Supply Response of Palm Oil in Papua New Guinea

Boniface Aipi[*]

Tanu Irau[‡]

and

Ludwig Aur Aba[†]

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[*] Boniface Aipi is the Manager for Projects Unit of the Research Department at the Bank of Papua New Guinea.

[‡] Tanu Irau is a Senior Research Analyst with the Projects Unit of the Research Department at the Bank of Papua New Guinea.

[†] Ludwig Aur Aba is a Research Analyst with the Research Analysis Unit of the Research Department at the Bank of Papua New Guinea.

Acknowledgements

Abstract

Both quantitative and qualitative analyses were done to study the impact of international price movements and other variables on the production and supply of palm oil. An Error Correction Model (ECM) confirmed the cross sectional data study for the palm oil industry that palm oil production and supply in both the short and long-run does not respond to international price movements but to other non-price variables that cannot be quantified due to lack of consistent time series data. The coefficient of the error correction term ECM_{t-1}, as expected has a negative sign and is significant at the 1% significance level. The significance of the error correction term supports cointegration and suggests the existence of long-run steady-state equilibrium between palm oil export supply, real export price and trade weighted income levels of major trading partner countries. Overall, supply response to changes in international prices is inelastic in the palm oil industry. Both the long and short-run estimates are consistent with the survey results. Price factors aren't influential in the production and supply of palm oil exports. In Papua New Guinea, non-price factors are pivotal in the determination of palm oil production and export supplies. Weather also plays an important role in determining production and supply of palm oil exports in PNG in the short-run. Results were also confirmed by growers during the field survey. It was found in the survey that price of palm oil is not the only factor that affects production, other non-economic and economic factors are also responsible.

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1.0 Introduction

The aim of this paper is to establish the effect of changes in the price of palm oil to the production and supply of palm oil in Papua New Guinea (PNG). Palm oil is a major source of employment and income for growers and foreign exchange earnings of PNG. Furthermore, other factors that impinge on palm oil production in PNG would also be highlighted in the study. Both quantitative and qualitative analyses were done to study the impact of international price movements and other variables on the production and supply of palm oil in PNG.

Palm Oil[1] in PNG is produced mainly by plantations, combined with a number of out-growers through Village Palm Oil (VOP), Land Settlement Scheme (LSS) and Customary Rights Purchase (CRP). A cross section data study was done on the producers, mainly plantations and out-growers, in West New Britain and New Ireland provinces to establish the variables that affect production and export supply of palm oil. Study results show that a wide variety of factors influence palm oil production and supply in PNG. It was established that, apart from prices, other non-price variables affect the production of palm oil, especially by out-growers. Factors like the need for revenue to meet community obligations such as compensation, schools fees, food, bride price payments, infrastructures like roads and bridges, labor, land, state of technology, cost of inputs, number of producers, age and stock of palm oil trees, etc. affect the amount of palm oil produced by out-growers. An Error Correction Mechanism (ECM) model confirmed the cross sectional data analysis for the palm oil industry that palm oil production and supply in both the short and long-run does not respond to international price movements but to other non-price variables that cannot be quantified due to lack of consistent time series data.

A number of studies have been done on palm oil production in PNG on all producer levels. Various publication by Oil Palm Industry Corporation (OPIC) and Koczberski, Curry and Gibson (2001) have alluded to availability of qualitative literature on palm oil production in PNG. However, there are only a few known established empirical publications on *'Supply Response of palm oil ', i.e. by Fleming (1999) on Palm Oil Supply Responsiveness to price and exchange rate in Papua New Guinea: He used palm oil prices, exchange rates and the lagged effect of small holder palm oil supply as the main economic variables to determine supply response in PNG.* However, there could be other economic and non-economic variables that affect production of palm oil in PNG. Therefore, this study attempts to identify these variables and establish whether they affect the producers' decision to produce palm oil.

The paper is structured as follows; section 2.0 covers a brief history of palm oil development in PNG, section 3.0 discusses economics of palm oil production in PNG, followed by section 4.0, which discusses the survey results, dissecting factors that

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[1] The palm oil industry is mainly plantation-based and all out-growers are assisted in various ways by the plantations. The palm oil plantations and CPO together form a Nucleus Estate. They established very good distribution network and supply systems so the plantations (nucleus estates) help the farmers with all necessary inputs, including pick-up of fresh fruit bunch, supply of tools and fertilizers, provide good roads and bridges, etc.

affect palm oil production and supply in PNG, while section 5.0 covers the major constraints that challenges the productive capacity of the palm oil industry. Since time series data is not available for all the variables discussed as major determinants of palm oil production and export supply, the next section will use those variables that have available time series data to develop a model for the palm oil industries supply response function. This will be followed by conclusion, recommendations and highlight areas of future study.

2.0 History of Palm Oil Development in PNG

Oil Palm is a tropical tree from which the palm oil and palm kernel oil (PKO) are extracted to be used in food and cosmetics. Oil Palm originated from Africa, and the Europeans were responsible for its spread throughout the world, while the Germans introduced palm into the country in the 1890s. Commercial palm oil development in PNG is fairly recent with the establishment of five oil palm plantations in PNG since the 1960s, jointly by the PNG government, World Bank and a few companies from the United Kingdom[2]. One of the pioneer companies was New Britain Palm Oil. Hargy palm oil emerged in 1972, Higaturu Palm Oil Plantations in 1976, Milne Bay Estates in 1990 and Poliamba in 1992. These palm oil plantations are set up in the form of a Nucleus Estate Scheme, in which the palm oil plantations and the Crude Palm Oil (CPO) mill[3] are jointly owned by the plantation companies. The areas around the plantation were allocated to smallholder producers, who grew their own palm oil to supply and feed their Fresh Fruit Bunch (FFB) to the mills for processing and subsequently for exporting of CPO. In return, apart from the earnings from the FFB, the smallholders are supplied with inputs such as seeds, tools, fertilizers, credits, extension services, etc, by the plantation companies. The out-growers also get advice on palm oil and other agricultural related matters from extension officers employed by the Oil Palm Industry Corporation (OPIC).

In West New Britain (WNB) province, New Britain Palm Oil Ltd (NBPOL) is based in Mosa, Kimbe, while Hargy is based in Biala. They are the only two major palm oil producers there. NBPOL is engaged in production of seedlings to operation of plantations, with palm oil mills, palm kernel mill, and a refinery. They also buy fruits from more than 7000 smallholders. The total land area of the plantations is more than 43305 hectares, while the smallholders cover more than 25000 hectares. NBPOL has a target to achieve 30 thousand tonnes of fresh fruit bunch per hectare (NBPOL Sustainability Report 2007-2010). Two thirds of the production comes from plantations, while the remaining one-third is from the production by smallholders through the various VOP, LSS and CRP.

NBPOL has recently acquired Ramu, Higaturu, Milne bay and Poliamba estates and expanded to the Solomon Islands, including a refinery in the United Kingdom. With these expansions, the total area of plantation coverage increased to 77,000 hectares

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[2] Commonwealth Development Corporation (CDC) and Harrisons and Crossfield.
[3] The palm oil plantations and CPO together form the Nucleus Estate and the small farmers around the plantations and mill, supply the palm oil fruit.

of palm oil, with an elevated production profile of both the plantations and smallholders. As a result, plantations produce around 75 percent of the total fruits, while the remaining 25 percent of fruits are being produced by around 15,000 smallholders. NBPOL now operates a total of 11 crude palm oil mills, one palm kernel mill and three palm kernel crushers, processing almost two million tonnes of FFB annually (NBPOL Sustainability Reports).NBPOL is now a major force in the production and supply of palm oil in PNG.

Palm Oil industry in PNG operates under a nucleus estate model and has undergone tremendous transformation, from the smallholder out-growers to plantations, with plantations taking over most of the palm oil production by being involved in growing and production of palm oil from the smallholder level up, to processing and refinery. As a result, palm oil overtook coffee and became PNG's leading agricultural export commodity for the first time in 2000, and has remained a leading agricultural export commodity since.

There are other new major palm oil plantations and developments in West Sepik and East New Britain provinces, which could add to the increasing trend in palm oil development and production.

3.0 Economics of Palm Oil Production

Palm oil has become an important cash crop in PNG since commercial development began five decades ago. It has created employment and generated income for the producers, and surpassed other export cash crops and is currently the leading agriculture tree crop export earner, continuing to perform persistently in the market. Regardless of the fluctuations in the price of palm oil and its associated products, production volume has increased steadily and in 2010 PNG exported over 485.6 thousand tonnes, earning around K1.025 billion in export receipts. Palm oil constitutes around 41 percent of all major agriculture commodity exports and has been the dominant agriculture cash crop both in terms of export volume and earnings since 2000. This partly reflects the willingness and commitment of the palm oil companies through years of dedicated research and development. The companies also diversified their core business activities, which resulted in growth and expansion of the palm oil companies and the smallholders. Extension services and other readily available facilities helped to assist production by smallholders.

