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Poverty impacts of natural resource revenues☆

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ABSTRACT

This study analyzes the effects on poverty incidence and other variables resulting from government expenditures associated with natural resource revenues, using Laos as a case study. The analysis uses a multi-sector/multi-household general equilibrium model of the Lao economy. The conceptual framework emphasizes the distinction between *official* and *marginal* expenditures financed by project revenues. A range of assumptions is considered regarding the direct distributional impact of the true marginal expenditures and their implications are compared. Poverty incidence declines under the entire range of distributional assumptions, but the most important determinant of these impacts is the degree of pro-rural bias.

1. Introduction

Natural resource-based projects often produce benefits primarily or even entirely in the form of foreign exchange revenues in the hands of the government, because the government asserts ownership rights over these resources. From the standpoint of the local population, these projects inevitably produce some environmental and social costs, but the benefits derived from the projects depend to a large extent on the way the government chooses to spend the project revenues. Different patterns of government expenditure generate different patterns of benefits across households. Moreover, regardless of the composition of the government expenditure, macroeconomic absorption of the foreign exchange revenues into the domestic economy can also be expected to produce indirect effects, including 'Dutch disease' effects, which may or may not have important distributional implications.

This paper explores these issues in the context of the Nam Theun II hydroelectric dam project (subsequently referred to as the NT2 project),[1] located in Lao PDR (subsequently Laos, for brevity). It is the largest of several hydroelectric dam projects either constructed, under construction or planned within Laos. Construction of the dam and associated infrastructure involved an investment, spread over the years 2004–2010, of almost US$1.5 billion, requiring an average annual rate of capital inflow over

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[1] A much smaller dam was earlier constructed on the same river and it is now known as Nam Theun I.

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this seven year period equivalent to around 3% of the country's annual GDP in 2010. Full operation of the project commenced in the latter part of 2010. The dam stores water used for generating electricity, primarily for sale to neighboring Thailand. These sales will produce foreign exchange revenues to be shared by the investors – a consortium of international institutions and private investors in conjunction with the government of Laos. The government's agreed share of these revenues is projected at roughly US$50 million per year, equivalent to around 0.8% of GDP and 4% of total government revenue in 2010.

All of the hydroelectric power projects in Laos have been controversial. In the case of the NT2 dam, much debate has focused on the environmental costs arising from the large intervention in water flows that it entails, along with the social costs of relocating the villages previously contained within the large area now inundated by the dam. In the design of the project, efforts have been made to minimize costs of this kind and to compensate groups affected negatively, but some such costs are inevitable and must be compared with the benefits arising from expenditure of the revenues received by the government. The reality of these supposed benefits has also been disputed, including whether the poor will truly share in them. The present study focuses on these distributional issues.

Two different kinds of distributional concerns have been discussed in the development economics literature dealing with the impacts of large natural resource projects like the NT2 dam. First, there is the *direct* distributional impact of government spending of these revenues, most notably the extent to which the spending produces benefits for poor households. Second, there is an *indirect* distributional impact arising from the absorption of foreign exchange into the domestic economy. Whether this absorption occurs through government spending or private spending, and whether or not it is pro-poor, absorption of the foreign exchange inflow can be expected to generate a 'Dutch disease' effect on the domestic economy – a decline in the domestic prices of internationally tradable goods and services relative to non-tradables – and this too may have distributional consequences.[2] It is not clear, *a priori*, whether the poor would gain or lose from these indirect effects.

A central objective of the NT2 project, agreed by all parties involved in the investment consortium, is to contribute to poverty reduction within Laos, one of the least developed countries in Southeast Asia. In its agreements with the project financiers, the government promised that the revenues arising from the NT2 project would be spent in ways consistent with the country's Poverty Reduction Strategy Report (PRSP). This requirement leaves considerable latitude for the expenditures that will officially be financed from these revenues. In any case, it must be recognized that the expenditure impact of the incremental revenues is not necessarily identical to, or even similar to, the expenditures officially earmarked to use the particular dollar inflows provided by the project because some of these expenditures might have occurred anyway. Rather, the impact is the *marginal expenditures* made affordable by the existence of these revenues and which would not have been undertaken in their absence. These could conceivably be quite different from the expenditures ostensibly being financed by the project revenues, as described in project agreements. The latter can be called the *official expenditures*.

