

## AID, MINING DEVELOPMENT AND STRUCTURAL ADJUSTMENT IN PAPUA NEW GUINEA

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*Papua New Guinea is a country endowed with abundant natural resources. The natural resource sector accounts for over 40 per cent of GDP. The country has a relatively small population of 4.6 million people, inhabiting a large land mass and substantial coastline. Despite the immense potential, its development record since independence from Australia in 1976 has been rather disappointing. The economy of Papua New Guinea has gone through a series of external shocks, starting with the Bougainville war in 1989. Successive governments have responded to the ensuing crises with a series of structural reforms, the latest of which was implemented in 2000. The purpose of this paper is to evaluate the combined macroeconomic impacts of aid flows, increased mining output and the structural reforms. The simulation results indicate that there is an increase in real output, exports and employment. However, there is a reduction in the output of services (education, health and government administration and defence).*

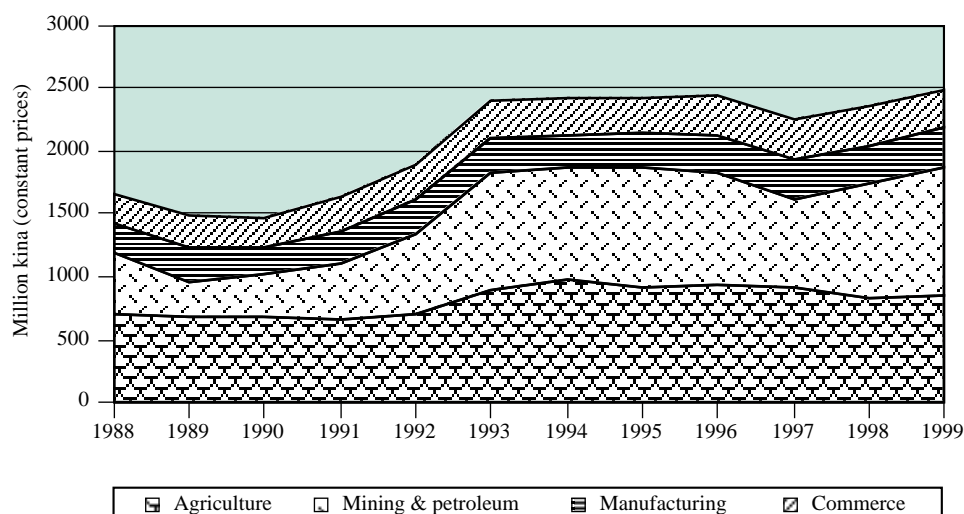
Papua New Guinea, with a population of 4.6 million and a land area of about 463,000 sq km, is the largest country in the South Pacific region. The country is well endowed with large reserves of renewable and non-renewable natural resources. The former include timber, which covers about 75 per cent of the land area, as well as agricultural and marine resources. Papua New Guinea's marine and coastal resources are the most extensive and diverse in the South Pacific region. The coastline is over 10,000 km long and the marine area inside the 200-mile economic exclusive zone covers 2.3 million sq km of ocean. The non-renewable resources include gold, copper, oil, gas and other minerals.

Agriculture is the dominant sector, accounting for about one third of GDP (figure 1) and providing wage employment for 75 per cent of the working population. However, since the early 1990s, mining and petroleum has made an increasingly significant contribution to national income. Figure 1 shows that the share of the minerals and petroleum sector in GDP increased from about 9 per cent of GDP in

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**Figure 1. Papua New Guinea: contribution to gross domestic product by the agricultural, mining and petroleum, manufacturing and commerce sectors**



Sources: Bank of Papua New Guinea (2000); Department of Treasury and Finance (2000).

1989 to about 26 per cent in 1999. The manufacturing sector contributes about 10 per cent of GDP and comprises mainly assembly-type and processing industries. The manufacturing sector has remained static over the last five years. In terms of foreign exchange earnings, the minerals sector can be considered as the backbone of the economy of Papua New Guinea. Table 1 shows that minerals and petroleum account for about two thirds of total exports while agriculture and forestry account for one third. Since 1992, petroleum exports have grown in significance and now account for nearly 40 per cent of mineral exports. The agricultural sector has been in decline due to a combination of external and internal factors. Average world market prices for Papua New Guinea's main agricultural exports of coffee, copra and palm oil have fallen by between 50 and 60 per cent in real terms.

