Journal of the Asia Pacific Economy, 2016
Vol. 21, No. 2, 235–256, http://dx.doi.org/10.1080/13547860.2016.1145789

Routledge
Taylor & Francis Group

Challenges for agricultural development in a resource-rich developing country: a case study of Papua New Guinea

Osborne Sanida[a], John Asafu-Adjaye[b]* and Renuka Mahadevan[b]

[a]*National Research Institute, Port Moresby, Papua New Guinea;* [b]*School of Economics, The University of Queensland, Brisbane, Australia*

Many resource-rich developing countries are often faced with the challenge of generating sufficient employment for poverty alleviation due to factors such as the capital-intensive nature of resource extraction, the lack of (or weak) linkages between the resource sector and the wider economy, and potential Dutch disease effects. Using Papua New Guinea as a case study, this paper uses a dynamic computable general equilibrium model to analyse some options for a resource-dependent developing country to boost growth in the agricultural and manufacturing sectors. Four policy experiments were conducted to examine the impacts of increased primary factor productivity growth in the agricultural and manufacturing industries; increased investment in agriculture; increased investment in agriculture in conjunction with improved infrastructure; and improved value adding and productivity in agro-processing. Our results indicate that investing in agriculture and manufacturing without addressing supply side constraints such as poor road infrastructure would fail to maximise the desired impacts. We also show that by shifting the emphasis from production of primary commodities for export to value adding or secondary production activities, resource-dependent developing countries could enhance growth and employment.

Keywords: Resource rich-developing countries; agricultural development; computable general equilibrium model; Papua New Guinea

JEL Classifications: Q18; C013; C68

1. Introduction

Developing countries tend to rely on their natural resources for their national incomes and the livelihoods of their populations. In many of these countries, the agricultural and mineral sectors typically account for well over 70% of real gross domestic product (GDP). Agricultural exports tend to be dominated by a few primary commodities (e.g., cocoa, coffee, tea, etc.), while agricultural production is characterised by subsistence and low-input farming practices and provides employment (formal and informal) and livelihood to the majority of the population. Resource-dependent developing countries such as Papua New Guinea (PNG) are faced with additional challenges of boosting employment creation and reducing poverty from exploitation of their mineral resources. These challenges stem from the fact that resource extraction tends to be capital intensive and creates relatively few direct and indirect jobs. Furthermore, many of the multinational companies operating in these countries mostly repatriate their earnings overseas and spend very little in the countries in which they operate. This implies that the country receives very few benefits from these companies and certainly very little that promotes employment. Thus the onus

*Corresponding author. Email: j.asafuadjaye@uq.edu.au

falls on the government to use their earnings from these resources to improve the living standards of the people.

Resource-dependent developing countries with a booming mining sector are susceptible to the Dutch disease. The Dutch disease (see Corden and Neary 1982; Wijnbergen 1984; Sachs and Warner 1997, 2001; Gylfason 2001) occurs due to the appreciation of the domestic currency as a result of the increase in the supply of foreign exchange reserves due to the large increase in exports. The stronger domestic currency makes the country's exports relatively more expensive (to foreign demanders) and the exports of the non-expanding export industries become less competitive on the world market. A *resource movement effect* occurs due to the higher prices in the expanding export industry (caused by a stronger real exchange rate). Consequently, factors of production are drawn or attracted away from the non-expanding export industries and the rest of the economy to the expanding export industry (Corden 1984).

PNG's reliance on primary commodity exports has exposed the economy to volatile economic growth. In boom times (e.g., when gold prices have increased drastically), there has been a positive effect on economic growth, although at the same time that has led to appreciation of the real exchange rate which has to some extent reduced the external competitiveness of the tradable agricultural sector. In simulations carried out by **Mahadevan and Asafu-Adjaye (2013) on the possible effects of the massive PNG Liquefied Natural Gas (LNG) project, which commenced operations in 2014, it was projected that it would result in appreciation of the real exchange rate and a contraction of the tradable agricultural sector. A similar conclusion was reached by Dixon, Kauzi, and Rimmer (2010) in their analysis of the impacts of the LNG project. Figure 1(a) shows that although the

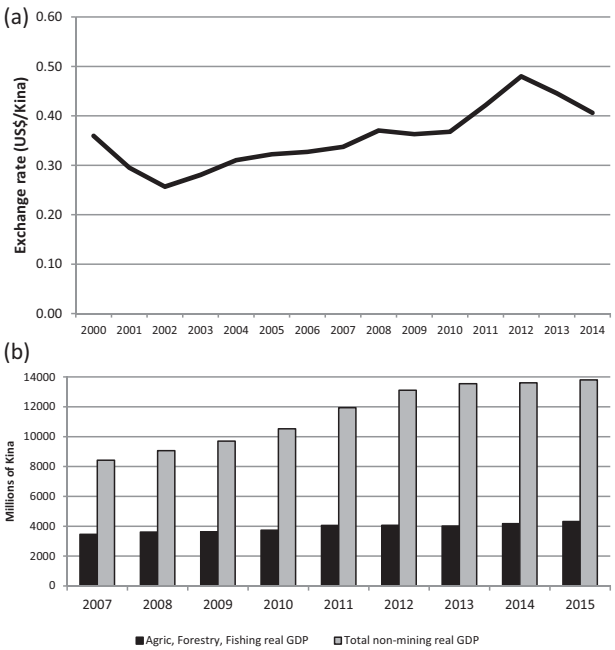

Figure 1. (a) Exchange rate (Kina/US$) movements.
Source: World Bank (2015). (b) Non-mining and agricultural real GDP.Source: Department of Treasury (2014).

nominal exchange rate (US$/Kina) had been steadily appreciating since 2002, there was a spike in the rate of appreciation when construction of the LNG project began in early 2010. Although the Kina weakened a little in 2014, the rate was still higher than in 2010. Figure 1(b) shows that while total non-mining real GDP has grown steadily since 2007, the growth rate of agriculture, forestry and fishing (dominated by agriculture) has stagnated. The effect of the LNG project can be seen here in the sense that between 2007 and 2010, the agricultural sector's real GDP grew at an average rate of about 3.5% per annum. However, since construction of the project began in 2010, the sector's growth rate has approximately halved to a rate of about 1.3% per annum.

Given this background, the aim of this paper is to analyse the potential options for a resource-dependent developing country to increase growth in its agricultural sector in the face of a booming mining sector, using PNG as a case study. The analysis is carried out with the aid of computable general equilibrium (CGE) model of the PNG economy. The paper makes a contribution to the literature on a number of fronts. First, although the effects of a resource boom have been extensively researched, very few studies have focused on what can be done to mitigate the adverse impacts beyond some general policy recommendations. In this paper, we consider specific policy responses that are backed up with empirical evidence. Second, in view of the fact that there are a large number of developing countries facing a similar problem as PNG, the study's results hold valuable lessons for such countries. Third, unlike static studies which discuss the final impacts of policy simulations, here, we use a dynamic model to examine the impacts over time which is useful for policy implementation. The CGE model is suitable for use as it analyses the impacts on a whole range of macroeconomic variables, providing a valuable tool to consider mitigating effects appropriately.

The remainder of the paper is organised in the following fashion. Section 2 sets the study in context by briefly describing the structure of the PNG economy. This is followed by a description of the modelling approach in Section 3. Section 4 describes the simulation scenarios to be analysed, while Section 4 presents and describes the simulation results. Section 5 provides the concluding remarks and the policy implications of the study's findings.