All growers and palm oil processors operate in an increasingly competitive global export environment. Therefore, to assist in maintaining competitiveness in the export sector, OPIC has reduced operational costs by progressively decreasing the ratio of extension officers to smallholders. In this environment, OPIC essentially tries to find ways of supporting extension officers more efficiently and effectively to increase their overall productivity, whilst simultaneously maintaining high quality service to smallholders.

The nature of the movement in palm oil price remains uncertain; as final prices are

Chart 1:   Percentage Share of Major Agriculture Exports Commodities in Papua New Guinea

Chart 1:   Exports Classified by Commodity

Source: Bank of Papua New Guinea
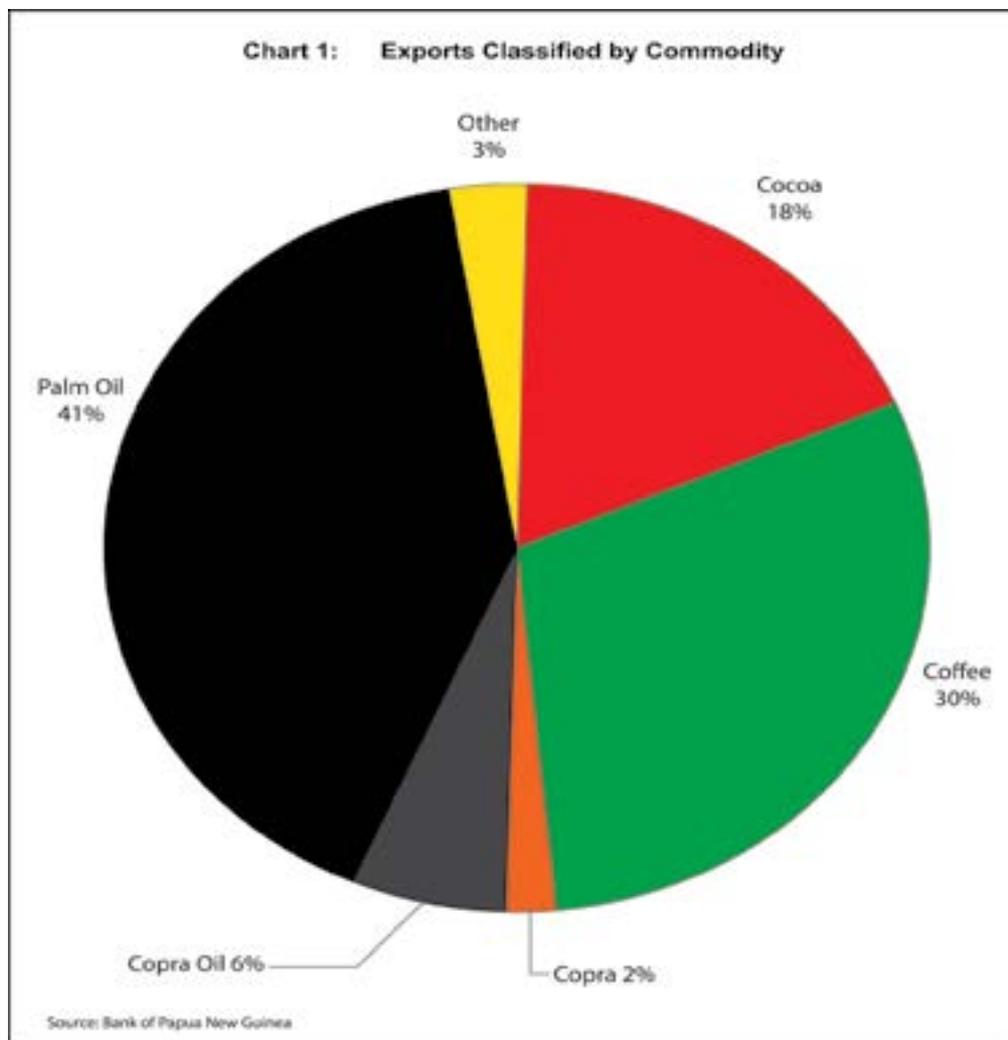
determined by international market fundamentals of supply and demand. Prices increased on average by 15 percent over the last decade and are currently at record high levels. Further increases are expected as demand grows for the commodity, especially for bio-diesel due to the higher prices of fuel and increasing demand for alternative sources of energy in the advanced and some emerging countries. This could push the demand for palm oil and ultimately crude palm oil prices even higher as more countries seek to reduce their reliance on fossil fuels. Also changes in climatic conditions due to global warming could affect demand for the commodity. Crude palm oil prices are expected to continue to rise as demand grows.

The price of palm oil and its associated products fluctuate over time but supply has

been increasing steadily, resulting from the direct assistance provided by plantations to the various levels of smallholder producers.

An increase in the price of palm oil and a depreciating kina exchange rate are regarded as two factors that could lead to an increased production in the long term. It is believed that there is always a lag in the transmission of change in the price and the kina exchange rate to the producers. Also the transmission of higher prices to the smallholders is sometimes distorted as reported by most of the smallholder respondents. If the production and supply of palm oil is inelastic (insensitive) to changes in the international price, this could imply that other independent factors determine a consistent production and supply of palm oil.

Chart 2: **Trade Weighted Index, percentage change in Export Volume and Price**

Chart 2: Exchange Rate Development, Price and Production Change

Source: Bank of Papua New Guinea and New Britain Palm Oil Limited
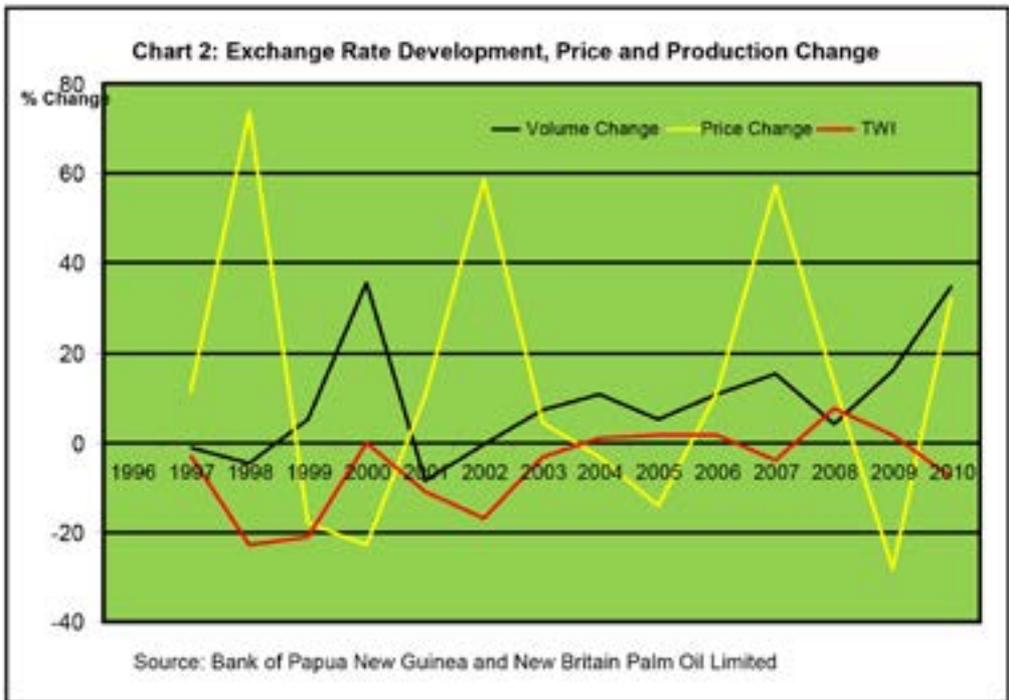
4.0 Survey Description

The Bank of PNG conducted field surveys in West New Britain and New Ireland provinces in 2009 and 2010 to establish, apart from movements in international prices, other variables that determine the production and supply of palm oil. Studies and initial analysis showed that in the long run only 82 percent of variations in export volume are caused by movements in international prices of palm oil and trade weighted

income levels of PNG's major palm oil trading partners, while the other 18 percent of the variation is caused by other independent factors. This study basically aims to identify these other non-price factors and whether the smallholders and plantations react to changes in prices. The main focus of this research is to identify the other factors that affect production and supply of palm oil in PNG? Some studies[4] have been done on improving productivity of the smallholder palm oil sector and the supply response to price and exchange rate movements in PNG. As these studies pointed out, there are number of independent factors that determine the productivity levels and responsiveness of the smallholder sector to price movements. For example the study by Fleming (1999) attempts to establish the elasticity of supply. That is; how much does supply respond to a percentage change in international price of palm oil. This study aims to establish both the short and long run relationship between changes in the international prices and production and supply of PNG's palm oil.