The official expenditures associated with the NT2 project are consistent with agreed criteria such as those outlined in the Poverty Reduction Strategy Report, but this may or may not apply to the marginal expenditures actually being financed. In this respect, the NT2 project raises issues common to many natural resource based projects, where the benefits accrue, in the first instance, to the government. The nature of these marginal expenditures, along with their true distributional impact, is not easily discovered and neither official project documents nor the pattern of past expenditures necessarily provide a reliable guide. Furthermore, knowledge of the true marginal expenditures is not the same as knowledge of their impact because the full impact includes the indirect effects of price changes induced by the marginal expenditures. To illustrate, many people may be affected indirectly by the project, through commodity and factor price effects, even if they are not direct beneficiaries of the marginal expenditures and even if they are untouched by any of the project's direct costs.

This paper explores the ultimate poverty-reducing effect of the basket of expenditures financed by the project. It studies the way these effects depend on the direct distributional characteristics of the expenditures. The analysis draws upon a multi-household, multi-sectoral general equilibrium model of the Lao economy. The case of the NT2 project illustrates the issues involved, but the relevance of the analysis is not confined to this particular project.

In Section 2, we describe the NT2 project. Section 3 provides a brief overview of poverty and inequality in Laos. The main features of the general equilibrium model to be used in the analysis are described in Section 4, focusing on three key points. First, the model distinguishes between rural and urban households, based on the Lao government's household income and expenditure survey data for 2003. Second, based on the same survey data, each of the categories of households (rural and urban) contains 100 household sub-categories, arranged by real expenditures per household member, giving a total of 200 household sub-categories within the model. Third, the production side of the economy is divided into 20 industries, based on an input–output table previously constructed for a major province of Laos. The details of the simulations and their results are presented in Section 5. Finally, Section 6 draws out the major conclusions implied by the results.

2. The NT2 project

The NT2 project involves the construction and operation of a US$1.45 billion hydropower facility that would generate 1080 MW of electricity (see Table 1). About 93% of the electricity generated by NT2 will be exported to Thailand, from which

[2] The term 'Dutch disease' refers to the effect on the Dutch economy of absorption of foreign exchange earned from exports of North Sea gas in the 1960s. Tradables industries such as manufacturing and agriculture contracted and non-tradables industries such as services expanded (Corden, 1982). Whether this effect deserves the epithet 'disease' is debatable.

Table 1
Laos: large hydroelectric dam projects to be operational by 2015.

Name of dam	Installed capacity (MW)	Production (GWh/year)	Cost (million $US)
Nam Theun 2	1,080	5,936	1,450
Xeset 2	76	227	138
Nam Ngum 2	615	2310	771
Xe Kaman 3	250	970	278
Theun Hinboun Expansion	210	518.3	288
Nam Ngum 3	460	1,919	630
Nam Ngiep 1	252	1,274	340
Total	2,943	13,154	3,895

Source: International Monetary Fund (2007).
Note: GWh, gigawatt-hour and MW, megawatt.

Table 2
Financing structure of Nam Theun 2 project ($US millions).

Project cost	1,450
Base cost	1,250
Contingency	200
Financing	1,450
Equity	450
Private	450
Eletricite de France International	158
Electricity Generating Public Company Ltd	113
Italian-Thai Development Public company	68
Theun 2 Power Company Ltd	112
Debt	1,000
Official creditors	160
International Banks	340
Thai commercial banks (THB loans)	500

Source: World Bank (2009).
Note: Dollar amounts are approximate due to exchange rate movements.

revenues will be generated through taxes, dividends, and royalties (or concession fees). The remaining 7% will be for domestic consumption. As of December 2009, project construction was essentially complete. NT2 is only one of several hydroelectric dam projects due to be completed in Laos by 2015. Their total investment cost is close to US$4 billion and all generate benefits to Laos primarily in the form of government revenues through foreign exchange earnings.

