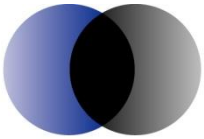
PNG LNG Economic Impact Study

An assessment of the direct and indirect impacts of the proposed PNG LNG Project on the economy of Papua New Guinea

Prepared for ExxonMobil

Final Report—6 February 2008



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Economics Policy Strategy

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Executive summary

The PNG LNG project offers a means of unlocking value from the extensive gas resources of the Southern Highlands region. The project has the potential to transform the economy of Papua New Guinea, boosting GDP and export earnings, providing a major increase in government revenue, royalty payments to landowners, creating employment opportunities during construction and operation, and providing a catalyst to further gas-based industry development. The benefits from the project would spread throughout the economy as the government applies the earnings from its substantial share of the project revenues to social and economic programs. These programs have the potential to improve the quality of life of Papua New Guineans by providing essential services and enhancing the country's productivity. Benefits would also flow through the economy as the wages and salaries of project staff are spent and as suppliers provide a range of goods and services to the project. Landowners stand to benefit from direct payments of royalties on production of gas and associated petroleum products, as well as improved social and economic infrastructure.

Direct benefits

The potential direct benefits offered by the PNG LNG Project are expected to flow from:

- capital investment in LNG production and support facilities, upstream gas production and processing development, pipelines, storage and other infrastructure
- employment
- direct cash flows to government and landowners in the form of taxes, royalties, development levies and other charges, and returns on equity participation
- potential for increased petroleum exploration and production (E&P) activity in the country.

The project is forecast to deliver direct capital investment of US$10 billion (K36 billion) in real terms over a 30-year life of the project.[1] Recurrent operating expenditure, including a significant level of local spending on support services, is expected to average K680 million per year. Total operational expenditure over the first 30 years after commencement of production from the project is expected to be around K23 billion (real 2007).

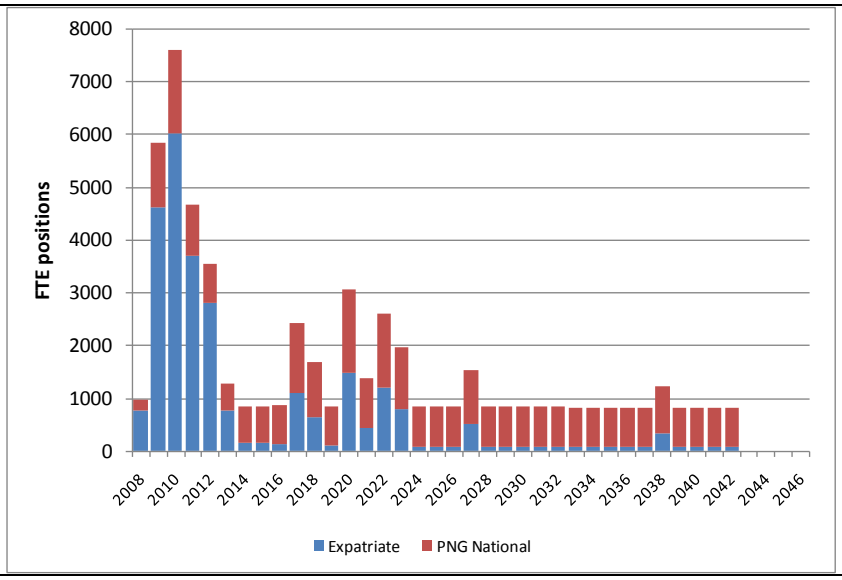
[1] This report assumes a conversion rate of US$1.00 = K3.6.

A project of this magnitude would affect the economy of Papua New Guinea and its balance of trade situation profoundly. The net benefits for the country and its people are potentially very large.

The PNG LNG project would provide a major boost to Gross Domestic Product (GDP) and exports. Under the Study Case assumptions, GDP would more than double, rising in real terms from K8.65 billion in 2006 to an average K18.2 billion per year. Oil and gas exports would increase more than four-fold, with average annual product value from the LNG project of K11.4 billion, compared to total PNG oil and gas exports of K2.6 billion in 2006.

The Project would provide a large number of jobs for PNG nationals. As shown in Figure ES1, during the initial construction phase up to 7,500 full time jobs would be created directly—around 20% of them for local workers. Once the project moves into the operational phase around 850 full-time equivalent positions would be maintained directly by the production operations, the majority of those positions being held by PNG nationals.

Figure ES 1 **Total direct employment**



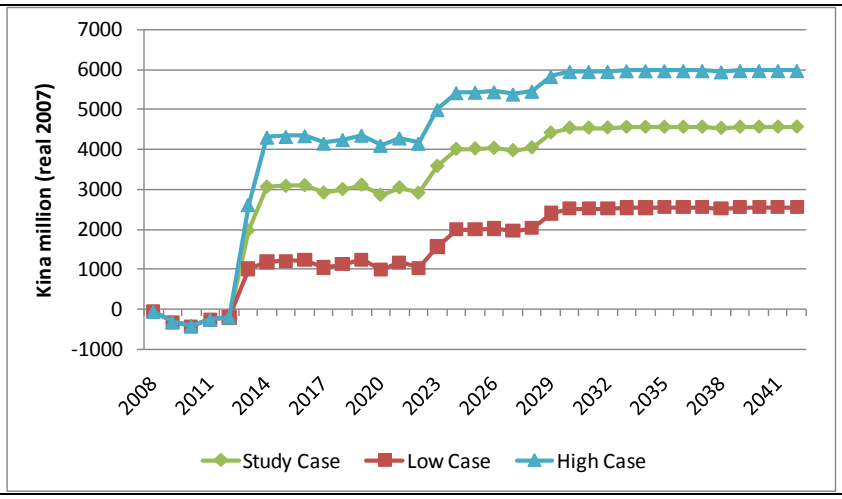
Data source: ACIL Tasman analysis based on proponent advice

The direct benefits of the LNG project would include valuable revenue streams for national and provincial governments and landowners through taxes, royalty payments, levies, and through equity participation in the project.

Under the Study Case assumptions, the total direct cash flow to the PNG government and landowners from the LNG project is estimated at US$31.7 billion (K114 billion) over a 30-year life of project. Figure ES2 shows the modelled annual direct cash flow to government and landowners from taxes, royalties and other payments as well as returns to equity. The cash flows shown

are net of the costs of equity contributions (and therefore negative in the early years). Net cash flow would reach a maximum of around K4.5 billion/year for the Study Case, within a range of K2.5 to 6 billion/year for the Low Case and High Case respectively.

Figure ES 2 **Total annual net cash flow to government and landowners**



Data source: ACIL Tasman analysis

This income would provide the PNG government with the opportunity to maintain a responsible program of expenditure on social programs and productivity-enhancing infrastructure development and maintenance. This in turn could provide long-term improvements in quality of life and economic stability for the people of Papua New Guinea. Apart from the direct impacts on government and landowners in terms of revenue and jobs, the PNG LNG project has the potential to boost the country's petroleum exploration and production (E&P) sector significantly, providing a focus for ongoing involvement by major international players that would help to attract investment and development in years to come.

Indirect benefits

While the direct benefits summarised above are important in their own right, the true significance of the PNG LNG project lies in its potential to influence economic performance throughout the economy *indirectly*, as a result of flow-on into other industry sectors. Spending by project participants, employees, government and landowner beneficiaries will lead to "multiplier effects" as the economic activities associated with the project impact on the broader economy. Investment in productive physical assets (such as roads and airports) or in social assets (such as improved education and health services) can also benefit the economy by enhancing the productivity of economic factors.

One of the significant impacts of the project will be the opportunities for local businesses. These opportunities include outsourcing of services such as catering, engineering, security, fuel supply, managerial and technical assistance.

The indirect macroeconomic impacts of the PNG LNG project have been estimated using a computable general equilibrium (CGE) model. The scale of the project relative to the current size of the PNG economy is such that the modelling results can only be regarded as indicative estimates. Nevertheless, the results point to a range of very large impacts: GDP up 97 to 99 per cent; private and public consumption up 85 to 107 per cent; aggregate employment up 42 to 45 per cent; and foreign currency exports up around 106 per cent.

On the other hand, the modelling indicates that growth in demand in the oil and gas sector and high rates of public and private expenditure will put upward pressure on the exchange rate, causing it to appreciate. A stronger kina, together with a tendency for the gas development to draw capital and labour away from the primary production sectors such as agriculture and forestry, has the potential to reduce the export competitiveness of those sectors. These potential adverse impacts are typical of the so-called "Dutch Disease" effects that have been noted in other countries where large resource projects have led to strong revenue inflows and exchange rate appreciation. These potential economic stresses will need to be anticipated and effectively managed through government programs to provide direct assistance to these sectors and to facilitate structural adjustment.

One effective approach to ensure that future generations of Papua New Guineans benefit from the LNG project would be to invest a substantial part of the government revenues from the project into an offshore fund. The interest on this fund would provide a perpetual source of revenue for productivity-enhancing investment in infrastructure and social programs such as improved health and education services. Investing revenues offshore can help to smooth out the effects on revenue of commodity price cycles, and can also mitigate the "Dutch Disease" problem by slowing down the rate of domestic absorption thereby reducing the impact on exchange rates and export competitiveness of the primary production sectors.

In conclusion, the LNG project will have a profound effect on the PNG economy. A project of such size (relative to the economy as a whole) will inevitably create some stresses and strains across the economy. However the net benefits arising from the project will be very large provided the potential adverse pressures on some sectors of the economy are properly managed. Responsible government expenditure policies and strong governance will be required to ensure that the large economic gains from the project translate into equivalent socioeconomic development for the nation as a whole.

1 Introduction

The purpose of this study is to assess the potential impacts of the proposed PNG LNG project, currently under investigation by ExxonMobil and others, on the economy of Papua New Guinea. The study is based on project data as at second half 2007. This data will be subject to future updates as detailed engineering studies are progressed.

The Study addresses two aspects of potential economic impact:

- Measurement of *direct impacts* of the project in terms of capital investment, ongoing operational expenditure, employment, production value and cash flows to the PNG government and landowners in the form of taxation payments, equity participation, royalties and other payments.
- Measurement of *indirect impacts* of the project through multiplier and productivity effects.

This study focuses primarily on the benefits that would arise from development of the PNG LNG Project for the purposes of the export of liquefied natural gas (LNG) internationally. While some commentary is provided on opportunities that LNG production might unlock for further in-country gas exploration and production, it does not attempt to quantify the benefits that might arise from the development of local gas-based industry. Recent developments suggest that in-country gas use for industrial development is a realistic possibility that could offer significant additional economic benefits, over and above those identified for the LNG export project.

The first part of the study, addressing the *direct impacts* of the project, explores three oil price/LNG price scenarios: a Study Case that assumes a long run oil price of US$65/bbl as the pricing basis for LNG and other product streams; a low oil price scenario that assumes a long run oil price of US$36/bbl; and a high oil price scenario that assumes a long run oil price of US$100/bbl. All monetary values (US$ and kina) quoted in this report are expressed in real (2007) terms.

The second part of the study addresses the potential cross-sectoral impacts of the project, and the flow on into the broader PNG economy. This analysis has been undertaken by Associate Professor Dr John Asafu-Adjaye of the University of Queensland, School of Economics using a computable general equilibrium model of the PNG economy.

2 Project overview

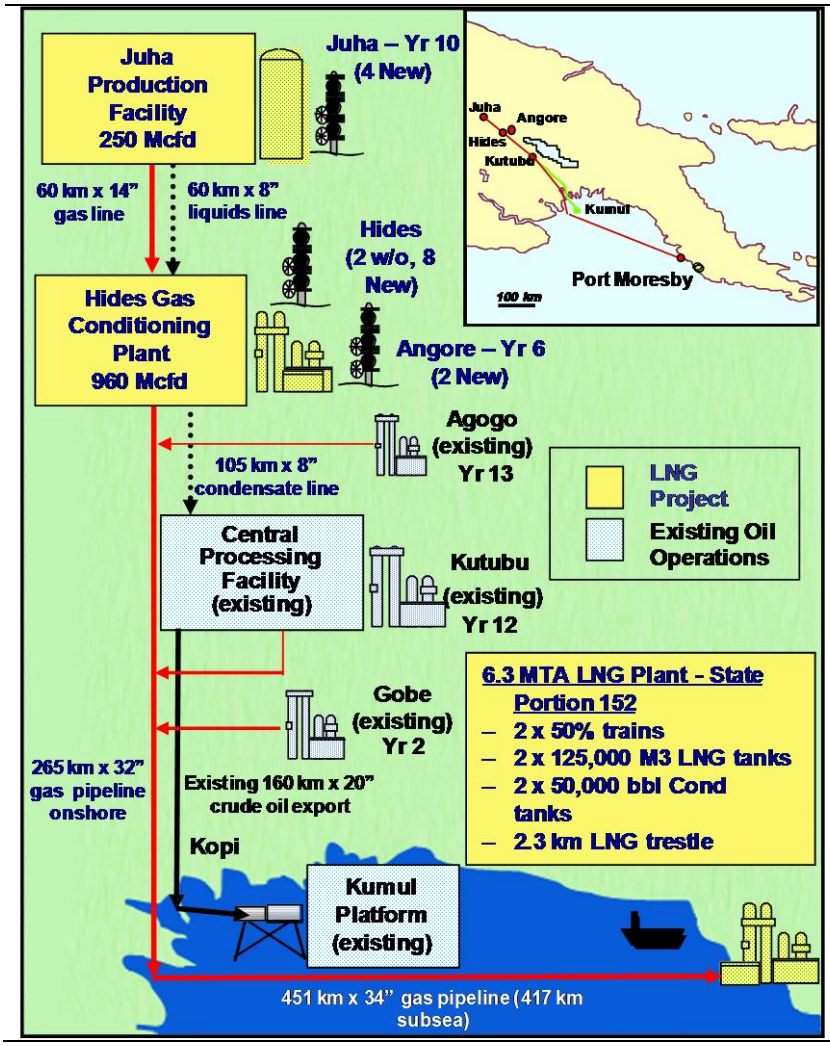
This section of the report summarises key aspects of the proposed PNG LNG development.

2.1 PNG LNG development concept

The PNG LNG development concept currently entails construction of a 6.3 million tonne per annum (6.3 mtpa) Liquefied Natural Gas processing plant and associated gas treatment, storage, jetty and marine offloading facilities. Site locations on the east cost of the Gulf of Papua are currently being evaluated with a location near Port Moresby currently the preferred site.

The current project concept is schematically illustrated in Figure 1.

Figure 1 **PNG LNG Project Schematic**



Data source: ExxonMobil

The project would draw on gas resources of the Hides, Angore, Juha, Gobe, Moran and Kutubu fields in the PNG Highlands. LNG product would be targeted principally to Asian markets.

In addition to LNG, the project would produce condensate and potentially future LPG.

Condensate will be recovered at the new Hides Gas Conditioning Plant and transferred by pipeline to the Central Production Facility at Kutubu, comingled with the liquid product stream and exported via the existing Pipeline Licence 2 (PL2) oil export system to the Kumul Platform.

LPG (propane, butane) will initially be reincorporated into the feed gas stream within the limits of the LNG specification. For modelling purposes we have assumed that separate production of LPG commences ten years after commissioning of the LNG production facilities. However the project proponents have advised that future LPG recovery will be subject to LNG Gross Heating Value (GHV) requirements following the signing of LNG sales and purchase agreements.

In the long run, the project could create the opportunity for establishment of further gas-based industries within Papua New Guinea. It has the potential to establish a "petroleum infrastructure hub" that would provide a focus for increased levels of petroleum exploration and production (E&P) investment in Papua New Guinea.