4.1 Survey Results and Discussions

The discussions in this section are based on interviews with various key stakeholders in the palm oil industry, including company executives, Oil Palm Industry Corporation (OPIC), extension officers, Oil Palm Research Association (OPRA), and smallholders during the field visits to WNB, including Biala and Poliamba in New Ireland Province. The survey results showed clearly why plantations and smallholder producers produce palm oil, and at the same time smallholders are also able to produce other alternative cash commodities. The results also identifies that the main problems faced by the producers which vary in each geographical location, affecting the production and export supply of palm oil. For example, the problems faced by a palm oil producer in Oro province will not be the same as the problems faced by a producer in West New Britain. The survey also discovered that the palm oil industry is a well organized industry, where the estates participate from the smallholder level up to the plantation and factory levels, including flow of assistance, research and development. This makes palm oil industry unique from the other agriculture commodities.

4.2 Determinants of Palm Oil Production and Supply

Palm Oil production is one of the many economic activities pursued by the producer of palm oil, that is; they divide their time and resources (inputs) in other economic and non-economic activities. There is division of labor and other inputs at each level of the four producer types; plantations, SS, VOP and CRP. These producers produce palm oil for varying reasons, one of which is the need for revenue. How much revenue a farmer earns hinges on changes in the prices of palm oil, and to some extent how much they can produce? The latter is limited due to fixed land area allocation for palm oil plantings. The former plays an important role in determining how much a producer, including plantations, can produce. Changes in international prices of palm oil and its associated products; prices of alternative cash crops; state of technology; inputs and

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[4] For example, see G. Koczberski et al. on improving productivity of the smallholder palm oil sector in PNG, and Euan Flemming on supply responsiveness to price and exchange rate in PNG.

prices of inputs including land, return on labor, tools and chemicals; infrastructure like roads and bridges; weather; management skills, number of producers; etc. also play integral roles in determining the amount of production and supply of palm oil.

Chart 3: **Palm Oil Production by Producer Type and Price of Palm Oil**

Chart 3: Production of Oil Palm by Producer Type and Prices

Source: Bank of PNG and New Britain Palm Oil Limited
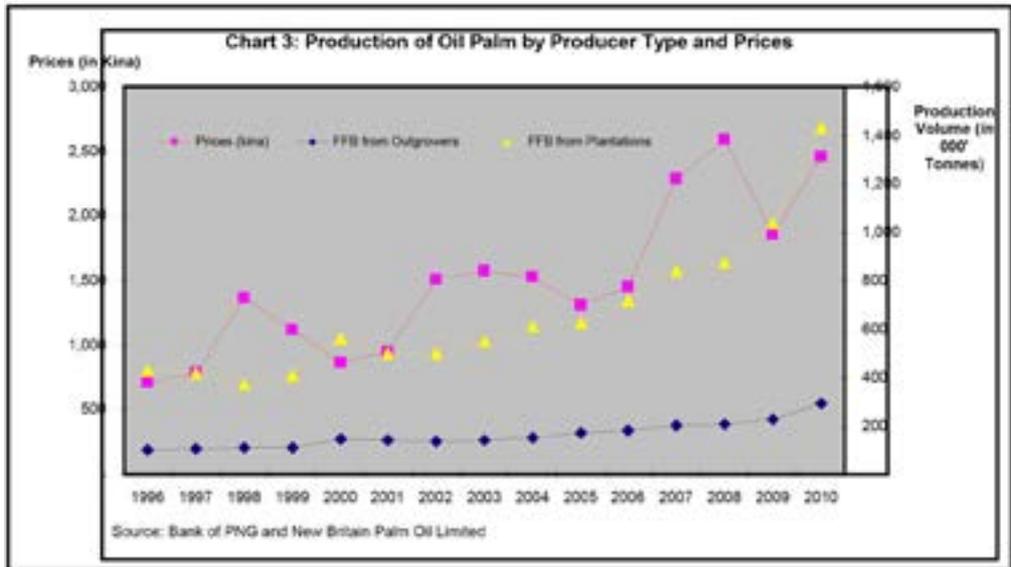
4.2.1 Plantations

New Britain Palm Oil Limited (NBPOL), apart from Hargy Palm Oil Limited, is the largest palm oil plantation and milling operator in Papua New Guinea, actively cultivating and processing palm oil into crude palm oil (cpo), palm kernel oil (pko) and palm kernel expeller (pke) for sales to both domestic and foreign markets. Until recently, it had acquired almost 90 percent of the palm oil plantations in PNG. It is also one of the world's largest private seed producers. It was found during the survey that changes (increase or decrease) in the international prices of palm oil and associated products have limited impact on the production of palm oil by plantations. If the prices go up, it can translate to more profits and increased research and development and capital investments for the companies but if it goes down, cost cutting measures are introduced, and capital expenditures are reduced. Almost 75 percent of total palm oil production is supplied by plantations. The companies have to maintain certain levels of production and supply to meet their contractual obligations offshore and onshore, as well as maximize shareholder values. In order to achieve this, they have undertaken extensive research and development of high yield seedlings for good fresh fruit bunches all year round. The progression over the years has been attributed to having a strategic management structure and operations of the plantations, through

which expansion and replanting plans are executed. Over the years the company has grown and expanded into new areas in WNB, other parts of PNG and the Solomon Islands.[5]

To achieve a target amount of palm oil production and maintain the supply at a certain level, the companies have to consistently improve their production methods through research and development, as well as assisting the out-growers[6] in different ways. Apart from government and smallholders assistance, the company funds 50 percent of extension services to the palm oil out-growers in PNG through OPIC. The companies also provide continuous support to smallholders with inputs such as interest free credit facilities for seedlings, tools and fertilizers. The companies also provide easy access to collection points, where fresh fruit bunch from the smallholder's block are picked on a fortnightly basis to ensure that the fruits remain fresh before they go into the mills for processing. In their endeavor to achieve business results, the companies encourage full participation of all stakeholders by including local landowners, settlers and government. It also has a vibrant workforce, well paid and looked after to continue to assist the estates to improve on production and achieve target production levels. The plantations/nucleus estates are involved from the start to assist the smallholder out growers, from seed planting through to the harvesting of the crops, when the FFB is harvested and sold to the nucleus estates and payment is received by the producers.

4.2.2 Smallholder schemes (VOP, LSS and CRP)

Involving communities and key stakeholders is one way of maintaining production at the required level. As part of this, a number of smallholder schemes evolved over time. The smallholders are categorized into three distinct groupings; VOP, LSS and CRP. The VOP is a village-based palm oil production on customary land. This scheme was designed to involve participation by the local landowners in the palm oil industry. The LSS is production of palm oil on state-leased land, while the CRP is production on customary land by aliens who have purchased the land from customary landowners. Although, production from the smallholders fluctuated most of the time, mostly depending on their capacity, the smallholder operates on an average of 4-6 hectare blocks. There are more than 7000 smallholders producing around 25 percent of the total palm oil production on more than 25000 hectares of land.

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[5] After the visit to NBPOL, most of the palm oil plantations, including Ramu, Milne Bay Estates, Poliamba and Higaturu Oil Palm were acquired by NBPOL.
[6] The term out-growers can be used interchangeably with smallholders.

Palm oil Fresh Fruit Bunch harvested and stacked for collection by smallholders in Mandopa in WNB province for transportation to Mosa processing mill. Photos: Aba and Aipi, 2009

4.2.3 Price of Palm Oil and Associated Products

The price of palm oil and products associated with palm oil plays a crucial role in determining how much palm oil a producer produces. The world market price of palm oil is determined by the interaction of market fundamentals of supply and demand for palm oil in the world and remains volatile and uncertain most of the time. Low supply of palm oil could result in high prices of palm oil around the world. The vice versa is true for an increase in world palm oil production and supply and when demand is low, resulting in the fall in international price of palm oil.

The interaction of the forces of supply and demand at the international market, exchange rate fluctuations and imposition of any levies or bounties by authorities, determines the final price a smallholder palm oil producer receives in PNG. The final price determines whether or not a smallholder palm oil producer will still produce palm oil at that price to sustain him and meet the demand for palm oil. For example, in WNB and New Ireland provinces, a drop in palm oil price discourages producers which can result in producers switching to other commodities like cocoa, copra, betelnut and other fresh garden foods, which could earn higher return in the short run than palm oil. This is because almost 90 percent of people in palm oil producing areas live in areas where they can still earn an income from producing and selling other cash crops.