The minerals sector has played a pivotal role in Papua New Guinea's development to date and will continue to do so in the foreseeable future. Since gold was first discovered in 1880, mining has contributed to infrastructure development in remote areas of the country. Even though mining is capital intensive and is often referred to as an enclave activity, there are significant backward and forward linkages between this sector and the other sectors of the economy. The government receives significant taxation, royalties, duties and dividends from the industry's revenues. For

**Table 1. Papua New Guinea: value of exports by sector**  
(K millions, nominal prices)

<i>Sector</i>	<i>1990</i>	<i>1991</i>	<i>1992</i>	<i>1993</i>	<i>1994</i>	<i>1995</i>	<i>1996</i>	<i>1997</i>	<i>1998</i>	<i>1999(E)</i>	<i>2000(P)</i>
Minerals and oil	757.5	1 005.3	1 371.5	1 767.8	1 782.7	2 435.5	2 244.6	1 838.9	2 455.1	3 528	3 895
Gold	393.2	666.9	745.9	681.6	702.3	840.1	773.6	718.7	1 227.8	1 530	1 650
Copper	349.2	323.8	313.5	256.3	367.4	754.5	387	259.8	395.7	574	739
Silver	15.1	14.6	10.7	12.1	10.3	13.2	10.1	8.2	18.5	26	31
Oil	0	0	301.4	817.8	702.7	827.7	1 073.9	852.2	813.1	1 398	1 475
Agriculture	204.6	204.6	223.6	270.1	374.6	502.4	578.6	777.2	1 020.2	1 095	1 159
Forestry	79.6	90.2	148.2	410.4	494.4	449.7	480.3	432.9	173.2	264	395
Other	79	91	119	79	10	12	10	10	40	233	179
Total	1 120.7	1 391.1	1 862.3	2 527.3	2 661.7	3 399.6	3 313.5	3 059	3 688.5	5 120	5 628

*Sources:* Bank of Papua New Guinea (2000); Department of Treasury and Finance (2000).

*Notes:* E – estimate

P – projected

example, in 1997 taxes and dividends from the Mineral Resource Stabilisation Fund accounted for over 21 per cent of total government revenue (Department of Treasury and Finance, 1997). As shown above, mining and petroleum are also significant providers of foreign exchange. Furthermore, mining companies provide rural infrastructure and services in areas where they operate. The severe dislocation of businesses in many parts of the country following the closure of the Bougainville copper mine is evidence of the significant impacts that mining has on the economy. A similar situation is likely to arise when the Ok Tedi mine closes in 2009.

Despite her significant endowment of natural resources, Papua New Guinea's development record since independence from Australia in 1976 has been rather disappointing. Life expectancy and adult literacy rates are well below those of neighbouring countries in the South Pacific and South-East Asia. Papua New Guinea was ranked 126<sup>th</sup> out of 174 countries based on a human development index, a composite measure of per capita income, life expectancy and literacy rates (UNDP, 1995). Average per capita GNP for Papua New Guinea was estimated at US\$ 890 in 1998, placing her in the category of medium human development countries. However, Papua New Guinea's per capita GNP growth rate lags behind those of her neighbours. For example, in the period 1975-1990, the annual per capita GNP growth rates for Indonesia and the Solomon Islands were 4.6 per cent and 2.5 per cent, respectively (UNDP, 2000).

The reported per capita GNP figures for Papua New Guinea masks the stark contrasts between urban and rural standards of living. Eighty-eight per cent of the country's population resides in the rural areas, with 12 per cent residing in the urban areas (NSO, 1996). The World Bank estimates rural per capita income to range from

US\$ 300 to US\$ 350, whilst average urban per capita income is estimated to be about US\$ 3,500 (World Bank, 1999).

The purpose of this paper is to evaluate the possible effects of recent government policies on the Papua New Guinea economy using a computable general equilibrium model and to address the implications for policy. The analysis includes the effects of recent developments in the mining sector referred to above, as well as the effects of aspects of the economic reform programme. The paper is organised as follows. Section 2 describes the methodology which includes a brief outline of the model structure, model closure and data sources. Section 3 presents an outline of the simulation scenarios while section 4 presents and discusses the simulation results. The summary and conclusions are contained in the final section.

