# INDUSTRIALIZATION OF ECONOMIES WITH LOW MANUFACTURING BASE

Atlaw Alemu

A Dissertation Submitted
to
The Department of Economics

Presented in Fulfillment of the Requirements for the degree of Doctor of Philosophy in Economics

Addis Ababa University

Addis Ababa, Ethiopia

May 2016

**Addis Ababa University**
**School of Graduate Studies**

This is to certify that the dissertation prepared by Atlaw Alemu entitled: *Industrialization of Economies with Low Manufacturing Base* and submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy (Economics) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the examining Committee:

Examiner ____________________signature ______________Date ________

Examiner ____________________signature ______________Date ________

Examiner ____________________signature ______________Date ________

Advisor ____________________signature ______________Date ________

Advisor ____________________signature ______________Date ________

______________________________________________

Chair of Department or Graduate Program Coordinator

## ACKNOWLEDGEMENT

It all began as an exciting exercise. Painful episodes followed with changes in ease and difficulty of meeting schedules of the coursework and writing the dissertation. At times, I regret that many people knew about my involvement in a PhD program, for the extension of period for completion raises undesirable comments. However, it went on with a determination to complete the undertaking whatever the difficulties! The driving forces that propelled the progress of the project were two. The urge to complete what I have started, a moral position, and the eagerness to arrive at a conclusion on the research issue, which was a curiosity to answer a life-long question. Now that I have reached the stage of concluding the project with answers to my questions, I am pleased and satisfied. The pains and anxiety are history, with lessons left behind.

My special gratitude goes to the patient and meticulous supervisor Professor Borje Johansson for his unreserved guidance and feedback. I don't forget Professor Ghazi Shukur for his kind support up to the time he quit advising for reasons beyond his control. Thanks to Kristofer Manson (PhD) to fill the gap created by the discontinuity of the role of Professor Ghazi Shukur. Kristofer's prompt responses and feedbacks were extremely important in enhancing the quality of the dissertation.

I thank the Department of Economics for the financial support to augment living costs. Addis Ababa University and IFPRI/IDRI have provided financial support to partially cover costs of the research. Jonkoping International Business School (JIBS), under the auspices of SIDA, strengthened the program by providing supervisors, by extending invitations to Sweden for seminars and consultations with advisors, and arranging visits of supervisors to AAU to follow up the progress of the dissertations. JIBS involvement was a crucial encounter that shaped the progress of the PhD program I went through.

The time I had for my family and close ones during the study was too short and hopefully I will compensate soon.

Atlaw Alemu
Addis Ababa, Oct 2015

## ***ABSTRACT***

*The basic theme of the dissertation is placing* ***structure*** *of economies as an intermediate explanatory factor for attainment of sustained growth of low-income economies that are in transition from stagnant agricultural economy to modern economic growth. The dissertation sets out with conceptualization of a model applicable to structures of low income and under industrialized economies, and hypothesizes on the long term outcomes of these structures. Sustained growth is the result of a particular structure where manufacturing growth drives economic growth. A structure where transaction services have expanded beyond certain levels stunts manufacturing. Empirical investigations were carried out to test the hypotheses on 71 countries that were low-income economies in 1970.The results provide support for centrality of manufacturing and for the retarding effect of non-optimal growth of transaction services on manufacturing growth.*

## Table of Contents

# CHAPTER I:  INTRODUCTION AND SUMMARY OF THE THESIS

# I INTRODUCTION

This dissertation is composed of four parts. Although the parts are closely related, each part is written in a chapter as a standalone article. The first chapter introduces the theme of the entire body of articles that deal with the central issue. The central issue is the crucial role of manufacturing in the process of industrialization of economies in transition from stagnant agrarian economy to modern economy. The second chapter addresses the conceptual framework and model. The third chapter is an empirical investigation seeking support from evidences on the centrality of manufacturing and the fourth chapter provides empirical findings on structural factors responsible for the pace of manufacturing growth where the relationship of manufacturing and transaction services is investigated.

## 1.1 BACKGROUND AND MOTIVATION

In the report of UNIDO-UNCTAD (2011) the share of manufacturing in 2008 was 24% in developing economies of the world, 11% in African developing economies, and 10% in economies of Easter Africa. Ethiopian national accounts data reveals that the contribution to GDP of the industrial sector has remained about and below 13% and that of manufacturing below 5% ( MOFED, 2011). For a citizen of a low-income economy, where manufacturing contributes less than 5% of GDP, while agriculture and services each contributes above 40% of GDP, engagement in inquiries about the constraints of industrialization is a legitimate concern. The fact that this feature of the economy is common to many other low-income economies makes it natural to consider these groups of countries together.

Most of these economies have remained low income for the past 50-60 years while few of them succeeded in industrialization and escaped low-income status( unstat, 2011). Explaining why most of them remained low income and why they failed to industrialize so far has remained a source of inspiration, and motivating factor for this study.

The counter argument working against this motivation is that these countries are in the process of industrialization and we need to wait to see their progress. However, accumulated world experience in development tells us that a period of 50-60 years in transition without escaping low-income status is a sign of failure. All economies were agrarian before mid eighteenth century (Bairoche, 1995; Maddisson, 2003). Per capita income (PCI) was low and stagnant in all agrarian economies. Agrarian technologies could not lead to sustained growth of PCI. Whenever PCI grew as a result of the introduction of new agrarian technology, population grew and depressed PCI (Hansen and Prescott,2002). Sustained growth in PCI was realized with the advent of industrialization that allowed modern economic growth (Kuznets, 1966). Some leading countries started modern economic growth characterized by a steady real per capita income growth (Bairoche 1995; Maddisson, 2003) at the second half of the $19^{th}$ century. The leading countries made transition to modern economic growth, escaping agrarian stagnancy, in a period of about 100 years (Bairoche 1995; Maddisson, 2003). Late comers reduced this transition period to 80years (USA), 50 years (Japan), and less than 50 years (newly industrialized economies). The failure of the others to escape low-income status in 50-60 years is a valid concern demanding explanation.

Moreover, the gap between the average income of the poorest and that of the richest group of countries is widening. In the early 1970s, there were over 70 countries below real per capita income of 1000USD. In 2011, the number declined to about 60. The average real per capita GDP of the richest 70 countries was about 35 fold of that of the poorest 70 countries in early 1970s. The disparity of average per capita GDP between the richest 60 countries and the poorest 60 countries grew to 60 fold in 2011(unstats, 2013).The gap in the average per capita GDPs is widening, partly because the poorest are not catching up. The failure to catch up needs explanation.

Among existing and most relevant explanations for failure to industrialize are:

- Differences in institutions[1] that define and enforce property rights, and encourage accumulation ( Acemoglu and Robinson, 2012)
- Differences in policies that enhance efficiency and TFP of the modern sector ( Parente and Prescott, 2003)

Both the explanations are plausible environmental[2] factors that influence economic decisions of individual economic actors. Apart from these environmental factors, there is an internal factor, upon which environmental factors work to shape economic decisions. This internal factor is societal mindset manifested in individual preferences for economic activities and products. Mindset of

[1] Institutions are the written and unwritten rules, norms and constraints that humans devise to reduce uncertainty and control their environment (Menard and Shirley, 2008)

[2] Seen from the perspective of the individual decision maker

individuals in society as internal factor and the institutions and policies as environmental factors are responsible for the formation of the structure of the economy. The two factors are interacting but independent influential factors for shaping economic structure. The environment influences internal factors but does not give it its quality in a sense that the ambient temperature does not convert an egg of a chicken to an owl. Structure becomes an exogenous factor since it is the embodiment of either the aggregation of individual choices following their mindset or the impression made by institutional constraining environment. Structure is the embodiment of aggregated individual preferences (choices of activities) or the form that is shaped by the impressions of institutional environment, or the product of both depending on whichever is the stronger. Some mindset results in a certain structure that inhibits long-term growth, in spite of the presence of good policies and institutions. In similar way, some bad policies and institutions tend to prevent structure arising from good mindset that would bring about long-term growth. What matters is the embodied structure, whichever way it is engendered. Societal mindset interacting with the environment (institutions and policies), underlies the structure and the structure shapes the long-term evolution of the economy. Thus, some structures that embody a certain preferences for economic activities combined with good institutions and policies enable the attainment of long-term (sustained) growth.

Members of society can make individual choices among economic activities based on their mindset. Society, collectively, can modify the economic environment by changing institutions and policies. For good policies and institutions to work, members of society have to make a choice of economic activity that ensures long-term growth. A choice of activity could be taming nature with traditional agriculture or extracting and harvesting nature with mining activities, giving less importance to manufacturing. This is one type of preference leading to a particular structure. A choice of manufacturing activity as the mode of dealing with nature and creation of products not given by nature to satisfy human needs is a preference forming the basis for another structure. These preferences combined with the institutional and policy environments result in different structures having long-term consequences on growth. If a combination of preferences for activities and the institutional environment lead to a structure where manufacturing drives economic growth, then this structure ensures sustained growth. In the absence of such choice for economic activities, good institutions and policies do not result in a structure that lead to sustained growth. Neglect of this structural requirement for sustained growth makes the explanations based only on institutions and policies incomplete. Thus, the need to explain why some economies remained low-income and under-industrialized, and the incompleteness of the existing explanations prompted the study.

The study raises issues that require further theoretical argument and empirical evidence. Structure as an important factor for sustained growth has garnered both support and rejection in the literature and policy circles. The importance of manufacturing as a structural factor has been ignored in many instances of policy-making on the pretext of the absence of comparative advantages of developing/ underdeveloped countries in manufacturing. Researchers are still raising the issue, particularly because policy-making in low-income countries has kept on neglecting the issue or because of the failure to attain sustained growth in the past many decades. Further theoretical arguments, models, and empirical evidences are called for, to assist policy-making and providing theoretical clarity and additional evidences.

It may be argued that the importance of structure for sustained growth has already been dealt with in Kaldor(1966) and by others, questioning the value addition in studying the same subject now. However, Kaldor studied 12 advanced European countries with a different structure from the countries included in the current study. Other researchers, such as Cornwall (1976, 1977), Cripps and Tarling 1973, didn't stop studying the issue because Kaldor has already studied it. Studying an issue already raised does not make it irrelevant or the fact that it has been studied previously does not mean it has garnered universal acceptance. Even if an issue is universally accepted, one can see any incongruent element and can question it. While it would not be irrelevant to raise issues that others have already raised, the current study is not a repetition of others. It is not a study about already advanced economies; it is about 71 countries that were low income in 1970, among which very few have come out of low-income status in 42 years period. On top of the relevance of studying structure as an issue, the group of countries studied makes it all the more relevant. The group of countries included in the study provides additional evidence on an issue that has not been settled. The fact that other researchers such as Wells and Thrilwall 2003 for Africa; Lavopa and Szirmai 2012 for 92 countries; Szirmai and Verspagen 2011 for 90 countries have raised similar issue shows that the issue is a live issue of contemporary importance.

The emphasis of governments and donors, concerned about the development and progress of low income countries, is still on current comparative advantage rather than structural transformation ensuring long-term growth of this group of countries. For economies dominated by subsistence agriculture those policies persist in promoting the same structure. This study argues that persistence in policies and practices promoting such structure does not lead to sustained growth and calls for change of mind.

Therefore, the value additions of the study are further strengthening the argument for manufacturing with a unique approach and a unique, structural theoretical growth model pertinent to dual economies. In addition to deriving important implications from the analysis of the model, the study provides empirical support to the implications of the model using a unique empirical method that uses wavelet decomposition of the time series data. Moreover, it incorporates, in original manner, structural factors that are not addressed by other studies. The incorporation of transaction costs within the structural model is a case in point. It is a different approach from others but converging with some of the existing studies on the importance of structure and manufacturing.

## 1.2 THE HYPOTHESES

The need to explain the failure of a number of countries to attain sustained growth and the failure to come out of low-income status through industrialization guided this study to formulate a conceptual model and hypotheses to be tested empirically. The first chapter sets the theoretical background and formulates the conceptual model from which implications are drawn. The implications form the hypotheses to be tested.

The first hypothesis is "*Manufactured goods production growth has greater impact than agricultural goods production growth on sustained growth of low-income economies at large*". Countries performance in the attainment of sustained growth is explained by the nature of the structure. The structure signifies the sector driving the growth of the economy. A low-income economy, the growth of which is not driven by manufacturing growth, fails to attain sustained growth. Agriculture led growth does not lead to sustained growth.

The second hypothesis is about structural factors responsible for manufacturing growth based on the claim that the level and direction of growth of transaction services matters for manufacturing growth. It states "*Growth of transaction services above the optimal level negatively affects manufacturing growth of* *low income economies and growth of transaction services below the optimal level enhance manufacturing*". Manufacturing growth is stunted in low-income economies with more than optimal transaction services. The faster growth of services suggests that greater magnitude of inputs is shifting to this sector. The service sector, which is meant to facilitate goods production, is receiving greater inputs while denying the flow of the necessary inputs to goods production.

## 1.3 THE OBJECTIVES

This study is composed of three parts addressing three broad and interconnected objectives. The themes of the three chapters forming the broad objectives of the chapters are:

- Establishing a theoretical framework and conceptual model that highlights the significance of structure and manufacturing for sustained growth of low income economies. This objective is addressed in the second part of the study.

- Providing empirical evidence on the centrality of manufacturing for sustained growth of LICs; The third part of the study addresses this objective.

- Establishing the structural relationship between manufacturing and transaction services and indicate the structural factors that prompt or inhibit manufacturing growth. The fourth part of the study addresses this objective.

## 1.4 THE METHODOLOGY

The general approach of the study is formulating a conceptual model to derive its implications and verifying those implications with empirical data in line with the "covering law" model of scientific explanation. The general approach and methodology followed to address the hypotheses is similar, with some peculiarities introduced to suit each hypothesis.

### Addressing the first hypothesis

The author's argument centers on structure, which is based on the contributions of sectors to long term GDP growth. It brings all the relevant components of GDP as structural factors and assesses their contributions. It is envisaged that all other influences affecting the sectoral contributions are taken care of through the sectoral contributions. Changes in GDP and changes in sectoral value added in goods production constitute the entire universe. Changes in services are taken care of with their relationship to goods production. As per this approach, the analysis needs only the structural components of GDP. Other factors work behind the structure. The first concern of the study is settling the issues of structure. The use of statistical or econometric techniques is subservient to the basic requirements of testing the implications of the theoretical model. The techniques are not the driving factors. Any worry about missing explanatory factors may be relieved if one appreciates the basis for the use of econometric techniques, which is the constructed theoretical model. The model has incorporated the pertinent factors suggested by the theoretical arguments and it does not require other factors.

Testing the first hypothesis requires identification of the structure of each low-income economy and follow through the effects of that structure on long-term growth of the economy. Identification of the structure of economies to explain the performance in sustained growth is tantamount to identifying which sector in the long-run influences GDP growth for that particular economy. The sign of Granger causality of manufacturing or agriculture on GDP establishes the structure of the economy. The identified structure is compared with the performance of the economy in terms of changes in real per capita GDP. To the best of the author's knowledge addressing the issue in this manner is a unique contribution.

The empirical study begins by identification of the structure of each country and then explores the effects of that particular structure on the long-term growth of that economy. Identification of the structure of economies requires various steps that include identification of lag effect, which differs from country to country. Apart from lag effects, time scale effects also could differ across countries. There is no guarantee to assume that sectoral interactions in each country behave in the same manner. In some countries, sectoral interactions would work themselves out in longer periods than in others. That means longer time scale time series may exhibit relationship in some countries while it may not in others. Since structures could be dissimilar across countries and since the aim is not to lump countries together to get an average structure, individual country-wise treatment and investigation becomes necessary. Time-series analysis rather than panel analysis became appropriate to meet the objectives of the study. After detecting the particular prevalent structure in each country, the study categorizes countries with similar structure and undertakes a meta analysis (the analysis of the results) later. The meta analysis includes contingent table analysis to evaluate whether the cases for and against the hypotheses are significantly different or not.

The sectors considered are agriculture, manufacturing, and services. Agriculture, manufacturing, and services are orthogonalized to other goods supplying sectors (construction, mining, utilities, and imports) to free the former from the effects of the latter. To capture the effects of time scales the study undertakes wavelet transformation of the time series data (Appendix I). The rationales for the use of wavelets are diverse but related. The time scales at which significant relations occur are not known a priori( every year, every two years, three years……???).The time scales of significant relations vary across interacting variables ( agriculture may affect GDP seasonally while manufacturing after many years ).The impacts of variables may differ across time scales ( the effect of manufacturing every year may differ from its effect in every four years period or what is invisible in shorter period may be visible at longer time scale). Sustained growth is a long-term change that can be detected by the differences of consecutive values of contributing sectors. The consecutive time could be every single year, two years, three years, etc. Differences of values between every single consecutive year or differences of averages of two years or three years provide data of distinct resolution. Thus, averages and differences of average outputs of sectors and the whole economy in various time scales have to be considered. To use topographic analogy, the average levels across longer time scales provide information on the bigger picture such as the profile of the mountain range, while the differences indicate the details such as the hills and valleys in the mountain range.

This is a contribution of this paper in using such method for the analysis of growth and structural relationships. Most studies do not consider time scale effects in relating macro economic variables.

The mathematical basis for the empirical model is the first difference relationship of sectors and GDP. The first difference of GDP is the change in value added expressed in terms of sectoral contributions. Which sector contributes more in the long-run can be analyzed on the basis of this underlying relationship. The change in sectoral value added necessitates deciding the time span with in which it is computed. The first difference could be annual difference or difference of averages of two years or more. What may be invisible at one time scale could be visible at others. Computing differences across various time scales and comparing sectoral contributions is undertaken using wavelets, which are filtering mechanisms useful to compute differences in weighted averages of certain functions across varying averaging periods or scales.

The orthogonalized and wavelet transformed sectoral time series data go through Granger causality and impulse-response tests with a VAR/VECM approach. There are four exclusive empirical possibilities that appear as outcomes of the analysis. In the long run, both sectors could be significantly and positively driving GDP; or manufacturing could positively driving while agriculture is negatively driving GDP; or both the sectors could be negatively driving GDP; or agriculture could positively drive GDP while manufacturing is negatively driving GDP. The cases represent the structures of the economies. To identify whether the particular structure is associated with sustained growth, we check the changes in attained per capita GDP in the period considered.

Pivoting on manufacturing, the identification of a structure characterized by positive Granger causality of manufacturing in the analysis and actual positive changes in per capita GDP of a country provides support to the hypothesis that manufacturing led growth is necessary for sustained growth. Identification of negative Granger causality of manufacturing and an actual decline in per capita GDP provide weak support to the hypothesis.

With regard to agriculture, the concurrence of positive Granger causality of agriculture and actual positive changes in per capita GDP of a country does not provide support to the hypothesis, while negative changes in per capita GDP with positive sign of Granger causality support the hypothesis. Negative Granger causality of agriculture and increase in per capita GDP provide support to the hypothesis, while negative sign of Granger causality of agriculture with actual decline in per capita GDP does not support the hypothesis.

**Addressing the second hypothesis**

The structural factor responsible for the performance of manufacturing is size of transaction services. Transaction services enhance manufacturing when they are at lower levels while tending to retard it at higher levels. After orthogonalizing and wavelet transforming the time series data on manufacturing, agriculture, and services, Granger causality and impulse response test are undertaken. Granger causality tests and the impulse responses indicate the structure, whether services are at a level that enhance manufacturing or not. The structure, coupled with the direction of change of services, allows prediction of performance in manufacturing growth. Comparison of predicted performance and actual performance in manufacturing either provides or denies support to the hypothesis. As in the method used for the first hypothesis in the second paper, to the best of the author's knowledge, addressing the issue in this manner is unique contribution.

There are two significant cases of Granger causality: Positive or Negative. There are three possible cases of actual direction of growth (trend) of services, positive (+), negative (-) or no(0) growth. Each direction of causality is considered with the actual direction of growth of service to predict the growth of manufacturing and to compare the prediction with the actual growth of manufacturing. Comparison of the predicted growth in manufacturing with the actual growth of manufacturing serves to verify the hypotheses.

If the hypothesis is valid, a detected positive Granger causality and an actual positive trend in growth of services must result in growth of manufacturing. To verify the hypothesis, the predicted growth in manufacturing is compared with the actual direction of change in manufacturing. If the predicted and the actual are the same, the hypothesis has gotten support, otherwise not.

## 1.5 CONTRIBUTIONS AND MAIN FINDINGS OF THE THREE CHAPTERS

**Summary of the first theme (Chapter II)**

In the second chapter, low-income economies are modeled in line with historical patterns of development to explain the structural factor influencing their sustained growth. The developed model of the study signifies that the economies under study deserve a structural model pertinent to the reality of low-income economy and that highlights the growth paths of dual economies. The growth of these countries is seen differently from the growth of developed countries where existing growth models are more relevant. The model for low-income economies, developed in this study, implies multiple equilibriums, where the higher-level equilibrium is unstable. This is not similar to Solow;, Neoclassical, Endogenous or any other growth model relevant to developed economies. The attempt here is to push the frontier of our knowledge on the evolution of low-income economies that are still in the transition phase from agrarian economies to modern economies. The theoretical model takes manufacturing and subsistence agriculture as goods producing sectors.

The argument of the study is that subsistence agriculture does not support more than itself and at times unable to maintain itself under population pressure. The discussion is not on agriculture output per se but on contribution of subsistence agriculture to long-term growth. The model in the study incorporates subsistence agriculture with diminishing returns. It is true that productivity growth in agriculture must exist for industrial development to succeed. The problem of subsistence agriculture is lack or slow pace of productivity growth, whether that comes from labor productivity or land productivity. Land productivity is dependent on growth of the use of modern land augmenting technologies and labor productivity is engendered as people, less number but more skilled, engage in harnessing the land. Subsistence agriculture does not use land augmenting or labor augmenting technologies as it is extremely hard to have adequate surplus to acquire these technologies. With growing manufacturing, availability of modern agricultural inputs locally expands and agriculture modernizes. Modern agriculture, which is an activity that uses land augmenting manufactured inputs, and that engages people conversant with the use of the technologies, enhances industrial development. The author envisages that as agriculture modernizes, and ceases to be subsistence, its production function becomes similar to that of manufacturing, and the dual economic structure vanishes.

Manufacturing is modeled with increasing returns in capital use while subsistence agriculture is with decreasing returns in labor use. Capital and labor committed to transaction services are treated as input reducing factors to goods production. Value added in services is modeled as a fraction of manufacturing and agricultural goods production. The formulated model of low-income economy has a dual nature as follows, where the first term in the right hand side is the value added of subsistence agriculture with its associated services and second term is the value added of manufacturing and its associated services.

$$Y_t = \left[ r\left(\frac{\psi}{\varsigma}\right)^u (R_t - \psi_t)^\beta \right] + \left[ \eta \left(\frac{\omega_t}{C_t}\right)^u (K_t - \omega_t)^{\alpha+\mu} (L_t - \varphi_t)^{1-\alpha} \right] \quad (1)$$

$(0 < \psi_t < R_t)$, $(0 < \beta < 1)$ $(0 < r < 1)$, $u \geq 0$, $(0 < \varphi_t < L)$

$(0 < \eta < 1)$, $(0 < \alpha < 1)$, $(0 < \mu < 1)$, $(0 < \omega_t < K_t)$

r, ς, β, u η, C, α, μ are parameters[3] of the economy while $\omega_t$, $\psi_t$, $\varphi_t$ are exogenous variables and $R_t$ and $K_t$ are the endogenous variable in the model.

[3] ref the symbols of the parameters in **APPENDIX 2: INDEX OF SYMBOLS**

This model, to the best of the author's knowledge, is a unique representation of a low-income economy in transition from subsistence agricultural economy to modern economy.

The model exhibits the possibility of stable equilibrium at lower level of capital accumulation and unstable equilibrium at a higher level of capital accumulation. The higher-level unstable equilibrium is associated with a critical stock of capital at which sustained growth follows when capital accumulation exceeds this critical stock in manufacturing sector. The critical capital stock is:

$$\mathbf{K}^* = \left(\frac{\delta}{s-\lambda}\right)^{\frac{\alpha}{\mu}} \left(\frac{1}{\eta}\right)^{\frac{1}{\mu}} \left(\frac{C}{\omega_t}\right)^{\frac{u}{\mu}} \left(\frac{\beta\bar{R}}{\theta(1-\alpha)}\right)^{\frac{1-\alpha}{\mu}} + \omega_t \tag{2}$$

A movement to this level of capital stock from the lower side requires a special effort of exogenous infusion of capital to the manufacturing sector and this is the unique contribution of this study.

Capital used for transaction services in manufacturing is $\boldsymbol{\omega}$. The commitment of capital in transaction services first facilitates the escape to sustained growth until it reaches some optimal level, beyond which it becomes hindrance. Manufacturing drives sustained growth, and expansion of transaction services in low income economies beyond the minimum required makes it increasingly difficult to attain sustained growth.

This description and depiction, of the causal relationships of transaction services and manufacturing, serves as a theoretical basis for balancing sectoral composition. Addressing the unhealthy growth of services at the expense of manufacturing in low-income economies is an important contribution of this study. The major structural factors implied by the model having policy implications are:

a) Manufactured goods production has greater impact than non-manufacturing goods production on sustained growth of the economy at large.
b) Difference in growth of share of manufacturing explains differences in the sustained growth of low-income economies.
c) Growth of transaction services in the long run stands in inverse relationship to manufacturing growth of low income economies
d) Institutional arrangements of society affect sustained growth of manufacturing through increased transaction services.
e) High depreciation, low effective saving rate and smaller difference in productivity between subsistence agriculture and manufacturing obstruct sustained growth.

The discussion on the "Theoretical framework and model" is an original work of the author and its difference from other growth models is clearly indicated on page 41 to 42 subtitled "THE ROAD MAP OF THE EVOLUTION OF LOW INCOME ECONOMIES"(section 4.1 ). That section helps to have a clearer view of how the author diverges from or enriches the existing literature.

**Summary of the second theme (Chapter III)**

In the third chapter, the study sets out to test that manufacturing led structure is central in attaining sustained growth of economies with low per capita income. The structure of economies and the sector driving the economy is detected with Granger causality and cumulative impulse-response tests for 71 economies.

Both manufacturing and agriculture have the same number of significant cases at the respective time scales. The differences appear in the significant number of positive or negative Granger causalities detected by the signs of cumulative impulse responses. The number of countries in which manufacturing positively or negatively Granger causes GDP increases with the time scale and the same holds for agriculture. The time scale dependence of the distribution of countries in positive, negative, and no causality of manufacturing or agriculture on GDP is significant.

Tab 1: Significant Granger Causal relations

| | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** |
|---|---|---|---|---|
| **Manufacturing** | | | | |
| positively Granger causes GDP | 11 | 20 | 28 | 34 |
| negatively Granger causes GDP | 18 | 22 | 25 | 36 |
| No causation | 42 | 29 | 18 | 1 |
| **Agriculture** | | | | |
| positively Granger causes GDP | 17 | 17 | 24 | 32 |
| negatively Granger causes GDP | 12 | 25 | 29 | 38 |
| No causation | 42 | 29 | 18 | 1 |

The number of cases supporting the hypothesis, either weakly or strongly across the time scales, is much greater than that not supporting the hypothesis. Sustained growth, as measured by positive changes in per capita GDP, is associated with structures where manufacturing positive Granger causality and negative agricultural Granger causality prevail. Failure to attain sustained growth, as measured by non-positive change in per capita GDP, is associated with structures where manufacturing negative causality and agriculture positive causality prevail.

Table 2: Cases for and against the hypothesis

| **Number of Cases** | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** |
|---|---|---|---|---|
| Weakly supporting the hypothesis | **6** | **11** | **12** | **23** |
| Strongly supporting the hypothesis | **18** | **25** | **32** | **29** |
| Either weakly or strongly supporting the hypothesis | **24** | **36** | **44** | **52** |
| Not supporting the hypothesis | **5** | **6** | **10** | **18** |
| Neither positive nor negative cases* | **42** | **29** | **17** | **1** |
| Total number of countries | **71** | **71** | **71** | **71** |

*****_these are cases where the Granger causality test does not show statistical significance_

**Summary of the third theme (Chapter IV)**

In the fourth chapter, an attempt is made to find structural explanation for why manufacturing growth and share are retarded in considerable LICs. The study sets out to investigate whether the growth of services has retarded manufacturing growth in low-income economies by crowding out manufacturing from accessing inputs.

The analytical work that served as the basis for this study suggested that transaction services at lower levels enhance manufacturing while they tend to retard it at higher levels. Time series data on value of manufacturing output and value of services in economies were transformed by Haar wavelet and their relationship was examined at various time scales. Granger causality and impulse-responses were tested. The results indicate that negative Granger causality between growth of services and manufacturing prevails in significantly greater number of countries in longer time scales than the prevalence of positive relations.

The number of countries providing support to the hypothesis, across each time scales, is much greater than those not supporting the hypothesis. This result suggests that the level and direction of growth of services matter for manufacturing and for sustained growth of economies. In the analysis, the number of significant Granger causal relations (at 10%) increases as the time scale increases.

Tab 3: Significant cases of Granger causality

| | Time scale 1 ( $D_1$) | Time scale 2 ($D_2$) | Time scale 3 ($D_3$) | Smooth (S) |
|---|---|---|---|---|
| **Significant cases** | 19 | 25 | 43 | 66 |
| **Non significant cases** | **52** | **46** | **28** | **5** |
| **Total number of cases** | **71** | **71** | **71** | **71** |

The time scale dependence of the distribution of significant and non-significant causation of services on manufacturing across time scales is significant (with p-value of 2.34933E-16 in chi-square test of the contingency table above). Services affect the evolution of manufacturing in most countries in longer time scales. The appearance of greater significant cases in longer time scales, as in Tab 4, suggests that structural relations are largely long-term relations.

Tab 4: Significant cases across time scales

| | Time scales | | | | Predicted Changes in Manufacturing Matching with Actual Changes | | | |
|---|---|---|---|---|---|---|---|---|
| | **D1** | **D2** | **D3** | **S** | **D1** | **D2** | **D3** | **S** |
| **Positive significant cases** | **9** | **16** | **17** | **29** | 4 | 11 | 11 | 21 |
| **Negative significant cases** | **10** | **9** | **26** | **37** | 9 | 6 | 13 | 19 |
| **Total** | **19** | **25** | **43** | **66** | 13 | 17 | 24 | 40 |

The number of countries with positive Granger causality at the longer time scales is generally lower than the number of those with negative Granger causality (Tab 5). The implication of this is that a greater number of countries have services beyond the optimal level while some are below the optimal level in the period of 42 years.

Positive or negative Granger causality occurs with any of the three possibilities of actual trends of service: positive, negative and no change in growth of service. Known positive or negative Granger causal relations and actual trends in services enable to predict manufacturing growth performance in the given period.

Positive Granger causality implies that the economy is facing shortage of transaction services needed for manufacturing and the growth of these services enhances manufacturing growth. The decline in the supply of these services impedes the progress of manufacturing. In cases of negative Granger causal relationship of transaction services to manufacturing, actual growth of services must cause manufacturing to decline, actual decline in services must cause growth of manufacturing, or no change in services is associated with no change in manufacturing. A structure with the sign of Granger causality combined with the trend of transaction services enables prediction of the direction of change of manufacturing. The hypothesis gets support if the predicted direction of change of manufacturing coincides with the actual direction of change in manufacturing.

The number of countries providing support to the hypothesis across all time scales is much greater than those cases not supporting the hypothesis. This result suggests that the level and direction of growth of services matter for sustained growth of manufacturing and the hypothesis enjoys overwhelmingly large supportive cases.

Tab 5: Cases for and against the hypothesis

| **Cases** | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** | **Consistent In all time scales** |
|---|---|---|---|---|---|
| Supporting the hypothesis | **14** | **18** | **24** | **41** | **32** |
| Not supporting the hypothesis | **5** | **6** | **18** | **13** | **3** |
| Indeterminate | 0 | 0 | 1 | 10 | 1 |
| Total | **19** | **24** | **43** | **64** | **36** |

## 1.6 POLICY IMPLICATIONS

The major findings of the study are:

- Existing structures of the economies in low-income countries is responsible for the pace of attainment of sustained growth,
- A structure with growing manufacturing ensures the attainment of long term growth, and
- Growth of services beyond the optimal level strangles manufacturing.

The policy implications of the findings are that low-income economies that are in transition from traditional agricultural economies to modern economies have to take structure in to account and work towards advancing manufacturing. The current policy emphasis on agriculture has to shift to manufacturing so that sectors other than manufacturing and the whole economy grow in sustained manner. Transaction services have significant influences on manufacturing growth of low- income economies. Low- income countries have to reduce the burden of transaction services when they are non-optimal and enhance transaction services when they are less than optimal.

## REFERENCES


Acemeglu, D. and Robinson J.A (2012) *Why Nations Fail: the Original of Power, Prosperity, and Poverty* , Crown publishing Group New York

Bairoche,P.(1995) *Economics and World History: Myths and Paradoxes* ; The University of Chicago Press

Claude Menard and Mary M. Shirley(2008 ) *Handbook of Institutional Economics*

Cornwall, J (1976) Convergence and Kaldor's Laws The Economic Journal, Vol. 86, No. 342 (Jun., , pp. 307-314 Published by: Wiley on behalf of the Royal Economic Society Stable URL: http://www.jstor.org/stable/2230749

Hansen, G.D and Prescott,E.C(2002) "Malthus to Solow" *The American Economic Review* , Vol 92, No.4 (Sep., 2002) 1205-1217

Maddisson, A. (2003) The World Economy: Historical Statistics OECD: *Development Center Studies*

Maddisson, A. (2005) *Growth and Interaction in the World Economy: The Roots of Modernity*, AEI Press; Washington D.C

Maria Elena Ayala Egüez( 2014) Manufacturing the only engine of growth? An extension of Kaldor´s first law

Naudé W, Szirmai A, Lavopa A (2013) Industrialization Lessons from BRICS: A Comparative Analysis IZA DP No. 7543

Partente, S.L and Prescott, E.C(2003) A Unified Theory of the Evolution of International Income Level, Preliminary
URl http://www.nbp.pl/konferencje/radisson/Mowcy/prescot/prescott_paper.pdf

Partente, S.L and Prescott, E.C(1999) Barriers to Riches , *The third Walras – Pareto lecture* , University of Lausanne, Revised October 1999

Szirmai A (2011) Industrialisation as an engine of growth in developing countries, 1950–2005 Structural Change and Economic Dynamics 23 (2012) 406– 420

Szirmai A, VerspagenB( 2011) Manufacturing and Economic Growth in Developing Countries, 1950-2005 *UNU-MERIT and Maastricht University, The Netherlands*

United Nations Statistics Division, National Accounts Main Aggregates Database, December 2013
URL http://unstats.un.org/unsd/snaama/dnlList.asp

United Nations Industrial Development Organization and United Nations Conference On Trade And Development ( 2011) Fostering Industrial Development In Africa In The New Global Environment *Economic Development In Africa Report 2011* :

Wells H., Thirlwall A.P.( 2003) Testing Kaldor's Growth Laws across the Countries of Africa African Development Bank 2003, Published by Blackwell Publishing Ltd 2003, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA.

## APPENDIX I: INDEX OF SYMBOLS

| | |
|---|---|
| $\alpha$ | *Parameter representing share of capital* |
| $\beta$ | *Parameter signifying diminishing returns in agriculture* |
| $\delta$ | *Rate of depreciation of capital in manufacturing* |
| $\eta$ | *The efficiency of attaining potential output* |
| $\theta$ | *A ratio of labor productivity in subsistence agriculture to that in modern sector* |
| $\lambda$ | *Part of saving rate wasted as leakage* |
| $\mu$ | *A parameter of increasing returns and externalities in manufacturing* |
| $\varsigma$ | *The minimum labor required to conduct most efficient transactions in or for agriculture* |
| $\varphi$ | *Manufacturing labor diverted to transaction services in manufacturing* |
| $\psi$ | *Agricultural labor diverted to transaction services in agriculture* |
| $\omega$ | *Capital used in transaction services in and for manufacturing* |
| c | *The minimum capital required to conduct most efficient transactions in and for manufacturing* |
| K | *Technology embodying capital stock* |
| $K^*$ | *Critical capital stock* |
| L | *Labor input in manufacturing* |
| R | *Total labor input available to subsistence agriculture* |
| $\overline{R}$ | *Per capita output in agriculture* |
| r | *The efficiency in attaining potential output with effective agricultural labor input* |
| s | *Aggregate saving rate* |
| u | *Exponential parameter of the multiplier of goods value added to include the arising service* |
| Y | *Total value added of the economy* |

## APPENDIX II: WAVELETS

A wavelet is any function that integrates to zero and is square integrable to one (Percival and Walden, 2000; Kaiser G.1994). It is expressed as a real valued function ψ (.) defined over the real axis (-∞, ∞) satisfying two properties: namely

(1) The integral of ψ (.) is zero, i.e. $\int_{-\infty}^{\infty} \psi(u)\, du = 0$

(2) The square of ψ (.) integrates to unity, i.e., $\int_{-\infty}^{\infty} \psi(u)^2\, du = 1.$ (14)

With this definition in hand we may look for functions fulfilling the two conditions. To that effect we begin with an expression of the **difference in averages** of a function X(u) at time t in an averaging time scale (λ ), which may be a year, two years, etc.

$$D(\lambda, t) = \frac{1}{\lambda}\left[\int_{t}^{t+\lambda} X(u)du - \int_{t-\lambda}^{t} X(u)du\right] \tag{15}$$

Since the two integrals above are integrals over adjacent non-overlapping intervals they can be combined into a single integral over the entire real axis with definition of domains for the functions as:

$$D(\lambda, t) = \int_{-\infty}^{\infty} V_{\lambda,t}(u)X(u)du, \tag{16}$$

where $V_{\lambda,t}(u) = -\frac{1}{\lambda}$ if $t\text{-}\lambda < u \leq t$

$= \frac{1}{\lambda}$ if $t < u \leq t + \lambda$

$= 0$ otherwise

The differences of averages on a unit time scale (λ) and at a center time t (the middle of the interval) is equivalent to integrating the product of the time series data (represented by the function $X(u)$) and a function $V_{\lambda,t}(u)$. The function $V_{\lambda,t}(u)$ would fulfill the definition for wavelet if divided by a constant $\sqrt{2}$ :

Where, $\int_{-\infty}^{\infty} \frac{V_{\lambda,t}(u)}{\sqrt{2}} = -\frac{1}{\sqrt{2\lambda}} + \frac{1}{\sqrt{2\lambda}} = 0$ and $\int_{-\infty}^{\infty} \left(\frac{V_{\lambda,t}(u)}{\sqrt{2}}\right)^2 du = 1$ (17)

$\frac{V_{\lambda,t}(u)}{\sqrt{2}}$ is a particular wavelet known as Haar wavelet $(V_{\lambda,t}{}^{H}(u))$.

Since $\lambda$=1 $V_{\lambda,t}{}^{H}(u) = -\frac{1}{\sqrt{2}}$ if $t\text{-}1 < u \leq t$

$= \frac{1}{\sqrt{2}}$ if $t < u \leq t + 1$

$= 0$ elsewhere,

At other time scales $V_{\lambda,t}{}^{H}(u) = \frac{-1}{\sqrt{2\lambda}}$ if $t\text{-}1 < u \leq t$

$= \frac{1}{\sqrt{2\lambda}}$ if $t < u \leq t + 1$

$= 0$ elsewhere

Thus $D(\lambda, t) = \int_{-\infty}^{\infty} \sqrt{2} V_{\lambda,t}{}^{H}(u)\, X(u) du$ and $\frac{D(\lambda,t)}{\sqrt{2}}$ is designated $W(\lambda, t)$

$$W(\lambda, t) = \int_{-\infty}^{\infty} V_{\lambda,t}{}^{H}(u)\, X(u) du \tag{18}$$

The time series transformed by varying λ continuously in $W^{H}(\lambda, t) = \int_{-\infty}^{\infty} V_{\lambda,t}{}^{H}(u) X(u) du$ is the Haar Continuous Wavelet Transform (CWT). $\mathbf{X}$(u) can be recovered from the integral of the product of $W^{H}(\lambda, t)$ and $V_{\lambda,t}{}^{H}(u)$. The Discrete Wavelet Transform (DWT) may be thought as purposeful sub sampling of CWT with dyadic scales i.e., picking only λ of $2^{J-1}$ and t separated by multiples of $2^{J}$ where J=1,2, 3…. In DWT analysis of any time series X (u), we make use of wavelets $h_J$ formed as basis-vectors, representing the time scales and shifts within a time scales, wavelet coefficients $w$, formed from matrix multiplication of these basis-vectors with $\mathbf{X}$, an averaging vector $\boldsymbol{v}$ on the basis of the highest time scale, and a scaling coefficient $\mathbf{v}$ formed as a dot product of $\boldsymbol{v}$ and $\mathbf{X}$. If we designate $D = h_J' w$ and $v'\mathbf{v}=\mathbf{S}$, recovering $\mathbf{X}$ from wavelet transforms goes as

$$\mathbf{X} = \left(\sum_{j=1}^{J} \mathbf{D_j}\right) + \mathbf{S} \tag{19}$$

This is a **multi-resolution** analysis of **X** where $\mathbf{D}_j$ are the details representing the differences of averages on various time scale and **S** is the smooth representing the moving average of the data on the highest time scale .

The wavelets of DWT are orthogonal. The averages and average of averages, formed from the DWT wavelets are sensitive to beginnings of the data points for averaging. The size of DWT wavelets is limited to the dyadic series and hence may suffer from too few observations for analysis. To overcome the deficiencies of DWT a modified version of DWT, which is Maximum Overlap Discrete wavelet Transform (MODWT), is used, although the orthogonality that is characteristic of DWT is lost in MODWT. In MODWT, the data is taken in circular fashion where the ends become adjacent points. At lower scales, this operation heavily distorts the differences of averages and hence the differences of the averages at the ends have to be dropped.

# CHAPTER II: MANUFACTURING AND SUSTAINED GROWTH OF LOW INCOME ECONOMIES


## *ABSTRACT*

*Low-income economies are seen in the perspective of historical patterns of development to explain the structural factor influencing their sustained growth. Structural factor pertains to sectoral composition and relations. The paper argues that goods production is the basis for production of services. In recognition of the stylized facts of low-income economies, a theoretical model is constructed taking manufacturing and subsistence agriculture as goods producing sectors. Manufacturing is modeled with increasing returns in capital use while subsistence agriculture is with decreasing returns in labor use. Production functions of these sectors incorporate inefficiencies affecting inputs and outputs. Capital and labor committed to transaction services are treated as input reducing factors to goods production. Value added in services is modeled as a fraction of manufacturing and agricultural goods production. The model exhibits the possibility of stable equilibrium at lower level of capital accumulation and unstable equilibrium at a higher level of capital accumulation. The higher-level unstable equilibrium is associated with a critical stock of capital at which sustained growth follows when capital accumulation exceeds this critical stock in manufacturing sector. Capital used for transaction services first facilitates the escape to sustained growth until it reaches some optimal level, beyond which it becomes hindrance. Manufacturing drives sustained growth, and expansion of transaction services in low income economies beyond the minimum required makes it increasingly difficult to attain sustained growth.*



**Keywords**: structure, dualism, modern growth, sustained growth, macro model, multi-sector growth, manufacturing, transaction services, industrialization, transformation, transition to modern growth, income convergence

JEL classification codes 0110, 014, 0410, 047, P52

## INDEX OF SYMBOLS

| | |
|---|---|
| $\alpha$ | *Parameter representing share of capital* |
| $\beta$ | *Parameter signifying diminishing returns in agriculture* |
| $\delta$ | *Rate of depreciation of capital in manufacturing* |
| $\eta$ | *The efficiency of attaining potential output* |
| $\theta$ | *A ratio of labor productivity in subsistence agriculture to that in modern sector* |
| $\lambda$ | *Part of saving rate wasted as leakage* |
| $\mu$ | *A parameter of increasing returns and externalities in manufacturing* |
| $\nu$ | *The ratio of effective capital to total capital in manufacturing* |
| $\varsigma$ | *The minimum labor required to conduct most efficient transactions in or for agriculture* |
| $\varphi$ | *Manufacturing labor diverted to transaction services in manufacturing* |
| $\psi$ | *Agricultural labor diverted to transaction services in agriculture* |
| $\omega$ | *Capital used in transaction services in and for manufacturing* |
| $b_1$ | *A parameter relating the value added in agricultural goods with that of services arising from agriculture* |
| $b_2$ | *A parameter relating manufactured goods value added with that of services arising from manufacturing* |
| c | *The minimum capital required to conduct most efficient transactions in and for manufacturing* |
| Cn | *Aggregate Consumption* |
| K | *Technology embodying capital stock* |
| $K^*$ | *Critical capital stock* |
| L | *Labor input in manufacturing* |
| M | *Value added of manufacturing and the associated services together* |
| $M_g$ | *Goods value added in manufacturing sector* |
| R | *Total labor input available to subsistence agriculture* |
| $\overline{R}$ | *Per capita output in agriculture* |
| r | *The efficiency in attaining potential output with effective agricultural labor input* |
| s | *Aggregate saving rate* |
| Ser | *Service value added* |
| u | *Exponential parameter of the multiplier of goods value added to include the arising service* |
| Y | *Total value added of the economy* |

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| GDP | Gross Domestic Product |
| ISI | Import Substitution Industrialization |
| LIC | Low Income Countries |
| TFP | Total Factor Productivity |
| UN SNA | United Nations System of National Accounts |
| USD | United States Dollar |
| UNIDO | United Nations Industrial Development Organization |
| UNCTAD | United Nations Conference of Trade and Development |

# I INTRODCUTION

In the early 1970s there were over 70 countries below real per capita income of 1000USD[4]. In 2012 the number declined to about 60. While the number of low-income countries declined, the disparity in income levels between countries has become staggeringly higher. Real per capita income of the richest 70 countries was about 35 fold of the poorest 70 countries in early 1970s. The disparity grew to 60 fold between the richest 60 countries to the poorest 60 countries in 2011(unstats, 2013). Income gaps are widening, partly because the poorest are not catching up. The failure to catch up needs explanation.

Historically all countries were having more or less similar or with little divergence in real per capita income before the 18th century (Bairoche,1995; Maddisson,2003) or rather before the beginning of the industrial revolution. Not only income differences were narrow, they were stagnant overall. Classical theory of the Iron Law of Wages of Malthus and Ricardo explains the stagnancy of income in agrarian economies. In those economies, output growth was offset by population growth resulting in stagnant per capita income (Hansen and Prescott, 2002).

Some leading countries started modern economic growth (Kuznets, 1966), which was characterized by a steady per capita income growth, at the second half of the 19th century, (Bairoche 1995; Madisson, 2003). Solow (1956, 1957) pioneered modeling this growth and that model evolved to other variants such as neoclassical and endogenous growth theories. Growth models of modern economies incorporate technology in a production function with variable factors where population has no offsetting effect on attained per capita income growth as it had in models of agrarian economies in classical growth theories.

The transition from classical stagnation to modern economic growth was characterized by irregular and unsteady growth, and, for leading countries, the transition to a steady growth in per capita income took nearly a century ( Bairoch 1995; Madisson,2003). The take off to steady income growth

[4] GDPs of all countries are at constant 2005 prices in US Dollars

took different length of time for different countries. For late comers the transition and catch up with leaders took shorter time (Bairoch 1995, Madisson 2003).