Does the price of palm oil has a bearing on the amount of palm oil produced in anyone time in PNG? Studies by Fleming (1999) using a static Nerlovian partial adjustment model shows that supply of palm oil by both estates and smallholders has an elasticity that ranges from 0.08 - 0.255, which means that a percentage change in the price of palm oil will result in a 0.08 - 0.255 percent change in the supply of palm oil. Aside from other factors, the price of palm oil tends to have a positive relationship with supply. This was confirmed by the survey carried out by the Bank of PNG that producers respond positively to changes in price of palm oil. Almost 100 percent of the producers interviewed indicated that a change in palm oil price affect their decisions to produce palm oil. That means, to some certain degree the quantity of palm oil supplied over a certain period of time is directly related to its price. Whereby an increase in an increase in the price of palm oil results in an increase in quantity supplied, and vice

versa.

The developments in the exchange rates, an appreciation or depreciation, also determines how much a palm oil producer gets in kina. In the paper by Kauzi and Sampson (2009), they found that the international prices of PNG's export commodities, including palm oil, have a significant impact in determining the value of the kina. These results showed that producers in PNG are vulnerable to external palm oil price shocks. This view was also confirmed in the BPNG survey that all the producers interviewed confirmed that exchange rate fluctuations are affecting the kina price they receive. Since the kina was floated, palm oil and other agricultural commodities producers have received higher return in kina, compared to the 'hard kina policy' period from 1975 - 1994. However, some of the plantations surveyed expressed that though a depreciation of kina assists the kina price of palm oil, most of their transactions are done in foreign currencies, so it affects them. After the exchange rate was devalued and floated, PNG palm oil exports became competitive at the world markets and improved greatly the kina prices producers in the villages and blocks receive.

4.2.4 Prices of alternative cash crops

As the prices of other competing commodities, which the producer is willing and can produce rises, it becomes economically worthwhile for the producer to shift some of his/her resources, including labor to the production of that commodity. The producer has the choice of producing other commodities that could earn him more income in the short run. Consequently not much attention is given to the palm oil blocks, resulting in the fall in production and supply of palm oil. For example, in WNB, if the prices of palm oil drop or remain stagnant, the producers tend to switch and concentrate their labor on producing other cash crops like cocoa, copra, betelnut or garden foods, while they temporarily abandon their oil palm blocks.

The sale of cocoa, copra, betelnut and garden produce provide an alternate cash income to more households in the palm oil growing provinces. Therefore, there is an inverse relationship between the price of other alternative cash crop and the supply and production of palm oil. This was confirmed through the BPNG survey that 90 percent of the palm oil producers interviewed expressed that when the price of other commodities that they grow increase, for example, cocoa, copra, betelnut or garden produce, they switch to producing those crops. This clearly shows that the prices of other agricultural commodities do affect peoples' decision on how much palm oil to produce and hence have an overall impact on the total production of palm oil.

4.2.5 State of technology

In the survey, it was found that the type and level of technological input varies with producer type. For example, a simple smallholder palm oil producer uses simple tools like wheelbarrow, chisel, sickle (harvesting pole), knapsack spray etc. while the plantations use more advanced and improved equipment and technology with the

aid of advanced research and development undertaken by the palm oil companies. With the advancement in technological input into the production process, the total cost is likely to fall and quantity of palm oil produced could increase. The increase in production of palm oil could be a result of research and development of high yielding crops, improved supply chain methodology, and increased extension services and assistance to out-growers.

4.2.6 Inputs and prices of inputs: land, labor, tools and chemicals

The inputs used to produce palm oil vary across all producer types. Some of the most common ones used by smallholders and plantations are highlighted below.

(a) Labor and Return on Labor

From the survey, it was found that there is a direct relationship between high returns to labor and high levels of participation in the production of palm oil. If the smallholders see that the amount of revenue he/she earns by working in the palm oil blocks is higher, they consider it worthy to work in their palm oil blocks, otherwise they can participate in other alternative economic activities, which can earn them higher returns on their labor. Where returns to labor for palm oil is lower than expected, production could take the form of 'target' amount to satisfy certain financial need. People can produce up to the point where they earn their target amount and then stop producing more palm oil.

Labor for the out growers mainly comprised of family members, thus limited supply of labor, on average 11 people per 4-6 hectare blocks of palm oil. It consists of father, mother, and their children and in some instances, extended family members. The amount of labor and time spent on the palm oil blocks varies with each family unit. It depends on the size of the palm oil blocks and alternative chores. According to the survey, division of labor is evident, where most families prefer to split their labor so that the other members take care of non palm oil activities, while the core family members attend to palm oil. This means the total man hour dedicated to palm oil is reduced. They attend to their palm oil blocks as and when there is a need to harvest the fruits. A bigger sized palm oil block needs more labor to clean and harvest during peak periods from the extended family members.

With inadequate help from modern tools, like tractors, the limited family labor is dedicated to working on the existing block, which is sufficient to cater for their basic needs and meeting some of their communal obligations. In some limited cases, extended relatives are engaged, while employment of outsiders is rare. The smallholders continue to produce more than 25 percent of the total fresh fruit bunch (FFB). Also non-availability of labor during harvest because of other commitments like elections, bride price etc. affects overall production.

Small Holders at their respective blocks. The labour input into the production of palm oil ranges from young to old. Photo: Aba and Aipi

(b) Land and Alternative Use

Land is one of the important factors of production. The fertility, locality and size of the land will determine the quality and how much palm oil can be produced. In the survey, all the farmers agreed that having access to bigger and much more fertile land will result in high yielding trees and increased production. The location of a piece of land is also vital as any locations outside of the estates could result in delayed collection of the FFB's.

In most of the palm oil producing regions in PNG, land is acquired by a developer through outright purchase or lease-lease-back methods. With the financial gain from palm oil achieving prominence, aliens have been flooding the oil palm growing areas to gain access to land and plant the commodity. There has been mixed reaction from the landowners. Some sold their land to the aliens while others refuse to sell their land. Some of these aliens have also bought land from the Government through the LSS. Access to an average of only 4-6 hectare of land, is a limiting factor in itself, as plans to expand cannot be executed and disputes normally erupt between alien settlers and original landowners, which result in displacement of block-holders. Also there is very limited government land and even if it is available, the process involved in trying to get one is tedious.

Of the 4-6 hectare of land, it is apportioned for other food crops for domestic consumption and for other competing cash crops which results in the reduction of the hectares of land for palm oil cultivation which results in lower production and supply of palm oil.

In the survey, it was highlighted that with the increase in population, there is already land pressures, where smallholder producers are in dispute over pieces of land. Original landowners and alien settlers also dispute over land. Although increase in population could increase the number of people participating in the production of palm oil, non increase in acreage will not improve the overall production profile of the industry.

(c) Chemicals

The use of chemicals has become a central part of keeping palm oil blocks healthy, free from the dangers of pests and diseases, which is vital for increasing production. During the survey, it was highlighted that plantations as well as smallholder blocks use chemicals like fertilizers, pesticides and insecticides on the palm oil trees. Some of the chemicals used in the palm oil blocks are subsidized by NBPOL. Proper tools are required from the time of planting to harvesting. Although the cost of inputs is subsidized and given out on credits, income from production by smallholders is deducted to cover for the credits, and reduces the take-home revenue. This practice becomes a disincentive to increase production because to increase production, more inputs will be required, which means more deductions for the small holder grower. OPIC also assist the out-growers through their extension services, especially with how to control the spread of pest and diseases and how to look after their palm oil trees. The out-growers in turn continue to contribute to OPIC through production levies. Transport for FFB pick up is provided by NBPOL but the smallholders who are far from the plantations and mill are disadvantaged in terms of pick up as sometimes, it takes up to 1 week before actual collection of their FFB's. Sometimes there are road blocks, which cause delays in transport. If there is any dispute between the NBPOL, its agents or workers, they will not pick the produce and the fruit bunches are left to rot.

(d) Machines and Equipment

In the smallholder blocks, tractors and other machinery are rarely used. They use uncomplicated tools like wheelbarrow to collect the FFB and transport them to the closest collection point, which is at the edge of their respective palm oil blocks. They also use other tools like chisel and sickle to harvest the fruits. The use of simple tools to harvest takes longer and is labor intensive during peak harvesting period. In contrast, palm oil estates use some of the most sophisticated machines and equipment for planting. Some of these machines and equipment are owned by the estates and are used to assist the smallholders. For example, the big trucks are used to collect the FFB's at certain pickup locations. This assists the smallholders in outlying areas and hence enhances production.

(e) Time management

Time management has become a critical factor in the production process. Management of time by out-growers is non-existent. During the survey, it was found that the smallholders divide their time among other activities, including tending to other crops like cocoa, copra, betelnut and food gardens and other customary obligations. They do not commit 100 percent of the time to palm oil blocks. The time and amount of labor spent into the production of other commodities differs from that of producing palm oil. During peak harvesting periods, the entire family labor force is employed in the palm oil blocks, while one or two members normally harvest food from their garden for dinner. A good time management system can improve the attendance at each palm oil blocks and attending to other commodities or customary obligations. This will greatly

benefit the industry by improving the productivity level of smallholders.