## I. MODEL DESCRIPTION

The model used in this study was originally developed by the National Centre for Development Studies (NCDS) at the Australian National University (Vincent et. al. 1991, Woldekidan 1993). This model is a miniature version of the Australian ORANI model (Dixon et. al. 1982). Both models were pioneered by the Swedish economist Johansen (Johansen 1960)<sup>2</sup>. In this approach the optimising behaviour of economic agents – consumers, producers and government – is represented by a system of equations which is non-linear in variables but which is then totally differentiated to produce a system linear in percentage changes of the variables. Simple matrix manipulation methods are then used to generate solutions.

### *Model Structure*

The model consists of 37 domestic industries, 34 commodities and 4 occupation types. Due to the importance of agriculture in the economy of Papua New Guinea, this sector is disaggregated into smallholder and plantation subsectors for each of its main export crops – coffee, cocoa, palm oil and copra (see appendix 1). The equations of the model are derived from neoclassical microeconomic assumptions about the behaviour of price-taking economic agents. That is, consumers maximise utility subject to their budget constraints and producers choose their inputs so as to minimise costs. Constant returns to scale production technology is assumed. The model equations can be divided into 7 major blocks: (i) commodity and factor demands; (ii) commodity supplies; (iii) zero pure profits; (iv) market clearing; (v) government sector; (vi) foreign sector; and (vii) miscellaneous equations. A stylised version of the model's equations is provided in appendix 2 and a list of variables is provided in appendix 3. Each of the above blocks is briefly discussed below.

### ***Commodity and factor demands***

The model recognises six categories of demand for commodities: demands for intermediate inputs; demands for labour, fixed capital and land; demands for inputs to capital creation; household demands for commodities; other demands and export demands. Equations 1 and 2 (appendix 2) are aggregations over the six domestic sources of demand for the  $2n$  commodities recognised in the model ( $n$  domestically produced and  $n$  imported). Export demand is shown separately in equation 4.

Equation 3 indicates that demand for primary factors (labour, capital, land) depends on domestic industry activity levels and factor prices. Thus, demand for primary factors is explained by the level of output (scale effect) and the relative prices between domestic and imported inputs (substitution effects). It is assumed that while factors can be substituted for each other, they cannot be substituted for intermediate inputs. Hence, factor prices do not appear in commodity demand equations (1) and (2).

The export equation (equation 4) indicates that Papua New Guinea depends on world prices for her exports. The small country assumption is invoked here. That is, Papua New Guinea's share of world exports are not large enough to affect world prices. Therefore export prices are determined exogenously.

### ***Commodity supplies***

Equation (5) is an aggregate of commodity outputs across the  $m$  industries. Commodity outputs are specified to depend on domestic factor inputs and prices of domestic commodities. The model allows for multi-product output by agriculture and mining but not the rest of the industries. It is assumed that producers are able to change their output mixes. This flexibility is determined by the extent of output transformation possibilities and relative prices. For example, in mining, the output transformation elasticity will be close to zero due to lack of scope for product transformation. On the other hand, agriculture will have greater flexibility in that it has greater scope to change the product mix in response to changes in output prices.

### ***Zero pure profits***

With the assumption of competitive behaviour and constant returns to scale in production, it follows that profits can only accrue to factors of production. That is, total revenue equals total cost in production, investment (capital creation), importing and exporting. Equations (6) to (9) therefore impose conditions of zero pure profit in production, consumption, exports, imports and capital creation.

***Market clearing***

The equations in this block (equations 10 and 11) equate demand to supply of domestic goods, labour, capital and land, implying that factor employment levels are satisfied. It should be noted that this does not necessarily impose full employment assumptions for any factor.

***The government sector***

The equations in this block explain the effects of various policies and other changes on government revenues and expenditures and the net budgetary position of the government sector. Equation (12) is an identity which defines government revenue to be equal to the sum of the products of the nominal values of the individual tax bases and their corresponding tax rates plus non-tax revenue. Equation (14) determines the net budgetary position of the government as the difference between aggregate government revenue and aggregate government expenditure.