Structured as a build-own-operate-transfer project, NT2 is being developed by the Nam Theun 2 Power Company Ltd (NTPC), a private company owned by a French-Thai-Lao consortium. Twenty seven other partners are involved in the project, including the World Bank and the Asian Development Bank. The financing structure is summarized in Table 2. The project has a concession period of 31 years, at the end of which all assets are to be transferred to the Lao Government.

The main benefit to Laos from NT2 will come from the revenues that the project will generate during the 25-year operation period (2010–2034). The revenues that will be derived from the sale of electricity are uncertain, but it is estimated that the Lao government will receive a cumulative nominal sum of just under $2 billion over this period. Revenues from the project are projected to rise gradually in the early years, averaging $30 million per year during 2010–2020, and then averaging about $100 million per year for the period up to 2034. These revenues are dominated by hard-currency sales of electricity to Thailand, but also include revenues from the small proportion of electricity sales expected to occur within Laos. Once all of the assets are transferred to Laos at the end of the concession period, NT2 could generate between $6 billion and $7 billion in profits for the government. These future revenues provide continuing opportunities for the Government to pursue its social development and poverty reduction programs.

Revenues generated by NT2 are officially targeted to fund poverty reduction initiatives under the government's National Growth and Poverty Eradication Strategy (NGPES). Thus, programs eligible for funding with NT2 revenues will be based on NGPES priorities. In June 2009, the Lao National Assembly approved the allocation of NT2 revenues as part of the FY2009/10 budget cycle. Subsequently, the Ministry of Finance provided the following indicative allocations for priority sectors: (i) education, 35%; (ii) rural roads, 30%; (iii) health, 20%; and (iv) environment and forestry, 15%. Sector ministries have begun finalizing the list of specific programs and expenditures, although these allocations could be revised in the future, to take account of performance and changing policy priorities (NT2 Board Update, July 2009).

The World Bank has worked closely with the Lao government to ensure that revenues are carefully managed and employed for poverty reduction programs. These programs may be implemented, in part, through statutory funds such as the Road Maintenance Fund and the Poverty Reduction Fund, which offer additional fiduciary safeguards in terms of financial reporting and oversight arrangements. The Poverty Reduction Fund is initially being financed by the IDA, but will eventually

Table 3
Poverty incidence and Gini index of inequality in Laos.

	Poverty incidence (headcount measure, %)				Gini index (%)			
	1992/3	1997/8	2002/3	2007/8	1992/3	1997/8	2002/3	2007/8
Laos	46.0	39.1	33.5	27.6	30.5	34.9	32.6	35.4
Area								
Urban	26.5	22.1	19.7	17.4	30.9	39.7	34.8	36.3
Rural	51.8	42.5	37.6	31.7	29.0	32.1	30.3	33.4
Rural with road	42.8	31.7	31.3	29.9	29.3	32.1	30.3	33.2
Rural w/o road	60.4	50.8	46.2	42.6	27.5	30.9	29.4	33.3
Region								
Vientiane	33.6	13.5	16.7	15.2	29.7	36.9	36.0	38.0
North	51.6	47.3	37.9	32.5	26.9	34.5	30.7	35.2
Central	45.0	39.4	35.4	29.8	31.5	32.5	31.0	34.0
South	45.7	39.8	32.6	22.8	32.3	32.4	31.4	32.2
Priority district								
First priority	56.1	63.0	49.4	43.5	29.9	29.7	27.9	31.9
Second priority	58.2	41.7	41.2	36.2	31.9	29.6	32.0	32.7
Other	40.5	30.5	26.3	19.9	30.1	34.9	32.7	35.1

Source: Government of Lao PDR (2009) and World Bank (2008c).

be funded by NT2 revenues. In keeping with the NGPES, the Poverty Reduction Fund is targeted to the 72 priority districts (see below), and its use is demand-driven; projects are identified by the villagers themselves, and village volunteers are trained to implement and monitor the projects in cooperation with project staff (World Bank, 2009).