Good infrastructures such as these roads in WNB province are vital in lifting the production profile of palm oil. Photos: Aba and Aipi, 2009

4.2.7 Infrastructure like roads and bridges

Timely transportation of FFB from the outlying blocks and plantations to the processing plants is vital. It shortens the collection time and preserves the freshness of FFB and ultimately the quality of the palm oil products. This will not be possible without good road networks and bridges linking the communities producing FFB and processing facilities. The conditions of transportation infrastructure like roads and bridges differ across the different palm oil producing provinces. For example, the roads and bridges in WNB are frequently maintained by NBPOL under the National Government tax credit scheme and are in excellent condition. However, the story could be different for roads and bridges in Oro province, where natural disasters had struck and damaged all infrastructures, including roads and bridges. The production profile of these two provinces will be different, due to different conditions of infrastructures. Transport infrastructure plays important role in improving productivity of palm oil.

4.2.8 Age and Stock of Palm Oil Trees

Maintaining a healthy stock of palm oil trees can enhance production. Palm oil trees can last up to fifty years if well cared for. From the survey, seventy six percent of the palm oil tree stock that is currently with the smallholders is more than 8 years old, while some are over 15 years old. The age of palm oil trees varies from smallholder and plantations. For the smallholders, the age of palm oil trees does not matter, as long as the trees can still bear fruits. The tree can only be replaced if it dies naturally or stop producing.

The stock and age of palm oil trees determine the amount and quality of palm oil fruit produced per tree. Palm oil trees that are planted in a new land and well looked after could bear more fruits than those abandoned and not looked after properly. Old and

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bad palm oil trees are removed and replaced with new seedlings. From the survey, it was found that 100 percent of palm oil trees removed is replaced with new seedlings. Although it takes some time for the newly planted palm oil trees to flower and bear fruits, affecting production for up to 2 and 4 years, yield is improved in the long run. The first harvest is not always full year harvest so there is a variation in production between the time the palm oil trees are uprooted and replanted, and the time of first and second harvest.

NBPOL and OPIC are running frequent rehabilitation programs with the smallholder producers to rehabilitate old palm oil trees to maintain or increase the level of production. For plantations there is a requirement that every tree should produce certain amount of palm oil fruits. As the palm oil tree grows older, the stem grow bigger and much of the land nutrients is being consumed by the stem and the fruits receive minimal amount of nutrients and reduce fruition. Therefore, taking care of older trees can improve the productivity of each tree and enhance the overall production of the industry.

The average palm oil tree each producer has depends on whether the producer is a smallholder VOP, LSS, CRP or plantation. The smallholders have on average 500 trees per producer in an area of 4-6 hectares of land. The amount of trees a producer has also depends on the land topography. For instance, palm oil planted in some areas will not be the same as in other areas; even if they grow, the production per tree will differ. For plantations, every tree is cared for and replacements of bad trees are frequently done by full time employees. A healthy palm oil tree grown in a good fertile land can yield more fruits and increase the overall level of production.

It was found in the survey that 76 percent of the palm oil trees are above 8 years old, confirming that most of the producers have stock of palm oil trees, which could be as old as 15-30 years. New plantings and trees less than a year old constitutes only 0.3 percent, 1-4 years old constitute 2.5 percent, while 5-8 years constitute 21.1 percent. Almost 100 percent of palm oil trees that are removed are replenished with new seedlings but there is a delay in the production by at least 3-4 years. This means the producers are harvesting palm oil their grandparents and their parents planted. Even some of the blocks and plantations are as old as 40-50 years.

4.2.9 Number of Producers

An increase in the number of producers could result in increased production and supply of palm oil. For smallholders, a standard family unit that consists of 11 members can have up to 4-6 hectares of palm oil blocks. If the producer sees that the area is big, he/she can decide to employ other people, mainly extended family members or relatives, to work in the palm oil blocks and during harvest they are paid in kind or cash. Palm oil production also increases when settlers from other non-palm oil producing areas migrate to palm oil growing areas. For instance, the recent increase in the price of palm oil lured a good number of people from Sepik and Highlands regions migrating

to WNB to either work on the palm oil plantations or cultivate palm oil. The number of smallholders varies from time to time, depending on their mood and need to involve in palm oil growing and production. However, with plantations, the number of producer is fixed over a certain period of time unless there is increase in acreage. For example, plantations can easily adjust the number of its employees to increase production during period of high yield. They can also expand to other new areas. Also entry of new producers of palm oil will increase the amount of palm oil being produced for export. This can only be possible if the number of producers increase through acquisition of new land and thus increasing existing acreage.

4.2.10 Weather: Change in Climatic Conditions

Palm oil is a tropical plant that grows well on warm and humid climate at altitudes below 500 meters above sea level. Any adverse weather patterns could affect production of palm oil. Productions by both smallholders and plantations are affected by changes in weather patterns. It is also a concern that unusual developments in weather patterns due to global warming could disrupt production.

4.2.11 Customs/Traditional Practices: Demand for Revenue

In the survey, it was found that production by the smallholders is mainly driven by the need/demand for revenue; for sustaining daily livelihood, as well as settlement of school fees and other community obligations such as bride price payment, death, compensation, etc. The need for revenue compels people to seek alternative/ complementary income generating activity. These behavior patterns are obvious because unlike the plantations, the out growers have no contractual obligations to meet. These factors seem to influence the smallholders' mood to increase production, regardless of the change in the price of palm oil. Also the fluctuating nature of the price of palm oil, including the lack of transmission of price increase and exchange rate appreciation forces the out-growers to even out their income by switching to alternative crops to supplement their income in the short run.

It was learnt that customary practices play a pivotal role in the production process. The demand for cash associated with bride price payment, compensation payments, 'head' pays, funeral expenses, etc. normally induces smallholders' palm oil producers to look for ways to earn money to contribute for these events. They are obliged through their customs to be involved in such practices through cash contributions. All the palm oil producers interviewed explained that the demands for cash in such circumstances force the people to work on their palm oil plots to raise enough money to meet these obligations, as well as their immediate personal and family needs. Also for example, fears of sorcery and reprisals can lead to absence from work in the palm oil blocks, which can affect production. The people believed to practice sorcery are chased out from their blocks and the blocks are abandoned or taken over by someone else.

4.2.12 Management skills

Good management practices are ingredients to improving productivity. Most of the out-growers lack skills to manage their time, returns from blocks, and other alternative cash crops. Most of the incomes are mismanaged through consumption of alcohol and gambling, hence there is nothing left to be reinvested back to the palm oil blocks. This limits the ability of farmers to expand or invest in other areas. Despite the assistance from OPIC, the smallholders from outliers also lack knowledge on management and control of pests and diseases, which affect production.

5.0 Constraints and Challenges

There are many challenges the palm oil industry faces today that hinders the production and supply of palm oil. These challenges differ across the various palm oil producing provinces given the varying geographical features and locations. For example, the problems faced by producers, both plantations and out growers, in West New Britain are not the same as the ones faced by producers in Oro province. Some of the common problems confronting the producers are highlighted below; limited land area for development, high population growth, changes in climatic conditions, poor conditions of infrastructure: roads and bridges, high cost of inputs and price distortions.

5.1 Limited Land Area and High Population Growth

It was found during the survey that there is shortage of land with the rise in population and migration of people from other regions to palm oil producing regions to settle in good fertile lands, resulting in the limited availability of good lands for further extension and improvement for high productivity, especially for large-scale production of palm oil. Increase in population has put pressure on land resulting in a lot of land disputes among settlers and original landowners. Original landowners become hostile to incoming aliens and or families dispute each other over ownership of land on which to grow palm oil. Also associated with the increase in population and movement of people, are the increase in social issues becoming a major concern during peak season of palm oil and high prices. It costs a lot of money to provide security and address such issues.

Smallholders are family-based and when their children are in schools, there is always a shortage of labor and those with big blocks find it hard to harvest and some of the fruits are left to rot. Therefore, with the limited manpower and inadequate capital and machinery, production by smallholders is limited, compared to production by plantations. Also smallholders produce for specific reasons, and if those reasons are satisfied, they do not bother producing more or try to expand to new areas to plant and develop new palm oil trees. An increase in population without increasing land size will not increase production, but create more social problems.

5.2 Changes in Climatic Conditions and Weather

It is very uncertain on the climatic conditions and weather patterns due to the effects of global warming and climate change. Since palm oil grows certain meters above see level and on certain climatic and weather conditions, any adverse change in the weather and climatic conditions can affect the overall production by both smallholders and plantations. For example, too much rain during harvest period is not good.