***Foreign sector***

The foreign sector equations comprise equation (15), the balance of trade (in foreign currency units), and equation (16), the current account. The latter is a function of the trade balance and foreign grants.

***Miscellaneous equations******Price indices:***

Equations (17) to (19) define the GDP deflator, capital goods price index and the CPI. The model is unable to 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 CPI. This measure gives us the relative price of tradables to non-tradables. The nominal exchange rate is held fixed (exogenous) and acts as the numeraire. Movements in the real exchange rate is determined by the ratio (or difference) between the nominal exchange rate and the CPI. For example, a fall in the CPI denotes an increase in (or depreciation of) the real exchange and hence an improvement in Papua New Guinea's international competitiveness.

***Consumption-income link:***

Equations (20) and (21) describe a simple aggregate consumption function. Aggregate nominal consumption by households is assumed to be proportional to

aggregate household income. Changes in aggregate household disposable income are related to changes in GDP. A shift term is added on to equation (20) to allow the consumption-income link to be switched off by making the shift term endogenous, in which case aggregate real consumption can be made to move proportionately with aggregate real investment.

#### *Gross Domestic Product:*

In equation (22), real GDP is defined as aggregate real demand for domestically produced goods plus exports less imports.

#### *Model Closure*

The complete model contains 15,175 equations and 17,122 variables. The difference between the short-run and long-run in the model lies in the assumptions regarding the fixity of capital and land. These two factors are assumed to be fixed in the short-run but mobile in the long-run. The model was solved using GEMPACK v6.0, a general purpose computer package (Codsí and Pearson, 1988). Further details about the theoretical structure and model specification for the model can be found in Woldekidan (1993).

#### *Data Sources*

The original model was based on input-output data for 1988 (Vincent et. al. 1991). However, the data base was recently updated to 1990, to account for the closure of the Bougainville copper mine and other changes in the agricultural and mining sectors (Welsch, 1993). The elasticity and parameter estimates were obtained from a literature search of CGE models of neighbouring countries. Since estimates have not been econometrically determined, the study results must be interpreted with caution. In particular, it would be more useful to view the results as likely effects of changes in government policy rather than as precise estimates of outcomes.

## **II. SIMULATION SCENARIOS**

Four short-run simulations were undertaken with the model to explore the impacts of various policy decisions on Papua New Guinea's economy. These were:

- Policy A: a 40 per cent increase in gold exports;
- Policy B: a 20 per cent increase in foreign aid;
- Policy C: a 20 per cent devaluation of the kina;
- Policy D: a 30 per cent reduction in government expenditure, and;
- Policy E: combined impact of policies A-D.

### III. RESULTS AND DISCUSSION

#### *Effects of a 40 per cent increase in gold exports*

As indicated above, Papua New Guinea has good prospects for increasing minerals production in the short to medium term. Gold production at the rich Lihir gold mine could represent a 35-50 per cent annual increase over previous production levels. To simulate the possible impacts of a resource boom, a shock of 40 per cent was applied to the volume of gold exports. The results (column 1, table 2) indicate that the resource boom has an overall positive effect on the economy. Aggregate real exports increase by 4 per cent, while real imports increase by 3 per cent. Since mining is capital intensive and has weak links with rest of the economy, the overall impacts on the economy are not spectacular. Real GDP grows by only 1 per cent while aggregate employment increases by 2 per cent. The CPI rises by 3 per cent, implying a real devaluation given that the nominal exchange rate is fixed.

At the sector level, the booming sector expands by 5 per cent as can be expected. However, the agricultural sector experiences a negative impact. Copra and forestry exports decline by 7 per cent and coffee exports decline by 2 per cent. The other export sectors record zero growth. In the non-export sector, very little growth is recorded by the domestic manufacturing industries, although the services sector records fairly significant growth. The largest growth is recorded by government administration and defence which is the recipient of large amounts of tax revenues. Government revenue grows faster (9 per cent) than expenditures (6 per cent), leaving the government's budget in surplus by K5.8 million. These results demonstrate the presence of 'Dutch Disease' effects in the economy (Corden and Neary, 1982). While overall the resource boom has a positive effect on the economy, a negative effect is found in the tradeable and import-competing sectors. This situation arises because the booming sector draws resources, in particular, labour, away from the other sectors.