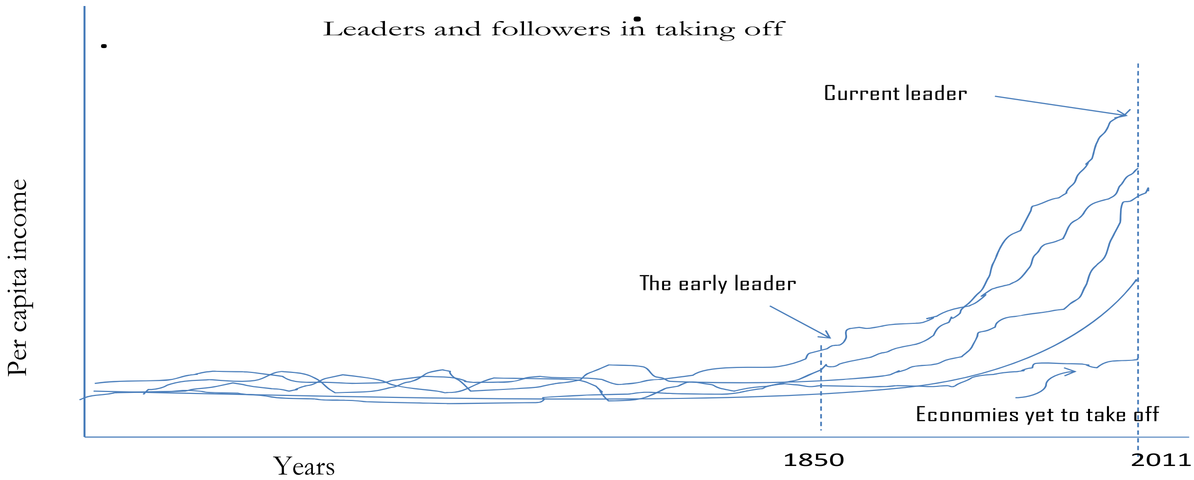



*Fig 1 A schematic of comparing Per capita income growth of countries before, during, and after the industrial revolution : Adapted from Economic historians and development thinkers' descriptions mentioned*

Considerable number of countries, particularly countries in Africa, has not taken off yet, while economies in other regions have exhibited retarded movement in catching up with the leaders. The differences in income levels and failures to catch up have been addressed with various explanatory theories where difference in institutions (Acemoglu and Robinson, 2012), and differences in policy (Parente and Prescott, 2003) are some of them. Parente and Prescott (2003) explain the delays and speed differences in taking off with their unified theory, where differences in efficiency and TFP in the modern sector arising from policy differences take the center stage.

Unable to be satisfied completely with existing explanations, this study reviewed early takeoffs to sustained growth, and explored the role of economic structure in explaining the failure to take off of contemporary low income countries. The cause of the dissatisfaction is the recognition that institutions and policies are important environmental factors that are only one side of the story while there is an internal factor upon which the environmental factors work. The internal factor is the aggregation of individual mindsets and preferences leading to choices of economic activities. Individual mind set and preferences on the one hand, and environmental factors on the other hand are embodied in structure of the economy. Environmental factors have effect on the existing mindset and preference in a sense that the ambient temperature does not convert an egg of a chicken to an owl. Thus this study, in contrast to the above explanations, recognizes a missing structural factor as an exogenous explanatory variable. This alternative perspective better fits to the realities of contemporary low-income countries and it informs development policies better in conducting focused interventions based on the historic structure of low-income countries. Under this perspective, the structure of the economies is analyzed as an immediate causal factor to sustained growth, and institutions and policies are assumed to affect sustained growth through their effect on structure.

Economic development is the overarching goal of underdeveloped and developing economies and it involves growth sustained for a long period. Is there a basic structural requirement that low income and under industrialized economies must have in order to initiate growth sustained for a long period? Yes, a particular structure ensures a low-income economy to attain sustained growth and that is a structure where changes in manufacturing output and share drive the growth process. Thus, the argument begins with construction of a theoretical model of the macro economy that, at the same time, reflects the structurally prominent features of low-income economies. The model is used to analyze the implications of the structure to economic stagnation and progress.

The objective of the study is to establish a theoretical framework and conceptual model that highlights the significance of structure for sustained growth of low-income economies with which the role of manufacturing is highlighted.

The paper deals with exploration of the literature on the relationship between structure and sustained growth in section 2. Section 3 formulates the theoretical framework; Section 4 presents the model structure; Section 5 describes the model implications and numerical illustrations. The last section is the conclusion and policy implication.

## 2. STRUCTURE AND SUSTAINED GROWTH

Following Kuznets (1966, 1989), structure here refers to the composition of the aggregate economy, particularly relative importance of sectors. Composition means the list of products, activities and actors (Pyka and Saviotti, 2011). Persistent long run change in the composition of the economy is known as structural change (Syrquin, 2008)

Growth is the expansion of the value added output in excess of the previous period. Sustained growth is self-reinforcing, rather than short lived and episodic, expansion of the production with extensive or intensive dimensions (Pyka and Saviotti, 2011; Lipsey, Carlow and Bekar, 2005).

Sustained growth and structural change are linked. The literature in economic history, growth, and development, dealing with sustained growth and structural change, do not share a common view, particularly on which specific structure leads to sustained growth of low income and under industrialized economies.

## 2.1 LESSONS FROM ECONOMIC HISTORY

The literature on economic history provides information on historical regularities where structure plays important role for economies to transform. Kuznets (1966, 1989) observes that modern economic growth is characterized by high rate of increase of product per worker or per capita, which is associated with a high rate of structural shifts, which were "changes in the shares of production sectors in the country's output, capital, and labor force". Kuznets concludes that the production sector that absorbs technology is the sector that contributes most for growth of total output per capita and that sector is the modern sector composed of manufacturing and related services in contrast to the agricultural sector. Similar historical regularity have been reported by Kaldor(1966), although the empirical findings were on twelve industrially developed countries. He concludes that the rate of growth of manufacturing (including public utilities and construction) is likely to exert a dominating influence on overall rate of economic growth, on account partly of the impact of manufacturing growth on the productivity of the industrial sector itself and partly by indirectly raising the productivity of the other sectors. The regularities have relevance for our study in that they put emphasis on sectoral contributions and structure. Maddison (2001) alludes to the importance of structure, by pointing to politicians and economist emphasis on sectors (physiocrats on agriculture, Kaldor, Mahalanobis, and many contemporary governments on industry) as important independent source of growth, and concludes that in the short term, structural shifts can be important for growth. Bairoch(1995) notices the labor productivity difference between manufacturing and agriculture before and after the industrial revolution in Western Europe, where agriculture remained with less labor productivity and far slower growth in labor productivity than manufacturing.

.

## 2.2 LESSONS FROM DEVELOPMENT LITERATURE

The literature in development economics provides various arguments on structure while they deal with growth, poverty and economic stagnancy. Growth through sectorally impartial market mechanisms or through selective protection of the industrial sector following Import Substitution Industrialization (ISI) strategy have been outstandingly competing approaches in development economics (Hewitt, Johnson and Wield, 1992; Rapley, 2002; Palma, 2008)

Modernization and structural change model of Lewis, A (1954), the early structuralist emphasis on manufacturing in the structure of production in the economies of the periphery (Hewitt, Johnson and Weild , 1992; Palma, 2008 ) were based on structure. UNIDO's (2009) emphases on tailored industrial policy approach for the bottom billion and for stagnant middle income countries, UNIDO/UNCTAD (2011) special report on "African Industrialization" are the other instances of the literature emphasizing the importance of structure and manufacturing for economic growth. The arguments place manufacturing as the main source of technology and a major conduit for diffusion of new technologies to other sectors.

Syrquin (2008) emphasizes that structural change retards or enhances growth, depending on its pace and direction. Hausmann and Rodrik (2006) emphasize the production and export of high productivity items as sources of growth, which is recognition of the importance of a particular structure in production. Mann (2011) emphasizes the need for meso-economic considerations to link micro to macro, and to recognize that sectors matter. The analysis on merit sectors (Mann, 2011) and the write up on economic growth through the emergence of new sectors (Pyka and Saviotti, 2011), are about structure. The thesis on Meso-economics, bridging micro and macro in a Schumpeterian Key (Dopfer, 2011), and changes in industrial structure and economic growth (Yoshikawa and Miyakawa, 2011) all share the theme that particular sector and structure matter for economic development and growth.

With the exception of few cases, neoclassical development thinking, in general, makes no differences among sectors as central to sustained growth, as all economic activities can equally be engines of growth if they happen to be sources of comparative advantage. Largely the view ignores structure and frames its analysis on a single aggregate production function. For this view, what matters for economic development is not what was produced but the unit price and the value of the output. The neoclassical development framework is based on generally competitive environment where technology and investment flow to a particular activity is guided by rate of returns that tend towards equalization across activities. The shift of resources among sectors is one of the most important elements of structural transformation (Syrquin, 2008). If returns are not equal across sectors, a shift of the factors to sectors with higher returns contributes to higher aggregate productivity growth. Under competitive markets, in economies with low manufacturing-base, there is a prospect of relatively high return on capital and technology in the manufacturing sector, and therefore the ensuing flow of capital and technology to the sector is crucial for growth. This theoretical argument can serve as a point of departure for the structuralist argument. The market reality on the ground is imperfect and lacking the neoclassical speed of adjustment and that must retard growth of the economy at large, prolonging the existing structure with capital starved manufacturing. Theoretically, interventions towards making markets competitive in these economies enhance structural change by diverting the flow of resources to manufacturing.

Lin's (2012) argument in his New Structural-Economics framework, though from a different angle, is an admission of the need for structural change using neoclassical framework. Pasinetti (1993) is the exception as far as our literature base is concerned. "Economic theory and the neglect of structural change" lies at the heart of our theme. The book raises the basic questions and reviews the relevant literature beginning from the classical period as to how structure has been treated in theoretical as well as empirical works. Pasinetti's work has emboldened our study to be a legitimate enquiry in to the importance of structure, an area enjoying perhaps less recognition than it deserves.

Various other strands of development thinking that do not lay emphasis on the existence of a particular structure to attain sustained growth are worth mentioning. In Sachs (2005) growth diagnosis and shock therapy, there is no clear entry point among economic activities that can, be singled out a priori, as necessary to bring about sustained growth, other than what the diagnosis tells. It could be manufacturing, service, or agriculture etc. Rodrik (2007) also uses growth diagnosis and emphasizes industrial policy, but the analysis does not single out a particular sector for promotion to effect sustained growth. For Collier (2007) there is no reference to structural factors, let alone the role of manufacturing, as causes for falling in to development traps.

Thus in development thinking there are divergent views on the importance of structure for attainment of sustained growth and the sector to be promoted for sustained growth. Emphasis on agriculture remained, for instance, a central government policy and donors' aid in Ethiopia and other African economies for decades. In the context of under industrialized economies in general, the sectoral emphasis has to be revisited, to both upgrade sectoral productivities and attain industrialization.

## 2.3 LESSON FROM THEORIES OF GROWTH

Single sector growth models reveal the underlying growth theory that does not recognize structure. Solow growth model (1956) and neoclassical growth models of Ramsey (1928)-Cass (1965)-Koopmans (1965) are instances of one sector models. Neoclassical growth theories assume the existence of aggregate production function relating optimally employed resources to a maximum net output. Exogenous technology and production factors constitute the arguments of the production function of the basic Solow and neoclassical growth models that lead to convergence of economies to common steady state equilibrium. Growth models with endogenous technology as well use a single production function. In growth theories employing single aggregate production function the attempts to explain growth do not lay specific emphasis on the structure of the economy. In these growth theories, there is no special importance attached to a faster growth of any particular sector to initiate and sustain long-term growth.

On the empirical front, we find efforts of many serious economists under the Global Research Project 'Explaining Growth' to compile the most comprehensive empirical assessment of growth in developing and transition countries (McMahon and Squire, 2003). The effort to explain growth in the studies rests on four aspects of growth: sources of growth, microeconomic agents of growth, the role of markets in growth and the political economy of growth. Although the studies address the issue both from the traditional view of convergence to a single equilibrium and from the view of multiple equilibrium(with a reference to political economy and coordination problems), the overall focus of the researches has no reference to structure, in terms of sectoral contribution and share as a factor influencing sustained  growth. The need to fill the literature gap on the role of structure in growth theories further inspires our study.

Despite the above-mentioned theoretical and empirical efforts that do not consider structure, some growth models consider the interactions of two or more sectors. Among earlier growth models, Uzawa's two-sector model, and Von Neumann's multisector growth model are cases in point. Leonitief's input-output model recognizes the importance of sectoral inputs and outputs in the economy. The sectors considered in Uzawa's two sector model are consumption good and investment goods production (Solow, 1961), which are different from the structure we want to address in accordance with the historical pattern of development (i.e, the importance of production sectors of agriculture and manufacturing). Von Neumann's model is about expanding multi-sectoral economy and its general equilibrium characteristics and the optimal growth path (Neuman, 1946). The model recognizes structure and, if pursued, hints about sectoral importance, though its focus is on the existence of equilibrium and optimal path rather than on the importance of specific sector in driving the structural change and sustained growth. Leonitief's input-output framework is, as well, recognition of structure without directly specifying which sector is more important for sustained growth. Similarly with the Neumann model, Leontief's model identifies input-output coefficients, $a_{ij}$, which may depict the input of service *i* per unit output of good *j* where a reduction of $a_{ij}$, will improve output in the entire economy.

Hansen and Prescott (2002) distinguish between classical and neoclassical growth to explain international income levels and differences. World economies remained under Malthusisan technology until mid–eighteenth century. Leading economies graduated to neoclassical technology and the onset of modern economic growth after 1820 (Madisson, 2005). There were periods in which Malthusian and Neoclassical technologies coexisted. Thus, the coexistence of the two is tantamount to a two-sector economy (land based or agricultural economy and modern industrial economy). The authors discuss this coexistence in their 'unified theory". The relevant aspect of the "unified theory" will be discussed in the section on theoretical models. Here it suffices to say that their approach is highly relevant to the concerns of our study.

# 3. THEORETICAL FRAMEWORK

This section deals with assumptions and theoretical arguments that served as foundations for the model that sets out with acceptance of the centrality of manufacturing. Section 3.1 argues, with the help of empirical regularities and theoretical underpinnings in previous works, why manufacturing is structurally important. Section 3.2 highlights the stylized facts of low-income economies, which are characterized by the coexistence of traditional agricultural sector and service dominated modern sector. In light of the theoretical arguments and the above stylized facts, section 3.3 formulates the mathematical model representing sectors of the economy and the factors that affect their evolution.

## 3.1 WHY MANUFACTURING IS STRUCTURALLY IMPORTANT

The long-term growth path of any economy is the time path of co-moving aggregate demand and aggregate supply. Aggregate demand and supply have their own structure. Differences in growth paths of economies are differences arising either from their supply or demand structures. Since the production side of the economy absorbs changes in technology (Kuznets, 1966; Lipsey, Carlow and Bekar, 2005), the supply side may be taken as the basis upon which demand patterns arise.

Supply is composed of outputs from domestic production sectors and imports. The sectoral outputs are manufactured goods, non-manufactured goods and services. Most services arise on the basis of goods supplied to the economy. Some services assist the production, consumption, and exchange of goods, while others are activities that are extensions of goods production. Change effecting services, marginal services and knowledge capturing services constitute the service sector in the United Nations System of National Accounts (UN SNA, 2008). Change effecting services arise to add value mainly on supplied goods. Knowledge capturing services are activities that arise essentially on the basis of high tech goods. Marginal services like insurance and banking are engendered to assist production and exchange. A structure of an economy with solid base in goods production is necessary to have viable services. Thus, goods from domestic production and imports are the basis for arising services. A structure of an economy that is founded on goods production provides opportunities and income for arising services and demand.

Economies differ in their sectoral compositions or structures. Differences between economies in their supply structure arise from differences in adopting economic activities (sectors) that apply technologies (products and processes) and that accumulate modern factors of production. Such differences in supply structure are reflected in differences in rates of sustained growth. Among structures of economies one with higher potential for production of a variety and large quantity of goods avails more opportunities for sustained expansion. A structure of an economy with limited scope in goods supply renders the economy stagnant at low level of equilibrium, while that structure well founded on a sector potentially capable of producing variety and large number of goods has a scope for expansion, allowing the economy to settle at higher level of equilibrium of demand and supply.

We may pose macroeconomic and microeconomic arguments for the centrality of manufacturing. Under macroeconomic arguments, we highlight that manufacturing has faster technology progress; it has less of saturation phenomena, it has richer opportunities of diversification, it has greater possibilities to develop supply chains causing inter-sectoral delivery networks to expand; on the micro level, we argue that manufacturing excels in facilitating entrepreneurship.

As attested by the historical accounts of patterns of economic development (Kuznets, 1966; Bairoch, 1993; Maddison 2005), manufacturing, among goods producing sectors, stands as the most efficient vehicle to carry technological progress and effect factor accumulation. Manufacturing has diverse scope for technological change. Technology is either product technology or process technology. Technological progress improves processes that conserve factors or introduces new products as capital goods or consumer goods (Pyka and Saviotti, 2011).

Not only lessons learned from historical experiences but also contemporary sustained growth experiences of newly industrializing economies support the view. Newly industrialized countries have gone through a structural transformation in line with the historical pattern. Inherent external economies in manufacturing (Krugman, 1981), its technology absorption and capital accumulative nature (Kuznets 1966, 1989), its nature as a basis for the rise of various services( tertiary activities) and for enhancement of the productivity of primary activities are responsible for this role. Krugman(1981) emphasizes the inherent external economies in manufacturing and because of the external economies in manufacturing production, whichever country has the larger capital stock will have a higher flow of profit and will therefore grow faster. Diminishing returns that may follow the accumulation of capital are offset with embodied technologies within newly invested capital. The result is an ever-increasing divergence between the regions.

Factors are repository of energy, the use of more means the use of more energy and hence more output. Modern manufacturing is characterized by the use of modern energy sources rather than human and animal power to transform inputs to outputs. Emanating from its use of energy intensive capital goods, incipient modern manufacturing exhibits higher labor productivity than the other sectors. The use of techniques with high energy input in the production process results in multifold output per unit time as compared to what would be produced otherwise. The possibility of fast or mass production and the ensuing high productivity of labor in modern manufacturing that consume energy from modern sources make it by far the faster way of transformation of inputs to outputs, and creating wealth and prosperity than other activities with incomparably low energy use. Jorgenson (1984) reports from results of empirical studies that electrification as well as nonelectrical energy uses are interrelated with productivity growth. The observed possibility of automation and mechanization in manufacturing further increases the productivity of the sector (Baumol, 1967). The use of manufactured inputs in other sectors makes the sectors more productive (Parente and Prescott, 2003 citing Johnson 2000)

In economies with a low manufacturing base, the return to manufacturing investment must be high by virtue of the existence of low capital in the sector. The high return to capital, coupled with embodied technology in the capital employed in manufacturing, enhances manufacturing growth to maturity and that propels the economy forward. If the economy is constrained by many factors that are not conducive to manufacturing growth, manufacturing will be suppressed and unable to propel the economy to higher rate of sustained growth.

In a setting of developing or underdeveloped economy, import is the largest current source of manufactured products and processes. In light of the fact that sustained ability to import requires a sustained ability to export, and a perpetual import cannot be a viable source for most products, some effort in import substitution remains an opportunity. Import substitution is largely the activity space and specialty of manufacturing. Developing technological capability in manufacturing is a long-term solution to a chronic indebtedness of a developing economy by enabling positive net export through manufactures.

Activities attracting or repelling entrepreneurial efforts affect supply and demand developments. Under conditions conducive to entrepreneurship, the sector, which likely hosts most entrepreneurs, will have to be that with larger opportunity for entrepreneurship in terms of availing products and processes. The manufacturing sector is the sector potentially having a large number of products and processes in itself and creating opportunities for service activities associated with manufactured products and processes. Manufacturing avails more opportunities for entrepreneurial engagement in goods production and related services provision. It is instrumental to employment creation for the growing labor forces of a developing economy.

Since manufacturing sector has the highest actual or potential capacity to provide a variety of goods for direct consumption, indirect consumption and in forming the basis for emergence of services, a structure with growing manufacturing sector is associated with sustained growth. This thesis begins with a prior assumption that takes growth of manufacturing as a driving force of sustained growth in under industrialized economies. For low-income economies, attainment of sustained growth rate requires structural change towards more manufacturing.

### 3.2 PERTINET STYLIZED FACTS OF LOW INCOME ECONOMIES

A typical low-income economy (LIC) is recognized by its dual characteristics: with large sector producing traditional agricultural goods producing sector and a modern economy with small manufacturing and relatively larger services. Considerable number of LICs have a dual structure ( unstat, 2013). The agricultural sector is labor using and unable to absorb capital because of various factors among which are extremely low size of land holdings and prevalence of subsistence. Manufacturing is more capital using than agriculture and labor saving in relative terms. Manufacturing generates positive externalities and scale economies (Krugman 1981). This characteristic paves the ground for multiple equilibriums.

Current share of manufacturing is low and the growth of its share varies across economies (unstat 2013). Underdeveloped economies host relatively large service sector composed largely of transaction services. Leakages of savings as a result of high uncertainties on investment outcomes, or due to capital flight are not uncommon. Slow capital formation and low rate of flow of capital to manufacturing characterize the economies. The markets are highly imperfect (Banergee and Duflo 2004) and returns on investment are far from homogenous across industries and firms. Unskilled labor, unemployment or underemployment predominate the economies (ILOSTAT Database). There is little competition for labor from the supply side as goods producing sectors draw labor (L) from the unemployed and underemployed pool. There is no substantial competition for capital (K) as it is predominantly demanded by the modern sector alone. Labor using subsistence agriculture affords little capital, until it modernizes and ceases to be subsistence.

# 4. THE MODEL STRUCTURE

In this section, the conceptual model is constructed. In the model construction-exercise, the road map of evolution of low-income economies is charted; the components constituting the structure of the economy are defined; capital use in transaction services is related with capital use in goods production; the mathematical expression of the model is specified; other relevant inefficiencies affecting the evolution are incorporated.

## 4.1 THE ROAD MAP OF EVOLUTION OF LOW INCOME ECONOMIES

The economy is viewed as evolving through stages in accordance with observed historical patterns (fig.4.1 below). The first stage is a stagnant agricultural economy, the second is a dual economy where subsistence agriculture coexists with small modern manufacturing economy, while the third stage is a matured economy with sustained growth (Kaldor, 1966; Kuznets, 1966, 1989; Hansen and Prescott, 2002; Parente and Prescott, 2003; Oded Galor, 2004) where the distinction between the modern and traditional sector disappears. The second stage, where multiple equilibriums are possible, is the focus of the modeling in this study. This stage is a dual economy model and differs from Solow model, which is a single aggregate production function fulfilling Inada conditions. It also differs from Roemer's endogenous growth model with its dual nature and possibility of multiple equilibriums.

Growth theories applicable to contemporary low-income economies must specifically take these economies as transition economies from agrarian to modern economies in line with Hansen and Prescott(2002), Parente and Prescott(2003), Oded Galor(2004). They are dual economies mingling some characteristics from both phases and demanding a separate treatment in modeling. The second stage is a distinct stage representing the dual economies that have not been addressed with a separate model in most growth literature. A separate treatment of these economies makes use of historical lessons and the perspective better highlights the reality of low-income countries in relation to earlier agrarian economies with Malthusian stagnation and advanced economies with modern sustained growth.

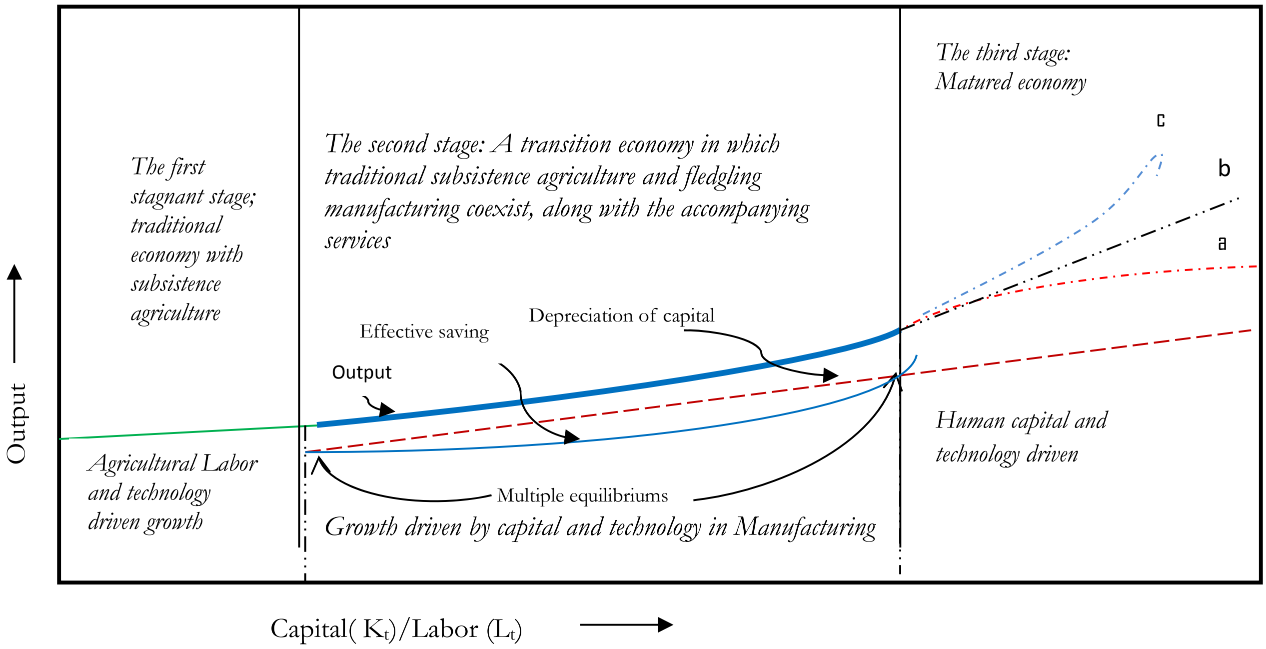



Fig 4.1 Evolution of output in three stages

Note that applicable models in the third stage are: a, b and c in fig 4.1 above, where

a - Solow model $Y= AK^{\alpha} L^{\beta}$ where Inada conditions are fulfilled,

b - AK model $Y= AK$

c - Roemer's Endogenous growth models = $AK^{\alpha+n}L^{1-\alpha}$

As observed in experiences of advanced economies, services could be drivers of growth as the economy matures, i.e., when it reaches the third stage, where a, b, c type growth models become relevant. The above discussion on centrality of manufacturing is applicable only to low-income economies.

## 4.2 THE STRUCTURAL COMPONENTS IN THE MODEL

In the model, the aggregate production function is composed of manufacturing as a modern goods production activity and agriculture as a traditional and subsistence activity, with the respective services arising from these goods production sectors. Manufacturing generates positive externalities and scale economies. It is also capital using with labor while agriculture is labor using with no capital. Inefficiencies that place actual output below potential output are incorporated reflecting prevalent market imperfections. The inefficiencies are output-affecting ones similar to that of Parente and Prescott (2003), on the one hand, and input-reducing ones, on the other. Input-reducing inefficiencies are factors not used in actual goods production. They are used to undertake transactions rather than direct use in goods production. Thus, the factor effectively used for goods production is obtained by subtracting the factor used for transaction services from the total amount of factors made available for production or as percentage of total inputs directly used for goods production.

Parente and Prescott (2003) used entirely multiplicative efficiency parameters and TFP as output side effects rather than introducing input deducted from total inputs. In our study, input side inefficiencies are introduced as *deductible*s from total inputs as well as *proportions* of total inputs not directly used for goods (equation 2a in Appendix 1). TFP is incorporated, in the model, through technology embodying capital (K), through parameters of externalities and scale economies (μ) and partly through multipliers (u). The inputs not directly used for goods production are essentially economy wide transaction costs for society that emanate from imperfections.

### 4.3 TRANSACTION AND NON TRANSACTION SERVICES

Let Y be the total value added, $f(R)$ be the value added of subsistence agriculture with services arising from it and $M(K, L) = M$ be the value added of secondary activities (manufacturing) and the associated services. Services are composed of change effecting services, marginal services, and knowledge carrying services (UNSNA, 2008) that thrive on the basis of the size of goods produced by manufacturing and agricultural sectors. These services are categorized as transaction and non-transaction services on the basis of the purpose they serve to society. Those extending the transformation of goods (or a group of goods) by adding new attributes to goods are non-transaction services and those services facilitating exchange of goods without adding new valuable attributes to the goods are transaction services. Non-transaction services are similar to goods production as they are more or less direct extension to goods production. Transaction services, though they arise to facilitate goods production and exchange, their association with goods production depends on the institutional arrangement prevailing in the economy.

Inputs to transaction services appear as transaction costs to goods production. Although non-transaction services compete for inputs with goods producing sectors they do not appear as transaction costs to society. Conceptually, non-transaction services could be lumped together with goods production. The total value added of the economy is the combined outcome of goods production and services that arose on the basis of goods produced. Since both transaction and non-transaction services that arise on the basis of goods production and consumption, the combined value added can be expressed in terms of the value added of goods production. The value added of goods production and arising services is conceptualized as the product of a multiplier and goods value added. In our model, the multipliers are positively associated to the ratio of actual transaction costs to the minimum transaction cost required to efficiently run goods production.

### 4.4 SECTORAL PRODUCTION FUNCTIONS

Subsistence agriculture and manufacturing are the basic elements of the structure. $f_g(R_t)$ and $M_{gt}$ are goods production in agriculture and manufacturing sectors. Services (Ser) are expressed in terms of goods producing sectors. Some services are assumed to arise on the basis of agricultural goods production and the others on the basis of manufactured goods. Thus, those services arising in or for agriculture are represented by a multiple of agricultural value added and a parameter $b_1$ while those arising in and for manufacturing are represented by manufacturing value added multiplied by a parameter $b_2$.

$$\text{Ser} = b_1 f_g(R_t) + b_2 M_{gt}, \qquad (1)$$

In the model, endogenous and exogenous variables have time subscripts since they change overtime. Parameters, which are assumed to persist for longer periods until institutional shocks take place, are expressed without time subscript.

**Value added of subsistence agriculture**

Subsistence agriculture is modeled as using only labor[5] and the total labor input available to subsistence agriculture is$(R_t)$. Goods value added in subsistence agricultural sector is $f_g(R_t)$. The

[5] Subsistence agriculture is assumed as not using physical and human capital. Physical and human capital is employed essentially in the production of goods and services of the modern sector. Manufacturing and arising services are the major users of capital formed.

value added of services arising from agriculture is expressed in terms of agriculture as $b_1 f_g(R_t)$ . The total value added owing to agriculture is, thus,

$$F(R_t) = f_g(R_t) + b_1 f_g(R_t) = (1 + b_1) f_g(R_t) \quad (2)$$

Transaction services consume some part of the available agricultural labor, designated by $\psi_t$, and render it unused for agricultural goods production. $\psi_t$ represents agricultural labor diverted to transaction services from goods production. It is an exogenous variable determined by the institutional setup of the economy. $R_t - \psi_t$ is the effective labor in subsistence agriculture. $r$ is the efficiency in attaining potential output with effective inputs. $\varsigma$ is the minimum labor that may be diverted from goods production to run agriculture most efficiently or it is the lower limit of $\psi_t$. Value added of services arising from agriculture is positively related to the labor diverted from agriculture $(\psi_t)$. Since $\varsigma$ is the minimum transactional labor required to run goods production in agriculture, services value added owing to agriculture is positively associated with some power of the ratio $\frac{\psi_t}{\varsigma}$ and the value of agricultural goods produced $(R_t - \psi_t)^\beta$.

The total value added owing to agriculture $F(R_t)$ is modeled as a concave function of labor engaged in agricultural goods production and services arising from agricultural goods production as:

$$F(R_t) = r(\frac{\psi_t}{\varsigma})^u (R_t - \psi_t)^\beta$$

$$\text{where } u \geq 0, (0 < \psi_t < R_t), \ (0 < \beta < 1), \ (0 < r < 1) \quad (3)$$

$r, \varsigma, \beta, u$ are parameters of the economy while $\psi_t$ is an exogenous variable and $R_t$ is an endogenous variable in the model. $b_1$ in equation (2) above becomes : $b_1 = (\frac{\psi_t}{\varsigma})^u - 1$ and the ratio $(\frac{\psi_t}{\varsigma})^u$ is the multiplier of agricultural goods value added. Multiplying this ratio with agricultural goods value added enables to incorporate the value of the arising service in and for agriculture in the total value added the economy owes to agriculture. This ratio has to be greater than zero signifying the impossibility of production without transaction services. A greater-than-one ratio expresses the existence and extent of services generated on the basis of agriculture. While transaction costs reduce

---

With more and more use of capital, subsistence agriculture gets transformed towards the modern sector, in which case it is no more treated as traditional subsistence sector.

output of goods by competing for resources from input side, they may increase total value added of the sector and the associated services from the output side.

In this model, land is fixed and that sets in diminishing returns on agricultural labor. The model suggests that output growth in agriculture is bound to stagnate[6]. The sector has little or no scope of contributing to the growth of the economy as agricultural population increases through time. From the input side, agricultural population growth increases labor. Agricultural labor diverted to transaction services ( $\psi_t$ ) rises or falls with prevailing transaction costs, which, in turn, reduce the available net input to goods production accordingly.

*Labor productivity in subsistence agriculture and arising services*

$$\frac{\partial f(R_t)}{\partial R} = r\left(\frac{\psi t}{\varsigma}\right)^{u} \beta \frac{(R_t - \psi_t)^{\beta}}{(R_t - \psi_t)} = \beta \frac{f(R_t)}{(R_t - \psi_t)} = \beta \bar{R} \quad \text{where } \bar{R} \text{ is per capita output in agriculture} \quad (4)$$

**Value added of manufacturing sector**

The inputs to manufacturing are both technology embodying capital$(K)$ and labor (L). Goods value added in manufacturing sector is $M_{gt}$. The value added of services arising from manufacturing is expressed in terms of manufacturing as $b_2 M_{gt}$. The total value added owing to manufacturing $(M_t)$ is, thus,

$$M_t = M_{gt} + b_2 M_{gt} = (1 + b_2) M_{gt} \quad (5)$$

Value added of the manufacturing sector exhibits increasing returns in capital use and capital embodies technology. Technology, which is the manner of "doing things" is embodied in the capital equipment and the knowledge of workers. Some capital is taken away from the available capital$(K_t)$ to be used in transaction services in and for manufacturing. "$\omega_t$" is capital used in transaction services in and for manufacturing. In the same way "$\varphi_t$" represents transaction cost in manufacturing in terms of labor. Both $\omega_t$ and $\varphi_t$ are exogenous variables determined by the institutional setting of the economy. $(K_t - \omega_t)$ is effective capital and$(L_t - \varphi_t)$ is effective labor in

[6] It is assumed , on the basis of the stylized facts , that subsistence agriculture is incapable of using capital and modern inputs

manufactured goods production. $\eta$ is the efficiency of attaining potential output. No goods production activity takes place without transaction costs. High transaction costs penalize the economy by depriving it of capital usable in goods production. C is the minimum capital required to conduct most efficient transactions in and for manufacturing or it is the lower limit of $\omega_t$.

Value added of services, which arise from manufacturing, is positively related to the amount of capital that is diverted from goods production $(\omega_t)$. Since "C" is the minimum amount of capital required for transactions needed to run goods production in manufacturing, services value added arising from manufacturing is positively associated with some power of the ratio $\frac{\omega_t}{C}$ , and the value of manufactured goods ($M_{gt}$.) Transaction costs cannot be avoided and hence the ratio $\frac{\omega_t}{C}$ has to be greater than zero.

The total value added owing to manufacturing $(M_t)$ is modeled as a function of capital and labor, with increasing returns to capital. It incorporates services arising from goods production manufacturing. Thus

$$M_t = \eta(\frac{\omega_t}{C})^u(K_t - \omega_t)^{\alpha+\mu}(L_t - \varphi_t)^{1-\alpha} , \quad (6)$$

$$(K_t - \omega_t)/K_t = \upsilon \qquad \omega_t = (1 - \upsilon)K_t \quad (6a)$$

$(0 < \eta < 1), (0 < \alpha < 1), (0 < \mu < 1), (0 < \omega_t < K_t), (0 < \varphi_t < L),$ u>0

$\eta, C, \alpha, \mu, u$ are parameters of the economy, where $\alpha$ is the share of capital parameter and $\mu$ is an increasing returns parameter, which is positive in sign. It signifies the positive externalities in manufacturing and other factors that are responsible for the existence of increasing returns to scale. $\omega_t$ and $\varphi_t$ are exogenous variables while $K_t$ is endogenous variable in the model. In manufacturing production function, if $\omega_t = C$, manufacturing output is penalized by reduction of available capital by an amount just enough to cover the optimal transactions. If $\frac{\omega_t}{C}$ is greater than one, then, manufacturing goods production is heavily penalized by capital flow away from it to conduct extra transaction services necessitated by the institutional environment. However, this is counted as additional value added in services on top of the values of manufactured goods. Hence $(\frac{\omega_t}{C})^u$ signifies the multiplier to value added of manufactured goods to incorporate value added in services created for and in manufacturing. $b_2$ in equation (5) above becomes : $b_2 = (\frac{\omega_t}{C})^u - 1$

The model implication for Labor productivity in manufacturing and arising services is derived as follows.

$$\frac{\partial M}{\partial L} = (1-\alpha)\eta(\frac{\omega_t}{C})^u(K_t - \omega_t)^{\mu+\alpha}(L_t - \varphi_t)^{-\alpha} \quad (7)$$

Labor productivities in the two sectors are not necessarily equal but assumed to move together. Assuming labor productivity of the traditional subsistence agricultural sector to be a fraction (θ) of that of the modern sector: *The relationship of labor productivities in the two sectors* is derived as follows:

$$\frac{\partial f(R_t)}{\partial R} = \beta\overline{R} = \theta\frac{\partial M}{\partial L_M} = \theta(1-\alpha)\eta(\frac{\omega_t}{C_t})^u(K_t - \omega_t)^{\mu+\alpha}(L_t - \varphi_t)^{-\alpha} \quad \text{where } (0<\theta \leq 1) \quad (8)$$

Solving for $L_t$ yields the following expression for labor demand in the modern sector as a function of labor productivity in subsistence agriculture ($\beta\overline{R_t}$) as:

$$L_t = \left[\frac{\theta(1-\alpha)}{\beta\overline{R_t}}\left(\eta(\frac{\omega_t}{C_t})^u\right)(K_t - \omega_t)^{\alpha+\mu}\right]^{\frac{1}{\alpha}} + \varphi_t \quad (9)$$

The labor demand in the manufacturing sector is composed of two components: the first expression within the brackets and that for transaction services ($\varphi_t$). The labor demand in manufacturing is inversely related to the productivity in manufacturing ($\frac{\beta\overline{R_t}}{\theta}$), which is expressed in terms of productivity in agriculture. Near full employment, the lower the productivity of agricultural labor $\beta\overline{R_t}$ the higher the labor demanded in manufactured goods production for a given ratio $\theta$ . Labor demand is linearly associated with transaction costs($\varphi_t$). The significance of the entire expression lies in its use in the capital formation equations below, where Labor productivity in subsistence agriculture ($\beta\overline{R}$) may be taken as an exogenous variable since it is determined outside the model pertinent to manufacturing.

**Total value added**

From the foregoing discussions, total value added of the economy ($Y_t$) is expressed as:

$$Y_t = \left[r(\frac{\psi_t}{\varsigma})^u(R_t - \psi_t)^\beta\right] + \left[\eta(\frac{\omega_t}{C})^u(K_t - \omega_t)^{\alpha+\mu}(L_t - \varphi_t)^{1-\alpha}\right] \quad (10)$$

## 4.5 INEFFICIENCIES

As mentioned in the stylized facts of low-income economies, additional to the transaction costs (ω), there are other inefficiencies in capital use. The inefficiencies are leakages of saved capital away from reinvestment in manufacturing. Part of savings may not be made available for investment as a result of the underdeveloped institutional environment or lack of information on investment outcomes, or due to capital flight. These not-invested savings are differences between the amount of output net of consumption and what is used in actual investment. The rate of saving being the ratio of output (Y) less consumption(Cn) to output (Y), i.e., s= (Y-Cn)/Y, effective saving rate is s-λ, where λ is that part of the saving rate that couldn't be used to the formation of capital. It is economic frictional loss so to speak. The implication of λ, which is that part of the saving rate that couldn't be used to the formation of capital, for the equilibrium of the model is referred in sections 4.6 and 5.4 below.

In an undeveloped economy, it is possible that depreciation could be higher than the effective saving as a result of heavy frictional losses that burden the gross saving. For saving to exceed depreciation, it requires either the removal of forces leading to leakages or securing additional capital exogenously to overcome depreciation and have net investment. The exogenous variables affecting capital formation in manufacturing sector are: rates of physical depreciation and technological distance from the frontier, designated by depreciation rate (δ), proportion of savings not available for investment(λ) and levels of resources diverted to transactions services(ω). They play important role in the second stage of development of the economy. They lift up the capital requirement needed to escape from predominantly subsistence agricultural economy, which is the lower level equilibrium. We analyze their effects on the evolution of the economy and equilibrium outcomes through the law of motion of capital (Acemoglu 2009).

## 4.6 CAPITAL ACCUMULATION AND ESCAPE TO SUSTAINED GROWTH

Capital accumulation takes place in the economy out of saving at some exogenous rate (s). The rate (s) is determined by various factors exogenous to the economy, which we do not pretend to have complete knowledge about. Whatever is saved, however, is used to replenish worn, torn, and outdated physical and human capital, cover investment related transaction costs necessitated by the institutional environment or the lack of it and the remaining used for the expansion of output.

Subsistence agriculture is assumed to save little and hence its savings are negligible. Capital formation is assumed to take place in manufacturing sector and associated services. Thus, effective saving partly replaces depreciated capital and partly forms additions (change in capital stock (dK)) on capital stock (Acemoglu 2009)

Thus, Effective saving = Net change in capital stock + Depreciation

$$(s-\lambda)\left(\eta\left(\frac{\omega_t}{C}\right)^u\right)(K_t-\omega_t)^{\alpha+\mu}(L_t-\varphi_t)^{1-\alpha} = dK \quad + \quad \delta(K_t-\omega_t) \tag{11}$$

Rearranging equation (11)

$$dK = (s-\lambda)\left(\eta(\frac{\omega_t}{C})^u\right)(K_t-\omega_t)^{\alpha+\mu}(L_t-\varphi_t)^{1-\alpha} - \delta(K_t-\omega_t) \tag{11a}$$

$$= (s-\lambda)\eta\left(\frac{\omega_t}{C}\right)^u (K_t-\omega_t)^{\alpha+\mu}\,[\frac{\theta(1-\alpha)}{\beta\bar{R}})\left(\eta\left(\frac{\omega_t}{C}\right)^u\right)(K_t-\omega_t)^{\alpha+\mu}]^{\frac{1-\alpha}{\alpha}} - \delta(K_t-\omega_t) \tag{11b}$$

where: $(0< s< 1)$, $(0< \delta< 1)$, and $(0< \lambda <1)$

The change in capital (dK) could be zero positive or negative. When change in capital (dK) is negative capital stock declines through time. The decline continues until capital stock (K) just covers the transaction services ($\omega_t$); i.e. $K_t = \omega_t$. This is the lower level equilibrium at which not only $K_t$ and $\omega_t$ but also depreciation and saving are equalized. When change in capital (dK) is positive accumulation of capital stock goes on, widening the gap between $K_t$ and $\omega_t$. In cases where $K_t$ and $\omega_t$ are different dK could be equal to zero when depreciation and saving equalize. This is the higher level equilibrium. The higher-level equilibrium capital stock is thus K=K* at which equation 11a above equals zero as in equation 12 below. This equilibrium is unstable since there is no endogenous force restoring K after changes in capital stock placing K below or above K* occurs.

$$(s-\lambda)\eta\left(\frac{\omega_t}{C}\right)^u (K_t-\omega_t)^{\mu+\alpha}\,[\frac{\theta(1-\alpha)}{\beta\bar{R}})(\left(\eta\left(\frac{\omega_t}{C}\right)^u\right)(K_t-\omega_t)^{\alpha+\mu}]^{\frac{1-\alpha}{\alpha}} - \delta(K_t-\omega_t) = 0. \tag{12}$$

Solving for $K_t$ we obtain the critical capital stock ($\mathbf{K}^*$) at that equilibrium. That capital stock at the state of the unstable equilibrium, expressed in terms of parameters and exogenous variables of manufacturing and related services, is:

$$\mathbf{K}^* = (\frac{\delta}{s-\lambda})^{\frac{\alpha}{\mu}}\left(\frac{1}{\eta}\right)^{\frac{1}{\mu}}(\frac{C}{\omega_t})^{\frac{u}{\mu}}(\frac{\beta\bar{R}}{\theta(1-\alpha)})^{\frac{1-\alpha}{\mu}} + \boldsymbol{\omega_t} \tag{13}$$

$K^*$ is the critical capital stock to be exceeded in order to attain sustained growth in the modern sector ( in manufacturing and services arising from manufacturing). The significance of the attainment of this critical capital stock for sustained growth of low-income economies is similar to the recognition of large-scale planned investment providing optimal size for complementarities and positive externalities of different industries in the "big push" literature (Rodan R, 1943; Murphy K.M., Shleifer A, Vishny R.W. 1989).

## 5. MODEL IMPLICATIONS AND NUMERICAL ILLUSTRATIONS

Low Income Countries (LICs) face multiple equilibriums at low level of output, the higher of which is unstable. The main challenge of economies in Low Income countries is placing themselves on a sustained growth path after escaping the multiple equilibriums. Escape is possible when the economy exceeds the critical capital stock (K*). The size of K* signifies the ease or difficulty of escaping to sustained growth. Analysis of the implication of the model goes by way of investigating (a) how the economy evolves with changes in critical capital (K*), (b) the effects of the changes in the exogenous variables and parameters on the critical capital stock (K*) and (c) the structural importance of manufacturing in driving the dual economy to sustained growth.

The exogenous variables of interest are: capital used in transaction services ($\omega_t$), or efficiency of capital use in manufacturing($\upsilon_t$), which is the ratio of effective capital to total capital, and labor productivity in manufacturing expressed in terms of labor productivity in subsistence agriculture ($\frac{\beta \bar{R}_t}{\theta}$). More important parameters of interest are depreciation rate of capital($\delta$), the rate of savings($s$), rate of leakage in savings ($\lambda$), efficient level of capital used in transaction services(C) and technical efficiency($\eta$). These exogenous variables and parameters deserve focused analysis and emphasis for their immediate relevance with manufacturing growth and policy implications.

The direction of growth of K* will be discussed in relation to other parameters to highlight the effects of institutional changes on escape to sustained growth. The parameters are reflections of deep-rooted institutional settings of the economy, such as share of capital ($\alpha$), measure of increasing returns and externalities generated by aggregate capital($\mu$), exponential converter of goods value added to total value added incorporating services (u).

### 5.1 CRITICAL CAPITAL STOCK K*, SAVINGS AND DEPRECIATION

The second stage of the economy, as depicted in fig 4.1 above, is bounded by a lower level subsistence economy and a higher-level matured economy. In this transition stage (second stage), there is an unstable equilibrium. If disturbed at the unstable equilibrium, the economy either moves to the lower level equilibrium or moves to higher level transformation depending on whether *K* is greater or less than $K^*$. If by chance or design the economy accumulates capital that exceeds K* and escapes the unstable equilibrium, a persistent change follows towards maturity where it assumes a different structure having no more a distinction between agriculture and manufacturing.

The transition becomes clearer with the analysis of the state of K and K*. If K>K* accumulation of technology embodied capital continues and sustained growth follows until a higher stage in structure of the economy is attained. It goes without saying that capital formation is greater than depreciation when capital stock is above the critical level (K*). When K is less K* capital stock continues to decline towards $\omega$ (i.e., $K \rightarrow \omega$) until a lower level equilibrium is reached, where the stock of capital is so low to keep the economy at near subsistence level (i.e., $Y \rightarrow (r\frac{\psi}{\varsigma}(R_t - \psi_t)^{\beta}$ . In this state, unless intervention takes place, capital in manufacturing does not endogenously sustain itself. If there is exogenous replenishment of capital from outside the modern sector, but without enabling capital stock to exceed K*, the economy remains between the two equilibriums in a state of disequilibrium. Economies in which K* is low, escape is easier and in others where K* is high, escape is difficult. It necessitates higher accumulation of capital to escape. It is important to note that economies having effective savings always greater than depreciation do not pass through the second stage and hence the move to sustained growth without experiencing multiple equilibriums.