2.1.1 Project facilities

The Project will include the following physical facilities:

- onshore production facilities, including wells, primary gas treatment plant and gathering facilities, within PNG
- an onshore gas pipeline from Juha to Hides and then to the coast near Kopi
- a condensate line to carry condensate from the Juha and Hides fields to the existing Kutubu/Agogo production facilities for transport via the existing crude oil export line to the Kumul Platform in the Gulf of Papua
- a subsea gas pipeline carrying gas approximately 450 km from the coast near Kopi to the LNG plant site near Port Moresby
- an LNG liquefaction plant, nominally of 6.3 mtpa production capacity
- additional gas treatment facilities, LNG and secondary condensate extraction and storage, potential LPG recovery, export jetty and marine offloading facilities

3 Assessment of Direct Impacts

This section of the report examines the *direct economic impacts* of the PNG LNG Project in terms of its anticipated effects on capital and recurrent expenditure, production, employment, direct cash flow to government and landowners, and potential impact on levels of exploration and production activity in the petroleum sector.

The following chapter examines the broader *indirect economic impacts* of the project resulting from flow-on effects to other sectors of the PNG economy.

The PNG LNG project will directly impact the economy in a number of ways. These include:

- direct capital investment in production and support facilities, raw gas and product pipelines, LNG liquefaction, storage and shipping facilities and associated infrastructure
- ongoing expenditure associated with the operation and maintenance of the facilities
- employment of PNG nationals and expatriate workers
- direct cash flows to governments and landowners in the form of taxes and charges including company tax, PAYE tax on kina-based labour during construction and operation, royalties and development levies
- equity participation by the State and landowners
- increased exploration and production (E&P) activity in the country.

3.1 Assessment methodology

ACIL Tasman has constructed a spreadsheet benefits model to allow quantification of the direct benefits and cash flows arising from the project. Many of the key assumptions incorporated into the benefits model (for example, in relation to facilities configuration, capital and operating costs, and production profiles) necessarily rely on information provided by the project proponents.

The data used reflects the outlook as at the second half of 2007 and is subject to ongoing studies. Detailed front end engineering and design has not yet been undertaken, and many aspects of the project remain subject to change. These include design and engineering aspects such as the sizing and configuration of facilities as well as commercial and fiscal terms that are subject to ongoing evaluation and negotiation by the relevant parties. Accordingly, the detailed assumptions on which the economic impact analysis is based are subject to change and will almost certainly vary over the period leading up to project commitment. While we have generally adopted assumptions that reflect the

current views and expectations of the proponents, we have also carefully reviewed the information provided to us to ascertain the basis for important assumptions and to allow us, where necessary, to modify those assumptions and input parameters to reflect ACIL Tasman's own assessments. All assumptions relating to commodity prices (oil, LNG and other project products) have been independently developed by ACIL Tasman and these views may differ from those of the project proponents.

3.2 Scenario definition

The analysis of direct benefits considers three scenarios:

- A **Study Case** under which long-run oil prices average US$65 per barrel, with LNG and other product lines set relative to this oil price.
- A **Low oil price case** under which long-run oil prices average US$36 per barrel and the value of LNG and other products fall accordingly.
- A **High oil price case** under which long-run oil prices average US$100 per barrel and the value of LNG and other products rise accordingly.

The oil price assumptions are in line with the most recent Base, Low and High long-run oil price scenarios published by the US Energy Information Administration (2007).

All scenarios adopt the same assumptions with regard to LNG project configuration, capital and operating costs, labour requirements, product output, commercial and fiscal terms: the only variables assessed in the scenarios are oil price and the relationship between oil price and LNG price.

In each scenario the project impacts are presented over a period of 35 years commencing 2008.

In quoting local currency comparisons, a rate of US$1.00 = 3.6 kina is assumed.

3.3 Study Case key assumptions

The following sets out the key assumptions we have made in modelling the direct impacts of the PNG LNG Project, and discusses the basis for those assumptions.

3.3.1 Production volumes

In accordance with advice from the proponents we have assumed LNG production commences in mid 2013 with the plant having a nominal capacity of 6.3 million tonnes per annum (mtpa). Taking into account production ramp-up, plateau production level and reserves depletion over time, we have

assumed an average annual production rate of 5.4 mtpa over a 30 year project life.

Condensate production is assumed to average 19,200 barrels per day. This represents a levelised rate of production over the life of the project.

Production of LPG as a separate product stream is assumed to commence in 2023 (after 10 years of LNG production), at an average rate of 11,700 barrels of oil equivalent per day. Again this represents a levelised rate of production over the life of the project. Whether or not LPG production occurs in accordance with this profile, or at all, will ultimately depend on the LNG specification (and specifically, the Gross Heating Value) reflected in final sales and purchase agreements. This will not be known until the completion of LNG marketing activities.

3.3.2 Capital and operating costs

Total capital cost of US$10 billion (real 2007) over the life of the project, with an initial cost of $8.3 billion, is based on information provided by the proponents. The profile of capital expenditure reflects current project assumptions regarding the construction program. Equipment is assumed to account for 55% of total capital cost with the balance attributed to labour.

Capital depreciation over 10 years, straight line is assumed for tax calculation purposes.

Operating costs are assumed to amount to some US$190 million per year on average, based on a unit rate of US$0.59/mmbtu of production.

3.3.3 Price assumptions

Prices for LNG, condensate and LPG are all assumed to be directly related to oil price. The Study Case adopts an oil price assumption of US$65/bbl (real 2007). The low and high oil price scenarios assume long run oil prices of US$36/bbl and US$100/bbl respectively, in line with the current US Energy Information Administration (EIA) long-run oil price scenarios[2].

LNG is typically priced relative to oil using a formula of the form

$$P = AX + B$$

where

P = LNG price

A = the slope of the price curve

[2] US Energy Information Administration, *"International Energy Outlook 2007"*

X = JCC or Japanese Customs Clearance oil price, which is the average CIF value of all oil imported to Japan in a specified trading period, based on statistics maintained by the Japanese Ministry of Finance.

B = a constant.

Until recently, it has been common for LNG pricing formulas to include cap and collar arrangements that limit upside and downside price movement, typically by reducing the slope of the price curve for oil prices below the defined lower limit, and above the upper limit. The result is a so-called "S-curve" price function which limits price risk for both buyers and sellers. Rather than make explicit assumptions about the pricing formula that will apply to PNG LNG (this being subject to on-going commercial negotiations), and as we understand that the market is tending to move away from the S-curve pricing relationship, we have adopted a range of LNG selling price assumptions that we consider to be reasonable in the light of recent LNG contract settlements, possible future long run oil prices and competitive market constraints.

In considering a reasonable range of future LNG prices, we have taken into account the following:

- LNG competes in international markets with major alternative fuels, in particular coal and fuel oil in power generation and industrial applications.
- Recent LNG contract prices have ranged between US $8 and $11/mmbtu at US$60/bbl oil prices (Fesharaki, 2007).
- The North West Shelf LNG allocation in mid-2006 yielded a price understood to be approximately US$7.90/mmbtu at $60/bbl oil. Oil prices have since moved higher, as have internationally traded thermal coal prices.
- The Qatar Rasgas-KOGAS contract settled in late 2006 was reportedly close to crude oil parity and uncapped, resulting in prices around $11/mmbtu at US$65/bbl, and potentially in excess of $15/mmbtu at current oil prices approaching $100/bbl.
  - Arguably prices at this level are not sustainable in the longer term, at least in power generation applications where coal is a price-competitive substitute even with explicit pricing of CO_2 emissions. We estimate that in order to be competitive with thermal coal for power generation in Eastern Asia, LNG would need to be priced in a range from US$8-12/mmbtu ex-plant[3] depending on coal price, plant location and assumptions regarding CO_2 emission pricing levels.

[3] For coal of typical export specification (6,700kcal/kg) at free-on-board price of US$75/t, taking into account shipping costs, terminal/ re-gasification costs for LNG, coal handling and ash disposal costs, differences in thermal efficiency of gas and coal generating plant, and CO_2 emission prices ranging from US$15 to 45/t.

In light of the foregoing, we have assumed for the purposes of the Study Case a free-on-board LNG price of $9.35/mmbtu corresponding to a long-run oil price of US$65/bbl, with a range from US$5.50 (Low Case) to $11.50/mmbtu (High Case).

Condensate is assumed to sell at a 5% premium to JCC price.

LPG is assumed to sell at 75% of the condensate price, or 79% of JCC price, reflecting historical relationships.

3.3.4 Fiscal regime

Fiscal terms for the PNG LNG project have not been settled at this stage. Accordingly we have assumed fiscal terms that are consistent with current legislation and otherwise generally similar to the terms agreed for the previous PNG Gas Pipeline project, as reflected in the most recent economic impact evaluation for that project (ACIL Tasman, 2005).

3.3.5 PNG Government equity participation

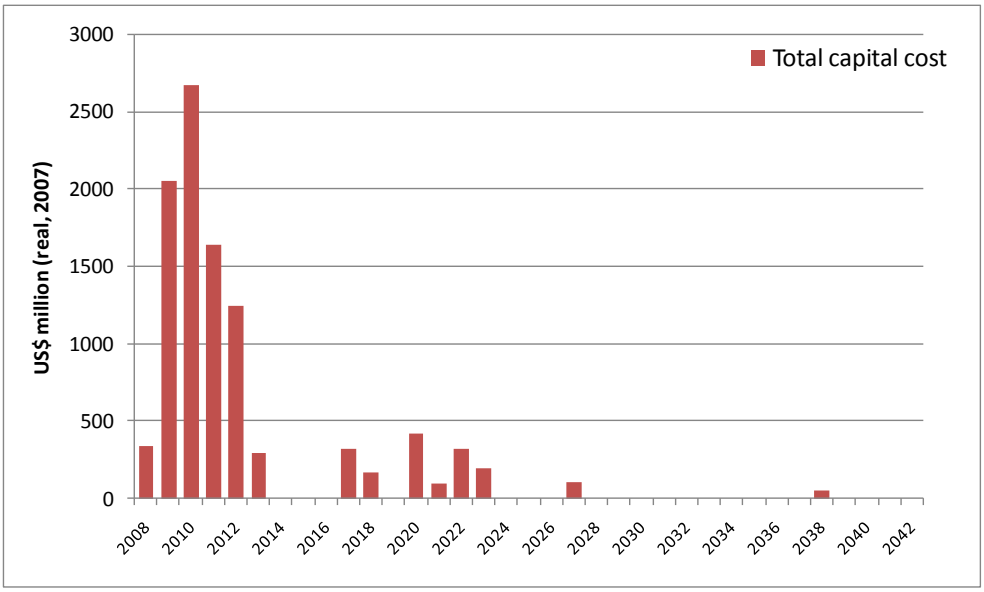
It is assumed that the PNG Government takes an effective 19% stake in the project (including any equity acquired on behalf of landowners and/or provincial governments). This implies a funding requirement of $1.57 billion for the initial capital cost of the project. The government contribution is assumed to be funded through a combination of equity (30%) and debt (70%), with debt in the form of a 15 year credit foncier loan at 8% interest, resulting in repayments of principal and interest totalling US$204 million per year.

3.4 Capital investment and recurrent expenditure

3.4.1 Capital investment

The capital expenditure profiles for each of the three scenarios are identical, since oil price is the only variable for the scenarios. Annual capital expenditure profile is illustrated in Figure 2.

Figure 2 **Total capital expenditure (Real US$, 2007)**



The investment shown includes the total value of capital invested over the life of the project, including capital sourced from overseas as well as within Papua New Guinea.

Total capital expenditure is expected to amount to some US$10 billion over the life of the project, with $8.3 billion spent over the initial construction period and the remainder after project commissioning. The capital cost covers field development, pipeline and LNG plant including liquefaction, storage and load out.

Capital equipment comprises 55% of the total capital spend, or US$5.5 billion, all of which is assumed to be sourced outside PNG.

The labour component of capital accounts for the remaining 45% of total capital, or US$4.5 billion, of which 90% is assumed to be expatriate labour and 10% local labour during the construction phase. For capital construction after commissioning an average 80% of labour cost is assumed to be expatriate labour and 20% local.

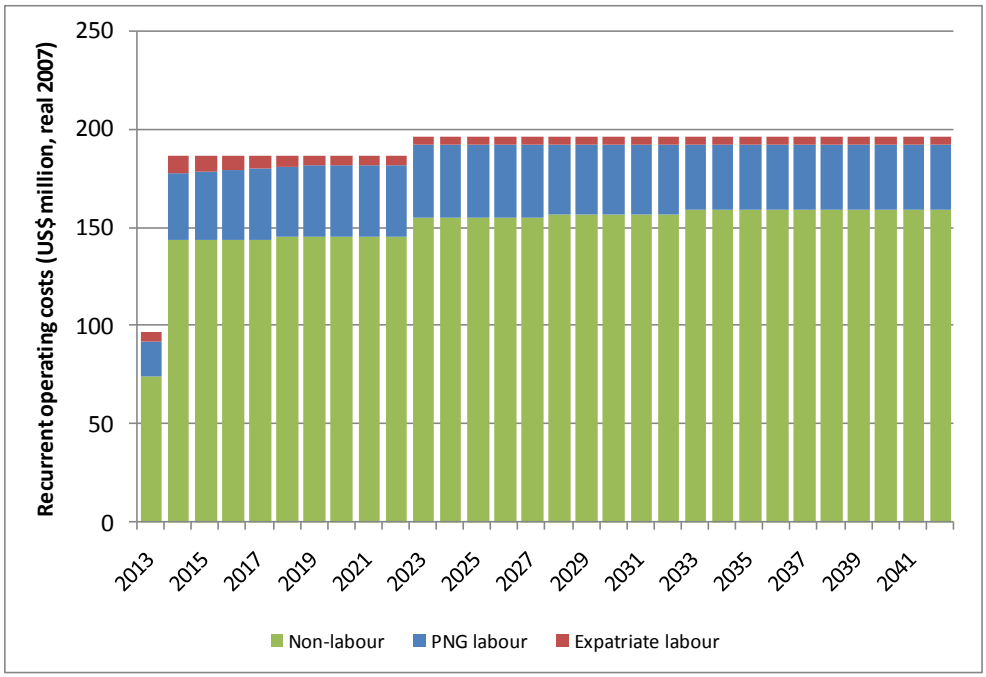
3.4.2 Recurrent operating expenditure

Recurrent operating expenditure profiles for each of the three scenarios are identical, since oil price is the only variable for the scenarios. The annual operating expenditure profile is illustrated in Figure 3. The constant operating expenditure profile at a maximum US$196 million per year, totalling US$4.9 billion over the assumed 30 year production life of the project, reflects the levelised production assumptions made for the purposes of this assessment. In

practice there will be some variation in operating expenditure year-on-year as a result of variations in the operating regime of the project.

The operating expenditure comprises around 80% non-labour costs and 20% labour costs, with 78% of labour costs initially local, rising to about 90% local after 10 years. The balance of labour operating costs relate to expatriate labour.