It seems possible that NT2 revenues could, at least in part, replace IDA funds or other forms of official capital inflow, most which are currently targeted towards poverty reduction. To the extent that this occurs, the expenditures derived from NT2 revenues merely replace poverty-targeted expenditures that would have occurred anyway, if the NT2 revenues had not been received. The net addition to public spending resulting from the inflow of NT2 revenues would then be smaller than the revenue inflow. Moreover, even if IDA funds do not decline as a result of the inflow of NT2 revenues, some of the NT2 funds could be used to finance other poverty-related expenditures that would have occurred anyway, freeing public revenues for new expenditures, which may or may not be poverty-targeted.

All this implies that, to some extent at least, both the size and the composition of the true marginal expenditures could be different from the size and composition of the official expenditures associated with the NT2 revenues, despite adherence to the agreed allocation of official expenditures associated with the project. It follows that both the size and composition of the true marginal expenditures are, to some extent, uncertain. This point has possible relevance for the extent to which the inflow of NT2 revenues actually reduces poverty. The uncertain nature of the true marginal revenues will be drawn upon in the design of our simulations, presented below.

3. Poverty and inequality in Laos

One of the poorest countries in Asia, Laos had a per capita GDP in 2010 of US$1204 (current prices), roughly one quarter of that in neighboring Thailand.[3] Close to 70% of its people live in rural areas; almost a fourth of adults are illiterate; life expectancy at birth is 65 years; 7 in 100 children die by the age of five; and only 60% of the population have access to an improved water source (World Bank, 2008b). Strong growth has produced a decline in poverty incidence, particularly over the past decade. Poverty incidence (headcount) declined significantly in both urban and rural areas, as shown in Table 3. The urban and rural poverty lines used in these calculations are the Lao government's official poverty lines, constructed with the assistance of the World Bank; their nominal monetary values are adjusted over time to hold their real purchasing power constant, taking account of the differences in price movements in urban and rural areas. Calculation of the headcount measure of poverty incidence in each area is based on the comparison of this poverty line with household level data on expenditure per person from the Lao Expenditure and Consumption Survey (subsequently LECS). Fig. 1 (see further description below) illustrates the estimation of poverty incidence. The estimated values of the Gini coefficient of inequality are also based on the LECS data on household expenditure per person.

Poverty in Laos is strongly influenced by geography. Although poverty incidence has declined in both urban and rural areas, it continues to be significantly higher in the latter. Within rural areas, those villages not serviced by all weather roads show significantly higher rates of poverty incidence. Variations both within and across the major regions of the country are likewise considerable. The Central Region as a whole accounts for the largest share of the poor population, but poverty incidence is higher in the northern region, which is more remote and has lower population density. In view of these disparities, the NGPES has targeted poverty reduction interventions to 72 priority districts (47 first priority and 25 second

[3] *Source*: IMF World Economic Outlook Database.

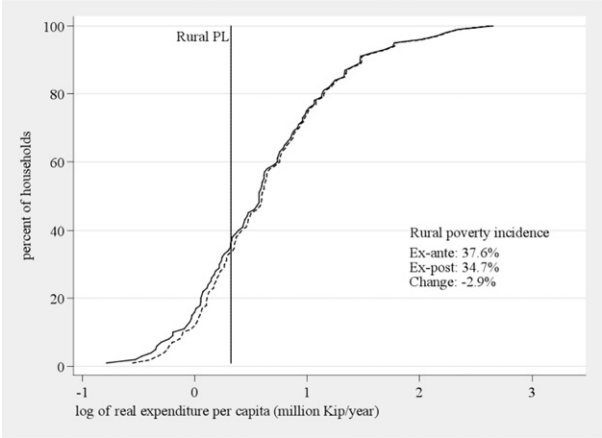

Fig. 1. Simulated changes in poverty incidence – rural households, Simulation 1. *Note*: The figure illustrates the method of calculating changes in poverty incidence, using the results for rural households in Simulation 1 as an example. The *ex ante* distribution of real expenditure per capita is shown by the solid curve. The *ex post* distribution of real expenditures per capita, generated by Simulation 1, and after re-sorting households according to real expenditures per capita, is shown by the dashed curve. 'Rural PL' is the poverty line for rural households, held constant in real terms.
Source: Authors' calculations.

priority districts), chosen using a set of basic needs indicators at the local level. All of these 72 priority districts can be considered mainly rural in nature. A policy intention therefore exists that public expenditures related to poverty should be directed increasingly towards rural areas.

