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China, Africa's New Colonial Master?

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I. Introduction

This paper aims to evaluate the impact of Chinese trade and investment relations on Nigerian economic growth. Trade relations between Nigeria and China has over the last two decades grown from a period of restrictive and periodic association to an era of increasingly complicated and expansive inter-relationship. Africa's importance in China's international relations led to the formation of the Forum on China-Africa Cooperation (FOCAC) in 2010 with the stated objective of implementing economic programs with Africa. China's sensational growth and subsequent demand for raw materials and market for its goods has led to increased association with Africa, creating lively debates among scholars and policy makers about its impact on the continent. China's new relationship offered a partnership viewed by Africans as a substitute to western relationship and a conveyor of economic growth. Chinese aid unlike western aid doesn't infringe on a country's sovereignty or meddle in its internal affairs and China's no string policy makes trade and foreign investment more manageable and user friendly. However, there has been a growing discomfort in Africa that it exports raw materials at cheaper prices while importing finished goods at a heavier cost and China has flooded the African market with cheap goods benefiting from low labour cost and a manipulated currency. True, Africans benefit from low cost goods too, but African workers and small business owners (especially in the retail sector) are often cast aside by the secrecy and quiet incursion of Chinese commerce. Stewart Jennings Chief executive of PG group asserted that "China is exporting unemployment to Africa", while Sanusi Lamido, Nigeria's Central Bank governor urged Africans to "wake up from their romance with China". The trade balance between China and Africa was the "essence of colonialism" he said and cautioned that Africa is willingly opening itself to a new form of imperialism. China, he stated is no longer a fellow under-developing country but a significant contributor to Africa's de-industrialization and underdevelopment. While trade volume prior to 2000 was nugatory, trade volume between Africa and China has grown from $9 billion in 2000 to $166 billion in 2012, making China, Africa's biggest trading partner. Concurrently, trade volume between Nigeria and China increased from 1.2 billion Naira in 1998 to 11.4 billion US dollar in 2011 making Nigeria, Africa second largest trading partner (UN Comtrade). Of the 11.4 billion US dollar, 10 billion US dollar was the total value of Nigeria import while total export totaled 1.4 billion US dollar. Natural resources depicts approximately 90% of Africa's export to China with Zambia, The Congo, Angola, South Africa and Ghana as major exporters. Over the years, there has been a growing structural imbalance in trade between Nigeria and China as well as between China and other African countries.

Hypothetically, the interrelationship between trade and economic growth are inclined to be positive. Mainstream economics provides a framework surmising that increased trade leads to growth. Neoclassical economics illustrates gains from trade due to comparative advantages in resource endowments (Hecksher-Ohlin model) or differences in technology (Ricardian model). They infer that trade leads to increased allocative efficiency as goods are produced by countries with lower opportunity costs even though the mechanism through which this affects growth is less obvious. Channels such as access to larger markets to harness economies of scale have been suggested (Kruger, 2003). Endogenous growth theories hypothesize that trade will lead to long-run growth through technological diffusion (Grossman, 1991), learning by doing (Lucas, 1988), and knowledge spill-overs. Others point to imports fuelling growth through access to cheaper and better quality inputs, which increases productivity. Trade can also lead to a macroeconomic stimulation as exports earn foreign exchange, which can be used to purchase imported inputs and technology (Morrissey, 2013). However, empirical results on causal relationship between trade and economic growth are mixed. Import competition has the potentials to adversely affect domestic producers (Giovanetti et al, 2009). Also economies that export mainly primary commodities are often faced with volatile, exogenous world prices, typically characterized by decreasing