Figure 3 **Recurrent operating expenditure (Real US$, 2007)**



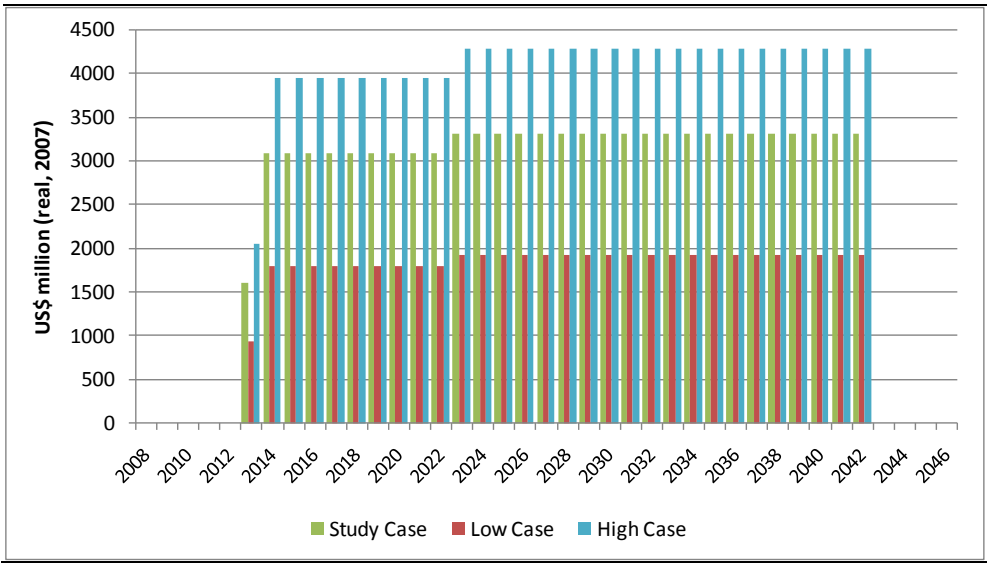
3.5 Value of output

The PNG LNG project will provide a major boost to oil and gas exports, which otherwise will fall to zero as oil production declines over the period to 2025. As shown in Figure 4, the total value of output under the Study Case would average around US$3.3 billion per year over the 30-year life of the project. The step-up in revenue from 2023 reflects the assumed commencement of LPG production as an additional product stream at that time. The otherwise constant revenue profile over the assumed 30 year production life of the project again reflects the levelised production assumptions made for the purposes of this assessment. In practice there will be some variation in revenue year-on-year as a result of differences in the operating regime of the project and changing commodity prices.

Under the High Case, with higher product prices driven by a higher oil price assumption, average revenue post 2023 would increase to around $4.25 billion per year, while under the Low Case with lower oil prices average revenue would fall to $1.9 billion per year.

Over the life of the project, the total value of outputs is estimated at US$95 billion (real 2007; K343 billion) in the Study Case, US$55 billion (K200 billion) in the Low Case and US$123 billion (K443 billion) in the High Case.

Figure 4 **Total value of output (real US$, 2007)**



Data source: ACIL Tasman analysis

3.6 Employment

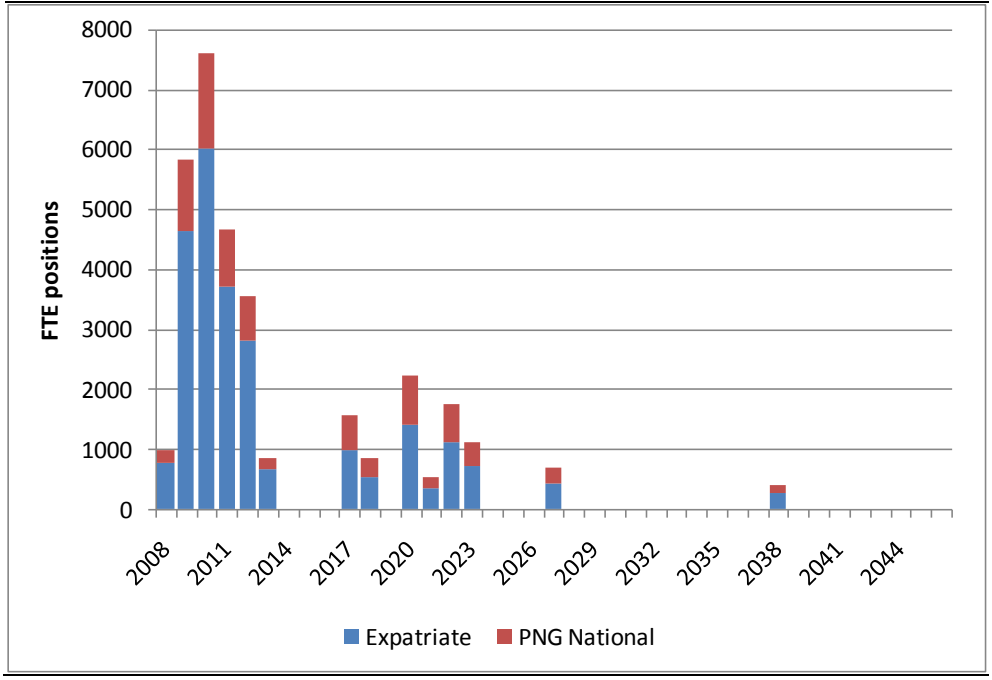
The employment profiles[4] for each of the three scenarios are identical, since oil price is the only variable.

The PNG LNG Project would have very significant employment impacts, both during construction and in terms of generation of new permanent jobs during the operational phase.

The construction workforce is expected to peak at around 7,500 workers including local and expatriate employees, contractors and administrative and support personnel (Figure 5). The major construction period is assumed to run from 2008 to 2013, with peak workforce numbers reached in 2010. Around 20% of the initial construction workforce is expected to be PNG nationals. During later construction periods (2017–18, 2020, 2022 and 2027) which relate to new upstream development and LPG recovery activities, a higher proportion of the construction workforce (between 35% and 40%) is expected to be made up of PNG nationals.

[4] Employment numbers quoted in this section refer to full-time equivalent (FTE) positions, which may be filled by individual workers (typically for local employees) or by two or more individuals working on rotation (typically for expatriate workers).

Figure 5 **Construction workforce direct employment and contractors**

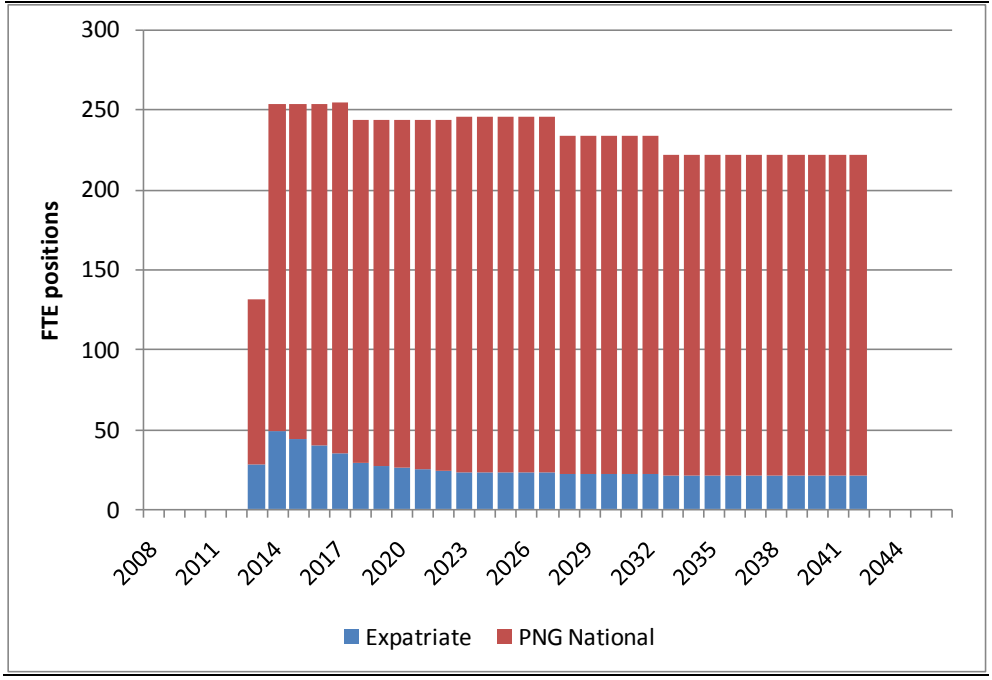


Data source: ACIL Tasman analysis based on proponent advice

During the operational phase commencing mid 2013, the project will provide around 450 to 500 full-time positions. PNG national employees are expected to account for between 75 and 80% of direct employment initially, rising to in excess of 90% over time.

In addition to employees, the project is expected to engage around 600 contract personnel per year during the operational phase, many of whom will be PNG nationals. Total employment in the operations phase, including staff and contractors, is therefore expected to average around 800 to 850 personnel. For modelling purposes, contractor services during the operational phase are included in non-labour costs.

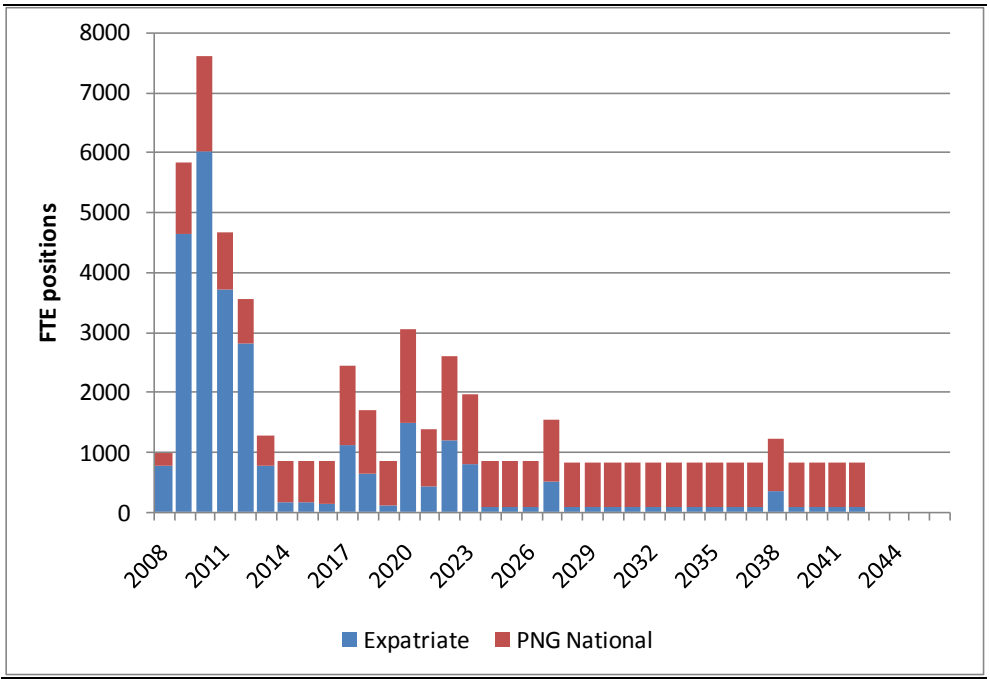
Figure 6 **Operations workforce direct employment**



Data source: ACIL Tasman analysis based on proponent advice

The total direct employment outcomes, covering both staff and contractors during construction and operations, are summarised in Figure 7.

Figure 7 **Total direct employment from construction and operations**



Data source: ACIL Tasman analysis based on proponent advice

3.7 Exploration and production activity

Petroleum exploration and production (E&P) activity in Papua New Guinea is heavily dependent on foreign oil companies. Prior to the Kutubu discovery, exploration activity had fallen to low levels. However, commercialisation of the Kutubu fields brought several major oil companies into the country and saw a substantial increase in the level of E&P activity that yielded important new discoveries.

Continued growth of the oil and gas sector in PNG will require ongoing investment in E&P activity, ideally with the active involvement of major companies that have the technical and financial resources to convert discoveries into producing assets.

The PNG LNG Project has the potential to boost E&P activity levels significantly. It would do so first because it would provide a strong incentive for major international petroleum companies to maintain an active involvement in the country. It would also enhance the attractiveness of Papua New Guinea as a location for E&P investment because it would boost the prospects of commercialising new gas discoveries, not least because of the powerful demonstration effect of a successful large-scale gas industry development. While the infrastructure facilities associated with the LNG project will be sized to meet the requirements of that project, and will therefore have limited capacity to accommodate new developments directly, they will provide a focal capability around which incremental expansion can occur.

The project would help to retain relevant skills and service capabilities within the region, and would provide access to production and transportation infrastructure. The continued active engagement of the major petroleum companies in Papua New Guinea would provide encouragement to other small and medium-sized explorers to invest in E&P activity, either in partnership with them or independently.

Although difficult to quantify, it is reasonable to assume that the PNG LNG Project will be a positive influence on levels of E&P activity in the country, and could encourage substantially higher levels of economic contribution from the petroleum sector in the long run.

3.8 Sources of income and direct cash flows

This section describes the sources of income to the PNG government[5] and landowners arising from the PNG LNG Project, and provides model-derived estimates of the direct cash flows from these sources.

The major items of direct income to the PNG government and landowners are:

- Taxation
  - Company Tax payable by the PNG LNG participants
  - PAYE or personal income tax
- Development Levy
- Royalty
- Equity participation

3.8.1 Taxation revenue

Company Tax

Company Tax represents the tax paid by the project participant companies to the PNG government on profits arising from the LNG Project. Royalties, which provide a tax offset, have been netted out. Thus, the net amount represents the total revenue actually flowing to the government from company tax.

PAYE Personal Income Tax

It is assumed that Pay As You Earn (PAYE) Taxation payments will be made by all PNG national wage and salary earners employed by the PNG LNG Project. We have not assumed any PAYE payments from expatriate workers in either the construction or operations phase. To the extent that some expatriate workers may be liable to pay personal income tax in PNG, this assumption is conservative. An average effective PAYE tax rate of 30% has been assumed.

3.8.2 Development Levy

Development Levy is calculated at 2 per cent of the well-head value of hydrocarbons produced. The well-head value has been derived by netting back capital and operating cost to the well-head. The proceeds of the Development Levy are assumed to be divided between provincial governments and

[5] Sources of income for provincial governments are included in the PNG government estimates.

landowners. Development Levy payments are taken to be deductible for purposes of calculating Company Tax liabilities.

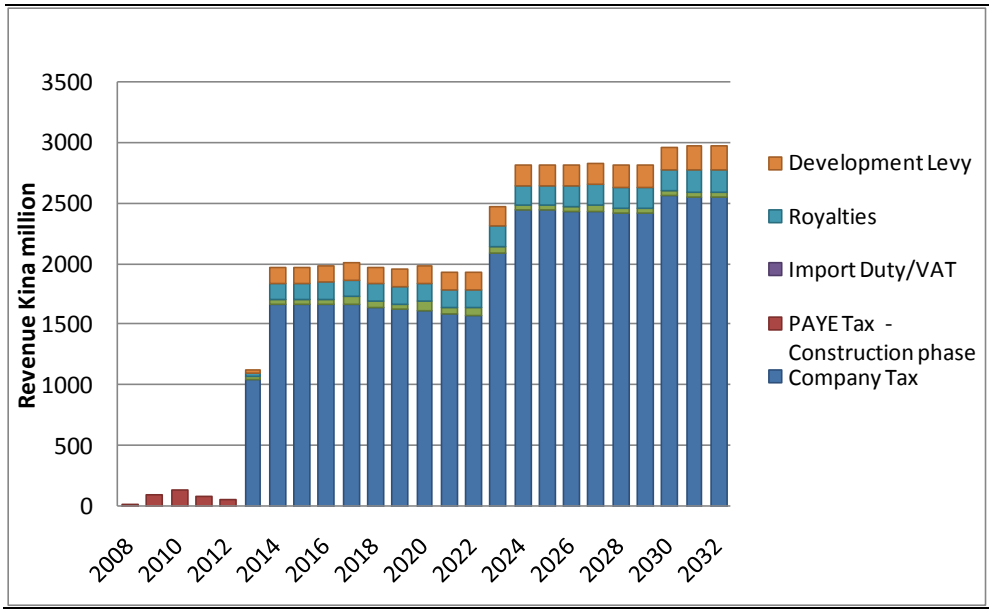
3.8.3 Royalty

Royalty is calculated at 2 per cent of the well-head value, derived by netting back the capital and operating cost to the well-head. Royalty payments are gathered by the PNG government for the benefit of landowners. The royalty payment by LNG Project participants is treated as a tax-credit for purposes of calculating Company Tax.