2. Overview of the Papua New Guinea economy

PNG has a population of about 7.3 million people[1] (United Nations 2008) and a land area of 462,840 square kilometres, which is made up of the eastern half of the main island of New Guinea[2] and the island groups of Bougainville, Manus, New Britain, and New Ireland. Although the country is rich in natural resources, it faces significant development constraints. These include challenging geography, extreme ethnic diversity, law and order issues, and a rapidly growing and widely dispersed population (ADB 2009). Moreover, its economy is relatively small and open and, therefore, very much susceptible to external market forces or influences.

The following significant features of the PNG economy are prevalent: a large subsistence and informal sector which caters for over 85% of the population; dominance of agriculture (including forestry and fisheries); high concentration of exports on primary products; and high dependence on imports, particularly manufactured goods. Increasing domestic development investment, good governance, encouraging external trade and investment, and fostering human resource development will help address the challenges and improve the living standards of the population. The agriculture sector, defined broadly to include forestry and fisheries, dominates the contribution to GDP, with an

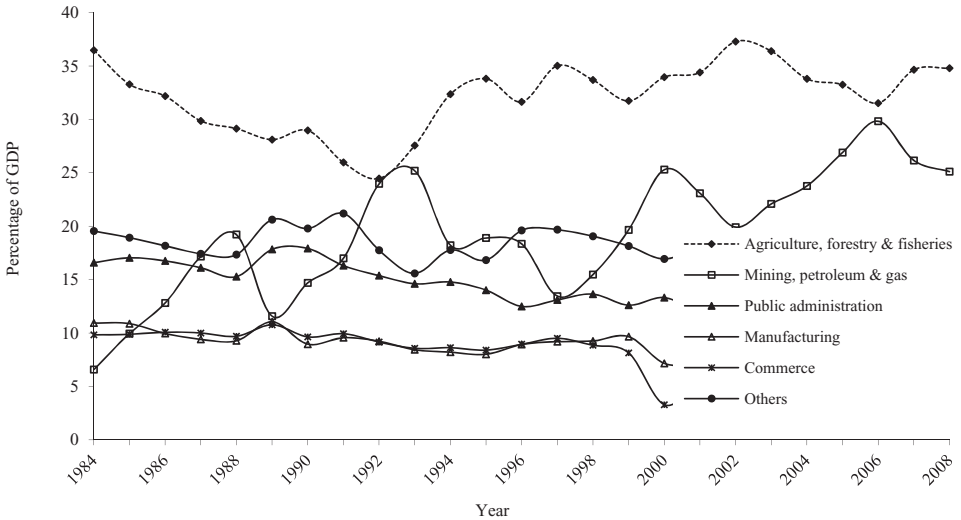

Figure 2. Sectoral contribution to Papua New Guinea's GDP (%).
Source: Bank of PNG (2010).

annual average share of 32% for the period 1984–2008. The agriculture sector has been and continues to be the backbone of the economy, supporting the livelihood of about 85% of the country's population.

The mining and petroleum sector has the second highest annual contribution to GDP of about 19%, on average, for the 25-year period. The strong performance of the mining and petroleum sector around mid-2000 (with a peak of 30% contribution to GDP in 2006) was mainly attributable to the increase in export commodity prices. Despite the strong contribution of the sector to GDP, it needs to be noted that most mine development impacts in PNG are short-lived and relatively unstable because the production quickly peaks (booms) and then tumbles (busts) (Mawuli and Sanida 2000). This is demonstrated by Figure 2, where the time series for the mining, petroleum and gas (contribution to GDP) is relatively volatile compared to the other sectors. The third main contributor to GDP is public administration, which refers to the value of community, social and personal services produced. Following public administration are commerce and manufacturing, each of which contributed about 8% to GDP, on average annually, for the period and have remained relatively stagnant. The manufacturing sector comprises mainly assembly type industries and processing industries, which are heavily dependent on imported capital and other inputs to create fixed domestic capital that feeds other industries. The performance of the sector is therefore very responsive to external market forces.

Exports in PNG are dominated by mineral exports (gold, copper and crude oil). Gold was PNG's highest contributor to mineral exports between 1990 and 2001 (45% per annum on average), followed by crude oil (32%), copper (22%) and others (1%). Agriculture exports are ranked second, after mineral exports, in terms of contribution to total export earnings, with an 18% share on average (Bank of Papua New Guinea 2010). Being a commodity export dependent economy, PNG is also highly susceptible to downswings in commodity prices. For example, the global financial crisis which began in September 2008 reduced the prices of commodities such as copra, tea, palm oil, crude oil and copper. Since then, however, commodity prices have rebounded, but prices of some commodities

such as copra and palm oil remain below their 2008 values. A major development in PNG's export sector is the massive LNG projected which is due to start production in 2014. The project is expected to increase the size of the economy by an additional Kina 9.6 billion per year from the current level of about Kina 12 billion per year (ACIL Tasman 2008).

3. Modelling approach

The model, PNGGEM, used in this analysis[3] has 43 industries producing 38 commodities (see Appendices 1 and 2). Because the agricultural sector is important in the PNG economy, it is disaggregated into 13 agricultural industries divided into smallholder and plantation sectors for the export crops (cocoa, coffee, palm oil and other tree crops). Most of the commodities in PNGGEM have competing imports, but as is the case in most CGE models, we invoke the Armington assumption so that the imported varieties of a commodity are considered to be imperfect substitutes for the domestically produced varieties. This section presents a brief overview of the theoretical structure of the model and describes how the labour market and capital utilisation are modelled.

The theoretical structure of PNGGEM is based on Walras' Law which envisages the economy as a circular flow of funds where the supply of goods equals the demand for goods. The supply side is given by the sum of production and imports; while the demand side is given by the sum of intermediate inputs, consumption, private investment, government consumption, government investment and exports. The circular flow of funds implied by the above Walrasian condition is first disaggregated into five core equations representing the following key sectors of the economy: production sector, household sector, government sector, external sector and finance sector. The left-hand side expressions (in change form) of the equations represent the sources of funds, while the right-hand side expressions (also in change form) represent the uses of funds. Each of the five core equations is briefly described below.

The production sector equation describes the flow of funds in each of the 43 industries in the model. The funds earned from selling the output are shown on the left-hand side, while on the right-hand side we have the allocation of these funds. The funds are applied to intermediate input costs, labour costs, payments to capital owners (net of tax), payment of government production and import taxes, and involuntary payments due to the external consequences of crime. In the household sector, the sources of funds are factor income receipts from labour and capital supplied to the production sector, net investment income from overseas, net private unrequited transfers from overseas and net government transfers. The funds are then applied to consumption, private savings, income taxes and the external costs of crime. Private savings are determined by the product of marginal propensity to consume out of disposable income and aggregate disposable income.

The government sector sources its funds from tax revenues, net foreign aid, payments to government-owned capital by the production sector and public unrequited transfers from abroad.[4] These funds are applied to consumption, investment, transfers to households and to the external costs of crime,[5] while the balance (change in government savings) goes to the budget surplus (or deficit), which is determined as the residual of revenues less expenditures. The external sector equation corresponds to the balance of payments and can be interpreted as the source and use of the local currency (Kina) to pay for imports or to transfer investment income overseas. The funds are applied to purchase exports, capital inflows investment income inflows, and net unrequited public and private transfers. The external sector also includes an expression for the external cost of crime

which is interpreted as a transfer of local funds to the rest of the world for PNG does not receive a return (i.e. it is a loss the economy).