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prices and terms of trade. Also, primary commodities have weaker linkages to other economic sectors and are susceptible to high transport costs. A notable fear is that trade may aggravate the resource curse or lead to Dutch Disease, discouraging diversification or industrialisation and so hinder growth (Zafar, 2007). Trade effects will depend on how local firms and the economy can adjust to competition. If firms respond by reallocating resources then trade benefits may arise. Kaplinsky (2007) argues that the key to long-term growth lies in increasing integration into the global economy. Trade can lead to growth if it incentivises integration of manufacturing into global value chains, structural transformation and spill-over effects. If not, growth may be temporary and more importantly may not lead to development. Giles and Williams (2000) examined export led economic growth hypothesis and observed a negative relationship between export and growth. Rahman (2009) observed that short run net effects of export on real GDP are more visible than those of FDI and remittances. Yucel (2009) examines the causality relations between financial development, trade openness and economic growth in Turkey. Using Augmented Dickey-Fuller (ADF) for unit root test, Johansen and Juselius (JJ) for co-integration and Granger causality test for causal relationship, he observed that while trade openness has a positive effect, financial development has a negative effect on growth. Moreover, the Granger causality test revealed the presence of bicausal relationship between financial development, trade openness and growth indicating that economic policies aimed at financial development and trade openness have a statistically significant impact on economic growth. Jenkins and Edwards (2006) examined the overall effect of trade and FDI from China and India on Africa. Combining a disaggregated approach at the 3-digit SITC level to analyze both the competitive and complementary effects, they concluded that while the Asian exports are mainly at the expense of European and American exporters, thereby reducing the likelihood of displacing local producers, the overall effect on growth is conditional on certain factors and vary among countries. These factors may include institutional factors, infrastructural quality, land to labour ratio and trade policies.

Conclusively, the relationship between trade openness and economic growth is inconclusive as there are differing views about the interrelationship. While some authors postulate a strong relationship, others report a weak relationship, or no relationship at all between trade and economic growth. A proper understanding of the direction of these variables is necessary to enable effective policy formulation in order to expedite growth. Empirical studies on the impact of Chinese trade on African economic growth have been few and far between. Chen (2007) applied an instrumental variable method for Chinese trade and observed a statistically significant positive relationship with growth between Africa and Chinese's trade though his regression methodology and results were subsequently criticized. Baliamoune Lutz (2010) applied a GMM estimation and noted a negative relationship between exports to China and growth. Elu and Price (2010) applied micro data from the CSAE to evaluate the effect of Chinese trade on African productivity, and observed no significant results. In essence, empirical evidence seems relatively uninformative. The objective of our study is to evaluate if China's trade has been a central driver of African economic growth over the past 2 decade. Unlike western nations who treat different African countries with different policies and objectives, China has just one policy towards all African countries, thus we can form an objective conclusion about Chinese trade in Africa, using an individual country as our case study. Our study investigates the relationship between Chinese trade and Nigerian GDP growth in a time series context from 1996 to 2012 using a GLM approach and a cointegration approach. This paper is exploratory by nature: its scope and the dept of analysis are constrained by the nature of data availability. To achieve our objective, the paper is structured as follows: section 2, specifies the model of the study, section 3 gives the data sources, section 4 gives the methodology applied, the results and an analysis of the results while section 5 concludes.

II. Theoretical Specification

Our paper seeks to test how well the Solow model fits a time series data. Surprisingly, scant attention has been paid to this issue. Most empirical research on the Solow model are mostly in Cross-Sectional analysis despite its associated drawbacks such as missing variables and endogeneity problems. We shall apply the Solow-growth model on a time series analysis to study the effect of Chinese trade on income per capita and economic convergence. A fundamental difference is that it differ from other studies which apply panel data analysis on trade effects on economic growth. The advantage of this method is that it is country specific and can also corrects simultaneity issues of variables. We begin by extending the solow model. By separating capital stock into stock of trade and domestic investment, the Cobb-Douglas production function can be expressed as:

$$Y_t = K_{Ct}^{\theta} K_{Dt}^{\gamma} (A_t L_t)^{1-\theta-\gamma} \tag{1}$$

with Y as output, A is technology level assumed to grow at an exogenous rate (A $= A_0 e^{gt}$)K_C is stock of Chinese trade, K_D is stock of domestic investment (GCF), and L is labour force. Subscript t denotes time. Further mathematical derivation(see Appendix B) results in :