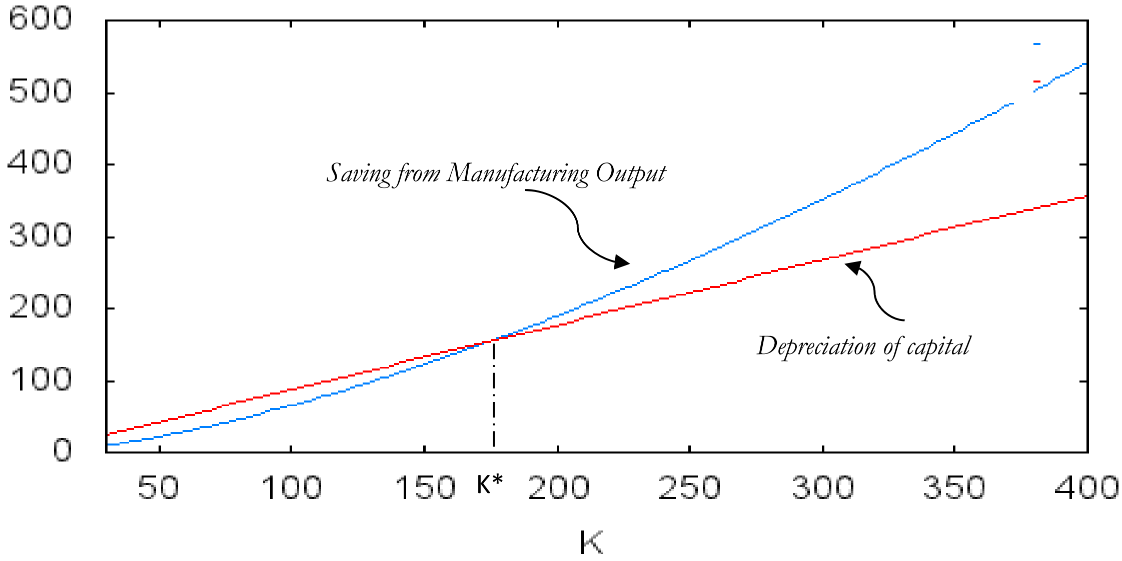



Fig 5.1 Savings, Depreciation and Critical Capital ( K*)

## 5.2 DEPRECIATION RATE (δ) AND CRITICAL CAPITAL STOCK (K*)

Depreciation rate (δ) signifies the rate of wear and tear of capital and the rate at which capital becomes outdated. Holding other parameters and exogenous variables constant, if δ increases, K* as well increases and it becomes more difficult to escape to a path of sustained growth. An economy experiencing high depreciation rate requires greater stock of capital to escape to sustained growth, which means greater difficulty to the economy. The growth of critical capital with growth of depreciation rate is positive but the rate of growth declines faster at lower levels of deprecation and steady at higher levels of depreciation (fig 5.2).

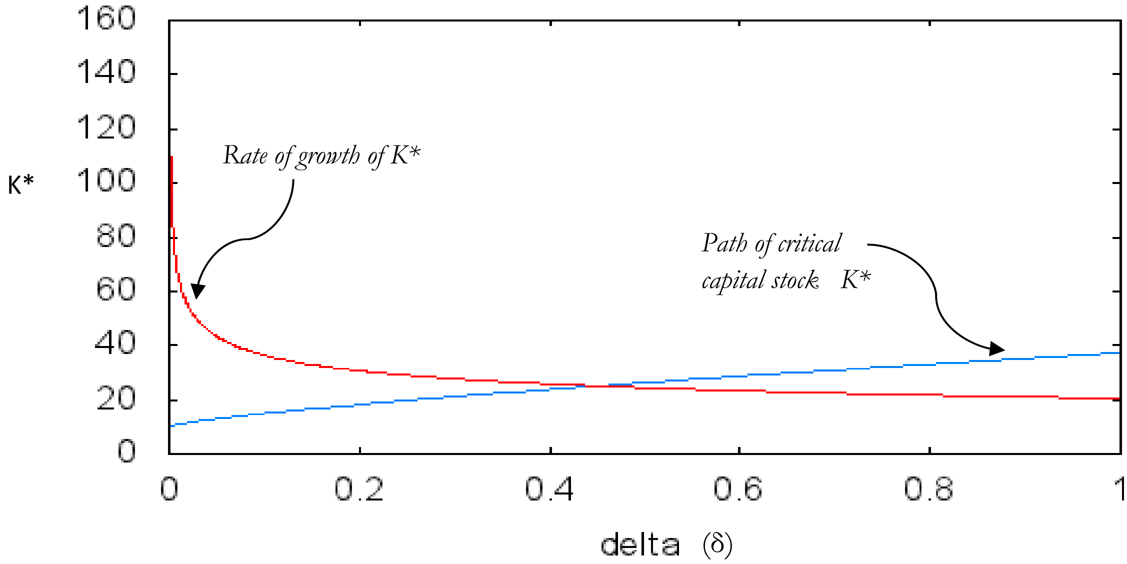



*Fig 5.2 the path of K* as the depreciation rate (δ) increases for specific values of parameters within their allowable range*

## 5.3 CAPITAL USED FOR TRANSACTION SERVICES (ω) AND CRITICAL CAPITAL (K*)

As the capital used for transaction services (ω) increases, the critical capital (K*) declines faster, until it reaches the minimum efficient level (C), making escape to sustained growth easier. After ω exceeds C, the critical capital stock increases, making escape to sustained growth more and more difficult in a linear fashion (fig.5.3). This suggests that the expansion of transaction services in low income economies beyond some minimum required is not helping the attainment of sustained growth.

The same can be analyzed with efficiency of use of capital in manufacturing and the critical capital stock. The efficiency of capital use, as expressed in equation 6a, is $\upsilon_t = (K_t - \omega_t)/K_t$. Keeping other parameters and exogenous variables constant, if $\upsilon_t$ increases the critical capital stock declines. As the efficiency of use of capital in manufacturing increases the critical capital stock declines, which means reduced capital usage in transaction service makes escape to sustained growth easier, confirming the result above. With increased efficiency in capital use, escape becomes easier. The rate of decline in the critical capital (K*) slows as efficiency increases. Since $\upsilon_t$ stands in inverse relationship to $\omega_t$, its effect on K* has to be opposite to that of $\omega_t$ i.e., as $\upsilon_t$ increases $\omega_t$ declines and K* also declines.

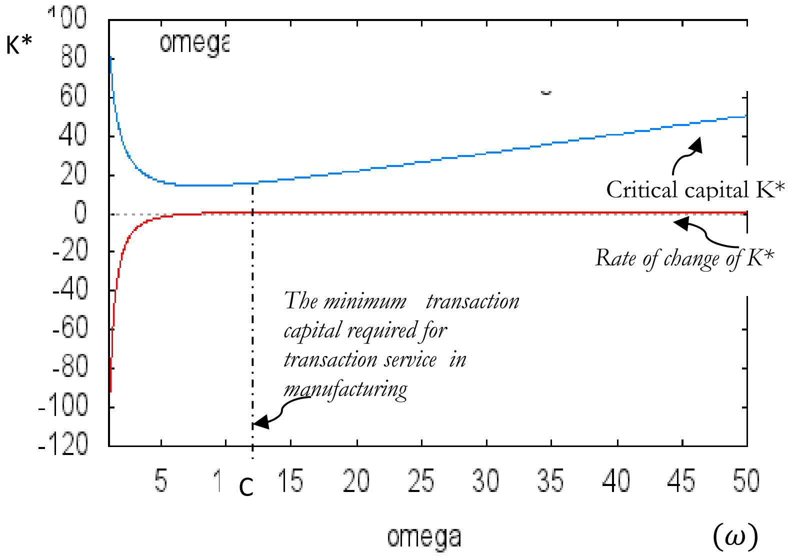



*Fig 5.3 the path of K* as capital used in transaction services (ω) increases for specific values of parameters within their allowable range*

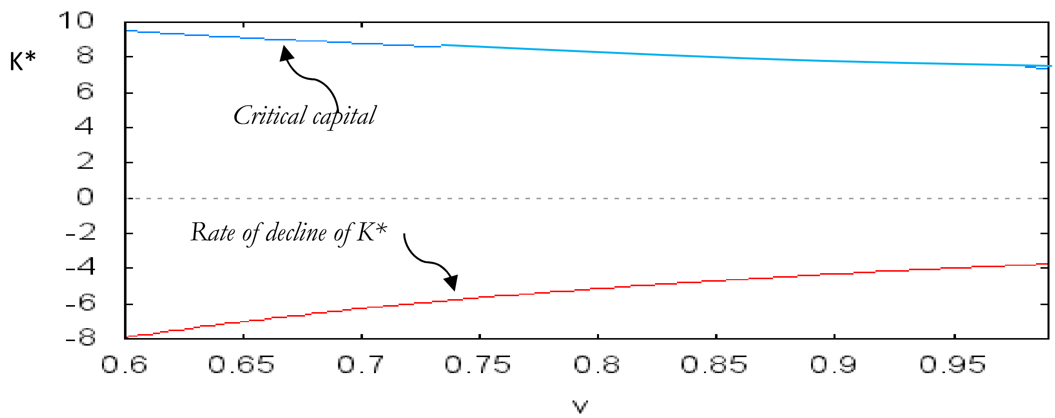



*Fig 5.4 the path of K* as the efficiency of capital usage in manufacturing (υ) increases for specific values of parameters within their allowable range*

## 5.4 RATE OF SAVING(s) AND THE RATE OF LEAKAGE OF SAVING (λ) AND ( K*)

The rate of saving is negatively related with the critical capital stock (K*). With higher saving rate the required capital stock to escape to sustained growth declines, making it easier to escape. On the other hand, increase in the rate of leakage of saving (λ) increases K*. Economies that waste their savings at a higher rate face more difficulty to escape to sustained growth. It implies that it is not only saving at higher rate that helps growth but also efficiently converting savings to investment.

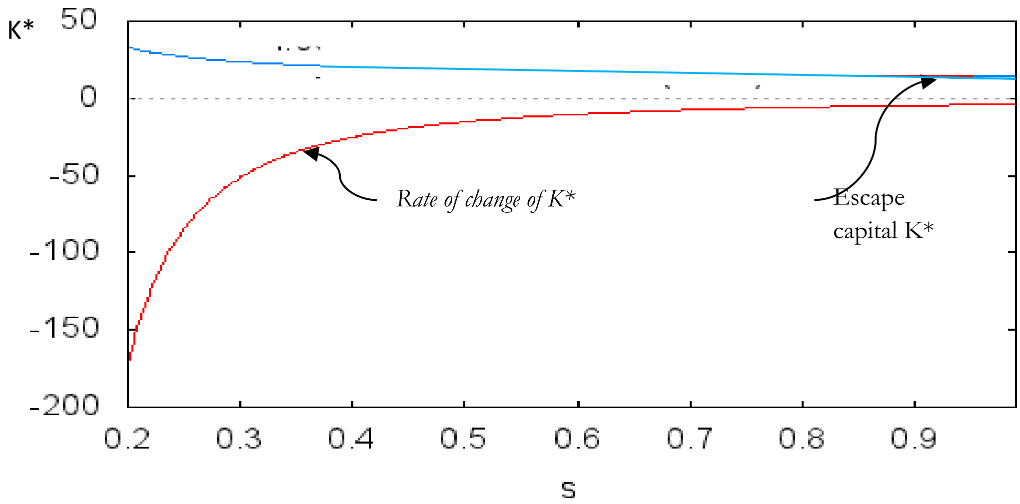



*Fig 5.5 the path of K* as the rate of saving (s) increases for specific values of parameters within their allowable range*

## 5.5 EFFICIENT LEVEL OF CAPITAL USED IN TRANSACTION SERVICES(C) AND K*

The efficient level of capital used in transaction service(C) is the minimum capital to be allocated to transaction services. This efficient level varies with the institutional setting and natural environment of the economy. Economies that accomplish transaction services at lower cost will have lower C. The level of trust, respect for property rights, rule of law, ease of flow of information, ease to transfer property, the ease in the social and natural environment to transport goods, the level of frictions etc shape the level of C. Critical capital stock (K*) increases with increases in C.

## 5.6 OTHER PARAMETERS AND K*

Increases in technical efficiency (η) reduce the critical capital requirement for obvious reason. Increase in share of capital (α) magnifies the effects of the ratio $\frac{\delta}{s-\lambda}$ and diminishes the effects of $\frac{\beta\bar{R}}{\theta}$. Greater labor elasticity of agricultural output (β) and greater exponential conversion of goods value added to total value added (u) also stand in positive relationship with K*. Externality generated by aggregate capital (μ) stands in negative relationship with K*. Productivity ratio of labor in agricultural and manufacturing(θ) is inversely related with K*. Average product of agricultural labor ($\bar{R}$) is positively related to K*.

## 5.7 SUBSISTENCE AGRICULTURE, MANUFACTURING SECTOR AND TOTAL VALUE ADDED

Manufacturing contribution increases faster than agricultural output as capital and labor inputs increase in the economy. Increasing returns and capital accumulation in manufacturing contribute to growth of total output greater than the contribution of agriculture. Value added of subsistence agriculture remains stagnant while manufacturing output rises in an increasing manner with the commitment of more resources to the economy. The share of manufacturing and associated services grows as output grows. Increasing returns in manufacturing is responsible for the shape of the total output that allowed unstable equilibrium. Economies that face depreciation of capital lower than saving in manufacturing right from the beginning do not experience multiple equilibriums and easily move on the sustained growth path. Manufacturing growth and share have to grow for output to grow in sustained manner ( fig 5.6).

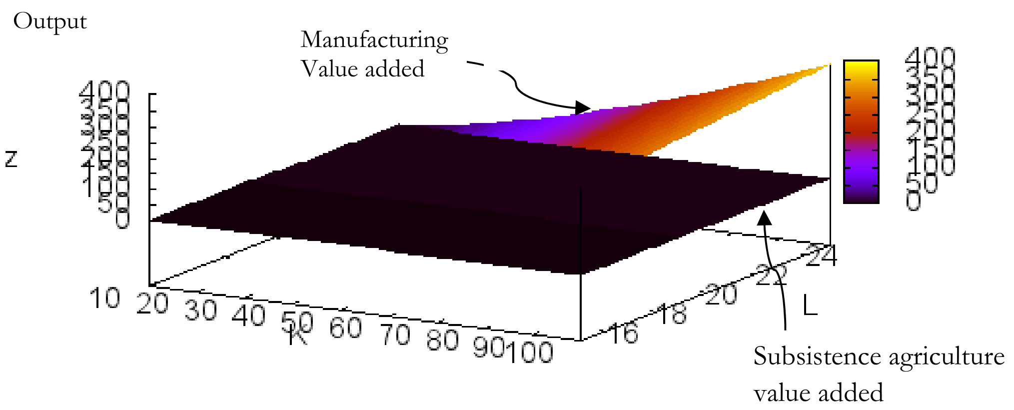



*Fig 5.6 The path of manufacturing and subsistence agriculture as the capital accumulation and labor increase for specific values of parameters within their allowable range.*

# 6 CONCLUSIONS

Based on the theoretical arguments and the stylized facts of low-income economies, a structural model is constructed, taking goods production as the basis for services, with incorporation of inefficiencies. Capital committed to transaction services is considered as transaction costs to society and it reduces the inputs required to goods production. As such, inefficiencies are considered not only as output affecting but also as input reducing as well.

Alternative modalities of incorporating the inefficiencies from the input side were compared with one another (Appendix 1). The alternative considerations of taking deductible input or taking the proportion of use of input in the production-function result in similar outcomes. The introduction of transaction costs as deductible from inputs provides additional insight to the role played by transaction services. Capital used for transaction services first facilitates the escape to sustained growth until it reaches some level, beyond which it becomes hindrance. Expansion of transaction services in low-income economies, beyond the required minimum, strangles manufacturing and is not helping the attainment of sustained growth.

The model conveys, as expected, that long run (sustained) output growth is driven by capital accumulation in manufacturing where embodied technology is employed. In the model, which is dictated by the theoretical base, manufacturing exhibits increasing returns to scale and that rendered the production function convexity in capital use. In the stage of transition where economies find themselves, the success to or failure from attaining sustained growth and industrialization depends on the attainment of growth in capital accumulation beyond the critical stock in manufacturing. If the share of manufacturing does not grow, that would retard the rate of accumulation of capital, and implicitly technology, in the economy and hence the economy fails to attain sustained expansion.

Factors working against the attainment of sustained growth of manufacturing and associated services are leakages in saving (e.g. capital flight), increasing depreciation, increased transaction costs and inefficiencies. Differences in the rates of savings, depreciation, levels of transaction costs and inefficiencies arising from prevailing market imperfections explain differences in the required critical capital stock in manufacturing and predict differences in attaining sustained growth of low-income economies. Institutional factors and inefficiencies affect sustained growth of Low Income Economies through their effect on manufacturing.

The peculiarity of the model is its emphasis on structure where success or failure in growth of manufacturing determines success or failure in sustained growth. Growth in manufacturing, in the presence of stagnant agriculture, implies growth in manufacturing share. An economy with growing manufacturing share is a structure with product and process technologies accommodating growing number of entrepreneurs and workers, employing ever-increasing capital and technology with self-reinforcing production. Moreover, the model finds expression for effects of deeper institutional factors shaping the level of transaction costs, transaction costs affecting formation of capital, which in turn affects manufacturing growth.

Since aggregate demand and supply levels move together, low trended supply has to go generally with low trended demand. If supply goes in a higher trended path demand will follow or if supply structure does not respond to growth of demand, demand will eventually follow the low trended supply. Differences in the time path of low-income economies are to be explained with the evolving structure and the factors behind the evolution. Thus, the major structural factors implied by the model have policy implications, which are summarized as follows:

f) Manufactured goods production has greater impact than non-manufacturing goods production on sustained growth of the economy at large.
g) Difference in growth of share of manufacturing explains differences in the sustained growth of low-income economies.
h) Growth of transaction services in the long run stands in inverse relationship to manufacturing growth of low income economies
i) Institutional arrangements of society affect sustained growth of manufacturing through increased transaction services.
j) In the low income economy, faster growth of share of services obstructs sustained growth of the economy
k) High depreciation, low effective saving rate and smaller difference in productivity between subsistence agriculture and manufacturing obstruct sustained growth through their effect on manufacturing.

The model is a representation of evolving low income economies that have not yet placed themselves on sustained growth path for certain. The model uses theoretical constructs and stylized facts to represent fairly a low income under industrialized economy. The significance of the model in representing the salient features of such economies is crucial for predictions and policy formulations. The implications stated above motivate empirical verifications in further studies to appraise of the representation, and to guide policies for structural transformation.

**REFERENCES**


Acemoglu D.(2009) *Introduction to Modern economic Growth* Princeton University Press, 41 William Street, Princeton

Acemoglu, D. and Robinson J.A (2012) *Why Nations Fail: the Original of Power, Prosperity, and Poverty* , Crown publishing Group New York

Banerjee, A and Duflo E (2005), Growth Theory through the Lens of Development Economics, in P. Aghion and S. Durlauf (eds), *Handbook of Economic Growth*, Vol.1A, Amsterdam: Elsevier, pp. 473–552.

Bairoche,P.(1995) *Economics and World History: Myths and Paradoxes* ; The University of Chicago Press

Baumol W. J. (1967) *Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis* , the American Economic Review Vol.57 No.3

Cass D. (1965) Optimum Growth in an Aggregative Model of Capital Accumulation *The Review of Economic Studies*, Vol. 32, No. 3. ( pp. 233-240). Stable URL: http://links.jstor.org/sici?sici=0034-6527%28196507%2932%3A3%3C233%3AOGIAAM%3E2.0.CO%3B2-H

Collier P. (2007) *The Bottom Billion: Why The Poorest Countries Are Ailing and What Can Be Done About It* Oxford University Press Inc 198 Madison Avenue New York, New York 10016

Dopfer,K.(2011) Mesoeconomics: Bridging Micro and Macro in a Schumpeterian Key in , S. (2011)(ED) *Sectors matter*, Springer Heildelberg Dordrecht London, NewYork

Hansen, G.D and Prescott,E.C(2002) Malthus to Solow *The American Economic Review* , Vol 92, No.4 (Sep., 2002) 1205-1217

Hausmann R · Hwang J · Rodrik D(2007) What you export matters *Journal of Economic Growth* 12:1–25 DOI 10.1007/s10887-006-9009-4 Published online: 30 December 2006 © Springer Science+Business Media, LLC 2006

Hausmann R, Rodrik D Economic development as self-discovery *Journal of Development Economics* 72 (2003) 603– 633 Elsevier

Hewitt,T. , Johnson H, Wield D ( Ed)( 1992) *Industrialization And Industrial Development*, Oxford University Press In Association With The Open University , Walten Street Oxford OX2 6dp UK

Jorgenson D W. (1984) The Role of Energy in Productivity Growth *The American Economic Review*, Vol. 74, No. 2, Papers and Proceedings of the Ninety-Sixth Annual Meeting of the American Economic Association (May, 1984), pp. 26-30:American Economic Association Stable URL: http://www.jstor.org/stable/1816325

Kaldor, N. (1966) *Causes of the Slow Growth in the United Kingdom*, Cambridge: Cambridge University Press

Kaplinsky R. Morris M(2000 ) *A Handbook For Value Chain Research Prepared For IDRC*

Krugman, P. (1981) Trade accumulation and Uneven Development, *Journal of Development Economics* 8 1499161. North-Holland Publishing Company

Kuznets, S.(1966) *Modern Economic Growth : Rate Structure and Spread* Yale University Press, New Haven and London

Kuznets, S. (1989) Economic Development, the family, and Income Distribution: Studies in The United States in the Twentieth Century in Galambos,L. and Gallman, R(1989)(ED) *Economic History and Policy* Cambridge University Press , Cambridge

Lewis A. (1954) Dutt A K and Ros J(2008)(edt) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA

Lin J Y (2012) *New Structural Economics a Framework for Rethinking Development and Policy* The World Bank 1818 H Street NW Washington DC 20433

Lipsey RG, Carlaw KI and Bekar CT(2005) *Economic Transformations : general purpose technologies and long term economic growth* Oxford University Press Inc., NY
Maddisson, A. (2003) *The World Economy: Historical Statistics OECD*: Development Center Studies
Maddisson, A. (2005) *Growth and Interaction in the World Economy: The Roots of Modernity*, AEI Press; Washington D.C
Mcmahon G and Squire L(2003) (ED)*Explaining Growth : A global Research Project* Palgrave Macmillan Houndmills, Basingstoke, Hampshire Rg21 6xs And175 Fifth Avenue, NewYork, N. Y. 10010
Murphy K.M., Shleifer A, Vishny R.W. (1989) Industrialization and the Big Push *Journal of Political Economy*, Vol. 97, No. 5: The University of Chicago Press Stable URL: http://www.jstor.org/stable/1831884
Neumann J. V.(1946) A Model of General Economic Equilibrium *The Review of Economic Studies,* Vol. 13, No. 1 (1945 - 1946), pp. 1-9 Oxford University Press Stable URL: http://www.jstor.org/stable/2296111
Oded Galor( 2004) From Stagnation to Growth: Unified Growth Theory In Aghion P. and Durlauf S. (2005) *Handbook of Economic Growth*(Ed) Elsevier
Palma, 2008 Dutt A K and Ros J(2008)(ED)*International Handbook Of Development Economics* Volume I Edward Elgar Cheltenham, UK • Northampton, MA, USA
Partente, S.L and Prescott, E.C(2003) A Unified Theory of the Evolution of International Income Level, Preliminary URl http://www.nbp.pl/konferencje/radisson/Mowcy/prescot/prescott_paper.pdf
Partente, S.L and Prescott, E.C(1999) Barriers to Riches , *The third Walras –Pareto lecture* , University of Lausanne, Revised October 1999
Pasinetti L.(1993) *Structural economic Dynamics : A theory of the economic consequences of human learning* Cambridge University Press
Pyka,A. Saviotti,P.P.( 2011 ) "Economic Growth Through Emergence of New Sectors" in Mann, S. (2011)(ED) *Sectors matter*, Springer
Ramsey F. P. (1928) "A Mathematical Theory of Saving": *The Economic Journal*, Vol. 38, No. 152 (pp. 543-559 Published by: Blackwell Publishing for the Royal Economic Society Stable URL: http://www.jstor.org/stable/2224098
Rapley, J.(2002) *Understanding Development* ;Lynne Rienner Publishers, Inc.3 henrietta street, Covent Garden, London WC2E 8LU
Ray D. (2000) *What's New in Development Economics*? New York University ` www.efm.bris.ac.uk/ecjrwt/raymult.pdf
Rodrik D.(2007) *One Economics Many Recipes: Globalization, Institutions, And Economic Growth.* Princeton University Press, 41 William Street, Princeton, New Jersey 08540
Ros(2008 Dutt A K and Ros J(2008)(edt) International Handbook Of Development Economics Volume IEdward Elgar Cheltenham, UK • Northampton, MA, USA
Rosenstein-Rodan P. N. (1943) Problems of Industrialization of Eastern and South-Eastern Europe *The Economic Journal*, Vol 53, No. 210/211 Blackwell Publishing for the Royal Economic Society Stable URL: http://www.jstor.org/stable/2226317
System of National Accounts 2008- SNA 2008 , http://unstats.un.org/unsd/nationalaccount/sna2008.asp
Sachs J. D. (2005) *The End Of Poverty Economic Possibilities For Our Time* The Penguin Press New York
Solow, R. M (1956)A Contribution to the Theory of Economic Growth *Quarterly Journal of Economics* (The MIT Press) 70 (1): 65–94

Solow, R. M (1957) Technical Change and the Aggregate Production Function *Review of Economics and Statistics* (The MIT Press) 39 (3): 312–320

Solow, R. M (1961) Note on Uzawa's Two-Sector Model of Economic Growth *The Review of Economic Studies*, Vol. 29, No. 1 (Oct., 1961), pp. 48-50 Oxford University Press ; Stable URL: http://www.jstor.org/stable/2296181

Syrquin,( 2008) in Dutt A K and Ros J(2008)(ED) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA

Szenberg M. (2004)(ED) *New Frontiers in Economics* Cambridge University Press

Takashima, M. (2009) The Sustained Growth and Its Relation to the Initial Conditions Basu, D.(2009) (ED) *Advances in Development Economics* World Scientific Publishing Co. Pte. Ltd.5 Toh Tuck Link, Singapore 596224

Tesfatsion,L. and Judd K.L.( 2006 ED) *Handbook of Computational Economics, Agent based computational economics* Volume 2 , Elsevier

Tesfatsion,L(2005) Agent-Based Computational Modeling and Macroeconomics *ISU Economic Report* 05023

United Nations Statistics Division, National Accounts Main Aggregates Database, December 2013 URL http://unstats.un.org/unsd/snaama/dnlList.asp

United Nations Industrial Development Organization and United Nations Conference On Trade And Development ( 2011) Fostering Industrial Development In Africa In The New Global Environment *Economic Development In Africa Report 2011* :

United Nations Industrial Development Organization (2009) New Industrial Challenges For the Bottom Billion and The Middle Income Countries Breaking In and Moving Up: *Industrial Development Report 2009*Unido Id No: 438

WB (2009) Reshaping Economic Geography *World Development Report*, Washington DC

Yoshikawa,H. and Miyakawa S(2011) Changes in Industrial Structure and Economic Growth : Post war Japanese Experience in Mann, S. (2011)(ED) *Sectors matter*, Springer Heildelberg Dordrecht London, New York

## APPENDIX I: Alternative expressions in the model

As alternative expression, we may use a proportion of $R_t$ rather than $R_t - \psi_t$ in (1) above. The alternative expression to (1) above, using input side *proportions* of capital dedicated to transaction services($\tau$) and transforming the corresponding output multipliers, keeping the parameter u= 1, becomes:

$$f(R_t) = r\frac{(1-\tau)\tau^{\beta}}{\varsigma}(\tau R_t)^{\beta+1} \qquad (1a)$$

The alternative expression to equation (3) above using input side proportions of capital used in transaction services and output multipliers, keeping the parameter u=1, becomes:

$$M_t = \eta\frac{(1-\upsilon)(\upsilon^{\alpha+\mu+1})}{C}(K_t)^{\alpha+\mu+1}(L_t-\varphi_t)^{1-\alpha}. \qquad (3b)$$

The alternative expression to (8) above, using input side *proportions* of capital dedicated to transaction services($\tau$) and ($\upsilon$) , and transforming the corresponding output multipliers, becomes:

$$Y_t = \left[r\frac{(1-\tau)\tau^{\beta}}{\varsigma}(\tau R_t)^{\beta+1}\right] + \left[\eta\frac{(1-\upsilon)(\upsilon^{\alpha+\mu+1})}{C}(K_t)^{\alpha+\mu+1}(L_t-\varphi_t)^{1-\alpha}\right]. \qquad (8a)$$

The alternative to the expression (13) above using proportions of capital removed to transaction services as: $K^* = \frac{1}{\upsilon^{\left(\frac{\alpha^2+\alpha\mu+\mu}{\alpha^2+\alpha\mu+\mu+1}\right)}}\left(\frac{\delta}{s-\lambda}\right)^{\frac{\alpha}{\alpha^2+\alpha\mu+\mu+1}}\left(\frac{(1+\beta)\overline{R}\,C}{\theta(1-\alpha)\eta}\right)^{\frac{1}{\alpha^2+\alpha\mu+\mu+1}}$ . (13a)

# CHAPTERIII: MANUFACTURING GROWTH AND SUSTAINED GROWTH OF LOW INCOME ECONOMIES: EMPIRICAL EVIDENCES


## *Abstract*

*The hypothesis that this empirical analysis tests claims that manufactured goods production has greater impact than agricultural goods production on sustained growth of low-income economies. The analysis uses wavelet-decomposed data of contributions of manufacturing and agriculture to capture the effects of time scales. The wavelet decomposition enables detecting long run sectoral contributions to sustained growth of GDP. For a large set of countries, the test provides empirical support to the hypothesis. The quantitative analysis for empirical evidence on centrality of manufacturing and the application of wavelet decomposition of the time series data in the analysis are the main contributions of the study.*



**Keywords:** time scales, wavelet decomposition, sectoral contribution, manufacturing growth, sustained growth, structure, dualism, modern growth, macro model, multi-sector growth, manufacturing, transaction services, industrialization, transformation, transition to modern growth, income convergence

JEL classification codes 0110, 014, 0410, 047, P52

# 1. INTRODUCTION

## 1.1 BACKGROUND AND THE PROBLEM

Historically all countries were having more or less similar real per capita income before the 18th century (Bairoche, 1995; Maddisson, 2003). In the period before the beginning of the industrial revolution economies were agrarian, where not only income differences were narrow they were stagnant overall. Classical theory of the Iron Law of Wages of Mathus and Ricardo explains the stagnancy of income in agrarian economies (Hansen and Prescott, 2002)

Some leading countries started modern economic growth (Kuznets, 1966), which is characterized by a steady per capita income growth, at the second half of the 19th century, ( Bairoche 1995; Madisson, 2003). Solow (1956, 1957) pioneered modeling this growth and that model evolved to other variants such as neoclassical and endogenous growth theories.

The transition from classical stagnation to modern economic growth was characterized by irregular and unsteady growth, and, for leading countries, the transition to a steady growth in per capita income took nearly a century ( Bairoch 1995; Madisson,2003). The take off to steady income growth took different length of time for different countries. For late comers the transition and catch up with leaders took shorter (Bairoch 1995, Madisson 2003). Considerable number of countries, particularly countries in Africa, has not taken off yet while economies in other regions have exhibited retarded movement in catching up with the leaders. The differences in income levels and failures to catch up have been addressed with various explanatory theories where difference in institutions (Acemoglu and Robinson, 2012), and differences in policy (Parente and Prescott, 2003) are some of them.

This study recognizes that institutions and policies are important environmental factors that act on the existing structure and the structure gives rise to important outcomes, in a sense that the ambient temperature does not convert an egg of a chicken to an owl. Consequently, the study pursues an alternative argument to explain the factors responsible for the transition from classical stagnation to modern economic growth. It hypothesizes the presence or absence of a particular structure, where manufacturing growth and share drives the growth of low-income economies, is responsible for the attainment of transition to modern economic growth.

## 1.2 THE OBJECTIVE OF THE STUDY

As per this alternative theoretical argument, the basic feature that ensures a low-income economy to attain sustained growth is the onset of growth driven by growth of output and share of manufacturing, which is the basis of structural change and industrialization. The objective of this study is to verify the centrality of manufacturing growth in attaining sustained growth of economies with low per capita income in contrast to growth led by agriculture.

## 1.3 THE HYPOTHESIS AND THE METHODOLOGY

The hypothesis to be empirically tested is "Manufactured goods production growth has greater impact than agricultural goods production growth on sustained growth of low-income economies at large" using data from United Nations National Accounts Main Aggregates Database. Four possible cases emerge as outcome of the analysis. The first case(**Case1)** is when both sectors are significantly and positively driving GDP in the long run. In **Case2,** manufacturing is positively driving while agriculture is negatively driving GDP in the long-run. In **Case 3,** both the sectors are negative in driving GDP in the long-run, and in **Case4** agriculture is positively driving GDP while manufacturing is negatively driving GDP. The cases represent the long-term structures of the economies. To glean whether the particular structure is associated with sustained growth we check the changes in attained per capita GDP in the period considered.

In **Case 1**, either GDP is positively responding to agriculture in greater magnitude or it responds to manufacturing in greater magnitude. The sector to which change in GDP responds in greater magnitude than the other is the driver of change of GDP. In **Case 1** and **Case2** If the structure is such that a greater manufacturing impact is leading to higher per-capita GDP there is strong support to the hypothesis or if the structure leads to decline in per capital GDP there is weak support via declining manufacturing growth. **Case3** and **Case4** provide strong support to the hypothesis via agricultural contribution leading to low performance in per capita GDP. In other words, we identify strong cases for the hypothesis by testing whether economies with positive impact of manufacturing really improved their per capita GDP or positive agricultural impact could not improve their per capita GDP; we identify weak supports when manufacturing is driving GDP growth but still per capita GDP has not increased. If we observe economies behaving as expected, the hypothesis is supported, otherwise not.

The economies under investigation are those with low per capita GDP, arbitrarily taken to be below 1000 USD in 1970. The per capita GDP is computed taking 2005 as base year. The economies falling into this category are 71 in number. Some of these countries have made big progress in attaining per capita GDP exceeding 1000 USD, while others are still below that mark. The study chose the period of the past 42 years between 1970 and 2011 based on availability of data for all economies. For various reasons the study treats the time series data per country separately. Moreover, the economies are economies in transition where considerable number of them is undergoing observable structural changes. The prevalence of structural change necessitates the recognition of the existence of unstable parameters and structural breaks in the analyses of the time series data. The relationships to be investigated are thus averages of the changing parameters in the period under investigation.

The paper sets out to test whether manufacturing led structure is central in attaining sustained growth of economies with low per capita income by isolating the sectoral contributions of manufacturing and agriculture from contributions of other goods supplying sectors. Manufacturing and agricultural sectors generate goods and provide the basis for many services. Other goods supplying sectors, which also generate associated services, interact with agriculture and manufacturing and we cannot ignore their contribution since the omission will bias the estimated impacts of manufacturing and agricultural sectors. Inclusion of other goods supplying sectors such as construction, mining, utilities, and imports, however, increases the number of variables in the analysis and leads to loss of degrees of freedom in a situation where the data points are small in number. Thus, we exclude other goods supplying sectors to avoid the loss of degrees of freedom that arise from using too many variables and their lags by orthogonalizing the included sectors from those excluded. We orthogonalize services in addition to manufacturing and agricultural sectors to free GDP from the effects of the excluded sectors.

Sectoral contributions are the first difference of sectors that make up first differences of GDP. Which sector contributes more in the long-run can be compared on the basis of this underlying relationship. The change in sectoral value added necessitates deciding the time span with in which it is computed. The first difference could be annual difference or difference of averages of two or more years. What may be invisible at one time scale could be visible at others. The time scale at which significant relations are detected cannot be predetermined. Thus, differences of average outputs of sectors and the whole economy in various time scales have to be considered. Computing differences across various time scales and comparing sectoral contributions is undertaken using wavelets. Wavelets are useful to compute differences in weighted averages of certain functions across varying averaging periods or scales. Among the various wavelet-transformations, the one selected for this purpose is Haar wavelet. Specifically, we chose Haar wavelet of the Maximum Overlap Discrete Wavelet Transform (MODWT). Changes in average output of the economy and the same for manufacturing and agriculture are filtered in various time scales using Haar MODWT as the wavelet is made to pass through the time series data. Such methods have been employed in few other economic studies (Månsson, K. 2012; Hacker R. S., Karlsson H. K. and Månsson K, 2012). To the best of the authors' knowledge however, the application of wavelets to detect the long run sectoral impacts to sustained growth is a unique contribution of our study.

Manufacturing value added, agricultural value added, and GDP thus obtained are wavelet decomposed in three time scales and one smooth or moving average. The wavelet-transformed data goes through granger-causality tests of changes in goods supply on changes of total value added of individual economies in 42 years span using VAR /VECM approach. The sector driving the economy is detected with Granger causality and cumulative impulse-responses tests in 71 economies.

## 1.4 RESULTS IN PREVIEW

The results of the analysis support the hypothesis in overwhelmingly large number of cases. Economies with positive granger-causality of change in manufacturing value added on change in GDP experienced sustained growth in per capita GDP while those with positive granger-causality of agriculture do not in large number of cases. Longer time scales reveal these relations in more number of cases than shorter time scales. The implication for development strategies in Low-Income economies is that structures matter for sustained growth and a structure in which manufacturing growth drives GDP growth is necessary for the attainment of sustained long-term growth in per capita GDP.

The contribution of this paper is both theoretical and methodological. The study provides support to an alternative explanation for success or failure of attainment of sustained growth and eventual narrowing of gaps in per capita GDP of LICs with advanced economies. The explanation lies in the structure of economies where manufacturing growth is driving the growth of a low-income economy. The methodological contribution is the application of wavelet decomposition of the time series in value added of sectors and the whole economy for subsequent analysis of granger-causality and impulse-responses. It transcends the usual method of analysis where a single time scale is considered.

### 1.5 ORGANIZATION OF THE PAPER

Section 2 goes to a brief excursion to past efforts in the literature to explain the factors responsible for sustained growth and then turns to highlighting the alternative theory that serves as the foundation of the empirical analysis. Section 3 discusses the methodological issues, data preparation and estimation methods. This section highlights the need for transforming the time series data and the model specifications along with the reason for employing the selected model. Section 4 reports the results of the analyses. Section 5 concludes and draws policy implications.

# 2 THE THEORETICAL FOUNDATION

Following Kuznets (1966, 1989), structure here refers to the composition of the aggregate economy, particularly, the relative importance of sectors. Composition refers to involved products, activities and actors (Pyka and Saviotti, 2011). Persistent and long run change in the composition of the economy is known as structural change (Syrquin, 2008). Sustained growth, in contrast to short lived and episodic growth, is self-reinforcing expansion of production, with extensive or intensive dimensions (Pyka and Saviotti, 2011; Lipsey, Carlow and Bekar, 2005).

Sustained growth and structural change are linked. The literatures in economic history, growth, and development, dealing with sustained growth and structural change, do not share a common view, particularly on which specific structure of low-income economies sustained growth depends. Kuznets (1966, 1989) concludes that the production sector that absorbs technology is the sector that contributes most for growth of total output per capita and that sector is the modern sector composed of manufacturing and services in contrast to the agricultural sector. Similar historical regularity have been reported by Kaldor(1966), although the empirical findings were on twelve industrially developed countries. Maddison (2001) alludes to the importance of structure, by pointing to politicians and economist emphasis on sectors (physiocrats on agriculture, Kaldor, Mahalanobis, and many contemporary governments on industry). Bairoch(1995) notices the productivity difference between manufacturing and agriculture before and after the industrial revolution in Western Europe, where agriculture remained with less productivity and far slower than manufacturing productivity growth.

Growth, through sectorally impartial market mechanisms on the one hand and through selective protection of the industrial sector, following "Import Substitution Industrialization (ISI)" strategy on the other hand, have been outstandingly competing approaches in development economics (Hewitt, Johnson and Wield, 1992; Rapley, 2002; Palma, 2008). Modernization and structural change model of Lewis, A. (1954), and the early structuralist emphasis on manufacturing in the structure of production in the economies of the periphery (Hewitt, Johnson and Weild , 1992; Palma, 2008 ) recognize structure. Among latest instances of the literature about the importance of structure and manufacturing for sustained economic growth are UNIDO's (2009) emphases on tailored industrial policy approach for the bottom billion and for stagnant middle income countries, and UNIDO/UNCTAD (2011) special report on "African Industrialization". The arguments place manufacturing as the main source of technology and a major conduit for diffusion of new technologies to other sectors.

Syrquin (2008) emphasizes that structural change retards or enhances growth, depending on its pace and direction. Hausmann and Rodrik (2006) emphasize the production and export of high productivity items for growth, which is recognition of the importance of a particular structure in production. Mann (2011) emphasizes the need for meso-economic considerations to link micro to macro, and to recognize that sectors matter. The analysis on merit sectors (Mann, 2011), and economic growth through the emergence of new sectors (Pyka and Saviotti, 2011) all recognize the role of structure in growth processes. Meso-economics: bridging micro and macro in a Schumpeterian Key (Dopfer, 2011), Changes in industrial structure and economic growth (Yoshikawa and Miyakawa, 2011), and "Economic theory and the neglect of structural change"

Pasinetti (1993) all share the theme that sectors and structure matter for economic development and growth.

Hansen and Prescott (2002) distinguish between classical and neoclassical growth to explain international income levels and differences. World economies are said to have remained under Malthusisan technology until mid–eighteenth century and leading economies crossed the threshold into neoclassical technology and the onset of modern economic growth after 1820 (Madisson, 2005). Thus the coexistence of the Malthusian and neoclassical technologies is tantamount to a two sector economy (land based or agricultural economy and modern industrial economy). How is a complete transition to modern economy taking place? How do economies with this dual nature transit to a higher-level structure through sustained growth?

## 2.1 ARGUMENTS ON CENTRALITY OF MANUFACTURING

As attested by the historical accounts on patterns of economic development (Kuznets, 1966; Bairoch, 1993; Maddison 2005), manufacturing, among goods producing sectors, stands as the most efficient vehicle to carry technological progress and effect factor accumulation. Newly industrialized countries have gone through a structural transformation in line with the historical pattern. Inherent external economies in manufacturing (Krugman, 1981), its technology absorption and capital accumulative nature (Kuznets 1966, 1989), its nature as a basis for the rise of various services( tertiary activities) and for enhancement of primary activities are responsible for this role.

Emanating from its intensive use of modern energy and capital goods, incipient modern manufacturing exhibits higher labor productivity than the other sectors. The possibility of fast or mass production and the ensuing high productivity of labor in modern manufacturing that consume energy from modern sources make it by far the faster way of transformation of inputs to outputs, and creating wealth and prosperity than other activities with incomparably low energy use. Jorgenson (1984) reports, from results of empirical studies, that electrification as well as nonelectrical energy uses are interrelated with productivity growth.

The observed possibility of automation and mechanization in manufacturing further increases the productivity of the sector (Baumol, 1967). The use of manufactured inputs in other sectors makes the sectors more productive (Parente and Prescott, 2003 citing Johnson 2000).

Developing technological capability in manufacturing is a long-term solution to a chronic indebtedness of a developing economy by enabling positive net export through manufactures.

Manufacturing sector is the sector potentially having a large number of products and processes in itself and creating opportunities for service activities associated with manufactured products and processes. Manufacturing avails more opportunities for entrepreneurial engagement in goods production and related services in the long run. The supply chains of manufacturing follow diverse routs and networks that the possibility for sustained growth of economic activities is high. It is instrumental to employment creation for the growing labor forces of a developing economy. Manufacturing having such powerful roles to play, what does its growth level and contribution look like in low-income economies?

## 2.2 STYLIZED FACTS OF LIC

We recognize a typical Low Income Country (LIC) by its dual characteristics: large traditional agricultural goods producing sector and a small modern economy composed of dwarf manufacturing and relatively larger services. The overview of the national accounts data of the UN (unstat, 2013) indicates that considerable number of LICs have a dual structure. The current share of manufacturing in this group of countries is low and the growth of its share varies across economies. The agricultural sector is labor using and unable to absorb capital because of various factors among which are extremely low size of land holdings and prevalence of subsistence. Manufacturing is more capital using than agriculture and labor saving in relative terms. Difficulties to start businesses are diverse and barriers to entry in manufacturing are strong (Jiang, C.N., and Koltko, O. 2014). Transaction services are non-optimal in size. The markets are highly imperfect (Banergee and Duflo 2004). Strong barriers to entry, non-optimal transaction services, high imperfection of markets, high uncertainties about investment outcomes and capital flight divert capital away from manufacturing. Savings fail to be converted to domestic investment in manufacturing as their conversion is blocked by all these factors. Thus, slow capital formation and low rate of flow of capital to manufacturing characterize the economies.

Unskilled labor, unemployment or underemployment predominate the economies (ILOSTAT Database).The existence of a large pool of unemployed and underemployed labor does not give rise to competition among economic sectors for labor. Rather the lack of adequate employment opportunity for the existing labor force characterizes the economies than inadequate supply of labor constraining the expansion of the sectors of the economies.

## 2.3 A STRUCTURAL MODEL OF LIC

This study models low-income economies as evolving through stages in accordance with observed historical patterns. The first stage is a stagnant agricultural economy, the second is a dual economy where subsistence agriculture coexists with small modern manufacturing economy, while the third stage is a matured economy (Kaldor, 1966; Kuznets, 1966, 1989; Hansen and Prescott, 2002; Parente and Prescott, 2003) where the distinction between modern and traditional sector disappears. Manufacturing generates positive externalities and scale economies (Krugman 1981). This characteristic paves the ground for multiple equilibriums. The second stage is the focus of the study, where multiple equilibriums are possible and the economy is a dual economy. The model for this stage differs from Solow model with single aggregate production function fulfilling Inada conditions. The dual nature and possibility of multiple equilibriums of this model makes it different from Roemer's endogenous growth model either.

In the model, the aggregate production function is composed of manufacturing and its associated services as a modern production activity and agriculture and its associated services as a traditional and subsistence activity. We note here that services arise from the respective goods producing sectors. Manufacturing generates positive externalities and scale economies. It is also capital using with labor while agriculture is labor using with no capital. There is no competition for labor from the supply side until full employment prevails as the goods producing sectors draw labor (L) from the unemployed and underemployed pool. There is no competition for capital (K), which embodies technology, either, as demand for capital comes from the modern sector alone, not from labor using agriculture until agriculture modernizes, and ceases to be subsistence. The model incorporates inefficiencies that place actual output below potential output. The inefficiencies are output-affecting ones similar to that of Parente and Prescott (2003), on the one hand, and input-reducing ones, on the other. Input-reducing inefficiencies are expressed either with subtraction from total factors used in actual goods production, while being used to effect transactions, or as percentage of total inputs not directly used for goods production. These inputs not directly used for goods production are essentially economy wide transaction costs for society that emanate from imperfections. Inputs to transaction services appear as transaction costs to goods production. Although non-transaction services compete for inputs with goods producing sectors they do not appear as transaction costs to society. Conceptually, non-transaction services could be lumped together with goods production. The total value added of the economy is the combined outcome of goods production and services that arose taking produced goods as their basis. Since both transaction and non-transaction-services emerge on goods production and consumption, the combined value added can be expressed in terms of the value added of goods production.