5.3 Poor Conditions of Infrastructure: Roads and Bridges

In order for the smooth mobility of the palm oil fruits to the factories, good roads and bridges are vital requirements. Though, some of the roads in some palm oil producing provinces are good, other provinces are faced with deteriorating conditions of roads and bridges. For example, in Oro province the natural disasters have caused havoc in the province and damaged all existing roads and bridges. Without repairs and maintenance, the roads can only be accessible with Four Wheeled drives. Also the roads leading to some of the plantations are in a very deteriorating condition, so much so that the plantations have to use their own machines and equipment to upgrade the roads leading to their palm oil plantations and the roads to some of the outlying palm oil growing places. Delays of FFB collection from smallholder growers leads to wastage of harvested fruits, since fruits have to be transported to mills when they are still fresh to get quality CPO's. Roads and bridges if well maintained will result in increased production from small holder growers.

5.4 High Cost of Inputs

The costs of inputs have been increasing over the years. All producers of palm oil are faced with increasing production costs. For example, the price of a spade, knife or sickle purchased by a producer in 2001 is not the same as in 2011, or wages paid to employees by a plantation are not the same each year, with the implementation of the minimum wage rates. With deterioration in the machines and equipment, combined with high fuel prices the cost of running them are high. High cost of inputs can result in low investment and loss of productivity.

5.5 Price Distortions

Most of the producers interviewed in the survey expressed that the price that they receive is below the world market price and also they dispute the pricing formula used by estates to pay the smallholders. This acts as a disincentive to the smallholder producers to continue to produce. They expressed that they have to cover for the shortfall in income by resorting to other alternative commercial activities. There is also evidence that price increases and exchange rate depreciations are not channeled to the farmers.

5.6 Other Constraints

Election is one event that disrupts palm oil production patterns. The mobility of the workers and producers to support their candidates during the elections affect the way people allocate their time and labor in the palm oil blocks. Lack of knowledge about good management of palm oil blocks can become hindrance for the industry's consistency in production. The income earned from palm oil is spent recklessly and sometimes mismanaged, especially among the youth. The urgent need to equip small block-holder farmers with sound financial management is vital for sustenance of the industry. With constant distortions in the price of palm oil, small holder producers are discouraged to work in their palm oil blocks. Whenever, there is price shocks, people respond to it directly by not producing palm oil. Therefore, removing price distortion is one way; people can be encouraged to improve productivity.

6.0 Methodology

Most supply response studies use Nerlove (1958) models to study the impact of price on supply of agricultural commodities. One of the major weaknesses of Nerlove models is that these are static models and are unable to capture short-run dynamics. In this study cointegration techniques will be used to study the impact of international price and non-price factors in determining the supply of palm oil exports in Papua New Guinea. The cointegration properties of the variables will be established first and then using error correction model the long-run equilibrium model and the short-run dynamic model will be estimated.

Due to data limitations, selected variables with extended time series data were used to model the supply response function of the palm oil industry.

6.1 The model

Using a similar model as that of Nkang, Abang, Akpan and Offem (2006), to model the supply response of cocoa in Nigeria to changes in international prices of cocoa and other variables, the supply response of palm oil to international price changes and other variables will be calculated for Papua New Guinea. The model assumes imperfect substitution and is founded on traditional supply response theory with the exclusion of export subsidies and inclusion of non-price variables as in Tambi (1999) and Gbetnkon and Khan (2002) thus:

$$LnQE_t = \lambda_0 + \lambda_1 LnREP_t + \lambda_2 LnTWY_t + \lambda_3 Trend_t + \lambda_4 SOI_t + \mu_t \qquad \textbf{(1.0)}$$

Where,

QE_t = export supply of palm oil measured in tonnes

REP_t = (REP_t/DP_t) the ratio of export price of palm oil to the domestic price index.

TWY_t = trade-weighted income levels of major importers of Papua New Guinea's palm oil exports.

Trend_t = trend variable to capture major technological changes in production and export processes.

SOI_t = Southern Oscillation Index[7] capturing weather patterns in Papua New Guinea.

μ_t = stochastic error term assumed to be independently and normally distributed with zero mean and constant variance.

A priori, $\lambda_1 \rightarrow \lambda_4 > 0$,

Time series data are known to be non-stationary as such any estimates of ordinary least squares (OLS) regression are known to produce spurious results with high R^2 and significant variables, however very low Durbin Watson statistics. Error correction models have been known to overcome problems of spurious regressions caused by non-stationarity of the time series data and also provide information for both the long-run relationships and short-run dynamics in the model. The model adopts Engle and Granger (1987) two-step procedures in establishing co-integration. According to "Granger Representation Theorem", establishment of co-integration implies error correction representation of the model.

As a first step, the stationarity of variables used in the model are tested using the Augmented Dickey-Fuller (ADF). The following equation specification is applied for the ADF test;

$$\Delta Y_t \quad = \quad \alpha_0 + \delta Y_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta Y_{t-i} + \mu_t \qquad \textbf{(2.0)}$$

Results of the ADF test are presented in table 1.

Table I. Results of Augmented Dickey Fuller (ADF) unit root tests with trend for individual series.

Variable Level	ADF statistics	Variable First Difference	ADF statistics
LnQE_t	-2.790	ΔLnQE_t	-8.016***
LnREP_t	-2.761	ΔLnREP_t	-5.777***
LnTWY_t	-3.095	ΔLnTWY_t	-3.404*

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[7] The Southern Oscillation Index (SOI) refers to the air pressure differential between Darwin and Tahiti, which drives trade winds. When this index is particularly low, this is called an SO event, and trade winds will be low. Periods of high water-surface temperatures and low air pressure differentials are called ENSO events which typically are associated with droughts in western Pacific countries, including Papua New Guinea. Rainfall in Papua New Guinea is determined by the long run EL Nino-Southern Oscillation (ENSO) system.

1% level	*-4.273*	
5% level	*-3.558*	
10% level	*-3.212*	

The ADF test results indicate that export quantity of palm oil (QE), ratio of export price to domestic price index (REP), and the trade weighted income index of Papua New Guineas major palm oil trading partners (TWY) are non-stationary at levels I(0). At first difference I(1), both REP and QE are stationary at 1 percent significance level, while TWY is stationary at 10 percent significance level, therefore all variables are I(1).

Table II.   **Results of ADF tests on residuals of cointegrating regressions.**

Variables	Long-run coefficients (t-statistics)	Residual Level ADF statistics
$LnQE_t$ on $LnREP_t$	-1.069 (-3.029)	-1.643*
$LnQE_t$ on $LnTWY_t$	1.202 (11.977)	-2.745***
$LnQE_t$ on both variables	see table III	-2.630**

1% level	*-2.642*	
5% level	*-1.952*	
10% level	*-1.610*	

Co-integration test were done on the bi-variant variables on each of the three independent variables on the dependent variable using Engel and Granger (1987) two step procedure. First by establishing the long-run relationship of the variables, then testing the residuals of the equations using ADF for co-integration. ADF results run on the residual of bi-variant models in table II shows co-integration. Testing for co-integration of all 3 independent variable against the dependent variable also establishes co-integration.

Table III.   Estimates of long-run cointegrating regression and diagnostics, sample: 1977 – 2009, Dependent variable: $LnQE_t$

Variable	Coefficient	Std.error	t-statistics	Probability
$LnREP_t$	-0.267	0.183	-1.458	0.156
$LnTWY_t$	1.136	0.109	10.463	0.000
Constant	-3.243	1.526	-2.124	0.042

R^2 = 0.834   adjusted R^2 = 0.823   DW = 0.681
$F_{(3, 31)}$ = 75.382[0.000]
Akaike Information Criteria (AIC) = 0.835;   Schwarz Criteria (SIC) = 0.971

Source: Author's calculation

The long-run co-integrating regression is presented in table III. In the long-run international export price of palm oil does not have any impact on the supply of palm oil exports, while income levels of Papua New Guinea's major palm oil trading partner countries play a significant role in determination of supply of palm oil exports. A percentage increase in trade weighted income of PNG's trading partner' countries results in an increase in palm oil export volume by more than 1.14 percent, i.e. supply response is elastic.

Establishment of co-integrating properties of the variables in the model qualifies error correction specification of the model, according to Granger Representation Theorem. Accordingly the error correction mechanism (ECM) of the model can be specified as:

$$\Delta Yt = \partial_0 + \partial_1 \Delta \bar{A} - \partial_2 (Y_t - Z_t)_{t-1} + \varepsilon_t \qquad\qquad (3.0)$$

Where

$\bar{A}$	= the vector of explanatory variables
Y_t and Z_t	= the co-integrating variables
∂_2	= the error correction mechanism (ECM)
∂_1	= the vector of parameters.