$$\dot{k}_C = s_c y_t - (n + g + \delta) k_{Ct} \tag{1a}$$

$$\dot{k}_D = s_D y_t - (n+g+\delta)k_{Dt} \tag{1b}$$

where $y = Y{=}AL$, $k_C = K_C{=}AL$ and $k_D = K_D{=}AL$ are income per effective unit of labour, Chinese trade stock per effective unit of labour and domestic capital stock(GCF) per effective unit of labour respectively. s_C and s_D are the share of Chinese trade and domestic investment respectively.

we derive the GDP per capita in a balanced growth path:

$$ln(\frac{Y_t}{L_t})^* = lnA_0 + g_t + \frac{\theta}{1-\theta-\gamma}ln(s_C)^* + \frac{\gamma}{1-\theta-\gamma}ln(s_D)^* - \frac{\theta+\gamma}{1-\theta-\gamma}ln(n+g+\delta) \tag{2}$$

Applying the taylor expansion first order approximation around the steady state of GDP growth, we derive the speed of convergence (appendix B) as:

$$\lambda = -(1-\theta-\gamma)(n+g+\delta) \tag{3}$$

Adopting Mallick (2002) assertion that at steady state, capital stock can be estimated by the level of investment (capital stock), we enhance the assumption by assuming that:

$$\dot{K}_C = I_C - \delta K_C$$

$$\dot{K}_D = I_D - \delta K_D$$

with I_C as tradeflows and I_D as domestic investment.

At steady state $\dot{K}_C = \dot{K}_D = 0$

thus

$$K_C^* = \frac{1}{\delta}I_C^* and\, K_D^* = \frac{1}{\delta}I_D^*$$

if we substitute it into the production function (eq.1), we get:

$$Y_t^* = \frac{1}{\delta^{\theta+\gamma}}(I_C^*)^{\theta}(I_D^*)^{\gamma}(A_tL_t)^{1-\theta-\gamma}$$

if we divide both sides by L and take the logs,it becomes

$$log(\frac{Y}{L})^* = log(\frac{1}{\delta^{\theta+\gamma}}) + \theta log(\frac{I_C}{L}^*) + \gamma log(\frac{I_D}{L}^*) + (1-\theta-\gamma)log(A_t)$$

with the assumption that A grows exogenously A = A0egt,

$$log(\frac{Y}{L}^*) = C + \theta log(\frac{I_C}{L}^*) + \gamma log(\frac{I_D}{L}^*) + (1-\theta-\gamma)gt \tag{4}$$

with $C = log(\frac{1}{\delta^{\theta+\gamma}}) + (1-\theta-\gamma)logA_0$

Finally, as population growth and exchange rate has been highlighted as growth determinants, we introduce both as additional explanatory variables. For our empirical estimation, eq(21) can be written as:

$$GDPgrowth_t^* = C + \theta log(trade_t)^* + \beta log(xrate_t)^* + \gamma log(GCF_t)^* + ngd + (1-\theta-\beta-\gamma)_{gt} + \epsilon_t \tag{5}$$

With GDPgrowth as growth per capita which is change in the log of real income per capita over time t, or $lny_t - lny_{t-1}$, trade as Chinese net trade per capita relative to Nigeria's net trade, xrate as exchange rate, GCF as domestic investment per capita, ngd denotes population growth, g is the exogenous growth rate of technology, t denotes time and ϵ is the error term. Fitting into a GLM with GDP as y and the covariates as X, the proposed model estimation regression function can be formalized as:

$$g\{E(y)\} = X\beta, y \sim F \tag{5}$$

With g(.) as the link function, and F, the distributional family.