We express the value added of the economies with a structural macroeconomic model as:

$$Y_t = \left[r\left(\frac{\psi}{\varsigma}\right)^u (R_t - \psi_t)^\beta\right] + \left[\eta\left(\frac{\omega_t}{C_t}\right)^u (K_t - \omega_t)^{\alpha+\mu}(L_t - \varphi_t)^{1-\alpha}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$Y_t = Ag_t + M_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1a)$$

-where the first expression in the right hand side is the production function of traditional agricultural sector and services arising from agriculture ($Ag_t$), while the second expression is the production function of the modern manufacturing sector and the services arising from it ($M_t$)

$(0 < \psi_t < R_t)$, $(0 < \beta < 1)$ $(0 < r < 1)$, $u \geq 0$, $(0 < \varphi_t < L)$

$(0 < \eta < 1)$, $(0 < \alpha < 1)$, $(0 < \mu < 1)$, $(0 < \omega_t < K_t)$

$r, \varsigma, \beta, u\ \eta, C, \alpha, \mu$ are parameters[7] of the economy while $\omega_t$, $\psi_t$, $\varphi_t$ are exogenous variables and $R_t$ and $K_t$ are the endogenous variable in the model.

Service outputs are expressed in terms of goods supply. While $Ag_t$ and $M_t$ incorporate goods and services produced in and for agriculture and manufacturing respectively, the respective services in isolation are expressed as:

$$Ser = b_1 Ag_{gt} + b_2 M_{gt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

[7] ref the symbols of the parameters in **APPENDIX 1: INDEX OF SYMBOLS**

Where, $b_1 = \left(\frac{\psi}{\varsigma}\right)^u - 1$ , $b_2 = \left(\frac{\omega}{C}\right)^u - 1$, $Ag_{gt} = r(R_t - \psi_t)^\beta$ , $M_{gt} = \eta(K_t - \omega_t)^{\alpha+\mu}\left(L_t - \varphi_t\right)^{1-\alpha}$

Expressing services in terms of goods production is rooted in the fact that most services arise on existing goods supply, be it goods from domestic production or imports. Services either extend activities or assist productive, consumptive and exchange activities of goods. The United Nations System of National Accounts (UN SNA, 2008) classifies services as change effecting, marginal and knowledge capturing services. Change effecting services arise to add value mainly on supplied goods. Knowledge capturing services arise essentially on high-tech goods. Marginal services like insurance and banking engender to assist production and exchange.

Labor productivity in agriculture and arising services is :

$$\left(\frac{\partial f(R_t)}{\partial R}\right) = r\left(\frac{\psi_t}{\varsigma}\right)^u \beta \frac{(R_t - \psi_t)^\beta}{(R_t - \psi_t)} = \beta \frac{f(R_t)}{(R_t - \psi_t)} = \beta \bar{R} \qquad (3)$$

where $\bar{R}$ is per capita output in agriculture, while labor productivity in manufacturing and arising services is :

$$\left(\frac{\partial M}{\partial L}\right) = (1-\alpha)\eta\left(\frac{\omega_t}{C}\right)^u (K_t - \omega_t)^{\mu+\alpha} (L_t - \varphi_t)^{-\alpha} \qquad (4)$$

Assuming labor productivity of the traditional subsistence agricultural sector to be a fraction of that of the modern sector,

$$\beta\bar{R} = \theta \frac{\partial M}{\partial L_M} = \theta\,(1-\alpha)\eta\left(\frac{\omega_t}{C_t}\right)^u (K_t - \omega_t)^{\mu+\alpha} (L_t - \varphi_t)^{-\alpha}, \text{ where } (0<\theta\leq 1) \qquad (5)$$

Labor demand in the modern sector as a function of labor productivity in subsistence agriculture is:

$$L_t = \left[\frac{\theta(1-\alpha)}{\beta \bar{R}_t}\left(\eta\left(\frac{\omega_t}{C_t}\right)^u\right)(K_t - \omega_t)^{\alpha+\mu}\right]^{\frac{1}{\alpha}} + \varphi_t \qquad (6)$$

The rate of saving being the ratio of output (Y) less consumption (Cn) to output (Y), i.e., s= (Y-Cn)/Y, effective saving rate is s-λ, where λ is that part of the saving rate that couldn't be used to the formation of capital as a result of the underdeveloped institutional environment or lack of information on investment outcomes, or due to capital flight.

Capital formation in manufacturing sector and services alone is thus,

$$dK = (s-\lambda)\left(\eta(\frac{\omega_t}{C})^u\right)(K_t-\omega_t)^{\alpha+\mu}(L_t-\varphi_t)^{1-\alpha} - \delta(K_t-\omega_t) \quad (7)$$

$$= (s-\lambda)\eta(\frac{\omega_t}{C})^u(K_t-\omega_t)^{\alpha+\mu}\,[\frac{\theta(1-\alpha)}{\beta\bar{R}})(\left(\eta(\frac{\omega_t}{C})^u\right)(K_t-\omega_t)^{\alpha+\mu}]^{\frac{1-\alpha}{\alpha}} - \delta(K_t-\omega_t) \quad (7a)$$

where: $(0< s< 1)$, $(0< \delta< 1)$, and $(0< \lambda <1)$

The change in capital (dK) could be zero positive or negative. The stock of capital at which dK=0 is a state of equilibrium, the stability of which depends on the level of depreciation and savings. There are two equilibrium states where dK=0: when $K_t = \omega_t$ at a low level of K and equilibrium capital stock K=K* at which equation 7a above equals zero as in equation 8 below.

The economy in transition from stagnancy to modern growth is bounded by a lower level equilibrium of subsistence economy and a higher-level matured economy. In this transition stage, there is an unstable equilibrium. If disturbed at the unstable equilibrium, the economy either moves to the lower level equilibrium or moves to higher level transformation depending on whether capital stock (K) in the modern sector is greater or less than a critical stock$(K^*)$, where $K^*$ is derived from the low of motion of capital as:

$$\mathbf{K^*} = (\frac{\delta}{s-\lambda})^{\frac{\alpha}{\mu}}(\left(\frac{1}{\eta}\right)^{\frac{1}{\mu}}\left(\frac{C}{\omega_t}\right)^{\frac{u}{\mu}})(\frac{\beta\bar{R}}{\theta(1-\alpha)})^{\frac{1-a}{\mu}} + \boldsymbol{\omega} \quad (8)$$

If the economy exceeds the critical stock and escapes the unstable equilibrium it moves to a persistent change towards maturity where it assumes a different structure showing no more a distinction between agriculture and manufacturing. The theoretical analysis places emphasis in capital accumulation in the modern manufacturing sector. Capital used in goods production sector propels the economy forward with generation of value added in goods and value added in services.

The model suggests that movement of a low-income economy to the higher equilibrium and escape to sustained growth depends on the presence or the absence of a particular structure in which manufacturing growth and share drives economic growth. This paper follows the argument that the transition of low-income economies from classical stagnation to modern economic growth hinges on this structure. The claim for this causal relationship rests on the fact that manufacturing is a sector having the highest actual or potential capacity to provide a variety of goods for direct consumption, indirect consumption and in forming the basis for emergence of services. This study aims to verify the hypothesis claiming the centrality of manufacturing in attaining sustained growth of economies with low per capita income.

# 3 METHODOLOGICAL FRAMEWORK

Methodology essentially aims to link data with hypotheses that emanate from theories. The methodology is about how to support or refute the hypotheses using an appropriate method of analysis and data. The nature of the hypothesis informs the choice of method of analysis and the method of analysis lays the foundation for the identification of required data and treatment of the data. This section begins with description of the method of analysis used that the hypothesis necessitates and moves to selecting and transforming the data to suit the method of analysis.

## 3.1 METHOD OF ANALYSIS

The hypotheses to be tested is "Manufactured goods production has greater impact than agricultural goods production on sustained growth of low-income economies at large". In other words, the hypothesis says that structural change towards manufacturing is necessary for long-term growth. An economy driven by manufacturing growth results in better per capita GDP in the long run than that driven by agricultural growth. The hypothesis is equivalent to the question: "the contribution of which sector is positively associated with long-term growth of the economy?" Addressing this question dictates the choice of the method of analysis.

Addressing the hypothesis or, alternatively, answering the research question requires comparison of the impacts of contributions of sectors on sustained growth of GDPs. Comparison of the impacts presupposes existence of causal relationship between changes in sectoral value added and changes in GDP. In a world of interaction among sectors and interactions of sectors with the whole economy, there is no better choice other than VAR/VECM analysis and Granger causality test to handle impacts of endogenous variables. Impacts of changes in value added of sectors, and changes in total value added are all endogenous variables, each influencing one another. Methods other than VAR/VECM do not handle this endogeneity and to identify Granger causality. Thus, comparison of the impacts of contributions of sectors to sustained growth aims at investigating the Granger causal relationship between changes in sectoral value added and changes in GDP.

Granger causality tests, in turn, require impulse-response tests to identify the signs of contributions of sectors to sustained growth. A statement saying that M Granger causes GDP means that M influences GDP, but says nothing about the direction of influence. Thus, an increase of M may cause GDP to drop or to increase. To determine the sign of causation we consult the cumulative impulse-response results, which have positive or negative signs. Indentified signs of Granger causality tell us whether the particular sector positively or negatively influences the long-term growth of GDP. The direction of the long-term influence will be juxtaposed with the actual change in per capita GDP to eventually glean supporting and non-supporting cases for the hypothesis in question.

In order to lay the basis for Granger causality and impulse-response tests, we specify the underlying relationship between contributions of sectors and changes in GDP. The first differences of sectoral value added are contributions to the first difference of GDP and the long-term association between these contributions and changes in GDP tell which sector is relatively responsible for growth of the economy.

The value added in goods production ($Y_{gti}$)is: $Y_{gti} = M_{gti} + Ag_{gti}$ (9)

Total value added (goods and services) ($Y_{ti}$) $Y_{ti} = Y_{gti} + Ser$ (10)

Expressing services in terms of goods: $Y_{ti} = M_{gti} + Ag_{gti} + b_1 Ag_{gti} + b_2 M_{gti}$ (10a)

$$Y_{ti} = (1 + b_2)M_{gti} + (1 + b_1)Ag_{gti} \quad (10b)$$

$$\Delta Y_{ti} = (1 + b_2)\Delta M_{gti} + (1 + b_1)\Delta Ag_{gti} \quad (11)$$

The first difference of GDP is the change in value added expressed in terms of sectoral contributions. Which sector contributes more in the long-run can be investigated on the basis of this underlying relationship.

POSSIBLE OUTCOMES AND SUPPORTIVE CASES FOR THE HYPOTHESIS

Granger causality and impulse response tests reflect the inherent structure of the economy. The structure could be that leading to long-term growth, or it may not. The granger-causality tests and the impulse-responses may show any of the following four cases that simply indicate what the structures look like. Pursuing the arguments of the theoretical foundation, each structure has implication for sustained growth. Whether the theoretical implications were true or not finds empirical support by comparing the implied effect to the actual attained changes in per capita GDP in the given period.

**Case 1** is an empirical situation where both sectors are significantly and positively Granger causal to GDP. Positive causality implies similar direction of change of the sectors and GDP, irrespective of the sign. This case incorporates two possibilities: either GDP is positively responding to agriculture in greater magnitude or it responds to manufacturing in greater magnitude. The sector to which change in GDP responds in greater magnitude than the other is the driver of change of GDP. Since both the sectors are positively Granger causal, the sector whose impulse generates higher response drives the growth of the economy more than the other does. As per the theoretical argument pursued, in case Agriculture is generating greater response while manufacturing impulse generates less, structural change is not expected. In case manufacturing is generating greater response while agricultural impulse is generating less, structural change would follow if manufacturing grows. If manufacturing is not allowed to grow, even if it generates high response, the economy does not show good performance in per capita income in the long-run. Favoring manufacturing or suppressing it is a choice of society and the choice has long-term consequence.

In **Case 2** manufacturing has positive Granger causality while agriculture has negative Granger causality. As the economy grows agriculture's contribution is declining. In this case, clearly manufacturing is the sector with greater contribution and the driver of growth of the economy. If the economy has grown, it must have done so because of growth of manufacturing. Manufacturing is driving the economy, offsetting the negative contribution of agriculture. If the economy has not grown, it must have been because of stagnation or decline of manufacturing growth. Note that in this case even if agriculture is growing, as long as manufacturing is not growing, the economy does not show growth sustained for long. The structure of the economy is such that transformation takes place if manufacturing expands. It is again a matter of choice.

In **Case 3,** both the sectors contribute negatively to GDP, which means although the economy is growing the contributions of the two sectors to GDP are declining. If the economy was declining, it was not the result of decline of manufacturing or agriculture. The source of growth and driver of the economy are services and structural change has yet to come.

In **Case 4,** agriculture is the sector positively Granger causal to GDP while manufacturing is negative Granger causal. The performance of the economy is dependent on agriculture, whether for its growth or stagnation. If the economy is still low-income economy, the economy is agricultural and no structural change is in the scene.

While the sectoral contributions in relation to GDP are detected by granger-causality and impulse-responses, they do not show the actual directions of changes in the sectoral contributions. Those economies having positive causality of manufacturing steadily grow if manufacturing is growing. This experience in structural change must have led to gaining higher per-capita income than others. Has this been observed in actual changes in per capita GDP? Have those economies, without positive causality of manufacturing, performed less in the attainment of per capita GDP? The answers to these questions help to verify the validity of the hypothesis. The detected granger-causal relations and the respective attained performance in per capita GDP together tell whether the data support the hypothesis or not. The per capita GDP considered is that computed excluding income from orthogonalized sectors. For example, we exclude the per capita GDP changes that result from natural resource extraction. We juxtapose the sign of impulse-response of the Granger causal relations of sectors with performance in changes in per capita GDP, net of resource incomes and incomes from other sectors, to verify the validity of the hypothesis. Such juxtaposition reveals whether the long-term impact of manufacturing corresponds with higher level of per capita GDP or long-term dependence on agriculture leads to lower level of per capita GDP. Tab 1 below shows the various cases and their implications to the hypothesis.

**Cases for the hypothesis**:

- If economies show positive Granger causality of manufacturing, it entails structural change and we expect the economy to have long-term growth accompanied by higher per capita GDP. Positive Granger causality of manufacturing combined with higher actual performance in per capita GDP attainment provides strong support to the hypothesis.

Positive Granger causality of manufacturing combined with lower actual performance in PCI attainment provides weak support to the hypothesis. This is because positive causality with declining manufacturing leads to lower growth.

- With regard to agriculture, negative Granger causality or lower magnitude of impact than manufacturing coupled with lower performance in per capita GDP lend support to the hypothesis.

**Cases against the hypothesis**

- Negative Granger causality of manufacturing coupled with high performance in per capita GDP does not provide support to the hypothesis.
- Positive Granger causality of agriculture and higher performance in per capita GDP do not support the hypothesis.

Accordingly, **Case 1** and **Case2** provide supports to the hypothesis via positive manufacturing drive of growth of GDP. If this structure is leading to higher per-capita GDP there is strong support to the hypothesis or if the structure leads to decline in per-capita GDP there is weak support via declining manufacturing growth. **Case3** and **Case4** provide strong support to the hypothesis via agricultural contribution leading to low performance in per-capita GDP. In other words, the strong cases for the hypothesis are those economies with positive impact of manufacturing really improving their per-capita GDP or positive agricultural impact not improving their per-capita GDP; weak supports are those economies where manufacturing was driving GDP growth but still per-capita GDP has not increased. If economies behave as expected, the hypothesis gets support, otherwise not (Tab 1 below). The task of the Results section (section 4) is finding out where each economy falls; in cases supporting the hypothesis or in cases that do not support the hypothesis.

Tab 1: **Possible outcomes and implications for the hypothesis**

| **Cases** | **Signs of Granger causality of sectors on change in GDP** | | **Further indicator required** | **Interpretation** | **Higher magnitude of cumulative IR** | **Long-term Trend** | **Changes in attained per capita GDP** | **Implications to the hypothesis** |
|---|---|---|---|---|---|---|---|---|
| **Case1** | **Manu** | **+** | Magnitude of the response (*which response is greater?*) | The sector with higher magnitude has higher impact; if manufacturing generates higher impulse, structural change is likely | Manuf | + | Positive | Strongly Supported |
| | | | | | | - | Negative | Weakly*supported |
| | **Agri** | **+** | | | Agri | + | Positive | Not supported |
| | | | | | | - | Negative | Not Supported |
| **Case2** | **Manu** | **+** | None | Manufacturing is driving the growth of GDP, suitable for structural transformation | | + | Positive | Strongly supported |
| | **Agri** | **-** | | | | - | Negative | Weakly*supported |
| **Case3** | **Manu** | **-** | None | The economy is services dependent , structural change yet to come | | + | Positive | Not supported |
| | **Agri** | **-** | | | | - | Negative | Strongly Supported |
| **Case4** | **Manu** | **-** | None | Agriculture is driving growth, structural change yet to come | | + | Positive | Not supported |
| | **Agri** | **+** | | | | - | Negative | Strongly Supported |

*Weak support is a support to the hypothesis on condition. For example, a case of positive Granger causality of manufacturing on GDP and negative change in per capita GDP supports the hypothesis if GDP is declining following the decline of manufacturing.

## 3.2 DATA AND TREATMENT OF DATA

The method of analysis specified above requires preparation of the data of selected sectors to detect long-term relations to GDP. The preparation of data involves orthogonalization and wavelet transformation of the time series data on sectoral GDPs and GDP of the economy at large.

THE SELECTED SECTORS AND THE NEED FOR ORTHOGONALIZATION

Among the sectoral GDPs in the economy, we consider manufacturing value added and agricultural value added in the analysis. Other goods supplying sectors, which also generate associated services, interact with the selected sectors (agriculture and manufacturing). We do not simply ignore goods supplying sectors other than agriculture and manufacturing, since the omission will bias the estimated impacts of the considered sectors, i.e., manufacturing and agriculture. The time series length of the available data is 42 years. Granger causality tests take place in a VAR (P) model that necessitates the use of some lags of the variables. The involved VAR (P) model and the time series length of the data available dictate the reduction of the number of vectors in the analysis. Inclusion of other goods supplying sectors such as construction, mining, utilities, and imports, however, increases the number of variables in the analysis and leads to loss of degrees of freedom.

Thus, we need to exclude other goods supplying sectors to avoid the loss of degrees of freedom that arise from using too many variables and their lags. Granger-causal analysis of growth of GDP, manufacturing value added, and agricultural value added, at various time scales, takes place net of effects of other sectors. This requires orthogonalizing manufactured and agricultural value added vectors from vectors of value added of other goods supplying sectors, before undertaking VAR regression of sectoral value added changes with GDP changes at different time scales. This enables to identify pure sectoral effects of manufacturing and agricultural goods production on growth of GDP. Orthogonalization is done using projection method (Han L. and Neumann M. 2007) as it is intuitive. The method orthonormalizes vectors in an inner-product space using the projection operator. Given vectors U and V the orthogonal Projection of V on U is :

$$\text{Projection}_{\text{U}}(\text{V}) = \frac{<\text{U,V}>}{<\text{U,U}>}\text{U} \tag{12}$$

where $< U, V >$ is the inner- product of the vectors U and V.

The projection vector is that component of the vector V lying in the vector space of U. The component of vector V that is orthogonal to vector U is:

$$V_1 = V - \text{Projection}_{U}(V) \qquad (13)$$

The targets of orthonalization are manufacturing and agricultural value added, (represented by vector V above) to remove the effects of the excluded goods supplying sectors represented by vector U above) from the analysis. The excluded goods supplying sectors, which also generate service value added, are construction, mining, utilities, and imports. The orthogonalized vectors of manufacturing and agricultural outputs are thus free from the contributions of the excluded sectors. The service sector has to be othogonalized from the excluded sectors to remove their effects from the GDP as well. Thus, the GDP is also net of the excluded sectors. Agriculture and manufacturing sectors are not orthogonalized with services as services are considered as the effects of these goods producing sectors and parts of contributions of these sectors to GDP.

Computation of the changes in these othogonalized manufacturing and agricultural sectors as contributions to changes in value added of the economy precede the Granger causality analysis. This computation of changes in sectoral value added necessitates deciding the time span within which the changes occur. The first difference could be annual difference or difference of averages of two or more years. We use wavelet transformations to decompose differences across various time scales.

## WAVELET TRANSFORMATION OF DATA

We may detect the sector contributing most to sustained growth from the relations of differences of consecutive values of contributing sectors to GDP. The consecutive time could be every single year, two years, three years, etc. Differences of values between every single consecutive year or differences of averages of consecutive two years or three years provide data of distinct resolution. What may be invisible at one time scale could be visible at others. The time scale at which significant relations occur is unknown from the outset. Before we detect the right time scale, we need to relate the differences of average value added of sectors and the whole economy in various time scales.

An analytic method that enables filtering differences and moving averages of value added of sectors and the economy at large at various time scales is wavelet analysis. Wavelets are useful to compute differences in weighted averages of certain functions across varying averaging periods or scales (Percival and Walden, 2000; Kaiser G.1994). Changes in averages over various time scales provide different quality of information than the average levels themselves. For example changes in annual output of consecutive years informs about the progress of the economy differently from the annual output levels themselves. Differences in the averages or weighted averages of two, three or four, etc., consecutive years, termed $D_1$, $D_2$ etc., provide various levels of information about the progress of an economy than the averages of outputs in two, three, four etc. years. To use topographic analogy, the average levels across longer time scales provide information on the bigger picture (about the profile of the mountain range) while the differences indicate the details (the hills and valleys in the mountain range).

With the use of appropriate wavelets, the time series data is transformed into other time series with characteristics reminiscent of the time scale considered. Among the various wavelet transformations, the one selected for this purpose is Haar wavelet; specifically, Haar wavelet of the Maximum Overlap Discrete Wavelet Transform (MODWT) type. The wavelet treatment filters changes in average output of the economy and the same for manufacturing and agriculture in various time scales as the wavelet passes through the time series data. The wavelet-transformed data further goes through Granger causality tests. For a little excursion in to the nature of wavelets, Appendix III provides highlights.

Applying wavelet analysis in economic time series data enables identification of relationships across various time scales. Annual outputs of sectors and the economy change over time. The changes over time are results of linkages and causal interactions of the sectors. The interactions and causalities could be between contemporaneous values or between past values of the outputs. The interactions may work themselves out in a relatively short or long period. Thus, we filter the behaviors of the outputs at various time scales and investigate the causal relationships in the corresponding time scales separately. One possibly could detect such causal relationships and effects of interactions more in differences of averages across one of the various time scales among many, than efforts in investigating of causal relations in mere annual differences. This is because the analysis captures the time lag effects of the interactions better by evaluation of the average differences across various time scales after they have sufficiently worked themselves out. Wavelets serve exactly this purpose.

Moreover, macroeconomic annual figures could possibly involve noises, arising from inaccuracies in data compilation and irregular disturbances or shocks affecting the economy. Differencing the averaged figures significantly filters some of these noises and the data better reveals more regular patterns and longer-term relations in the economy. Rather than differentially weighted averages of sorts, it evaluates the differences of equally weighted averages of consecutive figures, such as differences of averages of annual outputs in consecutive two, four, and eight, years. Månsson, K. (2012), Hacker R. S., Karlsson H. K. and Månsson K, (2012) employed wavelet transformation methods in other economic studies. To the best of the authors' knowledge, such analysis has not been applied in the analysis of sectoral impacts on sustained growth of GDP in a low-income economy setting.

In contrast to other wavelets, Haar wavelet is particularly suiting the purpose of this study. In addition to the analysis of relationships of differences of averages (the details $\mathbf{D}_j$), which are used to detect possible causality, it allows the analysis of the relationship of moving averages (smoothes **S**), representing the levels. The smoothes(S) indicate the long-term trends of sectoral and total outputs of the economy as they stand. The relationships between smoothes detect impacts of scaled levels of value added of sectors on GDP on long-term basis. The orthogonalized goods outputs and GDP undergo transformation with Haar MODWT wavelet to obtain the wavelet coefficients. The sum of the inner product of the wavelet coefficients and the wavelets produce the details ($D_i$) and the smooth(S).

Fig 1 below is wavelet-decomposed data $D_i$ and S for a particular economy. The details $D_i$ and S are made ready to undergo time series regression using VAR procedures and granger-causality tests with impulse-response analysis. Orthogonalized impulse-responses indicate the existing causal relationship (Lutkepohl 2005). The cumulative orthogonalized impulse-responses in longer steps (42 steps in this case) reveal the positive or negative effects of the respective sectoral growth to growth of GDP in the period of study.

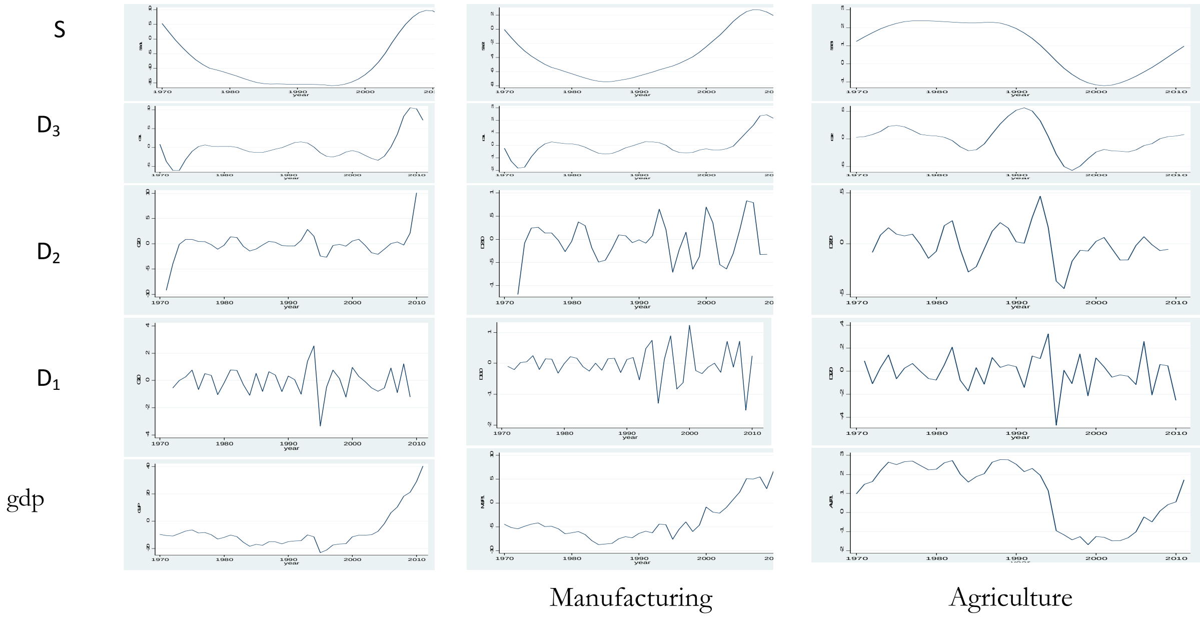



Fig1. Wavelet Decomposition of Value added (**Malaysia)** (excluding contributions of other sectors and services associated with those excluded sectors) The first graph at the bottom is before decomposition

Software program and coding used to prepare and analyze the data is Stata 12. The data set employed is accessible from United Nations National Accounts Main Aggregates Database for low-income economies listed in Appendix IV.

## GRANGER CAUSALITY TESTS AND IMPULSE-RESPONSE ANALYSIS

The wavelet-transformed data are first differences and moving averages at dyadic time scales. The first difference time series are stationary in nature and the moving averages are proportional to the trends that may or may not be stationary. The time series model appropriate for the stationary first difference transforms is VAR while for the non-stationary transforms, representing levels rather than differences, is VECM. The detail wavelet transforms (Dj) are by definition stationary series and we treat stationary multiple time series with VAR analysis. The functional form of the VAR (P) analysis is:

$$\mathbf{Y}_t = \mathbf{V} + \mathbf{A}_1\mathbf{y}_{t-1} + \cdots + \mathbf{A}_p\mathbf{y}_{t-p} + \mathbf{u}_t, \quad t = 0, \pm 1, \pm 2, \ldots, \tag{20}$$

where $\mathbf{Y}_t = (y_{1t}, \ldots, y_{Kt})$ is a $(K\times 1)$ random vector,

$\mathbf{A}_i$ are fixed $(K\times K)$ coefficient matrices,

$\mathbf{V} = (\nu_1, \ldots, \nu_K)$ is a fixed $(K \times 1)$ vector of intercept terms,

$\mathbf{u}_t$[8] $=(u_{1t}, \ldots, u_{Kt})$ is a K-dimensional white noise process,

where, $E(\mathbf{u}_t) = 0$, $E(\mathbf{u}_t\mathbf{u}'_t) = \boldsymbol{\Sigma}_u$ (covariance matrix)and $E(\mathbf{u}_t\mathbf{u}'_s) = 0$ for $\mathbf{s} \neq \mathbf{t}$.

$\mathbf{Y}_t$ vector, in the context of this study, consists of the wavelet transforms of GDP, manufacturing and agricultural value added, where t extends from 1 to 42 years.

We estimate a stable VAR relation to test the existence of Granger causality and subsequently impulse response tests to see whether the Granger causality is of positive or negative sign. Granger causality rests on the principle that a cause cannot come after the effect, and if a variable $X_t$ affects a variable $Y_t$, the former should help improving the predictions of the latter variable (Lutkephol, 2005).

While the detail wavelet transforms (Dj) are by definition stationary series and stationary multiple time series are treated with VAR analysis, smooth(S) may not be stationary. In that case, co-integration analysis would be the appropriate approach. Since co-integration relations are not unique, Johansen's method of co-integration estimation follows to identify the maximum number of co-integration relations and sets of coefficients. The first co-integration relation is the one that takes orthogonalized GDP as the explained variable, and the focus is on that co-integration relationship. Granger causality tests proceed following Lutkephol (2005), where we extend the lag length by one unit. Impulse-response relations proceed to see the positive or negative Granger causality associated with a pair of variables.

Granger causality tests indicate the sectoral causal influences on one another and on the economy at large. Granger causality tests, however, do not show the direction/sign of the impact. Impulse response relations show the positive or negative Granger causality associated with a pair of variables. The wavelet-decomposed time series data in various time scales undergo the tests. Vector autoregressive analysis on un-decomposed or non-transformed data lumps up effects on a single time scale and it does not detect the varying relations prevailing on various time scales. Lag lengths were determined statistically before performing VAR analysis. The appropriate lag lengths per country are taken based on agreement of the four information criteria (FPE, AIC, HQIC, and SBIC) (Lutkepohl, 2005). In cases where there is conflict between the criteria, we choose the suggested

[8] The use of "u" here has no relation to that symbol used in the conceptual model

length by most criteria. In case the criteria break even, we take the lag length suggested by AIC on the ground that it possesses characteristics better suited to short time series length (Lutkepohl, 2005).

DESCRIPTION OF TIME SERIES DATA AND SOURCES

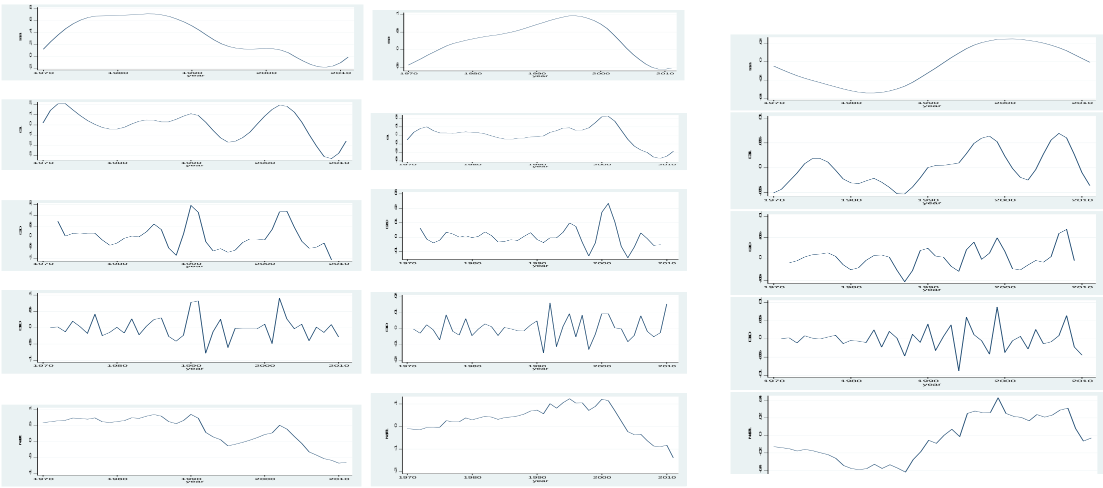
The data employed are those obtained from United Nations National Accounts Main Aggregates Database on GDP and components of GDP of all countries. The economies under investigation are those with low per capita GDP, arbitrarily taken to be below 1000 USD in 1970. The base year for computation of the per capita GDP was 2005. These economies are economies in transition from traditional agricultural economy to modern economy in the sense of Hansen and Prescott (2002) and Parente and Prescott (2003). The economies falling to this category are 71 in number (Appendix IV and V) the distribution being 43 from Africa, 24 from Asia and 4 from Latin America and Caribbean.

Tab2: Regional distribution of Countries with less than 1000USD per capita GDP in 1970 (at the value of 2005 USD)

| Region | Total Number of countries included |
|---|---|
| Africa | 43 |
| Asia | 24 |
| Latin America and Caribbean | 4 |

Some of these countries have made big strides in attaining per capita GDP exceeding 1000 USD, while others are still below that mark. The past 42 years (1970 to 2011) is a period where data is available for all economies. The time span of 42 years allows limited time scales in the wavelet analysis. The maximum time scale the periods allows is 8 years. The longer the time span the better it enables to detect long run relations.

The time path of the wavelet transformed time series sectoral and total GDP data of countries are with differing applicable lag lengths, and with differing relationship across time scales ( Fig 2 below). Thus, the time series data per country need a separate treatment. Fig 2 below indicates the variation in the structure of economies.



Afghanistan Ethiopia Niger

Fig:2: Haar MODWT decomposed manufacturing data in three time scales and smooth for three countries The first layer at the bottom is before decomposition

Moreover, the economies are economies in transition where considerable number of them is undergoing observable structural changes. The prevalence of structural change necessitates the recognition of unstable parameters and structural breaks in the analyses. The relationship between sectoral contributions and the economy at large are the averages of the changing parameters in the period under investigation. The structural breaks, and the entailed changes in the parameters are characteristics of the economies and the relations uncovered by the wavelet analysis are to be understood in ordinal sense.

# 4 EVIDENCES: RESULTS OF GRANGER CAUSALITY, CUMULATIVE IMPULSE-RESPONSES, AND CHANGES IN PER CAPITA GDP ACROSS VARIOUS TIME SCALES

The hypothesis we test is that "*Manufactured goods production growth has greater impact than agricultural goods production growth on sustained growth of low-income economies at large*" The central concept of the hypothesis lies in sectoral contribution of manufacturing and agriculture, without neglecting the contributions of other goods supplying sectors. The existing time series length does not allow the inclusion of the contributions of all goods supplying sectors. Therefore, we purge out the contributions of other goods supplying sectors before analyzing the contributions of manufacturing and agriculture. Thus orthogonalizing agriculture, manufacturing and GDP from the other goods supplying sectors is necessary before analyzing the sectoral contributions of the two sectors to GDP.

Sectoral contributions are first differences. But what time scale is to be used to compute first differences? Is that first differences of yearly averages, two years averages, three years averages etc? Since we do not know a priori which time scale is appropriate, we choose a method that computes the differences at various time scales. Wavelets decompose the differences of averages at various time scales. We used a particular wavelet, Haar wavelet, for the purpose at hand.

The maximum number of years the data allows detecting wavelet decomposition being eight years, that enables Granger causality tests between changes in the averages of, at most, four consecutive years (D3) and the moving averages in eight years(S) of the value added of sectors and the economy at large. Wavelet decomposed data at lower scales than D3, are D1 and D2, which are changes in annual averages and changes in averages of two consecutive years respectively. Thus, wavelet decomposed data up to D3 go through VAR, Granger-causality, and Impulse Response analyses to detect the sector the growth of which has significant causal effect on GDP growth in a period of 42 years. The co-integration, Granger causality and Impulse Response analysis in S detects the causal relationship of levels.

The results of the Granger Causality and Impulse-Responses indicate that sectoral impacts on GDP differ across countries and across time scales (Appendix VI). Possible outcomes of the analysis and supportive and non-supportive cases for the hypothesis are outlined as part of the methodology and the results are tabulated for each country in Appendix VI

## 4.1 GRANGER CAUSALITY ACROSS TIME SCALES

The significance (at 10%) of Granger causality increases as the time scale increases. The non-positive or negative cases decline as the time scale increases . These are cases with insignificant F values in Granger causality Wald tests and excluded from testing impulse response for being positive or negative. It is observed that 29 significant cases occur in time scale 1; 42 significant cases occur in time scale 2; 55 significant cases occur in time scale 3, and 70 significant cases occur for the smooth in time scale 3( Tab 3).

Tab 3: Significant cases of Granger causality ( at 10% significance )

| | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** |
|---|---|---|---|---|
| **Total significant cases** | **29** | **42** | **53** | **70** |

This suggests that the use of longer time scales are better to detect relations that seem insignificant at shorter time scales. The conventional treatment of a set of time series data, without decomposing it into different time scales, does not reveal underlying relationships. Annual outputs of sectors and the economy change over time as a result of sectoral linkages and causal interactions that may not be manifested in a predetermined time scale as the interactions may work themselves out in a relatively short or long period. Decomposition by time scale captures the time lag effects of the interactions better by evaluation of the average differences across various time scales after they have sufficiently worked themselves out. Thus, filtering the behaviors of the outputs at various time scales and investigating the causal relationships in the corresponding time scales separately becomes useful and the results obtained attest to the power of the method.

Both manufacturing and agriculture have the same number of significant cases at the respective time scales. The differences appear in the significant number of positive or negative Granger causalities detected by the signs of cumulative impulse responses. The number of countries in which manufacturing positively or negatively Granger causes GDP and the number of countries with no significant causation generally increase as the time scale increases (Tab 4).

Tab 4 : Manufacturing Granger Causing GDP

| | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** |
|---|---|---|---|---|
| positively Granger causes GDP | 11 | 20 | 28 | 34 |
| negatively Granger causes GDP | 18 | 22 | 25 | 36 |
| No Granger causation | 42 | 29 | 18 | 1 |

*Chi-square p-value of this contingency table is 4.19425E-11, which signifies the importance of time scales*

The time scale dependence of the distribution of countries in positive, negative, and no causality of manufacturing on GDP is significant (**with p-value of 4.19425E-11 in chi-square tests of the**

**contingency table**). The same is true for agriculture as indicated in Tab 5 below with a chi-square p value of 3.58928E-11.

Tab 5 Agriculture Granger Causing GDP

| | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** |
|---|---|---|---|---|
| positively Granger causes GDP | 17 | 17 | 24 | 32 |
| negatively Granger causes GDP | 12 | 25 | 29 | 38 |
| No Granger causation | 42 | 29 | 18 | 1 |

*Chi-square p value of this contingent table is 3.58928E-11, indicating the significance of differences in time scales*

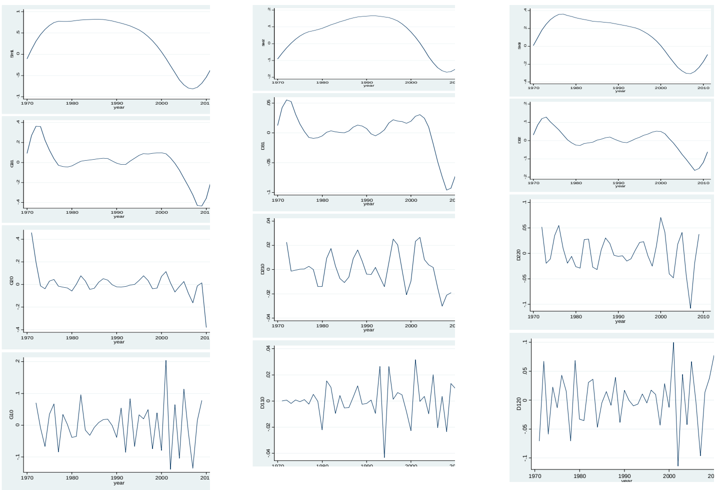
CATEGORIES OF SIGNIFICANT CASES

The combination of causality of manufacturing and agriculture on GDP are diverse. Either manufacturing or agriculture has positive causality or both the sectors have positive or they may have negative causality. In some countries, positive or negative impacts of manufacturing or agriculture appear only in a single time scale while in others it occurs in two or three time scales simultaneously. All the four cases (refer sections 3 above) are observed in all time scales at different frequencies. In Case 1, both manufacturing and agriculture is positively Granger causal on GDP of a country. In Case 2, manufacturing is positively Granger causal while agriculture is negatively Granger causal in the country. In Case 3, both the sectors are negatively Granger causal. In Case 4, agriculture is positively Granger causal while manufacturing is negatively Granger causal. Each case appears in more number of countries as the time scale increases (Tab 6).

Tab 6 : Four Observed cases

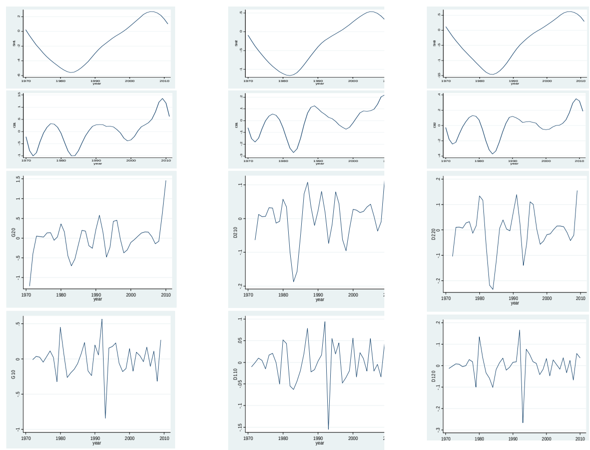
| **Cases** | **Time scale 1 ( $D_1$)** | **Time scale 2 ($D_2$)** | **Time scale 3 ($D_3$)** | **Smooth (S)** |
|---|---|---|---|---|
| **Case1 (**Both manufacturing and agriculture are positively Granger causal**)** | 7 | 7 | 13 | 16 |
| **Case2(** manufacturing is positively Granger causal, agriculture is negatively Granger causal to GDP) | 4 | 13 | 15 | 18 |
| **Case3(** Both sector are negative Granger causal**)** | 8 | 12 | 14 | 20 |
| **Case4(** Agriculture is positively Granger causal while manufacturing is negatively Granger causal) | 10 | 10 | 11 | 16 |
| **Total** | **29** | **42** | **53** | **70** |

Longer time scales reveal deeper structural factors that shape the progress of the economy. Changes in moving averages in longest time scale ($D_3$) and levels in longest moving averages(S) indicate such deep structural relations. Changes and levels of sectors in longer time scales reveal more number of significant cases. Economies falling in Case 1 category in both longer time scales ($D_3$ and S) are Cape Verde and Tunisia. Those falling in Case 2 category in the same time scales are Cameroon and Myanmar. Case 3 countries are Guinea and Zimbabwe, while those falling in category 4 are Iraq and Sao Tome and Principe. In terms of differences of averages of both the longer time scales $D_2$ and $D_{3,}$ the economies falling in Case 1 category are nil while those falling in Case 2 category are Central African Republic, Gambia and Lao Peoples Republic. Those falling in Category 3 in the same time scales simultaneously are Cambodia and Chad. Case 4 economies are Kenya, Malaysia, Maldives and Vietnam. The rest of the countries do not fall in the same category in the longer time scales simultaneously. Explaining the variation in structure of country at different time scales is left for future research.



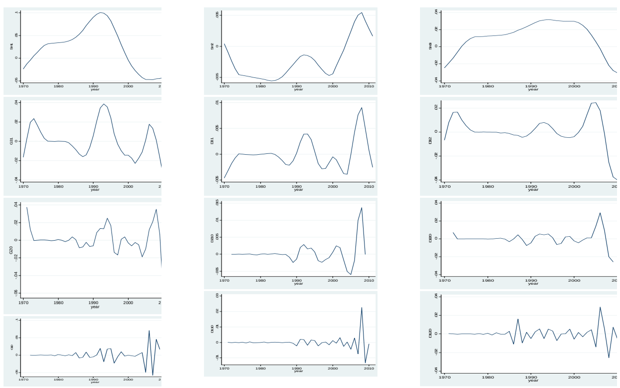
GDP Manufacturing Agriculture

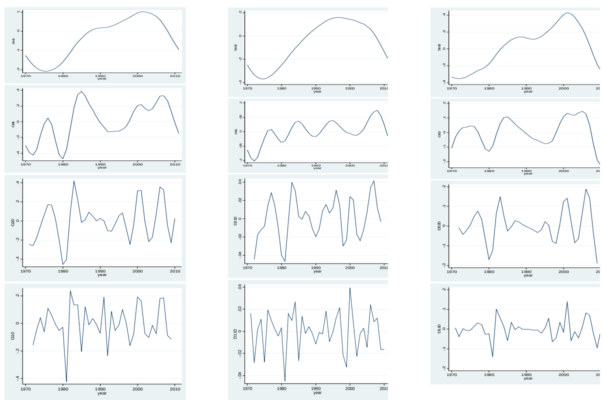
**a) A typical Case 1 country in S (Senegal)**



GDP Manufacturing Agriculture

**b) A typical Case 2 country in $D_3$ and S (Cameroon)**





GDP Manufacturing Agriculture

**c) A typical Case 3 country in $D_3$ and S (Guinea)**

GDP Manufacturing Agriculture

**d) A typical Case 4 country (Kenya) in $D_1$, $D_2$ and $D_3$**

Fig. 3 Typical Examples of the four cases

## 4.2 THE STRUCTURES OF THE ECONOMIES

The four cases and their combinations indicate the structure of the economy. In all cases, the structural relations manifest themselves in higher frequencies in longer time scales. The analyses indicate that the results depend on time scales, on the levels of the two driving sectors and on their growths or changes. The countries, the time scales, and the cases are tabulated in Appendix VI.

The total number of cases where manufacturing is positively Granger causal is the sum of case 1 and case 2. In these cases, manufacturing is disposed to drive the growth of the economy. Either the sector is leading the growth of the economy or its stagnation or decline has retarded the growth of the economies. Less than half of the economies have such a structure at the longest time scale. This structure indicates that the economies are ready for transformation through triggering growth of manufacturing. Countries revealing this structure in longer time scales of $D_3$ and S are those falling purely in cases 1 or 2 mentioned above and those that combine structures of case 1 and 2 as tabulated in Appendix VII, Table 1. Many other countries fall in this category in either of the time scales, but not in both. These countries, while they fall in either of the cases, they do not reveal other structures in the two time scales (Appendix VII: Tab 2)

In addition to these countries, others reveal positive Granger causality of manufacturing in one of the time scales while showing negative Granger causality in the other time scale. The explanation for such structure is left for future studies.

The total number of cases where agriculture is positively Granger causal is the sum of case 1 and case 4. Nearly half of the economies in the group have agricultural led structures in the longest time scale. That suggests these economies are substantially agricultural growth driven and require further structural reorientation towards manufacturing for transformation.

Negative causality of manufacturing occurs in cases 3 and 4. The number of economies with this structure increases as the time scale increases. Nearly half of the economies manifest such feature at the longest time scale. The occurrence of negative causality suggests that growth of these economies at that time scale is not driven by manufacturing. Manufacturing grows while GDP is declining or the other way round. In most of the countries, this structure does not reveal itself in all time scales at the same time. In economies where the structure appears in all time scales at the same time, the factors that have led the countries to have this structure require further investigation. One hypothesis, which emanates from the theoretical framework and conceptual model of this study, is that manufacturing is crowded out by other sectors and the economy is degenerating to service based growth where deindustrialization is taking place, which means manufactured goods production is giving way to services. The sustainability of growth in these economies is doubtful.

