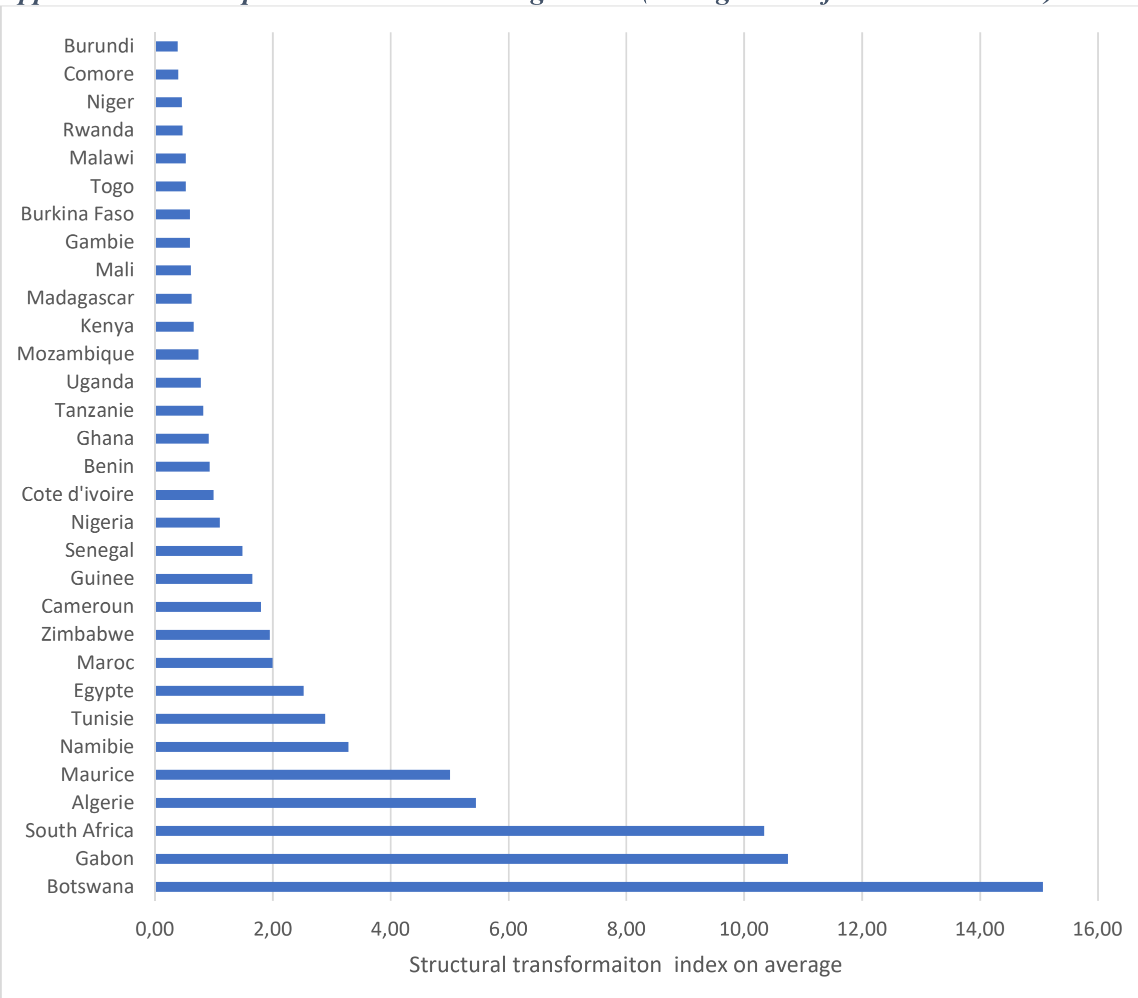
Source: The authors

Appendix 4:Table A 2: Descriptive statistics on structural transformation index by country from 1995 to 2017

