INVESTIGATING THE NEXUS BETWEEN INVESTMENT IN AGRICULTURE AND AGRICULTURE OUTPUT: A CASE FOR NAMIBIA

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ABSTRACT

This paper explores the link between agriculture investment and agriculture output in Namibia. The existing theory on investment and growth constitutes a basis for empirical work on investment-output nexus. Neither the neoclassical nor the new growth theories on investment have considered the growth effects of investment at sector and industry level and its implication on capital allocation, particularly for developing countries that are resource constrained. The key question addressed in this paper is whether investment in agriculture is associated with agriculture output, both at the sector and sub-sector levels. The paper adopted the ARDL bounds test model constructed with quarterly data for the period 2000 to 2020 and found that investment and agricultural output exhibit a long-run relationship. The coefficient estimates showed that public investment, development bank loans and agriculture export have a positive impact on agricultural output while inflation, lending rates and commercial bank loans have a deleterious effect. The long-run causality tests suggest that there is unidirectional causality between commercial credit expenditure and aggregate agriculture output, as well as a unidirectional causality running from exports to livestock and crop sub-sector output. Based on error correction terms, agriculture output tends to rapidly adjust to short-term disturbances, hence rebound of agriculture output to a long-run growth path can take place with minimum or no delays. This study concludes that the Keynesian hypothesis is valid for Namibia's agriculture and the direction of causality is from investment to agriculture growth. Therefore, the role of government in supporting sustainable development of the agricultural sector cannot be overemphasised.

Keywords: Agricultural output, ARDL bounds test, commercial loan credit, development loan credit, error correction, public investment, Namibia

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CHAPTER 1: INTRODUCTION

1.1.Background of the study

The theoretical and empirical strands of literature have underscored the role of investment as a source of economic growth and development. The classical theories of growth explored by John Keynes, Harrod-Domar, Robert Solow and Trever Swan, amongst others, converge to a conclusion that investment and capital accumulation are strategic drivers of economic growth (Thirlwall, 2011). By extension, investment supports industry and productive capacity, creates employment, attracts technological innovations, and contributes to the Government’s tax revenue (Sinha, 2017). The seminal work of Lewis provides an insight into contemporary policy development. Lewis’s model demonstrates that countries that are on a transformation path operate on a dual economic system where growth in the subsistence sector (agricultural sector) creates a demand for labor in the capitalist sector, thereby raising productivity in the economy (Fuglie & Rada, 2013). It, therefore, follows that increased agriculture serves as a foundation for economic growth, particularly for economies that rely on agriculture for national income, employment, and poverty reduction (Getahun et al., 2018; Mijiyawa, 2013). Total factor productivity (TFP), a measure of agricultural productivity, is defined as the efficiency of labour and capital employed in a production. Rising agricultural productivity supports economic growth through production and consumption (Badiane & Makombe, 2014). With regard to production, productivity leads to improved income for farmers, bolstering purchasing power for inputs and services produced in other industries. On the consumption side, demand for non-agriculture goods leads to industry growth and, subsequently, investment in capital (Badiane & Makombe, 2014).

The foregoing arguments point to the fundamental role of agriculture in economic growth and development. The Sustainable Development Goals (SDGs), an international development tool, calls for, amongst others, investment in the agricultural sector to achieve development outcomes such as poverty reduction, zero hunger and food security, particularly for developing countries, by 2030. On the African continent, the period between 1960 and early 2000s has seen a declining trend in agriculture investment, generating poor growth performance in agricultural sector (Mogues et al., 2012).

However, investment in agriculture has led to sustained and significant agricultural growth in South East Asia - coined as the ‘Green Revolution’ (Mogues et al*.,* 2012). The Green

Revolution has led to renewed interest in agricultural investment in sub-Saharan Africa, demonstrated by the initiative of the Africa Agricultural Development Programme (CAADP), also referred to as ‘The Maputo Declaration adopted by the African Union in 2002 under the New Partnership for Africa’s Development (NEPAD) (Woodhouse et al., 2017; Mengoub, 2018). In line with the CAADP framework, African governments have pledged to invest at least ten per cent of their country’s budget in the agricultural sector with a view to deliver a six per cent annual agricultural growth rate (Badiane & Makombe, 2014). In their agricultural policy strategies and investment plans, governments have committed to work with the private sector to increase investment for the sector and create an enabling environment for the private sector to participate in input supply, the marketing of outputs, and agro-processing (Mogues et al., 2012, p338). Government capital expenditure in agriculture and growth vary across all African countries. On average, the share of agricultural spending to the agricultural gross domestic product for Sub-Saharan African countries have declined from 3.16 percent in 2005 to 2.16 percent in 2016 (Statistics on Public Expenditures for Economic Development (SPEED, IFPRI; 2019a). Countries, such as Malawi (17.43%), Mali (12.31%), Niger (12.30%), Benin (11.78%), Senegal (10.60%) and Rwanda (10.55%) have recorded the highest ratio of agriculture public spending to the agriculture GDP. To the contrary, Namibia is one of the Southern African countries whose ratio of public expenditure to agriculture GDP ranges between 5& and6%. The annual average share of agriculture public expenditure in Namibia over the fiscal period 1994 to 2019 is recorded at 13%, exceeding the commitment of 10% annual budget allocation under CAADP. The ratios observed for some African countries are below the 10 percent target (Statistics on Public Expenditures for Economic Development (SPEED, IFPRI, 2019a). The trend in agricultural development expenditure has varied over time as is evidenced when tracking the national development budget allocation on expenditure, and reflecting on the correlation between the size of the national budget and allocation to the agricultural sector, notwithstanding a relatively high budget priority placed on the sector.

Namibia’s agricultural sector is largely based on primary production, representing the largest employer in the country and accounting for about 23% to the total labour force. In addition, agriculture contributes about 4% to the GDP and about 20% of the total export value. The livestock sub-sector contributes 60% to the agriculture GDP while crop and agro-processing industries account for 30% and 2%, respectively to the agriculture GDP. There is no doubt that the agricultural sector plays a significant role in the socio-economic development in Namibia.

The fiscal period between 1994 and 2011 has recorded the allocation of development capital below N$800 million while the subsequent period (2012 to 2019) has enjoyed an average allocation of N$1.3 billion (NPC, 2020). The current Medium-Term Expenditure Framework Period (MTEF) for the period 2019/20 to 2021/2022 has allocated 14 percent of the total capital budget, rendering agriculture as the second largest expenditure after the transport sector. There is clear evidence that the sector has enjoyed fiscal priority relative to other sectors in the past decade. This development has been marked by investment in irrigation infrastructures and market infrastructures through the construction of fresh produce hubs, storage facilities, as well as the construction and upgrading of meat processing facilities (NDP5,2009). Fiscal commitment to the agricultural sector reflects that the 'Maputo Declaration' continues to shape Namibia's agriculture policy programs to support development of the agricultural sector and economic growth at large. In addition to public investment, local development and commercial banks constitute a major source of capital for private investment in agriculture. The total agriculture debt increased by 10% on average during the past decade. While bank loans are important sources of private investment, non-performing loans have seen a significant increase of about 60% on average over the past decade (Bank of Namibia, 2020).

Despite decades of public and private investment in the sector, growth in agriculture continues to dwindle and remain below the expectations of 4% annual growth under CAADP (NSA, 2019). Following this extended period of low growth in the agricultural sector, the question that comes to mind is when and how will the sector return to or rise above its long-run growth path. Efforts towards the recovery of the agricultural sector require scientific investigation and full understanding of critical growth factors. The investment landscape offers a critical area of investigation to provide details on historical performance, together with the layout of the status and, ultimately, it will be able to chart a future growth path for the sector. While growth in agriculture remains a public policy priority, serious concerns have emerged as to whether further increase in investment is justified and how.

The empirical query on the relationship between investment and growth remains an unresolved issue and a wide range of analysis has produced varied findings from the analysis of investment in the agricultural sector. For example, Jitsuchon (2008), Matthew and Mordecai (2016), Attari and Javed (2013) and Sackey (2018) established that a negative relationship existed between investment and growth. On the contrary, Chandio et al. (2016), Ebener et al. (2019), Chaminuka et al. (2018), He et al. (2019) conclude that private and public investment in agriculture is a catalyst for agricultural output growth. From these empirical works, variable selection, stationarity of series, and cross-country heterogeneity, are some of econometric challenges presented in the literature. Nonetheless, the contribution of aggregate public agriculture investment flows, agriculture gross capital formation, as well as the influence of specific government programs, such as irrigation infrastructures, research and development, input subsidies, have been the subject of interest in the literature reviewed in this study. Furthermore, credit extension and foreign direct investment in agriculture have been used as proxies for private investment. By and large, investigation of the causal effect of aggregate or disaggregated public expenditures has delved into the overall sector growth. A measurement gap in this approach has been identified, which makes it difficult, if not impossible, to come to any conclusion on the responsiveness of the agricultural output at the sub-sector or industry level. In addition, this estimation method fails to recognise that various categories of agricultural investment assets complement each other in influencing growth in the sector. For example, investment in irrigation infrastructures may not be effective if the market and transport infrastructures are not conducive for doing business in agriculture. Hence, measuring public investment at program or project levels presents the risk of making distorted decisions in asset allocation. Other research studies have used gross fixed capital formation as an indicator for investment without regard to the distinction between private and public fixed capital formation. Therefore, as a result, the findings on this topic remain inconclusive across many studies.

The key question this study seeks to answer is whether investment (public and private) has an impact on the production output of the Namibian agricultural sector. Furthermore, the study intents to establish strategic development initiatives and interventions which may contribute to agriculture growth. Based on the available data, the analysis employed agriculture output at sector and sub-sector levels (livestock and crop/forestry sub-sectors) as the dependent variable while the exogenous variables were public and private agricultural investments. Commercial and development credit extension in agriculture have been identified as proxies for private investment. The application of the ARDL bounds test for the long-run co-integration model provides strong statistical evidence of the short-run relationship and long-run relationship between investment and performance of the agricultural sector. This study concludes that agriculture is a strategic sector for public investment coupled with development-oriented credit finance. The study provides evidence that supports public investments in agriculture as a catalyst for agriculture growth and contends that public investment should focus on programs and strategies to support economic growth, poverty reduction and food security.

1.2.Description of agricultural commodities produced in Namibia

Putting Namibia's agricultural sector into context, the agricultural sector is largely oriented towards the primary production of livestock and crops. Various tenure systems are practiced in Namibia and agricultural land makes up 76.9% of the land (Mendelsohn, 2006). According to the land statistics published by the Namibia Statistics Agency (NSA, 2018), the commercial freehold consists of 45.1% of this agricultural land, followed by communal state land 41.73% and 14.0% utilised by Affirmative Action and Resettlement emerging farmers. Livestock farming in Namibia comprises cattle, sheep, goats and pigs. In terms of output, beef production is the major livestock farming activity in Namibia followed by mutton/ lamb, goat and pork. Cattle production is practiced in most areas of Namibia, supporting most livelihoods in rural areas. Over the years, the national cattle herd has fluctuated from 1 515 283 to 2 713 394 over the past seven decades (Keet, 1950; DVS, 2017). Despite the relatively low average national offtake rate of 14%, Namibia is a net exporter of beef and live cattle. This sub-sector has always played an important role in the economy and currently contributes 43% to the total agriculture output.

The contribution of cereals to the agricultural sector is relatively small compared to other products such as livestock. Maize is planted in areas where there is sufficient rainfall and irrigation schemes. Pearl millet is planted in various parts of the country and, like wheat requires irrigation. Pearl millet is almost exclusively grown in communal areas while wheat is grown in commercial areas. Namibia is not self-sufficient in cereal production. Namibia imports about 68% of pearl millet's domestic demand while maize imports are 61% on average.

The horticulture sector has recorded a positive growth trend over the past number of years with fresh grapes and dates being the main forex earners (EU, United Arab Emirates, South Africa), while onions and tomatoes recorded an exportable surplus in some years. However, this sector also faces serious challenges arising from the lack of productivity, the lack of accessible markets especially for small-scale producers, the high post-harvest losses especially with vegetables, the lack of profitability owing to the high costs of input, and other productivity factors. The production of dates and grapes are fast-growing industries, export-oriented, and are able to exploit location advantage to gain international competitiveness. Namibian grapes and dates reach the market (EU, United Arab Emirates, South Africa) when their main competitors, who are mainly in the Northern hemisphere, are out of season (NAB,2020). Domestic production and marketing for locally sold commodities (i.e. carrots, onions, potatoes, tomatoes) have recorded an upward trend while imports have decreased dramatically. This can be attributed to the Namibian Horticulture Market Share Promotion (MSP) scheme which obliges all importers to source an agreed percentage of their purchases from local producers of fresh fruit and vegetables.

Namibian Swakara pelts have been marketed under the name Swakara since 1968 and have become highly recognised in European markets for its intrinsic tight curl pattern and shiny black skin and short hair. At the height of market recognition, the Swakara sheep adopted a new name and were referred to as Namibia's 'black diamonds' because of the export earnings and their contribution to the country's GDP. However, the production of Swakara pelts has been declining at an alarming rate, with the lowest being 54 514 pelts produced in 2019. This figure is 102% less than what was produced in 1970. In addition, over the years the number of breeders has dwindled, and industry data shows that only about 40 breeders were recorded in 2012 and thus, pelt supply has declined. As of 2019, only 54 147 pelts were supplied to the leading fur auction house in Windhoek. Despite the upward surge in the price for pelts, the supply of pelts continues to decline. Consequently, there is a great need to do a thorough study to understand and justify the dynamics of the agriculture commodities in Namibia. This will aid investment decision making and turn the challenges into opportunities for the betterment of agricultural sector.

1.3.Policies and institutional structure related to agriculture investment

According to Thirlwall (2011), public sectors of agriculture-based developing countries have an obligation to support agriculture productivity and reduce poverty levels through investments. After Namibia's independence, the government's agricultural policy aimed to create an enabling environment for the private sector to respond to market opportunities and invest in the development of the sector. The overall objective of the National Agricultural Policy of 1995 is to increase and sustain the levels of agricultural productivity, real farm incomes and national and household food security, within the context of Namibia's fragile ecosystem. Several public, private and civil society institutions have been identified as key players in the implementation of the National Agriculture Policy.

In the context of public agriculture investment, the Ministry of Agriculture is responsible for the budgeting of all agricultural public related expenditures while at the same time acting as a lead implementer and coordinating institution for all agriculture related investment programs and projects. As reflected in the national budget and expenditure records, budgeting and spending are executed at sectoral and project level, hence specific agriculture commodities benefit from public investment under the projects or sector budget (MoF, 2020). Public investment projects are multi-purpose, combining a wide range of activities for the benefit of all commodities falling under the livestock and the crop sub-sectors without targets for specific commodities. While there is no clear configuration of investments for specific commodities, public investment in Namibia's agricultural sector is targeted to increase output in strategic commodities such as beef, mutton, pelts, dates, grapes, maize, wheat and horticulture products that can be efficiently produced given local climatic conditions. Beef, grapes and dates are mainly destined for export markets while the other commodities are predominantly produced for local consumption.