Using equation 3.0 results of the over-parameterised error correction model is presented in table IV. A 3 year lag period has been used in the over-parameterised model as harvesting of crop commences after 3 years from initial planting.

Table IV.   Estimates of over-parameterised error correction model (ecm), sample: 1977 – 2009, Dependent variable: $\Delta LnQE_t$

Variable	Coefficient	Std.error	t-statistics	Probability
$\Delta LnQE_{t-1}$	0.128	0.259	0.493	0.632
$\Delta LnQE_{t-2}$	0.052	0.266	0.232	0.821

$\Delta LnQE_{t-3}$	-0.250	0.186	-1.344	0.206
$\Delta LnREP_t$	-0.077	0.482	-0.159	0.876
$\Delta LnREP_{t-1}$	-0.495	0.485	-1.019	0.330
$\Delta LnREP_{t-2}$	-0.860	0.472	-1.821	0.096
$\Delta LnREP_{t-3}$	-0.995	0.493	-2.017	0.069
$\Delta LnTWY_t$	-0.402	0.167	-2.408	0.035
$\Delta LnTWY_{t-1}$	0.177	0.176	1.002	0.338
$\Delta LnTWY_{t-2}$	-0.254	0.164	-1.544	0.151
$\Delta LnTWY_{t-3}$	-0.038	0.170	0.222	0.829
ECM_{t-1}	-0.694	0.206	-3.364	0.006
SOI_t	-0.033	0.064	-0.514	0.618
SOI_{t-1}	0.066	0.067	0.990	0.344
SOI_{t-2}	-0.095	0.075	1.263	0.233
SOI_{t-3}	-0.013	0.081	-0.158	0.877
Trend	-0.007	0.005	-1.377	0.196
Constant	0.377	0.162	2.238	0.040

R^2 = 0.833   adjusted R^2 = 0.575 σ = 0.165   DW = 2.228
$F_{(3, 31)}$ = 3.233 [0.026]
Akaike Information Criteria (AIC) = -0.4930;   Schwarz Criteria (SIC) = 0.3556

Source: Author's calculation

From the general over-parameterised model, an economically interpretable model was generated. Lags were reduced and variables were omitted to achieve a parsimonious ECM model. The reduction process was carried out using intuition and statistical significance and not based on any economic theory or scientific production theories. The parsimonious reduction process made use of stepwise regression, subjecting each stage of the reduction process to several diagnostic tests before arriving at an interpretable model which is presented in table IV.

Table V.   Estimates of parsimonious error correction model (ecm), sample: 1977 – 2009, Dependent variable: $\Delta LnQE_t$

Variable	Coefficient	Std.error	t-statistics	Probability
$\Delta LnTWY_{t-1}$	-0.817	0.355	-2.300	0.031
$\Delta LnREP_t$	-0.395	0.110	-3.588	0.002
$\Delta LnREP_{t-2}$	-0.271	0.114	-2.387	0.025
ECM_{t-1}	-0.351	0.106	-3.325	0.003
SOI_{t-1}	0.125	0.049	-2.582	0.016
Constant	0.086	0.045	1.924	0.066

Diagnostic tests

Jarque–Bera F-statistics   0.8859[0.642]

B-G LM test F-statistics	0.834[0.4901]
ARCH test F-statistics	2.727[0.1102]

$R^2 = 0.611$ adjusted $R^2 = 0.530$ $\sigma = 0.171$ DW $= 2.173$
F (3, 31) $= 7.546$ [0.0002]
Akaike Information Criteria (AIC) = -0.516;   Schwarz Criteria (SIC) = -0.236

Source: Author's calculation

The parsimonious model has a better fit compared with the over-parameterised model as indicated by a high value of the F-statistics (7.546), which is significant at the 1% level of significance compared with the F-statistics (3.233) of the over-parameterised model, which is significant at 5% level of significance.

The structural variables of the reduced model explain export supply of palm oil better than the over-parameterised model as indicated by the values of their adjusted coefficients of multiple determinations. Similar evidence is given by the Durbin-Watson (DW) statistics for first-order serial correlation and the two model selection criterion (that is Akaike & Schwarz information criterions).

Diagnostics test were applied to the model in order to test the validity of its estimates. Apart from the DW test for first order serial correlation, three other tests were applied on the residuals of the parsimonious model.

The Jarque-Bera Normality test on the residuals, with F-statistics of 0.8859, could not reject the null hypothesis of normality in the residuals, as indicated by the level of significance shown in table V.

Bruesch-Godfrey serial correlation Lagrange Multiplier (LM) test for higher order serial correlation with a calculated F-statistics of 0.834 could also not reject the null hypothesis of absence of serial correlation in the residuals.

Finally, the Autoregressive Conditional Heteroskedasticity (ARCH) tests were used to test for heteroskedasticity in the error process in the model. The results of the calculated F-statistics (2.727) indicated absence of heteroskedasticity in the model.

From the array of diagnostics tests the model is asserted to be well estimated and the observed data fits the model specification adequately, thus we expect that the residuals are distributed as white noise and the coefficients valid for policy discussions.

6.2 Discussion of the results.

The coefficient of the error correction term ECM_{t-1}, as expected has a negative sign and is significant at the 1% significance level. The significance of the error correction term supports cointegration and suggests the existence of long-run steady-state equilibrium between palm oil export supply, real export price and trade weighted

income levels of major trading partner countries. According to these estimates, the implied long-run equilibrium has both real export price of palm oil and trade weighted income levels of major trading partners explain 83 percent of export supply of palm oil in PNG. And if export supply of palm oil diverges from this equilibrium relationship with trade weighted income levels of PNG's major trading partner countries and real export price, then due to the negative error-correction coefficient, there will be a tendency for export supply to adjust towards the target value by 35 percent from previous period diversions. It almost takes 3 and half years for export supply of palm oil to return to its long run equilibrium path after short run adjustments. The speed of adjustment is sluggish.

Though the sign of short-run elasticity of real palm oil export prices is -0.66 as opposed to priori expectations of positive number, it is significant. In the long-run the sign of the coefficient as expected is positive; however it is insignificant in determining export supply of palm oil. In the short-run, if we play down on the signs of these coefficients then a 10 percent increase/decrease in the international price of palm oil would result in a 6.6 percent increase in the supply of palm oil, this is consistent with the survey results, whereby, smallholder growers which consist of 25 percent of suppliers are more responsive to price movements than estate or plantation owners. Overall, supply response to changes in international prices is inelastic in the palm oil industry.

Both the long and short-run estimates are consistent with the survey results. Price factors aren't influential in production and supply of palm oil exports. In Papua New Guinea, non-price factors are pivotal in the determination of palm oil export supplies.

According to the short-run model, trade weighted income levels of PNG's major palm oil trading partners play a pivotal role in determining the supply of palm oil. If we play down the negative sign on the short run coefficient, a 10 percent increase/decrease in the weighted income levels of PNG's major trading partners would result in an increase/decrease in supply of palm oil by 8.17 percent. In the long-run supply response is elastic to changes in trade weighted income levels of PNG's major palm oil trading partner countries.

Weather also plays an important role in the determination of supply of palm oil exports in PNG in the short-run. Results were also confirmed by growers during the field survey. When weather conditions are perfect for production, production and export supply of palm oil increases by 12.5 percent in the short run, while the vice versa is true when weather conditions are not favorable.

7.0 Conclusions

The factors that affect production of palm oil differ greatly, apart from international prices. Independent factors like the ones listed above also affect, especially the smallholders. Given that the smallholders will somehow sustain their daily living, they work in their blocks regardless of the fluctuations in the prices of palm oil. The overall

trend in production for both plantations and smallholders increased consistently, which indicate that the strategies, including extension services, farmers assistance, research and development, employed at WNB by NBPOL and Hargy are working very well for both the plantations and smallholders.

It was found in the survey that any change in the price of palm oil and its associated products can affect how much palm oil is being produced at the smallholder level. It was also found that price of palm oil is not the only factor that affects the producers decisions to produce coffee, there are other non-economic and economic factors like the income people earn, demand for revenue to meet community obligations, school fees, etc. the age and stock of palm oil trees, prices of inputs, the tools and the type of tools, etc. determines how much palm oil a producer can decide to produce. Some of the critical factors that concern the producers are the need to have good roads and bridges, the transmission of prices to the producer at the smallholder level

In the long-run palm oil supply is driven primarily be external factors, i.e. weighted income levels of major palm oil trading partners of PNG. When weighted income levels of major trading partner countries increase/decrease, export supply also response. Since Papua New Guinea exports raw crude oil and is not a price setter in the international palm oil market, the results are consistent. The domestic market for palm oil has not developed properly, hence, dependence on international markets can have an impact on the income levels of the palm oil industry during turbulences in external economies.