The total number of cases where agriculture is negatively Granger causal is the sum of case 2 and 3. In these cases, agriculture is either giving way to manufacturing or services. If agriculture is giving way to manufacturing, the economy is transforming. If services are replacing agriculture, the economy is likely to experience unsustainable growth. Slightly greater than half of the economies experience negative Granger causality of agriculture in the longest time scale (Tab 7).

Tab 7 : Positive and negative Granger Causalities

| **Cases** | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** |
|---|---|---|---|---|
| Total cases where manufacturing is positively Granger causal( case1+case2) | **11** | **20** | **28** | **34** |
| Total cases where manufacturing is negatively Granger causal(Cases3+4) | **18** | **22** | **25** | **36** |
| Total cases where Agriculture is positively Granger causal(Cases1+4) | **17** | **17** | **24** | **32** |
| Total cases where Agriculture is negatively Granger causal(Cases2+3) | **12** | **25** | **29** | **38** |

## 4.3 RESULTS VERSUS THE HYPOTHESIS

What was the outcome of interactions of sectors under the above structures? The hypothesis under test states that the economy in which manufacturing is driving the changes in GDP results in sustained growth. Whether sustained growth has occurred because of manufacturing or/and failure to attain sustained growth with agriculture driving the growth, can be checked using the attained per capita GDP in the economy after so long. The sector driving the economy is detected with Granger causality and the outcome of the drive is compared with the changes made in per capita GDP, i.e., positive or negative. Computed changes in per capita GDP are net of income from other sectors between 2011 and 1970 as shown in Appendix V. Using the Table 1 above, we detect cases supporting or not supporting the hypothesis. Appendix IV tabulates significant cases of Granger causality with the sign of impulse-responses in various time scales on the one hand, and the sign of changes in per capita GDP on the other hand. The same table indicates cases for and against the hypothesis.

Positive Granger causality of manufacturing entails a structure prone to transformation if manufacturing is given chance to grow. The economy tends to have long-term growth evidenced by higher per capita GDP if manufacturing is growing. Positive Granger causality of manufacturing, combined with the attainment of positive change in per capita GDP, provides strong support to the hypothesis. Positive Granger causality of manufacturing combined with lower actual performance in per capita GDP attainment provides weak support to the hypothesis as the economy could not grow with declining or stagnant manufacturing. Agricultural negative Granger causality coupled with lower performance in per capita GDP lent support to the hypothesis. Cases of negative Granger causality of manufacturing coupled with high performance in per capita GDP do not provide support to the hypothesis. Positive Granger causality of agriculture and higher performance in per capita GDP do not support the hypothesis.

The number of cases supporting the hypothesis either weakly or strongly across all time scales is much greater than that which do not support. Comparing results across time scales, cases that support the hypothesis are 24, 36, 44, and 52 while those not supporting the hypothesis are 5,6,10 and 18 in the respective time scale ordered from the lowest to the highest (Tab 10)[9]. The chi-square test of significance of the contingency table gives a p-value of 4.23331E-21.

A country may provide evidence in support of the hypothesis in one time scale while not supporting in another time scale. Cases where the results across all time scales do not support the hypothesis are only seven among the 71 countries, while those providing support simultaneously across all time scales are 46 in number. Eighteen countries provide support at some time scales while not supporting at other time scales. Thus, cases providing support in some or in all time scales are 64.

[9] Note that the table is constructed based on Appendix V

Tab 8: Cases for and against the hypothesis

| **Number of Cases** | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** |
|---|---|---|---|---|
| Weakly supporting the hypothesis | **6** | **11** | **12** | **23** |
| Strongly supporting the hypothesis | **18** | **25** | **32** | **29** |
| Either weakly or strongly supporting the hypothesis | **24** | **36** | **44** | **52** |
| Not supporting the hypothesis | **5** | **6** | **10** | **18** |
| Neither positive nor negative ( *cases of no Granger causality)* | **42** | **29** | **17** | **1** |
| Total number of countries | **71** | **71** | **71** | **71** |

There is no significant difference across regions in providing or denying support to the hypothesis. The proportion of supporting cases among the 43 African and 24 Asian & Pacific countries across time scales is as follows (Tab 9). Chi-square test of the contingency table indicates that the difference across regional distribution is not statistically significant (P value =1).

Tab9: Regional distribution of supporting and non-supporting cases

| | Time scale1 | Time scale 2 | Time scale 3 | smooth |
|---|---|---|---|---|
| Proportion of supporting cases from Africa | 0.28 | 0.53 | 0.56 | 0.74 |
| Proportion of supporting cases of Asian & Pacific region | 0.33 | 0.38 | 0.58 | 0.71 |
| Proportion of non-supporting cases from Africa | 0.09 | 0.09 | 0.12 | 0.26 |
| Proportion of non supporting cases of Asian & Pacific region | 0.04 | 0.04 | 0.17 | 0.21 |

The countries that do not provide support for the hypothesis are Guinea Bissau, Iraq, Kenya, Malaysia, Sao Tome and Principe, Zambia, and Zimbabwe. Taking the clearer case of Malaysia, the waveforms of GDP and Manufacturing at higher time scales are very similar, but still the orthogonalized impulse response indicate negative association. The waveforms support the hypothesis but the tests attest otherwise. This difference arises from the interaction of manufacturing and agriculture where the orthogonalized impulse-response could detect results different from what the similarity of the wave forms suggest. The cases against the hypothesis suggest a need for further investigation in the direction of the power of the test or in the direction of any other substantive explanation in future research.

Given the limitation posed by 42 years time span, the results are quite revealing. Longer time series would have allowed longer time scales to uncover long-run relations. Overall, the results seem to suggest that structure matters for sustained growth and the hypothesis "*Manufactured goods production growth has greater impact than agricultural goods production growth on sustained growth of low-income economies at large*" enjoys overwhelmingly large supportive cases. Those low-income countries with growing manufacturing sector that is positively associated with economic progress are more likely to experience sustained growth than those that rely on agriculture. Those low-income countries that have stagnated in manufacturing growth are likely to stagnate in the level of economic activities.

# 5 CONCLUSION AND POLICY IMPLICATIONS

The study tested he hypothesis that claims "*Manufactured goods production growth has greater impact than agricultural goods production growth on sustained growth of low-income economies at large*" with growth correlations across various time scales using Haar MODWT filtered time series data after orthogonalizing manufacturing and agriculture value added with other goods supplying sectors (construction, mining, utilities, and imports). The treatment of the two sectors alone has the methodological merit of allowing higher degree of freedom. The Haar wavelet computes the differences between averages of value added across various time scales and Granger-causality tests detect the possible causal relationship per time scale.

Positive Granger causality of manufacturing entails a structure conducive to transformation and the economy could grow in sustained manner, if circumstances in the economy allow manufacturing to grow. The analyses indicate that not only the changes but also the level of manufacturing sector matters. Positive Granger causality of manufacturing combined with higher actual performance in the attainment of per capita GDP provides strong support to the hypothesis. Agricultural negative Granger causality, coupled with lower performance in per capita GDP, lends support to the hypothesis from another angle. Few cases of negative Granger causality of manufacturing, coupled with high performance in per capita GDP, appeared as cases that do not provide support to the hypothesis. Some cases of positive Granger causality of agriculture and higher performance in per capita GDP appeared as cases against the hypothesis. Cases where the results across all time scales do not support the hypothesis are only seven among the 71 sample countries, while those providing support simultaneously across all time scales are 46 in number. Eighteen countries provide support at some time scales while not supporting at other time scales. Thus, cases providing support in some or in all time scales are 64.

Given the limitation posed by 42 years time span, the results are quite revealing. Longer time series would have allowed longer time scales that would enable to uncover long-run relations. Those low-income countries with growing manufacturing sector are more likely to experience sustained growth than those that rely on agriculture. Those low-income countries that have stagnated in manufacturing growth are likely to stagnate in the level of economic activities. This result thus lends credence to the hypothesis that "*Manufactured goods production growth has greater impact than agricultural goods production growth on sustained growth of low-income economies at large*"

The policy implication for Low Income Countries is that those economies the sectoral emphasis of which is non-manufacturing have to reconsider their strategies. The expansion of economic activities (growth of GDP) is likely to be more sustainable with growth of output of manufacturing. Manufacturing growth seems to enhance outputs of the rest of the sectors in the long-run as long run GDP growth is the result of all the sectors. Low income and under-industrialized countries have to enhance their manufacturing to achieve highly cherished goal of takeoff to sustained growth. As per the theoretical foundation of the study, manufacturing growth is driven by the accumulation of technology-embodied capital and this process faces unstable equilibrium, making it difficult to escape to sustained growth. Accumulation of technology embodying capital in the manufacturing sector requires policy support and intervention until it exceeds some critical stock. Identifying and removal of various obstacles is a major intervention. It would be rewarding to remove obstacles in front of manufacturing growth to ensure sustained growth.

The few cases that happened to be against the hypothesis should attract future researches to detect the exceptional underlying factors or the methodological limitations that led to that result. This study suggests reorganizing national accounts data that categorize transaction services, non-transaction services, and good producing sectors to uncover deeper relations and factors retarding manufacturing growth. Such effort will reorient policy in identifying and in promoting desirable structure for enhancement of long-term welfare of society.

One may wonder what the value added of the analysis is as it is known that countries cannot achieve high growth by relying on agriculture alone. Though this seems to be a generally shared view, the actual practices and policies pursued in low-income countries do not convince that shared view exists. The actual emphasis and policy support in these economies does not lie in developing manufacturing. Policymaking seems to luck the conviction on importance of manufacturing. There is a need to provide formal and convincing arguments to policymaking in this group of countries. This study provides a formal, theoretical and empirical basis, which goes beyond back-of-the-envelope calculations, for policymaking or for inspiring further studies addressing the crucial issues of failure to attain sustained growth by LICs. The causality analysis and the introduction of different time scales in detecting contributions of sectors and the structural relations to sustained growth provide firm basis to the arguments.

## REFERENCES


Acemeglu, D. and Robinson J.A (2012) Why *Nations Fail: the Origins of Power, Prosperity, and Poverty* , Crown publishing Group New York

Banerjee, A and Duflo E (2005) Growth Theory through the Lens of Development Economics in P. Aghion and S. Durlauf (eds), *Handbook of Economic Growth*, Vol.1A, Amsterdam: Elsevier, pp. 473–552.

Bairoche,P.(1995) *Economics and World History: Myths and Paradoxes* The University of Chicago Press

Baumol W. J. (1967) Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis. *The American Economic Review,* Vol.57 No.3

Collier P. (2007) *The Bottom Billion: Why The Poorest Countries Are Ailing and What Can Be Done About It* Oxford University Press Inc 198 Madison Avenue New York, New York 10016

Dopfer,K.(2011) Mesoeconomics: Bridging Micro and Macro in a Schumpeterian Key, in Mann, S. (2011)(ED) *Sectors matter*, Springer Heildelberg Dordrecht London, New York

Han L. and Neumann M. (2007) Inner Product Spaces, Orthogonal Projection, Least Squares, and Singular Value Decomposition, in Hogben L( EDs) *Handbook of Linear Algebra*, Taylor & Francis Group, LLC

Hacker R. S., Karlsson H. K. and Månsson K (2012) The Relationship between Exchange Rates and Interest Rate Differentials: A Wavelet Approach , *The World Economy* doi: 10.1111/j.1467-9701.2012.01466.x

Hamilton,J.D (1994) *Time series Analysis* Princeton University Press, Princeton , New York

Hansen ,G.D and Prescott,E.C(2002) *Malthus to Solow.* The American Economic Review , Vol 92, No.4 (Sep., 2002) 1205-1217

Hausmann R · Hwang J · Rodrik D(2007) What you export matters. *Journal of Economic Growth* 12:1–25 DOI 10.1007/s10887-006-9009-4 Published online: 30 December 2006 © Springer Science+Business Media, LLC 2006

Hausmann R, Rodrik D Economic development as self-discovery. *Journal of Development*

*Economics* 72 (2003) 603– 633 Elsevier
Hewitt,T. , Johnson H, Wield D ( Ed)( 1992) *Industrialization And Industrial Development*, Oxford University Press In Association With The Open University, Walten Street Oxford OX2 6dp UK
Jiang, C.N. and Koltko, O.( 2014) Doing Business Report , *World Bank Group*, Washington DC
Jorgenson D W. (1984) The Role of Energy in Productivity Growth. *The American Economic Review*, Vol. 74, No. 2, Papers and Proceedings of the Ninety-Sixth Annual Meeting of the American Economic Association (May, 1984), pp. 26-30:
American Economic Association Stable URL: http://www.jstor.org/stable/1816325
Kaiser G.(1994) *A Friendly Guide to Wavelets*. Reprint of the 1994 Edition, Birkhauser
Kaldor, N. (1966) *Causes of the Slow Growth in the United Kingdom*, Cambridge: Cambridge University Press
Kaplinsky R. Morris M( 2000 ) *A Handbook For Value Chain Research Prepared For IDRC*
Krugman, P. (1981) Trade accumulation and Uneven Development, *Journal of Development Economics* 81499161. North-Holland Publishing Company
Kuznets, S.(1966) *Modern Economic Growth : Rate Structure and Spread* Yale University Press, New Haven and London
Kuznets, S. (1989) in Galambos,L. and Gallman, R(1989)(ED) Economic Development, the family , and Income Distribution: *Studies in Economic History and Policy , The United States in the Twentieth Century* , Cambridge University Press , Cambridge
Lewis A. (1954) Dutt A K and Ros J(2008)(edt) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA
Lin J Y (2012) *New Structural Economics A Framework for Rethinking Development and Policy* The World Bank 1818 H Street NW Washington DC 20433
Lipsey RG, Carlaw KI and Bekar CT(2005) *Economic Transformations : general purpose technologies and long-term economic growth* Oxford University Press Inc., NY
Lutkepohl,H. (2005) *New Introduction to Multiple Time Series Analysis*, Springer, Berlin Heidelberg New York
Maddisson, A. (2003) *The World Economy: Historical Statistics* OECD: Development Center Studies
Maddisson, A. (2005) *Growth and Interaction in the World Economy: The Roots of Modernity*, AEI Press; Washington D.C
Mann, S. (2011)(ED) Sectors matter, Springer
Månsson, K (2012) A Wavelet-Based Approach of Testing for Granger Causality in the Presence of GARCH Effects *Communications in Statistics - Theory and Methods*, 41:4, 717-728, DOI: 10.1080/03610926.2010.529535
Mcmahon G and Squire L(2003) (ED)*Explaining Growth : A global Research Project*. Palgrave Macmillan Houndmills, Basingstoke, Hampshire Rg21 6xs And175 Fifth Avenue, NewYork, N. Y. 10010
Palma, 2008 Dutt A K and Ros J(2008)(ED) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA
Partente, S.L and Prescott, E.C(2003) A Unified Theory of the Evolution of International Income Level, Preliminary
URl http://www.nbp.pl/konferencje/radisson/Mowcy/prescot/prescott_paper.pdf
Percival D.B and Walden A.T.( 200?). *Wavelet Methods for Time series Analysis* Cambridge University Press New York
Partente, S.L and Prescott, E.C(1999) Barriers to Riches , *The third Walras – Pareto lecture* , Universoty of Lausanne, Revised October 1999

Pasinetti L.(1993) *Structural economic Dynamics : A theory of the economic consequences of human learning* Cambridge University Press

Patterson, K (2000) *An Introduction to Applied Econometrics: A time series approach* Palgrave

Pyka,A. Saviotti,P.P.( 2011 ) Economic Growth Through Emergence of New Sectors in Mann, S. (2011)(ED) *Sectors matter*, Springer

Rapley, J.(2002) *Understanding Development* ;Lynne Rienner Publishers, Inc.3 henrietta street, Covent Garden, London WC2E 8LU

Ray D. (2000) *What's New in Development Economics*? New York University ` www.efm.bris.ac.uk/ecjrwt/raymult.pdf

Rodrik D.(2007) *One Economics . Many Recipes: Globalization, Institutions, And Economic Growth.* Princeton University Press, 41 William Street, Princeton, New Jersey 08540

Ros(2008 Dutt A K and Ros J(2008)(edt) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA

Sachs J. D. (2005) *The End Of Poverty Economic Possibilities For Our Time* The Penguin Press New York

EC, IMF, OECD, UN and WB (2009) *System of National Accounts 2008*-, http://unstats.un.org/unsd/nationalaccount/sna2008.asp

Solow, R. M (1956) A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics* (The MIT Press) 70 (1): 65–94

Solow, R. M (1957) Technical Change and the Aggregate Production Function. *Review of Economics and Statistics* (The MIT Press) 39 (3): 312–320

Syrquin,( 2008) in Dutt A K and Ros J(2008)(ED) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA

Szenberg M. (2004)(ED) *New Frontiers in Economics* Cambridge University Press

Takashima, M. (2009) The Sustained Growth and Its Relation to the Initial Conditions Basu, D.(2009) (ED) *Advances in Development Economics* World Scientific Publishing Co. Pte. Ltd.5 Toh Tuck Link, Singapore 596224

Tesfatsion,L. and Judd K.L.( 2006 ED) *Handbook of Computational Economics, Agent based computational economics Volume 2* , Elsevier

Tesfatsion,L(2005) *Agent-Based Computational Modeling and Macroeconomics* ISU Economic Report 05023

United Nations Statistics Division, National Accounts Main Aggregates Database, December 2013 URL http://unstats.un.org/unsd/snaama/dnlList.asp

United Nations Industrial Development Organization and United Nations Conference On Trade And Development ( 2011) Fostering Industrial Development In Africa In The New Global Environment *Economic Development In Africa Report* 2011

United Nations Industrial Development Organization (2009): New Industrial Challenges For The Bottom Billion And The Middle Income Countries *Industrial Development Report 2009 Breaking In And Moving Up* Unido Id No: 438

United Nations statistics Division (2013) United Nations National Accounts Main Aggregates Database unstats.un.org/unsd/snaama/ Introduction .asp

United Nations Department of Economic and Social Affairs( 2008) International Standard Industrial Classification of All Economic Activities Revision 4 ST/ESA/STAT/SER.M/4/Rev.4 UNITED NATIONS PUBLICATION, New York

Wallis J.J. and North, D. (1986) Measuring the Transaction Sector in the American Economy, 1870-1970 URL: http://www.nber.org/chapters/c9679

Wallis J.J and North D (, 1988) Should Transaction Costs be Subtracted from Gross National Product ? *The Journal of Economic History*, Vol. 48, No. 3 pp. 651-654 Published by:

Cambridge University Press on behalf of the Economic History Association
Stable URL: http://www.jstor.org/stable/2121542
WB (2009) Reshaping Economic Geography *World Development Report*, Washington DC
Yoshikawa,H. and Miyakawa S(2011) Changes in Industrial Structure and Economic Growth : Post war Japanese Experience" in Mann, S. (2011)(ED) *Sectors matter*, Springer Heildelberg Dordrecht London, New York

## APPENDIX 1: INDEX OF SYMBOLS

| | |
|---|---|
| $\alpha$ | *Parameter representing share of capital* |
| $\beta$ | *Parameter signifying diminishing returns in agriculture* |
| $\delta$ | *Rate of depreciation of capital in manufacturing* |
| $\eta$ | *The efficiency of attaining potential output* |
| $\theta$ | *A ratio of labor productivity in subsistence agriculture to that in modern sector* |
| $\lambda$ | *Part of saving rate wasted as leakage* |
| $\mu$ | *A parameter of increasing returns and externalities in manufacturing* |
| $\nu$ | *The ratio of effective capital to total capital in manufacturing* |
| $\varsigma$ | *The minimum labor required to conduct most efficient transactions in agriculture or it is the lower limit of* $\psi$ |
| $\Sigma$ | *covariance matrix* |
| $\varphi$ | *Manufacturing labor diverted to transaction services in manufacturing* |
| $\psi$ | *Agricultural labor diverted to transaction services in agriculture* |
| $\omega$ | *Capital used in transaction services in and for manufacturing* |
| Ag | *Value added of Agriculture and the associated services* |
| $b_1$ | *A parameter relating agricultural goods value added with services value added arising from agriculture* |
| $b_2$ | *A parameter relating manufactured goods value added with services value added arising from manufacturing* |
| c | *The minimum capital required to conduct most efficient transactions in and for manufacturing* |
| Cn | *Aggregate Consumption* |
| $D_j$ | *Details* |
| S | *Smooth* |
| K | *Technology embodying capital* |
| $K^*$ | *Critical capital stock* |
| L | *Labor input in manufacturing* |
| M | *Value added of manufacturing and the associated services* |
| $M^g$ | *Goods value added in manufacturing sector* |
| $Q_t$ | *Information set containing all the relevant information in the universe* |
| R | *Total labor input available to subsistence agriculture* |
| $\bar{R}$ | *Per capita output in agriculture* |
| r | *The efficiency in attaining potential output with effective agricultural labor input* |
| s | *Aggregate saving rate* |
| Ser | *Service value added* |
| u | *Exponential parameter of the multiplier of goods value added to include the arising service* |
| Y | *Total value added of the economy* |

## APPENDIX II: ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AIC | Akaike Information criterion |
| CWT | Continuous Wavelet Transform |
| DWT | Discrete Wavelet Transform |
| FPE | Final Prediction Error( Criterion) |
| GDP | Gross Domestic Product |
| HQIC | Hannan Quinn Information Criteria |
| IR | Impulse-Response |
| ISI | Import Substitution Industrialization |
| LIC | Low Income Countries |
| MODWT | Maximum Overlap Discrete Wavelet Transform |
| MSE | Mean Squared Error |

| | |
|---|---|
| PCI | Per - Capita Income |
| SBIC | Schwartz Bayesian Information Criterion |
| UN SNA | United Nations System of National Accounts |
| USD | United States Dollar |
| UNIDO | United Nations Industrial Development Organization |
| UNCTAD | United Nations Conference of Trade and Development |
| VAR | Vector Auto Regressive |
| VECM | Vector Error Correction Model |

## APPENDIX III: WAVELETS

A wavelet is any function that integrates to zero and is square integrable to one (Percival and Walden, 2000; Kaiser G.1994). It is expressed as a real valued function ψ (.) defined over the real axis (-∞, ∞) satisfying two properties: namely

(1) The integral of ψ (.) is zero, i.e. $\int_{-\infty}^{\infty} \psi(\mathrm{u})\, \mathrm{du} = 0$

(2) The square of ψ (.) integrates to unity, i.e., $\int_{-\infty}^{\infty} \psi(\mathrm{u})^2\, du = 1.$ (14)

With this definition in hand, we may look for functions fulfilling the two conditions. To that effect we begin with an expression of the **difference in averages** of a function X(u) at time t in an averaging time scale (λ ), which may be a year, two years, etc.

$$\mathrm{D}(\lambda, \mathrm{t}) = \frac{1}{\lambda}\left[\int_{\mathrm{t}}^{\mathrm{t}+\lambda} \mathrm{X(u)du} - \int_{\mathrm{t}-\lambda}^{\mathrm{t}} \mathrm{X(u)du}\right] \qquad (15)$$

Since the two integrals above are integrals over adjacent non-overlapping intervals, they can be combined into a single integral over the entire real axis with definition of domains for the functions as:

$$\mathrm{D}(\lambda, \mathrm{t}) = \int_{-\infty}^{\infty} \mathrm{V}_{\lambda,\mathrm{t}}(\mathrm{u})\mathrm{X(u)du}), \qquad (16)$$

$$\text{where } \mathrm{V}_{\lambda,\mathrm{t}}(\mathrm{u}) = -\frac{1}{\lambda} \quad \text{if } \mathrm{t}\text{-}\lambda < u \leq \mathrm{t}$$
$$= \frac{1}{\lambda} \quad \text{if } \mathrm{t} < u \leq \mathrm{t} + \lambda$$
$$= 0 \quad \text{otherwise}$$

The differences of averages on a unit time scale (λ) and at a center time t (the middle of the interval) is equivalent to integrating the product of the time series data (represented by the function $\mathrm{X(u)}$) and a function $\mathrm{V}_{\lambda,\mathrm{t}}(\mathrm{u})$. The function $\mathrm{V}_{\lambda,\mathrm{t}}(\mathrm{u})$ would fulfill the definition for wavelet if divided by a constant $\sqrt{2}$ :

$$\text{Where, } \int_{-\infty}^{\infty} \frac{V_{\lambda,t}(u)}{\sqrt{2}} = -\frac{1}{\sqrt{2\lambda}} + \frac{1}{\sqrt{2\lambda}} = 0 \quad \text{and} \quad \int_{-\infty}^{\infty} \left(\frac{V_{\lambda,t}(u)}{\sqrt{2}}\right)^2 du = 1 \qquad (17)$$

$\frac{V_{\lambda,t}(u)}{\sqrt{2}}$ is a particular wavelet known as Haar wavelet $(V_{\lambda,t}{}^{H}(u))$.

Since $\lambda$=1 $\quad V_{\lambda,t}{}^{H}(u) = -\frac{1}{\sqrt{2}}$ if t-$1 < u \leq t$

$= \frac{1}{\sqrt{2}}$ if t $< u \leq t+1$

$=$ 0 elsewhere,

At other time scales $V_{\lambda,t}{}^{H}(u) = \frac{-1}{\sqrt{2\lambda}}$ if t-$1 < u \leq t$

$= \frac{1}{\sqrt{2\lambda}}$ if t $< u \leq t+1$

$=$ 0 elsewhere

Thus $D(\lambda, t) = \int_{-\infty}^{\infty} \sqrt{2} V_{\lambda t}{}^{H}(u)\, X(u) du$ and $\frac{D(\lambda,t)}{\sqrt{2}}$ is designated $W(\lambda, t)$

$$W(\lambda, t) = \int_{-\infty}^{\infty} V_{\lambda,t}{}^{H}(u)\, X(u) du \qquad (18)$$

The time series transformed by varying λ continuously in $W^{H}(\lambda, t) = \int_{-\infty}^{\infty} V_{\lambda,t}{}^{H}(u) X(u) du$ is the Haar Continuous Wavelet Transform (CWT). **X**(u) can be recovered from the integral of the product of $W^{H}(\lambda, t)$ and $V_{\lambda,t}{}^{H}(u)$. The Discrete Wavelet Transform (DWT) may be thought as purposeful sub sampling of CWT with dyadic scales i.e., picking only λ of $2^{J-1}$ and t separated by multiples of $2^{J}$ where J=1,2, 3…. In DWT analysis of any time series X (u), we make use of wavelets $h_J$ formed as basis-vectors, representing the time scales and shifts within a time scales, wavelet coefficients $w$, formed from matrix multiplication of these basis-vectors with **X** , an averaging vector $\boldsymbol{v}$ on the basis of the highest time scale, and a scaling coefficient $\mathbf{v}$ formed as a dot product of $\boldsymbol{v}$ and **X** . If we designate $D = h_J' w$ and $v'\mathbf{v}=\mathbf{S}$ , recovering **X** from wavelet transforms goes as

$$\mathbf{X} = (\textstyle\sum_{j=1}^{J} \mathbf{D_j}) + \mathbf{S} \qquad (19)$$

This is a **multi-resolution** analysis of **X** where $\mathbf{D_j}$ are the details representing the differences of averages on various time scale and **S** is the smooth representing the moving average of the data on the highest time scale .

The wavelets of DWT are orthogonal. The averages and average of averages, formed from the DWT wavelets are sensitive to beginnings of the data points for averaging. The size of DWT wavelets is limited to the dyadic series and hence may suffer from too few observations for analysis. To overcome the deficiencies of DWT a modified version of DWT, which is Maximum Overlap Discrete wavelet Transform (MODWT), is used, although the orthogonality that is characteristic of DWT is lost in MODWT. In MODWT, the data is taken in circular fashion where the ends become adjacent points. At lower scales, this operation heavily distorts the differences of averages and hence the differences of the averages at the ends have to be dropped.

## APPENDIX IV

**AGRICULTURAL, MANUFACTURING AND TOTAL VALUE ADDED AT CONSTANT 2005 PRICES IN MILLIONS US DOLLARS IN TEN YEARS INTERVALS (TAKEN FROM UNITED NATIONS MAIN AGGREGATES DATABASE)**

**(before orthogonalization )**

| COUNTRY | SECTOR | 1970 | 1980 | 1990 | 2000 | 2010 | COUNTRY | SECTOR | 1970 | 1980 | 1990 | 2000 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Afghanistan | Agriculture, | 4725 | 5036 | 1990 | 1938 | 2639 | Maldives | Agriculture, | 17 | 25 | 44 | 54 | 60 |
| | Manufacturing | 682 | 843 | 1165 | 592 | 1248 | | Manufacturing | 2 | 5 | 18 | 41 | 62 |
| | Total Value Added | 6255 | 6938 | 5700 | 3480 | 9776 | | Total Value Added | 62 | 113 | 450 | 850 | 1528 |
| Bangladesh | Agriculture, | 5864 | 5706 | 7250 | 9844 | 13815 | Mali | Agriculture, | 473 | 765 | 1306 | 1442 | 2706 |
| | Manufacturing | 2257 | 2729 | 3511 | 6567 | 13530 | | Manufacturing | 108 | 105 | 224 | 414 | 382 |
| | Total Value Added | 16205 | 18157 | 26753 | 42558 | 75275 | | Total Value Added | 994 | 1475 | 2598 | 3813 | 6580 |
| Benin | Agriculture, | 279 | 377 | 704 | 1198 | 1667 | Mauritania | Agriculture, | 755 | 538 | 540 | 576 | 657 |
| | Manufacturing | 137 | 144 | 164 | 284 | 373 | | Manufacturing | 43 | 60 | 95 | 180 | 140 |
| | Total Value Added | 1069 | 1433 | 2079 | 3287 | 4801 | | Total Value Added | 1186 | 1047 | 1265 | 1655 | 2604 |
| Bhutan | Agriculture, | 55 | 84 | 143 | 160 | 196 | Mongolia | Agriculture, | 226 | 396 | 516 | 512 | 551 |
| | Manufacturing | 4 | 4 | 22 | 43 | 113 | | Manufacturing | 43 | 75 | 139 | 95 | 206 |
| | Total Value Added | 85 | 126 | 333 | 547 | 1237 | | Total Value Added | 603 | 1058 | 1741 | 1696 | 2981 |
| Bolivia | Agriculture, | 398 | 596 | 707 | 947 | 1228 | Morocco | Agriculture, | 4001 | 4646 | 6726 | 5605 | 11373 |
| | Manufacturing | 452 | 724 | 677 | 955 | 1419 | | Manufacturing | 2276 | 3914 | 5955 | 7727 | 10031 |
| | Total Value Added | 3058 | 4778 | 4813 | 7154 | 10203 | | Total Value Added | 14104 | 22790 | 34575 | 43580 | 71320 |
| Botswana | Agriculture, | 79 | 174 | 197 | 202 | 234 | Mozambique | Agriculture, | 547 | 799 | 868 | 1122 | 2328 |
| | Manufacturing | 14 | 84 | 215 | 302 | 452 | | Manufacturing | 213 | 313 | 213 | 466 | 1082 |
| | Total Value Added | 328 | 1350 | 3995 | 7626 | 11112 | | Total Value Added | 1663 | 2435 | 2366 | 3940 | 8644 |
| Burkina Faso | Agriculture, | 439 | 436 | 629 | 1283 | 2960 | Myanmar | Agriculture, | 1122 | 1756 | 1984 | 3478 | 7697 |
| | Manufacturing | 177 | 269 | 351 | 391 | 486 | | Manufacturing | 157 | 218 | 234 | 525 | 3823 |
| | Total Value Added | 1117 | 1594 | 2147 | 3502 | 7314 | | Total Value Added | 2020 | 2998 | 3356 | 6373 | 20340 |
| Burundi | Agriculture, | 361 | 416 | 574 | 488 | 475 | Nepal | Agriculture, | 1131 | 1156 | 1805 | 2292 | 3193 |
| | Manufacturing | 79 | 148 | 252 | 132 | 168 | | Manufacturing | 82 | 109 | 237 | 610 | 664 |
| | Total Value Added | 555 | 735 | 1171 | 970 | 1577 | | Total Value Added | 2256 | 2619 | 4121 | 6736 | 9788 |
| Cambodia | Agriculture, | 1236 | 590 | 1053 | 1510 | 2480 | Niger | Agriculture, | 977 | 720 | 770 | 1074 | 2018 |
| | Manufacturing | 194 | 93 | 157 | 586 | 1617 | | Manufacturing | 47 | 143 | 162 | 163 | 216 |
| | Total Value Added | 2624 | 1253 | 2061 | 3822 | 8080 | | Total Value Added | 1923 | 2132 | 2064 | 2568 | 4042 |
| Cameroon | Agriculture, | 928 | 1803 | 2099 | 2647 | 3953 | Nigeria | Agriculture, | 12004 | 9468 | 13250 | 18528 | 51156 |
| | Manufacturing | 719 | 1292 | 2114 | 2513 | 2992 | | Manufacturing | 524 | 1849 | 2170 | 2060 | 4710 |
| | Total Value Added | 5053 | 9323 | 11426 | 12836 | 17700 | | Total Value Added | 32932 | 44918 | 52853 | 65027 | 153359 |
| Cape Verde | Agriculture, | 47 | 63 | 77 | 97 | 149 | Occupied | Agriculture, | 75 | 173 | 245 | 382 | 338 |
| | Manufacturing | 12 | 13 | 24 | 41 | 45 | Palestinian | Manufacturing | 113 | 258 | 377 | 513 | 520 |
| | Total Value Added | 206 | 222 | 373 | 693 | 1249 | Territory | Total Value Added | 566 | 1299 | 1863 | 3636 | 5018 |
| Central African | Agriculture, | 317 | 383 | 475 | 668 | 776 | Pakistan | Agriculture, | 6901 | 8685 | 12860 | 19852 | 25844 |
| Republic | Manufacturing | 55 | 76 | 80 | 80 | 101 | | Manufacturing | 2186 | 3710 | 8147 | 11883 | 23943 |
| | Total Value Added | 895 | 956 | 1073 | 1316 | 1451 | | Total Value Added | 18252 | 28691 | 52088 | 79779 | 126403 |
| Chad | Agriculture, | 595 | 510 | 537 | 1002 | 1641 | Papua New | Agriculture, | 645 | 768 | 973 | 1505 | 1841 |
| | Manufacturing | 137 | 94 | 256 | 226 | 410 | Guinea | Manufacturing | 174 | 203 | 189 | 273 | 399 |
| | Total Value Added | 1625 | 1296 | 2168 | 2864 | 6770 | | Total Value Added | 2103 | 2487 | 2853 | 4240 | 6329 |
| Comoros | Agriculture | 53 | 84 | 122 | 164 | 211 | Paraguay | Agriculture, | 363 | 697 | 1032 | 1211 | 2267 |
| | Manufacturing | 5 | 8 | 12 | 15 | 18 | | Manufacturing | 338 | 751 | 929 | 992 | 1130 |
| | Total Value Added | 143 | 227 | 302 | 343 | 434 | | Total Value Added | 1702 | 3840 | 5112 | 5989 | 8892 |
| Congo | Agriculture, | 126 | 170 | 225 | 203 | 332 | Philippines | Agriculture, | 5388 | 7984 | 8956 | 10940 | 14496 |
| | Manufacturing | 74 | 93 | 174 | 131 | 342 | | Manufacturing | 8002 | 14496 | 15842 | 20441 | 29503 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Total Value Added | 1468 | 2651 | 4385 | 4888 | 7707 |
| Democratic | Agriculture, | 2636 | 2754 | 3598 | 3347 | 4140 |
| Republic of the | Manufacturing | 784 | 1609 | 1356 | 333 | 460 |
| Congo | Total Value Added | 8474 | 8746 | 9896 | 5740 | 9144 |
| Djibouti | Agriculture, | 11 | 11 | 15 | 19 | 30 |
| | Manufacturing | 12 | 18 | 17 | 14 | 23 |
| | Total Value Added | 326 | 381 | 494 | 554 | 806 |
| Egypt | Agriculture, | 4482 | 5796 | 7963 | 10931 | 15231 |
| | Manufacturing | 1906 | 2841 | 7036 | 12954 | 20761 |
| | Total Value Added | 11727 | 25517 | 50683 | 74712 | 121780 |
| Equatorial | Agriculture, | 78 | 99 | 119 | 182 | 229 |
| Guinea | Manufacturing | 1 | 2 | 2 | 4 | 16 |
| | Total Value Added | 249 | 318 | 381 | 2538 | 10122 |
| Ethiopia | Agriculture | 2506 | 2840 | 2877 | 4242 | 7967 |
| (Former) | Manufacturing | 164 | 240 | 313 | 520 | 1026 |
| | Total Value Added | 3643 | 4780 | 5730 | 16756 | 39905 |
| Gambia | Agriculture | 114 | 109 | 104 | 152 | 230 |
| | Manufacturing | 12 | 18 | 26 | 31 | 40 |
| | Total Value Added | 226 | 274 | 396 | 542 | 749 |
| Ghana | Agriculture, | 2533 | 2855 | 2953 | 4082 | 6521 |
| | Manufacturing | 2008 | 1672 | 1830 | 1372 | 1942 |
| | Total Value Added | 6528 | 6601 | 8316 | 12732 | 22835 |
| Guinea | Agriculture, | 209 | 280 | 366 | 548 | 601 |
| | Manufacturing | 54 | 72 | 96 | 150 | 199 |
| | Total Value Added | 917 | 1227 | 1643 | 2342 | 2955 |
| Guinea-Bissau | Agriculture, | 139 | 89 | 186 | 237 | 299 |
| | Manufacturing | 90 | 100 | 98 | 74 | 73 |
| | Total Value Added | 293 | 365 | 560 | 567 | 654 |
| Haiti | Agriculture, | 1026 | 1193 | 1294 | 886 | 851 |
| | Manufacturing | 527 | 1175 | 969 | 376 | 348 |
| | Total Value Added | 2479 | 4012 | 4091 | 3841 | 4031 |
| Honduras | Agriculture, | 485 | 635 | 828 | 1063 | 1413 |
| | Manufacturing | 385 | 710 | 951 | 1405 | 2022 |
| | Total Value Added | 2324 | 4150 | 5130 | 7178 | 11671 |
| India | Agriculture, | 61855 | 71753 | 100984 | 127915 | 174403 |
| | Manufacturing | 15937 | 23630 | 48979 | 86748 | 188591 |
| | Total Value Added | 137942 | 186778 | 322153 | 556152 | 1174103 |
| Indonesia | Agriculture, | 12513 | 18190 | 25682 | 32049 | 44993 |
| | Manufacturing | 2556 | 10019 | 31735 | 61460 | 94886 |
| | Total Value Added | 38441 | 81617 | 150188 | 226918 | 377284 |
| Iraq | Agriculture, | 1326 | 1541 | 2391 | 2658 | 2730 |
| | Manufacturing | 370 | 1300 | 1129 | 1206 | 1164 |
| | Total Value Added | 18918 | 39513 | 34540 | 53273 | 59431 |
| Kenya | Agriculture, | 1556 | 2252 | 3331 | 3853 | 4821 |
| | Manufacturing | 354 | 922 | 1472 | 1676 | 2445 |
| | Total Value Added | 4825 | 7997 | 12421 | 14170 | 20683 |
| Lao People's | Agriculture, | 211 | 303 | 527 | 827 | 1144 |
| Democratic | Manufacturing | 14 | 20 | 46 | 144 | 347 |
| Republic | Total Value Added | 411 | 590 | 1042 | 1857 | 3845 |
| Lesotho | Agriculture, | 112 | 134 | 128 | 137 | 123 |
| | Manufacturing | 12 | 23 | 65 | 141 | 277 |
| | Total Value Added | 292 | 482 | 728 | 1097 | 1576 |
| Liberia | Agriculture, | 303 | 451 | 343 | 607 | 561 |
| | Manufacturing | 33 | 55 | 42 | 27 | 56 |
| | Total Value Added | 926 | 1198 | 601 | 788 | 927 |
| Madagascar | Agriculture, | 754 | 800 | 987 | 1178 | 1458 |
| | Manufacturing | 462 | 552 | 469 | 580 | 699 |
| | Total Value Added | 2760 | 3085 | 3419 | 4163 | 5293 |
| Malawi | Agriculture, | 300 | 457 | 524 | 861 | 1088 |
| | Manufacturing | 81 | 140 | 211 | 214 | 372 |
| | Total Value Added | 806 | 1474 | 1817 | 2352 | 3841 |
| Malaysia | Agriculture, | 3316 | 6530 | 9406 | 10142 | 13536 |
| | Manufacturing | 1573 | 5024 | 12219 | 31533 | 44957 |
| | Total Value Added | 14141 | 32365 | 57890 | 113908 | 176200 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Total Value Added | 28537 | 50891 | 61289 | 82358 | 131138 |
| Rwanda | Agriculture, | 379 | 685 | 719 | 749 | 1258 |
| | Manufacturing | 71 | 127 | 151 | 115 | 246 |
| | Total Value Added | 755 | 1306 | 1564 | 1682 | 3585 |
| Sao Tome and | Agriculture, | 8 | 14 | 14 | 20 | 28 |
| Principe | Manufacturing | 4 | 7 | 6 | 7 | 10 |
| | Total Value Added | 50 | 91 | 83 | 97 | 153 |
| Senegal | Agriculture, | 768 | 725 | 957 | 1206 | 1536 |
| | Manufacturing | 345 | 452 | 742 | 955 | 1268 |
| | Total Value Added | 2779 | 3292 | 4494 | 6086 | 9105 |
| Sierra Leone | Agriculture, | 512 | 644 | 918 | 420 | 1124 |
| | Manufacturing | 51 | 73 | 61 | 27 | 50 |
| | Total Value Added | 1158 | 1477 | 1929 | 884 | 2034 |
| Solomon | Agriculture, | 41 | 84 | 99 | 103 | 155 |
| Islands | Manufacturing | 6 | 13 | 17 | 25 | 24 |
| | Total Value Added | 106 | 218 | 296 | 375 | 501 |
| Somalia | Agriculture, | 1072 | 1295 | 1697 | 1060 | 1399 |
| | Manufacturing | 34 | 49 | 36 | 41 | 56 |
| | Total Value Added | 1411 | 1849 | 2263 | 1741 | 2316 |
| Sri Lanka | Agriculture, | 1,426 | 1,855 | 2,271 | 2,842 | 3,765 |
| | Manufacturing | 794 | 1,233 | 1,949 | 4,181 | 6,225 |
| | Total Value Added | 5,138 | 7,861 | 11,789 | 20,096 | 33,252 |
| Sudan | Agriculture, | 3271 | 3643 | 3828 | 9985 | 16191 |
| (Former) | Manufacturing | 433 | 609 | 795 | 1735 | 3755 |
| | Total Value Added | 6196 | 9106 | 11940 | 23838 | 46741 |
| Swaziland | Agriculture, | 55 | 115 | 163 | 173 | 183 |
| | Manufacturing | 39 | 128 | 576 | 741 | 786 |
| | Total Value Added | 356 | 746 | 1414 | 1862 | 2361 |
| Syrian Arab | Agriculture, | 1023 | 2771 | 2771 | 4858 | 5219 |
| Republic | Manufacturing | 290 | 514 | 456 | 141 | 1205 |
| | Total Value Added | 4345 | 11037 | 12534 | 22208 | 36081 |
| Thailand | Agriculture, | 4999 | 7341 | 10500 | 15249 | 18342 |
| | Manufacturing | 3534 | 9227 | 23653 | 41211 | 70840 |
| | Total Value Added | 22338 | 43719 | 93644 | 144620 | 226034 |
| Togo | Agriculture, | 281 | 368 | 572 | 764 | 1032 |
| | Manufacturing | 60 | 127 | 125 | 159 | 211 |
| | Total Value Added | 885 | 1347 | 1501 | 1864 | 2237 |
| Tonga | Agriculture, | 18 | 26 | 41 | 44 | 39 |
| | Manufacturing | 10 | 18 | 20 | 17 | 17 |
| | Total Value Added | 76 | 118 | 173 | 208 | 232 |
| Tunisia | Agriculture, | 862 | 1512 | 2022 | 2732 | 3148 |
| | Manufacturing | 503 | 1600 | 2652 | 4489 | 6267 |
| | Total Value Added | 6660 | 12231 | 15667 | 23888 | 37543 |
| Tanzania: | Agriculture, | 1177 | 1443 | 2153 | 3264 | 4985 |
| Mainland | Manufacturing | 403 | 571 | 497 | 762 | 1698 |
| | Total Value Added | 3463 | 4927 | 6223 | 9281 | 18259 |
| Uganda | Agriculture, | 1074 | 962 | 1320 | 1996 | 2569 |
| | Manufacturing | 311 | 103 | 161 | 505 | 958 |
| | Total Value Added | 2938 | 2249 | 3303 | 6578 | 13233 |
| Vanuatu | Agriculture, | 20 | 35 | 49 | 78 | 95 |
| | Manufacturing | 3 | 5 | 14 | 17 | 14 |
| | Total Value Added | 88 | 152 | 255 | 340 | 462 |
| Viet Nam | Agriculture, | 2439 | 3548 | 5987 | 9196 | 13078 |
| | Manufacturing | 1045 | 1522 | 2170 | 6292 | 17003 |
| | Total Value Added | 7025 | 10221 | 17439 | 36846 | 74268 |
| Zambia | Agriculture, | 686 | 658 | 1053 | 1444 | 1812 |
| | Manufacturing | 333 | 385 | 577 | 603 | 910 |
| | Total Value Added | 3950 | 4476 | 4994 | 5451 | 9635 |
| Zimbabwe | Agriculture, | 420 | 531 | 760 | 976 | 627 |
| | Manufacturing | 256 | 401 | 558 | 498 | 420 |
| | Total Value Added | 3707 | 4879 | 6601 | 7242 | 6239 |

Note: Service value added is the difference of total value added and sum of agricultural and manufacturing value added

## APPENDIX V: COUNTRIES IN THE STUDY, WITH THE RESPECTIVE GDP AND PER CAPITA GDP

$GDP_0$ is the exclusive value added of manufacturing and agriculture and arising services from these sectors at 2005 prices orthogonalized from other contributors to GDP(in billions of US). Negative signs arise out of the orthogonalizing exercise