III. Data and Data Analysis

The data used in the analysis are annual data taken in the period 1981-2012. GDP per capita, Labour and GCF data are from the TheGlobalEconomy.com database. The data are expressed in US dollar at 2000 real prices. Data on Chinese import and export were obtained from the International Trade Statistics Database (UN Comtrade) and controlled with respect to Nigerian trade with the rest of the world (ROW). This is meant to capture the effect of Chinese trade with Nigeria. Data on education attainment and institutional quality were excluded as a result of inadequate data. Indeed, our sample data will decrease by half if we co-opt the Barro and Lee education attainment data or the World Bank data for governance and institutional quality.

Regression Estimates of the Basic Solow Model

Table A1

	(1)
VARIABLES	g
lxrate	0.0417
	(0.132)
lgcf	0.224***
	(0.0534)
lctr	-0.251***
	(0.0774)
lngd	-0.591
	(0.983)
Constant	0.733
	(3.540)
Observations	16

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

singlelinecheck=off Results of the GLM technique

Regression results from table A1 shows the results of the analysis. The results indicate that the only significant coefficients are gross capital formation 0.224 (0.0534) and Chinese trade -0.251 (0.0774) at the 5% critical level. The estimated coefficient for exchange rate is positive 0.00417 (0.132) but not significant. From our GLM analysis, the coefficients of capital formation and population growth have signs that are in harmony with economic theory. Also the restriction that the coefficients on gcf and In (n+g+d) are opposite in sign is not rejected in the sample. Nigeria is observed to have a negative net trade balance with China. This trade deficit, leads to an unfavorable balance of trade because it results in net outflow of monetary payments. While trade deficit can be good, bad or immaterial depending on the situation (Schmidt 2008), few economists argue that trade deficits are always good. True it raises the standard of living of a country's resident since they now have access to a wider variety of goods and services at a more competitive price however, consistently borrowing from abroad or selling of capital assets to finance current purchase of goods and services is not a viable long term strategy and undermines future production. Also trade deficits create unemployment as importing certain goods rather than buying them domestically makes local companies go out of business. Since 1986, Nigeria's Naira has been observed to be highly overvalued with respect to the US Dollar (the main international currency used in international transaction) and this plays a crucial role in Nigeria's balance of payments deficit. Economists have long known that poorly managed exchange rates can be inimical for growth (Dornbusch, 2001; Miles, 2006; Slaughter, 2001) and as such, a country should avoid overvaluing its currency. Nigeria's overvalued exchange rate is associated with shortages of foreign currency, corruption, unsustainably large current account deficits and balance of payments crisis, all of which damages growth.

To evaluate the terms of trade effects in more details, Stuart Kendal observed that "a statistical relationship, no matter how strong and suggestive, can never establish causality relationship". We therefore employ the cointegration technique. Using time series data, series of econometric factors can affect the parameter estimation. Therefore before estimating the long run relationship of our variables, we need test for stationarity. A series is said to be stationary when the mean and variance are observed to be time invariant. Non stationarity of time series data have time dependent mean and can lead to spurious regression Granger and Newbold (1974). Thus stationarity of a stochastic process imply constant mean $[E(Y_t)]$ and variance $[var(Y_t)]$ of Y over time for all t, and the correlation between any two values of Y taken from different time periods $[cov(Y_t; Y_s)]$ depends on the difference apart in time between the two values for all t 6= s. To achieve stationarity, integration of order 0 [I(0)] is required of the series. Using the Augmented Dickey-Fuller test, the unit root test shows that our variables are not stationary in level but they are stationary in first difference (see results in appendix A).