Countries	Mean	Std. Err.	[95% Conf. Interval]		Rang
			lower bound	Upper bound	
Algerie	5.439556	0.3174447	4.816316	6.062795	4e
Benin	0.9271644	0.0602007	0.8089723	1.045357	16e
Botswana	15.06693	0.6915981	13.70911	16.42475	1er
Burkina Faso	0.5896032	0.0215574	0.5472796	0.6319268	25e
Burundi	0.384692	0.0113151	0.3624769	0.406907	31er
Cameroun	1.801571	0.0539763	1.6956	1.907543	11e
Comore	0.3948278	0.0075842	0.3799377	0.4097179	30ème
Cote d'ivoire	0.9956838	0.0316915	0.933464	1.057904	15e
Egypte	2.522052	0.1187682	2.288874	2.755229	8e
Gabon	10.73845	0.7575035	9.251241	12.22566	2e
Gambia	0.5933445	0.0460791	0.5028773	0.6838118	24e
Ghana	0.9116263	0.0814328	0.7517491	1.071504	17e
Guinee	1.652866	0.0523602	1.550068	1.755665	12e
Kenya	0.653946	0.0270947	0.600751	0.7071411	21er
Madagascar	0.6237391	0.0219064	0.5807302	0.666748	22e
Malawi	0.5197692	0.0120381	0.4961347	0.5434037	27e
Mali	0.6093308	0.026304	0.5576881	0.6609734	23e
Morocco	1.99283	0.0451098	1.904266	2.081394	9e
Maurice	5.007895	0.2132036	4.589312	5.426478	5e
Mozambique	0.7373983	0.0322865	0.6740102	0.8007864	20ème
Namibie	3.282695	0.1886256	2.912366	3.653024	6e
Niger	0.456729	0.0262022	0.4052862	0.5081718	29e
Nigeria	1.100693	0.0470668	1.008287	1.193099	14e
Rwanda	0.4688155	0.0217071	0.4261978	0.5114331	28e
Senegal	1.482424	0.0464469	1.391234	1.573613	13e
South Africa	10.3407	0.3114631	9.729204	10.9522	3e
Tanzanie	0.8182657	0.0460443	0.7278668	0.9086646	18e
Togo	0.5206014	0.015733	0.4897128	0.55149	26e
Tunisie	2.890238	0.1039528	2.686148	3.094329	7e
Uganda	0.7770214	0.0490202	0.68078	0.8732627	19e
Zimbabwe	1.948219	0.1396173	1.674108	2.22233	10e

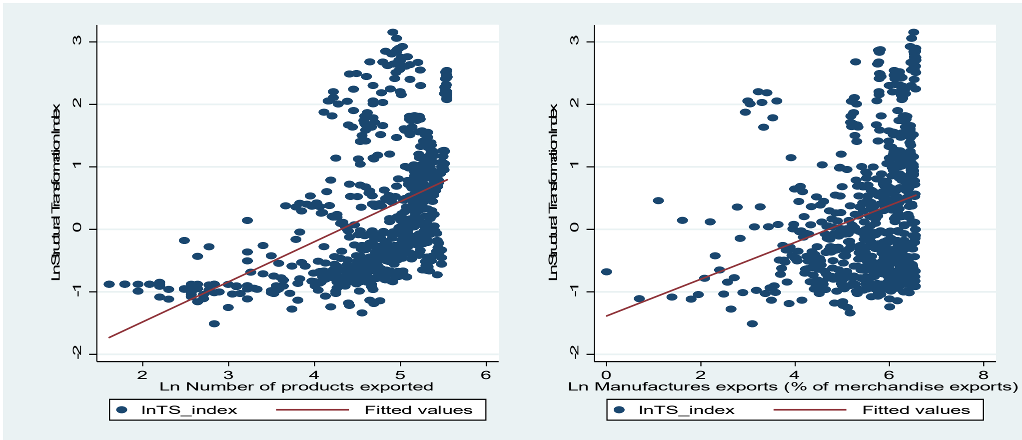
Source: The authors

Appendix 4 bis: Graph A.3: Structural change index (average value from 1995 to 2017)



Source: The authors

Appendix 5: Graph A.4: Structural Change Index with (a) the number of products exported and (b) the proportion of manufactured goods in exports.