Public investment in the crop and forestry sub-sector is streaming largely towards the development of irrigation projects at national level, the National Horticulture Development Initiative and the National Strategic Food Reserve facilities. These interventions aim to support increased production, beyond subsistence level, by grain producers in rural farming areas with a view to improve food security and income. With respect to public investment in the livestock-sub-sector, government aims to improve animal production, health, and marketing across the country. Key interventions include animal disease surveillance, compliance with animal and meat trade requirements and expansion of veterinary laboratory services across the country, with a focus on diagnosis and research on transboundary animal disease in the Northern Communal Areas. Although the records of public investments do not show regional spread of agriculture development expenditures, projects are mainly focused on supporting production in communal areas. Consistent with theory and the empirical work of Matthew and Mordecai (2016), this suggests that public investments and policy strategies are designed to curtail development challenges such as income inequality, poverty, and food security at the national level. Therefore, the coefficient on public investment in livestock, as well as livestock sub-sectors is expected to have a positive sign in the estimation model.

The regulatory and statutory institutions such as Meat Board and Namibia and Agronomic Board of Namibia are responsible for the development and management of national marketing and trade initiatives, the development and enforcement of standards, the maintenance of a competitive domestic market while ensuring fair competition (MBN, 2019; NAB, 2019). Agriculture production and marketing agencies such as the Agro-processing and Trade Agency (AMTA) and Agribusdev were established in 2013 as agencies of the Ministry of Agriculture and Land Reform, operating under the Agronomic Industry Act, 1992 (No. 20 of 1992). The overarching role of AMTA is to coordinate and manage the marketing and trading of agricultural produce in Namibia. AMTA's current mandate is to manage the Fresh Produce Business Hubs (FPBHs) and National Strategic Food Reserve (NSFR) infrastructure towards the attainment of food safety and security. The FPBH were built because Namibia's horticulture industry lacked bulk cold storage facilities, marketing facilities and logistical facilities for smallholder farmers. Public development expenditure for the NSFR over the period 2008–2020 accumulated to N$127.8 million (1% total agriculture development expenditure) while spending related to the FPBHs has been recorded at N$522.8 million (6% of cumulative agriculture development expenditure) over the same period (MoF, 2020).

Other policies and strategies that have been adopted within the framework of the agriculture policy include the Agriculture Marketing, Trade Policy and Strategy and the Green Scheme Policy. AgriBusDev is a government agency which was established in November 2011 in terms of the Companies Act, Act 2004, to manage and supervise the country's Green Scheme programme according to the Green Scheme Policy of 2008. The Green Scheme Policy's objectives are to support an increase in agricultural production through the empowerment of smallholder farmers, promoting private investment in agriculture through the leasing of fully equipped irrigation land and promoting food security. AgriBusDev is currently operating eleven Green Scheme Projects of in terms of specific farming models described in the Green Scheme Policy. Since the implementation of the green scheme in 2008, the Government has invested about N$1.766 billion over the period 2008–2020, accounting for 15% of the total agriculture development expenditures over the same period (MoF, 2020).

As indicated by IPPR (2019), the private sector and civil society institutions, such as farmers' unions/associations, non-governmental organisations and cooperatives, are the driving forces behind business and economic development, information dissemination and strategic collaboration across the value chain. Farmers' associations and unions represent communal and commercial farmers' interests respectively, therefore, playing an important role in addressing the needs of farmers, including advocacy and lobbying (IPPR, 2019).

With respect to private investment, credit finance is provided through development banks, commercial banks, and non-banking institutions (i.e. fund managers). Development banks are subsidised through annual fiscal allocations to promote financial inclusion and address market failures, particularly in the SME sectors. The Development Bank of Namibia (DBN), on the other hand, carries a mandate for the infrastructure and SMEs' finance, excluding the agricultural sector. The Agriculture Bank of Namibia, a state-owned development bank, referred to as 'Agribank' has been and continues to play a role in advancing relatively low interest and longer loan terms for the agricultural sector with a portfolio size of N$3 billion as at the end of the financial year 2020 (Agribank Annual Report, 2020) which combines small-holder and commercial farmers. Agribank is a major player in agriculture financing, recording a 38% market share compared to the market share of individual commercial banks as follows: First national Bank, 21%; Bank Windhoek, 25%, Nedbank, 5%, Standardbank,10% (Commercial Banks Annual reports). According to the Agribank Annual Report (2020), the bank supports communal/smallholder farmers and as part of its developmental mandate, Agribank offers the following main products for communal farmers:

- National Agriculture Credit Programme (NACP), under which communal farmers can access credit at a 4% interest rate to acquire livestock and production inputs. The NACP requires collateral.

- No-collateral loans: A credit facility for salaried communal farmers who do not have collateral to offer as loan security.

- Emerging Retail Financing Product (ERFP): A credit facility earmarked for full-time communal farmers without requirements of collateral as loan security. The ERFP seems to be a practical solution to meet the challenges of access to credit by communal farmers. However, its sustainability hinges on fiscal policy support such as credit guarantee schemes and fiscal transfer to Agribank.

- Complimentary to loans, Agribank offers mentorship services to its NCA clients, while training services are open to all farmers

These financial products offer an opportunity for communal farmers to invest in agriculture and expand their production scale. Major financing needs for communal farmers include purchasing livestock for breeding and restocking, as well as a wide range of production needs such as farm infrastructure, equipment and production inputs. The challenge, however, is that the majority of communal farmers are still unable to access Agribank credit due to the lack of collateral.

Commercial banking institutions represent an alternative source of private capital for investment in the agricultural sector. Based on the latest available figures drawn from their annual reports, commercial banks indicate that the total credit extension by commercial banking institutions stood at N$4.4 billion, while the combined credit extension for commercial banking institutions and Agribank accumulated to an amount of N$7.5 billion as at the end of September 2020 (Banks Annual Reports 2019–2020). By implication, Agribank holds a larger share of the total agriculture credit extension, recorded at 40% at the end of September 2020. Competitive interest rates and relatively long loan repayment periods are distinguishing features of Agribank when compared to commercial banking institutions.

Despite the policies and institutions in place, agriculture investment as a share of agriculture output has experienced a sharp downward trend. This may suggest that agricultural commodities and food supply markets have not been functioning efficiently at expected levels. The sector has faced market failures which could have inhibited the participation of the private sector in the agricultural market. See Figure 1 below.

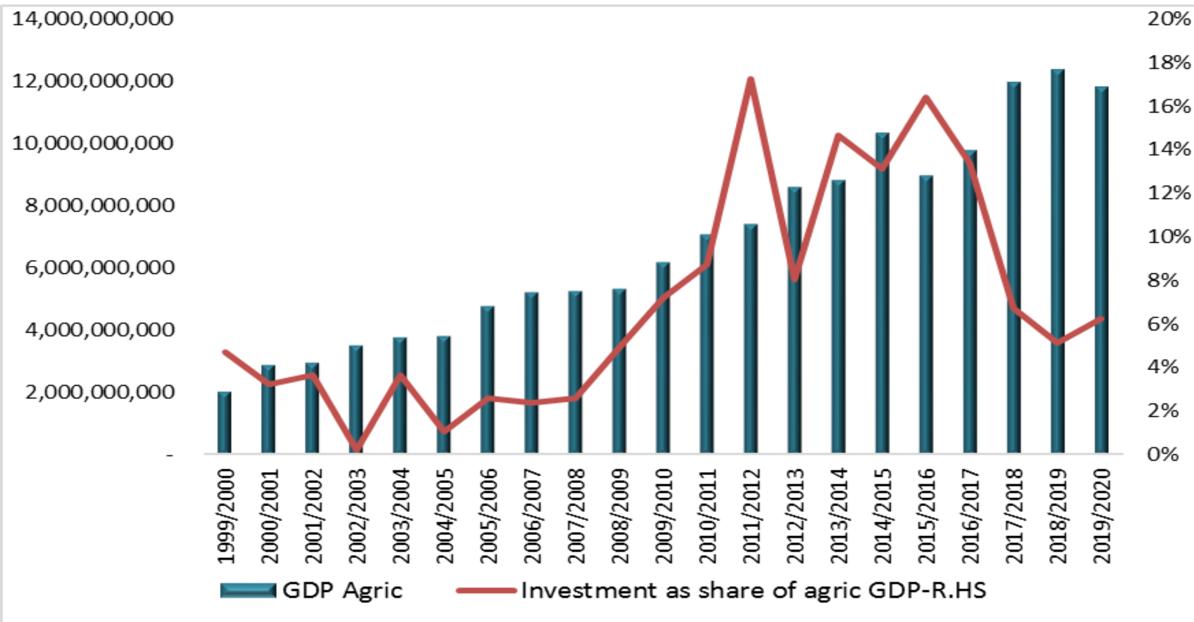

Figure 1: Agriculture public investment as a share of agriculture output (N$)
Source: Ministry of Finance/Researcher's own compilation

1.4.Problem statement

Economic returns on capital investment has been widely and hotly debated over time and across many economies. Two diverging views clearly emerge from the empirical and theoretical literature reviewed herein. On the one hand, neoclassical economists, such as John Keynes, Solow (1956), and Barro (1990), hold the view that public capital is a source of economic growth but under the assumption of diminishing return to scale. In addition, the new growth theory referred to as 'endogenous growth theory' and its proponents concur that economic growth can take place in perpetuity given capital accumulation and technological progress. Subsequent empirical work on public investment argues that public capital is an engine of growth as it provides an environment and public goods that drive private investments (Cullison, 1993; Fan Yu & Jitsuchon, 2008; Mijiyawa, 2013; Anik et al., 2017; Gong, 2018; Rada et al., 2019). On the other hand, capital investment does not automatically translate to growth performance in incidences of crowding out and inefficiency in allocation and the implementation of policy programs (Hangue & Kneller, 2015; Acharya & Nuriev, 2016). The debate between the aforementioned camps does not only derive from theoretical frameworks as it may also reflect other factors such as the source and type of data, as well as model specifications. Prior empirical work has suffered analytical challenges on the limited number of explanatory variables and the level of data disaggregation producing unbiased and inconsistent findings. Moreover, there is little or no empirical evidence of agriculture investment in Namibia, hence little is known as to whether public investments in agriculture have generated the desired growth outcomes.

1.5.Research questions

In general, public spending is expected to maximise production capacity of the economy (Benfica et al., 2019). An important lesson from the literature is that public spending interventions should focus on providing public goods that encourage private investments and subsequently generates growth outcome. A large share of total public spending allocations the agricultural sector reflects an economic and policy importance attached to the sector. An important question to be answered is whether public spending in the Namibia agricultural sector growth is enhancing. The specific objectives of the proposed study are as follows:

i. To evaluate the effect of public agriculture public expenditures on Agriculture output

ii. To identify strategies that can be employed to restore growth in the agricultural sector to or above its long-term growth.

The study aims to answer the following research questions:

i. Is there a link between agricultural investment and agricultural output in Namibia?

ii. What strategic initiatives are required for sustained growth in agriculture in Namibia?

1.6. Justification of the study

Preceding empirical and theoretical works have produced mixed results on the link between investment and the output growth in the agricultural sector. Some scholars argue that investment leads to growth in agricultural output (Chandio et al., 2016; Ebener et al., 2019; Chaminuka et al., 2018; He et al., 2019) while others are of the view that investments do not necessarily translate into output growth. Devarajan et al. (1996), Ndulu (2006), Afonso and Aubyn (2009), and Hangue and Kneller (2015) mainly attribute this to poor institutions, the misappropriation of resources and other structural challenges in the domestic economy. By and large, existing empirical literature have endeavoured to establish the impact of agricultural public investment on output without maintaining uniformity on investment variables. For example, many authors have assessed the impact of disaggregated public expenditures on overall agriculture growth or the impact of aggregate public expenditure on the output of a particular sub-sector or industry. This approach is flawed because it assumes that public investment in a particular asset, input, or services can generate efficiency gains for the whole sector or that each industry/sub-sector can benefit from any component of public investment, thus presenting a considerable oversight in this respect. This study provides an extension to the existing knowledge by matching sectoral investment to sectoral growth and aggregate investment to aggregate agriculture growth. Furthermore, in this study, the development loan variable is introduced in addition to commercial credit which has been the focus of various studies. The additionality of this paper is three-fold. First, the results of the Autoregressive Distributed Lag (ARDL) co-integration approach is the first bounds testing study to contribute to empirical evidence on the effectiveness of private and public investment on agriculture using Namibian data. Second, it reveals that that the Keynesian theory that advocates for public spending to support economic growth holds for Namibia's agricultural sector. Last, but no less important, the study validates sources of agriculture growth in Namibia which could support long-term policy decisions.

1.7.Organisation of the study

This study is organised into five chapters, which are as follows: Chapter 1 provides an introduction covering the research problem definition, research questions, research objectives and hypotheses, justification of the study, organisation of the study and the scope of the study. Chapter 2 focuses on the review of literature which provides an appraisal of empirical studies and theories relevant to the research topic. Chapter 3 discusses the methodology with detailed discussion of the variables and data, the model framework and specification and the various econometric techniques used to estimate the model. Chapter 4 presents and discusses the outcomes and findings of the paper. Lastly, Chapter 5 provides a conclusion, focusing on a summary of key findings and recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1.Introduction

The topic of investment and growth has been subject to extensive debate amongst many development economists. The debate has evolved over time through a series of theoretical and empirical models used to assess the relationship between investment and economic growth. Three sets of conclusions that emerge from different strands of literature are noteworthy. First, there is broad consensus among research pundits that capital stock, technology progression, labour, research and innovation are key determinants of economic growth (Solow-Swan,1986; Barro,1990; Jones, 1995; Romer, 2012). Second, literature focusing on agriculture investment argues that public agriculture-centred investments tend to favour agriculture as a vehicle for economic transformation in developing countries (Aschauer, 1989; Barro, 1990; Sanchez-Robles, 1998). Third, development literature highlights that institutions and efficiency in the implementation of public programs are key ingredients for productivity growth. Besides these broad conclusions, literature also presents a compelling argument that investments do not automatically translate into economic growth. Investment efficiency depends on other factors in the economic system, such as political factors, market systems and policies. In this section, theories that exist and empirical surveys on the role of investment in economic growth and development, with specific attention to the evidence on agriculture investment, are reviewed.

2.2.Theoretical literature

The role of capital accumulation has taken centre stage in theoretical literature for many decades. The growth of capital stock is impossible without investment in capital goods such as plant and machinery, infrastructures, research and development, technology and innovation, as well as social capital (Thirlwall, 2011). The ownership of capital is categorised into public capital, domestic private capital and foreign direct investment (FDI). By definition, public capital is expenditure that governments incur when the provision of public goods and services enhance production efficiencies and stimulate economic growth (Jones, 1995; Sanchez-Robles, 1998). Private capital, on the other hand, is sourced from private equity and borrowing from financial institutions. The foreign direct investment is a flow of capital from an enterprise in one economy to another enterprise in another economy having interest in the market, resources, and production efficiency in the recipient economy (Zekarias, 2016). Hangue and Kneller (2015) and Benfica et al. (2019) have suggested that scarcity and efficient financial allocation to enhance development are key challenges for many countries in the developing world, hence decisions on how much to invest in public capital and which sectors, programs or projects to invest in to maximise growth is generally expected to be evidence based.