Table A2 : Augmented Dickey-Fuller(ADF) unit root test

Variables	At levels(ADF T-Statistics)	1^{st}differences(ADF T-Statistics)
g	-2.501	-4.619^{***} .
$lngcf$	1.327	-3.788^{***}
$lctr$	-1.752	-7.180^{***}
$lxrate$	0.857	5.191^{***}

Note: (*); (**); (***) denotes level of significance at 10%, 5% and 1% respectively

From the results, we cannot reject the null hypothesis that logged values of our variables exhibit a unit root. However the values are observed to be stationary after first differencing indicating no unit roots. Next we apply the maximum likelihood estimation (MLE) method of Johansen and Juselius (1990) to find the long run relationship of our variables. Cointegration is a prerequisite for the existence of long run or equilibrium relationship between two or more variables having unit root (i.e I(1)). MLE is applied in estimating the vector error correction model (VECM) to determine the number of cointegrating ranks. Before applying cointegration test, we apply the Akaike information (AIC) and Schwartz information criterion (SIC) to determine the order of the lag length. Our lag order criterion indicate cointegration of order three.

Table A3 : Lag order criterion

lags	AIC	SIC
0	-8.03789	-7.83585 .
1	-28.9294	-27.7172
2	-175.215	-172.992
3	-311.556^{*}	-309.132^{*}

Note: (*) denotes lag order selected by the criterion. AIC refers to Akaike information Criterion. SIC refers to Schwarz information criterion

Next we carry out test on cointegration by using the Johansen and Juselius (1982) LR statistic. The johansen cointegration method is able to determine the number of cointegrated vectors in any given number of non-stationary variable of the same order. From our cointegration test, the trace statistic and the maximum eigenvalue statistic rejects the null hypothesis of no cointegration. Cointegration results from the likelihood ratio shows the cointegration of order three among our variables.

Table A4 : Johansen's Cointegration Test

Trace and Maximum Eigen Value Test			
Maximum rank	eigenvalue	trace statistics	critical value 5%
0	.	115.1377	47.21
1	0.98994	50.7528	29.68
2	0.90900	17.1966	15.41
3	0.68069	1.2142^{*}	3.76
4	0.08307		

** denotes rejection of the hypothesis at 5% significance level. L.R. test indicates two cointegrating equations*

Having determined that there is a co-integrating relationship, we estimate the parameters of a cointegrating VECM using vector error correction. Error correction model first applied by Sargan (1984) and later modified by Engle and Granger (1987) is a medium for reconciling the short run characteristic of a variable with its long run characteristic. The Granger representation theorem establishes the notion that cointegrated time series has error correction representation, which mirrors the short run adjustment mechanism. Cointegration among variables only points out the long run relationship between the variables. To observe the short run effects, a short run causality test is also required (Christpoulos and Tsionas (2004)). Causality is a statistical feedback concept highly applied in modeling forecasts. Prescribed by Granger (1969) and Sim (1972), Granger causality test is a method used for ascertaining if a time series is significant in forecasting another. The Granger causality test states if variable Y is Granger caused by variable X, implying that lagged

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values of X are statistically significant in explaining Y. X does not Granger cause Y if $E(y_t|y_{t-1}, y_{t-2}, .., x_{t-1}, x_{t-2}..) = E(y_t|y_{t-1}, y_{t-2}..)$ VECM confirms long run causality when a unidirectional long term causal relationship runs from changes in GCF, Labour, Trade openness and exchange rate to the GDP growth rates of Nigeria.

Table A5

	Error Correction Model				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	D_g	D_lxrate	D_lgcf	D_lctr	D_lngd
L._ce1	-0.957***	-0.0192	-1.179	-0.415	-6.67e-05
	(0.360)	(0.406)	(1.047)	(0.948)	(0.000204)
LD.g	0.173	0.357	2.574***	1.376	0.000116
	(0.341)	(0.384)	(0.991)	(0.897)	(0.000193)
LD.lxrate	-0.0103	0.436	-0.0923	1.318	-0.000268
	(0.393)	(0.442)	(1.142)	(1.034)	(0.000222)
LD.lgcf	-0.343**	-0.121	-0.860*	0.112	3.41e-05
	(0.157)	(0.177)	(0.458)	(0.414)	(8.90e-05)
LD.lctr	0.391**	0.154	0.928*	-0.173	7.56e-05
	(0.172)	(0.194)	(0.500)	(0.453)	(9.73e-05)
LD.lngd	-408.4**	23.42	-440.1	-302.5	0.963***
	(180.6)	(203.5)	(525.2)	(475.4)	(0.102)
Constant	0.133	-0.613	-1.057	2.722	-8.58e-05
	(0.791)	(0.891)	(2.301)	(2.082)	(0.000447)
Observations	14	14	14	14	14