Source: the authors

Appendix 6: Table A. 3: Correlation matrix with structural change index

	Structural change index	Number of exported products	Manufactures exports (% of merchandise exports)
Structural change index	1		
Number of exported products	0.2600*	1	
Manufactures exports (% of merchandise exports)	0.2931*	0.2587*	1

Note: * $p<0.05$

Source: The authors

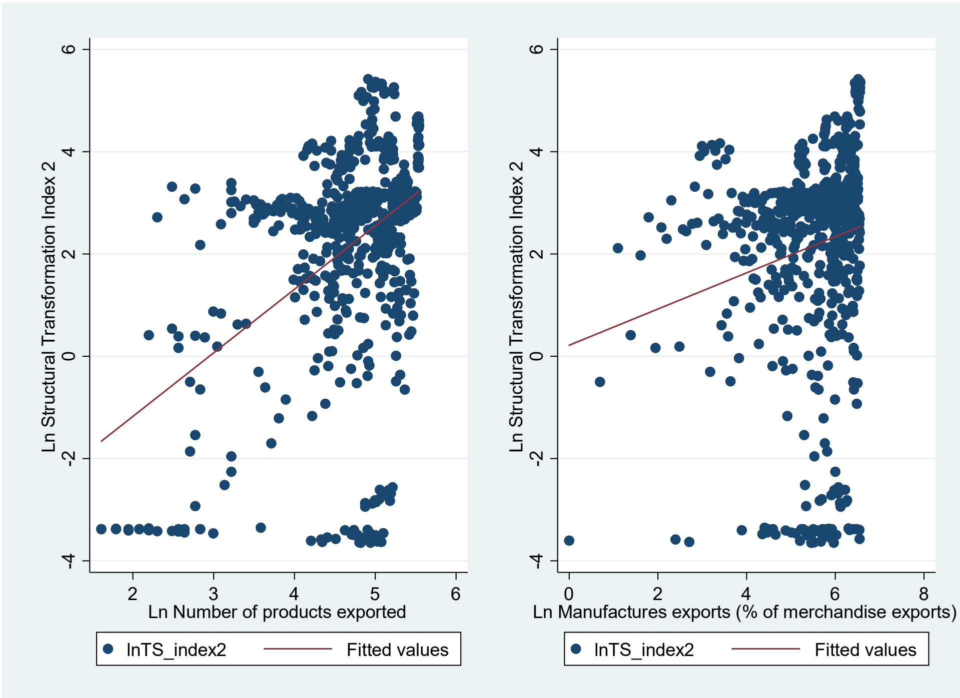
***Appendix** 7: Table A 4: Robustness check for the estimation with the manufacturing sector value added % GDP*