The theoretical propositions of John Keynes and Arthur Lewis have served as a foundation for numerous empirical investigations relating to investment and agriculture productivity. While the Keynesian hypothesis and Arthur Lewis's hypothesis are not the first to argue that public investment and prioritising agriculture plays a central role in development, they do provide a compelling framework for the thinking around economic development strategies, particularly for developing economies. Lewis expresses a view that developing countries should focus on agriculture owing to its capacity to generate spill-over effects to other sectors through production and consumption linkages (Fuglie & Rada, 2013; Thirlwall, 2011). Aschauer (1989) developed a theoretical model of the Cobb-Douglas production function which assumes that production output is a function of labour, capital and public capital stock. The model shows a strong positive relationship between output per unit of capital input, the private labour-capital ratio, and the ratio of the public capital stock to the private capital input (Aschauer, 1989). While public investment leads to an increase in capital stock and production output, fiscal expansion is generally enabled through public debt. Rising public debt has an impact on real interest rates presenting a risk of crowding out private investments, subsequently affecting private investment decisions and economic performance (Futugami, et al., 1994). Key takeaways from the work of Futagami et al. (1994) is that economies can achieve a steady-growth equilibrium, growth can be maximised when the income tax rate is equivalent to the rate of change between economic output and public capital; social welfare is achieved when the tax rate is lower than the tax rate that maximises economic growth. The latter argument reflects a Pareto optimal phenomenon, suggesting the need for fiscal policies that support private investment while at the same time safeguarding social welfare.

According to the Keynesian theory, there is a need for government intervention in the market to stimulate investment and demand in the economy (Ahmad & Qayyum, 2008). This hypothesis is contrary to the economic ideology of Adam Smith and David Ricardo who believe that the economy can self-correct and adjust to long-run equilibrium aftershocks. Keynes reared a two-pronged view on the growth impact of government spending. On the one hand, Futagami, Morita and Shibata (1993) and Solow (1994) argue that public spending has a positive multiplier effect on the economy as it supports an increase in stock of private capital, investment and, subsequently, economic output. On the other hand, public spending does not necessarily lead to growth due to the inefficient operations of public institutions, high public debt levels, and underdeveloped markets (Ghali, 2003; Ndulu, 2006; Afonso & Aubyn, 2009). The misallocation of public resources, inadequate public funding and the crowding out of the private sector due to excessive debt-financed spending may dampen the potential for the growth effect of public spending (Ahmad & Qayyum, 2008). In the literature, some economists have noted that government spending presents an upside risk of crowding in private investment. Bearing in mind diverging views on the growth impact of investment and the sensitivity of investment to anticipated and unanticipated disturbances to the economy, one needs to assess whether the Keynesian hypothesis is relevant to Namibia's agricultural sector. Being a small open economy faced with limited capital and resources, development expenditures are necessary to create an enabling environment for private investments.

Barro (1990) developed an endogenous growth model that focuses on the relationship between public expenditure and economic growth. Given that prior theoretical work considers savings as a sole means of capital accumulation and technology improvement, the author introduced taxes as a funding source for public expenditures, heralding an important observation that fiscal policy decisions place a significant role on economic growth. Jones (1995) introduced Research and Development (R&D) into the production function for economic growth, postulating that the creation of new knowledge has the potential to drive economic growth. These endogenous growth models assume that government expenditures serve as a distributive tool for services and inputs to households and businesses consumption and productive activities (Barro, 1990; Jones, 1995). Complementing the work of Barro and Jones, Futagami et al. (1994) presents a transitional dynamics model that incorporates private and productive and public capital stock. Intuitively, the stock of public capital serves as a production input for the private sector with prospects for raising marginal product of private capital. Likewise, economic growth is mainly driven by public investments and private investments when they interact in a complementary manner (Qayyum & Salam, 2008; Cullison, 1993). The authors highlight that output growth depends on capital accumulation and a sustainable long-term growth is possible through technological progress.

Agriculture is considered an engine of growth through four major channels: product contribution, factor contribution, market contribution and foreign exchange contribution (Thirlwall, 2011, p.180). Agriculture contributes to increased food production beyond subsistence levels which influences prices and an increased demand for food thus addressing food security challenges (World Bank, 2019). Consequently, industries would not be compelled to increase wages while benefitting from profits, capital accumulation and growth (World Bank, 2008). With regard to factor contribution, when agriculture productivity rises, there is an increased supply of labour to the industry which acts as a catalyst for industrial development (World Bank, 2008). A case in point being South East Asia which recorded a remarkable drive for supply of labour from agriculture. From the market contribution side, the institutional arrangements of marketing and regulatory boards require the payment of levies on marketed agriculture produce thereby generating government revenue (World Bank, 2008). In addition, agriculture serves as a market for industrial goods when production inputs and services are considered. At the same time, agricultural products serve as material inputs for industrial manufacturing and processing (World Bank, 2008). Foreign exchange earnings are derived from the export of agriculture commodities which serves to finance the import of goods that cannot be produced locally which in turn strengthens the balance of payments and further boosting economic growth (World Bank, 2008).

Dercon and Gollin (2014) have identified public investments and effective public policies as catalysts for private investment. This argument assumes that public policies are responsive to the dynamic and changing economic environment. The authors are less optimistic that strategic investment in agriculture is an appropriate policy instrument for economic development. They argue that the impetus for agriculture-centred public support may be specific to food security, poverty reduction, particularly for rural populations that rely on agriculture for their livelihood as opposed to overall economic growth. The theoretical views of Dercona and Gollin (2014) serve as a departure point for this study to focus on a country-specific analysis, that is, countries where public agriculture policies and interventions are pursued to reduce poverty and improve food security in their specific country. Therefore, in this study, the approach of assessing the relationship between public investment and agriculture sub-sectors (i.e., crops and livestock) was pursued to establish the strategic sub-sector for public investments.

2.3. Empirical review

Scientific debate on the linkage between capital investment and growth has been topical in the academic and policy space. While there is no standard model for analysing investment and growth, the modern and classical growth theories provide an appropriate basis for general and sector specific growth analysis. Premised on the Keynesian and Solow-Swan (1986) hypotheses, several studies have examined the role of public and private spending on overall growth (Nell & Thirlwall, 2018; Hangue & Kneller, 2015; Mijiyawa, 2013; Acharya & Nuriev, 2016; Matthwe & Mordecai, 2016; Rada, 2016; Anik et al., 2017; Ebener et al., 2019; Chaminuka et al., 2018, He et al., 2019, Attari & Javed, 2013; Chandio et al., 2016).

Nell and Thirlwall (2018) explore a cross-country analysis to explain the variation in returns to investment across developing and developed economies over the period 1980 to 2011. The outcome of this study is defiant of Solow's hypothesis of diminishing return to capital, arguing that government spending, macroeconomic stability, trade openness and government consumption support investment productivity. Therefore, in the long-run, investment has a positive effect on growth in both poor and rich countries. Remarkably, the study found that an increase in government expenditure was counterproductive, suggesting that public investment is not relevant to growth. This inference may have been flawed as the study did not distinguish between investment and consumptive expenditure. Similarly, Thirlwall (2000) finds that the variation in productivity of capital across a regional grouping of countries (i.e. Africa, OECD, Asia, Latin America) was largely due to factors such as the level of education, R&D expenditure, financial sector development, trade openness and political stability.

In their study, Acharya and Nuriev (2016) investigated how development and working public capital are related to economic growth at state level across emerging economies. They applied the Least-Squares Dummy Variable (LSDV) regression model to estimate the impact of public investment on growth using the annual exogenous variable of annual public capital expenditure, public current expenditure, private domestic capital flow, FDI, and revenue/GDP ratio. The data spanned 16 years for the period 1995 to 2010 and the independent variable was the GDP growth rate. The results reveal that while public investment shows a significant and positive impact on growth, its contribution to poverty and poverty gap reduction remains lacklustre. This thesis illustrates the importance of pro-poor development strategies focusing on sectors which play a meaningful role in the livelihoods of those living in low income countries. In Namibia, the agricultural sector remains a strategic sector in the economy on the basis that the majority of the population derive their livelihood from agriculture through production and consumption. Hence, a topic on the link between investment and agriculture growth in Namibia is justified in order to unpack strategic areas of intervention for the development of Namibia's economy.

Using the vector autoregression model, Afonso and Aubyn (2009) estimate the impact of public investment on growth in 14 European Union countries, Canada, Japan and the USA for the period 1960 and 2005. This study produced inconsistent outcomes across the countries under review. For some countries, public investment had crowding-in effects on private investment, promoting economic growth. On the other hand, large public investment derived from high tax levels or government borrowing discouraged savings and generated high interest rates, leading to a crowding-out effect on private investment thus putting a damper on economic growth (Afonso & Aubyn, 2009). Hangue and Kneller (2015) explain that an economy with pervasive corruption attracts misallocation and the inefficient allocation of public resources subsequently leading to poor growth performance. Due to information asymmetry between policy makers and bureaucrats, the bureaucrats often have a tendency of delivering low quality procurement services at high costs beyond the efficient level (Hangue & Kneller, 2015). This is a compelling argument, bringing to light the reason why increased public spending in some countries has failed to yield positive economic growth rather than relying on the argument on diminished return to capital.

To a large extend, literature assumes that public investment at an aggregate and disaggregated level have a similar effect on the economy. This, however, does not recognise the distinguished importance of industries and sub-sectors in the economy and. therefore, the impact on private and public investments at industry/sub-sector would vary. To tackle this issue, Wanjiku (2016) considered sectoral expenditure in relation to the aggregate growth level. The author explored the neoclassical approach of the Cobb-Douglas Production function and econometric tools such as the co-integration test, the granger causality test and the error correction model to analyse the relationship between sectoral expenditure and economic growth in Kenya. The analysis considered various sectoral government expenditure such as agriculture, transport infrastructures, defence, public safety, education, health care and public debt spending as exogenous variables and GDP growth as the dependent variable. It emerged that only public debt expenditure was found to have a significant and positive effect on long-term economic growth, while education expenditure has led to increased GDP growth in the short run. The outcome of this analysis points to the role of education and fiscal stability in the Kenyan economy. However, this study appears to have suffered a strong presence of multicollinearity, in other words, a significantly positive correlation between independent variables. One would argue that the conclusion that public expenditure in all selected sectors is fruitless which is likely to be a type-two error, presenting the risk of diverting fiscal priorities from sectors and the misallocation of resources. In this paper, the author deliberately guarded against this methodological gap by using Perasan, Shin and Smith bound testing approach.

While some research pundits found a positive relationship between investment and economic growth, others contend that public investment is not a panacea to growth challenges. A case in point is that of Devarajan et al. (1996) who find a negative impact of transportation and communication expenditure on economic growth across 43 Least Developed Countries. The authors attribute this contrasting finding to the fact that the procurement costs of the infrastructure spending under review was markedly above their productive capacity. Kelly (1997) explored the growth impact of public expenditure, including social investment variables and net exports, across 97 countries over the period 1970 to 1980. The study further expands on the impact of specific public expenditure components on growth. The result reveals that on aggregate, public capital expenditure stimulates economic growth while disaggregated capital expenditures yields mixed impact on economic growth, demonstrating that specific spending components are inefficient, hence low growth. The authors conclude that by using aggregate capital expenditure, the model ignores the dynamics of specific capital expenditure components. With such classification, not all public expenditure is growth enhancing, therefore, the allocation of public capital needs to be evidence based and priority should be accorded to the most productive activities.

Using the vector autoregression model, Afonso and Aubyn (2009) estimated the impact of public investment on growth in 14 European Union countries, Canada, Japan and the USA for the period 1960 to 2005. The outcome of this study was inconsistent across the countries under review. The states where public investment had little impact on private investment experienced low growth while on the other hand expansionary fiscal policy had a crowding-in effect, hence supporting growth. The intuition is that public investment triggers high tax levels or government borrowing from the capital market, which results in less savings and high interest rates, leading to a crowding-out effect on investments. Ndulu (2006) reminds us that growth in Africa has plummeted primarily as a result of vested interests. Therefore, given the crucial role of public investment, the author advises that African countries must strive for efficient institutions, improved infrastructure, and protection of property rights in order to attract investments. This justifies a detailed examination of government spending in economic sectors, with a view to advise on the strategies which are oriented to economic development.

The global share of the agricultural labour force has declined while the economic transformation has been at a snail's pace which is partly attributed to meagre capital accumulation (Fuglie & Rada, 2013). Fan Yu and Jitsuchon (2008) developed a growth model for the agricultural sector using the cross-sectional data of various provinces in Thailand for the period 1977 to1999. The model was designed to estimate the marginal effects of various components of government expenditure on agriculture growth and poverty reduction. Public spending in agricultural research and development, as well as on agricultural extension was used as proxy from agricultural R&D. The study highlights that investment in agricultural R&D, rural electricity, telecommunication and education substantially contributed to agricultural productivity growth with variations across provincial areas and spending categories. Equally, an analysis of China's Hundred Billion Plan (HBP) provides evidence of the positive causal relationship between public investment and agriculture productivity (He et al., 2019). The effectiveness of the HBP was mainly driven by increasing the use of fertiliser as an input by households and the crowding-in effect of public investment (He et al., 2019). India's growth in agricultural investment in agriculture-dependent and low-income states was associated with an uptick in income and decline in poverty levels (Bathla, 2014). The study used public gross capital formation in agriculture, private gross capital formation in agriculture, terms of trade and institutional credit as explanatory variables. Vertical integration in the agricultural value chain has spurred improvement in technology and alliances between farmer and the agro-processing industry for rapid growth in the agricultural sector (Bathla, 2014).

In the African context, the majority of the population are found in rural areas and their livelihoods rely on agriculture (Allen & Ulimwengu, 2015). Despite the critical role of the agricultural sector to the African economies, Ebenezer et al. (2019) noted that agricultural productivity has shown a downward trend owing to low levels of government investment in agriculture.

There is a range of literature that assesses the role of investment in agriculture across African countries and the outcome of a number of these studies confirms that there is a link between investment and agricultural growth. Therefore, the topic on investment in agriculture in the African context is relevant from the point of view of policy. A cross country analysis of sub-Saharan Africa by Allen and Ulimwengu (2015) conducted an analysis of the link between public expenditure and agricultural productivity using a production function model constructed using expenditure data over the period 1990 to 2002. The study concludes that public expenditure on health services had a positive impact on agriculture productivity in sub-Saharan

Africa. Gollin (2013) provides evidence that misallocations across sectors and even across firms explains the disparity in income levels across countries of sub-Saharan Africa. Bathla (2014) notes that Africa's growth is stagnant due to policy choices for agriculture and the overall economy. The author advises that development policies, and interventions should be aligned to the theory of the development process by pursuing agriculture-pro growth strategies. While these studies support the theory of growth and investment, this study relied on a limited number of countries for which the data was available, and it did not recognise the uniqueness and diversity of the agricultural and economic structures across sub-Saharan Africa. While investment at sub-sector levels captures heterogeneity at the sector level, different agricultural commodities may respond differently to investments.

A case study analysis of public spending on agricultural R&D in South Africa argues that investment in R&D presents an opportunity to build the capacity of the country to deal with the modern challenges facing the agricultural sector such as climate change and macroeconomic shocks (Chaminuka et al., 2018). A single country analysis by Wanjiku (2016) examines the growth impact of public expenditure at sectoral levels which included agriculture, defence, health, safety and transport in Kenya. The study explores the error correction model in the framework of the neoclassical growth theory and used real GDP data from 1980 to 2006. The results show that expenditure on health, education, agriculture and defence do not have a significant relationship with economic performance in the short and long-run. In this study, Wanjiku (2016) does not classify the components of expenditure under each of the sectors under review. For example, it is not clear whether the study used working or capital expenditure in agriculture and specific components of agriculture expenditure were not considered. Therefore, the type of data and model specification could be a reason for the insignificant role of public expenditure across all sectors considered. The implication of this study suggests using disaggregated data for an improved understanding of the dynamics of public investments.