3.8.4 Modelled taxation, development levy and royalty payments

Figure 8 shows the modelled direct payments to the PNG Government (including payments collected on behalf of provincial governments and landowners) as a result of taxation, development levy and royalties, under the Study Case assumptions. Company tax will account for the majority of the revenue—around 85% of the annual contribution. Total tax, levy and royalty receipts are estimated at about K2 billion in real terms for the first ten years of operation of the project, rising to K3 billion thereafter as interest deductions and depreciation allowances fall and output value is boosted by commencement of separate LPG production.

Figure 8 **Taxation, Development Levy and Royalty Payments—Study Case**

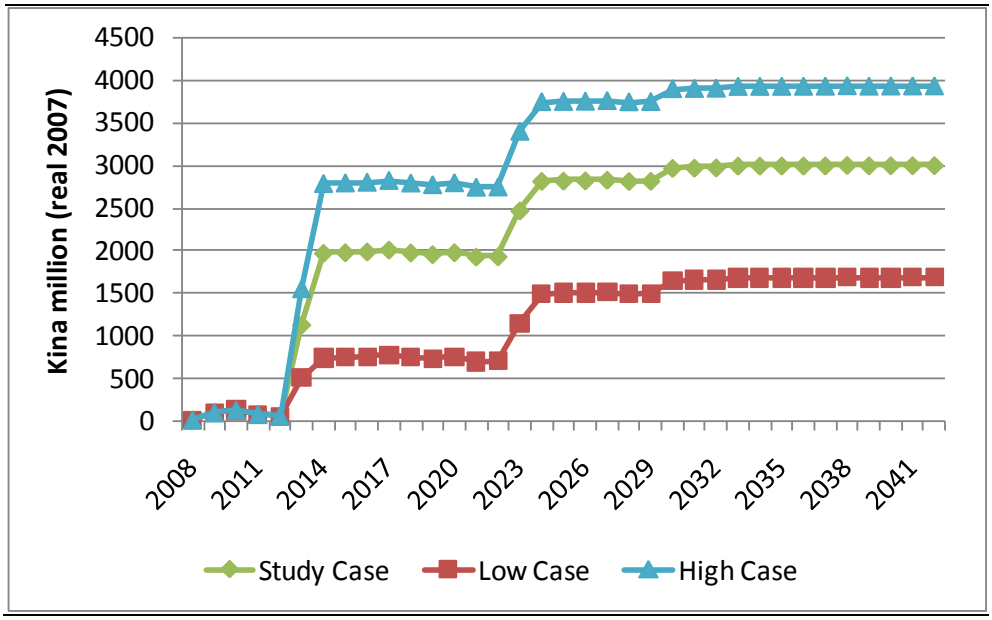


Data source: ACIL Tasman analysis

The sensitivity of total government receipts from taxation, levies and royalty to prices realised for the output of the LNG Project has been assessed through the High and Low oil price cases. Because of the linkage of LNG and other

product prices to international oil prices, the high oil price case results in more revenue while the low oil price case yields less revenue. The results are summarised in Figure 9. Total annual receipts would reach about K1.7 billion under the Low Case and K3.9 billion under the High Case.

Figure 9 **Comparison of total government tax, levy and royalty receipts for Study Case, Low and High oil price cases**



Data source: ACIL Tasman analysis

3.8.5 Equity participation in the Gas Project

State participation is an essential feature of Papua New Guinea's fiscal regime as it is in many other countries hosting foreign companies for oil and gas exploration and development. In Papua New Guinea, equity participation by the national government has served a dual purpose as:

- a means of sharing in any economic rent available from resource development and sharing the proportionate rewards in any growth, and
- a way of enrolling the support of local landowners and provincial governments, given that a part of the returns from State participation is earmarked for the benefit of these parties.

Under legislation, the PNG government has the option to acquire up to a 22.5 per cent participating interest in oil and gas development projects once they reach the development phase. This non-carried buy-in right is now embedded in the *Oil and Gas Act 1998*.[6]

[6] The right is non-carried because the PNG government is required to pay its share of past and future costs in order to acquire and maintain its equity share.

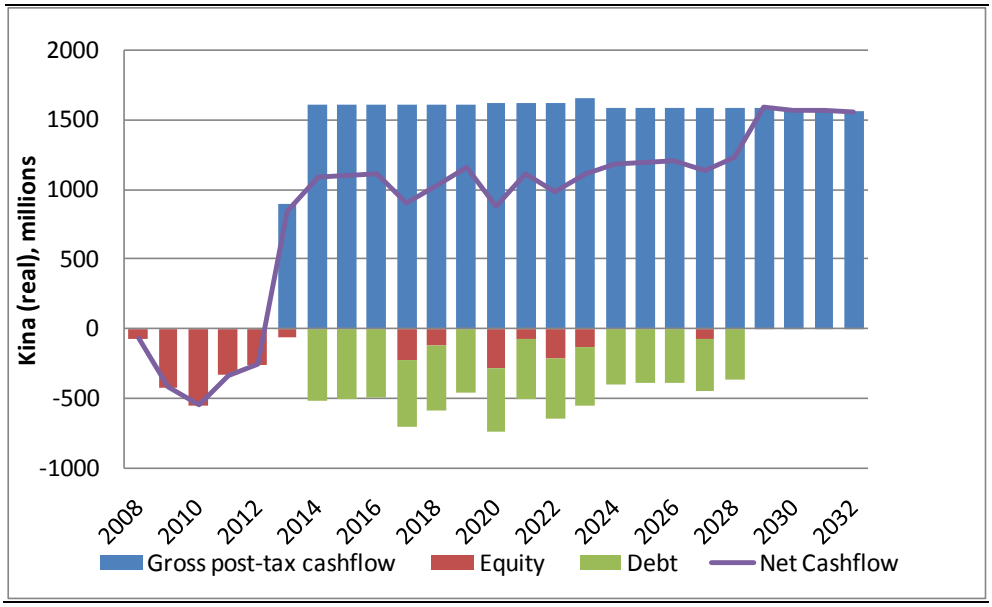
The PNG national government (initially as a matter of policy, and subsequently with legislative support) sets aside a certain part of its participating interest for the benefit of provincial governments and landowners. In the case of the Kutubu oil project, this amounted to a 6.75 per cent share that also included a part (2.70 per cent) for the host provincial governments (Southern Highlands and Gulf). In the case of both the Gobe and Moran oil projects, the participating interest provided for the benefit of landowners was 2 per cent.

While these precedents may offer some guidance as to how government equity in the project may be treated, the arrangements for the PNG LNG project have not yet been settled. Nevertheless, the total level of PNG national government participation, and its allocation to landowners and provincial governments, will be important issues for the project. Unlike an oil project, the PNG LNG Project involves long-term contractual commitments for uninterrupted supply of gas to customers. The alignment of government and landowner interests with the interests of the project is an important consideration in managing the risks of business interruption. Such risk management strategies are essential when considering a multi-billion dollar investment decision such as PNG LNG.

For the purposes of quantification of impacts in this study, a PNG government direct equity interest of 19% (inclusive of any allocations to landowners and provincial governments) has been assumed. The PNG government will indirectly hold additional equity in the project through its shareholding in Oil Search.

Actual returns to governments and landowners from PNG government equity holdings in the PNG LNG project will depend on a range of factors and it is beyond the scope of this study to forecast those returns. However, in order to gain an indication of the magnitude of returns that a 19% equity share might potentially provide, we have estimated the net cash flow after tax and financing costs (assuming financing arrangements as described in section 3.3.5). As shown in Figure 10, under Study Case assumptions this level of equity holding could result in a net cash flow of around K1 billion per year (real 2007) for the first 15 years after commissioning, rising to K1.5 billion per year after debt is fully repaid.

Figure 10 **PNG government equity share of net cash flow (after tax and financing costs)—Study Case**



Data source: ACIL Tasman analysis

For the Low Case the net cash flow would be a maximum of around K0.87 billion per year, while for the High Case the corresponding net cash flow would be around K2.0 billion per year.

Over the life of the Project, aggregate net cash flow to PNG government equity after tax totals about K38 billion under the Study Case assumptions.

3.8.6 Other potential sources of direct benefit

While not quantified for purposes of this study, there are a number of other potential sources of direct benefit to national, provincial and local governments and to landowners. The value and extent of these benefits will be part of the fiscal and benefits sharing agreements to be negotiated between the project and affected landowners, between the project and government, and between the government and designated beneficiary groups. These are briefly discussed in this section.

Local Business Dividends

Local Business Dividends represent the dividends declared out of the net profits from local business development activities undertaken by landowner businesses supported by the Project. These have not been quantified as part of the direct benefits. However the assessment of economy-wide impacts implicitly includes the flow-on effects into local business activities.

Other benefits

Expenditures under the Tax Credit Scheme and Discretionary Spending, while not strictly speaking direct cash flows, are mentioned in the consideration of benefits for completeness since they result in tangible direct benefits to local communities.

- A Tax Credit Scheme provides developers with a credit against Company Tax for amounts spent in the project area. While not direct revenue payments, such expenditures typically provide benefits in the form of improved local amenities.
- Discretionary spending represents expenditure by developers on social infrastructure *in addition* to money spent under the Tax Credit Scheme. Again, such discretionary spending does not represent direct cash flow to government, landowners or local communities, but it provides significant benefits in the form of improved local services and amenities.

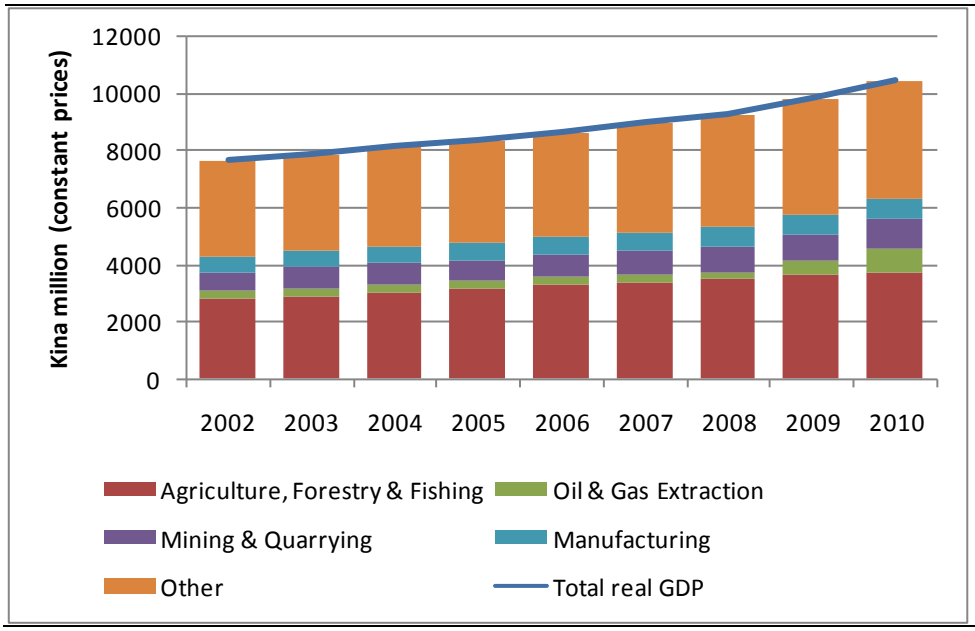
In order to support construction and ongoing operations, the project developers can be expected to make substantial investments in new and upgraded infrastructure such as roads, bridges, airfields and other logistical support components. Future access, operation, ownership and maintenance of this infrastructure are likely to require additional negotiations and agreements between the project developers, the impacted communities and government agencies.

4 Economy-wide Impacts of the PNG LNG Project

4.1 Overview of the PNG economy: the role of petroleum and mining

Papua New Guinea is a country well endowed with significant reserves of natural resources including oil, gas, gold, copper, timber, agricultural and marine resources. Papua New Guinea's marine and coastal resources are the most extensive and diverse in the South Pacific region. Agriculture is the dominant sector, accounting for about one-third of Gross Domestic Product (GDP) and providing wage employment for about 80 per cent of the working population. However, since the early nineties, mining and oil have made an increasing contribution to national output, and the share of agriculture in GDP and exports has declined. The projections indicate that growth in this sector will be sluggish and mining and petroleum are expected to play an increasing role (Figure 11). The manufacturing sector contributes less than 10 per cent of real GDP and will continue to remain static for a long period.

Figure 11 **Contribution to GDP by industry sector**

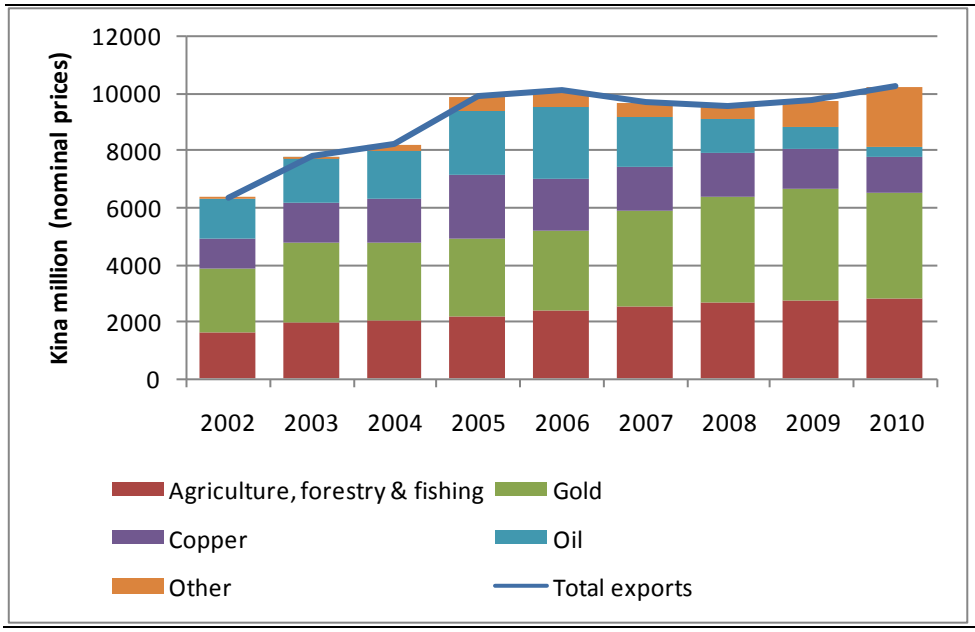


Data source: GOPNG (2005), Appendix 3, Table 3.1

Although agriculture provides the main source of income and livelihood for the majority of Papua New Guineans, minerals are the main source of national income. Minerals currently account for 69 per cent of the total value of exports while agriculture and forestry account for 26 per cent. Since 1993, petroleum

exports have grown in significance, increasing from K817 million to just over K2 billion in 2007. Petroleum exports now account for a third of mineral exports. Over the medium-term, oil exports are projected to fall sharply to K342 million by 2010 (Figure 12). This outcome reflects natural depletion of reserves from the country's existing oil fields. There is therefore an urgent need for new projects such as the LNG project to offset the expected decline in export revenues.