4. A general equilibrium model of the economy of Laos

This section briefly describes *LaoGEM* (Lao General Equilibrium Model), a 20 sector, 200 household general equilibrium model of the Lao economy, constructed specifically for the analysis of the way changes in economic policy and other economic shocks affect poverty incidence in Laos. A full description of *LaoGEM* is available online in Warr and Yusuf (2010). Unless otherwise stated, the database of the model refers to the year 2002. The model's main features are as follows.

4.1. Model structure

LaoGEM belongs to the class of general equilibrium models that are linear in proportional changes, sometimes referred to as Johansen models. Its theoretical structure is relatively conventional. It assumes competitive profit maximization on the part of all firms and competitive utility maximization on the part of consumers. Each industry has a constant returns to scale technology and there is at least one industry-specific factor present in each industry. In the simulations reported in this paper, the markets for final outputs, intermediate goods and factors of production are all assumed to clear at prices that are determined endogenously within the model. The nominal exchange rate between the Lao *kip* and the US dollar is fixed exogenously and its role within the model is to determine, along with international prices, the nominal domestic price level.

4.2. Industries

The model contains 20 industries, including three agricultural industries: crops; livestock and poultry; and forestry and logging. Non-agricultural industries include: mining and quarrying; seven manufacturing industries; and nine services and utilities industries. Each industry produces a single output, and the set of commodities therefore coincides with the set of industries. Exports are not identical with domestically sold commodities. In each industry the two are produced by a transformation process with a constant elasticity of transformation.

The core of the production side of the model is a 20 sector input–output table for Laos, estimated specifically for this study. No official input–output table is currently available and the table constructed for the present study is thus the first publicly available input–output table for the country. It is based on information from two sources. First, there is a 20 sector input–output table for Savannakhet Province of Laos, relating to the year 2003, recently constructed in a detailed study by researchers at the Asian Development Bank (Sim et al., 2007). This table is then adjusted using data from the Lao National Accounts for 2002. The method of adjustment may be understood as follows. The value added totals for the various sectors of the Savannakhet table are compared with those for Laos, derived from the National Accounts. The Savannakhet table is then amended using a method called RAS (row and column sum) to force the value added totals to match those for Laos.

The resulting table reflects the industry structure of Laos, as indicated in its National Accounts, but within each industry the input–output technology reflects that of Savannakhet Province. The method thus assumes that the input–output technology for each industry in Laos is similar to that of Savannakhet, even though the relative importance of these various

industries in Laos is quite different from that of Savannakhet. Fortuitously, Savannakhet Province seems a suitable basis for this kind of exercise in that it is roughly intermediate within the provinces of Laos in terms of its level of technology, neither the most nor the least advanced. The resulting table seems to make sense. When a properly constructed input–output table for Laos becomes available, it should presumably replace the table estimated as above. In the meantime, this table is considered the best available.

4.3. Commodities

Although the sets of producer goods and consumer goods have the same names, the commodities themselves are not identical. Each of the 20 consumed goods consists of a composite of the domestically produced and imported version of the same commodity, where the two are imperfect substitutes. The proportions in which they are combined reflect consumer choices and depend on both (a) the relative prices of these imported and domestically produced versions of the good and (b) the (Armington) elasticity of substitution between them.

4.4. Factors of production

The mobility of factors of production is a critical feature of a general equilibrium system, where the term 'mobility' here means the capacity to move across economic activities (industries), and not necessarily the capacity to move geographically. The greater the inter-sectoral factor mobility that is built into the model, the greater is the flexibility of the economy, as reflected in its simulated capacity to respond to changes in the economic environment. It is clearly essential that assumptions about the mobility of factors of production be consistent with the length of run that the model is intended to capture. The analysis of this paper is short-run, where this should be understood as an adjustment period of around three years.