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

As revealed from our target model, the co-integrating equation 1(ce1) which shows that the estimated coefficient (λ = -0:957) is negative and statistically significant in its associated t-value. The coefficient signifies a satisfactory convergence rate to equilibrium per point. This confirms that there is no problem in the long run equilibrium relation between our variables. Also Chinese trade, gross capital formation and population growth are observed to have causal relationship on Nigeria's economic growth. Our decision rule states that while there is a long run causality between Chinese Trade on Nigerian economic growth, there is also short run causality between Chinese trade and Nigerian economic growth. Also Gross capital formation and population growth are significant for growth. Exchange rate however tend to be insignificant for long run growth. Reasons might be probably due to inconsistencies in Nigeria's exchange rate policies. Exchange rate policies in developing countries are usually sensitive and controversial, mainly because of the kind of structural transformation required, such as reducing imports or expanding non-oil exports, which leads to a depreciation of the nominal exchange rate. Such domestic adjustments, due to their short run impact on prices and demand are perceived as damaging to the economy Akpan and Atan (2012). According to Solow(1956) and Acemogoglu(2009), the faster the speed of convergence, the greater economic growth moves far from its equilibrium. Thus, from our study, we can see that there is long run equilibrium between our variables, implying that the economy does converge to its steady state. To find the short run effects of Chinese trade and FDI on per capita growth, we use the Granger causality test of lagged values of Chinese trade and FDI. Our short run causality test using the Granger Causality test of lagged values of Chinese trade shows that lagged values of our variable do influence Nigerian economic growth. The chi-square value is 5.16 and our corresponding probability value is less than 5% meaning that it is not 0 implying that there is short run causality running from Chinese trade to Nigerian growth and that Chinese trade can influence Nigerian growth.

Table A6

lctr VECM Short run causality test

(1) $[D\_gpc]LD.lctr = 0$

$$\chi 2(\quad 1) = \quad 5.16$$
$$prob > \chi 2 = \quad 0.0230$$

Using the Granger causality specification, we reject the null hypothesis that all coefficients of lag of trade are equal to 0. Therefore Chinese trade has causal relationship on economic growth in the short run. We can see that the lagged values of our variable does influence economic growth. The results indicate that Chinese trade has significant effect and is a good predictor of Nigeria's economic growth in the short run. This findings is similar to the findings of Alici (2003) for Turkey.

Generally, the model shows no sign of misspecification. The adjusted R-square is high enough to ensure that the model can explain the behaviour of the data. The homoskedasticity test, model specification test, multicolinearity test, white noise test, serial correlation test and normality tests are all well below their critical values.

IV. Conclusion

In this paper, we perform an analysis of the effect of Chinese trade on Nigerian economic growth. In the GLM method, the empirical analysis on the basis of GLM method suggest there is a negative relationship between Chinese trade balance and Nigerian GDP and thus, a negative terms of trade. However, while the GLM regression analysis can establish dependence between both variables, it does not imply causation. The cointegration test confirmed that economic growth and Chinese trade are cointegrated, indicating an existence of long run equilibrum relationship and the Granger causality test also confirms causality between both variables in the short run. The empirical results shows that Chinese trade is significant to Nigeria's economic growth. However while possibilities certainly exist for Nigeria to derive higher value from China's growing influence and trade, Nigeria have not fully capitalized on the potential benefits. Far more needs to be done to expand policy creation, institution building, human capital, entrepreneurship, and the culture and leadership capabilities to maximize gains. To achieve the status similar to that of China, Nigeria should focus on investments, diversification and export upgrading, both in the public and private sector, avoid the resource curse that so often plaque African countries along with weak institutions, invest in human capital formation and of vital importance, properly manage its exchange rate, borrowing from the Chinese model. An exchange rate that will not erode its competitiveness in the world market, instead, to assist in promoting export and thus growth. Most importantly, Nigeria needs to develop a comprehensive strategy to more effectively balance the engagement of China to leverage its own strength and create a plan for sustainable development that resonates with its citizens.