The final core equation depicts the finance sector. Here the source of funds is from private savings, net government savings and net capital inflows. These funds are then applied to private investment. Private and government savings are determined within the household and government sector equations, while private investment is determined at the industry level and aggregated across industries. Dealing with investment and capital consumption in CGE modelling presents a difficult challenge because CGE models are effectively one period models, whereas current investment generally tends to be realised over future periods as well as the current period.

In addition to the five core equations described above, there are two additional types of equations: (1) equations designed to determine variables in the core equations (e.g., prices, different types of demand, output supply, etc.) and (2) equations designed to determine variables independent of the core equations (e.g., real GDP, exports, imports and aggregate employment).

3.1. Modelling the labour market

In this application, we split the PNG labour market into four sectors: village, plantation, urban and urban 'murky' (or informal) sectors. For the first three sectors, there are three categories of labour defined – skilled, semi-skilled and unskilled labour, while the village and murky sectors are assumed to utilize only unskilled labour. Equations are specified to determine the level of demand for each labour type for a given level of labour requirement by each industry. We employ a modified version of the Harris–Todaro mechanism (Harris and Todaro 1970) in which the labour market is split into rural and urban sectors. The urban sector is characterised by a distorting urban sector wage which draws labour from the rural to the urban areas. However, because the wage is sticky downwards, employment does not respond to the increased labour supply and, therefore, the rural–urban migration results in a labour surplus. Rural–urban migration continues until the expected return (given that urban employment is not guaranteed because of surplus labour) for an urban worker equals the opportunity costs of leaving the rural environment. The surplus labour feeds into the 'murky' sector (Fields 1975) which is made up of legitimate informal employment and crime.

3.2. Modelling capital utilisation

Unlike some CGE models such as the MONASH model (Dixon and Rimmer 2001) where capital is assumed to be utilised at full capacity (or at a constant ratio of full capacity), here capital utilisation is allowed to vary according to profitability with the following assumptions.

(1) Industries adjust their capital stock levels through investment to target an optimal level of capacity utilisation.
(2) Within a given period, industries adjust their capacity utilisation according to the changes in market conditions. For example, if there is an increase in demand leading to increased profit opportunities and increased rates of return, then the industry will respond by increasing its factor usage (including its capital usage).

Let the optimal level of capital consumption in industry j be given by F_{kj}^{opt} for a given stock level, K_j.[6] The percentage deviation of capital consumption (U_j) from its optimum level can then be written as

$$U_j = \frac{F_{kj} - F_{kj}^{\text{opt}}}{F_{kj}^{\text{opt}}} \tag{1}$$

When the optimal level of capital consumption is being used, then $U_j = 0$. Next, it is assumed that there is a relationship between the real price of capital (i.e. the real gross return on a unit of capital before depreciation) and the percentage change in the deviation of capital consumption from the optimum whereby increases in the real price of capital lead to increases in the employment of capital. Let the relative price of capital in industry j in percentage terms be w_{kj}^{rel} (net after tax). The percentage change in net relative returns is then defined as the change in nominal returns less inflation and less the cost of capital (the real interest rate). That is,

$$w_{kj}^{\text{rel}} = w_{kj}^{\text{net}} - \rho - r \tag{2}$$

where w_{kj}^{net} is net nominal returns, ρ is the GDP deflator and r is the real interest rate. If relative returns in industry j improve, then capital utilisation (and consumption) in that industry will increase. This relationship is captured as follows:

$$dU_j = \sigma_j^k \cdot w_{kj}^{rel} + h_{kj}^f \tag{3}$$

where dU_j is the change in capital consumption and h_{kj}^f is an exogenous shock term.

The next step is to determine the optimal or target level of capital utilisation (F_{kj}^{opt}). This is expressed as a fixed proportion of capital stock ($\boldsymbol{\zeta}_j$) and the current capital stock level (K_j^{t0}) as follows:

$$F_{kj}^{\text{opt}} = \zeta_j \cdot K_j^{t0} \tag{4}$$

The fixed proportion is the variable (so that ζ_j is not the same across industries). The model also defines the capital stock level for the next period, F_{kj}^{opt1} (which is determined according to the investment and depreciation in the current period) and the optimal level of capital utilisation in the next period (K_j^{t1}). The relationship between the two is expressed as

$$F_{kj}^{\text{opt1}} = \zeta_j \cdot K_j^{t1} \tag{5}$$

The next step is to model investment. It is assumed that future expectations are based on current circumstances. In this case, net investment (i.e. investment less depreciation) will respond in the same direction as dU_j if capital consumption is initially at the optimal level. In other words, if capital consumption increases beyond the optimal level so that $dU_j > 0$, then the industry will respond so that net investment will be greater than zero. That is, if $dU_j > 0$, then there will be net additions to the capital stock in response.

These net additions to the capital stock will then increase the optimal level of capital consumption in the next period. A gradual process of adjustment is assumed so that if

percentage capital consumption (f_{kj}) is initially at the optimal level, then $f_{kj}^{\text{opt1}} = \gamma_j \cdot f_{kj}$, where c (the speed of adjustment) lies between 0 and 1, and f^{opt1} is the optimal level of capital consumption for the next period. Based on the assumption of gradual adjustment, the change in the optimal level of capital consumption in the next period will be a partial correction of the disequilibrium at the end of the current period. That is,

$$dF_{kj}^{\text{opt1}} = \gamma_j[(F_{kj} - F_{kj}^{\text{opt}}) + (F_{kj} \cdot f_{kj} - dF_{kj}^{\text{opt}} \cdot f_{kj}^{\text{opt}})] \tag{6}$$

Finally, investment is determined in the following relationship:

$$dK_j^{t1} = F_j^i - D_j \tag{7}$$

where dK_j^{t1} is the change in the capital stock level in the next period, F_j^i is investment and D_j is depreciation.

The model is a recursive dynamic model in that each period is solved as a static equilibrium problem given the stock of capital and investment.[7] The results for a particular period are used to update the database to form the basis for the next simulation and so on.[8] In the simulations, we compute changes in the endogenous variables from their values in the initial solution caused by changes in the exogenous variables. Two types of simulations are carried out in these multi-step simulations. The first is the base case simulation that represents the projection path the PNG economy will follow under *business as usual* conditions. This is in effect a forecasting simulation where forecasts are made about the growth rates of key socioeconomic variables such as population, real output, real government consumption and investment expenditure, domestic and world inflation, and export and import prices, which are all set exogenously. The forecasts are from expert agencies such as the World Bank, the International Monetary Fund and official government forecasts (see Appendix 3). The second simulation is a policy scenario that measures the path the economy would take following the introduction of a policy (e.g., a tariff reduction). The difference between the policy scenario and the base case scenario measures the impact of the policy.

Typical exogenous variables in the policy scenario include tax rates, import and export prices, tariffs, various exogenous shock terms, and the consumer price index (CPI), which is the *numeraire*. Although the base year for the model is 2002, it was not necessary to update it because the base case simulations used actual percentage changes in the key variables to update the model by applying them as shocks. The model was solved using Version 9 of *GEMPACK* (Harrison and Pearson 1996).

4. Simulation scenarios

In order to analyse options available to PNG to increase growth in its agricultural sector, given a booming mining sector, we undertake four policy experiments using the model. These are as follows: (1) the impacts of increased primary factor (capital and labour) productivity growth in the agriculture, manufacturing and service industries; (2) the impacts of increased investment in agriculture; (3) the impacts of increased investment in agriculture and improved infrastructure and (4) the impacts of improved value adding and productivity in agro-processing. Each of these scenarios is briefly discussed.