Per capita GDPo is per capita income computed from $GDP_0$

| | Country | $GDP_0$ in billions USD 2011 | Per capita GDPo 2011 | Per capita GDPo 1970 | Differences in Per capita GDPo between 2011 and 1970 |
|---|---|---|---|---|---|
| 1 | Afghanistan | -4.019269 | -124 | 462 | -586 |
| 2 | Bangladesh | -8.162964 | -54 | 101 | -155 |
| 3 | Benin | -0.1715073 | -19 | 99 | -118 |
| 4 | Bhutan | -0.1491949 | -202 | 253 | -455 |
| 5 | Bolivia | -0.9195141 | -91 | -152 | 61 |
| 6 | Botswana | 1.639839 | 808 | 154 | 654 |
| 7 | Burkina Faso | -2.135859 | -126 | -72 | -54 |
| 8 | Burundi | -0.3831797 | -45 | 91 | -135 |
| 9 | Cambodia | 0.6749802 | 47 | 197 | -150 |
| 10 | Cameroon | 3.827981 | 191 | -341 | 532 |
| 11 | Cape Verde | -0.0834865 | -167 | 142 | -309 |
| 12 | Central African Republic | 0.1845473 | 41 | -116 | 157 |
| 13 | Chad | -0.7824554 | -68 | 200 | -268 |
| 14 | Comoros | 0.061074 | 81 | -239 | 320 |
| 15 | Congo | -0.1067321 | -26 | 342 | -368 |
| 16 | Democratic Republic of the Congo | -1.15323 | -17 | 108 | -125 |
| 17 | Djibouti | -0.0870996 | -96 | 17 | -113 |
| 18 | Egypt | 3.49575 | 42 | 145 | -102 |
| 19 | Equatorial Guinea | -0.0674816 | -94 | 351 | -445 |
| 20 | Ethiopia (Former) | -1.622915 | -19 | 12 | -31 |
| 21 | Gambia | 0.0494467 | 28 | 12 | 16 |
| 22 | Ghana | -13.80292 | -553 | 198 | -751 |
| 23 | Guinea | -0.16933 | -17 | 6 | -23 |
| 24 | Guinea-Bissau | 0.3068232 | 198 | -261 | 459 |
| 25 | Haiti | -1.555881 | -154 | 350 | -503 |
| 26 | Honduras | 2.986303 | 385 | -212 | 598 |
| 27 | India | 40.82113 | 33 | 27 | 5 |
| 28 | Indonesia | 41.60589 | 172 | -83 | 255 |
| 29 | Iraq | 3.165073 | 97 | -314 | 411 |
| 30 | Kenya | -0.474159 | -11 | -169 | 158 |
| 31 | Lao People's Democratic Republic | -1.509344 | -240 | 72 | -312 |
| 32 | Lesotho | -0.3269909 | -149 | 188 | -337 |
| 33 | Liberia | 0.1595524 | 39 | -265 | 303 |
| 34 | Madagascar | -3.248501 | -152 | 177 | -330 |
| 35 | Malawi | -0.6283386 | -41 | 17 | -58 |
| 36 | Malaysia | 40.25828 | 1395 | -894 | 2289 |

| | | | | | |
|---|---|---|---|---|---|
| 37 | Maldives | -0.1414002 | -442 | 310 | -752 |
| 38 | Mali | -0.5689961 | -36 | 75 | -111 |
| 39 | Mauritania | -0.1870885 | -53 | 210 | -263 |
| 40 | Mongolia | 0.1258482 | 45 | 9 | 36 |
| 41 | Morocco | -3.1122 | -96 | -112 | 15 |
| 42 | Mozambique | -1.205959 | -50 | 88 | -139 |
| 43 | Myanmar | -4.08097 | -84 | 21 | -105 |
| 44 | Nepal | -0.3458015 | -11 | 76 | -87 |
| 45 | Niger | 0.3252515 | 20 | 217 | -197 |
| 46 | Nigeria | 29.60299 | 182 | -97 | 279 |
| 47 | Occupied Palestinian Territory | -2.414666 | -582 | 118 | -700 |
| 48 | Pakistan | 14.71413 | 83 | 60 | 23 |
| 49 | Papua New Guinea | -0.3055474 | -44 | 189 | -232 |
| 50 | Paraguay | 0.3835433 | 58 | 356 | -298 |
| 51 | Philippines | 4.41417 | 47 | 204 | -158 |
| 52 | Rwanda | -1.133378 | -104 | 41 | -144 |
| 53 | Sao Tome and Principe | 0.0063461 | 38 | -24 | 61 |
| 54 | Senegal | -1.768754 | -139 | 207 | -346 |
| 55 | Sierra Leone | 0.4195702 | 70 | -491 | 561 |
| 56 | Solomon Islands | -0.0271471 | -49 | -70 | 21 |
| 57 | Somalia | -0.1758791 | -18 | 8 | -26 |
| 58 | Sri Lanka | -6.911685 | -328 | 89 | -417 |
| 59 | Sudan (Former) | -8.619357 | -1340 | 338 | -1678 |
| 60 | Swaziland | 0.2822676 | 214 | -1909 | 2122 |
| 61 | Syrian Arab Republic | 2.230369 | 185 | 129 | 56 |
| 62 | Thailand | 10.59331 | 17 | 97 | -80 |
| 63 | Togo | 0.1632272 | 192 | 46 | 145 |
| 64 | Tonga | -0.1318812 | -1273 | 135 | -1408 |
| 65 | Tunisia | 7.130305 | 571 | -1552 | 2124 |
| 66 | Uganda | -1.887883 | -310 | 139 | -450 |
| 67 | United Republic of Tanzania: Mainland | -1.533947 | -36 | 107 | -143 |
| 68 | Vanuatu | -0.1382865 | -247 | 184 | -431 |
| 69 | Viet Nam | -0.1577668 | -2 | 64 | -66 |
| 70 | Zambia | -0.0779469 | -3 | -836 | 833 |
| 71 | Zimbabwe | -1.114164 | -87 | -105 | 18 |

**APPENDIX VI: SUMMARY OF RESULTS ACROSS TIME SCALES**

| | Country | Cases | | | | The sector with higher magnitude of impact | | | | Sign of Change in per capita GDP | Standing with the hypothesis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time scale 1 | Time scale 2 | Time scale 3 | Smooth | Time scale 1 | Time scale 2 | Time scale 3 | Smooth | | Time scale 1 | Time scale 2 | Time scale 3 | Smooth |
| 1 | Afghanistan | | | 3 | 4 | | | | | - | | | | SS |
| 2 | Bangladesh | | 2 | 2 | 3 | | | | | - | | SS | WS | SS |
| 3 | Benin | | | 2 | | | | | M | - | | | | WS |
| 4 | Bhutan | 1 | 3 | 1 | 2 | A | | A | | - | WS | SS | WS | WS |
| 5 | Bolivia | | | 3 | 2 | | | | | + | | | | SS |
| 6 | Botswana | | 2 | 1 | 3 | | | A | | + | | SS | NS | NS |
| 7 | Burkina Faso | 7 | 2 | | 4 | | | | | - | SS | WS | | SS |
| 8 | Burundi | 1 | 3 | | 1 | M | | | M | - | WS | SS | | WS |
| 9 | Cambodia | 4 | 3 | 3 | 2 | | | | | - | SS | SS | SS | WS |
| 10 | Cameroon | | | 2 | 2 | | | | | + | | | SS | SS |
| 11 | Cape Verde | | 2 | 1 | 1 | | | M | A | - | | WS | WS | WS |
| 12 | Central African Republic | | 2 | 2 | 3 | | | | | + | | SS | SS | NS |
| 13 | Chad | | 3 | 3 | 1 | | | | M | - | | SS | SS | WS |
| 14 | Comoros | 3 | 2 | 1 | 3 | | | M | | + | NS | SS | SS | NS |
| 15 | Congo | | | | 1 | | | | A | - | | | | WS |
| 16 | Democratic Republic of the Congo | | 2 | 3 | 4 | | | | | - | | WS | SS | SS |
| 17 | Djibouti | | 3 | 4 | 1 | | | | A | - | | SS | SS | WS |
| 18 | Egypt | | 3 | | 4 | | | | | - | | SS | | SS |
| 19 | Equatorial Guinea | | | 2 | 4 | | | | | - | | | WS | SS |
| 20 | Ethiopia (Former) | 3 | 4 | | 2 | | | | | - | SS | SS | | WS |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Gambia | 1 | 2 | 2 | 3 | M | | | | + | SS | SS | SS | NS |
| 22 | Ghana | 4 | 4 | 1 | 3 | | | M | | - | SS | SS | WS | SS |
| 23 | Guinea | 4 | 1 | 3 | 3 | | A | | | - | SS | SS | SS | SS |
| 24 | Guinea-Bissau* | | | | 3 | | | | | + | | | | NS |
| 25 | Haiti | | 4 | 1 | 3 | | | M | | - | | SS | WS | SS |
| 26 | Honduras | 1 | 1 | 2 | 1 | M | M | | A | + | SS | SS | SS | WS |
| 27 | India | | 1 | 4 | 3 | | A | | | + | | WS | NS | NS |
| 28 | Indonesia | | | 2 | 4 | | | | | + | | | SS | NS |
| 29 | Iraq* | | | 4 | 4 | | | | | + | | | NS | NS |
| 30 | Kenya* | 4 | 4 | 4 | 3 | | | | | + | NS | NS | NS | NS |
| 31 | Lao People's Democratic Republic | 2 | 2 | 2 | 3 | | | | | - | WS | WS | WS | SS |
| 32 | Lesotho | | 2 | 3 | 1 | | | | A | - | | WS | SS | WS |
| 33 | Liberia | 2 | | 4 | 2 | | | | | + | SS | | NS | SS |
| 34 | Madagascar | | 2 | | 4 | | | | | - | | WS | | SS |
| 35 | Malawi | | | | 3 | | | | | - | | | | SS |
| 36 | Malaysia* | 4 | 4 | 4 | 3 | | | | | + | NS | NS | NS | NS |
| 37 | Maldives | 1 | 4 | 4 | 3 | M | | | | - | WS | SS | SS | SS |
| 38 | Mali | 1 | | 3 | 4 | M | | | | - | WS | | SS | SS |
| 39 | Mauritania | 4 | 3 | 4 | 3 | | | | | - | SS | SS | SS | SS |
| 40 | Mongolia | 2 | 1 | | 1 | | M | | M | + | SS | SS | | SS |
| 41 | Morocco | | 3 | 2 | 1 | | | | M | + | | NS | SS | SS |
| 42 | Mozambique | 3 | 1 | 4 | 2 | | M | | | - | SS | WS | SS | WS |
| 43 | Myanmar | 4 | | 2 | 2 | | | | | - | SS | | WS | WS |
| 44 | Nepal | | | 3 | 1 | | | | A | - | | | SS | WS |
| 45 | Niger | | 2 | 1 | 3 | | | M | | - | | WS | WS | SS |
| 46 | Nigeria | | | 1 | 4 | | | M | | + | | | SS | NS |
| 47 | Occupied Palestinian Territory | 3 | 4 | 1 | 2 | | | M | | - | SS | SS | WS | WS |
| 48 | Pakistan | | | 2 | 1 | | | | A | + | | | SS | NS |
| 49 | Papua New Guinea | | | 1 | 2 | | | M | | - | | | WS | WS |
| 50 | Paraguay | 2 | 2 | | 1 | | | | M | - | WS | WS | | WS |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | Philippines | | | | 1 | A | | | | - | | | | SS |
| 52 | Rwanda | | | 2 | 3 | | | | | - | | | WS | SS |
| 53 | Sao Tome and Principe* | | | 4 | 4 | | | | | + | | | NS | NS |
| 54 | Senegal | 3 | 3 | | 1 | | | A | | - | SS | SS | | SS |
| 55 | Sierra Leone | | 3 | 1 | 2 | | | M | | + | | NS | SS | SS |
| 56 | Solomon Islands | 4 | 3 | 2 | 4 | | | | | + | NS | NS | SS | NS |
| 57 | Somalia | 4 | 1 | 3 | 2 | | A | | | - | SS | SS | SS | WS |
| 58 | Sri Lanka | 3 | 2 | 1 | 2 | | | | M | - | SS | WS | SS | WS |
| 59 | Sudan (Former) | | | 3 | 2 | | | | | - | | | SS | WS |
| 60 | Swaziland | | 1 | 2 | 3 | | A | | | + | | SS | SS | NS |
| 61 | Syrian Arab Republic | | | 3 | 2 | | | | | + | | | NS | SS |
| 62 | Thailand | | | 3 | 4 | | | | | - | | | SS | SS |
| 63 | Togo | 3 | | | 2 | | | | | + | NS | | | SS |
| 64 | Tonga | | | | 4 | | | | | - | | | | SS |
| 65 | Tunisia | | 4 | 1 | 1 | | | A | A | + | | NS | SS | SS |
| 66 | Uganda | | | | 2 | | | | | - | | | | WS |
| 67 | United Republic of Tanzania: Mainland | 1 | 4 | | 2 | M | | | | - | NS | SS | | WS |
| 68 | Vanuatu | 4 | | 1 | 4 | | | A | | - | SS | | SS | SS |
| 69 | Viet Nam | | 4 | 4 | 1 | | | | M | - | | SS | SS | WS |
| 70 | Zambia* | | | | 3 | | | | | + | | | | NS |
| 71 | Zimbabwe* | | | 3 | 3 | | | | | + | | | NS | NS |
| | **Total** | **29** | **42** | **55** | **70** | | | | **WS+SS** | | **24** | **36** | **44** | **54** |
| | | | | | | | | | **NS** | | **5** | **6** | **10** | **17** |

*-countries that consistently do not support the hypothesis in all time scales

SS - strongly support, WS – weakly support , NS- not support , A- agriculture , M- manufacturing

1 – case 1, 2- Case 2 3- Case 3 4- Case 4

**APPENDIX VII**

Table 1: Countries falling in Cases 1 and 2 in the longest time scale 3(D3) and Smooth(S) together

| Country | Cases in Time scale 3($D_3$) | Cases in Smooth (S) |
|---|---|---|
| Bhutan | 1 | 2 |
| Cameroon | 2 | 2 |
| Cape Verde | 1 | 1 |
| Honduras | 2 | 1 |
| Morocco | 2 | 1 |
| Myanmar | 2 | 2 |
| Occupied Palestinian Territory | 1 | 2 |
| Pakistan | 2 | 1 |
| Papua New Guinea | 1 | 2 |
| Sierra Leone | 1 | 2 |
| Sri Lanka | 1 | 2 |
| Tunisia | 1 | 1 |

Table 2: Countries falling in Cases 1 or 2 in one of the time scales (D3 or S )

| Country | Cases in Time scale 3($D_3$) | Cases in Smooth (S) |
|---|---|---|
| Benin | 2 | |
| Burundi | | 1 |
| Congo | | 1 |
| Ethiopia | | 2 |
| Mongolia | | 1 |
| Paraguay | | 1 |
| Philippines | | 1 |
| Senegal | | 1 |
| Togo | | 2 |
| Uganda | | 2 |
| United Republic of Tanzania Mainland | | 2 |

# CHAPTER IV: MANUFACTURING GROWTH AND TRANSACTION SERVICES IN LOW INCOME ECONOMIES: A WAVELET APPROACH

---

***ABSTRACT***

*The study claims that the level and direction of growth of transaction services matters for manufacturing growth. We begin with detection of Granger causal and impulse-response relationship. Based on the detected relationship and the actual direction of change of services we predict growth of manufacturing value added at various time scales. We compare the predicted and the actual direction of changes of the manufacturing value added. The results indicate that negative Granger causality between growth of services and manufacturing prevails in significantly greater number of countries in longer time scales than the prevalence of positive relations. The countries where the predicted direction of change in manufacturing value added coincided with the actual direction of change were significantly greater in number than those countries where coincidence does not appear. This result provides evidence for the hypothesis that the level and direction of growth of services matter for manufacturing and policies towards the provision of optimal services is important for manufacturing growth in low-income economies.*

**Keywords**: Manufacturing growth, Transaction services, Granger causality, Impulse-response tests, structure, dualism, modern growth, sustained growth, macro model, multi-sector growth, industrialization, transformation, transition to modern growth, income convergence

**JEL classification codes** 0110, 014, 0410, 047, P52

# I INTRODUCTION

## 1.1 BACKGROUND AND THE PROBLEM

Aggregates data for low-income economies in the United Nations (2012) database indicates that the structure of these economies is such that the share of agricultural and services value added dominate while manufacturing share is stunted. The general trend is declining agricultural share and growing service share. In many cases, the gradually declining share of agricultural sector is giving way to the expansion of share of services rather than manufacturing. Declining share of agriculture and stagnant manufacturing with expanding services, characterize most of the low-income economies. In most low-income countries (LICs), the share of services has been growing to reach and exceed about 50%. What was the impact of faster growth and share of services on manufacturing growth? What is the long-term impact of the faster development of services on manufacturing in low-income economy setting?

This state of low manufacturing share and growing share of services provided valid motivation to model the economies and investigate whether the growth of output of services and growth of share of services has retarded manufacturing growth in low-income economies by crowding out manufacturing from accessing inputs. Tentatively, the faster growth of services suggests that a greater magnitude of inputs is shifting to this sector. The service sector, which is meant largely to facilitate goods production, is receiving greater inputs while denying the flow of the necessary inputs to goods production.

Thus, the aim of this study is explaining the structural factor responsible for growth or stagnation of manufacturing in low-income economies. The structural factor under consideration is the level and growth of transaction services. The theoretical model of low-income economies used in this study defines the link between manufacturing growth and transaction services and problem of the study is investigating case by case whether the expansion of services has led to manufacturing growth or whether it has retarded manufacturing growth. Here, the underlying assumption is that the formation of large service is a long-term process that embodies the aggregate preference of members of society and the imprint of the institutional environment. As such, structure as a slowly changing variable, is an exogenous factor that can be taken as a policy variable.

## 1.2 THE OBJECTIVES

The overall objective of the study is investigating the effects of services on manufacturing growth. The specific objectives are:

- investigating the existence of Granger causality of services on manufacturing and the sign of causality by impulse-response analysis
- predicting the direction of change of manufacturing value added based on the sign of Granger causality

## 1.3 THE HYPOTHESIS AND THE METHODOLOGY

The guiding hypothesis states "Growth of transaction services above the optimal level negatively affects manufacturing growth of low income economies and growth of transaction services below the optimal level enhance manufacturing". The economies under investigation are those with low per capita GDP, arbitrarily taken to be below 1000 USD in 1970. The economies falling to this category are 71 in number.

Goods production provides the basis for emergence of many services. The focal sectors are manufacturing, agriculture, and services to avoid the loss of degrees of freedom that arise from using too many variables and their lags. The effects of other goods supplying sectors have to be removed This is taken care of by orthogonalizing the included sectors from those excluded.

Consideration of interactions of sectors necessitates deciding the time span within which the interactions take place. Wavelet decomposition of the time series data detects the outcomes of interactions in various time scales. Among the various wavelet transformations, the one selected for this purpose is Haar wavelet. Other economic studies have employed wavelet decomposition to capture effects of time scales (Månsson, K. 2012; Hacker R. S., Karlsson H. K. and Månsson K, 2012). Orthogonalized manufacturing, agricultural, and service data are wavelet decomposed in three time scales and one smooth or moving average. The wavelet transformed data is further used in Granger causality tests of value added of agriculture and services on manufacturing value added of individual economies in 42 years span using VAR /VECM approach. The detected sectoral impacts with Granger causality and cumulative impulse-responses enable prediction of the direction of growth of manufacturing. The study compares the predicted and actual directions of changes in manufacturing to test the hypothesis.

## 1.4 THE RESULTS IN PREVIEW

The results of the analysis support the hypothesis in overwhelmingly large number of cases. Economies with positive Granger causality of services on manufacturing experienced sustained growth in manufacturing when services grow or they experienced decline in manufacturing when services declined. Those economies with negative Granger causality of services on manufacturing experienced growth in manufacturing with decline in services and decline in manufacturing with growing services in a large number of cases. The structural relations of most economies support the hypothesis. Longer time scales reveal these relations in more number of cases than shorter time scales. The implication for development strategies of low-income economies is that structures matter for sustained growth (long-term growth) of manufacturing and a structure with prevalence of optimal services is necessary for the attainment of sustained growth of manufacturing.

One of the contributions of this paper is that it provides empirical evidence on the explanation for success or failure of attainment of long-term manufacturing growth. The explanation lies in the structure of economies with optimal services. The other contribution is methodological, which is the application of wavelet decomposition of time series data for subsequent analysis of Granger causality and impulse-responses to detect causality at various time scales. It transcends the usual method of analysis where a single time scale is considered.

## 1.5 ORGANIZATION OF THE STUDY

Part 2 goes to a brief excursion to theory that defines the relationship between services and goods production and the rationale for taking services as extensions of goods production. It highlights the analytical and empirical implications of the assumptions of the theory that served as the basis for the hypothesis. Part three discusses methodological issues: data preparation and estimation methods. The need to transform the time series data, empirical model specifications and the reason behind the selected model get highlighted in this section. In part four results of the analyses will be reported. In Part five conclusions and policy implications are drawn.

# 2. SERVICES AS EXTENSIONS OF GOODS PRODUCTION

## 2.1 THE UNDERLYING MODEL

As attested by the historical accounts on patterns of economic development (Kuznets, 1966; Bairoch, 1993; Maddison 2005), manufacturing, among goods producing sectors, stands as the most efficient vehicle for transformation. Newly industrialized countries have gone through a structural transformation in line with the historical pattern. Inherent external economies in manufacturing (Krugman, 1981), its technology absorption and capital accumulative nature (Kuznets 1966, 1989), its nature as a basis for the rise of various services( tertiary activities) and for enhancement of primary activities are responsible for this role. Emanating from its use of energy intensive capital goods, incipient modern manufacturing exhibits higher labor productivity than the other sectors. The possibility of fast or mass production and the ensuing high productivity of labor in modern manufacturing that consume energy from modern sources make it by far the faster way of transformation of inputs to outputs, and creating wealth and prosperity than other activities with incomparably low energy use. Jorgenson (1984) reports from results of empirical studies that electrification as well as nonelectrical energy uses are interrelated with productivity growth. The observed possibility of automation and mechanization in manufacturing further increases the productivity of the sector (Baumol, 1967). The use of manufactured inputs in other sectors makes the sectors more productive (Parente and Prescott, 2003 citing Johnson 2000). Developing technological capability in manufacturing is a long term solution to a chronic indebtedness of a developing economy by enabling positive net export through manufactures. Manufacturing sector is the sector potentially having a large number of products and processes in itself and creating opportunities for service activities associated with manufactured products and processes. Manufacturing avails more opportunities for entrepreneurial engagement in goods production and related services provision. It is instrumental to employment creation for the growing labor forces of a developing economy.

A typical low-income economy (LIC), however, has dual characteristics: with large traditional agricultural goods producing sector and modern economy with small manufacturing and relatively larger services. UN data base (unstat, 2013) indicates that considerable number of LICs have a dual structure. The agricultural sector is labor using and unable to absorb capital because of various factors among which are extremely low size of land holdings and prevalence of subsistence. Manufacturing is more capital using than agriculture and labor saving in relative terms. Current share of manufacturing is low and the growth of its share varies across economies (unstat 2013). Under developed economies suffer from non-optimal transaction services and from leakages in savings as a result of high uncertainties on investment outcomes, or due to capital flight. Slow capital formation, entry barriers and low rate of flow of capital to manufacturing characterize the economies. The markets are highly imperfect (Banergee and Duflo 2004). Unskilled labor, unemployment or underemployment predominate the economies (ILOSTAT Database).

A low-income economy evolves through stages in accordance with observed historical patterns. The first stage is a stagnant agricultural economy, the second is a dual economy where subsistence agriculture coexists with small modern manufacturing economy, while the third stage is a matured economy (Kaldor, 1966; Kuznets, 1966, 1989; Hansen and Prescott, 2002; Parente and Prescott, 2003) where the distinction between modern and traditional sector disappears.

Fitting to the second stage and the stylized facts of LICs, a model conceptualizes the aggregate production function composed of manufacturing as a modern goods production activity and agriculture as a traditional and subsistence activity, with services arising from these goods production sectors respectively. Manufacturing generates positive externalities and scale economies. It is also capital using with labor while agriculture is labor using with no capital. There is no competition for labor from the supply side until full employment prevails as the goods producing sectors draw labor (L) from the unemployed and underemployed pool. There is no competition for technology embodying capital (K) either, as it is demanded by the modern sector alone, not by labor using agriculture until agriculture modernizes and ceases to be subsistence.

Inefficiencies that place actual output below potential output are incorporated reflecting prevalent market imperfections. The inefficiencies are output-affecting ones similar to that of Parente and Prescott (2003), on the one hand, and input reducing ones, on the other. Input reducing inefficiencies are expressed either with subtraction of factors not used in actual goods production while being used to effect transactions, or as percentage of total inputs not directly used for goods production. These inputs not directly used for goods production are essentially economy wide transaction costs for society that emanate from imperfections. Inputs to transaction services appear as transaction costs to goods production. Although non-transaction services compete for inputs with goods producing sectors they do not appear as transaction costs to society. Conceptually non- transaction services could be lumped together with goods production. The total value added of the economy is the combined outcome of goods production and services that arose based on goods produced. Since both transaction and non-transaction-services emerge based on goods production and consumption, the combined value added can be expressed in terms of the value added of goods production.

The value added of the economies is expressed with a structural macroeconomic model as:

$$Y_t = \left[r\left(\frac{\psi}{\varsigma}\right)^u (R_t - \psi_t)^\beta\right] + \left[\eta\left(\frac{\omega_t}{C_t}\right)^u (K_t - \omega_t)^{\alpha+\mu} (L_t - \varphi_t)^{1-\alpha}\right] \text{..........................(1)}$$

$$Y_t = Ag_t + M_t \text{ ..............................................................(1a)}$$

The first expression in the right hand side is the production function of traditional agricultural sector and services arising from agriculture ($Ag_t$). The second expression is the production function of the modern manufacturing sector and the services arising from it ($M_t$). $\psi_t$ denotes transaction costs in agriculture where $(0 < \psi_t < R_t)$, $\beta$ is agricultural parameter where $(0 < \beta < 1)$, r is technical efficiency in agriculture where $(0 < r < 1)$, u is a parameter of services where $u \geq 0$, $\eta$ is technical efficiency in manufacturing, where $(0 < \eta < 1)$ $\alpha$ is the share of capital where $(0 < \alpha < 1)$, $\mu$ Parameter of externalities and increasing returns, where $(0 < \mu < 1)$ $\omega_t$ and $\varphi_t$ are transaction costs in manufacturing where $(0 < \omega_t < K_t)$ and $(0 < \varphi_t < L)$. $\omega$ is capital, and $\varphi$ is labor.

$r, \varsigma, \beta, u\ \eta, C, \alpha, \mu$ are parameters of the economy, $\omega_t$, $\psi_t$, $\varphi_t$ are exogenous variables and $R_t$ and $K_t$ are the endogenous variables in the model.

Service outputs are expressed in terms of goods supply. While $Ag_t$ and ($M_t$) incorporate goods and services produced in and for agriculture and manufacturing respectively, the respective services in isolation are expressed as:

$$Ser = b_1\ Ag_{gt} + b_2\ M_{gt} \qquad (2)$$

Where, $b_1 = \left(\frac{\psi}{\varsigma}\right)^u - 1$, $b_2 = \left(\frac{\omega}{C}\right)^u - 1$, $Ag_{gt} = r(R_t - \psi_t)^\beta$, $M_{gt} = \eta(K_t - \omega_t)^{\alpha+\mu}(L_t - \varphi_t)^{1-\alpha}$

Labor productivity in agriculture and arising services:

$$\left(\frac{\partial f(R_t)}{\partial R}\right) = \Gamma\left(\frac{\psi_t}{\varsigma}\right)^u \beta \frac{(R_t - \psi_t)^\beta}{(R_t - \psi_t)} = \beta \frac{f(R_t)}{(R_t - \psi_t)} = \beta \bar{R} \quad \text{where } \bar{R} \text{ is per capita output in agriculture} \tag{3}$$

Labor productivity in manufacturing and arising services:

$$\left(\frac{\partial M}{\partial L}\right) = (1-\alpha)\eta\left(\frac{\omega_t}{C}\right)^u (K_t - \omega_t)^{\mu+\alpha} (L_t - \varphi_t)^{-\alpha} \tag{4}$$

Assuming labor productivity of the traditional and subsistence agricultural sector to be a fraction of that of the modern sector,

$$\beta\bar{R} = \theta \frac{\partial M}{\partial L_M} = \theta\,(1-\alpha)\eta\left(\frac{\omega_t}{C_t}\right)^u (K_t - \omega_t)^{\mu+\alpha} (L_t - \varphi_t)^{-\alpha}, \text{ where } (0<\theta\leq 1) \tag{5}$$

Labor demand in the modern sector as a function of labor productivity in subsistence agriculture is:

$$L_t = \left[\frac{\theta(1-\alpha)}{\beta \bar{R_t}}\left(\eta\left(\frac{\omega_t}{C_t}\right)^u\right)(K_t - \omega_t)^{\alpha+\mu}\right]^{\frac{1}{\alpha}} + \varphi_t \tag{6}$$

The rate of saving(s) is the ratio s= (Y-C)/Y, where Y is output and C is consumption. Effective saving rate is s-λ, where λ is that part of the saving rate that couldn't be used to the formation of capital as a result of the underdeveloped institutional environment or lack of information on investment outcomes, or due to capital flight or due to entry barriers.

Capital formation in manufacturing sector and services alone is thus,

$$dK = (s-\lambda)\left(\eta\left(\frac{\omega_t}{C}\right)^u\right)(K_t - \omega_t)^{\alpha+\mu}(L_t - \varphi_t)^{1-\alpha} - \delta(K_t - \omega_t) \tag{7}$$

$$= (s-\lambda)\eta\left(\frac{\omega_t}{C}\right)^u (K_t - \omega_t)^{\alpha+\mu}\left[\frac{\theta(1-\alpha)}{\beta\bar{R}}\right)\left(\left(\eta\left(\frac{\omega_t}{C}\right)^u\right)(K_t - \omega_t)^{\alpha+\mu}\right]^{\frac{1-\alpha}{\alpha}} - \delta(K_t - \omega_t) \tag{7a}$$

Where: $(0< s< 1)$, $(0< \delta< 1)$, and $(0< \lambda <1)$

The change in capital (dK) could be zero positive or negative. When dK is negative capital stock declines through time until dK=0, while it is positive accumulation of capital stock goes on until dK=0. Accumulation or de-accumulation of capital stock stops when dK becomes zero. The stock of capital at which dK=0 is a state of equilibrium the stability of which depends on the level of depreciation and savings. The equilibrium capital stock is thus K=K* at which equation 7a above equals zero as in equation 8 below.

The model has led to the important finding of a critical capital stock K* that has to be exceeded in order the economy to be in a sustained growth path. The economy in transition from stagnancy to modern growth is bounded by a lower level equilibrium of subsistence economy and a higher-level matured economy. In this transition stage, there is a possibility for the existence of an unstable equilibrium depending on the size of the parameters of the economy such as $\delta$, $s$ and $\lambda$. Economies having effective savings always greater than depreciation move to sustained growth without experiencing multiple equilibriums. In the presence of the unstable equilibrium, the economy either moves to the lower level equilibrium or moves to higher level transformation depending on whether capital stock (*K*) in the modern sector is greater or less than a critical stock$(K^*)$, where $K^*$ is derived from low of motion of capital as:

$$\mathbf{K}^* = \left(\frac{\delta}{s-\lambda}\right)^{\frac{\alpha}{\mu}}\left(\left(\frac{1}{\eta}\right)^{\frac{1}{\mu}}\left(\frac{C}{\omega_t}\right)^{\frac{u}{\mu}}\right)\left(\frac{\beta\bar{R}}{\theta(1-\alpha)}\right)^{\frac{1-a}{\mu}} + \boldsymbol{\omega}_t \qquad (8)$$

If the economy exceeds the critical stock and escapes the unstable equilibrium it moves to a persistent change towards maturity where it assumes a different structure having no more a distinction between agriculture and manufacturing. The theoretical analysis places emphasis in capital accumulation in the modern manufacturing sector that propels the economy forward with generation of additional value added in services. Critical stock $(\mathbf{K}^*)$ varies with $\boldsymbol{\omega}$**.** Critical stock first declines and then increases as $\boldsymbol{\omega}$ increases. $\boldsymbol{\omega}$ represents transaction services, which are transaction costs to society. The model prediction of the evolution of $\mathbf{K}^*$ with changes in $\boldsymbol{\omega}$ is depicted Fig 1 below**.**

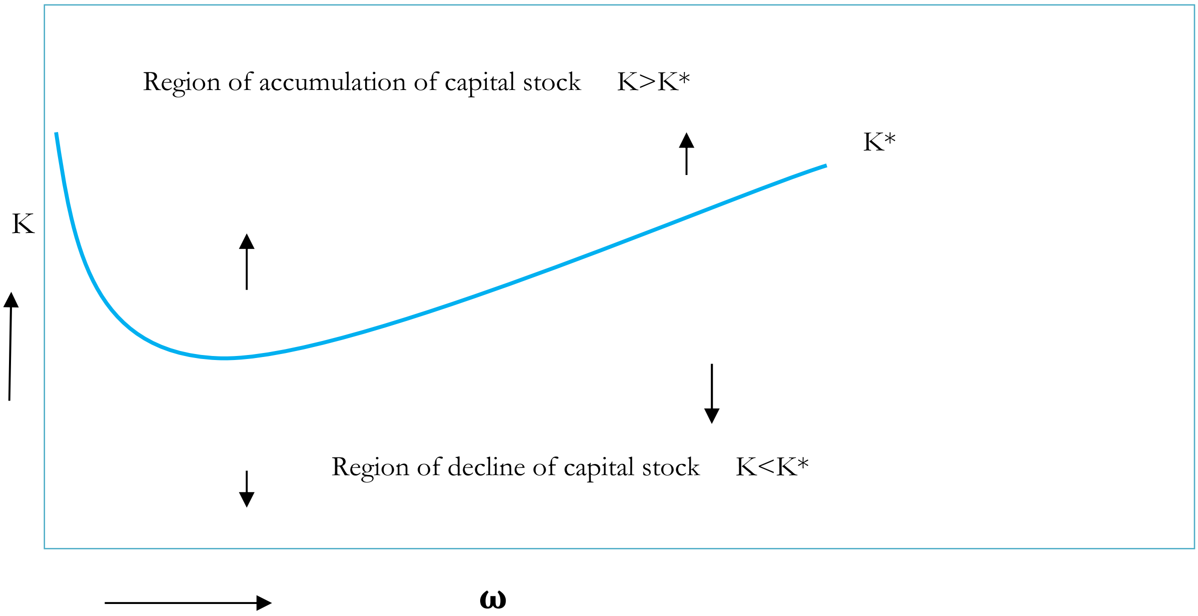



Fig 1 Critical capital stock K* and **ω**

The alternative explanation pursued in this paper for transition of low-income economies from classical stagnation to modern economic growth hinges on structure. The onset of structural change characterized by faster growth of output and share of manufacturing is the basic feature that ensures a low-income economy to attain sustained growth. Do LICs have this structure? If not what explains the prevalence of a structure where manufacturing growth and share is retarded?

## 2.2 THE NATURE OF SERVICES

What is the economic role of services and how do they relate with goods production and exchange? Why does the model conceptualize inputs to services as reductions from inputs of goods producing sectors? What are the analytical and empirical implications of such conceptualization? How does this conceptualization underlie the hypotheses? The next section deals with these questions.

Expressing services in terms of goods production is rooted in the fact that most services arise based on goods supply, be it goods from domestic production or imports. Services assist the production, consumption, and exchange of goods. Services are classified as change effecting, marginal and knowledge capturing services in the United Nations System of National Accounts (UN SNA, 2008). Change effecting services arise to add value mainly on supplied goods. Knowledge capturing services arise essentially on high tech goods. Marginal services like insurance and banking engender to assist production and exchange.

Economic production is an activity that produces goods and services for others. SNA (2008) defines goods as physical, produced objects with demand whose ownership can be transferred in market transactions. The production of goods and exchange of goods are separate activities. Services are results of production activity that change the conditions of consuming units (change effecting services) or that facilitate the exchanges of products(margin services) or that provide storage, communication and dissemination of information, advice and entertainment with repeated access (knowledge capturing products).

In change-effecting services, production and trading are not separate activities. In this type of services, the conditions of the consuming units change when changes are made on: condition of the consumer's goods by transporting, cleaning, or repairing them; physical or mental condition of persons by transporting, providing accommodation, undertaking medical/surgical treatment, improving the appearance, providing education, information, advice and entertainment. For change-effecting services such as transporting, cleaning, and repairing, consumer goods must exist. The magnitude of such services is dependent on the magnitude of produced goods. As such, they are extensions of goods production. Changes in physical or mental conditions of persons occurs largely with the use of goods in the form of gadgets and facilities, such as transport vehicles, houses, and appliances in accommodations, medicines and equipment, chemicals and tools, stationery and laboratory facilities, electronic and musical equipment, which are all goods. The magnitude of provision of these services is dependent on the magnitude of the available relevant goods and as such there is reasonable ground to establish the relationship between service outputs and relevant goods output.

In margin services too, production and trading do not take place separately. These services are required for facilitation of exchange of goods and other services as it happens with wholesaling, retailing, and financial intermediations. Wholesaling and retailing services are dependent on the supply of goods. Financial services in the final analysis assist production and consumption activities. The magnitude of output of these services is associated with goods supply in the economy. As such, there is adequate ground to associate the output of such services with the output of goods production processes.

The provision, storage, communication and dissemination of information, advice and entertainment to the consuming unit in accessing the knowledge repeatedly through knowledge-capturing products is performed with the use of goods( paper or electronic media). The provision of these services is directly associated with relevant goods production. The magnitude of the output of these services is dependent on the magnitude of the output of the goods used in providing the services.

Services accomplish two activities: extending the transformation of goods (or a group of goods) by adding new attributes valuable to users, and they facilitate exchange of goods without adding new valuable attributes to goods. Those services facilitating exchange are treated as transaction services in this study while the others are non-transaction services. Non-transaction services are similar to goods production as they are more or less direct extension to goods production. Transaction services, though they arise to facilitate goods production and exchange, their association with goods production depends on the institutional arrangement prevailing in the economy and on individually chosen method of dealing with the institutional and technological arrangements by economic actors. The evolution of transaction services is a slow process that takes place in longer period to be taken as exogenous. More discussion on this issue follows in the next section.

The two services may be performed by same institutional unit and may not be recorded in its accounts as separate entities. However, they remain to be conceptually different kinds of services based on their importance in improving the welfare of society. Society's welfare improves by committing more resources to introduce more attributes per unit of existing goods (or group of goods). Society's welfare does not improve by increased commitment of resources to increase the costs of facilitation, because utility is derived from the attributes of the goods not from the facilitation cost. Society becomes better off from the perpetual reduction of transaction costs and with perpetual increment in attributes of goods.

In International Standards for Industrial Classification (ISIC) revision 4 (2008) and in SNA (2008), services are classified into various sectors: wholesale and retail, transport and communication, and others.

Tab 1 Classifying services into Transaction and Non transaction services

| ISIC/ SNA classification of services | Regrouping as transaction or non transaction services in this study | |
|---|---|---|
| | Transaction | Non transaction |
| G 45–47 Wholesale and retail trade; repair of motor vehicles and motorcycles | Wholesale and retail trade | Repair |
| H 49–53 Transportation and storage | √ | |
| I 55–56 Accommodation and food service activities | | √ |
| J 58–63 Information and communication | √( those facilitating transactions) | √( those providing utility) |
| K 64–66 Financial and insurance activities | √ | |
| L 68 Real estate activities | √ | |
| M 69–75 Professional, scientific and technical activities | √( facilitators ) | √( used in creation of products and knowledge ) |
| N 77–82 Administrative and support service activities | √ | |
| O 84 Public administration and defense; compulsory social security | √ | |
| P 85 Education | | √ |
| Q 86–88 Human health and social work activities | | √ |
| R 90–93 Arts, entertainment and recreation | | √ |
| S 94–96 Other service activities | √ | |
| T 97–98 Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use | | √ |
| U 99 Activities of extraterritorial organizations and bodies | √ | |

Conceptual and analytical requirements of this study demand reclassification of activities that are categorized as services in national accounts statistics. Transaction and non-transaction services are lumped together in the national accounts data of countries and it becomes clear from the outset that the organization of existing statistics necessitates careful interpretation of results, as it is not organized in line with the conceptual framework of this study. Transaction services constitute the overwhelmingly larger part of services. For example in Ethiopian national accounts 86% of the entire services fall as transaction services(Tab 2),. In many low income countries the situation is similar. When we talk about services we are predominantly talking about transaction services. It is hoped that the data used for services reflects the extent of transaction services. Future studies can improvise on this aspect by careful segregation of the transaction and non transaction services in the countries covered by the study. Thus, the service sector is largely transaction services and taking the service sector in lieu of transaction services is justified as similar dominance of the transaction services in the service sector prevails in low-income countries.

Tab 2: Shares of transaction and non-transaction services within the services sector of Ethiopia

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Whole Sale and Retail Trade | 0.37 | 0.37 | 0.37 | 0.36 | 0.36 | 0.36 | 0.37 | 0.38 | 0.38 | 0.37 | 0.36 | 0.34 | 0.35 | 0.36 |
| Hotels and Restaurants | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.06 |
| Transport and Communications | 0.09 | 0.10 | 0.10 | 0.11 | 0.11 | 0.12 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Financial Intermediation | 0.05 | 0.05 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.05 | 0.06 | 0.07 | 0.05 |
| Real Estate, Renting and Business Activities | 0.14 | 0.15 | 0.18 | 0.19 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.19 | 0.21 | 0.20 | 0.18 |
| Public Administration and Defense | 0.15 | 0.13 | 0.11 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.09 | 0.10 |
| Total transaction services | | | | | | | | | | | | | | 0.86 |
| Education | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Health and Social Work | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Other Community , Social & Personal Services | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.05 | 0.07 |
| Private Households with Employed Persons | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Total non-transaction services | | | | | | | | | | | | | | 0.14 |

## 2.3 TRANSACTION SERVICES: AS FACILITATORS AND COSTS TO SOCIETY

Essentially a substantial portion of services facilitates production and consumption of goods. Their existence largely depends on the extent of the difficulty faced in accessing inputs by goods producers and difficulties in accessing finished goods by consumers on the one hand and on the choices made in the method of addressing the constraints of production and consumption by economic actors on the other hand. When difficulties abound in goods production, resources are committed to services to overcome the difficulties and to facilitate the production of goods. Had these difficulties been non-existent, these resources would have been committed to goods production and consumption. Reduction of the difficulties necessitates reduction of resources committed to transaction services. The expansion of transaction services diverts inputs that would, otherwise, be used for the expansion of production of goods. Society's utility is derived from the goods not from the transaction services. Transaction services are transaction costs to society. The amount of resources committed depends not only on the extent of difficulties faced but also on the method introduced to address them. The level of resources committed in transaction services is in the short run an exogenous factor reflecting the introduced institutional and technological change in society on the one hand, and individually opted responses to the institutional and technological arrangements on the other.

Transaction costs are thus additional resources committed during production and exchange apart from direct input or output costs. They are committed in securing inputs by the producer and in availing outputs to the buyer, in the process of production or consumption of goods. These costs incorporate search-and-information costs, bargaining costs, costs of agreement and drawing contract, costs of enforcement of contracts, brokerage and bank fees, state taxes, costs of traveling, costs of transporting, costs of storing and waiting in effecting the transactions. On aggregate level, part of the costs in public administration and defense, banking, insurance and financial services, part of costs in transport and telecommunication services, costs for wholesaling and retail services are transaction costs for society.

Part of change effecting services, all margin services, and part of knowledge capturing services are facilitating transactions taking place between producers and consumers and fall into transaction services. Wallis and North (1986, 1988) take wholesale, retail trade, finance, insurance and real estate as aggregate transaction sectors. The authors exclude transport from the category of transaction sectors on the ground that transportation services are transformation costs rather than transaction costs. Transaction costs arise in making exchanges or in performing the transaction function while transformation costs arise in transforming inputs into outputs or in performing the transformation function (Wallis and North, 1986). Our study categorizes transportation costs as transaction costs on the ground that they arise during exchange of goods by intervening operators to facilitate exchange between producers and consumers. Moreover, neither the producer's nor the consumer's welfare improves by the added cost of transportation during exchange as the goods' physical attributes do not change in a sense that the consumer does not distinguish between a good of the same quality that was transported from distant places and that produced locally. Bread produced locally, with ingredients that are identical with that produced in a different place but transported to the former locality, provides same satisfaction to the consumer. The labor and capital spent in producing (transforming) the inputs to outputs are same in both but one is bought from local sources with no transportation costs while the other is bought from distant places with additional costs incurred to have it( transaction costs).

Transformation process changes goods used as inputs to different quality goods called outputs, providing utility to the user different from the inputs.  If changes in quality of a good are measured by the additional satisfaction created as a result of the change, the change brought about by transportation service is not a transformation cost since welfare of the person consuming the transported bread is no better than when consuming the local bread made of identical ingredients. On aggregate level, a country using the same technology of production with another country but experiencing more transportation costs within or outside the country is no better in its welfare. A country does not increase the quality and quantity of its output by new impediments that increase the costs of transportation of goods. In other words, it is better conceptually to incorporate transportation with transaction services rather than transformation services. In taking this conceptualization, it might be useful to be reminded of Kuznets remark (as cited in Wallis and North, 1986) "no economic measure is neutral, that is unaffected by economic theories of production, value, and welfare, and the broader social philosophy encompassing them."

Transaction costs are incurred in return for transaction services. Some of these transaction services reduce the effects of uncertainty. Some reduce spatial and temporal barriers while some are regulatory. Some are sources of government finance while some of them may be instruments of policy.  Some of them are rents squeezed by agents who do not contribute to production but who could be obstacle when unsatisfied (bribery and other forms of corruptions are cases in point). Most of them affect input and output prices while some are directed at regulating exchanges and enforcing property rights. They may be visible in official statistic in aggregate form to some extent while a significant portion may not be visible in official statistics.

Transaction costs for brokerage services is incurred by agents to reduce the ignorance and uncertainty about the various dimensions of commodities that producers purchase or sale as inputs or outputs. The information needed could be about any of the spatial, temporal, qualitative, or quantitative dimensions of the commodities. When there is no supply of brokerage service in situations where producers face dearth of information, there follows a heavy loss in terms of actual profit or planned profit. If there exists limited supply of brokerage services, prices of brokerage will be exorbitant and unfavorable to producers. Too low brokerage fee leads to insufficient supply of the service and hence more lack of information. That means there is an optimal range of brokerage fee that society cannot avoid as long as information lack prevails. Unless sources of information are abundant, such services are necessary to facilitate economic transactions. Society can only reduce transaction costs of the brokerage type to an optimal level, not avoiding them completely. Similarly, insurance, contract drawing, and contract enforcement costs cannot be avoided but reduced as they are outcomes of uncertainties and absence of trust. Bank fees, state taxes, transport and telecommunication costs can similarly be reduced but not avoided.

In the short run, transformation costs are largely endogenous to the economic system while transaction costs are exogenous impositions on the economic system. Economic forces of demand and supply interact to result in transformation costs, where prices and quantities reflect scarcity of the commodities directly or the scarcity of the inputs used in their production. Endogenous economic processes ensue subsequent to shocks on market forces to restore previous states unless a stronger non-market force is at work in blocking the restoring process. The non-market force works by way of blocking market interactions and increasing the transaction costs of the market.

Non-economic factors engender transaction costs. The mechanisms for the reduction of these costs lie in adoption of new institutional arrangements and by introduction of new methods of interactions. While adopted technologies generally increase productivity by reducing transformation costs, obsolete and persistent institutions, and rigid mindset that does not adopt new method of social interactions perpetuate transaction costs. Non-existence of appropriate institutions also keeps transaction costs soaring. Market forces are in favor of selecting beneficial technologies through transactions unless blocked by non-economic factors that increase transaction costs. North and Wallis (1994) acknowledge that historically *at the level of the firm, over time, transformation costs have been falling, while transaction costs have been rising*. Rigid institutional arrangements and environments may not have allowed declining transaction costs to occur. The distinction between institutionally and preference caused exogenous transaction costs and endogenous transformation costs leads to an important orientation of the focus of analysis to the effects of transaction costs on economic growth, with a particular focus on manufacturing growth. This orientation directs eventually to selecting policy variables, which happen to be exogenous to the economic system.

Transaction costs may be reduced by working from two directions; one by reduction of causes of lack of information / uncertainty, and the other by optimal supply of the institutions that reduce risks and provide information and insurance services. Reduction of causes of uncertainty and ignorance include expansion of technical knowledge on causes and effects, expansion of technology, removal of communication barriers, building thrust, understanding and social responsibility. Optimal supply of transaction sector reduces transaction costs. Keeping low supply of the services would raise prices of the services too much for transactions to take place. Too much transaction costs are fetters to economic activity. What facilitates transaction is not the total absence of transaction costs, which is tantamount to experiencing infinite costs, but the presence of the transaction services at low costs.