A recent study by Ebener et al. (2019) endeavoures to assess the link between government expenditure in agriculture and agricultural productivity in South Africa using annual data for the period 1983 to 2016. They used the agriculture productivity index, derived from the output-input ratio as a dependent variable, while public spending in agriculture and urbanisation were used as explanatory variables. The results of the Autoregressive Distributed Lag (ARDL) bounds testing approach revealed that public finance in agriculture plays a significant role in improving agricultural productivity in South Africa and confirmed the presence of the co-integration between government expenditure on agriculture and agricultural productivity. The outcome of this study underlines the critical role of government funding of the agricultural sector in South Africa.

Nevondo et al. (2019) attempts to evaluate the impact of public investment on research and development in the beef industry which resulted in the genetic improvement and productivity of beef cattle in South Africa. The study employed time series financial data for the National Beef Scheme covering 44 years from 1970 to 2014 to construct a production function coupled with key econometric tests such as the normality test and heteroscedasticity serial correlation. The research expenditure comprised actual expenses of labour costs and benefits, administration and overhead expenditure. The study found a positive and significant impact from R&D on the performance of the South African beef industry. The study acknowledges that agricultural commodities may not be homogenous in respect of their responsiveness to investment. While this approach provides insights into the dynamics of public investment at a commodity level, the lack of reliable time data is a major obstacle for many researches. Benfica et al. (2019) notes that the provision of mentorship and training to smallholder farmers through public spending contributes to reduction in poverty levels across many regions in Mozambique, while public investment in irrigation infrastructures facilitated growth in agriculture in areas that are characterised by less favourable climatic conditions. Using the computable general equilibrium (CEG) model, Benifica et al. (2019) estimates the production function for crop commodities (cereals, horticulture, and root crops), using investment plan data on agriculture extension, input subsides and irrigation infrastructure in Mozambique. Similarly, Dhehibi et al. (2016) assesses the determinants of TFP for the agricultural sector in Egypt using agriculture production which is also disaggregated into crop and livestock output. Analysis of public expenditure at disaggregated level has an important bearing on public policy choices when undertaking public budget appropriation particularly for developing countries faced with budget constraints and Namibia, which is the unit of this study, is not exempt from these circumstances.

In the Namibian context, the public budget as per the agricultural investment plan does not record research and development as a separate budget item. The R&D investments are across all investment programs making it difficult to extract R&D spending from the expenditure budgets. The same applies to agricultural infrastructures such as irrigation and markets. In addition, while an analysis of the components of public agricultural investment may paint a different picture and need to be considered, public projects and programs are not homogenous across the study period of this paper. Projects are implemented for a specific period, while program objectives/activities have varied over time in line with the National Development Programs (NDPs). As a result, collecting disaggregated data on public spending in agriculture at project and program level proved difficult. Nonetheless, Namibia's agricultural sector is largely oriented towards primary agriculture, namely, crops and livestock production, in which projects and programs act in a complementary manner in providing services and inputs to the agricultural sector. Furthermore, Namibia's national account data on gross capital formation in agriculture does not distinguish between public and private capital, placing a limitation on using this variable as a proxy for public agricultural expenditure. The foregoing observations prompts this study to consider aggregate public agricultural development expenditure, as opposed to disaggregated data by programs and projects.

The study of Matthew and Mordecai (2016) uses analytical tools such as the Error Correction Model (ECM), the Augmented-Dickey-Fuller test, the co-integration test and the Granger Causality (GC) tests and established a long-run relationship between agricultural output and public agricultural expenditure, commercial bank loans and interest rates. However, the results of the ECM model indicate a significant negative impact of public expenditure while commercial bank loans and interest rates have an insignificant positive influence on agricultural output. The study did not distinguish between development and operational expenditure which might have distorted the estimates. Attari and Javed (2013) explore a similar econometric approach using data on development and operational expenditure. They conclude that operational expenditure did not have an influence on agricultural growth in Pakistan, while development capital yielded positive long-run growth outcomes, suggesting that this type of analysis needs to distinguish between operational and capital expenditure. Notably, the bulk of prior scientific work on the relationship between investment and growth barely reflects on development bank loans. Development bank loans play an important role in addressing the financing needs of the agricultural sector on the ground. The majority of farmers in developing countries are smallholders, who are faced with the challenges of accessing credit due to credit requirements by commercial banks which are not oriented to development impacts. This is one area of modification where this study explored development bank loans as a proxy for private investment which could contribute to the existing literature. Damoense-Azevedo (2013) constructed an Error Correction Model (ECM) to evaluate the long-run determinants of growth in Mauritius and confirms that domestic, public and private investments in agriculture have played a key role in economic growth. Using the total factor productivity growth approach, Rada (2016) confirms that India's rapid agricultural growth at the beginning of the twentieth century was the product of investment in technologies and, subsequently, the increase in the area under production permitted an increased area under irrigation. Anik et al. (2017) demonstrate that the total factor productivity growth in South Asia countries (Bangladesh, Pakistan, India and Nepal) for the period between 1980 and 2013 was largely driven by technology and land capital. Interestingly, financial capital was not instrumental to productivity growth in agriculture (Anik et al., 2017). Awunyo-Vitor and Sackey (2018) used the ECM to evaluate the relationship between foreign direct investment flow to the agricultural sector and economic growth. The study reveals that foreign direct investment has contributed to economic growth while the government expenditure showed negative results. Chandio et al. (2016) attempts to estimate the effect of agricultural public expenditure and agriculture output on overall economic growth in Pakistan. Their research work adopted the Ordinary Least Square (OLS) technique and econometric tests of stationarity and a long-run relationship using the Augmented Dickey-Fuller (ADF) unit root test and the Johansen co-integration test respectively, using time series data for the period 1983 to 2011.

Evaluating the effects of public expenditure and trade on agriculture productivity in China between 2004 and 2015, Gong (2018) provides evidence that public expenditure and trade has improved agricultural productivity. According to Gong (2018), a negative relationship between public investments and growth reflects administration corruption by the bureaucrats, crowding out of the private sector and rent-seeking behaviors. On the other hand, a positive relationship echoes the success of public investment in addressing market failure. Rada et al. (2019) provides empirical evidence that in Brazil technical assistance and education for individuals involved in production was positively associated with TFP, while access to credit was negatively correlated.

A range of econometric tools have been employed in the literature to explore the nexus investment in agriculture and growth, but very little is known for Namibia. These tools include the Computable General Equilibrium Model (CGE), the Least-Squares Dummy Variable (LSDV) regression, the Vector Autoregression (VAR) model, the Cobb-Douglas Production Function, the Error Correction Model (ECM), Ordinary Least-Squares (OLS) model and the Autoregressive Distributed Lag (ARDL) model. Many researchers used on annual time series spanning 30 to 40 years for a single country analysis. These are relatively small samples, hence deriving solid inferences might prove difficult, particularly in the case where the model designs are not suitable for short time series and where testing of model adequacy and robustness are not considered. For considerable length and breadth, the variation in analytical approaches is the major source of inconclusive debate on this topic. At the heart of this debate is the differences in the level of disaggregation of variables data, analytical framework, model specifications and structure. Pesaran et al. (2001) endeavors to resolve this modeling issue and proposes the bound testing approach, a procedure that has been empirically tested and proven relevant by the UK Treasury Macroeconomic model. The Pesaran, Shin and Smith (PSS) approach is tailor-made for a long-run level relationship between the dependent and exogenous variables. A unique feature of the PSS econometric technique is its asymptotic characteristic which makes provision for analysing the level relationships between dependent and independent variables, irrespective of the order of integration of the underlying explanatory variables. The sample period for this study is 20 years covering the period 2000 to 2019 using quarterly data. Therefore, the PSS is befitting for this paper which relies on quarterly data covering a period of 20 years.

The sensitiveness of the level of investments and resource endowment to political factors and institutional structures is one aspect that has been overlooked by many scholars. According to Rodríguez-Pose et al. (2012), the allocation, distribution and spending of public capital is largely influenced by political decisions and prevailing political regimes rather than economic fundamentals. Namibia is not exempt to this scenario; hence, yearly fluctuated spending across economic assets is evident. Between 2000 and 2019, public agricultural investment represented on average 6 percent of the annual agricultural GDP of the country. There have been considerable yearly fluctuations in the amount of public investment funds. Generally, public investment in agriculture was strongest in the second half of the period considered (2011–2019) owing to substantial investment in irrigation, water, and marketing infrastructures. Public investment peaked in 2015, reaching 19 percent of the agricultural GDP (NSA, 2019) and since then, the agriculture GDP growth has been in a negative territory without recovery. Despite public investment, it remains unclear whether such efforts have paid off in terms of economic returns. Hence, the main question to be answered in this paper is whether there is link between agriculture investments and agriculture growth. To do this, a dataset was used that allowed access to the extent and the direction of the relationship between investments and growth in agriculture at overall and sub-sector levels (crops and livestock sub-sectors sectors). The study's hypothesis is that investment in agriculture is expected to produce economic gains subject to further capital deepening in the sector. both in the short and long-run. Investment at sub-sector levels may vary in respect of the impact on outputs, which has an important bearing from a fiscal policy perspective.

2.4.Chapter summary

The existing literature provides a basis for analysing the growth effect of public investment. Literature has identified the following sources of agricultural growth: improved productivity and diversification, quality institutions, infrastructure development, technological change, and access to markets (Muzari, 2014). Meeting these requirements would be impossible without public and private investments. Against this backdrop, the agriculture GDP has been identified as a dependent variable, while agricultural public investments, agricultural private investment, average lending rates and agricultural exports are independent variables. The variables are discussed in the following sections. There is strong evidence of a link between agricultural investment and agricultural growth, complementing neoclassical and new growth theories. On a contrary, however, other researchers are less optimistic that public investment translates into economic gains and that investment in agriculture is a growth catalyst. Furthermore, literature has presented a compelling view that public investment alone cannot automatically lead to growth because investments are sensitive to political factors and the quality of institutions. With considerable length and breadth, the debate on this topic has resulted in diverse and intriguing findings. At the heart of this debate are the differences in model specifications, uniformity, availability, and choice of data, as well as the fact that countries have their own unique specific conditions.

With respect to data, differences in the level of disaggregation of investment data, proxies for investment capital, the frequency and time span of data are some of the major sources of contradictions in the literature on growth and investment. For example, analytical tools that relied on the value of economic output as a dependent variable which generated an insignificant or no impact on government expenditure on the overall economic or sectoral output. It is observed further that private investments and structural arrangements of the economies play a complementary role on returns to public investment. Differences in the structure of the agricultural sector, the level of economic development and category or disaggregation level of public investments suggests that measurement variables and model specification are not uniform across economies. This underscores the need for individual country analysis.

Scholars that attempted to estimate the relationship between investment and growth have explored co-integration tools such as VAR, ECM, OLS and ARDL. These tools have not been used without modeling limitations. One of the challenges is that these models, except for ARDL, are sensitive to the order of integration of series. Therefore, in this paper, the ARDL model developed by Pesaran et al. (2001) was adopted due to its exceptional feature of robust and efficient performance when dealing with small sizes of sample data. Furthermore, the Pesaran, Shin and Smith (PSS) approach does not require the series to be of the same order of integration. In Namibia's case, reliable data on public investments is only available from the late 1990s, which is not a surprise as Namibia only gained independence in 1990 and meaningful quarterly records for investments are only available from the year 2000. Given a considerable fiscal priority to the agricultural sector and based on the growth theories, this study's hypothesis is that public investments in agriculture matters for agriculture growth. Other factors such as interest rates, exports, and credit may have an impact on the performance of the sector, hence the need to integrate them in the model.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Introduction

This chapter discusses the research approach and analytical techniques explored in the study. It defines data and variables of interest, sketches the methodology used, the statistical tests and hypothesis testing with a view to meeting the study's objectives. Various research methods have been developed, adopted and adapted in the literature to examine the relationship between investment and agricultural output using time series data. These techniques include but are not limited to the following: panel regression models, the computable general equilibrium (CGE) model, the vector auto regression (VAR) model and the auto regressive distributional lag (ARDL) model. Supported by the literature reviewed in Chapter 2, this chapter is made up as follows: section 3.2 deals with the research approach and strategy, section 3.3 describes the data and variables, section 3.4 presents the model specifications, section 3.5 deals with the data analysis methods, section 3.6 outlines the research reliability and validity, section 3.7 highlights the limitations of the study and section 3.8 provides the chapter's summary.

3.2. Research approach and strategy

The methodology followed in this study is guided by a quantitative research approach, concentrating on causal comparative research on the link between variables and identifying the cause and effect relationships between the variables. According to Williams (2007), quantitative research requires numerical data and statistical analysis to answer the interactionary aspects of variables of interest. This study uses quarterly time series data converted in logarithms, covering the period from the first quarter of the year 2000 (1Q2000) to the last quarter of 2020 (1Q2020). The selection of the variables is informed by existing theories on investment and growth. Data is quantified and analysed using a systematic econometric procedure for time series. A stationarity test was conducted to ensure that the variance of the data was constant and normally distributed. The co-integration test was performed to establish if there was a long-run equilibrium relationship between variables, and the bound test served to determine the order of integration. These tests preceded the estimation of the long-run coefficient and error correction term. Post estimation tests were performed to guarantee the reliability and validity of the study's methodological approach. For preference and ease, the statistical package, Eviews, was selected to perform econometric analysis.

3.3. Model specification

In evaluating the investment in agriculture, this study developed an autoregressive distributed lag (ARDL) model. By design, the ARDLs are standard least squares regressions that account for lags of both the response variable and stimulus variables as regressors (Greene, 2008). According to Greene (2008) the ARDL model has been applied to study the relationship between economic variables in a single-equation time-series setup for many decades. ARDL became famous for its ability to account for the co-integration of nonstationary variables, which is seen as an equivalent to an error-correction (EC) process. The ARDL has reparameterisation in EC form (Engle and Granger, 1987; Hassler and Wolters, 2006). Of critical importance is that the existence of a long run co-integrating relationship can be tested using the existence of the EC component. Based on the argument of Pesaran et al. (2001), it is acknowledged that a built-in bound testing procedure allows for inference without knowledge of whether the variables are integrated of order zero or one, I (0) or I (1). Further indication from Pesaran et al. (1999) affirm that inference regarding the perceived estimation of long-run properties in a model are based on standard asymptotic normal theory. Further arguments point out that there are large volumes of alternatives that can allow the testing of the hypothesis of series that are integrated of orders 1 and order 0.