4.1. Increased primary factor productivity

PNG stands on the verge of another major resource boom, with the LNG project which started in 2014. Therefore, to simulate the impacts of increased primary factor productivity, we take the LNG project as our base case simulation and show how government efforts to improve the productivity of labour and capital can mitigate the adverse impacts of the resource boom. A large resource project such as the LNG project has the potential to cause the real exchange rate to appreciate due mainly to the huge inflows of investment into PNG. The real exchange rate appreciation, combined with a flow of capital into the resource sector, results in a reduction in the external competitiveness of industries such as agriculture, fishing, manufacturing and some services and thus leads to a decline in their output. Additionally, the rates of return decline in these sectors, resulting in an outflow of labour and capital to the booming sector. In general, productivity in PNG agriculture and manufacturing, as reflected by skills levels and the use of improved technology, are quite low (AusAID 2006). In this scenario, it is assumed that the government lifts productivity in agriculture and manufacturing by increasing expenditure in education and training. The annual growth in productivity (10%) in these sectors is proxied by the rate of growth in the government's development budget as revealed in the *Medium Term Development Plan (MTDP) 2011−2015* (Department of National Planning and Monitoring 2010).

4.2. Increased investment in agriculture and improved infrastructure

In addition to improving productivity, there is a need for the government to address supply side constraints in the economy that prevent output from reaching its true potential. Although PNG has the potential to improve agricultural production, capital inflows (both public and private) have been negative until the last few years due to the LNG project. The lack of investment in agriculture is linked with other factors such as government policies and the prevailing business environment which we highlight below. Another serious obstacle to output expansion is the lack of or inefficient physical infrastructure such as roads, bridges and ports. PNG is a highly mountainous country and many areas in the hinterland are only accessible by air. The few roads that exist are not well maintained, while the cost in air transportation tends to be high. Therefore, overall, the inefficient transportation system negatively affects the movement of factors of production and final products from their sources to their destinations/markets. The need to boost investment in the agriculture sector is also warranted by the fact that 85% of the PNG population lives in the rural areas and depends on agriculture for sustenance and income creation. Therefore, the increase in investment for agriculture would boost income creation and employment opportunities for the bulk of the population that resides in the rural areas.

To simulate investment in agriculture, we shock total real investment by 7.3% per annum for the period 2014−2018. The magnitude of the shock is taken from the government's projection contained in the National Agriculture Development Plan (Ministry of Agriculture and Livestock 2006).

In order to conduct the infrastructure policy experiment, we focus exclusively on road transportation in the agricultural sector in view of the importance of agriculture's contribution to national income and employment. We shock the productivity of road transportation as an input into the agriculture industries coffee, cocoa, palm oil and copra by 7%. This percentage is based on the estimated average annual growth of sealed national roads contained in the government's MTDP 2011−2015 (Department of National Planning and Monitoring 2010).

4.3. Improved value adding and productivity in agro-processing

With a comparative advantage in primary agricultural production, PNG could increase food production and employment by adding value to agricultural commodities. For example, this could be done through improving investment and productivity in the food processing industry. The need to increase food output is based on both government policy and the opportunities for trade. In terms of government policy, under the *MTDP 2011–2015*, food processing is an important policy objective of government because 'its development will pave the way for value adding to PNG's agricultural sector' (Department of National Planning and Monitoring 2010). Besides value adding, the MTDP also emphasises the need to address food security and also to take advantage of export market opportunities (such as the Economic Partnership Agreement with the European Union that has been ratified, as well as other trade agreements) for processed food (Department of National Planning and Monitoring 2010). To undertake this policy experiment, we shocked intermediate inputs used by the food processing industries from the coffee, cocoa and palm oil industries. This reflects increased use of these products by the food processing industries. We also assume that the food processing industry increases its use of new technology and therefore we shock labour and capital productivity in the industry by 10%.

5. Simulation results

The results of the three policy experiments are presented under two broad headings: macroeconomic and sectoral impacts. As indicated in Section 4, the policy simulations are undertaken in two steps. In the first step, the effects of the LNG project are estimated as a base case. The second simulation then involves imposing the given policy scenario on the base case. For each chosen variable, percentage changes are reported for the base case, the effect of the policy scenario plus the base case, and the policy effect (the difference between the base case and the policy scenario). The figures reported here are period averages for the forecast period, which is 2011–2018.

5.1. Macroeconomic impacts

5.1.1. Impacts of increased primary factor productivity

The macroeconomic impacts of increasing primary factor productivity are shown in Figure 3. It can be seen that the LNG project could reduce economic growth by 15 percentage points in the absence of the mitigation measures. In other words, implementing the LNG project together with mitigation measures increases GDP by an additional 15 percentage points compared to the scenario where the LNG project is undertaken on its own. This positive impact is in turn due to positive impacts of the mitigation measures on household consumption (16%), real investment (5%), and a higher trade surplus due to a higher positive impact on exports (21%) compared to imports (10%). The higher exports are due to the negative impact on the real exchange rate (−1%). Real national welfare is also positively impacted by the mitigation measures (32%). Overall, the mitigation measures have a positive macroeconomic impact.

5.1.2. Impacts of increased investment in agriculture and improved infrastructure

Next, we show results for the macroeconomic impacts of increasing investment in the agricultural sector (Figure 4). It can be seen that total real private consumption grows by

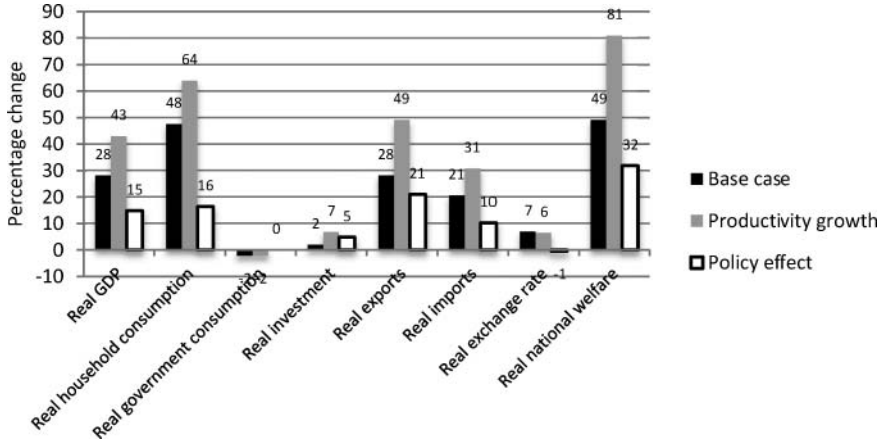

Figure 3. Macroeconomic impacts of factor productivity growth (percentage changes).
Note: The base case represents export expansion in the resources sector including the LNG project.
Source: PNGGEM simulation results.

35 percentage points in this policy scenario, which is 28 percentage points higher than the base case growth rate. The positive impact on household consumption is driven by increases in income due to the increase in the employment of labour, which grows by about 13 percentage points above the base case growth of 5 percentage points. Aggregate government consumption is also positively affected by the investment shocks, increasing by 3 percentage points above the base case growth of 11 percentage points.