### 2.4 GOODS AND SERVICES COMPETING FOR RESOURCES

The economy in transition from agrarian stagnancy to modern growth is bounded by a lower level equilibrium of subsistence economy and a higher-level matured economy. In this transition stage, there is an unstable equilibrium. If disturbed at the unstable equilibrium, the economy either moves to the lower level equilibrium or moves to higher level transformation depending on capital stock (*K*) in relation to the critical stock$(K^*)$ in the modern sector, which is

$$\mathbf{K}^* = \left(\frac{\delta}{s-\lambda}\right)^{\frac{\alpha}{\mu}}\left(\left(\frac{1}{\eta}\right)^{\frac{1}{\mu}}\left(\frac{C}{\omega_t}\right)^{\frac{u}{\mu}}\right)\left(\frac{\beta\bar{R}}{\theta(1-\alpha)}\right)^{\frac{1-a}{\mu}} + \boldsymbol{\omega_t} \quad \text{(From equation 8 above)}$$

If the economy exceeds the critical stock and escapes the unstable equilibrium it moves to a persistent change towards maturity where it assumes a different structure having no more a distinction between traditional agriculture and modern manufacturing. The parameters $\omega$ and $\lambda$ in play important role in determining the required critical capital $K^*$to escape lower level equilibrium. Higher values of $\omega$ and $\lambda$ tend to increase the required capital K*. The higher the allocation of capital in transaction services the more difficult and resource demanding will be escaping to higher-level equilibrium.

Capital committed to transaction services, which dominate the service sector, reduces the inputs going to goods production. Transaction costs are manifestations of inefficiencies. As such, inefficiencies are considered not only as output affecting, but also as input reducing as well. Capital used for transaction services first facilitates the escape to sustained growth until it reaches some level, beyond which it becomes hindrance. Expansion of transaction services in low-income economies beyond the minimum required crowds out manufacturing and retards the attainment of sustained growth. Increased transaction costs and inefficiencies are causes for the failure to attain sustained growth in manufacturing and associated services. Differences in the levels of transaction costs and inefficiencies arise from prevailing market imperfections of low-income economies.

The theoretical analysis places emphasis in capital accumulation in the modern manufacturing sector, which propels the economy forward. Manufacturing enables generation of value added of services in and for it. The rate of change of manufacturing value added with respect to changes in resources committed to transaction services **ω** is:

$$\frac{dM}{d\omega} = d/d\omega\left[\eta\left(\frac{\omega_t}{C_t}\right)^{u}(K_t-\omega_t)^{\alpha+\mu}\left(L_t-\varphi_t\right)^{1-\alpha}\right] = \left[\frac{u}{\omega}-\frac{\alpha+\mu}{K-\omega}\right]M \qquad (9)$$

$$\frac{dM}{d\omega} = 0 \quad \text{at} \quad \boldsymbol{\omega} = \frac{u}{\alpha+\mu+u}K = \boldsymbol{\omega}^{*} \ , \qquad (9a)$$

$$\frac{dM}{d\omega} > 0 \text{ at } \boldsymbol{\omega} < \frac{u}{\alpha+\mu+u}K (\text{Transaction services are helpful for manufacturing until } \omega = \omega^{*}) (9b)$$

$$\frac{dM}{d\omega} < 0 \quad \text{at} \quad \boldsymbol{\omega} > \frac{u}{\alpha+\mu+u}K \ (\text{Transaction services retard manufacturing after } \omega > \omega*) \qquad (9c)$$

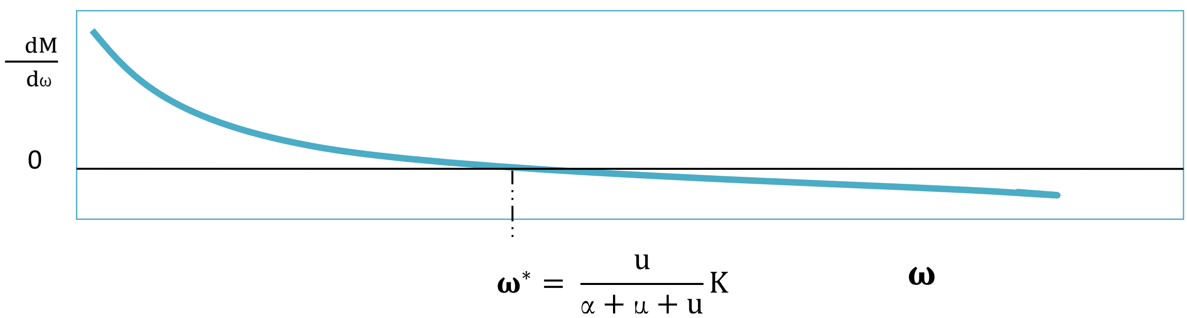



Fig 2 Rate of change of manufacturing with respect to transaction costs

The model shows that the expansion of transaction services has negative effect on manufacturing after reaching some stage of usage of capital $\boldsymbol{\omega}^{*}$, which is a function of capital stock(K). The expansion of services beyond this level causes retarded value added growth associated with manufacturing in low income economies. When capital used in transaction services **ω** is less than

$\boldsymbol{\omega}^*$**,** change in the value added of manufacturing is positive with changes in $\boldsymbol{\omega}$. In economies where manufacturing and services are negatively related we have the ground to conclude that transaction services are greater than $\omega^*$. Conversely, in economies with positive causal relationship of services to manufacturing, we may conclude that transaction services have not exceeded the minimum level of transaction services required for facilitation. This study empirically explores the prevailing causal relationship of services and manufacturing, and infers whether the transaction cost level is greater or less than $\boldsymbol{\omega}^*$ **.**

Note that $\boldsymbol{\omega}^*$, which is capital stock spent on optimal transaction services, grows with growth of capital stock K. For higher stock of capital (K), the capital required to run optimal transaction services ($\boldsymbol{\omega}^*$) increases. For a particular value of K, $\boldsymbol{\omega}^*$ assumes fixed value. Otherwise, as K grows $\boldsymbol{\omega}^*$ also grows.

# 3. METHODOLOGICAL FRAMEWORK AND MODEL

This section aims at undertaking empirical verification of the theoretical claims made above via testing the hypothesis using econometric methodological framework. Designating $\boldsymbol{\omega}^*$ **as** the optimum level of transaction costs required to facilitate transactions, the hypothesis becomes:

- Growth of transaction services, which use capital less than $\boldsymbol{\omega}^*$, advances manufacturing growth, while growth of transaction services making use of capital beyond $\boldsymbol{\omega}^*$ (which have grown beyond the optimal required for facilitating transactions) retards manufacturing growth in low-income economies.

The study sets out to test whether or not growth of services in economies with capital spent on transaction services $\omega$ where $\omega < \omega^*$ advance manufacturing growth while services using $\omega > \omega^*$ retard manufacturing growth. In the method followed to test the hypothesis changes in manufacturing value added and changes in value added of services and agriculture are filtered in various time scales by the chosen wavelets. VAR / VECM approach and Granger causality tests are performed to detect the nature of causalities.

## 3.1 THE METHOD OF ANALYSIS

The method of analysis directly follows from the relations in equations: 9, 9a, 9b and 9c.

$$\frac{dM}{M} = \left[\frac{ud\omega}{\omega} - \frac{(\alpha+\mu)d\omega}{K-\omega}\right] = f\left(\frac{d\omega}{\omega}\right) \quad (10)$$

Growth in manufacturing is a function of growth in transaction costs. The model also implies that growth of manufacturing is zero when $\boldsymbol{\omega} = \frac{u}{\alpha+\mu+u}K = \boldsymbol{\omega}^*$, positive when $\omega < \frac{u}{\alpha+\mu+u}K$ and negative when $\omega > \frac{u}{\alpha+\mu+u}K$.

Since the level of $\boldsymbol{\omega}^*$ for an economy is not known, the level of $\boldsymbol{\omega}$ is inferred from the direction of Granger causality of services on manufacturing. The analysis proceeds by identifying Granger causal relationship between services and manufacturing. The direction of causality enables infer the relative level of $\boldsymbol{\omega}$ with respect to $\boldsymbol{\omega}^*$. The actual direction of change of service is used to predict the performance in growth of value added associated with manufacturing, as per the hypothesis, and comparing the predicted performance of manufacturing with actual performance enable to verify the hypothesis.

Granger causality and impulse response tests indicate positive, negative or no relationship of services with manufacturing. Under positive relationship with manufacturing growth, actual growth of services predicts advances in manufacturing or negative growth of services predicts retarded manufacturing. Under inverse relationship with manufacturing, growth of services predicts retarded manufacturing and decline in services predicts advances in manufacturing.

If the predicted performance in manufacturing is the same as the actual performance in manufacturing the hypotheses gets support from the data. The following table (Tab.3) outlines the various empirical possibilities and verification schemes applied in this study. There are two significant cases of Granger causality: Positive and Negative. There are three possible cases of actual direction of growth (trend) of services, positive (+), negative (-) or no(0) growth. Each direction of causality is considered with the actual direction of growth of service to predict the growth of manufacturing and to compare the prediction with the actual growth of manufacturing. For example, a case where positive Granger causality is detected and the actual trend in growth is positive for services, if the hypothesis is valid, that must result in growth of manufacturing. To verify the hypothesis, the predicted growth in manufacturing is compared with the actual direction of change in manufacturing. If the predicted and the actual are same the hypothesis has gotten support, otherwise not.

Tab 3: Possible Outcomes and Supportive Cases for the Hypothesis

| Granger causality of orthogonalized Services on Manufacturing | Actual trend of services in 42 years | Predicted direction of changes in manufacturing | Actual Direction of Changes of Manufacturing | Implications for the hypothesis |
|---|---|---|---|---|
| **+ve** (Under positive causal relationship, the implied level of services consume capital ω<ω*) | - | - | 0 | weakly supportive |
| | | | - | supportive |
| | | | + | Not supportive |
| | + | + | 0 | weakly supportive |
| | | | - | Not supportive |
| | | | + | supportive |
| | 0 | 0 | 0 | supportive |
| | | | + | Not supportive |
| | | | - | Not supportive |
| | | | | |
| **-ve** ( Under negative causal relationship Implied Level of services consume capital ω>ω*) | - | + | 0 | weakly supportive |
| | | | - | Not supportive |
| | | | + | supportive |
| | + | - | 0 | weakly supportive |
| | | | - | supportive |
| | | | + | Not supportive |
| | 0 | 0 | 0 | supportive |
| | | | - | Not supportive |
| | | | + | Not supportive |

### 3.2 DATA AND TREATMENT OF DATA

The method of analysis specified above requires preparation of the data to detect long-term relations between services and manufacturing. The preparations of the data involve orthogonalization of the considered sector from the excluded sectors on the one hand and the wavelet transformation of data to suit the analysis.

THE SELECTED SECTORS AND THE NEED FOR ORTHOGONALIZATION

Among the sectors in the economy manufacturing value added, agricultural value added and services are taken in the analysis. The value added data of manufacturing, agriculture, and services that underwent treatment are tabulated in APPENDIX IVA in ten years interval. The growth rates of the value added in 40 years are tabulated in APPENDIX IVB . For most countries the value added of these sectors has grown together and the general positive association obscures the underlying causal relationship. The effects of other sectors has also to considered. The value added of other goods supplying sectors to the economy ( construction, mining, utilities and imports) are available in *unstat*. Inclusion of these, other goods supplying sectors, i.e., construction, mining, utilities, and imports, increases the number of variables in the analysis and leads to loss of degrees of freedom. The lags involved in VAR (P) model in time series length of 42 years dictates the reduction of vectors to be analyzed. VAR analysis of growth of GDP and shares of Manufacturing and Agriculture at various time scales has to be analyzed net of effects of other sectors. This requires orthogonalizing vectors of outputs of manufactured, agriculture and services from vectors of outputs of other goods supplying sectors, before undertaking VAR regression of sectoral interactions with manufacturing growth at different time scales. This enables to identify the exclusive sectoral effects of changes in services and agriculture on changes in growth of manufacturing. Orthogonalization is done using the projection method (Han L. and Neumann M. 2007) as it is intuitive. The projection method orthonormalizes vectors in an inner-product space using the projection operator. Given vectors U and V the orthogonal Projection of V on U is :

$$\text{Projection}_{\,U}(V) = \frac{<U,V>}{<U,U>}U \tag{14}$$

where $< U, V >$ is the inner- product of the vectors U and V.

The projection vector is that component of the vector V lying in the vector space of U. The component of vector V that is orthogonal to vector U is:

$$V_1 = V - \text{Projection}_{\,U}(V) \tag{15}$$

The orthogonalized manufacturing, service and agricultural outputs are thus free from the contributions of the excluded sectors in the included sectors. Manufacturing and agriculture are not orthogonalized with services as services are considered to be the effects of goods production. The orthogonalized time series data on sectoral value added undergo transformation with Haar MODWT wavelet at various time scales to obtain the wavelet coefficients. The sum of the inner product of the wavelet coefficients and the wavelets produce the details ($D_i$) and the smooth(S). The details $D_i$ and S are made ready to undergo time series regression using VAR procedures and Granger Causality tests with Impulse-Response analysis. Orthogonalized impulse-responses are used to sense the causal relationship (Lutkepohl 2005). The cumulative orthogonalized impulse-responses in longer steps (42 in this case) are considered to judge the positive or negative effects of the respective changes of sectoral outputs to changes in growth of GDP. The data set employed is accessible from United Nations National Accounts Main Aggregates Database.

WAVELET TRANSFORMATION OF DATA

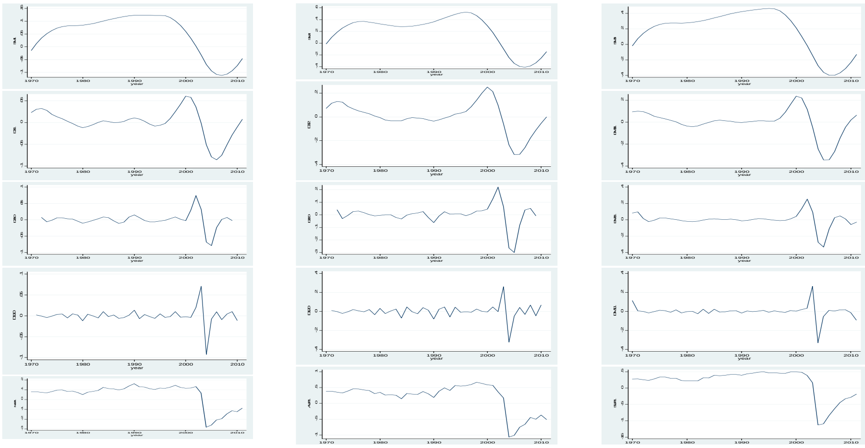
Change can be detected by differences of consecutive values. The consecutive time could be every single year, two years, three years, etc. Differences of values between every single consecutive year or differences of averages of two years or three years provide data of distinct resolution. What may be invisible at one time scale could be visible at others. The time scale at which significant relations are detected may not to be predetermined. Thus, differences of average outputs of sectors and the whole economy in various time scales have to be considered. An analytic method chosen that enables filtering relations between sectors and the economy at large at various time scales is wavelet analysis (Percival and Walden, 2000; Kaiser G.1994). Wavelets are useful to compute differences in weighted averages of certain functions across varying averaging periods or scales. Changes in averages over various scales provide several of layers of information different from the average levels themselves (Percival and Walden, 2000; Kaiser G.1994). For example, changes in annual output of consecutive years may inform differently about the progress of the economy than the annual output levels themselves. Differences in the averages or weighted averages of two, three, or four, etc., consecutive years may provide different information about the progress of an economy than the averages of outputs in two, three, four etc. years. To use topographic analogy, the average levels across longer time scales provide information on the bigger picture such as the profile of the mountain range, while the differences indicate the details such as the hills and valleys in the mountain range. This is a contribution of this paper in using such method for the analysis of growth and structural relationships. Most studies do not consider time scale effects in relating macro economic variables.

With the use of appropriate wavelets, the time series data is transformed into other time series with characteristics reminiscent of the time scale considered. Among the various wavelet transformations the one selected for this purpose is Haar wavelet. Specifically, Haar wavelet of the Maximum Overlap Discrete Wavelet Transform (MODWT) is chosen (Percival and Walden, 2000; Kaiser G.1994). Changes in average growth of output of the economy and changes in share of manufacturing and agriculture are filtered in various time scales using Haar MODWT as the wavelet is made to pass through the time series data. The wavelet-transformed data is further used in Granger causality tests. A little excursion in to the nature of wavelets is helpful and it is provided in Appendix III.

Applying wavelet analysis in economic time series data enables identification of relationships across various time scales. Annual outputs of sectors and the economy change over time. The changes over time are results of linkages and causal interactions of the sectors. The interactions and causalities could be between contemporaneous values or between past values of the outputs. The interactions may work themselves out in a relatively short or long period. Thus, the behaviors of the outputs at various time scales have to be filtered and the causal relationships in the corresponding time scales investigated separately. Among the differences of averages across various time scales one possibly could detect such causal relationships and effects of interactions more than efforts in investigating in mere annual differences. This is because the time lag effects of the interactions can be captured better by evaluation of the average differences across various time scales after they have sufficiently worked themselves out. Wavelets serve exactly this purpose. Such methods have been employed in other economic studies (Månsson, K. 2012; Hacker R. S., Karlsson H. K. and Månsson K, 2012)

Moreover, macroeconomic annual figures could possibly involve noises, arising from inaccuracies in data compilation and irregular disturbances or shocks affecting the economy. Differencing the averaged figures significantly filters some of these noises and the data better reveals more regular patterns and longer-term relations in the economy. Rather than differentially weighted averages of sorts it evaluates the differences of equally weighted averages of consecutive figures. In contrast to other wavelets, Haar wavelet is particularly suiting the purpose of this study. Differences of averages of annual outputs in consecutive two, four, and eight, years are addressed with Maximum Overlap Discrete Wavelet transform (MODWT) of Haar wavelet.

In addition to the analysis of relationships of differences of averages (the details $\mathbf{D}_j$), which are used to detect possible causality, it allows the analysis of the relationship of moving averages (smoothes **S**). The smoothes(S) indicate the long-term trends of sectoral outputs of the economy as they stand. The relationships between smoothes are investigated for causality to detect impacts of scaled levels of value added of sectors on one another on long-term basis. Fig 1 below is wavelet-decomposed data $D_i$ and S for a particular economy. The details $D_i$ and S are made ready to undergo time series regression using VAR procedures and Granger Causality tests with Impulse-Response analysis.



S

$D_3$

$D_2$

$D_1$

Manufacturing Agriculture Service

Fig 3: Wavelet transformation of sectoral value added for Chad

GRANGER CAUSALITY TESTS AND IMPULSE-RESPONSE ANALYSIS

The wavelet-transformed data to be analyzed are first differences and moving averages at dyadic time scales. The first difference time series are stationary in nature and the moving averages are proportional to the trends that may or may not be stationary. The time series model appropriate for the stationary first difference transforms is VAR while for the non-stationary transforms is VECM. The detail wavelet transforms (Dj) are by definition stationary series and stationary multiple time series are treated with VAR analysis. The functional form of the VAR (P) analysis is:

$$\mathbf{Y}_t = \mathbf{V} + \mathbf{A}_1\mathbf{y}_{t-1} + \cdots + \mathbf{A}_p\mathbf{y}_{t-p} + \mathbf{u}_t, \quad t = 0, \pm 1, \pm 2, \ldots, \qquad (20)$$

where $\mathbf{Y}_t = (y_{1t}, \ldots, y_{Kt})$ is a (K×1) random vector,

$\mathbf{A}_i$ are fixed (K×K) coefficient matrices,

$\mathbf{V} = (\nu_1, \ldots, \nu_K)$ is a fixed (K × 1) vector of intercept terms,

$\mathbf{u}_t$[10] $= (u_{1t}, \ldots, u_{Kt})$ is a K-dimensional white noise process,

where, $E(\mathbf{u}_t) = 0$, $E(\mathbf{u}_t\mathbf{u}'_t) = \Sigma_u$ (covariance matrix)and $E(\mathbf{u}_t\mathbf{u}'_s) = 0$ for $\mathbf{s} \neq \mathbf{t}$.

$\mathbf{Y}_t$ vector , in the context of this study, consists of Manufacturing($M_{gt}$) Agriculture ($A_{gt}$) and Service( S) value added and their wavelet transforms in a period of 42 years.

[10] The use of "u" here has no relation to that symbol used in the conceptual model

A stable VAR relation is estimated to test the existence of Granger Causality and subsequently impulse response tests to see whether the Granger causality is of positive or negative sign. The basis for Granger causality is the principle that a cause cannot come after the effect. If a variable $X_t$ affects a variable $Y_t$, the former should help improving the predictions of the latter variable (Lutkephol, 2005).While the detail wavelet transforms (Dj) are by definition stationary series and stationary multiple time series are treated with VAR analysis, smooth(S) may not be stationary. In that case co-integration analysis would be the appropriate approach. Granger causality is tested following Lutkephol (2005), where the VAR lag length is extended by one unit. Impulse response relations are estimated to see the positive or negative Granger causality associated with a pair of variables.

Granger Causality tests are expected to indicate the sectoral causal impacts on one another. Granger causality tests, however, do not show the direction/sign of the impact. Impulse response relations are estimated to see the positive or negative Granger causality associated with a pair of variables. The tests are performed on wavelet decomposed time series data in various time scales. Vector autoregressive analysis on un-decomposed or non-transformed data lumps up effects on a single time scale and it does not detect the varying relations prevailing on various time scales. Statistical determination of lag lengths was undertaken before performing VAR analysis and performing Granger Causality test with Impulse Response mapping. The lag lengths per country are taken based on agreement of the four information criteria (FPE, AIC, HQIC and SBIC) (Lutkepohl, 2005). In cases where there is conflict between the criteria, the suggested length by most criteria is chosen. In case the criteria break even, the lag length suggested by AIC is taken on the ground that it possesses characteristics better suited to short time series length (Lutkepohl, 2005).

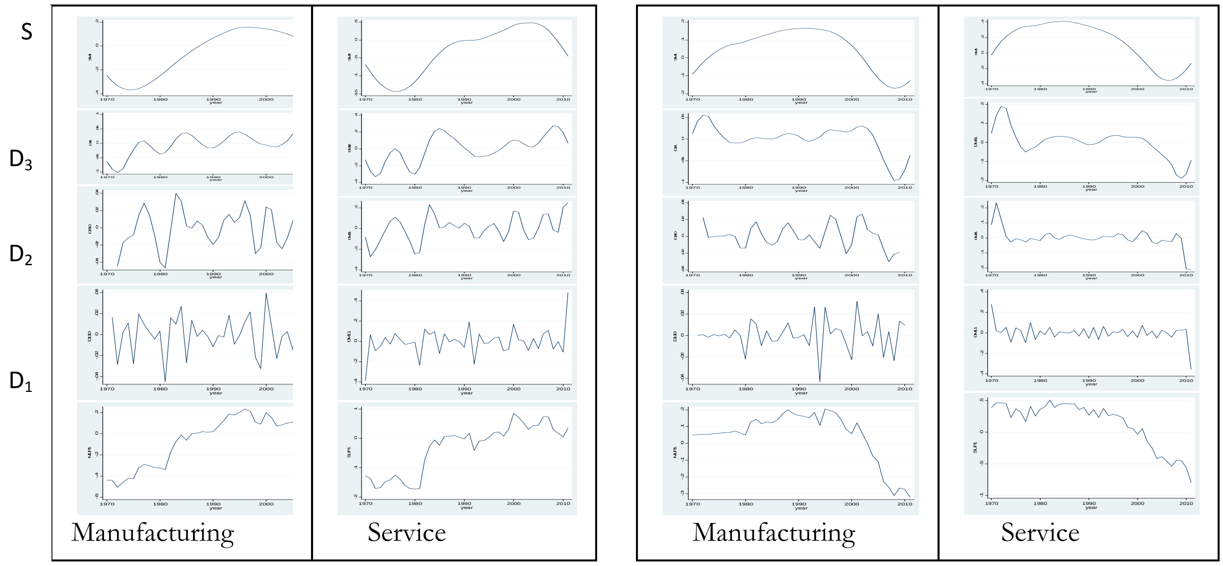
DESCRIPTION OF TIME SERIES DATA AND SOURCES

The data employed are those obtained from United Nations National Accounts Main Aggregates Database on GDP and components of GDP of all countries. The economies under investigation are those with low per capita income (PCI), arbitrarily taken to be below 1000 USD in 1970. The PCI is computed taking 2005 as base year. These economies are economies in transition from traditional to modern in the sense of Hansen and Prescott (2002) and Parente and Prescott (2003).The economies falling to this category are 71 in number (Appendix IV)

Tab 4: Regional distribution of Countries with less than 1000USD PCI in 1970 in 2005 USD

| Region | Total Number of countries included |
|---|---|
| Africa | 43 |
| Asia | 24 |
| Latin America and Caribbean | 4 |

Some of these countries have made big strides in attaining PCI exceeding 1000 USD, while others are still below that mark. The period of the past 42 years (1970 to 2011) is chosen on the basis of availability of data for all economies. The time span allows limited time scales in the wavelet analysis, and the maximum time scale with in which changes are to be investigated is 8 years.




Kenya

Senegal

Fig 4: Differences in Wavelet decomposed data of Manufacturing and Services across countries

The time path of the wavelet-transformed, time-series sectoral data are with differing applicable lag lengths, and with differing time scale relationship. Thus the time series data per country has to be treated separately. Fig 4 above indicates the variation in the structure of the economies.

Moreover, the economies are economies in transition where considerable number of them is undergoing observable structural changes. The prevalence of structural change necessitates the recognition of existence of unstable parameters and structural breaks in the analyses. The relationship between sectoral contributions and the economy at large that are to be investigated are thus averages of the changing parameters in the period under investigation. The structural breaks and the entailed changes in the parameters are characteristics of the economies and the relations to be discovered by the wavelet analysis are to be understood in ordinal sense.

## 4. GRANGER CAUSALITY AND IMPULSE-RESPONSE RESULTS AND THE EVIDENCES ON THE HYPOTHESIS

### 4.1 GRANGER CAUSALITY ACROSS TIME SCALES

The number of significant (at 10%) Granger-causal-relations increases as the time scale increases. It is observed that 19 significant cases occur in time scale 1; 25 significant cases occur in time scale 2; 43 significant cases occur in time scale 3, and 66significant cases occur for the smooth in time scale 3( Tab.5).

Tab 5: Significant cases of Granger causality

| | **Time scale 1 ( $D_1$)** | **Time scale 2 ($D_2$)** | **Time scale 3 ($D_3$)** | **Smooth (S)** |
|---|---|---|---|---|
| **Significant cases** | 19 | 25 | 43 | 66 |
| **Non significant cases** | **52** | **46** | **28** | **5** |
| **Total number of cases** | **71** | **71** | **71** | **71** |

The time scale dependence of the distribution of significant and non-significant causation of services on manufacturing across time scales is significant (with p-value of 2.34933E-16 in chi-square test of the contingency table above)

Services affect the evolution of manufacturing in most countries in longer time scales. The appearance of greater significant cases in longer time scales, as in Tab 4, suggests that structural relations are largely long-term relations. Granger Causality in the longest time scale using $D_3$ and Smooth (S), in particular, detects deeper structural relations while faster relations, which happen to be less fundamental and skin deep causal relationships and responses, are observed in time scales 1 and 2($D_1$ and $D_2$). Whenever outcomes in shorter and longer time scales are different, the results where the actual attained changes in manufacturing growth agrees with the predicted change in manufacturing is taken as the relevant relationship.

There is no significant difference across regions in providing or denying support to the hypothesis. The proportion of supporting cases among the 43 African and 24 Asian & Pacific countries across time scales is as follows in Tab 5. Chi-square test of the contingency table indicates that the difference across regional distribution is not statistically significant (P value =1) .

Tab6: Regional distribution of supporting and non-supporting cases

| | Time scale1 | Time scale 2 | Time scale 3 | smooth |
|---|---|---|---|---|
| Proportion of supporting cases from Africa | 0.16 | 0.23 | 0.40 | 0.53 |
| Proportion of supporting cases of Asian & Pacific region | 0.21 | 0.13 | 0.17 | 0.46 |
| Proportion of non-supporting cases from Africa | 0.07 | 0.05 | 0.09 | 0.23 |
| Proportion of non supporting cases of Asian & Pacific region | 0.04 | 0.08 | 0.25 | 0.04 |

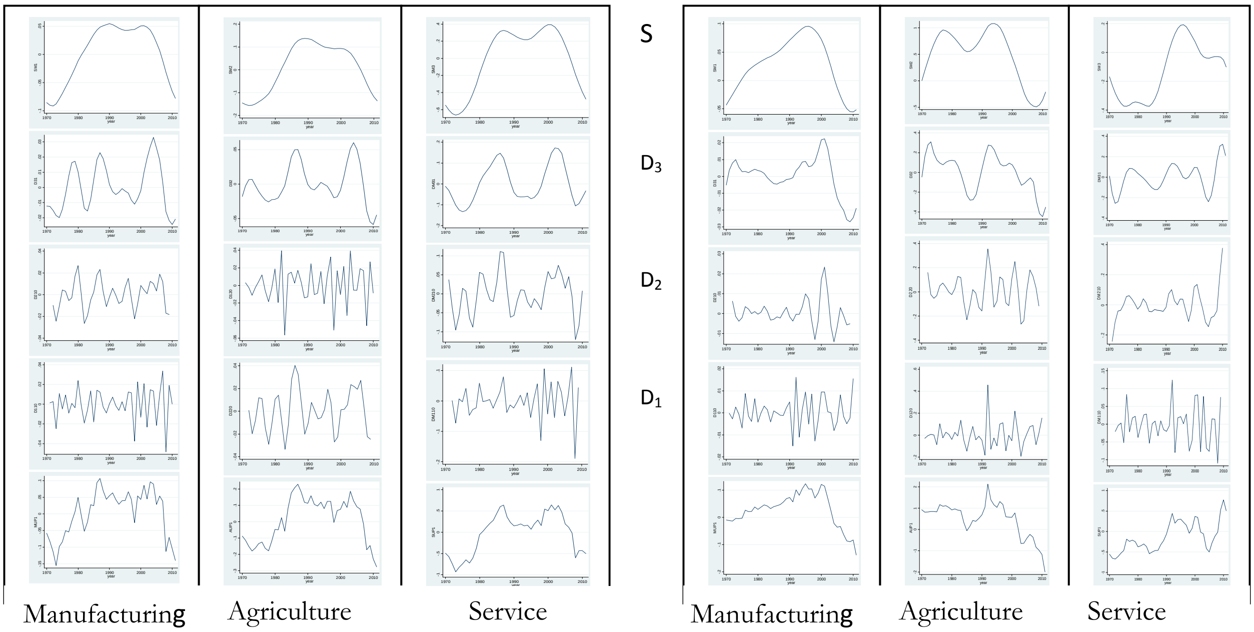
## 4.2 THE CATEGORIES OF SIGNIFICANT CASES

The combinations of causality of changes in services on changes in manufacturing vary from country to country. Some of the countries manifest positive Granger causality in a particular time scale while others show negative causality. The number of countries with positive Granger causality at the longer time scales is generally lower than the number of those with negative Granger causality (Tab 7). The implication of this is that a greater number of countries have services beyond the optimal level while some are below the optimal level in the period of 42 years.

Tab7: Positive and negative Granger causal cases across time scales

| **Cases** | **Time scale1 ($D_{1}$)** | **Time scale2($D_{2}$)** | **Time scale3($D_{3}$)** | **Smooth (S)** |
|---|---|---|---|---|
| Case 1( Positive Granger causality of services on manufacturing ) | **9** | **16** | **17** | **29** |
| Case 2(Negative Granger causality of services on manufacturing ) | **10** | **9** | **26** | **37** |
| No Causation | **52** | **46** | **28** | **5** |
| **Total number of significant cases** | **19** | **25** | **43** | **66** |

The time scale dependence of the distribution of countries in positive, negative, and no causality of services on manufacturing is significant (with p-value of 5.45223E-15 in chi-square tests of the contingency table : Tab 7 above ).




**Case 1 Economy (Bolivia)** **Case 2 Economy (Ethiopia)**

Fig 5: Typical economies with services below optimal and above optimal levels

Positive or negative Granger causality occurs with any of the three possibilities of actual trends of service: positive, negative and no change in growth of service (Tab 2 above). Actual assessment of the trends of services across countries indicates that there are many cases. Some are with single long term trend; some are cases where there is no single trend and the rest are cases with structural breaks. The sign of change in services is determined by taking these variations in to considerations. Known positive or negative Granger causal relations and actual trends in services enable to predict manufacturing growth performance in the given period. If the trends are changing sign in a number of times in the period of analysis, prediction becomes difficult and the cases are indeterminate. In an economy with a single structural break in the middle of the period, trends before and after the break could easily be identified. When the breaks are multiple the cases are indeterminate. Changing trends and cases with structural break are few and noted in Appendix V.

The number of countries with positive trend of services is greater than that of countries with declining trend of services. The former are 33 in number while the latter are 21. In addition, there are 13 countries with changing trends of services. Prediction of the prospect of manufacturing in economies with clearly defined single trends is straightforward in 54 countries and in some of the 13 economies with single structural break at the middle of the period.

Tab 8: Cases of positive and negative Granger causality versus trends in service growth

| Time scales | D1 | D2 | D3 | S | Direction of growth of services ( trends) |
|---|---|---|---|---|---|
| Positive significant cases | 9 | 16 | 17 | 29 | 33 |
| Negative significant cases | 10 | 9 | 26 | 37 | 21 |
| Total | 19 | 25 | 43 | 66 | 54 |

### 4.3 STRUCTURAL RELATIONS AND THE HYPOTHESIS

The hypothesis to be tested states that Growth of transaction services, which are not greater than the optimal required to facilitate transactions, advances manufacturing growth while growth of transaction services, which have grown beyond the optimal required for facilitating transactions, retard manufacturing growth in low income economies.

What was the outcome of interactions of services and manufacturing under the above structures? Under positive Granger causal relationship, actual growth of services must cause manufacturing to grow, actual decline in services must cause manufacturing to decline or no change in services is associated with no change in manufacturing. Positive Granger causality implies that the economy is facing shortage of transaction services needed for manufacturing and the growth of these services enhances manufacturing growth. The decline in the supply of these services impedes the progress of manufacturing. A structure with positive Granger causality combined with the trend of transaction services enables prediction of the direction of change of manufacturing. The hypothesis gets support if the predicted direction of change of manufacturing coincides with the actual direction of change in manufacturing.

In cases of negative Granger causal relationship of transaction services to manufacturing, actual growth of services must cause manufacturing to decline, actual decline in services must cause growth of manufacturing, or no change in services is associated with no change in manufacturing. Such a structure of economies implies that there is excessive transaction service, beyond the required level, and the further expansion of services strangles manufacturing. In reverse, the reduction in transaction services relieves manufacturing from the burden of transferring resources away to services that would have been a source of growth for itself. A structure with negative Granger causality, combined with the trend of transaction services, enables to predict the direction of change of manufacturing. Verification of the hypothesis requires comparison of the predicted changes in manufacturing with the actual change in manufacturing. Like in the positive Granger causality case, the hypothesis gets support if the predicted direction of change of manufacturing coincides with the actual direction of change in manufacturing.

Transaction and non-transaction services are lumped together in the national accounts data of countries. The trend of transaction services is proxied by the trend of services in general. Observed changes in trends and structural breaks are taken into consideration. Positive, negative, flat or changing trends of services in 42 years period indicate whether transaction services were increasing, declining, or stagnant.

The number of cases, where predicted changes in manufacturing match with actual changes in manufacturing, are 40 in smooth and 24 in $D_3$ as tabulated below (Tab 9). The numbers indicate the cases supporting the hypothesis in the respective time scale. Each case occurs in higher frequency as the time scale increases (Tab 8). All the cases and their implications for the hypothesis are analyzed with reference to Table 1 above.

Tab 9: Significant cases across time scales

| | **Time scales** | | | | **Predicted Changes in Manufacturing Matching with Actual Changes** | | | |
|---|---|---|---|---|---|---|---|---|
| | **D1** | **D2** | **D3** | **S** | **D1** | **D2** | **D3** | **S** |
| **Positive significant cases** | **9** | **16** | **17** | **29** | 4 | 11 | 11 | 21 |
| **Negative significant cases** | **10** | **9** | **26** | **37** | 9 | 6 | 13 | 19 |
| **Total** | **19** | **25** | **43** | **66** | 13 | 17 | 24 | 40 |

The number of countries providing support to the hypothesis across all time scales is much greater than those cases not supporting the hypothesis. A country may provide evidence in support of the hypothesis in one time scale while not supporting the hypothesis in another time scale. Cases where the results across all time scales do not support the hypothesis are only 3 among the 71 countries, while those countries which do not manifest non supporting cases in any of the time scales are 32 in number.

Cases in support of the hypothesis in the longest time scale (smooth) are 41 in number while those not supporting the hypothesis in this time scale are 13 in number. The number of economies providing support increases with the time scale. The pattern in all time scales is that cases in support of the hypothesis are much greater than those that do not support (Tab 9). This result suggests that the level and direction of growth of services matter for sustained growth of manufacturing and the hypothesis enjoys overwhelmingly large supportive cases. The chi square test for the contingency table, Tab 10, indicates that the number difference of supporting and non supporting cases across time scales is significant ( p value=0.03).

Tab 10: Cases for and against the hypothesis

| **Cases** | **Time scale 1 ( D1)** | **Time scale 2 (D2)** | **Time scale 3 (D3)** | **Smooth (S)** | **Consistent In all time scales** |
|---|---|---|---|---|---|
| Supporting the hypothesis | **14** | **18** | **24** | **41** | **32** |
| Not supporting the hypothesis | **5** | **6** | **18** | **13** | **3** |
| Indeterminate | 0 | 0 | 1 | 10 | 1 |
| Total | **19** | **24** | **43** | **64** | **36** |

## 5. CONCLUSIONS AND POLICY IMPLICATIONS

This study is based on an alternative explanation for the transition of low-income economies from classical stagnation to modern economic growth that hinges on structure. In the explanation, the presence or absence of a particular structure in which manufacturing growth and share looms large is crucial. The onset of structural change characterized by faster growth of output and share of manufacturing is the basic feature that ensures a low-income economy to attain sustained growth. The analytical work that served as the basis for this study suggested that larger manufacturing contributions are associated with higher rate of sustained growth. The claimed causal link for this role of manufacturing is that manufacturing is a sector having the highest actual or potential capacity to provide a variety of goods for direct consumption, indirect consumption and in forming the basis for emergence of services. What structural factors explain the prevalence of a structure where manufacturing growth and share are retarded? One structural factor explaining retarded manufacturing growth is non-optimal level of services that hampers or crowds out manufacturing.

Capital committed to transaction services, which dominate the service sector, are considered as transaction costs reducing inputs to goods production. Transaction costs are sources of inefficiencies. As such inefficiencies are considered not only as output affecting but also as input reducing as well. Capital used for transaction services first facilitates the escape to sustained growth until it reaches some level, beyond which it becomes hindrance. Expansion of transaction services in low-income economies, beyond the optimal required, strangles manufacturing and is not helping the attainment of sustained growth. Failure to attain sustained growth of manufacturing and associated services is the outcome partly of increased transaction costs and inefficiencies. Differences in the levels of transaction costs and inefficiencies arise from prevailing market imperfections, the extent of the difficulty faced in accessing inputs by goods producers and difficulties in accessing finished goods by consumers of low-income economies and from the choices made in the method of addressing the constraints by economic actors.

Transaction services at lower levels enhance manufacturing while they tend to retard it at higher levels. In light of this hypothesis and the actual expansion of services in low-income economies, it would be informative to investigate case by case whether the expansion of services has led to more manufacturing growth or whether it has retarded manufacturing. The study planned to test the hypothesis that growth of transaction services, which are less than the optimal required to facilitate transactions, advances manufacturing growth and economic performance in low-income economies while growth of transaction services, which have grown beyond the optimal required for facilitating transactions, retard manufacturing growth, and economic performance in low-income economies.

The method followed to test the hypothesis is using Haar Maximum Overlap Discrete Wavelet (MODWT) transformation in a VAR / VECM approach and Granger Causality tests**.** Changes in manufacturing value added and changes in services and agriculture are filtered in various time scales using Haar MODWT. Haar MODWT filters the changes in average outputs and moving averages at different time scales as the wavelet is made to pass through the time series data. Granger Causality tests and impulse response relations are estimated to see the positive or negative Granger causality associated with services and manufacturing. The tests are performed on wavelet decomposed time series data on various time scales. Hence, the Granger causality and impulse response tests are undertaken on each time scale so that changes in short term and long term sectoral impacts are better detected. This is in contrast to vector autoregressive analysis on un-decomposed or non-transformed data that lumps up effects on a single time scale. Analysis in one time scale may not detect the varying relations that possibly prevails in various time scales.

The data employed are those obtained from *unstats*, United Nations National Accounts Main Aggregates Database on GDP and components of GDP of all countries. The economies under investigation are those with low per capita income, arbitrarily taken to be below 1000 USD in 1970 (computed taking 2005 as base year. These economies are economies in transition from traditional to modern in the sense of Hansen and Prescott (2002) and Parente and Prescott (2003). The economies falling to this category are 71 in number. Some of these countries have made big strides in attaining per capita income exceeding 1000 USD, while others are still below that mark. The period of the past 42 years (1970 to 2011) is chosen based on availability of data for all economies. The time span allows limited time scales in the wavelet analysis, which is not the ideal to detect long run relations. The maximum time length with in which changes are to be investigated is 8 years.

Granger causality and impulse response tests indicate positive, negative or no relationship of services with manufacturing. Under positive relationship with manufacturing growth, growth of services predicts advances in manufacturing or negative growth of services predicts retarded manufacturing. Under inverse relationship with manufacturing, growth of services predicts retarded manufacturing and decline in services predicts advances in manufacturing. Thus, the Granger causality tests and the impulse responses detected express the prevailing structure. This structural relation is compared to the actual direction of change of services to predict the direction of change of manufacturing. Comparison of the predicted direction of change of manufacturing with the actual change in manufacturing serves to verify the hypothesis.

The results of the analysis indicate that negative Granger causality cases are generally greater than positive Granger causality cases, which means, services in more number of low income economies have grown at the expense of manufacturing. The number of countries providing support to the hypothesis across all time scales is much greater than that which do not support. Cases where the results across all time scales do not support the hypothesis are only 3 among the 71 sample countries, while those providing support across all time scales are 32 in number. Cases in support of the hypothesis across time scales increases with the length of the time scales. In the longest time scales ( D3 and Smooth) the number of cases for the hypothesis are 28 and 41 respectively. This result suggests that level and direction of growth of services matter for sustained growth of manufacturing and the impact of services on manufacturing is long term in nature. The hypothesis enjoys overwhelmingly large supportive cases.

The policy implication of the results is that structure mattes and growth of transaction services has to be examined for being below optimal or above optimal level.

Particular emphasis goes to the low-income economies, which are considerably more in number, where low level of manufacturing and long-term stagnancy of growth in manufacturing are observed. This state of manufacturing in this group of countries is the result of the structure of the economies where transaction services have out grown manufacturing. The prevailing factors in these economies have given rise to a service dominating structure that has crowded out manufacturing in resource use to the extent that growth in manufacturing and growth in the overall economy has been retarded in the long-run. To reverse this outcome manufacturing growth has to be emphasized and establishing favorable condition towards reducing transaction costs through institutional changes has to be pursued.

In economies with less than optimal services, which are less in number than those dominated by transaction services, it would be advisable in expanding services to facilitate manufacturing growth. The process of identification of optimal levels of services could be informed with Granger causality and impulse response test of wavelet decomposed sectoral value added.

To advance knowledge in this area of research, the reorganization of national accounts data in a way that enables to identify transaction and non-transaction services is important. Future research with the use of longer time series length and wavelet decomposition in longer time scales would enrich our knowledge on the structural importance and sectoral interdependence in low-income economies.

## REFERENCES


Acemeglu, D. and Robinson J.A (2012) *Why Nations Fail: the Original of Power, Prosperity, and Poverty* , Crown publishing Group New York

Banerjee, A and Duflo E (2005), Growth Theory through the Lens of Development Economics, in P. Aghion and S. Durlauf (eds), *Handbook of Economic Growth*, Vol.1A, Amsterdam: Elsevier, pp. 473–552.