The advantage of the ARDL model is, it can analyse long-run relations when variables (y_t and X_t) are I (1), I (0) or integrated. In this study, an ARDL system of disaggregated agriculture public investments are estimated as independent variables together with private investment variables. The ARDL system for public investment comprises equations capturing performance of crops sub-sector production output and livestock sub-sector production. Thereafter, an aggregate model is developed to estimate the impact of overall public investment and private investments on agricultural output. This gives a sum of three (3) model equations. The equations are developed in such manner that response variables are expressed as a function of past changes and present truncation of the stimulus determinants and one-period-lag error correction term to capture the deviations from the long-run equilibrium. In this paper, the following ARDL (p, q) formation was considered:

$$y_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{p} \emptyset_i y_{t-1} + \beta' X_t + \sum_{i=0}^{q-1} \beta_i^{*\prime} \Delta X_{t-i} + \mu_t, \quad (1)$$

$$\Delta X_t = P_1 \Delta X_{t-1} + P_2 \Delta X_{t-2} + \cdots + P_s \Delta X_{t-s} + \varepsilon_t, \quad (2)$$

where X_t is the k-dimensional I (1) stimulus variables (for example, response and stimulus variables) that are not co-integrated, μ_t and ε_t are serially uncorrelated disturbances with zero means and constant variance-covariance. P_i are $k \times k$ coefficient matrices such that the vector autoregressive process in ΔX_t is stable. t = max (p, q), . . . ,T. For simplicity, assuming that the lag order q is the same for all variables in the $K \times 1$ vector x_t. Alternatively, let L denote the usual lag operator and define $\emptyset(L)$ and $\beta_j(L)$as the lag polynomials:

$$\emptyset_t = 1 - \sum_{i=1}^{p} \emptyset_i L^i and\ \beta_j(L) = 1 - \sum_{l_j}^{q} \beta_{j,l} L^{l_j}$$

Therefore, equation 1 can be expressed as:

$$\emptyset(L) y_t = \alpha_0 + \alpha_1 t + \sum_{j=1}^{k} \beta_j(L) x_{j,t} + \varepsilon_t \qquad (3)$$

The generic ARDL representation qualifies the assumption that the roots of $1 - \sum_{i=1}^{p} \emptyset_i z^i = 0$ fall outside the unit circle and there exists a stable unique long-run relationship between y_t (endogenous variables) and x_t. $\alpha_0, \alpha_1, \beta, \ldots\ \beta^*{}_1, \beta^*{}_{q-1}$ and $\emptyset = (\emptyset_1, \ldots, \emptyset_p)$ are parameters to be estimated. Thus, following this general formulation, three alternative clarifications can be made. While all three can be used for parameter estimation, the first is typically used for intertemporal dynamic estimation, the second for post-estimation derivation of the equilibrium. The third is a reduction of (equation 1) to the conditional error correction (CEC) representation in the Pesaran (2001) bounds test. The above three alternative representations are based on the Beveridge-Nelson decomposition representation. For conciseness, these alternative representations are not explained in this study. Thus, ARDL is preferred in this study as this study has a small sample period (Pesaran., et al., 1999) and to variables (y_t and X_t) are I (1) and I (0) order of integration.

3.4. Data and variable description

This study used a dataset from 1Q2000 to 1Q2020, translating into 81 observations. Various databases have been accessed to obtain all the data required for this study. The quarterly actual public investment data were obtained from the public ledger account system of the Ministry of Finance of Namibia and recorded as balances at the end of each quarter. In the Namibian context, public development expenditure is allocated at project and program levels on a quarterly and annual basis. Development loans and commercial credit data is sourced from the Agriculture Bank of Namibia and commercial banks, reflecting the outstanding loans (loan book at the end of each quarter). Quarterly averages of inflation and lending rates were obtained from Bank of Namibia (Central Bank). Finally, the quarterly sum of agriculture exports in terms of the Namibian Dollar was obtained from the Namibia Statistics Agency (NSA).

3.4.1. Agriculture output

Many studies have defined the concepts of agricultural output and agricultural production as income generated from agricultural output and notably are used interchangeably. These studies include those of Bathla (2014), Chandio et al. (2016), Benfica, et al. (2019), Ebenezer (2019) and Rada et al. (2020). Indicators of agricultural production/output found in the literature are the level and growth of the agricultural GDP and the total factor productivity (TFP). The above studies explored agricultural output as a dependent variable disaggregated into the agricultural sub-sector and, in some cases, commodities and investment indicators as independent variables. Existing literature is illustrative and the basis for this study was to consider agriculture output at a sub-sector level. In this study, agricultural output is measured in Namibian Dollar value to reflect the value of agricultural production, at an aggregate level and disaggregated level of the livestock sub-sector and crop and forestry sub-sector. The disaggregation of the dependent variables is aligned to the national accounts database.

3.4.2. Public investment

Public investment is a popular theme in the academic space owing to its relation to the level of income and economic growth (Easterly & Rebelo, 1993; Ghali, 2003; Qayyum & Salam, 2008; Benfica et al., 2019). For example, public agriculture infrastructures and R&D have stimulated agriculture growth and paved the way out of poverty in China (Fan & Zhang, 2002). Differences in agricultural output across African countries is largely attributed to the failure to provide an enabling investment climate and the provision of public goods (Wiggins, 2000). According to Singh and Sahni (1984), annual public spending is sensitive to seasonal and cyclical fluctuation, suggesting that data remain stable over time. In this paper, a different approach of using quarterly public spending data was adopted to account for potential shocks. Public investment variables used in the study are aggregate agriculture development expenditures (PAGIN), crop and forestry sub-sector development expenditure (CASP) and livestock sub-sector development expenditure (LASP). Based on the Keynesian theory and subsequent theoretical and empirical proponents, public investment was expected to have a significant and positive impact on agricultural output.

3.4.3. Commercial loan credit

In addition to public investments, private investors and farmers may seek credit to invest in their trades for which they expect to improve productivity and realise investment returns. Lack of affordable and innovative financial services such as credit limit the ability of farmers to adopt technology and innovation to diversify or enhance farm productivity (Allen and Ulimwengu (2015). Presumably, borrowed funds are invested in productive farm assets and farm to increase farm output (Nguyen and Trinh, 2018). Matthew and Mordecal (2016) and Chisasa (2015) have used commercial credit as a proxy for private investment to study the link between investment and agriculture output while Bathla (2014) explored private gross capital formation in agriculture (GCFA) which would have included capital acquired through loans as an independent variable. For purposes of this study, commercial credit extended to agriculture (CCEXT) is considered at an aggregate level based on publicly available data. Given the empirical evidence on the role of credit finance in agriculture, we expect the coefficient of commercial credit is significant and positive.

3.4.4. Development loan credit

The researcher noted that some of the activities undertaken by state-owned enterprises are associated with public spending. Competitive interest rates and loan conditions are distinguished features of the Agriculture Bank of Namibia (Agribank), a state-owned Development Finance Institution (DFI). Agribank is the only DFI that is responsible for agricultural lending in Namibia with an orientation to development impact when compared to commercial credit. The Development Bank of Namibia (DBN), on the other hand, carries a mandate for infrastructure and SMEs finance, excluding the agricultural sector. These DFIs are subsidised through annual fiscal allocation. However, these transfers are not captured in the agricultural development expenditures of the Ministry of Agriculture because these DFIs report directly to the Ministry of Finance. Prior empirical studies that explored the impact of agricultural investment suffer from the exclusion of private investments made through development loans. To correct this potential bias, this study considered development credit extended by Agribank to the agricultural sector (DCEXT) as an additional variable. It is assumed that the borrowed funds are used to invest in productive assets to generate income. Therefore, a positive contribution to agriculture output was expected, hence a statistically significant and positive coefficient.

3.4.5. Average lending rates

Investment through private equity and borrowed funds facilitates capital accumulation and the formation of new capital to increase productivity. The average lending rates are a variable of consideration as it reflects the cost of borrowing which has an impact on the income and profits of an agribusiness (Nguyen & Trinh, 2018). The amount that an investor can borrow is influenced by factors such as interest rates, hence the lower the interest rates, the higher the demand and repayment ability for loan credit. On the supply side, financial intermediaries/ banks supply to earn returns through interest margin, the difference between borrowing and lending rates. In this regard, the real average lending rate (RALR) is designated as an independent variable to control omitted variables, a common econometric problem. High lending rates reflect the increased cost of capital which could dampen prospects for business confidence, hence a negative and statistically significant contribution to agriculture output is expected.

3.4.6. Agriculture exports

Levine and Renelt (1992) introduced the trade variable (GDP/trade ratio) in a cross-country growth equation incorporating investment variables. As noted by Levine and Renelt (1992), neoclassical theorists, such as Adam Smith, posit that trade openness and access to markets serves to enhance productivity and specialisation of the private sector to the advantage of competitive markets. The extent to which the economy is open to trade has an impact on agricultural productivity and, subsequently, industrialisation (Diao et al., 2018). Based on prior studies, this study considers the value of agricultural export (AGEXP) as an additional independent variable which is expected to have a positive and statically significant contribution to the performance of agriculture output.

3.4.7. Inflation

Over the years, the Namibian agricultural sector experienced moderate inflation, increasing from 7.78% in 4Q2000 to 2.28% in 1Q2020, with slower increases in food items than inputs. A surge in inflation resulted in lower levels of profitability and reduced the purchasing power parity of agricultural products, thus a market risk. Similarly, input price inflation is responsible for cash flow problems, as well as debt accumulation for farmers. This double whammy has implications of weakening the competitive position of the agricultural sector. Therefore, in this study, the linkage between agricultural output and the inflation rate (LINFR) is imperative for analysis. The *apriori* expectation of the variables is summarised in the following table.

Table 1: Variables and their apriori expectations

Variable	**Expected impact**
Public investment in agricultural sector (PAGIN)	+
Public investment in the crop-sub-sector (PCAS)	+
Public investment in the livestock-sub-sector (PLAS)	+
Commercial credit extended to agriculture (CCEXT)	+
Development credit extended to agriculture (LDCEXT)	+
Agricultural export (AGEXP)	+
Real average lending rate (RALR)	-
Inflation rate (LINFR)	-

3.5.Data analysis method

3.5.1. Test for stationarity

A unit root test procedure was done using the Augmented Dickey Fuller test (ADF). The advantage of a unit root test is to identify the stationarity of the variables. By definition, stationarity implies that the variance and mean are assumed to be same over time.

The following representation shows the unit root test specification:

$$Y_t = \alpha + \rho Y_{it-1} + \varepsilon t_i \quad (4)$$

The parameters are as defined by Rodríguez-Pose et al. (2012), where ε is an error term or white-noise disturbance which is assumed to have constant variance and normally distributed around the mean. The autocorrelation function (ACF) and partial autocorrelation function (PACF) plays an important role in making a choice of the number of lags (*p*) to be included in the unit root test. Using the ACF and PACF graphical plots, the value of *p* depicts that the lags are assumed to be the number of lags at which the ACF cuts off or the number of lags of the PACF that are significantly different from zero. The general rule of thumb is that the calculated value of ACF sums up to one-third to one-quarter of the length of the time series. For example, Uko and Nkoro (2012) point out that the AR process is cognisant of the properties of the residual. From equation 4, ρ is the order of the autoregressive, α and Y_i representing intercept and the lagged variables, respectively. The testing of the unit root will test the following hypothesis:

- $H_0: \varphi_i = 0$, variables are not stationary over time
- $H_1: \varphi_i \neq 0$, variables are stationary over time

A general decision-making rule directs that values of $\varphi < 1$ at 5% level of significance, permits the rejection of the null hypothesis (of a unit root which imply that the time series of all the variables are stationary) and the implications are that the effects of external shocks would decay. Contrary, however, is that if the value of $\varphi > 1$, the null statement cannot rejected and that the shocks affect growth over time. In an event that the null statement cannot be rejected, the recommendations are the differencing of the series to estimate the optimal lag structure. Doing so requires that the Akaike Information Criterion (AIC) be instrumental in guiding the choice of the optimal lag length (He et al., 2019).

3.5.2. Determination of the existence of the long-run relationship of the variables

At the first stage, the existence of the long-run relationship between the variables under investigation was tested by computing the Bound F-statistic (bound test for co-integration) in order to establish a long-run relationship among the variables. This bound F-statistic was carried out on each of the variables as they stand as endogenous variables while others are assumed as exogenous variables. In practice, testing the relationship between the forcing variable(s) in the ARDL model leads to hypothesis testing of the long-run relationship among the underlying variables. In doing this, current values of the underlying variable(s) are excluded from the ARDL model approach to co-integration. For each application, there is a band covering all the possible classifications of the variables into I(0) and I(1). However, according to Narayan (2005), the existing critical values in Pesaran et al. (2001) cannot be applied for small sample sizes as they are based on large sample sizes. Hence, Narayan (2005) provides a set of critical values for small sample sizes, ranging from 30 to 80 observations. The critical values are 2.496 - 3.346, 2.962 – 3.910, and 4.068 – 5.250 at 90%, 95%, and 99%, respectively. In summary, if a long-run relationship exists between the underlying variables, while the hypothesis of no long-run relations between the variables in the other equations cannot be rejected, then ARDL approach to co-integration can be applied. The issue of finding the appropriate lag length for each of the underlying variables in the ARDL model is very important because of the need to have Gaussian error terms (i.e., standard normal error terms that do not suffer from non-normality, autocorrelation, heteroscedasticity, etc.). In order to select the appropriate model of the long-run underlying equation, it is necessary to determine the optimum lag length (k) by using proper model order selection criteria such as the Akaike Information Criterion (AIC), the Schwarz Bayesian Criterion (SBC) or the Hannan-Quinn Criterion (HQC).

3.5.3. Empirical model representation

The empirical model for this study is represented in the following 3 equations:

1. Agricultural output model: (5)

$$\Delta LAGOUT_t = \alpha + \sum_{i=1}^{n} \beta\, \Delta LAGOUT_{t-1} + \sum_{i=1}^{n} \delta\, \Delta LAGEXP_{t-t} + \sum_{i=1}^{n} \delta\, \Delta LCCEXT_{t-t} + \sum_{i=1}^{n} \theta\, \Delta LDCEXT_{t-1} + \sum_{i=1}^{n} \gamma\, \Delta LPAGIN_{t-1} \sum_{i=1}^{n} \varphi\, \Delta LINFR_{t-1} + \sum_{i=1}^{n} \omega\, \Delta LRALR_{t-1} + \beta_i LAGOUT_{t-t} + \delta_i LCCEXT_{t-t} + \theta_{t-i} LDCEXT_{t-1} + \gamma_{t-i} LPAGIN_{t-1} + \varphi_{t-i} LINFR_{t-1} + \omega_{t-i} LRALR_{t-1} + \tau_i ECT_{t-1} + \varepsilon_t$$

2. Crop sub-sector output model: (6)

$$\Delta LAGCSSO_t = \alpha + \sum_{i=1}^{n} \beta\, \Delta LAGCSSO_{t-1} + \sum_{i=1}^{n} \vartheta\, \Delta LAGEXP_{t-t} + \sum_{i=1}^{n} \delta\, \Delta LCCEXT_{t-t} + \sum_{i=1}^{n} \theta\, \Delta LDCEXT_{t-1} + \sum_{i=1}^{n} \gamma\, \Delta LLCASP_{t-1} \sum_{i=1}^{n} \varphi\, \Delta LINFR_{t-1} + \sum_{i=1}^{n} \omega\, \Delta LRALR_{t-1} + \beta_i LAGCSSO_{t-t} + \delta_i LCCEXT_{t-t} + \vartheta_I LAGEXP_{t-1} + \theta_{t-i} LDCEXT_{t-1} + \gamma_{t-i} LLCASP_{t-1} + \varphi_{t-i} LINFR_{t-1} + \omega_{t-i} LRALR_{t-1} + \tau_i ECT_{t-1} + \varepsilon_t$$

3. Livestock sub-sector output model: (7)

$$\Delta LALSSO_t = \alpha + \sum_{i=1}^{n} \beta \, \Delta LALSSO_{t-1} + \sum_{i=1}^{n} \vartheta \, \Delta LAGEXP_{t-t} + \sum_{i=1}^{n} \delta \, \Delta LCCEXT_{t-t}$$
$$+ \sum_{i=1}^{n} \theta \, \Delta LDCEXT_{t-1} + \sum_{i=1}^{n} \gamma \, \Delta LLPASP_{t-1} \sum_{i=1}^{n} \varphi \, \Delta LINFR_{t-1}$$
$$+ \sum_{i=1}^{n} \omega \, \Delta LRALR_{t-1} + \beta_i LAGCSSO_{t-t} + \delta_i LCCEXT_{t-t} + \vartheta_I LAGEXP_{t-1}$$
$$+ \theta_{t-i} LDCEXT_{t-1} + \gamma_{t-i} LLPASP_{t-1} + \varphi_{t-i} LINFR_{t-1} + \omega_{t-i} LRALR_{t-1}$$
$$+ \tau ECT_{t-1} + \varepsilon_t$$

In the equations above, Δ is the difference operator and variables are as defined earlier. The parameters, β, ϑ, δ, θ, γ, φ, ω, and τ are to be estimated. While ECT_{t-1} is the error correction term defined as earlier. This ECT is obtained from the long-run relationship. This requires estimating a Vector Error Correction Model (VECM) replication of equation 5, 6 and 7. Equations 5 to 7 are the empirical models estimated in this study.