Dependent Variable: Ln (Manufacturing, value added (% of GDP))	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Independent Variables	Between-effects model	Fixed-effects model	A fixed-effects model with robust variance	Random-effects model1	GLS i.i.d. error structure	GLS heteroskedastic but uncorrelated error structure	GLS heteroskedastic and correlated error structure	GLS independent autocorrelation structure	GLS AR1 autocorrelation structure	GLS panel-specific AR1 autocorrelation structure
ln (Labor force, Total)	0.0567	0.0154	0.0154	0.1222	0.1133*	0.0274	0.1173***	0.1133*	0.3129***	0.2383***
	(0.8555)	(0.9553)	(0.9824)	(0.4910)	(0.0575)	(0.3136)	(0.0000)	(0.0575)	(0.0018)	(0.0013)
ln (Gross fixed capital formation (% of GDP))	-0.0022	0.0624	0.0624	0.0399	-0.0416	0.2395***	-0.0440***	-0.0416	0.0970	0.1394
	(0.9982)	(0.6518)	(0.7480)	(0.7675)	(0.7980)	(0.0003)	(0.0000)	(0.7980)	(0.5357)	(0.2668)
ln (Number of exported products)	0.8946	0.3728**	0.3728	0.3816**	0.7401***	0.2100***	0.7294***	0.7401***	0.1517	0.1889*
	(0.1550)	(0.0445)	(0.4925)	(0.0187)	(0.0000)	(0.0074)	(0.0000)	(0.0000)	(0.2978)	(0.0629)
ln (Manufactures exports (% of merchandise exports))	-0.1983	0.0111	0.0111	0.0092	-0.0288	0.0160	-0.0273***	-0.0288	0.0149	0.0071
	(0.7707)	(0.8029)	(0.8451)	(0.8352)	(0.6769)	(0.6707)	(0.0000)	(0.6769)	(0.6842)	(0.8135)
Constant	1.0800	2.8089	2.8089	1.2128	0.1146	3.1784***	0.0962**	0.1146	-0.8212	0.1608
	(0.8569)	(0.4431)	(0.7608)	(0.6106)	(0.9038)	(0.0000)	(0.0447)	(0.9038)	(0.5685)	(0.8927)
Observations	713	713	713	713	713	713	713	713	713	713
R-squared	0.1837	0.0146	0.0146							
Number of ind	31	31	31	31	31	31	31	31	31	31
Log-likelihood	-53.52	-956.3	-956.3		-1369			-1369		
Wald chi2(4)				14.56	108.0	39.19	35896	108.0	18.54	20.67
Prob > chi2				0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: pval in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: The authors

***Appendix 8**: Graph A 4: Structural transformation index with the manufacturing sector value added % GDP*



Source: The authors

Appendix 9: Table A 5: Robustness check for the estimation with the second structural transformation index

Dependent Variable: Ln (Structural Transformation Index 2)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Independent Variables	Between-effects model	Fixed-effects model	A fixed-effects model with robust variance	Random-effects model1	GLS i.i.d. error structure	GLS heteroskedastic but uncorrelated error structure	GLS heteroskedastic and correlated error structure	GLS independent autocorrelation structure	GLS AR1 autocorrelation structure	GLS panel-specific AR1 autocorrelation on structure
ln (Labor force, Total)	-0.2516	0.4130	0.4130	0.1402	-0.2324***	-0.2309***	-0.2301***	-0.2324***	0.0125	-0.0093
	(0.4739)	(0.1307)	(0.5443)	(0.4580)	(0.0003)	(0.0000)	(0.0000)	(0.0003)	(0.8991)	(0.9029)
ln (Gross fixed capital formation (% of GDP))	0.3289	0.0370	0.0370	0.0469	0.1176	0.1271*	0.1160***	0.1176	0.1919	0.1984
	(0.7719)	(0.7877)	(0.8582)	(0.7279)	(0.5070)	(0.0542)	(0.0000)	(0.5070)	(0.2460)	(0.1157)
ln (Number of exported products)	1.5119**	0.4609**	0.4609	0.6292***	1.4277***	1.0796***	1.4231***	1.4277***	0.7010***	0.7045***
	(0.0366)	(0.0124)	(0.4014)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ln (Manufactures exports (% of merchandise exports))	0.0496	0.0028	0.0028	0.0069	0.0260	0.0954**	0.0290***	0.0260	0.0242	0.0012
	(0.9482)	(0.9491)	(0.9600)	(0.8751)	(0.7290)	(0.0157)	(0.0000)	(0.7290)	(0.5407)	(0.9699)
Constant	-2.3295	-6.4178*	-6.4178	-3.0928	-1.4727	0.0137	-1.4988***	-1.4727	-2.0104	-1.6240
	(0.7292)	(0.0778)	(0.4739)	(0.2225)	(0.1539)	(0.9767)	(0.0000)	(0.1539)	(0.1546)	(0.1820)
Observations	713	713	713	713	713	713	713	713	713	713
R-squared	0.2962	0.0399	0.0399							
Number of ind	31	31	31	31	31	31	31	31	31	31
Log-likelihood	-57.11	-951.1	-951.1		-1430			-1430		
Wald chi2(4)				33.93	212.0	340.9	75162	212.0	35.77	64.80
Prob > chi2				0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: pval in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Source: The author