#### *Effects of a 20 per cent increase in foreign aid*

Papua New Guinea is the largest recipient (in absolute terms) of Official Development Assistance (ODA), with most of it coming from Australia. For example, in 1992-1993, Australian aid to Papua New Guinea amounted to A\$322 million, which was almost one quarter of Australia's total aid program. Australian aid to Papua New Guinea has been provided as untied budget support since independence in 1975<sup>1</sup>. However, in May 1989 the Australian and Papua New Guinea governments signed a Treaty on Development Cooperation. Under the terms of the treaty, budget support

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<sup>1</sup> This implies that the Australian Government places no conditions on how the funds are spent. The expenditure is determined by the parliament of Papua New Guinea through its annual budgetary processes.

**Table 2. Short-run simulation results for policies A and B**  
(percentage changes from underlying growth path)

	<i>Policy A: Resource boom</i>	<i>Policy B: Increase in foreign aid</i>
<i>Macroeconomic variables:</i>		
Real GDP	1.0	4.0
Real household consumption	4.0	16.0
Consumer price index	3.0	-14.0
Aggregate real imports (US\$)	3.0	13.0
Aggregate real exports (US\$)	4.0	-4.0
Aggregate employment	2.0	6.0
<i>Exports:</i>		
Coffee	-2.0	-8.0
Cocoa	0.0	-14.0
Palm oil	0.0	-6.0
Copra	-7.0	-22.0
Forestry	-7.0	-1.0
Copper	0.0	-1.0
Gold	5.0	-1.0
<i>Other sectors:</i>		
Timber processing	0.0	2.0
Food processing	0.0	2.0
Beverages and tobacco	2.0	9.0
Metals and engineering	-5.0	-3.0
Road transport	1.0	6.0
Air transport	3.0	10.0
Education	4.0	15.0
Health	4.0	16.0
Government admin. and defence	6.0	15.0
<i>Government sector</i>		
Government revenue	9.0	12.0
Government expenditure	6.0	12.0
Government budget position (million kina)	42.0	0.0

will be phased out by the year 2000. Over the same period, there will be a progressive increase in programme aid, which is expected to reach a target of A\$300 million by the year 2000 (AusAID, 1994).

Net ODA declined from 33 per cent of total government revenue to 18 per cent between 1986 and 1994. Following the renegotiation of the structural reforms with the IMF and the World Bank, net ODA is set to rise substantially. The effect of the increased aid is simulated by applying a shock of 20 per cent to foreign grants in the model. In this simulation, the government's budget deficit is forced to remain in

balance. The model then simulates the changes in government expenditure necessary to satisfy this restriction. Theoretically, this simulation is similar to the previous one in the sense that the increased government revenues, given a fixed deficit, implies that government expenditures must rise. Thus, in this case, the aid results in a boom in the government sector.

The results of this simulation are reported in the second column of table 2. Real GDP increases by 4 per cent while real household consumption increases by 16 per cent. An important result in this simulation is that the CPI declines by 14 per cent. Given that the nominal exchange rate is fixed, this implies an appreciation of the real exchange rate. That is, the price of non-tradables rises in relation to that of tradables. The net result is that the external competitiveness of the export sector declines. It can be seen from the results that real exports decline by 4 per cent while real imports increase by 13 per cent. At the sector level, there is a consistent decline in all categories of exports, although the impacts on the mineral sectors (gold, silver and copper) are much lower compared to the agricultural sectors (coffee, cocoa, palm oil and copra). On the other hand there are large increases in the output of the service sectors. The overall result is an increase in aggregate employment of 6 per cent.

The foregoing results suggest that an increase in foreign aid, in the absence of any other complementary government policies, has effects which can be described as typical of the 'Dutch Disease'. There is an expansion in the domestic production of non-tradables, mainly in the services sectors, including government administration and defence. On the other hand, there is a contraction in the tradables sectors. The increased spending due to the increase in aid leads to an increase in wages, resulting in a decline in external competitiveness. As can be seen from the above simulations, the adverse effects are greater in the labour-intensive sectors, in particular, agriculture.