3.5.4. The Engle-Granger two-step method

Borrowing from Damoense-Azevedo, (2013), Ghali (2003), Singh and Sahni (1984), and Cullison (1989), the next step of the statistical analysis is the Granger Causality test to validate the causative track of agricultural investment and agricultural GDP growth (Rodríguez-Pose, Psycharis & Tselios, 2012). In particular, the Granger Causality test will be considered if the model outcome demonstrates a positive and significant relationship.

$Y_t = b_0 + \rho_0 X_t + \sum_{i=1}^{m} \rho_i X_{t-i} + \sum_{i=1} b_i Y_{t-i} + \mu_t$ (long-run analysis) (8)

$X_t = \gamma_0 + \omega_0 Y_t + \sum_{i=1}^{m} \delta_i X_{t-i} + \sum_{i=1} \omega_i Y_{t-i} + \varepsilon_t$ (short term analysis (9)

The equations (8) and (9) represent the Granger Causal Model which is generally estimated by the OLS (Singh & Sahni, 1984). From the estimated results, if $\rho_0 = \omega_i$ but $\rho_i \neq 0$, it would imply that investments cause agriculture growth. However, if $\omega_0 = \rho_i$ but $\omega_i \neq 0$, it would imply that agricultural growth leads to investments. Lastly, the study concludes with diagnostic or post estimation tests to validate the robustness of the results. As seen in Attari & Javed (2013), these tests are the Breusch-Pagan to test for heteroskedasticity, the Breusch-Godfrey test to test if the errors are normally distributed, as well as the Durbin-Watson test for the autocorrelation of the errors from the estimated models.

3.6. Research Reliability and Validity

This study is designed in such manner that it addresses the problem statement defined in Chapter 1. Furthermore, by reviewing the literature described in Chapter 2 in order to test the hypotheses formulated in Chapter 1. The methodological approach is explained in Chapter 3 to illustrate the econometric analysis applied on secondary quarterly data that is transformed into logarithm. However, in order to perform the econometric analysis, a series of procedures, such as testing for stationarity and co-integration of dependent and independent variables, are performed to account for the statistical requirement of obtaining robust results. Furthermore, the study carried out post-estimation tests (normality test, Breusch-Pagan LM serial correlation test and Ramsey RESET test) that demonstrated the reliability and validity of the model.

For brevity, only the definitions of the three diagnostic tests were performed on the residuals of three models for spuriousness (Gujarati, 2004). The Jarque-Bera (JB) test is a goodness-of-fit test of whether sample data have the skewness and kurtosis matching a normal distribution. Furthermore, Gujarati (2004) states that if the data comes from a normal distribution, the JB statistic asymptotically has a chi-squared distribution with two degrees of freedom, so the statistic can be used to test the hypothesis that the data are from a normal distribution (Greene, 2008). The null hypothesis is a joint hypothesis of the skewness being zero and the excess kurtosis being zero (Greene, 2008; Gujarati, 2004). In addition, Greene (2008) and Gujarati (2004) indicate that samples from a normal distribution have an expected skewness of 0 and an expected excess kurtosis of 0. The definition of JB shows any deviation from this increases the JB statistic.

The Breusch-Godfrey is a test for autocorrelation in the errors in a regression model (Greene, 2008; Gujarati, 2004). It makes use of the residuals from the model being considered in a regression analysis, and a test statistic is derived from these. The null hypothesis is that there is no serial correlation of any order up to p (Greene, 2008). A similar assessment can be also carried out with the Durbin-Watson test and the Ljung-Box test. However, the test is more general than that using the Durbin-Watson, which is only valid for non-stochastic regressors and for testing the possibility of a first-order autoregressive model for regression errors. Greene (2008) and Gujarati, (2004) indicate that the B-G test has none of these restrictions and is statistically more powerful than Durbin's h statistic.

The Ramsey Regression Equation Specification Error Test (RESET) test is a general specification test for validating the linear regression model. More importantly, it tests whether non-linear combinations of the fitted values help explain the dependent variable. Greene (2008) states that the intuition is that if non-linear combinations of the explanatory variables have any power in explaining the response variable, the model is misspecified in the sense that the data generating process (DGP) might be better approximated by another non-linear functional form. The results and discussion of the study are presented in Chapter 4.

3.7. Assumptions and Limitations of the Study

The available data provided by the Ministry of Finance did not capture the regional spread of agriculture investments. Addressing this constraint, the scholar assumed that a large proportion of public spending has been directed to communal areas where the majority of farmers are smallholders. An attempt to disaggregate private investment at program and project levels proved impractical in the context of Namibian data. Public agricultural investment at program and project levels is not consistently tracked in the database owing to variations in the expenditure components and objectives every five years when the National Development programs are revised. Statistics on Official Development Assistance (ODA) as a category of investment that is specific to the agricultural sector could not be obtained on a consistent and annual basis over the sample period. Similarly, records for domestic direct investments which are specific to the agricultural sector could not be traced. For this reason, domestic private equity investments and foreign direct investments are excluded from the analysis. Nonetheless, the researcher assumes that credit finance is a compelling representation of private investment in Namibian agriculture.

3.8. Chapter Summary

This chapter outlined the methodological approaches adopted to answer the research objectives and hypothesis of the study. The study applies the proposed theory to investment in agricultural quarterly data and estimates the significance impact of these investment on agriculture. The empirical study uses three models on quarterly aggregate agricultural output, crop and livestock sub-sector output augmented on the exogenous variable such as public investment in agriculture, development credit extension to agriculture, commercial credit extension to agriculture, agricultural export, the national average lending rate, and the rate of inflation. The hypothesis of the study was tested by using the ARDL bounds test of co-integration methodology. The proposed approach was applied successfully to the Namibian context to account for variables that are integrated of order zero and one. Post estimation procedures to validate the robustness of the model results were based on the Pesaran, Shin and Smith (2001) bounds test. For more perspective, many time series variables were stationary only after differencing. Hence, using differenced variables for regressions implies the loss of relevant long-run properties or information of the equilibrium relationship between the variables under consideration. This means that there is a need to devise a way of retaining the relevant long-run information of the variables. Therefore, co-integration makes it possible to retrieve the relevant long-run information of the relationship between the considered variables that had been lost on differencing. That is, it integrates short run dynamics with long-run equilibrium. It must be noted that co-integration is the preferred step for modelling empirically meaningful relationships of the deterministic stationary process. More emphatically, co-integration is concerned with the analysis of long-run relations between integrated variables and reparametrising the relationship between the considered variables into an Error Correction Model. Under the conventional Granger (1981) and Engle and Granger (1987) co-integration analysis is not applicable in cases of variables that are integrated of different orders (i.e. variable series-A is I(1) and variable series-B is I(0)) while in the Johansen and Juselius (1990), and ARDL co-integration procedure it is applicable. It is highlighted in this chapter that the ARDL co-integration technique was used in determining the long-run relationship between series with different orders of integration. The reparametrised result gives the short-run dynamics and long-run relationship of the considered variables. Therefore, the ARDL co-integration technique was adopted in this study. The results obtained from the methodological procedure (i) unit root results, (ii) lag length determination, ARDL co-integration long run based on the bounds test, (iii) error correction model results and Granger Causality/ Exogeneity test results in this chapter are presented and discussed in Chapter 4.

CHAPTER 4: RESULTS AND DISCUSSION

4.1.Introduction

This chapter presents the model results of the study. The results are based on the model derivation and empirical representation discussed in Chapter 3. The chapter is outlined as follows: the data behaviour is presented first to identify any potential challenges to the validity of the estimation procedure. Then the stationarity test results are presented to determine whether the variables exhibit unit root processes using the ADF approach. Thereafter, the results of determining the lag length structure using the information criterion is explained. This precedes the results of the ARDL long-run co-integration estimation which follows provision of the Pesaran, Shin and Smith (2001) bounds test. The bound test is employed to either reject or accept the null hypothesis of the long-run relationship using the critical values of the bands in the bounds test. Confirming

existence of a long-run equilibrium, then requires error correction results. Thus, EC_t is used to account for disequilibrium and how such disequilibrium is corrected from previous periods. To conclude, the estimation procedure and the Granger Causality /Block Exogeneity test results are presented. Finally, post-estimation tests and graphical presentations are presented to offer conclusive remarks on the model performance.

4.2. Results of the descriptive statistics

The starting point for analysis is to understand the nature or property of the time series. In general, the dependent variables represented by agricultural production (LAGOUT) showed an upward trend, while the independent variables such as public investments (LAPAGIN), corporate credit extension (LCCEXT), development credit extension (LDCEXT), cumulative crop investment spending (LCASP) and livestock cumulative investment spending (LLASP) were volatile over the period of study. The primary agricultural sector comprised of outputs from the crop sub-sector (LAGCSSO) and livestock production (LALSSO). Table 2 provides a summary of the variables. Kurtosis numbers are less than -1, indicating that the distribution of the data is too flat. Similarly, the skewness values confirm the nature of the skewed distribution of the data. Therefore, a distribution exhibiting skewness and kurtosis that are considered non normal. The data should be normalised. This procedure was followed in the estimation of the model in the study by generating new values (taking the individual value minus the mean and dividing it by the standard deviation). The number of observations (n) is 81 and has eight (8) independent variables.

Table 2: Summary of descriptive statistics

Variables	Mean	Std. Error	Std. Dev.	Kurtosis	Skewness	Range	Minimum	Maximum	Number of Obs. (N)
LAGOUT	9.200	7.692	8.646	-0.338	0.049	9.296	8.873	9.435	81
LAGCSSO	8.823	7.315	8.269	-0.338	0.049	8.919	8.496	9.058	81
LALSSO	8.964	7.455	8.410	-0.338	0.049	9.059	8.637	9.198	81
LPAGIN	9.566	8.643	9.598	-0.820	0.864	10.068	7.991	10.071	81
LCCEXT	9.308	8.231	9.185	-1.041	0.603	9.717	0.000	9.717	81
LDCEXT	9.193	7.909	8.864	-0.940	0.469	9.395	8.728	9.480	81
LAGEXP	9.110	7.836	8.791	-0.760	-0.028	9.398	8.212	9.425	81
LINFR	0.794	-0.530	0.424	-0.164	0.606	1.086	0.134	1.132	81
LCASP	8.823	7.315	8.269	-0.338	0.049	8.919	8.496	9.058	81
LLASP	8.964	7.455	8.410	-0.338	0.049	9.059	8.637	9.198	81
LRALR	0.666	-0.646	0.308	-0.908	0.098	0.913	-0.038	0.959	81

Note: The variables are defined in Chapter 3. In order to increase the adequacy of the econometric model, the variables were taken in a logarithmic manner. The descriptive statistics were also presented for logarithmic values.

Despite having the least fiscal spending, the livestock sub-sector accounted for a larger share of the total agricultural sector output, followed by the crop sub-sector. Cumulative public investment for crop improvement largely focused on the development of green scheme irrigation projects, the National Horticulture Development Initiative and the National Strategic Grain Reserves. The objective of these programs is to promote the local production of horticulture thereby reducing the country’s dependence on imports and improving national food security. The direction of cumulative government spending on the livestock sub-sector has been towards improving animal health and livestock marketing facilities. The trend analysis shows that the agricultural output and investment variables have been tracking an upward path, with some seasonal fluctuations. This suggests that the mean and variance are time variant, giving an impetus for pre-estimation tests and relevant procedures to guard against inherent econometric limitations such as spurious regression.

4.3. Results of the unit root testing

Table 3 below presents the results that justifies the order of integration and shows that the data series for agricultural exports (LAGEXP), the rate of inflation (LINFR) and cumulative investment spending on livestock (LLASP) are integrated of the zero order (thus implying that the level is stationary (I(0)), while the rest of the variables are integrated of the order one (I(1)). This statement means that the variables are stationary at the first differencing level. Therefore, the null statement is rejected at the level of significant of 5%. The conclusion is, therefore, that all variables except agricultural exports and rate of inflation are stationary at their first difference series. The inference is in affirmation with Pesaran et al. (2001), hence there is a minimal risk of running a spurious regression.

Table 3: A summary on testing for Unit root results based on Augmented Dickey-Fuller

Variables	**In Levels**		**First difference**		**Order of co-integration**
	ADF *t-statistics*	*p-value*	ADF *t-statistics*	*p-value*	
LAGOUT	-1.9826	0.2938	-4.57036	0.0004	I(1)
LAGCSSO	-1.9826	0.2938	-4.57036	0.0004	I(1)
LALSSO	-1.9826	0.2938	-4.57036	0.0004	I(1)
LAGEXP	-3.3945	0.0141	-11.2254	0.0001	I(0)*
LCCEXT	-0.6745	0.8462	-7.0837	0.0000	I(1)
LDCEXT	-1.4051	0.5758	-9.4624	0.0000	I(1)
LPAGIN	-0.5824	0.8673	-2.8434	0.0573	I(1)
LINFR	-3.0849	0.0318	-6.2682	0.0000	I(0)*
LCASP	-2.3085	0.1719	-12.5389	0.0001	I(1)
LLASP	-7.7687	0.0000	-10.2168	0.0000	I(0)*
LRALR	-2.4439	0.1334	-3.4834	0.0114	I(1)

Note: * denotes that the variables are integrated of order zero I(0) while other variables are of order one, I(1) and this satisfies the evoking of ARDL bounds test.

According to Gujarati (2003), if the calculated absolute value of *t*-statistic is more than the critical t-statistic value, traditionally, the null hypothesis is rejected (that is ∫ = 0), in that it is assumed that the time series data is stationary. In opposition, if the calculated t-value is below critical t-value, the null statement is not rejected and thus, the conclusion is then that the time series is non-stationary (Gujarati, 2003). Therefore, for the data series under consideration, the models for the four equations follow an integrating order of I (1) process. It, therefore, follows that the selected data series can be used for time series modelling subject to the selection of an appropriate lag length.