Figure 12 **Value of main export commodities**



Data source: GOPNG (2005), Appendix 3, Table 3.5

4.2 Methodology and assumptions

The model used in this economic assessment is a computable general equilibrium (CGE) model[7] of the PNG economy designed to assist the analyst or policymaker to address the following 'what if' or policy issues:

- policies which occur at the sector level - industry, commodity, occupation
- policies which occur at the macroeconomic level
- changes in international economic conditions.

In accordance with the usual practice in applying CGE models to estimate economic impacts, a base case has been established which represents the PNG economy *in the absence of the project*. This is then compared with an alternative

[7] 'Computable' in CGE refers to the fact it is a quantitative model which is solved by means of a computer. The term 'general equilibrium' refers to the fact that the production and consumption relationships, prices and the interaction between supply and demand in factor and product markets are all simultaneously considered.

case in which the project is assumed to go ahead—thereby imposing what economists refer to as a "shock" on the economy. The term "shock" relates to the fact that the event being examined (whether it is a major investment such as the PNG LNG project, or a significant government policy change such as a major tax reform) will create effects that move through the economy like shock waves—or like ripples when a stone is dropped into a pond. These responses to the economic "shock" can be measured using the CGE model. The term "shock" is not intended to imply that the impacts of the project are in any way startling, unexpected, or undesirable

The model is a static model based on Woldekidan (1993) which we have updated using 2006 data. The model consists of 37 domestic industries, 34 commodities and 4 labour types. Owing to the importance of agriculture in PNG's economy, this sector is disaggregated into smallholder and plantation subsectors for each of PNG's main export crops—coffee, cocoa, palm oil and copra. A list of the commodities and industries is given in Table 1. The model's theoretical structure describes the purchasing decisions of the industries, investors, a single representative household, the government sector and the external sector. Given that models are an abstraction from reality, various simplifying assumptions are made regarding the behaviour of industries, investors and households. The links between production and consumption within the economy, as well as links to the external economy, are represented by the model's input-output structure. The data base also allows various structural coefficients—sales and cost shares—to be computed.[8]

A key feature of the model is that it is comparative static in nature, which means it only provides projections at one point in time, the solution. In general, comparative static models are solved for a short run impact (about 2 years) and a long run impact (5 to 10 years). They are not very specific about the timing of effects and represent the time taken for an economy to adjust following a policy shock. The assumptions about adjustment have to do with the 'closure' adopted. The closure refers to variables whose values are endogenous (that is, determined within the model) and those whose values are exogenous (that is, determined outside the model and therefore fixed for modelling purposes). In the simulations reported below, land and capital are assumed to be exogenous in the short run but are free to adjust in the long run.

The model does not have a monetary sector and therefore cannot determine the absolute level of prices. It does, however, determine the real exchange rate and hence the relative prices of traded and non-traded goods and services. The real exchange rate is defined as the nominal exchange rate (Kina/US$) divided by the rate of inflation, as measured by the consumer price index (CPI). This

[8] Technical details of the model are provided in Appendix A for interested readers.

measure yields the relative price of tradables to non-tradables. The CPI is kept exogenous and acts as the *numeraire*.[9] The other exogenous variables in the model include import and export prices, tariffs, tax rates on company profits and mining rents, real wages, and the number of households.

Table 1 **List of commodities and industries in the model**

Commodity	Industry
1 Subsistence crops	1 Subsistence agriculture
2 Non-ruminant livestock	2 Smallholder coffee
3 Coffee	3 Smallholder cocoa
4 Cocoa	4 Smallholder palm oil
5 Palm oil	5 Smallholder copra
6 Copra	6 Plantation coffee
7 Other tree crops	7 Plantation cocoa
8 Other agriculture	8 Plantation palm oil
9 Fishing	9 Plantation copra
10 Forestry	10 Other tree crops
11 Copper	11 Other agriculture
12 Gold	12 Fishing*
13 Other minerals	13 Forestry
14 Quarrying	14 Porgera Gold Mine
15 Timber Processing	15 OK Tedi Gold Mine
16 Food processing	16 Other mining
17 Beverages and tobacco	17 Quarrying
18 Metals and engineering	18 Timber processing
19 Machinery repairs	19 Food processing
20 Chemicals	20 Beverages and tobacco
21 Petroleum products	21 Metals and engineering
22 Other manufacturing	22 Machinery repairs
23 Road transport	23 Chemicals
24 Water transport	24 Petroleum products
25 Air transport	25 Other manufacturing
26 Education	26 Road transport
27 Health	27 Water transport
28 Electricity and garbage	28 Air transport
29 Building and construction	29 Education
30 Commerce	30 Health
31 Finance and investment	31 Electricity and garbage
32 Govt. admin. and defence	32 Building and construction
33 Other services	33 Commerce
34 Oil	34 Finance and investment
	35 Govt. admin. and defence
	36 Other services
	37 Oil

[9] In a model without absolute prices, one price must be nominated as the *numeraire* and kept fixed (that is, set to unity) in order to obtain a solution.

4.3 Direct and indirect impacts during construction and operation

Prior to examining the macroeconomic and sectoral implications of the economic shock caused by the LNG project, we first discuss the impacts of the project on income during the construction and operation phase. This particular analysis is not based on the CGE model but uses data from the project. The income impacts can be divided into direct and indirect impacts. The direct impacts are in the form of revenues flowing to individuals and groups. This comprises labour income earned by domestic and expatriate workers, landowners' compensation, and private investors' share of the profits, as well as national and provincial governments' income from personal and company taxes, dividends and other taxes. The indirect impacts arise from the multiplier effects of the money spent in the local economy by the various income recipients. For example, the increased expenditures lead to an industry's purchase of inputs from other businesses in the economy and the further purchase of inputs by those other businesses, and so on. In this analysis, we conservatively assume a multiplier of 0.7. That is, for every K1.0 increase in spending in the local economy, total income would increase by K0.7. This estimate is lower than the input-output multipliers derived by the Fiji Bureau of Statistics and the Queensland Government Statistical Office for use in those jurisdictions, reflecting the current structural nature of the PNG economy compared to Queensland or Fiji.

4.3.1 Nature of the impacts

The direct impacts of the project are expected to be felt at the local level. Since goods and services will be sourced from the National Capital District, it too will receive some of the indirect impacts. Based on the experience of large resource projects in PNG, the local impacts of the project are expected to be in the form of:

- employment created during the construction and operation phase
- payments to landowners
- improved infrastructure provision within the project area and improved connections between the project area and other centres
- business opportunities generated by the supply of inputs such as fuel, security, and catering services to the project
- employment and business opportunities resulting from the expenditure of incomes earned from the project and associated community and infrastructure projects.

Section 3.6 of this report has already discussed the direct employment impacts during the construction and operation phases of the project. The other direct

impact is in the form of payment of royalties to landowners. Most of these payments will be spent in the local areas on food, vehicles, household durables and other items such as bride price. However, it is expected that some of the payments will be invested in local businesses. According to Filer (1999), 65 to 75 per cent of the compensation paid to Porgera landowners was consumed, 20 to 25 per cent was invested in local businesses and 5 to 10 per cent was invested in local alluvial gold mining.

The LNG project will develop significant infrastructure including roads, bridges and telecommunications. The improved transport infrastructure will enhance access to remote areas and make education and health services more accessible. It will also assist neighbouring communities by providing opportunities for wage employment and for trading cash crops. In general, the infrastructure development would result in other significant benefits such as savings in transport costs and improved security of supply. It is expected that some of the Government's proceeds from the project will be spent on the construction of new schools and health facilities, as well as the upgrade of existing facilities. Also, some of the funds would be spent on the employment and training of teachers and health professionals.

One of the significant impacts of the project will be the opportunities for local businesses. These opportunities include outsourcing for services such as catering, engineering, security, fuel supply, managerial and technical assistance. The influx of workers into the project area will also increase the demand for various services, including food. Therefore there will be an opportunity for local farmers to increase their incomes by producing more food crops. In the case of the Kutubu oil project, the developer provided a range of agricultural extension services to support agricultural activity in the area (Simpson & others, 1998b). The improved transport infrastructure may also make it easier for local producers to extend their supply networks to nearby markets.

Despite the unique opportunity for governments at all levels to channel their share of the proceeds into improving infrastructure and services for the local communities, there is a risk that much of these resources will not reach the target beneficiaries. For example, Simpson & others (1998a) observed that in the Southern Highlands, there was little evidence of direct investment by the Provincial Governments in infrastructure and services. There is also a risk that the large sums of money flowing to individuals could aggravate social and health problems brought on by the consumption of alcohol and tobacco, imported foods, and could increase income inequalities (Filer, 1999). However, as we show below, the local impacts of the project are minor when compared to the broader economic impacts.

4.3.2 Estimate of the direct and indirect income impacts

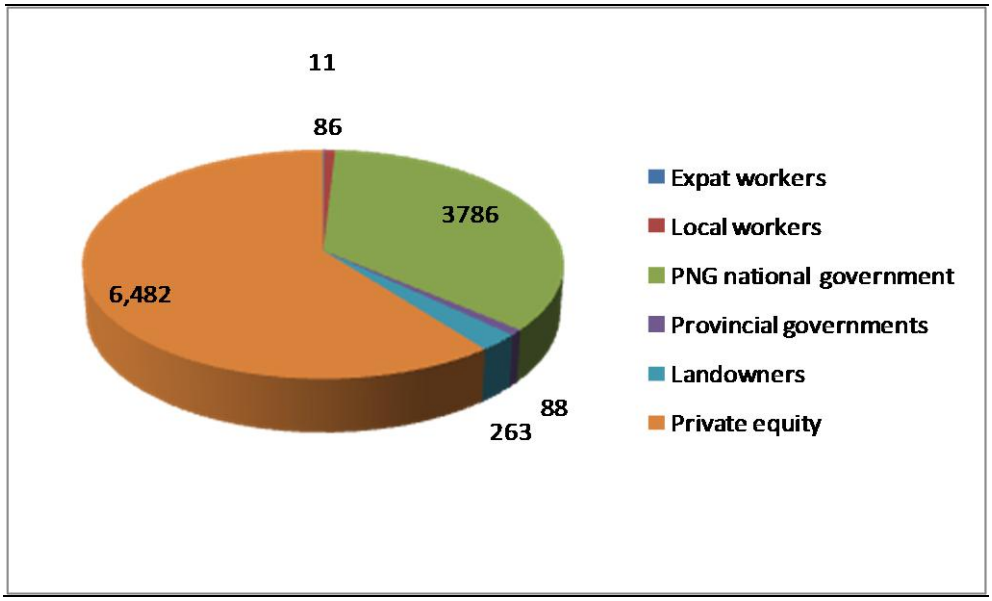
Construction phase

The direct income impacts presented here comprise payments to workers, landowners, local businesses, governments and private investors, while the indirect impacts relate to spillovers from spending by these groups. It is assumed that governments, landowners and private investors do not receive payments during the construction period. During the 4 to 5 year construction phase, post-tax wages and salaries paid to local and expatriate staff are estimated to average around K250 million and K2,250 million per annum, respectively. The local business dividend is estimated to be 1 per cent of the capital expenditures sourced locally which is equivalent to be about K2 million per annum. In estimating the indirect impacts, it is estimated that local workers spend half of their disposable income locally whereas expatriate workers spend 10 per cent. Applying a multiplier of 0.7, the indirect impacts during construction are estimated to average K245 million per annum in real terms.

Operation phase

The distribution of direct income between the various stakeholders during the operational phase is summarised in Figure 13. Labour payments during the operation period are estimated to be approximately 20 per cent of the project's operating expenditures, which amount to an average of K140 million per annum in real terms. The post-tax earnings by expatiate workers are estimated to be K11 million per annum, while that of local workers are estimated to be K86 million per annum (Figure 13). The National Government's receipts come from the various taxes and its equity share in the project. Both the Development Levy and Royalty are calculated at 2 per cent of the well-head value. In the absence of any settled policy position on distribution of Development Levies, we have assumed that 50 per cent of receipts are passed through to provincial governments, and the balance paid to landowners in the areas directly affected by the Project. In accordance with current policy we assume that 100 per cent of royalty receipts are paid to affected landowners.

Figure 13 **Direct income impact during project operation (average Kina million per annum, real prices)**



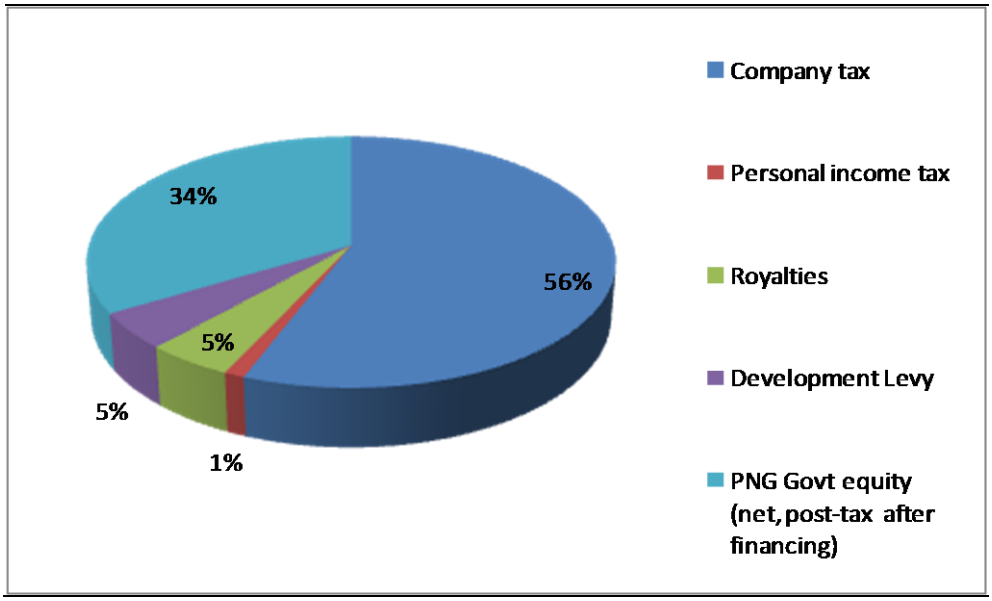
Data source: Consultants' estimates based on ExxonMobil data

On the basis of the foregoing, payments flowing to the PNG national government are estimated to average K3.8 billion per annum in real terms during the operational phase of the project, payments to provincial governments are estimated to average K88 million per annum, while payments to landowners are estimated to average K263 million per annum. On the basis that private equity accounts for 81% of total equity (the remaining 19% being held by the PNG government), returns to private equity during the operational phase are estimated to average some K 6.5 billion per annum.

The indirect impacts result from the multiplier effects of spending by workers, landowners, and by local level and provincial governments. This is estimated to be about K195 million annually, based on a multiplier of 0.7 and assuming that half of the local beneficiaries' payments and 10 per cent of expatriate workers' salaries are spent locally.

Figure 14 shows the percentage distribution of taxation and other revenues received by PNG governments and landowners during the operational phase. Government revenue from company taxes account for 56 per cent of total revenue, while revenue from equity shares after financing costs is 34 per cent. Royalties and the Development Levy account for 5 per cent each, while personal income taxes account for 1 per cent.

Figure 14 **Distribution of revenue flows**



Data source: Consultants' estimates based on ExxonMobil data

4.4 Economy-wide impacts

The model used in this analysis estimates the economic impacts of the project at a given point in time under the key assumption that the economy will remain the same. In other words, it is assumed that the "economic shock" resulting from the project does not cause any change in the underlying structure of the economy or its sectoral makeup. However, in the case of PNG LNG, the scale of the project compared to the size of the economy is such that this assumption is not realistic. Therefore, it is important not to interpret the modelled outcomes as forecasts or accurate estimates of the size of the economic impacts. What is more meaningful about the analysis is that it helps to identify the industry sectors that stand to benefit from the project, and those that are potentially disadvantaged, thereby allowing policy makers to focus on how best to manage these impacts.