The challenge for the industry would be to develop its domestic market. Currently, some products are being extracted from palm oil fruits for the domestic market; however, export of raw palm oil far outweighs any amount of processed product that is produced from extracts of palm oil. Development of a robust domestic market would mitigate impacts of external shocks in the palm oil industry.

Due to data limitations, research has been concentrated on international price of palm oil and trade weighted income levels of PNG's major palm oil trading partners. Further research can be done by segregating the plantation/estate sector against the small holder growers and estimate the responsiveness of palm oil supply to price movements in each sector. Other researches can also be done on the variables that were highlighted from the survey by collecting panel data and run panel data test on the variables to estimate the supply response.

Appendix 1. Survey Results

Supply Response Field Trip Data for Palm Oil - New Britain Palm Oil Limited, Hargy Oil Palm Limited and Poliamba Limited

1. Houseold Data	A. Mandopa CRP	B. MAI VOP	C. MAI VOP	D. Mandopa VOP	E. MOSA VOP (CRP)	F. 009003-0884 (LSS)	G. 003-920 (LSS)	H. 003-915 (LSS)	I. 003-1010 (LSS)	J. SARAKO-LOP (LSS)	AVERAGE
Head	1	1	1	1	1	1	1	1	1	1	
Spouse	1	1	1	1	1	0	1	1	1	1	
Children >15	2	0	1	1	3	6	15	2	6	4	
Children 10-14	0	0	2	2	2	0	0	1	0	0	
Children <10	0	4	3	0	0	0	0	0	0	0	
Relatives > 15	6	0	7	2	2	2	0	3	0	0	
Relatives > 10-14	0	0	0	0	0	0	0	0	0	0	
Relatives < 10	3	2	0	0	0	0	0	0	0	0	
Employees (Others)	0	0	0	5	0	0	0	0	3	3	
Total manpower	13	8	15	12	9	9	17	8	11	9	11
2. Crops Cultivated	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	
Oil Palm Tree	5	4	3.1	4	3	6	3	3	8	4	4
Other Perennial	3	0	3	3	4.5	0	0	0	0	0	1
Annual Crops	1	0	2	1	0	0	0	0	0	0	0
Total Area	9	4	8.1	8	7.5	6	3	3	8	4	6
3. Age of Palm Tree (Current)											
<1	0	0	0	0	0	0	0	0	0	0	0
1-2	0	120	0	0	0	0	0	0	0	0	12
3-4	0	0	0	0	0	0	0	0	0	0	0
5-6	0	0	0	0	0	0	0	0	0	0	0
7-8	0	240	0	240	0	0	120	0	0	0	60
>8	600	120	380.0	240	480	700	240	360	960	1080	516
4. Removal, Replanting & New Palm Tree											
Trees Uprooted	0	0	0	0	10	480	120	120	18	480	123
Trees replanted	0	0	20	0	10	480	120	120	24	480	125
New tree (acreage)	70	0	15	0	120	0	0	0	8	480	69

	A. Mandopa CRP	B. MAI VOP	C. MAI VOP	D. Mandopa VOP	E. MOSA VOP (CRP)	F. 009003-0884 (LSS)	G. 003-920 (LSS)	H. 003-915 (LSS)	I. 003-1010 (LSS)	J. SARAKO-LOP (LSS)	AVERAGE
5. Other perennial and annuals											
Kaukau	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Yam	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
Vegetables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
Others	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	
6. Inputs & Labor											
Fertilizer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Insecticide	nil	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Herbicide	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Tractor (rent)	truck	Truck/Wheel-barrow	Truck/Wheelbar-row	Truck/Wheel-barrow	Truck/Wheel-barrow	No	No	No	No	No	
No. of workers	13	8	15	12	9	9	17	8	11	9	11
7. Wealth Owership											
Cattle	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Pigs	Nil	Nil	Yes	Nil	Yes	Yes	Yes	Nil	Nil	Yes	
Sheep and Goat	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
HMCD	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Other (specific)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Other sources of income	Nil	Nil	Yes, trade Store and Liquor shop	Nil	Yes, poultry	Nil	Nil	Nil	Canteen	Nil	
8. General Comments											

	A. Mandopa CRP	B. MAI VOP	C. MAI VOP	D. Mandopa VOP	E. MOSA VOP (CRP)	F. 009003-0884 (LSS)	G. 003-920 (LSS)	H. 003-915 (LSS)	I. 003-1010 (LSS)	J. SARAKO-LOP (LSS)	AVERAGE
	6-7 tons/harvest and 10-12 tonnes/ month. Cost of inputs increased & Transport + other costs are also high. There is no bidding agreement with the NBPOL for as-sistance. Pricing formula is also a concern for most of the growers.	Regard-less of the changes in price, still work in blocks due to revenue demand. Assistance from NBPOL in terms of tools, chemicals, seedlings etc are bought.	Harvest is every 2 weeks and still clearing new areas to expand. Harvest about 3 tonnes every 2 weeks. Regardless of price changes, still work on block because of demand for rev-enue for school fees and social obligatio in loca price not same as at international market.	Stealing is a con-cern. Help from NBPOL is good but transport is also high. Mainly family members work in the Block but from time to time they get assistance from their neighbour block holders. They have mixed cropping with coconut and cocoa.	NBPOL assists with tools and chemcials. Harvest is 6-7 tons per harvest and 12-14 tons per month. 2 harvests per month. Apart from palm oil, they also caltivate cocoa (about 500 trees).	They still produce regardless of the fall in price. Produce about 10 tonnes annually. Labor is mainly from family.	Regardless of prices, they still produce due mainly to revenue de-mand. Produce around 72 tonnes annually or 6 tonnes per month.	Even though prices are down, they still work in their blocks to harvest to meet other pressing demands. Produce around 104 tonnes annually (8.7 ton per month).	There is no sensitivity to movements in prices. Produc-tion is based on need basis. Produce about 20 tonnes per month (208tons/year)	Even if the price is down, they still have to produce as there is no other commodities they can switch to. Still want to extend the oil palm but shortage of land. Produce around 240 tons annually.	

References

Bank of Papua New Guinea, 2011, **Quarterly Economic Bulletin,** June 2011 Issue, Bank of Papua New Guinea, Port Moresby

Engle, R. F. and Granger, C. W. J. (1987). **"Co-integration and error-correction: Representation, estimation and testing".** Econometrica (Econometrica, Vol. 55, No. 2) 55 (2): 251–276.

Gbetnkom, D. and S.A. Khan, 2002. **"Determinants of agricultural exports: the case of Cameroon".** African Econ. Res. Consortium (AERC), 120: 1–41

Jan Willem van Gelder, 2002, **"Australian economic links with the Palm oil sector of Papua New Guinea: A research paper prepared for Humane Society International,"** Profundo, De Bloemen 24, 1902 GV Castricum The Netherlands.

Katherine G., Koczberski, G., and Curry, G., 2003, **"Working With Smallholders To Improve Productivity - An Extension Manual for OPIC Officers,"** Department of Human Geography, Research School of Pacific and Asian Studies, Australian National University, Canberra ACT 0200 AUSTRALIA.

Kauzi, G., and Samson, T., 2009, *Determinants of Exchange Rate in Papua New Guinea: Is the Kina a Commodity Currency,* Bank of Papua New Guinea working paper series 2009/01.

Koczberski, G., Curry, George N.C., 2008, **"Smallholder Mobile Card Trial, Bialla Palm oil Project, West New Britain Province, Papua New Guinea,"** Research Unit for the Study of Societies in Change, Curtin University of Technology, Perth, Western Australia.

Koczberski, G., Curry, George N.C., 2004, **"Mobilising Smallholder Labour In Palm oil Production: Results Of The Mobile Card Trial, Hoskins, West New Britain, Papua New Guinea,"** Department of Social Sciences, Curtin University of Technology, GPO Box U1987, Perth WA 6845.

Koczberski, G., Curry, G., and Gibson, K., 2001, **"Improving Productivity of the Smallholder Palm oil Sector in Papua New Guinea: A Socio-Economic Study of the Hoskins and Popondetta Schemes,"** The Australian National University Department of Human Geography, Research School of Pacific and Asian Studies, Canberra ACT 0200.

McLaren, P., and Fleming, E., 1999, **"Palm oil Supply Responsiveness to price and exchange rate in Papua New Guinea: Tree Crop Policy Options Project in** New Britain Palm Oil Limited, **"Annual Reports,"** Various Issues (2000 – 2010), PMB, Kimbe, West New Britain Province.

Papua New Guinea," Occasional Paper 3. School of Economics Studies, University of New England.

New Britain Palm Oil Limited, **"Sustainability Handbook, Version Three,"** 2009, PMB, Kimbe, West New Britain Province.

Tambi, N.E., 1999. **"Cointegration and Error Correction Modelling of Export Supply in Cameroon".** Agric. Econ. Elsevier, 20: 57–67