4.4. Explanation of the determining the lag-length results using the AIC

Table 4 shows that four tests are used to determine the appropriate length of the lag of the model. The AIC and HQ confirms that the model should have eight lags, for quarterly data, while the LR and SC indicates that the appropriate lags should be four and one, respectively. The two most used criteria are the Akaike Information Criterion (AIC) and the Schwartz/Bayesian Information Criterion (SBIC). As described in Chapter 3, section 3.3, the AIC was chosen because it offered the model more parsimony and robust results and accounts for well-behaved coefficients, which permits considerable flexibility in the shapes of the lag distributions. It is equally important to note that lengthening the lags in the ARDL model can eliminate serial correlation in the error term. For quarterly data, eight lag periods are equivalent to two full years in annual data and this is appropriate time lag for agriculture output analysis owing to the time lag between investment and actual gains and the length of the production cycle of agriculture activities. The argument is that the 'main ingredient' in both information criteria is the ability to minimise the sum of squared residuals. Thus, principle to choose the model and the criterion that yields the smallest AIC value.

Table 4: A summary of the results on determining lag length

Lag order	LogL	LR**	AIC**	SC**	HQ**
0	-248.5752	NA	7.029459	7.280468	7.129490
1	252.0699	877.8435	-4.933422	-2.674338*	-4.033138
2	336.9585	130.2401	-5.505713	-1.238555	-3.805177
3	391.6277	71.89368	-5.250073	1.025158	-2.749285
4	482.0003	99.03849*	-5.972611	2.310695	-2.671570
5	560.6603	68.96220	-6.374255	3.917125	-2.272962
6	667.7491	70.41453	-7.554769	4.744685	-2.653224
7	839.5633	75.31585	-10.50858	3.798943	-4.806788
8	1194.936	77.88990	-18.49140*	-2.175797	-11.98935*

Note: ** denotes, LR sequential modified LR test statistic (each test at 5% level), AIC for Akaike information criterion, SC for Schwarz information criterion and HQ for Hannan-Quinn information criterion

After determining the appropriate lag length, the empirical analysis process follows by establishing if agricultural output, agricultural export, corporate credit extension, development credit extension, public investment, cumulative spending on crop sub-sector, lending rate and inflations are co-integrated. The results of the bounds test for long-run co-integration are based on the procedure explained in Chapter 3 are presented in the next section.

4.5. Explanation of the ARDL bounds test for long-run co-integration

From Table 5, it was deduced that when the regression is normalised on agricultural output (LAGOUT), the calculated F-statistics 24.2019 is more than the upper bound critical value 4.15 at 1 percent level. Thus, the null hypothesis of no co-integration is rejected, implying the existence of long-run co-integration relationships amongst the variables when regressions are normalised on agricultural output. A similar conclusion is drawn for the crop-sub sector (17.3313) and livestock sub-sector (28.3333) with calculated F-statistics greater than the respective F-critical values at 1 percent. Thus, the null hypothesis of $\alpha = \beta = \vartheta = \delta = \theta = \gamma = \varphi = \omega = 0$. This is argued against the alternative (that at least one of them is not equal to zero). For example, Narayan (2005) points out that the model calculated F-statistics should be compared with critical value. An inference is made if the calculated F-value is more that critical value, then the null hypothesis is rejected at the 1% level of significance. The rejection would then imply that there exists no relationship response variable and stimulus variable in the long run. It is often argued that if the null hypothesis is rejected at the 1% level of significance, then there is a possibility that further rejection will occur at levels 5 % and 10%, respectively.

Table 5: A summary of the ARDL Long Run Form and Bounds Test

Model equations	**F-statistics**	**Critical value**	**Bound I(0)**	**Bound I(1)**	**Conclusion**
1. Aggregate agriculture production output	24.2019	10%	2.08	3	Long-run relationship exists
		5%	2.38	3.38	
		2.5%	2.7	3.73	
		1%	3.06	4.15	
2. Crop sub-sector output	17.3313	10%	2.08	3	Long-run relationship exists
		5%	2.38	3.38	
		2.5%	2.7	3.73	
		1%	3.06	4.15	
3. Livestock sub-sector output	28.3333	10%	2.08	3	Long-run relationship exists
		5%	2.38	3.38	
		2.5%	2.7	3.73	
		1%	3.06	4.15	

Note: Asymptotic critical bounds are obtained for the unrestricted intercept and no trend for k=3 (Pesaran, *et al*, 2001).

Following the establishment of the long-run relation co-integration relationship, an equation 5 to 7 was estimated. The results are obtained by normalising on agricultural output, crop sub-sector and livestock sub-sector output and we present the long run results in table 4, 5 and 6, respectively.

4.5.1. The long-run estimates for agricultural output

From Table 6, the long-run coefficient of LAGOUT (-1) is -2.158 and significant at 5%, implying that previous levels of agricultural output have significant and negative impact of 2.15% on the current agricultural output in a long-run. The estimated coefficients of the long-run relationship show that corporate credit to agriculture (LCCEXT) and inflation (LINFR) are -16.30 and -1.17, hence both have a significant negative effect on agricultural output. The result implies that the past trend of corporate credit extension and inflation had an adverse impact of 16% and 1.17% on the current agricultural output, leading to disequilibrium in the long run. This is consistent with the theory on agricultural investment and productivity such as the findings of Zepeda (2001), Gong (2018) and Bizikova (2016). In the Namibian context, these findings could suggest that commercial credit is characterized by high lending rates implying that investments are high and costly in agricultural production and that output from agriculture is not instantaneous, while at the same time, the loan terms are not aligned with the uniqueness of the agricultural production environment such as the production cycle and climatic risks. High inflation rates erode the profitability gains for agricultural producers and there is a risk that corporate gains are less than the earnings when actual services are delivered. However, the impact of development credit extension (LDCEXT) and public investment on agriculture (LPAGIN) has a positive value of 4.17 and is statistically significant at 5%. This is attributable to the long-term view of development finance and public investment that is focused on addressing societal needs and food security (Zepeda, 2001). The short-run coefficients present different dynamics and mixed results that drift from the long-run equilibrium. For example, the real lending rate in the short run leads to drifts away from the long-run equilibrium. Similarly, development credit extension (D(LDCEXT) yields negative and significant coefficients in periods 3, 4, 5 and 7, implying that agricultural output in the short run will drift away from the long-run equilibrium for every development credit extension. This is true because agricultural investment responds positively in the long term rather than in the short term (Mogues, Yu, Fan & McBride, 2012; Zepeda, 2001).

Table 6: A summary of results for agricultural output estimated Long-run coefficients using the ARDL bounds test approach

Dependent variable is LAGOUT				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	1.672951	0.611384	2.736334	0.0127
LAGOUT(-1)*	-2.158971	0.391131	-5.519820	0.0000*
LCCEXT(-1)	-16.30292	6.219815	-2.621126	0.0164*
LINFR(-1)	-1.166294	0.295279	-3.949808	0.0008*
LPAGIN(-1)	4.170542	1.651615	2.525129	0.0201*
D(LAGOUT(-1))	0.717042	0.305717	2.345447	0.0294*
D(LAGOUT(-2))	0.558119	0.160303	3.481645	0.0024*
D(LAGEXP(-4))	-0.988360	0.475882	-2.076903	0.0509*
D(LAGEXP(-5))	-0.939171	0.432268	-2.172659	0.0420*
D(LCCEXT(-1))	17.53224	6.364651	2.754627	0.0122*
D(LCCEXT(-2))	16.40575	5.675953	2.890395	0.0090*
D(LCCEXT(-3))	12.46972	5.506605	2.264502	0.0348*
D(LDCEXT(-3))	-4.292751	1.725742	-2.487481	0.0218*
D(LDCEXT(-4))	-4.564655	1.848082	-2.469941	0.0226*
D(LDCEXT(-5))	-3.993671	1.560028	-2.560000	0.0187*
D(LDCEXT(-7))	-4.261244	1.421544	-2.997618	0.0071*
D(LPAGIN(-3))	10.11090	3.951131	2.558988	0.0187*
D(LPAGIN(-6))	7.180976	3.482034	2.062294	0.0524*
D(LRALR(-5))	-0.629493	0.331174	-1.900794	0.0718**

Note: Only significant variables are reported in the table, where * and ** denotes significant coefficients at 5% and 10% level, respectively. D denotes the difference operator for short-run effect on equilibrium or they relate to the short-run dynamics of the model's convergence to equilibrium.

4.5.2. The long-run estimates for crop sub-sector output

Table 7 presents a summary of results of estimated coefficients for the crop sub-sector output. The estimated coefficients of the long-run relationship show that agricultural export (LAGEXP) and cumulative crop credit to crop sub-sector have a positive impact on the current crop output. However, in the short run, agricultural export D(LAGEXP(-1)) yields a negative and significant parameter. This means that in the short run exports drift away from the long-run equilibrium. Meanwhile, development credit extension to crop production (LDCEXT) and inflation (LINFR) have a significantly negative impact on crop output. The result implies that the past trend of development credit extension and inflation had an adverse impact on the current crop output. The cumulative public investment on the crop sub-sector (LCASP) in the long run is positive and significant. While in the short run, the coefficient of D(LCASP(-1)) yields a negative sign. As expected, investment in the crop sub-sector requires long-term projection. The reason for this is that investments are high and costly in crop production but output is influenced by other factors such drought, pest outbreaks and high input costs, thus the crop output does not quickly respond to development credit advances (Mogues, Yu, Fan & McBride, 2012; Zepeda, 2001).

Table 7: A summary of the Crop sub-sector long-run coefficients based on equation 5

Dependent variable: LAGCSSO				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	1.229322	0.287986	4.268693	0.0001
LAGCSSO(-1)*	-1.645694	0.204508	-8.047069	0.0000*
LAGEXP(-1)	0.710574	0.299254	2.374490	0.0222*
LDCEXT(-1)	-1.207045	0.635697	-1.898775	0.0645**
LINFR(-1)	-1.333370	0.203942	-6.537993	0.0000*
LCASP(-1)	0.490102	0.170390	2.876354	0.0063*
D(LAGCSSO(-1))	0.398434	0.179692	2.217316	0.0321*
D(LAGCSSO(-2))	0.445564	0.110333	4.038369	0.0002*
D(LAGEXP(-1))	-0.585162	0.193316	-3.026970	0.0042*
D(LDCEXT(-2))	-2.408807	1.139503	-2.113910	0.0405*
D(LDCEXT(-3))	-3.679149	1.085407	-3.389650	0.0015*
D(LDCEXT(-4))	-4.281420	1.119320	-3.825017	0.0004*
D(LDCEXT(-5))	-4.125969	1.106222	-3.729785	0.0006*
D(LDCEXT(-6))	-2.400087	1.159032	-2.070769	0.0446*
D(LDCEXT(-7))	-3.178779	1.079283	-2.945269	0.0052*
D(LINFR(-1))	0.856645	0.241636	3.545189	0.0010*
D(LCASP(-1))	-0.266977	0.090699	-2.943557	0.0053*
D(LRALR(-2))	-0.377709	0.208778	-1.809141	0.0776**
D(LRALR(-3))	-0.611743	0.172567	-3.544966	0.0010*
D(LRALR(-5))	-0.414677	0.161727	-2.564049	0.0140*

Note: Only significant variables are reported in the table, where * and ** denotes significant coefficients are 5% and 10% level, respectively. D denotes the difference operator for short-run effect on equilibrium or they relate to the short-run dynamics of the model's convergence to equilibrium.

4.5.3. The long-run estimates for livestock sub-sector output

Table 8 provides a summary of the estimated coefficients of the long-run relationship. The same table shows that cumulative public investment spending on livestock lagged one period (LLASP(-1)) yields a positive and significant value. This means that a one percent increase in cumulative investment in livestock production activities in the long run will lead to an increase of about 0.435 percent in livestock sub-sector output, holding other factors constant. While the rate of inflation lagged one period (LINFR(-1)) and the real average lending rate lagged one period (LRALR(-1)), this had a negative and significant impact on the livestock sub-sector output in the long run. The result implies that the past trend of cumulative investment on the livestock sub-sector is likely to improve performance of the sub-sector, while inflation and the real lending rate have an adverse impact on the current livestock output. Similarly, this can be noted in the difference operator coefficients for the short run. The argument is that investment requirements are high and costly in livestock production, at the same time output from the sector is influenced by other factors such as drought, livestock disease outbreaks and high input costs (Mogues, Yu, Fan & McBride, 2012; Zepeda, 2001). Thus, the livestock output is not instantaneous to development credit advancement, or cumulative spending on livestock in the short run. Recovery from drought or disease outbreaks for herds requires at least s 2.5 to 3-year production period. Modest to high inflation rates erode the profitability gains for livestock producers. It can, therefore, be argued that both fiscal and monetary policy matter for the Namibian agricultural sector.

Table 8: A summary of the Long-run coefficients based on equation 6

Dependent variable: LALSSO				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Constant	1.473130	0.315478	4.669514	0.0001
LALSSO(-1)*	-1.298359	0.198275	-6.548259	0.0000*
LINFR(-1)	-1.166430	0.229459	-5.083384	0.0000*
LLASP(-1)	0.435184	0.204076	2.132458	0.0407*
LRALR(-1)	-0.576965	0.218892	-2.635844	0.0128*
D(LALSSO(-2))	0.199277	0.113592	1.754326	0.0889**
D(LAGEXP(-5))	-0.499077	0.225064	-2.217492	0.0338*
D(LCCEXT(-2))	6.774570	2.328208	2.909779	0.0065*
D(LCCEXT(-3))	5.425034	1.959567	2.768486	0.0093*
D(LDCEXT)	-2.335437	1.263901	-1.847800	0.0739**
D(LDCEXT(-1))	-2.079617	1.199185	-1.734192	0.0925**
D(LDCEXT(-2))	-3.488849	1.300551	-2.682593	0.0115*
D(LDCEXT(-3))	-4.673909	1.201813	-3.889048	0.0005*
D(LDCEXT(-4))	-5.034560	1.361132	-3.698804	0.0008*
D(LDCEXT(-5))	-3.537515	1.181951	-2.992946	0.0053*
D(LDCEXT(-6))	-2.342093	1.158989	-2.020807	0.0517*
D(LDCEXT(-7))	-3.894840	1.109733	-3.509709	0.0014*
D(LINFR(-1))	0.475924	0.269239	1.767665	0.0867**
D(LLASP(-1))	-0.380140	0.161846	-2.348768	0.0252*

Note: Only significant variables are reported in the table, where * and ** denotes significant coefficients are 5% and 10% level, respectively. D denotes the difference operator for short-run effect on equilibrium, or they relate to the short-run dynamics of the model's convergence to equilibrium.

4.5.4. Results of the error correction term

As stated in Chapter 3, Table 9 presents the results of the error correction term. The term ECT_t as the speed of adjustment parameter or feedback effect is derived as the error term from the co-integration model whose coefficients are obtained by normalising the equations 5, 6 and 7, respectively. It is important to state that the presence of the ECT_t accounts for correction of the disequilibrium, that is, to indicate disequilibrium in the previous period, adjusting in yt. In most cases it is suggested that signs on the coefficient indicates a divergence (positive sign) or convergence (negative sign). A conclusion is the drawn such that a value ECT_t summing to 1 (or 100%) depicts an adjustment that is assumed within the period, or the adjustment expressed to be very instantaneous and full. Contrary to that is the estimate ECTt value of about 0.5 (50%) suggesting an adjustment in each period/year. Whilst a 0 value of ECTt, confirms the existence of no adjustment in any period. However, a conclusion that claims that there is a long-run relationship yields no logical analysis. In this analysis, model satisfies the negative coefficient for convergence to equilibrium and further indicates that adjustment to equilibrium takes places outside the period, or the adjustment is too instantaneous, more than 100%.