On the other hand, real aggregate private investment declines by 38 percentage points below the base case. This result is somewhat unexpected given that an increase in industry investment is expected to have a positive impact on the total investment. However, in this case, it is possible that the investment increases in the four key agriculture sectors

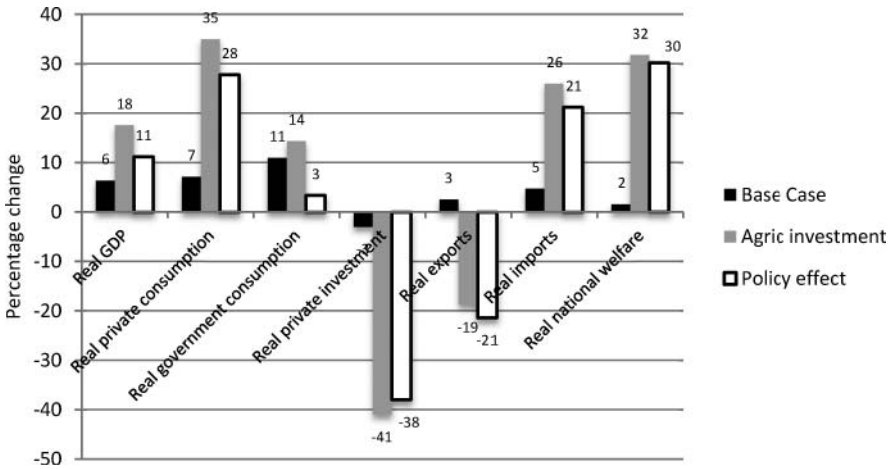

Figure 4. Macroeconomic impacts of agricultural investment (percentage changes).
Note: The base case represents export expansion in the resources sector including the LNG project.
Source: PNGGEM simulation results.

also draws resources away from the other sectors (i.e. a sort of crowding out effect) which would reduce investment in those sectors and thus reduce total investment.

For the aggregate trade demand variables, the investment shocks have a negative impact on aggregate real exports but a positive impact on aggregate real imports. This occurs via the real exchange rate effect. In terms of the real exchange, it can be seen that the increase in investment for the four agriculture industries drives up the real exchange rate by 8 percentage points. The higher real exchange rate makes PNG exports relatively more expensive, hence there is a decline in the value of real exports by about 19 percentage points. On the other hand, the higher real exchange rate makes imports relatively cheaper (i.e. the Kina can buy more foreign currency to finance more imports) and thus real imports increase by 21 percentage points.

Overall, the increase in aggregate consumption (both private and government) outweighs the decrease in aggregate investment and hence real aggregate economic growth increases by 11 percentage points above the base case. The increase in consumption as well as the positive effect on savings (13 percentage points for Government and 68 percentage points for households) increases the real aggregate national welfare by 30 percentage points.

As indicated earlier, one of the key supply side constraints in PNG is the poor physical infrastructure (e.g., roads and bridges), which adversely affects road transportation services. In the second simulation we examine the combined effects of increased agricultural investment and improved transportation services. It can be seen from Figure 5 that almost all the aggregate demand variables grow positively under the policy scenario. For example, aggregate real private consumption, real private investment and real exports grow significantly higher than in the base case. These results suggest the bad road conditions adversely affect the growth of aggregate (private and government) consumption. The positive effect on real investment is driven by the fall in the cost of capital (investment price index) by 14 percentage points below the base case. All in all, the macroeconomics results indicate that the improvement in road infrastructure has beneficial effects on the PNG economy by increasing aggregate demand.

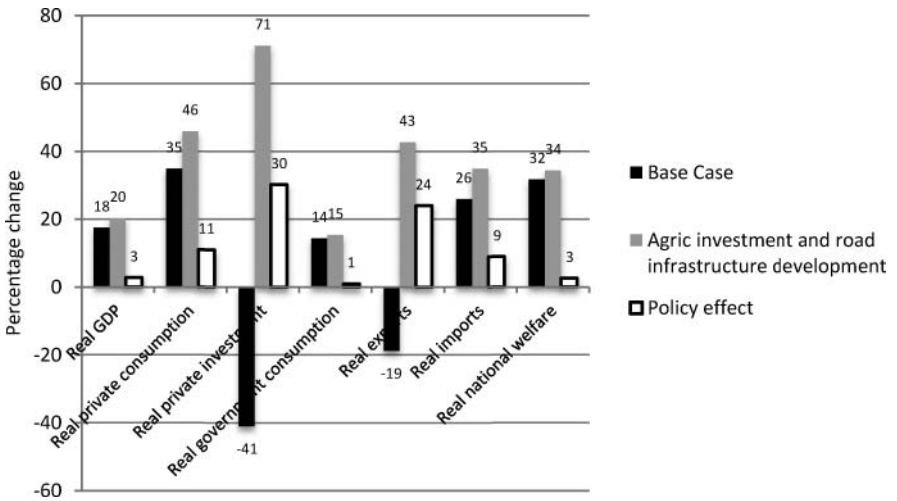

Figure 5. Macroeconomic impacts of road infrastructure investment (percentage changes).
Note: The base case represents investment in the agricultural sector. Source: PNGGEM simulation results.

Although we have shown that improving infrastructure could improve economic growth, ensuring that infrastructure spending is directed to the needed areas in local communities faces a major challenge in PNG. Although PNG's Local Government Law was amended in 1996 to encourage the participation of local communities in infrastructure decisions, Hasnain, Keefer, and Menzies (2014) found that these formal institutional arrangements have had little impact on actual infrastructure allocations using survey data. Rather, political factors such as whether a Member of Parliament (MP) had visited an area and whether it was difficult to buy votes in the area were more likely to increase the supply of infrastructure. Their findings suggest that further reforms are needed to ensure the optimal use of infrastructure funds. These include making MPs more accountable and transparent in the disbursement of funds, as well as building the capacity of local communities to increase their influence over the allocation of infrastructure resources.

5.1.3. Improved value-adding and productivity growth in agro-processing

The third policy experiment investigates the impacts of value-adding and productivity growth in agro-processing. The results in Figure 6 indicate that real GDP increases by 15 percentage points under the policy scenario. This positive impact on economic growth is driven by the positive impact (of the policy shocks) on aggregate private and government consumption, which outweighs the negative impact on aggregate investment and the worsening of the trade deficit. Real aggregative private consumption increases by 22 percentage points above the base case scenario. Given that the CPI (inflation) is constant, this positive impact is driven by the increase in nominal aggregate consumption, which in turn is due to an increase in aggregate employment. Aggregate government consumption increases by 22 percentage points above the base case, which is driven by a 297 percentage point increase in total tax revenue.

Real aggregate private investment declines by 72 percentage points below the base case due to a negative effect of the policy shock on nominal aggregate investment and a positive effect on the investment price index, which is used as a proxy for cost of capital. That is, an increase in the cost of capital reduces the demand for capital and hence there is a decline in investment. In terms of the trade balance, there is a net negative impact (i.e. increase in the deficit) given that the policy shocks affect real exports negatively and real imports positively. That is, real exports fall by 11 percentage points below the base case, while real imports increase by 16 percentage points above the base case. The

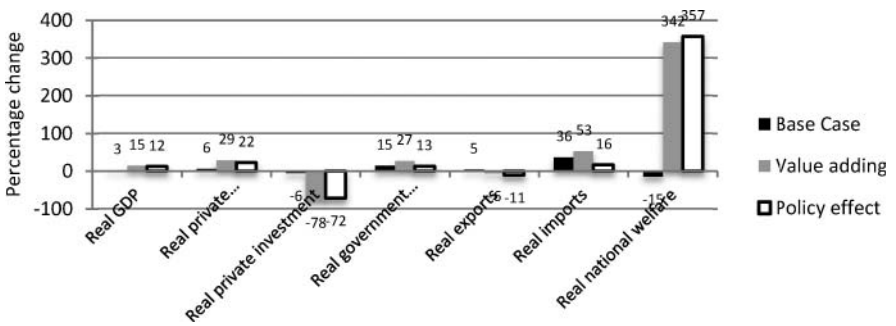

Figure 6. Macroeconomic impacts of value adding in agro-processing (percentage changes).
Note: The base case represents investment in road infrastructure. Source: PNGGEM simulation results.

decrease in exports and increase in imports is due to a 30 percentage point appreciation of the real exchange rate above the base case. Finally, national welfare improves by 357 percentage points above the base case, which is due to a positive effect on private consumption (discussed above) and savings (i.e. private savings increases by 143 percentage points and government savings by 96 percentage points).