The modelling highlights the fact that the proposed LNG project will have a massive impact on the PNG economy. The following statistics provide a sense of the order of magnitude of the project's impacts. In 2006, the oil and gas sector's contribution to real GDP (that is, the economic value-added from the oil and gas sector) was about K305 million compared with total GDP of K8,652 million, which is equivalent to a share of 3.5 per cent. With the project, the additional value-added from oil and gas will average an estimated K9.6 billion per annum[10] over 30 years, equivalent to a 111 per cent per annum increase in the size of the economy as it is now. To simulate the macroeconomic impacts of the LNG project, we have modelled the effect of a 440 per cent per annum increase in oil and gas exports (this is the "economic shock" imposed on model), which is the additional annual increase over the 2006 nominal export value of K2.6 billion (GOPNG, 2005). We present below the model results for the macroeconomic impacts, followed by the sectoral impacts and impacts on the government sector.

4.4.1 Macroeconomic impacts

Results for the simulation of a 440 per cent expansion of oil and gas sector exports are displayed in Table 2. The modelling results show that the project increases the value of PNG's aggregate foreign currency exports by 106 per cent. This is less than the increase in oil and gas exports because production of some export commodities (shown later) decline.

[10] Calculated as average annual product value of K11.4 billion, less labour inputs of K0.68 billion, less capital inputs of K1.05 billion.

Table 2 **Macroeconomic impacts of the PNG LNG Project**

Variable	Short run	Long run
Real GDP	96.6	99.1
Real aggregate foreign currency exports	106.1	107.0
Real aggregate foreign currency imports	57.7	48.0
Total government expenditure	85.3	84.5
Real household consumption	106.0	107.0
Household disposable income	84.2	87.5
Aggregate employment	42.2	44.8
Ratio of real investment to real consumption	-83.7	-86.7
Nominal exchange rate (kina/US$)	-8.9	-10.5

Note: Values expressed as percentage change from underlying growth path

Data source: Model simulation results

Imports also increase, but at a slower rate of 58 per cent, resulting in a positive trade balance. Following the large increases in payments to the government, total government expenditure grows by 85 per cent. Real household consumption increases by 106 per cent due to the increase in household disposable income, which is in turn due to a 42 per cent increase in aggregate employment. Real GDP in the model is defined from the expenditure side as the sum of real household consumption, government consumption, investment and exports, less imports. In view of the growth in all these components, the net effect is an increase in real GDP of 97 per cent in the short run. This impact is not transitory because in the long run (which is defined as 5-10 years in this model), real output increases by 99 per cent.

Real consumption grows at a faster rate than real investment, as can be seen from the negative real investment to consumption ratio of minus 84 per cent. As a result of the large increase in oil and gas exports, the nominal exchange rate (kina/US$) appreciates by 9 per cent in the short run and by 11 per cent in the long run. Since the CPI (the *numeraire*) is held exogenous, the real exchange rate (defined as the ratio of the nominal exchange rate to the CPI) also appreciates by the same amount, by implication. As shown below, this exchange rate appreciation has the potential to reduce the external competitiveness of other export sectors (for example, agriculture and forestry), causing them to contract—a dynamic that will need to be managed through appropriate government policies.

4.4.2 Sectoral impacts

The modelling shows that while the LNG project has a very large net positive effect on the economy of PNG as a whole, it will not directly benefit all sectors of the economy. So, for example, the results show that the project has the potential to impact adversely on the agricultural sector in general, and

smallholder production of cash crops, in particular. The modelling results summarised in Table 3 show that value added in the plantation crop sector could contract in the short run at rates ranging from 2 to 7 per cent. Value added in the smallholder sector potentially declines at much higher rates ranging from 13 per cent (smallholder coffee) to 94 per cent (smallholder palm oil).

Table 3 **Impacts of the PNG LNG Project on value-added, by sector**

Sector	Short run	Long run
Agricultural output:		
Smallholder coffee	-13.4	-13.3
Smallholder cocoa	-14.6	-16.9
Smallholder palm oil	-94.2	-60.5
Smallholder copra	-19.7	-18.0
Plantation coffee	-7.4	-9.2
Plantation cocoa	-6.2	-6.1
Plantation palm oil	-1.9	-2.5
Plantation copra	-0.2	-0.1
Other output:		
Oil and gas	440	440
Porgera gold mine	-1.5	-2.7
Ok Tedi gold mine	-0.1	-0.8
Other mining	-1.0	-2.8
Quarrying	37.5	54.2
Timber processing	0.1	6.4
Food processing	16.2	31.5
Beverages and tobacco	72.1	77.0
Metals and engineering	-3.5	18.5
Other manufacturing	12.3	53.9
Road transport	39.3	60.6
Water transport	26.4	36.2
Air transport	64.7	74.7
Education	84.0	87.4
Health	84.2	87.5
Electricity and garbage	50.3	67.2
Building and construction	19.6	22.9
Commerce	10.2	42.0
Financial services	42.6	60.4
Government admin. and defence	83.8	87.3

Note: Values expressed as percentage change from underlying growth path

Data source: Model simulation results

The modelled impacts on gold and other mining activities also see declines in these sectors, but by relatively small amounts. On the other hand, the manufacturing and service sectors expand, with the latter growing much faster as a result of the LNG project. The highest growth is observed for education, health, and government administration and defence which all expand by around 84 per cent in the short run, followed by beverages and tobacco, transport, commerce, and building and construction which grow at rates ranging from 10 to 65 per cent.

The potential adverse impact of the booming oil and gas sector on agriculture fits the classic example of the so-called "Dutch Disease" (Corden and Neary, 1982). This phenomenon was first identified in Holland, when revenue from North Sea oil flooded into the country. It occurs when an influx of income from resource wealth, and the spending that comes with it, drives up the exchange rate and inflates the domestic economy. This is a problem because it reduces the international competitiveness of the country's non-resource exports and import-competing activities. The result is that a resource project can indirectly take place at the expense of other forms of activity.

Apart from the appreciating exchange rate, the other causal factor in the Dutch Disease phenomenon is that the high rate of return generated by the booming oil and gas sector tends to bid resources away from other competing exports, further depressing their output. Sectors that perform strongly in the resource boom are those that provide services to the oil and gas sector, as well as social services (health and education) and government administration which benefit from increased government expenditures.

In the past, the inflow of revenue from Papua New Guinea's mining and oil sector was also supplemented by a large inflow of funds from the international donor community, notably the budget support of Australia. This inflow of foreign exchange added to the Dutch Disease problem by supporting an exchange rate at unsustainably high levels.[11] Although the precise extent of the problem in PNG in the past is somewhat unclear, a sense of the potential impact is provided by the large fall in the nominal value of the kina since it was floated in 1994. This devaluation can be attributed to declining mining and oil revenue, the gradual removal of Australian budget support and large Government budget deficits. At the time of the float, the kina was roughly at parity with the US$1. Such a high exchange rate proved unsustainable and the kina declined to less than a quarter of its pre-float value in US dollar terms, before returning to current levels of around US$0.36.[12]

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[11] See AusAID (1999), Duncan et. al. (1998) and King and Sugden (1996) for a discussion of the Dutch Disease problem in Papua New Guinea.

[12] The fall in the nominal value of the kina was also in part a result of over-expenditure by the National Government. Had the National Government operated balanced budgets and not

It is important to appreciate that past Dutch Disease effects in Papua New Guinea associated with mining and petroleum could have been largely avoided had the revenues been managed differently. The original intention of the Government was that revenue from the mining and oil sector was to be saved in the Mineral Resource Stabilisation Fund (the MRSF). While positive account balances were recorded over the 1990s, these 'savings' were only book entries and budget deficits meant that the Government actually quickly spent the mining and oil revenue. If instead the mining and oil revenue had been saved and spent gradually as originally intended, the effect on the exchange rate and hence non-mining and oil sectors would have been much less. In one sense, therefore, the Dutch Disease problem can be seen as a result of how the Government chooses to use the revenue from resource extraction, rather than a result of the resource extraction activity itself. It follows that the potential impact of the proposed PNG LNG project on other sectors will depend fundamentally on the future stance of Government management and how it chooses to spend revenue from the project.

4.4.3 Employment impacts

The oil and gas industry is classified in the CGE model as primarily an urban-based industry. Therefore, the direct impact of the oil and gas project is an increase in urban skilled and unskilled employment levels, which grow by 66 and 31 per cent respectively (Table 4). On the other hand, the model shows rural skilled and unskilled employment levels declining by 12 and 24 per cent, respectively. These changes are consistent with a decline in activity in the agricultural sector and here we observe that the largest fall in employment occurs in the unskilled sector which is the major supplier of labour to the smallholder agricultural sector.

Table 4 **Employment impacts of the PNG LNG Project**

Occupation type	Short run	Long run
Urban skilled	65.6	65.5
Urban unskilled	31.1	36.1
Rural skilled	-11.8	-10.3
Rural unskilled	-23.5	-22.0

Note: Values expressed as percentage change from underlying growth path

Data source: Model simulation results

the large deficits seen over an extended period, the nominal value of the kina would have been maintained at a considerably higher level – see Sugden (2002).

4.4.4 Impacts on the PNG government budget

As indicated by Figure 13, the PNG national government sector is the largest recipient of non-equity revenue flows from the project, with company taxes contributing the bulk of the revenue. This is confirmed by the modelling results which show that government revenues from company tax grow by 133 per cent in the short run, and by a slightly higher 135 per cent in the long run (Table 5). The next highest growth in government revenue is from personal income tax receipts which grow by 20 per cent. Smaller rates of growth are observed for mining royalties, other non-tax, other taxes and import duties.

Table 5 **Impacts on the Government sector**

Revenue source	Short run	Long run
Government revenue from other non-tax revenue	8.4	9.0
Government revenue from tax on labour	20.0	19.5
Government revenue from company taxes	133.0	135.0
Government revenue from consumption taxes	4.0	4.9
Government revenue from mining royalties	5.0	4.5
Government revenue from other taxes	2.6	2.8
Government revenue from import duties	2.2	1.9

Note: Values expressed as percentage change from underlying growth path

Data source: Model simulation results

4.5 Summary of the overall impacts

The LNG project will have a profound effect on the PNG economy. Not all of the potential impacts will necessarily be positive: a project of such size (relative to the economy as a whole) will inevitably create some stresses and strains across the economy. However the net benefits arising from the project will be very large provided the potential adverse pressures are properly managed.

At the macroeconomic level, there will be large increases in private and public consumption and net exports, resulting in very large increases in real output. On the downside, the growth in demand in the oil and gas sector and the high growth rate of public and private expenditures will put upward pressure on the exchange rate, causing it to appreciate. A stronger kina will tend to reduce the external competitiveness of the agricultural and forestry sectors, potentially leading to a contraction of their output and a reduction in rural skilled and unskilled employment. The modelling results indicate that there may also be some contraction in gold and other mining, although this is relatively minor compared to the agricultural sector. The clear winners of the oil and gas expansion are the government sector which receives very large revenue flows from taxes and other payments, urban households whose disposable incomes

increase from the rapid increase in total employment[13], and the manufacturing and service sectors, which benefit from the flow on effects.

Overall, the project will increase real output at several times the current rate of growth. However, the potential adverse impacts on the agricultural sector raise the possibility of worsening poverty if the economic transformation is not well managed. Although we do not directly address the issues of poverty and income inequality in the modelling, the results show a reduction in employment in rural areas where agriculture and forestry are important economic activities. This in turn implies that, in the absence of effective policies to address these pressures, there is a risk that incomes will fall in those regions, thereby increasing poverty.

4.6 Managing the impacts to sustain the benefits

Over the last decade or so, the PNG economy has benefited from implementation of a number of reforms in the areas of governance and macroeconomic management. Following the enactment of the Organic Law on the Integrity of Political Parties, some stability has been introduced to the political process. Before the introduction of the law, no government since independence had survived a full five-year term in office. That the current government under the Rt Hon Sir Michael Somare GCMG CH PC MP is the first to do so is testimony to the impact of the Organic Law. In the area of macroeconomic management, the changes include monetary and fiscal policy reform, tax reform, and financial sector reform. As a result of these reforms, inflation has fallen from a high of nearly 16 per cent in 2000 to 1.7 per cent in 2005. Government debt as a percentage of GDP has fallen from 57 per cent in 2000 to about 32 per cent in 2006 and government expenditure as a percentage of GDP has lagged far behind the growth in revenues. The PNG Treasury has forecast that government expenditure will be limited to below 30 per cent of GDP in 2007.

The PNG government is therefore arguably in a better position now than in the past to ensure that the impacts of the proposed LNG project, in terms of real exchange rate and inflation, are effectively managed so as to avoid distortion of incentives in the economy. Firm and responsible government management will be required to ensure that the large economic gains from the project translate into equivalent socioeconomic development. This in turn highlights the need for continued reforms in the area of governance. These and other issues related to sustainable management of the project's impacts are discussed in further detail below.

[13] The model does not capture the payments landowners receive from royalties and dividends.

To sustain the income derived from the LNG project, the PNG Government would be well advised to be guided by the Hartwick Rule. According to Hartwick (1977) in order to sustain income from a non-renewable resource, a society must invest the rents in other forms of capital to yield a social rate of return equal to or greater than alternative investments. This implies that to obtain the highest rate of return, the government must invest the money offshore. Doing so will mitigate the effects of the Dutch Disease because the large revenue flows would in effect be 'sterilised'. This, in fact, was the main intention when the PNG Government established the Mineral Resource Stabilisation Fund (MRSF). However, the original objective of the MRSF was defeated as the government of the day continually 'dipped' into the Fund to cover its budget deficits. Much can be learned from the experience of countries such as Norway and Brunei Darussalam that have successfully managed the income from their mineral resources. Norway established an offshore fund in 1995 into which it directs all the tax revenue from its North Sea oil resources. This essentially guarantees that the country can spend the real interest on its natural resources long after the oil resources have been exhausted. This is a good example of how a non-renewable resource can be transformed into a financial asset that will last forever. Importantly, by creating this fund Norway has minimised the negative effects of natural resource wealth by sending the rents offshore. Instead of driving up the exchange rate and making the country less competitive, the revenue simply drives up the value of the fund.

The prices of mineral products have been shown to be highly volatile, thus generating export and fiscal revenue fluctuations (Bosson and Varon, 1977). The revenue volatility implies that the contribution of mineral extraction to economic growth tends to be cyclical (Auty, 1993). This is relevant to the LNG project, because the revenues from the project (and hence the taxation and other returns to the government and people of PNG) are a function of oil price, which has exhibited high levels of volatility over time. However, the accumulation of savings in a fund acts as a cushion to adverse price shocks and mitigates the effects of the Dutch Disease by slowing down the rate of domestic absorption.

The question of how large PNG's fund should be to sustain the income indefinitely can be addressed with the aid of the following equation which is based on the Hartwick Rule.

$$\hat{Y} = P\hat{y} = rFk \qquad (1)$$

where:

$\hat{Y}$ = desired national income
P = population
$\hat{y}$ = desired national income per capita
r = real rate of return (expressed as a fraction)

F = capital investment fund
k = income multiplier

Solving equation (1) for F yields:

$$F = \hat{Y} / rk \qquad (2)$$

Possible values for the parameters are as follows:

$\hat{Y}$ = US$4528.6 million (1997, nominal GDP)
r = 6 - 12%
k = 1.0 - 2.0

Assuming a mid-point income multiplier of 1.5 and a real rate of return of 6 per cent, the required size of the capital fund is estimated to be US$50.3 billion. Allowing for the current population growth rate of 2.7 per cent per annum, and assuming values of $r = 0.06$ and $k = 1.5$, the capital fund would have to grow by at least US$1 billion per annum to sustain current incomes.