### ***Effects of a 20 per cent devaluation of the kina***

Devaluation of the domestic currency, the kina, has been a major plank in the Government of Papua New Guinea major policy interventions since 1990. The major justification for a currency devaluation is that it increases the domestic price of tradables, therefore creating an incentive to increase the volume of exports. The important variable, in this respect, is a real devaluation rather than a nominal devaluation. However, it is often assumed that a nominal devaluation would eventually lead to a real devaluation.

The macroeconomic and sectoral impacts of a 20 per cent devaluation of the kina are shown in the first column of table 3. It can be seen that the policy results in a 19 per cent increase in the general price level (i.e. the CPI). Based on the closure rule adopted, this implies a small depreciation of the real effective exchange rate. This depreciation is sufficient to cause an increase of 2 per cent in aggregate real exports while aggregate real imports decline by 3 per cent. Real household

**Table 3. Short-run simulation results for policies C and D**  
(percentage changes from underlying growth path)

	<i>Policy C: 20 per cent devaluation of the kina</i>	<i>Policy D: 30 per cent reduction in govt. expenditure</i>
<i>Macroeconomic variables:</i>		
Real GDP	2.0	-8.0
Real household consumption	-0.3	-24.0
Consumer price index	19.0	-22.0
Aggregate real imports (US\$)	-3.0	-20.0
Aggregate real exports (US\$)	2.0	5.0
Aggregate employment	4.0	-9.0
<i>Exports:</i>		
Coffee	0.0	12.0
Cocoa	1.0	13.0
Palm oil	1.0	6.0
Copra	1.0	13.0
Forestry	12.0	21.0
Copper	1.0	1.0
Gold	1.0	2.0
<i>Other sectors:</i>		
Timber processing	9.0	7.0
Food processing	3.0	-1.0
Beverages and tobacco	1.0	-11.0
Metals and engineering	6.0	6.0
Road transport	5.0	-10.0
Air transport	2.0	-15.0
Education	-0.2	-23.0
Health	-0.3	-24.0
Government admin. and defence	-0.2	-23.0
<i>Government sector</i>		
Government revenue	26.0	-21.0
Government expenditure	18.0	-37.0
Government budget position (million kina)	50.0	255.0

consumption declines by 0.3 per cent. Overall, there is a positive impact on the economy with real GDP expanding by 2 per cent. The real exchange rate devaluation implies a fall in real resource costs, in particular, wages. Consequently, aggregate employment increases by 4 per cent.

At the sectoral level, the export sectors all show some positive growth, although the most significant increase is recorded by the forestry sector. In the domestic industries, import-competing sectors increase output while the services sectors

(education, health and government administration and defence) contract. In the government sector, government revenue increases by 26 per cent, while government expenditure declines by 18 per cent, resulting in a budget deficit of K50 million.

### ***Effects of a 30 per cent reduction in government expenditure***

The reduction in government spending causes aggregate real imports to decline by about 20 per cent while aggregate real exports increase by about 5 per cent (column 2, table 3). However, there are some negative macroeconomic impacts. Real output falls by 8 per cent and real household consumption declines by 24 per cent. Since government is a major employer, the reduction in expenditures causes aggregate employment to decline by 9 per cent.

The fall in the price level causes industries' real costs to decline and increases the output of the export industries, especially the labour-intensive agricultural and forestry sectors. However, the reduction in current government expenditure has an adverse social impact since most services are publicly funded as is the case in most developing countries. As can be expected, there are reductions in education, health, transportation and government services. In the government sector, government revenue declines as a result of the decline in value added of domestic producing sectors. However, government expenditure declines faster than revenue, leaving the government's budget position in surplus by K255 million.

### ***Effects of combined impact of policies A-D***

The final simulation involves evaluating the overall impacts of the policies. The solution algorithm used to solve the system of equations is based on the Johansen approach (Johansen, 1960). In this approach the system of equations which is non-linear in variables is totally differentiated to produce a system linear in percentage changes of the variables. This system allows the combined impacts of the four policies to be approximated by a horizontal summation of the individual effects. The results of this simulation are reported in table 4.

The results suggest that in the short-run, real GDP declines by 1 per cent while real household consumption declines by 4 per cent. Overall, the policies put downward pressure on prices and reduce resource (e.g. wage) costs. As a result, exports grow by 7 per cent, imports decline by 7 per cent and there is a 3 per cent increase in aggregate employment.