5.2. Sectoral impacts

The next set of figures show results for the impacts of the three policy experiments at the sector level of PNG's economy.

5.2.1. Impacts of increased primary factor productivity

The results for the sectoral impacts of increasing primary factor productivity are shown in Figure 7. In terms of the export-oriented industries, it can be seen that overall, the mitigation measures have a positive impact in terms of increasing sectoral output by 3.7 percentage points on average. The biggest improvers are the agriculture industries, where the mitigation measures resulted in the average output of the agriculture industries to be 12 percentage points better than without the mitigation measures (i.e. LNG export expansion alone). The exception is the mining industries whose output in the presence of the mitigation measures is lower by 6 percentage points than without them. This negative impact is mainly due to the negative impact on the 'other mining' industries (i.e. −31 percentage points) although the main mining and petroleum industries remain relatively unaffected by the mitigation measures. Nevertheless, the negative impact on the 'other mining' industries suggests that targeted improvements in productivity (i.e. by industry) is required in order to increase output for the industries. The remaining export industries are positively impacted by the mitigation measures (fishing, 6 percentage points; export

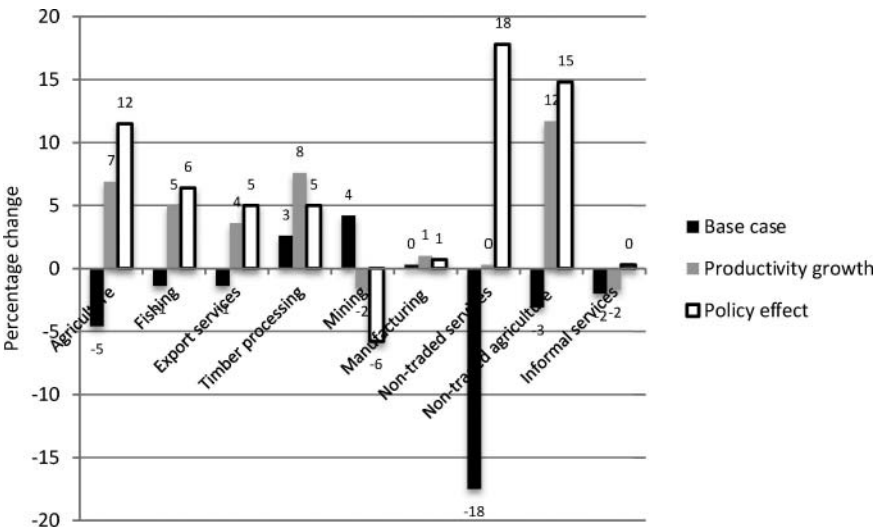

Figure 7. Sectoral impacts of primary factor productivity growth (percentage changes).
Note: The base case represents export expansion in the resources sector including the LNG project.
Source: PNGGEM Simulation results.

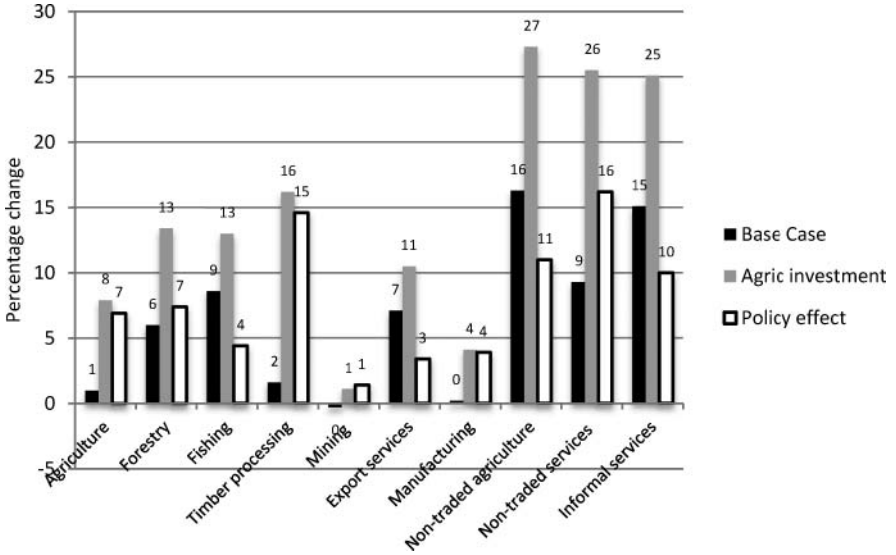

Figure 8. Sectoral impacts of agricultural investment (percentage changes).
Note: The base case represents export expansion in the resources sector including the LNG project.
Source: PNGGEM simulation results.

services, 5 percentage points; and timber processing, 5 percentage points), as a result of the flow on effects of the productivity growth in agriculture and manufacturing.

5.2.2. *Impacts of increased investment in agriculture and improved infrastructure*

Increasing investment in agriculture has positive economy-wide impacts overall (see Figure 8). As expected, the main beneficiary is the agricultural sector, in particular non-traded agriculture. However, the non-traded services sector also benefits with the highest net gain of 16 percentage points. This is followed by timber processing with a net gain of 15 percentage points, while informal services gain by 10 percentage points. Manufacturing output grows by 4 percentage points, which can be mainly attributed to the positive effects on the food processing, beverage and tobacco, and metals and engineering, and other manufacturing. In terms of primary factor usage, the positive impact on the manufacturing industry's output (as a whole) is driven mainly by an increase in labour employment of 8 percentage points above the base case. This outweighs the decline in the use of capital for the industry of 1 percentage points below the base case.

Figure 9 shows the effects of improving infrastructure on the average annual growth of output for traded and non-traded industries. Overall, growth in the outputs of all the industries increased in the presence of road infrastructure improvement, resulting in higher growth rates than the base case. In terms of policy implications, this suggests that investment in the export industries, per se, is necessary but not sufficient to maintain the growth of the export industries. The foregoing results indicate that road transportation (or all modes of transportation, in general) as a margin service also requires investment in order to contribute positively to the growth of other industries.

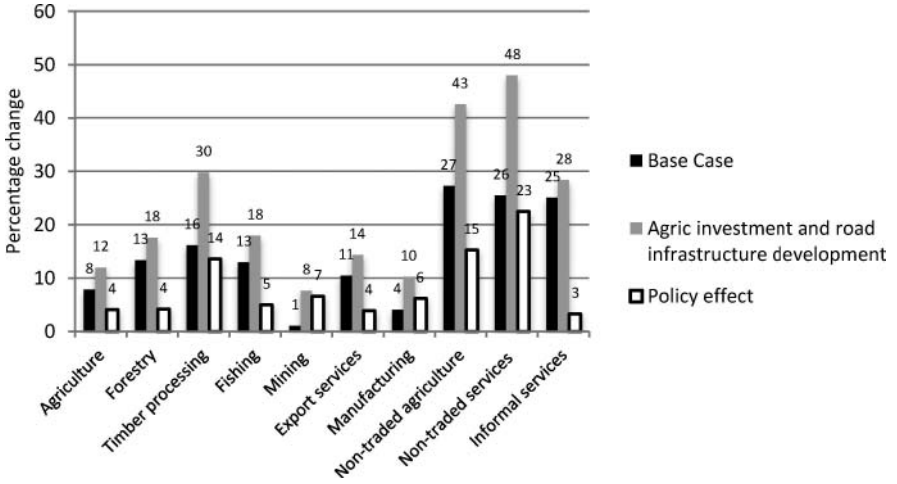

Figure 9. Sectoral impacts of road infrastructure investment (percentage changes).
Note: The base case represents investment in the agricultural sector. Source: PNGGEM simulation results.