Of course, PNG has pressing domestic needs and may not be able to afford to invest such a large sum of money overseas. However, the main point of this analysis is to demonstrate the importance of the State investing a significant amount of money overseas in order to earn high returns for the people of PNG.

Given that the agricultural sector has been identified as a major potential loser from the project, some of the project's revenues should be used to assist this sector. However, the project not only offers an opportunity to develop the agricultural sector but also to diversify the merchandise export base. There are currently no linkages between the agricultural and manufacturing sectors. This situation could be rectified by increasing the development and processing of agricultural produce for domestic consumption as well as for export. Such a strategy will not only strengthen the links between the agricultural and manufacturing sectors, but will also create greater employment and output opportunities. A move in this direction would set the pace for the accelerated development of agro-industrialisation which involves the inter-related activities of production, processing, transport, storage, financing, marketing and distribution of specific agricultural produce.

To promote agro-industrial development, there would need to be a suite of complementary policies to encourage agribusiness development and rural development. Development of agro-industrial policy must go hand in hand with institutional reforms and the development of appropriate policies to remove the supply-side constraints which prevent local producers from responding effectively to favourable movements in the terms of trade. These constraints include low skill levels, lack of marketing and transport networks,

lack of access to credit for agricultural investment, and the virtual absence of a market for leasehold land.

The fisheries sector is one area whose vast potential remains to be tapped. The major constraint in this area is lack of sufficient domestic investment. Other constraints include lack of supporting infrastructure such as fishing wharves and electricity for refrigeration and processing in rural areas. The government could attract investment into this sector by adopting a policy package which includes tax incentives, financial assistance for local producers, and infrastructure development schemes.

Large scale expansion of fisheries or agriculture clearly has the potential to impact the environment adversely and that would also need to be properly managed. In this respect, there are two key implications for policy makers. First, the immediate need will be for the government to assist the current participants in the agricultural and fishing industries to adjust to the economic changes brought on by the project. Second, there is an opportunity for the government to apply part of its share of revenue from the LNG project to support further development and expansion of these sectors in order to promote employment creation. However, this should be based on principles of environmental sustainability in order to minimise any negative impacts.

Our analysis indicates that government spending has the capacity to either worsen or to mitigate the economic pressures associated with a resource boom, depending on the type of expenditure. In Appendix A we show that an increase in government consumption expenditure has effects similar to the Dutch Disease in that it results in a decline in some domestic industries. This occurs because increase in government consumption expenditure tends to 'crowd out' private expenditure, which in turn constrains the output of some sectors. The main implication for policy is that, rather than applying project revenues to consumption expenditure, the government should aim at expenditures that build the country's capital base yielding benefits that are sustainable in the long run.

To conclude, in order to successfully manage the impacts and sustain the very large net benefits associated with the LNG project, the Government will need to accelerate reforms in the area of governance. Large resource projects create opportunities for rent-seeking and corrupt behaviour amongst stakeholders, government bureaucrats and politicians which if not properly addressed can result in conflict, discord and, in extreme cases, civil war (Gylfason and Zoega, 2006; Iimi, 2006). As shown in the foregoing analysis, tax revenue is the dominant form of economic linkage given that oil and gas extraction, like other mining activities, tends to be a capital intensive and enclave activity. Dealing firmly with issues of governance and accountability can help to ensure that resources are not diverted from productive investment to unproductive

ventures. This implies a need for transparency in the disbursement and use of revenues accruing from the project. Finally, fiscal discipline, sound monetary policy and structural reform will be required if the recent improvements in the economy are to be maintained and full advantage is to be taken of the opportunity for sustained economic development offered by the PNG LNG project.

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A The economic assessment framework

A.1 The PNG CGE model

An economic model has been described as "a schematic simplification that strips away the non-essential aspects to reveal the inner working, shapes, or design of a more complicated mechanisation" (Klein 1983:1). Economic models may be broadly categorised into partial equilibrium and general equilibrium models. Partial equilibrium models (for example, econometric models) can be used to measure the impacts of a given policy variable in a single sector, holding all other relevant variables constant. General equilibrium models, on the other hand, are able to measure the impacts of one or more policy variables on several sectors simultaneously. Examples of general equilibrium models include input-output models, linear programming models, and computable general equilibrium (CGE) models.[1]

The PNG model may be described as an economy-wide, comparative-static, CGE model of the Johansen type (Johansen 1960)[2]. It allows the analyst to evaluate the impacts of the various policy shocks, as well as developments in the external sector, on the level and composition of industry activity and employment, trade, macroeconomic outcomes and the government's budgetary position. The current version belongs to the 'ORANI' family of CGE models (Dixon & others, 1982). Within the last decade or so, there has been a boom in CGE modelling due to two main reasons:

- the development of suitable computer software and the increase in computing power which allows huge amounts of data to be processed;
- the realisation that CGE models, unlike partial equilibrium models, allow the simulation of policies in ways which are easily understood or explained, and are perceived to be relevant by decision makers.

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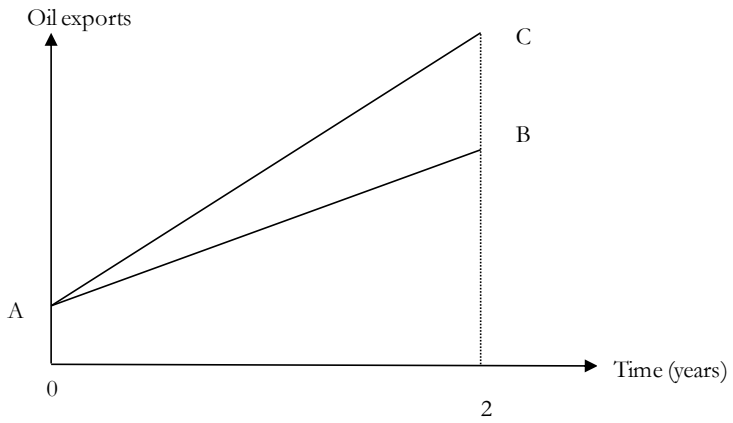
[1] 'Computable' in CGE refers to the fact it is a quantitative model which is solved by means of a computer. The term 'general equilibrium' refers to the fact that the production and consumption relationships, prices and the interaction between supply and demand in factor and product markets are all simultaneously considered.

[2] The Johansen approach can be contrasted by another approach in which the system of equations is solved in the levels of its variables. The latter approach is commonly used by the World Bank and in North-America (Dervis de Melo and Robinson 1982). Although it produces exact solution, it requires tailor-made solution algorithms which need to be redeveloped after any changes in model specification. Recent development of multi-step solution algorithms have enabled fairly accurate solutions to obtained for Johansen-type simulations.

The PNG model is termed *economy-wide* because it contains a level of disaggregation which enables the effects of a policy to be traced to all the different sectors of the economy. It is *comparative-static* because it provides projections at only one point in time, the solution. The comparative static approach may be illustrated with the aid of Figure A1. Let the path AB represent the underlying time path of a given variable, say exports of oil, as a result of current economic conditions. The line AB may be considered the 'control' solution. Now suppose at time t=0, a shock is imposed, say a 10 percent increase in the price of oil. After adjustment to the price shock, exports of oil would have increased to point C. Comparative statics is only concerned with gap BC. It does not say anything about how the economy got to point C. The gap, BC, measures how much PNG's exports of oil would increase as a result of the 10 percent increase in oil prices, compared with the level they would have reached had the price change not taken place. In general, comparative models are solved for a short run (t = 2 years) and a long-run (t = 5-10 years). They are not very specific about the timing of effects and represent the time taken for an economy to adjust following a policy shock. The assumptions about adjustment have to do with the 'closure' adopted. This is discussed in a little detail later.

Finally, the PNG model is termed a *computable general equilibrium* model. 'Computable' refers to the fact it is a quantitative model which is solved by means of a computer. The term 'general equilibrium' refers to the fact that the production and consumption relationships, prices and the interaction between supply and demand in factor and product markets are all simultaneously considered.

Figure A1 **The comparative – static approach**



Model structure

The model's theoretical structure describes the purchasing decisions of the industries, investors, households, the government sector and the external sector. The model's equations can be grouped into eleven blocks: industry inputs; final demands; commodity supplies; zero pure profit; market clearing; investment and capital creation; the government sector; price indices and the external sector; consumption-income link; gross domestic product and miscellaneous.

Major behavioural assumptions, based on standard neoclassical premises of perfect competition and constant returns to scale, are imposed on industries and households. Industries are assumed to choose their inputs to current production and capital formation to minimise the costs of these activities. Input-output separability is assumed for current production so that the composition of inputs is independent of the composition of output. The model equations reflect the nested structure of the input side of the production functions assumed for current production and capital creation. At the top level of the nests is the Leontief assumption of no substitution between input categories or between them and the composite inputs. The second level allows CES substitution between sources in the formation of composites, resulting in source-specific demand functions. At the third level are CES functions describing substitution between different occupations within the aggregate labour category. At each stage the degree of substitution is determined by the values assigned to the respective substitution elasticities.

The model utilises one representative household which is assumed to maximise a nested utility function subject to an aggregate budget constraint. At the top level of the nest is a Stone-Geary utility function (Stone 1954, Geary 1950) which leads to a linear-expenditure system. The second level allows for CES substitution between imported and domestic sources of each commodity.

Industry inputs

A schematic representation of the model's equations is shown in Appendix Table 1 and the variables are listed in Appendix Table 2. Equations 1-3 describe industry demands for inputs into current production. Demand for intermediate and primary inputs is expressed as a function of industry output levels and input prices. All users are assumed to be price takers. Industries use commodities and primary factors as inputs while other users (investors, households and purchasers of exports) use commodities only. Commodities are obtained from two

sources - domestic and import, although purchasers of exports use only domestic sources. The sources of primary factors are labour, capital and land. The degree of substitution between factors of production depend on relative price changes and the magnitudes of the various substitution elasticities.

Final demands

Equations 4-10 describe final demands and price formation. Equation 4 describes the commodity inputs into capital creation. They depend on the level of investment by each industry and relative prices between domestic and imported inputs. They contain parameters describing the ease of substitution between domestic and imported inputs into capital creation. Equations 5-8 describe household consumption of commodities which is a function of total consumption, the number of households, relative prices between domestic and imported sources of each good and the relative prices between consumption categories. The significant parameters in these equations are the expenditure, own and cross price elasticities of demand for each good, and substitution elasticities between domestic and imported sources of each commodity. Provision is made in Equation 8 for an exogenous shift term (f3) which allows the model to capture the effects of consumption taxes.

Equation 9 describes demands for exports. Exports depend on export prices and the exchange rate. Two shift terms (f4p and f4q) are included to allow simulations of changes in export prices or export volumes to be conducted.

In Equation 10, Government demand is specified to depend on real household consumption and a shift term (f5). The latter allows for exogenous changes in the commodity composition of government demand.

Commodity supplies

It is assumed that producers choose their output mixes, given their activity level and output prices, to maximise revenue subject to CET transformation frontiers (Powell and Gruen 1968). This results in supply functions, Equation 11. Equation 12 imposes the adding up condition that the total production of each commodity must equal the sum of its separate production in each of the industries in which it is produced.

Zero pure profit conditions

Equations 16-19 represent the model's pricing system. Given the assumptions of perfect competition and constant returns to scale, no pure

profits can be earned. Since profits only accrue to factors of production, total revenue equals total cost in production, investment, imports and exports. In Equation 13 a unit value of an output equals input costs. In the same way, Equation 14 defines a unit value of capital as the sum of intermediate input costs. Equation 15 defines the basic prices of inputs as their c.i.f. duty paid prices, while Equation 16 equates the domestic currency price paid by foreigners for a unit of export to revenue from exports. The revenue from exports comprises the foreign currency f.o.b. price converted to local currency via the exchange rate plus export subsidies.

Market clearing

Equations 17-20 impose market clearing for domestically produced commodities. The left-hand side of Equation 17 represents total supply and the right-hand side total demand which consists of intermediate inputs to current production and capital creation, final consumption, export and government demands. Equation 18 equates the supply of labour of each occupation type to the demand for it. By this, it is implied that labour of the same occupation type is homogeneous and mobile across industries. Equations 19 and 20 equate supply with demand for capital and land, respectively, in each industry. It is assumed that both capital and land are industry specific and fixed in the short-run. It is important to note that while these equations imply that factor employment levels are satisfied, they do not necessarily impose any assumptions of full employment on the economy.

Investment and capital creation

Equation 21 specifies the rate of return to capital in each industry as a function of the cost of using one unit of capital relative to the cost of producing or buying a unit of capital. Equation 22 computes the economy-wide expected rate of return on fixed capital as a weighted ratio of the current fixed capital stock to the future fixed capital stock and the rate of return to capital. Equation 23 expresses the aggregate capital stock as a function of the industry's current capital stock, industry investment and an industry investment shift variable. Equation 24 equates industry investment to aggregate real investment and the industry investment shift term. Aggregate real investment is defined in Equation 25 as a function of investment by all industries, while nominal investment (Equation 26) is defined as the sum of aggregate real investment and the capital goods price index.

Government sector

Equations 27-37 explain the effects of various policy and other changes on government revenue, government expenditure and the net budgetary position of the government sector. Equations 27-29 model government revenue from company taxes, import duties, and oil and gas. There are no personal income taxes in PNG. Revenue from company tax (Equation 27) depends on the company tax rate on profits and returns to capital. Revenue from import duties (Equation 28) depends on the rate of import duty, import prices and import volumes, while revenue from oil and gas (Equation 29) depends on the tax rate on oil and gas profits and returns to capital. Equations 30 and 31 index government revenue from other taxes and other non-tax revenue to GDP. Total government revenue (Equation 32) is the sum of the revenue from the various sources. Government consumption expenditure (Equation 33) is described as a function of government demand and commodity prices. Government investment expenditure (Equation 34) and other expenditure (Equation 35) are also indexed to GDP and are summed to yield total government expenditure (Equation 36). Equation 37 defines the net budgetary position of the government sector.

Price indices and the external sector

Equations 38-41 define the prices of industry outputs, the capital price index, the consumer price index, and the government price index, respectively. Equation 42 expresses import volumes as a function of domestic and imported intermediate inputs. Equations 43 and 44 explain aggregate nominal and real imports in foreign currency. The foreign currency value of exports in nominal and real terms are defined in Equations 46 and 47, respectively. Equations 45, 48 and 49 define the import price index, export price index and GDP deflator, respectively. The real balance of trade (Equation 50) is defined as the difference between foreign currency exports and imports. Equations 52 and 53 define domestic currency imports and exports while Equation 53 defines the nominal balance of trade. The terms of trade (Equation 54) is defined as the difference between the export price index and import price index.

The CPI acts as the *numeraire* in this model and is set to unity. The model does not have a monetary sector and therefore cannot determine absolute prices. However, with the CPI set exogenously, the model determines endogenously the real exchange rate, that is, the relative price of traded and non-traded goods which is equivalent to the ratio of the domestic cost level relative to world prices. Movements in the real exchange rate are determined by the nominal exchange rate. A rise in the nominal exchange rate denotes an increase in domestic costs relative to world prices, that is, an appreciation of the real exchange rate and a fall in PNG's international

competitiveness. On the other hand, a fall in the nominal exchange rate implies a depreciation in the real exchange rate and a rise in PNG's international competitiveness.