At the sector level, there is a positive impact on all the export-oriented sectors except the copra industry. Forestry expands by 25 per cent, although there are much smaller gains in cocoa, palm oil and the mining industries. In the domestic producing sectors, there is an increase in the output of the import-competing sectors. However, services (education, health and government administration and defence) contract. The policies result in an improvement in the government's budgetary position because in

**Table 4. Short-run simulation results for combined effects of policies A to D**  
(percentage changes from underlying growth path)

	<i>Policy E: Combined Effects of Policies A-D</i>
<i>Macroeconomic variables:</i>	
Real GDP	-1.0
Real household consumption	-4.3
Consumer price index	-14.0
Aggregate real imports (US\$)	-7.0
Aggregate real exports (US\$)	7.0
Aggregate employment	3.0
<i>Exports:</i>	
Coffee	2.0
Cocoa	0.0
Palm oil	1.0
Copra	-15.0
Forestry	25.0
Copper	1.0
Gold	7.0
<i>Other sectors:</i>	
Timber processing	18.0
Food processing	4.0
Beverages and tobacco	1.0
Metals and engineering	4.0
Road transport	2.0
Air transport	0.0
Education	-4.2
Health	-4.3
Government admin. and defence	-2.2
<i>Government sector</i>	
Government revenue	26.0
Government expenditure	-1.0
Government budget position (million kina)	299.2

aggregate government revenue increases by 26 per cent while government expenditure declines by 1 per cent, resulting in a budget surplus of K299 million.

#### IV. SUMMARY AND POLICY IMPLICATIONS

The Papua New Guinea economy has experienced a series of major shocks since 1989. The closure of the Bougainville copper mine and the advent of the civil war was the first shock. This was followed by a series of structural adjustment programmes

– the first in 1989, the second in 1995 and recently in 2000. During this period, there have been a number of mineral booms including the commencement of petroleum exports in 1992 and the opening of two major gold mines. The aim of this paper was to assess the macroeconomic and sectoral impacts of these developments using a computable general equilibrium model of the economy of Papua New Guinea. This objective was achieved by conducting five counterfactual simulations: a 40 per cent increase in gold exports; a 20 per cent increase in foreign aid; a 20 per cent devaluation of the kina; a 30 per cent reduction in government expenditure, and the combined impact of the four policies.

A resource boom, represented by a 40 per cent increase in gold exports, has an overall positive impact on real output and aggregate employment. However, at the sector level, there is evidence of ‘Dutch Disease’ effects in the sense that the booming sector draws resources away from the labour-intensive export sectors such as agriculture and forestry. The major beneficiaries are the service sectors – education, health and government administration and defence.

The results of a 20 per cent increase in foreign aid has booming sector effects similar to the gold production case. Since most of the foreign aid is channeled into government current expenditure, government administration becomes the booming sector in this simulation. Again, ‘Dutch Disease’ characteristics are observed in the sense that there is an expansion in the production of nontradables and a contraction in the production of tradables. The increase in government expenditure leads to an increase in real wages, a decrease in external competitiveness and a decline in export earnings. The major policy implication of this result is that merely expending funds from foreign grants without complementary policies could have adverse implications for some sectors of the economy. Such effects could be more serious if the aid money is expended on consumption goods as opposed to investment goods.

A 20 per cent devaluation of the kina has positive impacts on the economy with real output, exports and aggregate employment increasing. All sectors record increases in value added except the nontradable or services sectors which contract. A 30 per cent reduction in government expenditures has adverse impacts on real output and employment since government is the major employer and provider of services. The ability of the Government of Papua New Guinea to restrain public expenditure was at the root of the recent economic crisis which necessitated the structural adjustment programme. There is justification in increasing government expenditures in areas where there is the potential for job creation. Examples include programmes to encourage small business development and agricultural processing industries.

The simulation of the combined impacts of the four policies suggest that, overall, there is an increase in real output, exports and employment. However, there is a contraction in the non-tradable sectors, in particular, services. There is also

an improvement in the government's budgetary position which is in surplus. The major policy implication of these results is that policies which are implemented in isolation are unlikely to be effective unless they are accompanied by complementary policies. In this respect, there is a need for the government to address structural constraints which inhibit economic agents' abilities to respond to price incentives. These constraints include problems in acquiring skilled labour, inflexible land tenure arrangements, inconsistent government trade and regulatory policies, law and order and a bloated and inefficient government bureaucracy.