5.2.3. *Impacts of improved value-adding and productivity growth in agro-processing*

Figure 10 shows the impacts of improving value-adding and productivity growth in agro-processing for selected traded and non-traded industries. On average, the boost to productivity and intermediate inputs for the food processing industry has a negative impact on the average output of the export sector industries, whereby the average annual output of export industries fall by 3 percentage points below the base case average growth. The negative impact on the export industries (as a whole) is attributed to the negative impact

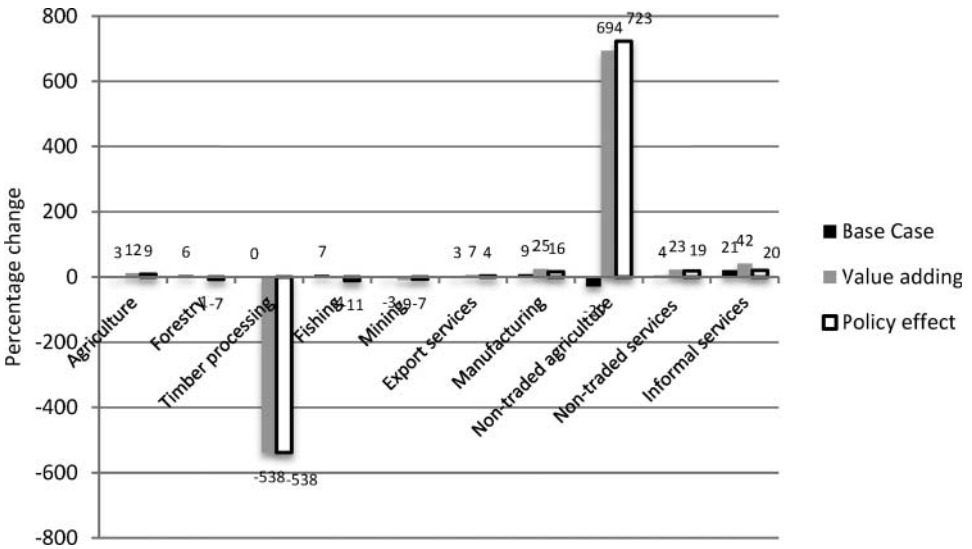

Figure 10. Sectoral impacts of value adding in agro-processing (percentage changes).
Note: The base case represents investment in road infrastructure.Source: PNGGEM simulation results.

on the output performance of four of the industries: forestry, fishing and mining. The forestry industry's output declines by 7 percentage points below the base case, which is driven by the negative impacts of the policy shocks on both labour employment (-53 percentage points) and capital use (−13 percentage points). A similar trend is observed for the fishing and mining industries, whose outputs fall below their base case by 11 percentage points and 7 percentage points, respectively. These negative impacts are due to the declines in the use of labour and capital below the base case for the concerned industries. For the fishing industry, labour use falls by 5 percentage points (below the base case), which offset a 17 percentage points positive effect on capital use. The decline in the mining industry is due to a negative effect on both labour and capital use; that is, by 63 percentage points and 6 percentage points, respectively. The overall decline in output and the factors of production for these export industries suggests that there is a reallocation of resources away to other industries (i.e. non-export industries).

The agriculture and export services industries are exceptions because they are positively impacted by the supply side shocks in the food processing industry. In the case of agriculture, there is an increase in output of about 9 percentage points above the base case rate, which is attributable to a positive impact (of the shocks) on labour and capital use by 231 percentage points and 26 percentage points, respectively. In relation to the policy simulation, the positive impact in the agriculture industries occurs because the increase in the output of the food processing industry (due to higher productivity and intermediate input supply of the four agriculture commodities) encourages the production of more intermediate inputs from the agriculture industries, hence the increase in their output. It can be seen that industries in the non-export sector are positively impacted by the shocks in the food processing industry given that average, the output of the non-export industries increase by 18 percentage points above base case average growth rate.

To summarise, the foregoing simulation results indicate that the shock to productivity (of labour and capital) and intermediate inputs (of coffee, cocoa and palm oil) for the food processing industry has an overall positive impact on the non-export industries but an overall negative impact on the export industries. However, within each sector (export and non-export), there are both winners and losers. What is clear is that the food processing industry gains from the productivity improvements and the increased use of the intermediate inputs.

6. Conclusions and policy implications

This study set out to analyse the options available to a resource-dependent developing country such as PNG to increase growth in its agricultural sector in the face of a booming mining sector. As shown in previous empirical studies, such resource-dependent countries are susceptible to volatile economic growth and erosion of the external competitiveness of other tradable sectors such as agriculture and manufacturing. Given such challenges, our study has shown that the adverse effects of a resources boom can be offset by improving productivity growth in agriculture and manufacturing. Agriculture, for example, provides a means of livelihood for the majority of the people and yet farm production systems use low-input technologies and are very inefficient. The key policy implication here is that developing resource-rich countries such as PNG need to invest significant proportions of their resource revenues in education and training to enhance the skills and knowledge of workers in industries such as agriculture and manufacturing. There is also a need to improve the use of modern technology in these industries.

One of the factors preventing PNG from taking advantage of favourable commodity prices when they occur is the existence of supply side constraints such as poor physical infrastructure which imposes severe costs on getting products to local markets and for

export. Here we have shown that investment in agriculture when coupled with improved infrastructure has beneficial impacts on the PNG economy. Infrastructure is shown to be a binding constraint as investment in agriculture alone does not show an improvement given poor infrastructure.

Developing countries such as PNG could increase both rural and urban employment by shifting the emphasis away from production and export of primary commodities to value adding or secondary production activities. In this paper, we have shown that increasing the productivity of labour and capital and the use intermediate inputs (e.g., coffee, cocoa, and palm oil) in food processing alone leads to large overall gains in the economy. Therefore, the key policy implication is that given a comparative advantage in primary agricultural production, PNG could be well placed to increase employment and economic growth by investing in agro-processing industries that could source cheap inputs from the various agricultural commodities that are produced in the country. As shown in this study, value adding in this manner contributes more to growth than the current production structure of producing primary products for exports. In the medium term, this strategy could be extended to other natural resources such as natural gas of which PNG also has plentiful supplies.

Notes

1. The estimate is for the year 2013.
2. The western half of the island of New Guinea is part of Indonesia (i.e. West Papua or Irian Jaya).
3. See Levantis (2004) for a detailed model description and documentation.
4. Public unrequited transfers are assumed to be exogenous.
5. The external costs of crime are borne involuntarily and are assumed to be a fixed share of the economy-wide external costs of crime.
6. It is assumed here that capital utilisation is the same as capital consumption.
7. This approach can be contrasted with other dynamic models in which there is inter-temporal optimisation.
8. Thus, the model is solved in a multi-step fashion rather than as one-shot percentage changes.

Acknowledgement

We are grateful for helpful comments from two anonymous reviewers that helped to improve the quality of this paper.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Osborne Sanida holds a PhD in applied economics from the University of Queensland. He is currently a deputy director, at the PNG National Research Institute in Port Moresby. His research interests include CGE modelling, time series econometrics, international trade and foreign direct investment and economic policy analysis. He is the author (or co-author) of several policy papers and monographs on the PNG economy.