Bairoche,P.(1995) *Economics and World History: Myths and Paradoxes* ; The University of Chicago Press

Baumol W. J. (1967) Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis. *The American Economic Review* Vol.57 No.3

Collier P. (2007) *The Bottom Billion: Why The Poorest Countries Are Ailing and What Can Be Done About It* Oxford University Press Inc 198 Madison Avenue New York, New York 10016

Dopfer,K.(2011) Mesoeconomics: Bridging Micro and Macro in a Schumpeterian Key in Mann, S. (2011)(ED) *Sectors matter*, Springer Heildelberg Dordrecht London, NewYork

EC, IMF, OECD, UN and WB (2009) *System of National Accounts SNA-2008* New York

Han L. and Neumann M. (2007) Inner Product Spaces, Orthogonal Projection, Least Squares, and Singular Value Decomposition' in Hogben L( EDs) *Handbook of Linear Algebra*, Taylor & Francis Group, LLC

Hacker R. S., Karlsson H. K. and Månsson K (2012) The Relationship between Exchange Rates and Interest Rate Differentials: A Wavelet Approach , *The World Economy* doi: 10.1111/j.1467-9701.2012.01466.x

Hamilton,J.D(1994) *Time series Analysis* Princeton University Press, Princeton , New York

Hansen ,G.D and Prescott,E.C(2002) Mathus to Solow. *The American Economic Review* , Vol 92, No.4 (Sep., 2002) 1205-1217

Hausmann R · Hwang J · Rodrik D(2007) What you export matters *Journal of Economic Growth* 12:1–25 DOI 10.1007/s10887-006-9009-4 Published online: 30 December 2006 © Springer Science+Business Media, LLC 2006

Hausmann R, Rodrik D Economic development as self-discovery *Journal of Development Economics* 72 (2003) 603– 633 Elsevier

Hewitt,T. , Johnson H, Wield D ( Ed)( 1992) *Industrialization And Industrial Development,* Oxford University Press In Association With The Open University , Walten Street Oxford OX2 6dp UK

Jorgenson D W. (1984) The Role of Energy in Productivity Growth.*The American Economic Review*, Vol. 74, No. 2, Papers and Proceedings of the Ninety-Sixth Annual Meeting of the American Economic Association (May, 1984), pp. 26-30: American Economic Association Stable URL: http://www.jstor.org/stable/1816325

Kaiser G.(1994) A *Friendly Guide to Wavelets* Reprint of the 1994 Edition, Birkhauser

Kaldor, N. (1966) *Causes of the Slow Growth in the United Kingdom*, Cambridge: Cambridge University Press

Kaplinsky R. Morris M( 2000 ) *A Handbook For Value Chain Research Prepared For IDRC*

Krugman, P. (1981) Trade accumulation and Uneven Development, *Journal of Development Economics* 8 1499161. North-Holland Publishing Company
Kuznets, S.(1966) *Modern Economic Growth : Rate Structure and Spread* Yale University Press, New Haven and London
Kuznets, S. (1989) Economic Development, the family, and Income Distribution in the United States in the Twentieth Century in Galambos,L. and Gallman, R(1989)(ED): *Studies in Economic History and Policy* Cambridge University Press , Cambridge
Lewis A. (1954) Dutt A K and Ros J(2008)(edt) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA
Lin J Y (2012) *New Structural Economics a Framework for Rethinking Development and Policy* The World Bank 1818 H Street NW Washington DC 20433
Lipsey RG, Carlaw KI and Bekar CT(2005) *Economic Transformations : general purpose technologies and long term economic growth* Oxford University Press Inc., NY
Lutkepohl,H. (2005) *New Introduction to Multiple Time Series Analysis*, Springer, Berlin Heidelberg New York
Maddisson, A. (2003)The World Economy: *Historical Statistics OECD: Development Center Studies*
Maddisson, A. (2005) *Growth and Interaction in the World Economy: The Roots of Modernity,* AEI Press; Washington D.C
Månsson, K (2012) A Wavelet-Based Approach of Testing for Granger Causality in the Presence of GARCH Effects *Communications in Statistics* - Theory and Methods, 41:4, 717-728, DOI: 10.1080/03610926.2010.529535
Mcmahon G and Squire L(2003) (ED)*Explaining Growth : A global Research Project* Palgrave Macmillan Houndmills, Basingstoke, Hampshire Rg21 6xs And175 Fifth Avenue, NewYork, N. Y. 10010
North,D.C. and Wallis J.J.( 1994) Integrating Institutional Change and Technical Change in Economic History: A Transaction Cost Approach; *Journal of Institutional and Theoretical Economics* Vol 150 , No 4
Palma, 2008 Dutt A K and Ros J(2008)(ED) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA
Partente, S.L and Prescott, E.C(2003) A Unified Theory of the Evolution of International Income Level, Preliminary
URl http://www.nbp.pl/konferencje/radisson/Mowcy/prescot/prescott_paper.pdf
Percival D.B and Walden A.T.( 200?). *Wavelet Methods for Time series Analysis* Cambridge University Press New York
Partente, S.L and Prescott, E.C(1999) Barriers to Riches , *The third Walras – Pareto lecture* , Universoty of Lausanne, Revised October 1999
Pasinetti L.(1993) *Structural economic Dynamics : A theory of the economic consequences of human learning* Cambridge University Press
Patterson, K (2000) *An Introduction to Applied Econometrics: A time series approach* Palgrave,
Pyka,A. Saviotti,P.P.( 2011 ) Economic Growth Through Emergence of New Sectors in Mann, S. (2011)(ED) *Sectors matter*, Springer
Rapley, J.(2002) *Understanding Development* ;Lynne Rienner Publishers, Inc.3 henrietta street, Covent Garden, London WC2E 8LU
Ray D. (2000) *What's New in Development Economics*? New York University `
www.efm.bris.ac.uk/ecjrwt/raymult.pdf
Rodrik D.(2007) *One Economics Many Recipes: Globalization, Institutions, and Economic Growth.* Princeton University Press, 41 William Street, Princeton, New Jersey 08540
Ros(2008 Dutt A K and Ros J(2008)(edt) *International Handbook Of Development Economics Volume I*

Edward Elgar Cheltenham, UK • Northampton, MA, USA
Sachs J. D. (2005) *The End Of Poverty Economic Possibilities For Our Time* The Penguin Press New York
System of National Accounts 2008- SNA2008 , http://unstats.un.org/unsd/nationalaccount/sna2008.asp
Solow, R. M (1956) A Contribution to the Theory of Economic Growth *Quarterly Journal of Economics* (The MIT Press) 70 (1): 65–94
Solow, R. M (1957) Technical Change and the Aggregate Production Function *Review of Economics and Statistics* (The MIT Press) 39 (3): 312–320
Syrquin,( 2008) in Dutt A K and Ros J(2008)(ED) *International Handbook Of Development Economics Volume I* Edward Elgar Cheltenham, UK • Northampton, MA, USA
Szenberg M. (2004)(ED) *New Frontiers in Economics* Cambridge University Press
Takashima, M. (2009) The Sustained Growth and Its Relation to the Initial Conditions Basu, D.(2009) (ED) *Advances in Development Economics* World Scientific Publishing Co. Pte. Ltd.5 Toh Tuck Link, Singapore 596224
Tesfatsion,L. and Judd K.L.( 2006 ED) *Handbook of Computational Economics, Agent based computational economics* Volume 2 , Elsevier
Tesfatsion,L(2005) Agent-Based Computational Modeling and Macroeconomics *ISU Economic Report* 05023
United Nations Statistics Division, National Accounts Main Aggregates Database, December 2013 URL http://unstats.un.org/unsd/snaama/dnlList.asp
United Nations Industrial Development Organization and United Nations Conference On Trade And Development ( 2011) Fostering Industrial Development In Africa In The New Global Environment *Economic Development In Africa Report 2011*
United Nations Industrial Development Organization (2009) New Industrial Challenges for the Bottom Billion and the Middle Income Countries *Industrial Development Report 2009 Breaking In And Moving Up*:Unido Id No: 438
United Nations statistics Division (2013) United Nations National Accounts Main Aggregates Database unstats.un.org/unsd/snaama/ Introduction .asp
United Nations Department of Economic and Social Affairs( 2008) International Standard Industrial Classification of All Economic Activities Revision 4 ST/ESA/STAT/SER.M/4/Rev.4 UNITED NATIONS PUBLICATION, New York
Wallis J.J. and North, D. (1986) ***Measuring the Transaction Sector in the American Economy,*** **1870-1970** URL: http://www.nber.org/chapters/c9679
Wallis J.J and North D (, 1988) Should Transaction Costs be Subtracted from Gross National Product? *The Journal of Economic History*, Vol. 48, No. 3 pp. 651-654 Published by: Cambridge University Press on behalf of the Economic History Association Stable URL: http://www.jstor.org/stable/2121542
WB (2009) Reshaping Economic Geography *World Development Report*, Washington DC
World Bank (2013) Doing Business Economy Rankings URL: doingbusiness.org/ rankings
Yoshikawa,H. and Miyakawa S(2011) Changes in Industrial Structure and Economic Growth : Post war Japanese Experience in Mann, S. (2011)(ED) *Sectors matter*, Springer Heildelberg Dordrecht London, New York

## APPENDIX I: INDEX OF SYMBOLS

| | |
|---|---|
| $\alpha$ | *Parameter representing share of capital* |
| $\beta$ | *Parameter signifying diminishing returns in agriculture* |
| $\delta$ | *Rate of depreciation of capital in manufacturing* |
| $\eta$ | *The efficiency of attaining potential output* |
| $\theta$ | *A ratio of labor productivity in subsistence agriculture to that in modern sector* |
| $\lambda$ | *Part of saving rate wasted as leakage* |
| $\mu$ | *A parameter of increasing returns and externalities in manufacturing* |
| $\nu$ | *The ratio of effective capital to total capital in manufacturing* |
| $\varsigma$ | *The minimum labor diverted from agriculture most efficiently or it is the lower limit of* $\psi$ |
| $\Sigma$ | *covariance matrix* |
| $\varphi$ | *Manufacturing labor diverted to transaction services in agriculture* |
| $\psi$ | *Agricultural labor diverted to transaction services in agriculture* |
| $\omega$ | *Capital used in transaction services in and for manufacturing* |
| Ag | *Value added of Agriculture and the associated services* |
| $b_1$ | *A parameter relating agricultural goods value added with services arising from agriculture* |
| $b_2$ | *A parameter relating manufactured goods value added with services arising from manufacturing* |
| c | *The minimum capital required to conduct most efficient transactions in and for manufacturing* |
| Cn | *Aggregate Consumption* |
| $D_j$ | *Details* |
| S | *Smooth* |
| K | *Capital that embodies technology* |
| $K^*$ | *Critical capital stock* |
| L | *Labor input in manufacturing* |
| M | *Value added of manufacturing and the associated services* |
| $M_g$ | *Goods value added in manufacturing sector* |
| $Q_t$ | *Information set containing all the relevant information in the universe* |
| R | *Total labor input available to subsistence agriculture* |
| $\overline{R}$ | *Per capita output in agriculture* |
| r | *The efficiency in attaining potential output with effective agricultural labor input* |
| s | *Aggregate saving rate* |
| Ser | *Service value added* |
| u | *Exponential parameter of the multiplier of goods value added to include the arising service* |
| Y | *Total value added of the economy* |

## APPENDIX II: ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AIC | Akaike Information criterion |
| CWT | Continuous Wavelet Transform |
| DWT | Discrete Wavelet Transform |
| FPE | Final Prediction Error( Criterion) |
| GDP | Gross Domestic Product |
| HQIC | Hannan Quinn Information Criteria |
| IR | Impulse-Response |
| ISI | Import Substitution Industrialization |
| LIC | Low Income Countries |
| MODWT | Maximum Overlap Discrete Wavelet Transform |
| MSE | Mean Squared Error |
| PCI | Per - Capita Income |

| | |
|---|---|
| SBIC | Schwartz Bayesian Information Criterion |
| UN SNA | United Nations System of National Accounts |
| USD | United States Dollar |
| UNIDO | United Nations Industrial Development Organization |
| UNCTAD | United Nations Conference of Trade and Development |
| VAR | Vector Auto Regressive |
| VECM | Vector Error Correction Model |

## APPENDIX III : WAVELET DECOMPOSITION IN BREIF AND THE RATIONALE

A wavelet is any function that integrates to zero and is square integrable to one (Percival and Walden, 2000; Kaiser G.1994). It is expressed as a real valued function ψ (.) defined over the real axis (-∞, ∞) satisfying two properties: namely

(1) The integral of ψ (.) is zero, i.e. $\int_{-\infty}^{\infty} \psi(u)\,du = 0$

(2) The square of ψ (.) integrates to unity, i.e., $\int_{-\infty}^{\infty} \psi(u)^2\,du = 1.$ (16)

With this definition in hand we may look for functions fulfilling the two conditions. To that effect we begin with an expression of the **difference in averages** of a function X(u) at time t in an averaging time scale (λ ), which may be a year, two years, etc.

$$D(\lambda, t) = \frac{1}{\lambda}\left[\int_{t}^{t+\lambda} X(u)du - \int_{t-\lambda}^{t} X(u)du\right] \quad (17)$$

Since the two integrals above are integrals over adjacent non-overlapping intervals they can be combined into a single integral over the entire real axis with definition of domains for the functions as:

$$D(\lambda, t) = \int_{-\infty}^{\infty} V_{\lambda,t}(u)X(u)du), \quad (18)$$

where
$$V_{\lambda,t}(u) = -\frac{1}{\lambda} \quad \text{if } t-\lambda < u \le t$$
$$= \frac{1}{\lambda} \quad \text{if } t < u \le t+\lambda$$
$$= 0 \quad \text{otherwise}$$

The differences of averages on a unit time scale (λ) and at a center time t (the middle of the interval) is equivalent to integrating the product of the time series data (represented by the function $X(u)$) and a function $V_{\lambda,t}(u)$. The function $V_{\lambda,t}(u)$ would fulfill the definition for wavelet if divided by a constant $\sqrt{2}$ :

Where, $\int_{-\infty}^{\infty} \frac{V_{\lambda,t}(u)}{\sqrt{2}} = -\frac{1}{\sqrt{2\lambda}} + \frac{1}{\sqrt{2\lambda}} = 0$ and $\int_{-\infty}^{\infty} \left(\frac{V_{\lambda,t}(u)}{\sqrt{2}}\right)^2 du = 1$ (19)

$\frac{V_{\lambda,t}(u)}{\sqrt{2}}$ is a particular wavelet known as Haar wavelet $({V_{\lambda,t}}^{H}(u))$.

Since λ=1 $\quad {V_{\lambda,t}}^{H}(u) = -\frac{1}{\sqrt{2}}$ if $t-1 < u \le t$

$$= \frac{1}{\sqrt{2}} \quad \text{if} \quad t < u \leq t+1$$

$$= 0 \quad \text{elsewhere,}$$

At other time scales $V_{\lambda,t}^{H}(u) = \frac{-1}{\sqrt{2\lambda}}$ if $t\text{-}1 < u \leq t$

$$= \frac{1}{\sqrt{2\lambda}} \quad \text{if} \quad t < u \leq t+1$$

$$= 0 \quad \text{elsewhere}$$

Thus $D(\lambda, t) = \int_{-\infty}^{\infty} \sqrt{2} V_{\lambda,t}^{H}(u)\, X(u) du$ and $\frac{D(\lambda,t)}{\sqrt{2}}$ is designated $W(\lambda, t)$

$$W(\lambda, t) = \int_{-\infty}^{\infty} V_{\lambda,t}^{H}(u)\, X(u) du \quad (20)$$

The time series transformed by varying λ continuously in $W^{H}(\lambda, t) = \int_{-\infty}^{\infty} V_{\lambda,t}^{H}(u) X(u) du$ is the Haar Continuous Wavelet Transform (CWT). **X**(u) can be recovered from the integral of the product of $W^{H}(\lambda, t)$ and $V_{\lambda,t}^{H}(u)$. The Discrete Wavelet Transform (DWT) may be thought as purposeful sub sampling of CWT with dyadic scales i.e., picking only λ of $2^{J-1}$ and t separated by multiples of $2^{J}$ where J=1,2, 3…. In DWT analysis of any time series X (u) we make use of wavelets $h_J$ formed as basis vectors representing the time scales and shifts within a time scale, wavelet coefficients $w$ formed from matrix multiplication of these basis vectors with **X** , an averaging vector $\boldsymbol{v}$ on the basis of the highest time scale, and a scaling coefficient $\mathbf{v}$ formed as a dot product of $\boldsymbol{v}$ and . If we designate $D = h_J' w$ and $\boldsymbol{v}'\mathbf{v}=\mathbf{S}$ , recovering **X** from wavelet transforms goes as

$$\mathbf{X} = \left(\sum_{j=1}^{J} \mathbf{D_j}\right) + \mathbf{S} \quad (21)$$

This is a **multi-resolution** analysis of **X** where $\mathbf{D}_j$ are the details representing the differences of averages on various time scale and **S** is the smooth representing the moving average of the data on the highest time scale. The wavelets of DWT are orthogonal. The averages and average of averages, formed from the DWT wavelets are sensitive to beginnings of the data points for averaging. The size of DWT wavelets is limited to the dyadic series and hence may suffer from too few observations for analysis. To overcome the deficiencies of DWT a modified version of DWT, which is Maximum Overlap Discrete wavelet Transform (MODWT), is used, although the orthogonality that is characteristic of DWT is lost in MODWT. In MODWT, the data is taken in circular fashion where the end points become adjacent points. At lower scales this operation heavily distorts the differences of averages and hence the differences of the averages at the end points have to be dropped.

**APPENDIX IV A: VALUE ADDED OF AGRICULTURE, MANUFACTURING, AND SERVICES AT CONSTANT 2005 PRICES IN MILLIONS US DOLLARS IN TEN YEARS INTERVAL (before orthogonalization )**(*taken from United Nations Main Aggregates Database* )

| COUNTRY | SECTOR | 1970 | 1980 | 1990 | 2000 | 2010 |
|---|---|---|---|---|---|---|
| Afghanistan | Agriculture, | 4725 | 5036 | 1990 | 1938 | 2639 |
| | Manufacturing | 682 | 843 | 1165 | 592 | 1248 |
| | Service | 848 | 1059 | 2545 | 950 | 5889 |
| Bangladesh | Agriculture, | 5864 | 5706 | 7250 | 9844 | 13815 |
| | Manufacturing | 2257 | 2729 | 3511 | 6567 | 13530 |
| | Service | 8084 | 9722 | 15992 | 26147 | 47930 |
| Benin | Agriculture, | 279 | 377 | 704 | 1198 | 1667 |
| | Manufacturing | 137 | 144 | 164 | 284 | 373 |
| | Service | 653 | 912 | 1211 | 1805 | 2761 |
| Bhutan | Agriculture, | 55 | 84 | 143 | 160 | 196 |
| | Manufacturing | 4 | 4 | 22 | 43 | 113 |
| | Service | 26 | 38 | 168 | 344 | 928 |
| Bolivia | Agriculture, | 398 | 596 | 707 | 947 | 1228 |
| | Manufacturing | 452 | 724 | 677 | 955 | 1419 |
| | Service | 2208 | 3458 | 3429 | 5252 | 7556 |
| Botswana | Agriculture, | 79 | 174 | 197 | 202 | 234 |
| | Manufacturing | 14 | 84 | 215 | 302 | 452 |
| | Service | 235 | 1092 | 3583 | 7122 | 10426 |
| Burkina Faso | Agriculture, | 439 | 436 | 629 | 1283 | 2960 |
| | Manufacturing | 177 | 269 | 351 | 391 | 486 |
| | Service | 501 | 889 | 1167 | 1828 | 3868 |
| Burundi | Agriculture, | 361 | 416 | 574 | 488 | 475 |
| | Manufacturing | 79 | 148 | 252 | 132 | 168 |
| | Service | 115 | 171 | 345 | 350 | 934 |
| Cambodia | Agriculture, | 1236 | 590 | 1053 | 1510 | 2480 |
| | Manufacturing | 194 | 93 | 157 | 586 | 1617 |
| | Service | 1194 | 570 | 851 | 1726 | 3983 |
| Cameroon | Agriculture, | 928 | 1803 | 2099 | 2647 | 3953 |
| | Manufacturing | 719 | 1292 | 2114 | 2513 | 2992 |
| | Service | 3406 | 6228 | 7213 | 7676 | 10755 |
| Cape Verde | Agriculture, | 47 | 63 | 77 | 97 | 149 |
| | Manufacturing | 12 | 13 | 24 | 41 | 45 |
| | Service | 147 | 146 | 272 | 555 | 1055 |
| Central | Agriculture, | 317 | 383 | 475 | 668 | 776 |

| COUNTRY | SECTOR | 1970 | 1980 | 1990 | 2000 | 2010 |
|---|---|---|---|---|---|---|
| Maldives | Agriculture, | 17 | 25 | 44 | 54 | 60 |
| | Manufacturing | 2 | 5 | 18 | 41 | 62 |
| | Service | 43 | 83 | 388 | 755 | 1406 |
| Mali | Agriculture, | 473 | 765 | 1306 | 1442 | 2706 |
| | Manufacturing | 108 | 105 | 224 | 414 | 382 |
| | Service | 413 | 605 | 1068 | 1957 | 3492 |
| Mauritania | Agriculture, | 755 | 538 | 540 | 576 | 657 |
| | Manufacturing | 43 | 60 | 95 | 180 | 140 |
| | Service | 388 | 449 | 630 | 899 | 1807 |
| Mongolia | Agriculture, | 226 | 396 | 516 | 512 | 551 |
| | Manufacturing | 43 | 75 | 139 | 95 | 206 |
| | Service | 334 | 587 | 1086 | 1089 | 2224 |
| Morocco | Agriculture, | 4001 | 4646 | 6726 | 5605 | 11373 |
| | Manufacturing | 2276 | 3914 | 5955 | 7727 | 10031 |
| | Service | 7827 | 14230 | 21894 | 30248 | 49916 |
| Mozambique | Agriculture, | 547 | 799 | 868 | 1122 | 2328 |
| | Manufacturing | 213 | 313 | 213 | 466 | 1082 |
| | Service | 903 | 1323 | 1285 | 2352 | 5234 |
| Myanmar | Agriculture, | 1122 | 1756 | 1984 | 3478 | 7697 |
| | Manufacturing | 157 | 218 | 234 | 525 | 3823 |
| | Service | 741 | 1024 | 1138 | 2370 | 8820 |
| Nepal | Agriculture, | 1131 | 1156 | 1805 | 2292 | 3193 |
| | Manufacturing | 82 | 109 | 237 | 610 | 664 |
| | Service | 1043 | 1354 | 2079 | 3834 | 5931 |
| Niger | Agriculture, | 977 | 720 | 770 | 1074 | 2018 |
| | Manufacturing | 47 | 143 | 162 | 163 | 216 |
| | Service | 899 | 1269 | 1132 | 1331 | 1808 |
| Nigeria | Agriculture, | 12004 | 9468 | 13250 | 18528 | 51156 |
| | Manufacturing | 524 | 1849 | 2170 | 2060 | 4710 |
| | Service | 20404 | 33601 | 37433 | 44439 | 97493 |
| Occupied Palestinian Territory | Agriculture, | 75 | 173 | 245 | 382 | 338 |
| | Manufacturing | 113 | 258 | 377 | 513 | 520 |
| | Service | 378 | 868 | 1241 | 2741 | 4160 |
| Pakistan | Agriculture, | 6901 | 8685 | 12860 | 19852 | 25844 |

| | | | | | | |
|---|---|---|---|---|---|---|
| African Republic | Manufacturing | 55 | 76 | 80 | 80 | 101 |
| | Service | 523 | 497 | 518 | 568 | 574 |
| Chad | Agriculture, | 595 | 510 | 537 | 1002 | 1641 |
| | Manufacturing | 137 | 94 | 256 | 226 | 410 |
| | Service | 893 | 692 | 1375 | 1636 | 4719 |
| Comoros | Agriculture | 53 | 84 | 122 | 164 | 211 |
| | Manufacturing | 5 | 8 | 12 | 15 | 18 |
| | Service | 85 | 135 | 168 | 164 | 205 |
| Congo | Agriculture, | 126 | 170 | 225 | 203 | 332 |
| | Manufacturing | 74 | 93 | 174 | 131 | 342 |
| | Service | 1268 | 2388 | 3986 | 4554 | 7033 |
| Democratic Republic of the Congo | Agriculture, | 2636 | 2754 | 3598 | 3347 | 4140 |
| | Manufacturing | 784 | 1609 | 1356 | 333 | 460 |
| | Service | 5054 | 4383 | 4942 | 2060 | 4544 |
| Djibouti | Agriculture, | 11 | 11 | 15 | 19 | 30 |
| | Manufacturing | 12 | 18 | 17 | 14 | 23 |
| | Service | 303 | 352 | 462 | 521 | 753 |
| Egypt | Agriculture, | 4482 | 5796 | 7963 | 10931 | 15231 |
| | Manufacturing | 1906 | 2841 | 7036 | 12954 | 20761 |
| | Service | 5339 | 16880 | 35684 | 50827 | 85788 |
| Equatorial Guinea | Agriculture, | 78 | 99 | 119 | 182 | 229 |
| | Manufacturing | 1 | 2 | 2 | 4 | 16 |
| | Service | 170 | 217 | 260 | 2352 | 9877 |
| Ethiopia (Former) | Agriculture | 2506 | 2840 | 2877 | 4242 | 7967 |
| | Manufacturing | 164 | 240 | 313 | 520 | 1026 |
| | Service | 973 | 1700 | 2540 | 11994 | 30912 |
| Gambia | Agriculture | 114 | 109 | 104 | 152 | 230 |
| | Manufacturing | 12 | 18 | 26 | 31 | 40 |
| | Service | 100 | 147 | 266 | 359 | 479 |
| Ghana | Agriculture, | 2533 | 2855 | 2953 | 4082 | 6521 |
| | Manufacturing | 2008 | 1672 | 1830 | 1372 | 1942 |
| | Service | 1987 | 2074 | 3533 | 7278 | 14372 |
| Guinea | Agriculture, | 209 | 280 | 366 | 548 | 601 |
| | Manufacturing | 54 | 72 | 96 | 150 | 199 |
| | Service | 654 | 875 | 1181 | 1644 | 2155 |
| Guinea-Bissau | Agriculture, | 139 | 89 | 186 | 237 | 299 |
| | Manufacturing | 90 | 100 | 98 | 74 | 73 |
| | Service | 64 | 176 | 276 | 256 | 282 |
| Haiti | Agriculture, | 1026 | 1193 | 1294 | 886 | 851 |
| | Manufacturing | 527 | 1175 | 969 | 376 | 348 |
| | Service | 926 | 1644 | 1828 | 2579 | 2832 |
| Honduras | Agriculture, | 485 | 635 | 828 | 1063 | 1413 |
| | Manufacturing | 385 | 710 | 951 | 1405 | 2022 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Manufacturing | 2186 | 3710 | 8147 | 11883 | 23943 |
| | Service | 9165 | 16296 | 31081 | 48044 | 76616 |
| Papua New Guinea | Agriculture, | 645 | 768 | 973 | 1505 | 1841 |
| | Manufacturing | 174 | 203 | 189 | 273 | 399 |
| | Service | 1284 | 1516 | 1691 | 2462 | 4089 |
| Paraguay | Agriculture, | 363 | 697 | 1032 | 1211 | 2267 |
| | Manufacturing | 338 | 751 | 929 | 992 | 1130 |
| | Service | 1001 | 2392 | 3151 | 3786 | 5495 |
| Philippines | Agriculture, | 5388 | 7984 | 8956 | 10940 | 14496 |
| | Manufacturing | 8002 | 14496 | 15842 | 20441 | 29503 |
| | Service | 15147 | 28411 | 36491 | 50977 | 87139 |
| Rwanda | Agriculture, | 379 | 685 | 719 | 749 | 1258 |
| | Manufacturing | 71 | 127 | 151 | 115 | 246 |
| | Service | 305 | 494 | 694 | 818 | 2081 |
| Sao Tome and Principe | Agriculture, | 8 | 14 | 14 | 20 | 28 |
| | Manufacturing | 4 | 7 | 6 | 7 | 10 |
| | Service | 38 | 70 | 63 | 70 | 115 |
| Senegal | Agriculture, | 768 | 725 | 957 | 1206 | 1536 |
| | Manufacturing | 345 | 452 | 742 | 955 | 1268 |
| | Service | 1666 | 2115 | 2795 | 3925 | 6301 |
| Sierra Leone | Agriculture, | 512 | 644 | 918 | 420 | 1124 |
| | Manufacturing | 51 | 73 | 61 | 27 | 50 |
| | Service | 595 | 760 | 950 | 437 | 860 |
| Solomon Islands | Agriculture, | 41 | 84 | 99 | 103 | 155 |
| | Manufacturing | 6 | 13 | 17 | 25 | 24 |
| | Service | 59 | 121 | 180 | 247 | 322 |
| Somalia | Agriculture, | 1072 | 1295 | 1697 | 1060 | 1399 |
| | Manufacturing | 34 | 49 | 36 | 41 | 56 |
| | Service | 305 | 505 | 530 | 640 | 861 |
| Sri Lanka | Agriculture, | 1426 | 1855 | 2271 | 2842 | 3765 |
| | Manufacturing | 794 | 1233 | 1949 | 4181 | 6225 |
| | Service | 2918 | 4773 | 7569 | 13073 | 23262 |
| Sudan (Former) | Agriculture, | 3271 | 3643 | 3828 | 9985 | 16191 |
| | Manufacturing | 433 | 609 | 795 | 1735 | 3755 |
| | Service | 2492 | 4854 | 7317 | 12118 | 26795 |
| Swaziland | Agriculture, | 55 | 115 | 163 | 173 | 183 |
| | Manufacturing | 39 | 128 | 576 | 741 | 786 |
| | Service | 262 | 503 | 675 | 948 | 1392 |
| Syrian Arab Republic | Agriculture, | 1023 | 2771 | 2771 | 4858 | 5219 |
| | Manufacturing | 290 | 514 | 456 | 141 | 1205 |
| | Service | 3032 | 7752 | 9307 | 17209 | 29657 |
| Thailand | Agriculture, | 4999 | 7341 | 10500 | 15249 | 18342 |
| | Manufacturing | 3534 | 9227 | 23653 | 41211 | 70840 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Service | 1454 | 2805 | 3351 | 4710 | 8236 |
| India | Agriculture, | 61855 | 71753 | 100984 | 127915 | 174403 |
| | Manufacturing | 15937 | 23630 | 48979 | 86748 | 188591 |
| | Service | 60150 | 91395 | 172190 | 341489 | 811109 |
| Indonesia | Agriculture, | 12513 | 18190 | 25682 | 32049 | 44993 |
| | Manufacturing | 2556 | 10019 | 31735 | 61460 | 94886 |
| | Service | 23372 | 53408 | 92771 | 133409 | 237405 |
| Iraq | Agriculture, | 1326 | 1541 | 2391 | 2658 | 2730 |
| | Manufacturing | 370 | 1300 | 1129 | 1206 | 1164 |
| | Service | 17222 | 36672 | 31020 | 49409 | 55537 |
| Kenya | Agriculture, | 1556 | 2252 | 3331 | 3853 | 4821 |
| | Manufacturing | 354 | 922 | 1472 | 1676 | 2445 |
| | Service | 2915 | 4823 | 7618 | 8641 | 13417 |
| Lao People's Democratic Republic | Agriculture, | 211 | 303 | 527 | 827 | 1144 |
| | Manufacturing | 14 | 20 | 46 | 144 | 347 |
| | Service | 186 | 267 | 469 | 886 | 2354 |
| Lesotho | Agriculture, | 112 | 134 | 128 | 137 | 123 |
| | Manufacturing | 12 | 23 | 65 | 141 | 277 |
| | Service | 168 | 325 | 535 | 819 | 1176 |
| Liberia | Agriculture, | 303 | 451 | 343 | 607 | 561 |
| | Manufacturing | 33 | 55 | 42 | 27 | 56 |
| | Service | 590 | 692 | 216 | 154 | 310 |
| Madagascar | Agriculture, | 754 | 800 | 987 | 1178 | 1458 |
| | Manufacturing | 462 | 552 | 469 | 580 | 699 |
| | Service | 1544 | 1733 | 1963 | 2405 | 3136 |
| Malawi | Agriculture, | 300 | 457 | 524 | 861 | 1088 |
| | Manufacturing | 81 | 140 | 211 | 214 | 372 |
| | Service | 425 | 877 | 1082 | 1277 | 2381 |
| Malaysia | Agriculture, | 3316 | 6530 | 9406 | 10142 | 13536 |
| | Manufacturing | 1573 | 5024 | 12219 | 31533 | 44957 |
| | Service | 9252 | 20811 | 36265 | 72233 | 117707 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Service | 13805 | 27151 | 59491 | 88160 | 136852 |
| Togo | Agriculture, | 281 | 368 | 572 | 764 | 1032 |
| | Manufacturing | 60 | 127 | 125 | 159 | 211 |
| | Service | 544 | 852 | 804 | 941 | 994 |
| Tonga | Agriculture, | 18 | 26 | 41 | 44 | 39 |
| | Manufacturing | 10 | 18 | 20 | 17 | 17 |
| | Service | 48 | 74 | 112 | 147 | 176 |
| Tunisia | Agriculture, | 862 | 1512 | 2022 | 2732 | 3148 |
| | Manufacturing | 503 | 1600 | 2652 | 4489 | 6267 |
| | Service | 5295 | 9119 | 10993 | 16667 | 28128 |
| Tanzania: Mainland | Agriculture, | 1177 | 1443 | 2153 | 3264 | 4985 |
| | Manufacturing | 403 | 571 | 497 | 762 | 1698 |
| | Service | 1883 | 2913 | 3573 | 5255 | 11576 |
| Uganda | Agriculture, | 1074 | 962 | 1320 | 1996 | 2569 |
| | Manufacturing | 311 | 103 | 161 | 505 | 958 |
| | Service | 1553 | 1184 | 1822 | 4077 | 9706 |
| Vanuatu | Agriculture, | 20 | 35 | 49 | 78 | 95 |
| | Manufacturing | 3 | 5 | 14 | 17 | 14 |
| | Service | 65 | 112 | 192 | 245 | 353 |
| Viet Nam | Agriculture, | 2439 | 3548 | 5987 | 9196 | 13078 |
| | Manufacturing | 1045 | 1522 | 2170 | 6292 | 17003 |
| | Service | 3541 | 5151 | 9282 | 21358 | 44187 |
| Zambia | Agriculture, | 686 | 658 | 1053 | 1444 | 1812 |
| | Manufacturing | 333 | 385 | 577 | 603 | 910 |
| | Service | 2931 | 3433 | 3364 | 3404 | 6913 |
| Zimbabwe | Agriculture, | 420 | 531 | 760 | 976 | 627 |
| | Manufacturing | 256 | 401 | 558 | 498 | 420 |
| | Service | 3031 | 3947 | 5283 | 5768 | 5192 |

## APPENDIX IV B: SECTORAL GROWTH IN 40 YEARS

| Countries | Agriculture | Manufacturing | Services |
|---|---|---|---|
| Afghanistan | -0.44 | 0.83 | 5.94 |
| Bangladesh | 1.36 | 4.99 | 4.93 |
| Benin | 4.97 | 1.72 | 3.23 |
| Bhutan | 2.56 | 27.25 | 34.69 |
| Bolivia | 2.09 | 2.14 | 2.42 |
| Botswana | 1.96 | 31.29 | 43.37 |
| Burkina Faso | 5.74 | 1.75 | 6.72 |
| Burundi | 0.32 | 1.13 | 7.12 |
| Cambodia | 1.01 | 7.34 | 2.34 |
| Cameroon | 3.26 | 3.16 | 2.16 |
| Cape Verde | 2.17 | 2.75 | 6.18 |
| Central African Republic | 1.45 | 0.84 | 0.10 |
| Chad | 1.76 | 1.99 | 4.28 |
| Comoros | 2.98 | 2.60 | 1.41 |
| Congo | 1.63 | 3.62 | 4.55 |
| Democratic Republic of the Congo | 0.57 | -0.41 | -0.10 |
| Djibouti | 1.73 | 0.92 | 1.49 |
| Egypt | 2.40 | 9.89 | 15.07 |
| Equatorial Guinea | 1.94 | 15.00 | 57.10 |
| Ethiopia (Former) | 2.18 | 5.26 | 30.77 |
| Gambia | 1.02 | 2.33 | 3.79 |
| Ghana | 1.57 | -0.03 | 6.23 |
| Guinea | 1.88 | 2.69 | 2.30 |
| Guinea-Bissau | 1.15 | -0.19 | 3.41 |
| Haiti | -0.17 | -0.34 | 2.06 |
| Honduras | 1.91 | 4.25 | 4.66 |
| India | 1.82 | 10.83 | 12.48 |
| Indonesia | 2.60 | 36.12 | 9.16 |
| Iraq | 1.06 | 2.15 | 2.22 |
| Kenya | 2.10 | 5.91 | 3.60 |
| Lao People's Democratic Republic | 4.42 | 23.79 | 11.66 |
| Lesotho | 0.10 | 22.08 | 6.00 |
| Liberia | 0.85 | 0.70 | -0.47 |
| Madagascar | 0.93 | 0.51 | 1.03 |

| Countries | Agriculture | Manufacturing | Services |
|---|---|---|---|
| Maldives | 2.53 | 30.00 | 31.70 |
| Mali | 4.72 | 2.54 | 7.46 |
| Mauritania | -0.13 | 2.26 | 3.66 |
| Mongolia | 1.44 | 3.79 | 5.66 |
| Morocco | 1.84 | 3.41 | 5.38 |
| Mozambique | 3.26 | 4.08 | 4.80 |
| Myanmar | 5.86 | 23.35 | 10.90 |
| Nepal | 1.82 | 7.10 | 4.69 |
| Niger | 1.07 | 3.60 | 1.01 |
| Nigeria | 3.26 | 7.99 | 3.78 |
| Occupied Palestinian Territory | 3.51 | 3.60 | 10.01 |
| Pakistan | 2.74 | 9.95 | 7.36 |
| Papua New Guinea | 1.85 | 1.29 | 2.18 |
| Paraguay | 5.25 | 2.34 | 4.49 |
| Philippines | 1.69 | 2.69 | 4.75 |
| Rwanda | 2.32 | 2.46 | 5.82 |
| Sao Tome and Principe | 2.50 | 1.50 | 2.03 |
| Senegal | 1.00 | 2.68 | 2.78 |
| Sierra Leone | 1.20 | -0.02 | 0.45 |
| Solomon Islands | 2.78 | 3.00 | 4.46 |
| Somalia | 0.31 | 0.65 | 1.82 |
| Sri Lanka | 1.64 | 6.84 | 6.97 |
| Sudan (Former) | 3.95 | 7.67 | 9.75 |
| Swaziland | 2.33 | 19.15 | 4.31 |
| Syrian Arab Republic | 4.10 | 3.16 | 8.78 |
| Tanzania: Mainland | 3.24 | 3.21 | 5.15 |
| Thailand | 2.67 | 19.05 | 8.91 |
| Togo | 2.67 | 2.52 | 0.83 |
| Tonga | 1.17 | 0.70 | 2.67 |
| Tunisia | 2.65 | 11.46 | 4.31 |
| Uganda | 1.39 | 2.08 | 5.25 |
| Vanuatu | 3.75 | 3.67 | 4.43 |
| Viet Nam | 4.36 | 15.27 | 11.48 |
| Zambia | 1.64 | 1.73 | 1.36 |

| | | | |
|---|---|---|---|
| Malawi | 2.63 | 3.59 | 4.60 |
| Malaysia | 3.08 | 27.58 | 11.72 |

| | | | |
|---|---|---|---|
| Zimbabwe | 0.49 | 0.64 | 0.71 |

## APPENDIX V: SUMMARY OF RESULTS ACROSS TIME SCALES

| | Country | Cases of Granger causal relationships | | | | Actual Trends in growth of services | Predicted sign of changes in manufacturing on the basis of Granger causality and actual trends in services | | | | Actual Sign of Change in manufacturing | Standing with the hypothesis | | | | Overall Cases for or against the hypothesis | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time scale 1 | Time scale 2 | Time scale 3 | Smooth | | Time scale 1 | Time scale 2 | Time scale 3 | Smooth | | Time scale 1 | Time scale 2 | Time scale 3 | Smooth | | |
| 1 | Afghanistan | | | + | + | - | | | - | - | - | | | **SS** | **SS** | **S** | |
| 2 | Bangladesh | - | | | + | - | | | | - | - | | | | **SS** | **S** | |
| 3 | Benin | | | - | + | ± | | | - | - | ± | | | **SS** | **SS** | **S** | |
| 4 | Bhutan | + | | - | - | - | - | | + | + | - | **SS** | | **NS** | **NS** | | |
| 5 | Bolivia | | | + | + | + | | | + | + | + | | | **SS** | **SS** | **S** | |
| 6 | Botswana | - | | | - | + | - | | | - | - | **SS** | | | **SS** | **S** | |
| 7 | Burkina Faso | | | - | - | + | | | - | - | - | | | **SS** | **SS** | **S** | |
| 8 | Burundi | | - | - | - | + | | - | - | - | - | | **SS** | **SS** | **SS** | **S** | |
| 9 | Cambodia | | | - | | + | | | - | | - | | | **SS** | | **S** | |
| 10 | Cameroon | + | | | - | + | + | | | - | + | **SS** | | | **NS** | | |
| 11 | Cape Verde | | | - | + | 0 | | | 0 | 0 | ± | | | **SS** | **SS** | | |
| 12 | Central African Republic | | | | + | ± | | | | ± | ± | | | | **SS** | **S** | No single trend |
| 13 | Chad | | + | + | - | + | | + | + | - | + | | **SS** | **SS** | **NS** | | before structural breaks |
| 14 | Comoros | | | | + | - | | | | + | - | | | | **SS** | **S** | With structural breaks |
| 15 | Congo | | | | - | ± | | | | ± | ± | | | | **IND** | **IND** | No single trend |
| 16 | Democratic Republic of the Congo | | - | | + | - | | + | | - | - | | **NS** | | **SS** | | |
| 17 | Djibouti | | + | + | - | ± | | ± | ± | ∓ | - | | **IND** | **IND** | **IND** | | |
| 18 | Egypt | | + | - | + | ± | | ± | ∓ | ± | ± | | **IND** | **IND** | **IND** | | |
| 19 | Equatorial Guinea | | | | | - | | | | | - | | | | | | |
| 20 | Ethiopia | | | | - | + | | | | - | - | | | | **SS** | **S** | |
| 21 | Gambia | - | | - | - | + | - | | - | - | 0 | **WS** | | **WS** | **WS** | **WS** | |
| 22 | Ghana | | | - | + | + | | | - | + | - | | | **SS** | **NS** | | |
| 23 | Guinea | - | - | - | + | - | + | + | + | - | + | **SS** | **SS** | **SS** | **NS** | | |
| 24 | Guinea-Bissau | - | | | + | + | - | | | + | - | **SS** | | | **NS** | | |
| 25 | Haiti | | - | - | + | - | | + | + | - | - | | **NS** | **NS** | **SS** | | |
| 26 | Honduras | - | - | - | - | + | + | + | + | + | + | **SS** | **SS** | **SS** | **SS** | **S** | |
| 27 | India | | + | - | - | + | | + | - | - | + | | **SS** | **NS** | **NS** | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | Indonesia | | | - | + | + | | | - | + | + | | | **NS** | **SS** | **S** | |
| 29 | Iraq | | | - | | + | | | - | | - | | | **SS** | | **S** | |
| 30 | Kenya | | | - | + | + | | | - | + | + | | | **NS** | **SS** | **S** | |
| 31 | Lao People's Democratic Republic | - | + | - | - | - | + | - | + | + | + | **SS** | **SS** | **NS** | **SS** | | |
| 32 | Lesotho | | | - | - | - | | | + | + | + | | | **SS** | **SS** | **S** | |
| 33 | Liberia | | | + | + | + | | | + | + | + | | | **SS** | **SS** | **S** | |
| 34 | Madagascar | | + | | - | - | | - | | + | - | | **SS** | | **NS** | | |
| 35 | Malawi | | | | + | - | | | | + | - | | | | **SS** | **S** | before structural breaks |
| 36 | Malaysia | - | + | + | - | + | - | + | + | - | + | **NS** | **SS** | **SS** | **NS** | | |
| 37 | Maldives | | | | - | + | | | | - | - | | | | **SS** | **S** | before structural breaks |
| 38 | Mali | | | + | | - | | | - | | - | | | **SS** | | **S** | |
| 39 | Mauritania | | + | + | + | + | | + | + | + | + | | **SS** | **SS** | **SS** | **S** | |
| 40 | Mongolia | + | | - | | + | + | | - | | - | **NS** | | **SS** | | | |
| 41 | Morocco | | | | - | + | | | | - | + | | | | **NS** | **NS** | |
| 42 | Mozambique | | | + | - | ± | | | - | + | - | | | **SS** | **IND** | | increasing and decreasing |
| 43 | Myanmar | + | - | - | - | - | - | + | + | + | ± | **SS** | **IND** | **IND** | **IND** | | |
| 44 | Nepal | | | | | - | | | | | **0** | | | | | | |
| 45 | Niger | | | + | - | ± | | | - | + | - | | | **SS** | **IND** | | |
| 46 | Nigeria | | + | - | - | + | | + | - | - | + | | **SS** | **NS** | **NS** | | |
| 47 | Occupied Palestinian Territory | + | + | - | + | - | - | - | + | - | - | **SS** | **SS** | **NS** | **SS** | | |
| 48 | Pakistan | | + | + | - | - | | - | - | + | + | | **NS** | **NS** | **SS** | | |
| 49 | Papua New Guinea | | | - | - | ± | | | + | + | ± | | | **NS** | **IND** | | |
| 50 | Paraguay | | | + | - | + | | | + | - | - | | | **NS** | **SS** | | |
| 51 | Philippines | | | | - | + | | | | - | - | | | | **SS** | **S** | |
| 52 | Rwanda | | | | | + | | | | | - | | | | | | |
| 53 | Sao Tome and Principe | | | | + | + | | | | + | + | | | | **SS** | **S** | |
| 54 | Senegal | + | + | | - | - | - | - | | + | ± | **SS** | **SS** | | **IND** | | |
| 55 | Sierra Leone | | + | | + | ± | | + | | + | ± | | **SS** | | **SS** | **S** | |
| 56 | Solomon Islands | | + | | + | + | | + | | + | + | | **SS** | | **SS** | **S** | |
| 57 | Somalia | - | + | + | + | + | - | + | + | + | + | **NS** | **SS** | **SS** | **SS** | | |
| 58 | Sri Lanka | + | - | - | + | - | - | + | + | - | - | **SS** | **NS** | **NS** | **SS** | | |
| 59 | Sudan (Former) | | | + | + | - | | | - | - | - | | | **SS** | **SS** | **S** | |
| 60 | Swaziland | | | - | + | + | | | - | + | + | | | **NS** | **SS** | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | Syrian Arab Republic | | | + | - | - | | | - | + | + | | | **NS** | **SS** | | With manufacturing structural break |
| 62 | Thailand | | - | | - | - | | + | | + | + | | **SS** | | **SS** | **S** | |
| 63 | Togo | + | + | + | + | - | - | - | - | - | ± | **SS** | **SS** | **SS** | **IND** | | |
| 64 | Tonga | + | | | + | - | - | | | - | - | **SS** | | | **SS** | **S** | |
| 65 | Tunisia | | - | - | - | + | - | - | - | - | + | **NS** | **NS** | **NS** | **NS** | **NS** | |
| 66 | Uganda | | | | - | ± | | | | ∓ | - | | | | **WS** | | |
| 67 | United Republic of Tanzania: Mainland | - | | | - | - | + | | | + | - | **NS** | | | **NS** | **NS** | |
| 68 | Vanuatu | | | | - | - | | | | + | + | | | | **SS** | **S** | |
| 69 | Viet Nam | | | + | - | ± | | | - | + | ± | | | **SS** | **IND** | | multiple structural Breaks |
| 70 | Zambia | | | | + | + | | | | + | + | | | | **SS** | **S** | |
| 71 | Zimbabwe | | | | - | + | | | | - | - | | | | **SS** | **S** | |
| **POSITIVE CAUSALITY** | | **9** | **16** | **17** | **29** | | | | | | **Supportive** | **14** | **18** | **24** | **41** | **Total** | |
| **NEGATIVE CAUSALITY** | | **10** | **9** | **26** | **37** | | | | | | **Non supportive** | **5** | **6** | **18** | **13** | **S=32** | |
| **TOTAL** | | **19** | **25** | **43** | **66** | | | | | | **IND**<br>**TOTAL** | **19** | **24** | 1<br>**43** | 10<br>**64** | **NS=3**<br>**IND=1** | |

*-Countries that consistently do not support the hypothesis in all time scales

SS - support, WS- Weak support, NS- not support, IND - Indeterminate

# APPENDIX VI

Tab 1: Service and Manufacturing causality in longer time scale across countries

| | **Countries with Granger causality of services on manufacturing in S** | | | | **Countries with Granger causality of services on manufacturing in $D_3$** | | |
|---|---|---|---|---|---|---|---|
| | **Positive** | | **Negative** | | **Positive** | | **Negative** |
| 1 | Afghanistan | | Bhutan | | Afghanistan | | Benin |
| 2 | Bangladesh | | Botswana | | Bolivia | | Bhutan |
| 3 | Benin | | Burkina Faso | | Chad | | Burkina Faso |
| 4 | Bolivia | | Burundi | | Djibouti | | Burundi |
| 5 | Cape Verde | | Cambodia | | Liberia | | Cambodia |
| 6 | Central African Republic | | Cameroon | | Malaysia | | Cape Verde |
| 7 | Comoros | | Chad | | Mali | | Egypt |
| 8 | D R of the Congo | | Congo | | Mauritania | | Gambia |
| 9 | Egypt | | Djibouti | | Mozambique | | Ghana |
| 10 | Ghana | | Equatorial Guinea | | Niger | | Guinea |
| 11 | Guinea | | Ethiopia | | Pakistan | | Haiti |
| 12 | Guinea-Bissau | | Gambia | | Paraguay | | Honduras |
| 13 | Haiti | | Honduras | | Somalia | | India |
| 14 | Indonesia | | India | | Sudan (Former) | | Indonesia |
| 15 | Kenya | | Lao People's DR | | Syrian Arab Republic | | Iraq |
| 16 | Liberia | | Lesotho | | Togo | | Kenya |
| 17 | Malawi | | Madagascar | | Viet Nam | | Lao People's DR |
| 18 | Mauritania | | Malaysia | | | | Lesotho |
| 19 | O. Palestinian Territory | | Maldives | | | | Mongolia |
| 20 | Sao Tome and Principe | | Morocco | | | | Myanmar |
| 21 | Sierra Leone | | Mozambique | | | | Nigeria |
| 22 | Solomon Islands | | Myanmar | | | | O. Palestinian Territory |
| 23 | Somalia | | Niger | | | | Papua New Guinea |
| 24 | Sri Lanka | | Nigeria | | | | Sri Lanka |
| 25 | Sudan (Former) | | Pakistan | | | | Swaziland |
| 26 | Swaziland | | Papua New Guinea | | | | Tunisia |
| 27 | Togo | | Paraguay | | | | |
| 28 | Tonga | | Philippines | | | | |
| 29 | Zambia | | Senegal | | | | |
| 30 | | | Syrian Arab Republic | | | | |
| 31 | | | Thailand | | | | |
| 32 | | | Tunisia | | | | |
| 33 | | | Uganda | | | | |
| 34 | | | Tanzania: Mainland | | | | |
| 35 | | | Vanuatu | | | | |
| 36 | | | Viet Nam | | | | |
| 37 | | | Zimbabwe | | | | |