Appendix 9A: Table A.5 A: *Estimation results with the value-added of the industry sector*

Dependent Variable: Ln (Industry (including construction), value added (% of GDP))	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Independent Variables	*Between-effects model*	*Fixed-effects model*	*A fixed-effects model with robust variance*	*GLS i.i.d. error structure*	*GLS heteroskedastic but uncorrelated error structure*	*GLS heteroskedastic and correlated error structure*	*GLS independent autocorrelation structure*	*GLS AR1 autocorrelation structure*	*GLS panel-specific AR1 autocorrelation structure*
ln (Labor force, Total)	-0.1153**	-0.0105	-0.0105	-0.0654***	-0.0368***	-0.0648***	-0.0654***	-0.0131	0.0079
	(0.0399)	(0.7855)	(0.9120)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.4358)	(0.6231)
ln (Gross fixed capital formation (% of GDP))	0.5011***	0.0425**	0.0425	0.2248***	0.1106***	0.2165***	0.2248***	0.0402**	0.0287*
	(0.0075)	(0.0288)	(0.4299)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0449)	(0.0978)
ln (Number of exported products)	**0.3626*** **	**0.0250**	**0.0250**	**0.2579*** **	**0.2775*** **	**0.2555*** **	**0.2579*** **	**0.1210*** **	**0.1359*** **
	(0.0020)	(0.3372)	(0.6092)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ln (Manufactures exports (% of merchandise exports))	**-0.2249***	**-0.0021**	**-0.0021**	**-0.0406*** **	**-0.0167** **	**-0.0373*** **	**-0.0406*** **	**0.0025**	**0.0025**
	(0.0644)	(0.7396)	(0.8358)	(0.0013)	(0.0368)	(0.0000)	(0.0013)	(0.5674)	(0.5403)
Constant	2.9420***	3.0422***	3.0422**	2.4616***	2.1050***	2.4695***	2.4616***	2.6021***	2.2124***
	(0.0080)	(0.0000)	(0.0267)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	713	713	713	713	713	713	713	713	713
R-squared	0.5239	0.0132	0.0132						
Number of ind	31	31	31	31	31	31	31	31	31
Log-likelihood	0.896	444.0	444.0	-155.7			-155.7		
Wald chi2(4)				334.6	704.7	18794	334.6	46.03	90.73
Prob > chi2				0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: pval in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Source: The authors

Appendix 9B: Table A.5 B: Estimation results with the structural transformation index

Dependent Variable: Ln (Structural Transformation Index)	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Independent Variables	Between-effects model	Fixed-effects model	A fixed-effects model with robust variance	Random-effects model1	GLS i.i.d. error structure	GLS heteroskedastic but uncorrelated error structure	GLS heteroskedastic and correlated error structure	GLS independent autocorrelation structure	GLS AR1 autocorrelation structure	GLS panel-specific AR1 autocorrelation structure
ln (Labor force, Total)	-0.4236**	0.3871***	0.3871***	0.2237***	-0.4111***	-0.4123***	-0.4091***	-0.4111***	-0.2195***	-0.1492***
	(0.0123)	(0.0000)	(0.0043)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ln (Gross fixed capital formation (% of GDP))	0.8322	0.0170	0.0170	0.0304	0.3840***	0.3401***	0.3734***	0.3840***	0.1055**	0.0912**
	(0.1152)	(0.6000)	(0.8071)	(0.3581)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0136)	(0.0140)
ln (Number of exported products)	*0.9798****	*0.1131****	*0.1131*	*0.1866****	*0.9455****	*0.9667****	*0.9364****	*0.9455****	*0.3925****	*0.5627****
	(0.0042)	(0.0096)	(0.1981)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ln (Manufactures exports (% of merchandise exports))	*0.0231*	*-0.0103*	*-0.0103*	*-0.0081*	*0.0142*	*0.0427***	*0.0122****	*0.0142*	*0.0046*	*0.0083*
	(0.9470)	(0.3220)	(0.6182)	(0.4466)	(0.6609)	(0.0343)	(0.0000)	(0.6609)	(0.6263)	(0.3157)
Constant	-0.4674	-6.1845***	-6.1845***	-4.0856***	0.8743**	0.7244***	0.9316***	0.8743**	1.4045**	-0.3567
	(0.8785)	(0.0000)	(0.0012)	(0.0000)	(0.0491)	(0.0010)	(0.0000)	(0.0491)	(0.0110)	(0.2650)
Observations	713	713	713	713	713	713	713	713	713	713
R-squared	0.5285	0.1559	0.1559							
Number of ind	31	31	31	31	31	31	31	31	31	31
Log-likelihood	-32.68	76.15	76.15		-828.3			-828.3		
Wald chi2(4)				108.0	573.3	2080	44544	573.3	96.90	360.30
Prob > chi2				0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: pval in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Source: The authors