Consumption-income link

Equations 55 and 56 define a simplified aggregate consumption function. Nominal household consumption is assumed to move in proportion to changes in disposable income (Equation 55). A shift term (fc) is included in this equation to enable the consumption-income link to be switched off by making it endogenous. In the absence of personal or consumption taxes in PNG, changes in disposable income are equated to changes in GDP (Equation 56).

Gross domestic product

Equation 57 defines real domestic product as the sum of real household consumption, investment, government expenditure and exports less imports. Nominal GDP is defined in Equation 58 as the sum of real GDP and the GDP price index.

Miscellaneous equations

The remainder of the model's equations (59-63) consist of miscellaneous equations. Equation 59 allows wages to be indexed to the CPI by occupation type and by industry. Equation 60 defines aggregate government demand while Equation 61 defines aggregate employment. Equation 62 models real investment as the sum of changes in real consumption and a shift variable while equation 63 defines nominal consumption as the sum of real consumption and the CPI.

Model closure

Given that there are more variables than equations, a number of variables must be set exogenously to enable a solution to be achieved. The rationale for the choice of the exogenous/endogenous split and numeraire in this set of simulations is as follows. The main aim of the model is to examine the impacts of government policy instruments on the government's budgetary position and other macroeconomic variables. Therefore government taxes (i.e., company tax rate, mineral rents, consumption taxes, import taxes), nominal government consumption expenditure and tariffs are set exogenously. Export demand is made exogenous because of the small country assumption. That is, PNG's exports (mainly oil and gas) are too small to affect world prices. Import prices are also set exogenously on account of the small country assumption. Since population is determined by demographic factors, it is

also set exogenously. In keeping with the short-run comparative-static modelling environment, capital stocks are fixed and therefore set exogenously. The other exogenous variables in the model are real wages, investment and the shift variables. Since the model does not determine absolute prices, there is the need to choose a numeraire. Candidates for numeraire include domestic prices, the nominal exchange rate, the CPI and the other price deflators. In this analysis we use the CPI as the numeraire, to allow the real exchange rate to move in proportion to the nominal exchange rate.

Model solution

The model can be written in matrix form as:

$$Az = 0 \quad (1)$$

where A is a m x p matrix of coefficients (m = number of equations and p = number of variables); and z is a p x 1 vector of the variables in the model. After the choice of the closure rule equation (1) becomes:

$$A_1z_1 + A_2z_2 = 0 \quad (2)$$

where z_1 and z_2 are, respectively, the column vectors of endogenous and exogenous variables, and A_1 and A_2 are the columns of A corresponding to the endogenous and exogenous variables, respectively. The shocks are the values to use for z_2. Once these are known, we solve the above system for z_1. That is,

$$z_1 = A_1^{-1} + A_2z_2 \quad (3)$$

The model can be solved using GEMPACK v8.1, a general-purpose computer package (Harrison and Pearson, 1996).

Data sources

The model was initially developed by Woldekidan (1993) and the database has been updated to 2006. Elasticity and parameter estimates are generally not available for PNG. These estimates (see Appendix Table 3) were obtained from a literature search of CGE models of neighbouring countries. Since the true values of these estimates may differ from their hypothesised values, this study's results must be interpreted with caution. It would be more useful to view the results as likely effects of changes in government policy rather than as precise estimates of outcomes.

Illustrative simulation: increase in government consumption expenditure

The argument has often been made that, given the weak links of the oil and gas sector with the rest of the economy, government expenditure must be used as an avenue of job creation. As indicated in Figure 13, the Government's total tax receipts from the project average K3.1 billion per annum, which represents a 91 per cent increase over its current tax take. To test the effects of such a development strategy, we imposed a shock of 91 per cent on government consumption expenditure.

It can be seen from Appendix Table 4 that real GDP increases by 32 per cent. However, as can be expected, real household consumption increases by 143 per cent while household disposable income grows by 24 per cent. Given the particular closure adopted in this simulation whereby the CPI is fixed, the increase in government consumption expenditure increases the nominal exchange rate, and hence the real exchange rate, by 4 per cent in the short run and by 20 per cent in the long run. This results in an erosion of PNG's international competitiveness. Consequently aggregate foreign currency exports decline by 14 per cent while aggregate foreign currency imports increase by 987 per cent, resulting in a deficit in the real trade balance.

At the sectoral level the effects of increased government spending produces Dutch Disease effects, with a contraction in agricultural activity. Particularly hard hit is smallholder cash crop production, where smallholder palm oil declines by 138 per cent and smallholder cocoa decline by 15 per cent. The effects on plantation agriculture are relatively minor. As expected, the main beneficiary is the public sector, where education, health and government administration which each increase by over 140 per cent, followed by air transport (112 per cent), road transport (73 per cent), and water transport (48 per cent). The service sectors (e.g., beverages and tobacco and engineering) also grow rapidly, with relatively slower growth in manufacturing.

Concluding remarks

The foregoing simulation results indicate that a large increase in government expenditure could have effects similar to those of the resource boom. Although there is an increase in real GDP, the currency appreciates in real terms increasing production costs and therefore the competitiveness of exports, resulting in a negative real trade balance. The beneficiaries of this particular strategy are the public sector and some industries in the non-traded sector service sector. A far better strategy is to increase investment expenditure which builds up the physical and human capital base. Such a strategy has the potential to yield high returns long after the oil and gas resources have been depleted.

Appendix Table 1 **Schematic representation of the model's equations**

No.	Equation	Number
	Industry inputs	
(1)	$x1 = f_1(z, p)$	$2n^2$
(2)	$x1prim = f_2(z, p1prim)$	3n
(3)	$x1lab = f_3(p1prim, p1lab)$	4n
	Final demands	
(4)	$x2 = f_4(y, p)$	$2n^2$
(5)	$x3 = f_5(x3\_s, p3)$	2n
(6)	$x3\_s = f_6(q1, c1, p3\_s)$	n
(7)	$p3 = f_7(p)$	n
(8)	$p3\_s = f_8(p,f3)$	2n
(9)	$x4 = f_9(p4, \phi, f4p, f4q)$	n
(10)	$x5 = f_{10}(cr, f5)$	2n
	Commodity supplies	
(11)	$x1ci = f_{11}(z, p)$	n^2
(12)	$x1c = f_{12}(x1ci)$	n
	Zero pure profit	
(13)	$pi1 = f_{13}(p)$	n
(14)	$\pi = f_{14}(p)$	n
(15)	$p(c, \text{“import”}) = pm + t + \phi$	n
(16)	$p(c, \text{“domestic”}) = p4 + v + \phi$	n
	Market clearing	
(17)	$x1c = f_{15}(x1, x2, x3, x4, x5)$	n
(18)	$lq = f_{16}(x1lab)$	4
(19)	$kc = x1prim(\text{“capital”}, i)$	n
(20)	$n = x1prim(\text{“land”}, i)$	n
	Investment and capital creation	
(21)	$r = f_{17}[p1prim(\text{“capital”}, i), \pi]$	n
(22)	$\omega = f_{18}(kf, kc, r)$	1
(23)	$k = f_{19}(kc, y, f2)$	n
(24)	$y = ir + f2$	n
(25)	$ir = f_{20}(Y)$	1
(26)	$in = ir + \zeta$	
	Government sector	
(27)	$rtc = f_{21}(tci, p1prim, x1prim)$	1
(28)	$rti = f_{22}(t, \phi, pm, xm)$	1

Appendix Table 1 (continued)

(29)	rtm = f_{23}(tm, p1prim, x1prim)	1
(30)	rto = f_{24}(gdp)	1
(31)	rnto =f_{25}(gdp)	1
(32)	grev = rtc + rti + rtm +rto + rnto	1
(33)	gc = f_{26}(x5, p)	1
(34)	gi = f_{27}(gdp)	1
(35)	go = f_{28}(gdp)	1
(36)	gexp = gc + go + go	1
(37)	$100\Delta GB = f_{29}$(grev, gexp)	1
	Price indices and external sector	
(38)	pi1 = f_{30}(p)	1
(39)	$\zeta = f_{31}(\pi)$	1
(40)	$\varepsilon^3 = f_{32}$(p3)	1
(41)	$\varepsilon^5 = f_{33}$(p3)	1
(42)	xm = f_{34}(x1, x2, x3, x5)	1
(43)	mf = f_{35}(pm, xm)	1
(44)	mf_r = f_{36}(xm)	1
(45)	ε^2 = mf - mf_r + ϕ	1
(46)	ef = f_{37}(p4, x4)	1
(47)	ef_r = f_{38}(x4)	1
(48)	ε^4 = ef - ef_r + ϕ	1
(49)	$\varepsilon^1 = f_{39}(\varepsilon^4, \varepsilon^2)$	1
(50)	$100\Delta B = f_{40}$(ef, mf)	1
(51)	md = f_{41}(pm, xm, ϕ)	1
(52)	ed = f_{42}(p4, x4, ϕ)	1
(53)	$100\Delta Bn = f_{43}$(ed, md)	1
(54)	tot = $\varepsilon^4 - \varepsilon^2$	1
	Consumption-income link	
(55)	c1 = yd - fc	1
(56)	yd = gdp	1
	Gross domestic product	
(57)	gdpr = f_{43}(cr, ir, xg, ef_r, mf_r)	1
(58)	gdp = gdpr + ε^1	1
	Miscellaneous equations	
(59)	p1lab = $f_{44}(\varepsilon^3$, f1qi, f1q, f1)	1
(60)	xg =f_{45} (x5)	1
(61)	lp = f_{46}(lq)	1
(62)	ir = cr + ic	1
(63)	c1 = cr + ε^3	1
	Total	**$5n^2+27n+43$**

Appendix Table 2 **Variables of the model**

Variable (dimensions)	Definition	Number
x1(c,s,i)	Demand for inputs for current production	$2n^2$
x2(c,s,i)	Demand for inputs for capital creation	$2n^2$
z(i)	Industry activity levels (value-added)	n
p(c,s)	Domestic prices of domestic and imported goods	2n
x1prim(f,i)	Industry demands for primary factors	3n
p1prim(f,i)	Price of primary factors	3n
x1lab(q,i)	Industry demand for labour	4n
p1lab(q,i)	Price of labour	4n
y(i)	Investment by industry	n
x3(c,s)	Household demand by source	2n
x3_s(c)	Household demand, composite commodities	n
q1	Number of households	1
c1	Aggregate household consumption	1
p3(c,s)	Household purchaser prices	2n
p3_s(c)	Household purchaser prices, composite commodities	n
f3(c,s)	Shifter, household consumption price	2n
p4(c)	Foreign currency export prices, f.o.b.	n
x4(c)	Export demand	n
f4q(c)	Export demand shifter, quantity	n
f4p(c)	Export demand shifter, price	n
x5(c,s)	Government demand	2n
f5(c,s)	Government demand shifter	n
x1ci(c,i)	Commodity output by industry	n^2
x1c(c)	Commodity output level	n
pi1(i)	Industry output prices	n
pm(c)	Foreign currency imp price, c.i.f	n
v(c)	One plus export subsidy	n
t(c)	One plus ad valorem tariff	n
ϕ	Exchange rate, B/US	1
lq(q)	Employment by labour type	4
kc(i)	Industry capital stock	n
kf(i)	Future industry capital stocks	n
k	Aggregate capital stock	1
ni(i)	Agricultural land	n
r(i)	Industry rate of return to capital	n
ω	Economy-wide expected rate of return	1
ir	Aggregate real investment	1
in	Aggregate nominal investment	1
f2(i)	Industry investment shift term	n
ε^1	GDP deflator	1
ε^2	Import price index	1

Appendix Table 2 (continued)

Variable (dimensions)	Definition	Number
ε^3	Consumer price index	1
ε^4	Export price index	1
ε^5	Government cons price index	1
ζ	Capital goods price index	1
$\pi(i)$	Cost of unit of capital by industry	n
pi1(i)	Industry output prices	n
xm(c)	Import volumes	n
mf	Aggregate foreign currency imports (US$ mil)	1
mf_r	Real foreign currency imports (US$ mil)	1
md	Aggregate domestic currency imports (B$ mil)	1
ef	Real foreign currency exports (US$ mil)	1
ed	Aggregate domestic currency exports (B$ mil)	1
ΔB	Real trade balance (B$ mil)	1
tot	Terms of trade	1
ΔBn	Nominal trade balance (B$ mil)	1
yd	Household disposable income	1
fc	Consumption function shift term	1
f1qi(q,i)	Employment type by industry wage shifter	4n
f1q(q)	Employment type wage shifter	4
f1	Economywide real wage shifter	1
gdp	Nominal GDP	1
gdpr	Real GDP	1
xg	Aggregate govt (other) demand	1
lp	Aggregate employment: persons	1
ic	Ratio of real investment to real household consumption	1
tci(i)	Company tax rate	n
rtc	Government revenue from company tax	1
rti	Government revenue from import duties	1
rto	Government revenue from other taxes	1
rtm	Government revenue from mining royalties	1
rnto	Government revenue from non-tax sources	1
tm(i)	Power of tax - mining	n
gc	Nominal government consumption expenditure	1
cr	Real household consumption	1
gi	Nominal government investment expenditure	1
go	Nominal other government consumption expenditure	1
grev	Aggregate government revenue	1
gexp	Aggregate government expenditure	1
ΔGB	Government budget position	1
	Total	**$5n^2 + 51n + 49$**

Appendix Table 3 **Elasticity values for the PNG model**

Elasticity	Value
Substitution elasticities between domestic goods and imports for current production and investment	2.0
Substitution elasticities between domestic goods and imports for household consumption	2.0
Substitution elasticities between primary factors	1.5
Substitution elasticities between occupations	2.0
Transformation elasticities between outputs of industries:	
Multiproduct agricultural industries	2.0
All other industries	0.0
Reciprocal of export demand	0.05
Frisch parameter	-6.0
Household expenditure:	
Subsistence crops	1.0
Agriculture, forestry, fishing	0.65
Food	0.65
Beverages	0.87
Manufactures	1.16
Transport	1.86
Education, health, government administration	1.06
Other services	1.16

Sources: Dixon & others (1982) and Lluch & others (1977).

Appendix Table 4 Increase in Government current expenditures

Variable	Short run	Long run
Macroeconomic impacts:		
Real GDP	0.32	0.37
Real aggregate foreign currency exports	-0.16	-0.05
Real aggregate foreign currency imports	0.98	0.90
Total government expenditure	0.99	0.99
Real household consumption	1.43	1.64
Household disposable income	0.24	0.23
Aggregate employment	0.78	0.84
Ratio of real investment to real consumption	-1.41	-1.61
Nominal exchange rate (kina/US$)	-0.04	-0.20
Agricultural output:	-0.13	-0.25
Smallholder coffee	-0.15	-0.31
Smallholder cocoa	-1.38	-1.07
Smallholder palm oil	-0.18	-0.33
Smallholder copra	-0.08	-0.17
Plantation coffee	-0.07	-0.11
Plantation cocoa	-0.03	-0.05
Plantation palm oil	0.00	0.00
Plantation copra	-0.13	-0.25
Other output:		
Timber processing	0.08	0.12
Food processing	0.29	0.59
Beverages and tobacco	1.23	1.44
Metals and engineering	-0.01	0.35
Other manufacturing	0.26	1.01
Road transport	0.73	1.14
Water transport	0.48	0.68
Air transport	1.12	1.40
Education	1.42	1.64
Health	1.43	1.64
Commerce	0.24	0.79
Financial services	0.83	0.94
Government admin. and defence	1.47	1.54

Note: The figures represent a +/- 100% change in a given parameter as a result of the project. E.g., 1.43 represents a 143% increase, while -0.16 represents a 16% decline.

Data source: Model simulation results

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