John Asafu-Adjaye is an associate professor in the School of Economics, the University of Queensland. His research interests are in the areas of energy economics and policy, agricultural economics and environmental economics, with a focus on Asia-Pacific economies and Africa. He has recent publications in *Journal of African Economies*, *Economic Modelling*, Energy Economics and *Energy Policy*.

Renuka Mahadevan is an associate professor in the School of Economics, the University of Queensland. She works on policy oriented issues in development economics, trade and tourism economics. She has recent publications in *Journal of Travel Research*, *Regional Studies*, *Energy Economics* and *World Economy*.

References

ACIL Tasman. 2008. *PNG LNG Impact Study*. Melbourne: ACIL Tasman Pty.

ADB (Asian Development Bank). 2009. *Key Indicators for Asia and the Pacific 2009*. Manila: ADB.

AusAID (Australian Agency for International Development). 2006. "Australian Aid Promoting Growth and Stability." A White Paper on the Australian Government's Overseas Aid Program, Canberra, July.

Bank of Papua New Guinea (PNG). (2010) *Quarterly Economic Bulletin*. Port Moresby: Bank of PNG.

Corden, W.M. 1984. "Booming Sector and Dutch Disease Economics: Survey and Consolidation." *Oxford Economic Papers* 36: 359–380.

Corden, M., and P. Neary. 1982. "Booming Sector and De-industrialization in a Small Open Economy." *Economic Journal* 92: 825–848.

Department of National Planning and Monitoring. 2010. *Medium Term Development Plan 2011–2015: Building the Foundations for Prosperity*. Port Moresby: Department of National Planning and Monitoring.

Department of Treasury. 2014. *2015 National Budget: Volume 1 – Economic and Development Policies*. Port Moresby: Department of Treasury.

Dixon, P.B., and M.T. Rimmer. 2001. *Forecasting Policy, History, and Decomposition: The Monash Model of the Australian economy*. Melbourne: mimeo, Centre for Policy Analysis, Monash University.

Dixon, P.B., G. Kauzi, and M.T. Rimmer. 2010. "Effects on the PNG Economy of Major LNG Project." *Economic Papers* 29 (2): 143–155.

Fields, G.S. 1975. "Rural-Urban Migration, Urban Unemployment and Underemployment, and Job Search Activity in LDCs." *Journal of Development Economic* 2: 165–187.

Gylfason, T. 2001. "Lessons from the Dutch Disease: Causes, Treatment, and Cures." Institute of Economic Studies, University of Iceland. Working Paper Series, W01:06. Accessed 9 December 2013. http://notendur.hi.is/gylfason/pdf/statoil22.pdf.

Harris, J.R., and M.P. Todaro. 1970. "Migration, Unemployment and Development: A Two Sector Analysis." *American Economic Review* 60: 126–142.

Harrison, W.J., and K.R. Pearson. 1996. "Computing Solutions for Large General Equilibrium Models Using GEMPACK." *Computational Economics* 9: 83–127.

Hasnain, Z., P. Keefer, and N. Menzies. 2014. "Formal Rules, Clientelism, and the Allocation of Project Funds Across Villages in Papua New Guinea." In *Problem-Driven Political Economy Analysis: The World Bank's Experience*, edited by V. Fritz, B. Levy, and R. Ort, 211–230. Washington, DC: The World Bank.

Levantis, T. 2004. *PNGGEM: ABARE's Model of the Papua New Guinea Economy*. Canberra: Australian Bureau of Agricultural and Resource Economics.

Mawuli, A. and O. Sanida. 2000. "Landowners and Miner Rent Quest and Use in Papua New Guinea." (NRI Discussion Paper No. 95.) Port Moresby: National Research Institute.

Ministry of Agriculture and Livestock. 2006. *National Agriculture Development Plan (2007-2016): Implementation Plan*. Port Moresby: Ministry of Agriculture and Livestock.

Sachs, J.D., and A.M. Warner. 1997. "Natural Resource Abundance and Economic Growth." (NBER Working Paper No. 5398.) Accessed 21 April 2010. http://www.hks.harvard.edu/cid/ciddata/warner_files/natresf5.pdf.

Sachs, J.D., and A.M. Warner. 2001. "The Curse of Natural Resources." *European Economic Review* 45: 827–838.

United Nations. 2008. *World Population Prospects: The 2008 Revision Population Database*. New York, NY: UN.

Wijnbergen, S.V. 1984. "The 'Dutch Disease': A Disease After All?" *The Economic Journal* 94: 41–55.

World Bank. 2015. *World Development Indicators*. Washington, DC: World Bank.

Appendix 1. **Industries in the PNG model**

Industry name	Industry no.
Traditional agriculture	1
Smallholder coffee	2
Smallholder cocoa	3
Smallholder palm oil	4
Smallholder copra	5
Smallholder other tree crops	6
Plantation coffee	7
Plantation cocoa	8
Plantation palm oil	9
Plantation copra	10
Plantation other tree crops	11
Plantation fruit and veg	12
Other agriculture	13
Fishing	14
Forestry	15
Gold mining	16
Ok tedi mine	17
Other mining	18
Petroleum	19
Quarrying	20
Timber processing	21
Food processing	22
Beverages and tobacco	23
Metals and engineering	24
Machinery, repairs	25
Chemicals and oils	26
Other manufacturing	27
Road transport	28
Water transport	29
Air transport	30
Education	31
Health	32
Electricity and garbage	33
Building and construction	34
Commerce	35
Hotels and accommodation	36
Restaurants and fastfood	37
Finance and investment	38
Government admin and defence	39
Other private services	40
Security services	41
Informal retail	42
Crime	43

Appendix 2. **Commodities in the PNG model**

Commodity name	Commodity no.
Fruit, vegetables and betelnut	1
Livestock	2
Coffee	3
Cocoa	4
Palm oil	5
Copra	6
Other tree crops	7
Other agriculture	8
Fishing	9
Forestry	10
Copper	11
Gold	12
Other minerals	13
Petroleum	14
Quarrying	15
Timber processing	16
Food processing	17
Beverages and tobacco	18
Metals and engineering	19
Machinery and repairs	20
Chemicals and oils	21
Other manufacturing	22
Road transport	23
Water transport	24
Air transport	25
Education	26
Health	27
Electricity and garbage	28
Building and construction	29
Commerce	30
Hotels and accommodation	31
Restaurants and fast food	32
Finance and investment	33
Government admin and defence	34
Other private services	35
Security services	36
Informal retail	37
Crime	38

Appendix 3. **Growth forecasts of key macroeconomic variables (%)**

Variable	2011	2012	2013	2014	2015–2018
GDP[a]	6.2	2.8	2.1	8.5	9.3
Domestic inflation[a]	6.5	6.5	4.0	4.0	4.2
World inflation[b]	2.0	2.0	2.0	2.0	2.0
Population growth rate[c]	2.3	2.4	2.4	2.4	2.4
Import prices[d]	2.0	2.0	2.0	2.0	2.0
Government consumption expenditure[e]	7.3	6.8	2.1	5.0	5.6
Government investment expenditure[e]	2.1	0.0	0.0	4.0	3.8

Sources: [a]Government Budget Statements for 2011.
[b]IMF, World Economic Outlook 2011.
[c]Based on five-year average growth rates from the World Economic Indicators database of the World Bank.
[d]Based on World Bank projections for world inflation rates.
[e]Government projections based on 2011 Budget Statements.