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**Appendix 1. List of commodities and industries in  
the Papua New Guinea model**

<i>Commodity</i>		<i>Industry</i>	
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	Other tree crops*
10	Forestry	11	Other agriculture
11	Copper	12	Fishing*
12	Gold	13	Forestry
13	Other minerals	14	Porgera Gold Mine
14	Quarrying	15	Ok Tedi Gold Mine
15	Timber Processing	16	Other mining
16	Food processing	17	Quarrying
17	Beverages and tobacco	18	Timber processing
18	metals and engineering	19	Food processing
19	Machinery repairs	20	Beverages and tobacco
20	Chemicals	21	Metals and engineering
21	Petroleum	22	Machinery repairs
22	Other manufacturing	23	Chemicals
23	Road transport	24	Petroleum
24	Water transport	25	Other manufacturing
25	Air transport	26	Road transport
26	Education	27	Water transport
27	Health	28	Air transport
28	Electricity and garbage	29	Education
29	Building and construction	30	Health*
30	Commerce	31	Electricity and garbage
31	Finance and investment	32	Building and construction
32	Govt. admin. and defence	33	Commerce
33	Other services	34	Finance and construction
34	Oil	35	Govt. admin and defence*
		36	Other services
		37	Oil

Note: \* Indicates exogenous investment industry.

## Appendix 2. Schematic representation of the model equations

### Commodity and factor demands

1.  $D = f_1(Z, P_d, P_m)$
2.  $M = f_2(Z, P_d, P_m)$
3.  $L = f_3(Z, P_l)$
4.  $X = f_4(P_x^f)$

### Commodity supplies

5.  $Y = f_5(L^*, P_d)$

### Zero pure profit

6.  $V(P_d) = W(P_d, P_m, P_l)$
7.  $P_d = P_x^f + \phi + v$
8.  $P_m = P_m^f + \phi + t$
9.  $K = h(P_d, P_m)$

### Market clearing

10.  $Y = D + X$
11.  $L = L^*$

### Government sector

12.  $GR = \sum_{i=1}^n R_i r_i$
13.  $GE = f_6(Y, P_d, P_m)$
14.  $FB = GR - GE$

### Foreign sector

15.  $TB = P_x^f X - P_m^f M$
16.  $CA = f_8(TB, FG)$

### Price Indices

17.  $\varepsilon_1 = f_9(P_d)$
18.  $\varepsilon_2 = f_{10}(K)$
19.  $\varepsilon_3 = f_{11}(P_d, P_m)$

### Consumption-income link

20.  $C = f_{12}(Y_d, qc)$
21.  $Y_d = f_{13}(GDP)$

### Gross Domestic Product

22.  $GDP = D + X - M$

**Appendix 3. List of model variables**

<b>Variable</b>	<b>Definition</b>
D	Demand for domestically produced commodities
Z	Domestic industry activity levels
$P_d$	Domestic prices of domestic commodities
$P_m$	Domestic prices of imported commodities
X	Demand for exports
M	Demand for imports (volume)
L	Demand for primary factors
$P_l$	Prices of primary factors
$P_x^f$	Foreign currency prices for exports
$P_m^f$	Foreign currency prices for imports
$L^*$	Factor employment levels
Y	Commodity output levels
R	One plus ad valorem rates of export subsidy (tax)
$\phi$	Nominal exchange rate (kina/US\$)
t	One plus ad valorem tariff
K	Cost of capital
GR	Government revenue
GE	Government expenditure
FB	Government fiscal balance
R	Individual tax bases
r	Individual tax rates
TB	Trade balance
CA	Current account
FG	Foreign grants
$\varepsilon_1$	GDP deflator
$\varepsilon_2$	Capital goods price index
$\varepsilon_3$	Consumer price index
K	Cost of capital
C	Aggregate consumption
qc	Shift variable for consumption
$Y_d$	Aggregate household disposable income
GDP	Nominal gross domestic product