Appendix A

Variable	Definition	Source
GDP per capita	Gross Domestic Product (GDP) per capita, cons. US$ (2005)	theGlobalEconomy (2014)
Investment	Gross Capital Formation,% of GDP	theGlobalEconomy (2014)
Population Growth	Population growth rate in %	theGlobalEconomy (2014)
Chinese Trade	Chinese import + export divided by ROW trade, % of GDP	UN Comtrade (2014)
Exchange Rate	Local currency unit per US.Dollar	theGlobalEconomy (2014)

Appendix B

B1. *Derivation of exchange rate and trade openness in Solow model.*
Disaggregating Trade and GCF in a Cobb-Douglas production function:

$$Y_t = K_{Ct}^{\theta} K_{Dt}^{\gamma} (A_t L_t)^{1-\theta-\gamma}$$

Let $y = Y/AL, k_C = K_C/AL$ and $k_D = K_D/AL$ be Chinese trade per capita and Gross Capital formation per capita respectively.

We can write Eq.(B1) as eq(B2):

$$y_t = k_{Ct}^{\theta} k_{Dt}^{\gamma}$$

Taking derivative of $k_c = K_c/AL$ and $k_D = K_D/AL$ WRT time gives us eq(B3):

$$\frac{\dot{K_C}}{K_C} = \frac{\dot{k_C}}{k_C} + n + g \text{ and } \frac{\dot{K_D}}{K_D} = \frac{\dot{k_D}}{k_D} + n + g$$

with n as labour growth rate and g as the rate of technological growth.
If we theorize that

$$\dot{K_C} = S_C Y - \delta K_C, \text{ and } \dot{K_D} = S_D Y - \delta K_D$$

with $\delta_C = \delta = \delta_D = \delta$ as *depriciationrate*, S_C and S_G as the share of trade and GCF to economic growth, substituting into eq(B3) gives eq(B4)

$$\dot{k_C} = S_C y_t - (n+g+\delta)K_{ct}$$
$$\dot{K_D} = S_D y_t - (n+g+\delta)K_{Dt}$$

Solving for k_C and k_D in steady state and inserting into eq(B2) and taking logs, leads us to:

In $(\frac{Y_t}{L_t})^* = lnA_0 + g_t + \frac{\theta}{1-\theta-\gamma} ln(S_C)^* + \frac{\gamma}{1-\theta-\gamma} ln(S_D)^* - \frac{\theta+\gamma}{1-\theta-\gamma} ln(n+g+\delta)$

With $A = A_0 e^{gt}$

B2.*Speed of convergence*
Reversing eq(B4) into the pattern

$$\frac{\dot{k_C}}{k_C} = S_C e^{(\theta-1)lnK_C} . e^{\beta lnK_F} . e^{\gamma lnK_G} - (n+g+\delta)$$

$$\frac{\dot{K_D}}{K_D} = S_D e^{\theta lnK_C} . e^{\beta lnK_F} . e^{(\gamma-1)lnK_D} - (n+g+\delta)$$

Applying Taylor expansion to approximate around the steady state and substituting into $\frac{\dot{y}}{y} = \theta(\frac{\dot{k_C}}{k_C} + \gamma(\frac{\dot{k_G}}{k_G})$, gives

$$\frac{\dot{y}}{y} = -(1-\theta-\gamma)(n+g+\delta)[\theta(lnk_C - lnk_C^*) + \gamma(lnk_G - lnk_G^*)]$$

The speed of convergence is defined as

$$\lambda = -(1-\theta-\gamma)(n+g+\delta)$$

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