Technical appendix

$$Ln\ (Y_{it}) = LnA + \delta\ Ln\ (IX_{it}) +\ \alpha\ Ln\ (K_{it}) +\ \beta\ Ln\ (L_{it}) + \varepsilon_{it} \qquad \textit{Equation (7)}$$

Equation 7 is the general equation.

From

$$Y_t = A\ \ IX_t^{\delta}\ K_t^{\alpha}\ L_t^{\beta} \qquad \textit{Equation (5)}$$

We have for agriculture and industry, where Y_t^1 respectively Y_t^2 is the value added of each sector.

$$Y_t^1 = A^1\ \ IX_t^{\delta 1}\ K_t^{\alpha 1}\ L_t^{\beta 1} \qquad (1)$$

$$Y_t^2 = A^2\ \ IX_t^{\delta 2}\ K_t^{\alpha 2}\ L_t^{\beta 2} \qquad (2)$$

$$STI_t = \frac{Y_t^2}{Y_t^1} = \frac{A^2\ \ IX_t^{\delta 2}\ K_t^{\alpha 2}\ L_t^{\beta 2}}{A^1\ \ IX_t^{\delta 1}\ K_t^{\alpha 1}\ L_t^{\beta 1}} \qquad (3)$$

$$STI_t = \widetilde{A}\ \widetilde{IX}_t^{\delta} \widetilde{K}_t^{\alpha} \widetilde{L}_t^{\beta} \ = \ \frac{Y_t^2}{Y_t^1} = \frac{A^2\ \ IX_t^{\delta 2}\ K_t^{\alpha 2}\ L_t^{\beta 2}}{A^1\ \ IX_t^{\delta 1}\ K_t^{\alpha 1}\ L_t^{\beta 1}} \qquad (4)$$

We assume that factors are homogenous and each sector uses a certain quantity to produce a homogenous final good which is exported or consumed as inputs, where

$$\tilde{A} = \frac{A^2}{A^1} = A \qquad (5)$$

$$\widetilde{IX}_t^{\delta} = \frac{IX_t^{\delta 2}}{IX_t^{\delta 1}} = IX_t^{\delta 2 - \delta 1} = IX_t^{\delta} \qquad (6)$$

$$\widetilde{K}_t^{\alpha} = \frac{K_t^{\alpha 2}}{K_t^{\alpha 1}} = K_t^{\alpha 2 - \alpha 1} = K_t^{\alpha} \qquad (7)$$

$$\widetilde{L}_t^{\beta} = \frac{L_t^{\beta 2}}{L_t^{\beta 1}} = L_t^{\beta 2 - \beta 1} = L_t^{\beta} \qquad (8)$$

Finally, from the general *equation (5)* above and after transformation *(1)-(8),* we can write the following specification in *equation 9*.

$$Ln\ (STI_{it}) = LnA + \delta\ Ln\ (IX_{it}) +\ \alpha\ Ln\ (K_{it}) +\ \beta\ Ln\ (L_{it}) + \varepsilon_{it} \qquad \textit{Equation (9)}$$