Table 9: A summary of the ECT model values

Model	**ECT value**
Aggregate agriculture production output	-2.1589
Crop sub-sector output	-1.6456
Livestock sub-sector output	-1.2983

4.5.5. Results of the Granger Causality Testing

The seminal work of Granger (1987) stipulates that if a pair of I(1) series are co-integrated, then there must a unidirectional causality running in either way. If the agricultural output and its exogenous variable, crop sub-sector output and its exogenous variables, and livestock sub-sector and its exogenous variables are not co-integrated, the causality is better investigated by initially estimating Vector Autoregressive (VAR) in first differences form. The bounds test offers a conclusion which pinpoints that these equations are yielding co-integration results. Therefore, the Granger causality test is included to account for period lags in error correction term (ECT). To carry out this process requires the Vector Error Correction (VEC) technique on equations and the model results for Granger Causality as presented in Table 8. From Table 10, it is evident that in the short run, there exists causality relaying from credit extension by corporates to agricultural output at a 10% level of significance. Furthermore, in the short run, there is causality relaying from AGEXP (agricultural exports) to crop and livestock output at a 10% and 5% level of significance, respectively. This is indicative of the fact that their causal impact on exports is enhancing agricultural production and productivity. Therefore, it is argued here that any policy suggestions that disruption of agricultural exports can have a causal impact on the performance of crop and livestock output in the short run only.

Table 10: A summary of the Granger Causality results

Dependent variable	Source of Granger Causality (Independent variable) Short-run					
Agricultural output (LAGOUT)	ΔLAGEXP	ΔLCCEXT	ΔLDCEXT	ΔLPAGIN	ΔLINFR	ΔLRALR
	4.4879 [0.1060]	5.2652 **[0.0719]***	0.0071 [0.9965]	3.0486 [0.2178]	1.8198 [0.4026]	1.489 [0.4748]
Crop/Forestry sub-sector output (LAGCSSO)	ΔLAGEXP	ΔLCCEXT	ΔLDCEXT	ΔLCASP	ΔLINFR	ΔLRALR
	5.3492 **[0.0689]***	4.3345 [0.1145]	0.1398 [0.9325]	2.4849 [0.2887]	3.9559 [0.1383]	3.9564 [0.1383]
Livestock sub-sector output (LALSSO)	ΔLAGEXP	ΔLCCEXT	ΔLDCEXT	ΔLLSAP	ΔLINFR	ΔLRALR
	7.7390 **[0.0209]***	4.2529 [0.1193]	0.2529 [0.8812]	0.1939 [0.9079]	0.9579 [0.6194]	2.4140 [0.2993]

Note: Values in square brackets are Chi-square statistics, while those in curly brackets are p-values.* Denotes that the Chi-square value for Causality is statistically significant at 1%.

4.6. Residual diagnostic test

As part of the post estimation test, we use the RESET test to detect if there exhibit a nonlinear combination of explanatory variables and interactive terms to the specification. Table 11 provides the diagnostic test results for the three equations and it can be deduced from the normality test that the data deviates from a normal distribution because 0.2972, 0.6849 and 0.6957 probabilities are greater than 0.005 for all three estimated equations. This conforms to Kurtosis and skewness values presented in the descriptive statistics section (refer to table 2). The Breusch-Pagan LM test for the presence of serial correlation indicates that the null for serial correlation is rejected at the 0.05 level for all the three equations. The regression equation specification error test (RESET) suggests that a non-linear combination of the explanatory variables may have power in explaining the response variable which may result in model misspecification with probabilities greater than 0.05. However, the model results in this analysis all yield appropriate probabilities, 0.0062, 0.0231 and 0.0322, respectively which are smaller than 0.05 for all three equations.

Table 11: A summary of the residual diagnostic test

Equation	Tests		
	Normality	**LM test for serial correlation***	**Stability Test Ramsey RESET**
Aggregate agriculture output	2.4263 [0.2972]	24.9289 [0.0000]	5.3547 [0.0062]
Crop production output	0.7567 [0.6849]	10.1022 [0.0064]	2.6341 [0.0231]
Livestock production output	0.7254 [0.6957]	41.4368 [0.0000]	2.6223 [0.0322]

Note: the values in square parenthesis are probabilities. * Breusch-Godfrey serial correlation LM Test

4.7. Chapter summary

The estimated results for the agricultural output, crop and livestock sub-sectors conform to the expected results with theory. Results presented in Tables 6, 7 and 8 yield the same conclusion that extending credit increasing output has a significant impact in the long run and that public investment and output tend to drift away from the long-run equilibrium. The error correction model term indicates that the model satisfies the negative coefficient for convergence to the equilibrium and the adjustment to the equilibrium takes places outside the period, or the adjustment is too instantaneous, more than 100%. It is equally noted that it can be deduced that in the short run, there is causality running from corporate credit extension to agricultural output at a 10% level of significance. In the short run, there is noticeable causality running from AGEXP (agricultural exports) to crop and livestock output at 10% and 5% levels of significance, respectively. This is indicative of the fact that the causal impact of exports is enhancing agricultural production and productivity. Therefore, it is argued here that any policy suggestions that the disruption of agricultural exports can have a causal impact on the performance of crop and livestock output in the short run only. The findings from the diagnostic test results such as the normality test shows that the data deviates from a normal distribution because the p-value is greater than 0.005. This conforms to Kurtosis and skewness values described in the descriptive statistics section. The Bresuch-Pagan LM test for the presence of serial correlation indicates that the null for serial correlation is rejected at 0.05 level. Under the RESET, the hypothesis is that, non-linear combinations of the explanatory variables have power in explaining the response variable and thus must yield appropriate probability less than 0.05. Thus the results of this study adequately addresses the problem identified and conform to the findings of He, Ho, Yo & Zhu (2019), Gong (2018), Getahun, Baumuller, and Nigussies (2018); Bizikova (2016); Hangue and Kneller (2015) and Zepeda (2012).

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1. Introduction This chapter offers the findings of the study and thereafter concludes on how the objectives of the study were addressed. In addition, a section on suggested policy recommendations is offered in support of the critical findings of the study. The findings and recommendation are helpful directives for public policies oriented to develop the agricultural sector. The chapter further proposes areas for prospective research.

5.2. Summary, findings and conclusion

Preceding empirical and theoretical works have produced mixed results on the link between investment and agricultural output growth. It has been widely argued that investment is a conduit for economic growth, with much needed efficiency gains for economies with a low level of capital and at an early stage of economic transformation. Therefore, without investment, there would be no capital accumulation, making it difficult to reach optimum production capacity of the economy. Some authors argue that investments do not necessarily translate into growth. By and large, existing empirical literature have endeavoured to establish the link between agricultural public investments on output without maintaining uniformity on investment variables. For example, some researchers looked at actual public expenditure and its link to overall agriculture growth. Others explored disaggregated public expenditure in relation to a particular agricultural sub-sector or industry. The first objective of this study was to assess the impact of public investment on agricultural production. For uniformity and accuracy, the role of public agricultural investment is investigated by linking aggregate investments to aggregate outputs and sub-sector investments to sub-sector outputs. Additional variables adopted in this study are commercial agriculture credit, development agricultural loan credit, agricultural exports, inflation, and nominal average lending rates. This paper explored the Autoregressive Distributed-lag (ARDL) model to estimate the long-run coefficients and short-run ECM estimates on the relationship between agricultural investment and growth in agriculture and the impact thereof. Estimation of the ARDL model was preceded by critical econometric techniques, namely, a stationarity test of data series and a co-integration test of the variables. This analytical approach is buttressed by theoretical framework demonstrated by Barro (1990), Cullison (1993) and Pesaran et al. (2001).

The results of the ARDL model reported in this study are summarised as follows. The study found evidence of a long-run relationship amongst variables for all the model equations of aggregate agricultural output, the livestock-sub-sector and the crop and forestry sub-sector output. This indicates that sources of agriculture growth can be derived from the ARDL model. A positive and significant long-term coefficient of public investment is consistent with the Keynesian and Barro’s endogenous growth theories that advocate for government spending to support economic growth. The coefficient of development loans suggests that agriculture credit finance should be oriented towards development, providing low interest rates and flexible loan conditions if the long-term growth is to be sustained. In Namibia, this can be achieved through effective collaboration between the state agriculture bank and government. It should be noted that weak agricultural productivity in sub-Sahara Africa is a result of the lack of access to affordable credit (Fuglie & Rada, 2013). According to Badiane and Makombe (2014), incredible growth in cereal production in east and southern Africa was an outcome of access to credit, amongst other factors. Therefore, by implication, a long-run growth path for Namibia’s agricultural sector depends on public investment.

Importantly, the Granger Causality results show that there is unidirectional causality between commercial credit, agricultural export and agricultural output across all three dependent variables. However, the causal effect is not applicable to all variables under study. In the case of aggregate agricultural output, causality flows from commercial credit expenditure to output. With respect to the crop and forestry sub-sector output and livestock sub-sector, there is causality running from agricultural export to output. By implication, this reinforces the argument that the Keynesian hypothesis is valid for Namibia’s agriculture.

Furthermore, this study reveals that agricultural export is a key determinant of long-run growth for the crop sub-sector. Namibia’s major crop exports are grapes and dates, hence continued access to lucrative export markets and market diversification should remain a policy focus. While public investments, development loans and exports play a significant role in the agricultural sector, agricultural output tends to diverge from the long-run equilibrium in relation to commercial credit, lending rates and inflation rates. A significant negative coefficient of lending rates, inflation, and commercial loans implies that high input prices and the cost of borrowing erodes performance of the sector over time.

The coefficient value of the error correction term for all model equations under study have satisfied the conditions for convergence to the equilibrium. As a rule of thumb, the signs on the coefficients have implications on the nature of the equilibrium, meaning that a positive coefficient identifies a divergence and in contrast, a negative coefficient points to a convergence to the equilibrium. In this study, the estimates of the error term for aggregate agricultural output, crop sub-sector output and livestock sub-sector output are -2.1589, -1.6456 and -1.2983 respectively and they are both statistically significant. The error correction term that yields negative and statistically significant coefficients constitute the required conditions for adjustments to the equilibrium. In this respect, more than 100% of the deviations from the long-run equilibrium would be corrected instantaneously if appropriate interventions were effectively actioned.

The findings of this paper suggest that there exists a long-run relationship between agricultural output, public expenditures, development credit advances, commercial credit advances, exports, lending rates and inflation. Further public investment, development credit advances and exports are key drivers of the agricultural GDP output. This outcome supports the Keynesian theory of public investment and its proponents, such as Aschauer (1989), Barro (1990), Solow (1994), Ahmad and Qayyum (2008) and Cullison (1993). Correspondingly, this finding suggests the importance of Lewis's proposition that is instructive in respect of the critical role of agriculture in the process of development. As noted earlier, budget allocation to the agricultural sector has been inconsistent and unevenly spread across programs and activities, and thus restructuring of public investment is needed to achieve a balancing act and efficiency. Further, it is noted that lending rates and inflation are derailers of agricultural growth which is as expected in line with the views presented by Nguyen and Trinh (2018). This is because a high interest environment and escalating inflation rate represent a high cost of capital and production inputs which is prohibitive in terms of income and profits, hence affecting the GDP output. Interest subsidies are, therefore, essential to safeguard farmers from the negative impact of interest rates and inflation. Commercial credit advances are not favourable to the agricultural sector, since commercial credit institutions are not oriented towards development, hence they are non-responsive to the needs and peculiarities of the agricultural sector in terms of adequacy and conditions of credit supply. Therefore, policy interventions are required to improve the accessibility of farmers to affordable and tailor-made financing solutions. From the study's findings, it is evident that access to competitive and lucrative export markets for agricultural commodities is necessary for the sustainability of agricultural growth, confirming the findings of Levine and Renelt (1992) and Diao, McMillan and Wangwe (2018). Moreover, the study highlights that agricultural growth depends on the past deviation from the steady state equilibrium. This means that about 100% of the deviations of the agricultural output from the equilibrium can be corrected annually following a change in investments and other variables considered in the study. Therefore, it is important that agricultural investment increases should have a positive impact on the growth of agricultural output gains. Thus, Namibia provides sufficient evidence of investment-led agriculture growth over the period under consideration in this study. This finding thus collaborates with the foundation of the Keynesian theory that states that public investment matters for a country's growth.

5.3. Policy recommendations from the study

The study findings show that there is convergence to the long-run growth path, hence increased public support of the sector is undeniably a catalyst for agricultural growth. In this regard, government has an important role of facilitating access to affordable credit and efficient markets for agriculture output if optimal agriculture output is to be achieved. Therefore, efforts towards capital deepening in the agricultural sector should be encouraged. Further, it is imperative that government maintains a stable economic environment to attract private investments in agriculture. Government should also consider strategic interventions which can inspire the participation of small-scale and communal farmers in the mainstream economy, thereby increasing income and reducing poverty. Credit finance to small-scale farmers and communal farmers should be improved in terms of accessibility and affordability through institutional collaboration and policy harmonisation. Through affordable and innovative financing of small-scale and communal farmers and an efficient marketing system, Namibia can expect to increase the production of food and maintain a secure income among its citizens, in addition to fostering the enhancement of sustainable agriculture. This strategic approach will boost investment confidence in agriculture, contribute to increased capital formation, allow access to technological innovation so that farmers are able to increase agricultural production to ensure the long-term sustainability of agricultural development. Another policy implication arising from this study is that to unleash the full potential of the agricultural sector, there is a need to increase production from the current levels and promote the export of agricultural commodities. Greater emphasis must be placed on trade policies seeking to maintain and improve access to competitive and lucrative markets. The specific policy recommendations from this study are follows:

5.3.1. A high level of coordination in the agricultural sector is needed for an institutional arrangement which creates a conducive environment for agricultural investment, particularly to smallholder/communal farmers.

5.3.2. A pilot program needs to be established that identifies smallholder farmers in the crop and livestock sector together with the development of a value chain financing model where farmers have access to credit and guaranteed markets for their farm produce. Such a pilot scheme could be implemented in partnership with strategic partners providing services such as training and business support, supply/off-take agreements for farm outputs and credit guarantee facilities for farmers. Currently, the loans guaranteed for small-scale farmers are only available for small-scale farmers operating on the government's irrigation farms (referred to as Green Scheme).

5.3.3. Public investment projects that are operated on a commercial basis should be privatised and discourage government interventions in real business sector. Government spending on agriculture should be restructured towards infrastructures such as water, irrigation, roads, telecommunication, as well as the strengthening of market developments. This will improve efficiency in public spending and achieve the best balance between the public and private investments.

5.3.4. There is a need to enhance and restructure the public account information system for completeness and transparency by ensuring data integrity, user-friendly reporting of budget allocation and execution at project, sector and regional levels to support future studies.

5.4. Future Research

This paper relied on investment data over a period of 20 years from 2000 to 2020. A longer period could have been used but proved impossible due to data limitations arising from the absence of quarterly public investment data prior to the year 2000. Considering the agricultural sector's importance to Namibia's economy, there is need to draw attention to a longer period of analysis in the future when the current financial information system has gathered longer-time series. Furthermore, future research can attempt to assess if investment has supported smallholder farmers in terms of production. This has an important policy implication given that Namibia's agricultural sector is characterised by a dual system where smallholder farmers represent the majority yet do not have the potential to address the challenges of income inequality and poverty in the country.

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