Labor is assumed to be of two kinds: paid and unpaid. Wage labor is fully mobile across all sectors, implying that wages must be equal in all sectors, and must move together. Non-wage labor means primarily family labor, which is not paid a formal wage and which is much less mobile across industries than paid labor. The most important form of non-wage labor occurs in agriculture, in the form of family farm labor, but important examples also exist in many services industries and in petty trading. Non-wage labor is assumed to be immobile between industries in the short run. There are two kinds of capital: agricultural and non-agricultural. Agricultural capital is mobile across industries within agriculture, but immobile between agriculture and non-agriculture. Non-agricultural capital is similarly mobile across non-agricultural industries but immobile between non-agriculture and agriculture. Finally, land is assumed to be immobile across agricultural industries.

In this treatment, fixed capital in agriculture is thought of as meaning 'land', but also some light machinery and equipment of an industry-specific kind. Mobile capital in agriculture includes some land but also machinery such as light tractors and also draft animals that can be used in the production of a range of agricultural commodities. Neither agricultural land nor agricultural capital (machinery and draft animals) is usable in the non-agricultural industries. Non-agricultural capital is thought of as including industrial machinery and buildings.

4.5. Technology

In every sector there is constant elasticity of substitution (CES) production technology with constant returns to scale for all factors combined; there is diminishing returns to scale to variable factors alone, but there is also a sector specific fixed factor (immobile capital or land) in each sector. For convenience, we shall refer to the set of specific factors in the agricultural sectors as 'land', and to the set of those in the non-agricultural sectors as 'fixed capital', but for the reasons described above, this language is accurate only in an approximate way. The assumption of constant returns means that all factor demand functions are homogeneous of degree one in output. In each sector, there is a zero profit condition, which equates the price of output to the minimum unit cost of production. This condition can be thought of determining the price of the fixed factor in that sector.

4.6. Households

The model contains two major categories of households – urban (24% of the population) and rural (76% of the population). The incomes of these two household types depend on their ownership of factors of production, the returns to those factors, and their non-factor incomes, mainly consisting of transfers from others. Since our focus is on income distribution, the sources of income of the households are of particular interest. These differ between the two household categories. The data are extracted from the 2002–03 household income and expenditure survey, the Lao Expenditure and Consumption Survey, commonly called LECS 3.[4] The SAM is based on data from this survey, the input–output table described above, the Lao National Accounts for 2002 and Lao trade data.

[4] As noted above, the "3" in LECS 3 signifies that it is the third such survey to be conducted. The previous two (LECS 1 and 2) were for 1992–1993 and 1997–1998, respectively.

Table 4
Factor income shares of poor and average households, urban and rural.

	Urban poor	Rural poor	Urban	Rural
Wage labor	64.00	35.22	55.64	31.32
Non-wage labor	12.93	23.27	15.94	24.67
Agriculture capital	6.11	10.99	7.53	11.66
Non-agriculture capital	13.90	25.01	17.13	26.52
Land	3.05	5.50	3.76	5.83
Total	100	100	100	100

Source: Authors' calculations.

Within the *LAOGEM* model, each of the two household categories is sub-divided into a further 100 sub-categories (centile groups) each of the same population size, arranged by real consumption expenditures per capita, giving a total of 200 sub-categories.[5] The consumer demand equations for the various household types are based on a Cobb–Douglas demand system, using data on expenditure shares extracted from the LECS 3 survey. Within each of the two major categories, the 100 sub-categories thus differ according to (i) their per capita expenditures, (ii) their budget shares in consumption and (iii) their sources of factor and non-factor incomes. The sources of factor incomes of the households play an important role in distributional analysis. They are summarized in Table 4.

4.7. Elasticity estimates

The elasticity estimates used in *LaoGEM* for the factor demand systems were taken from empirical estimates derived econometrically for a structurally similar model of the Thai economy, known as *PARA*. These parameters were amended to match the differences between the databases for *LaoGEM* and *PARA* so as to ensure the homogeneity properties required by economic theory. All export demand elasticities were set equal to 20. This high number reflects the fact that Laos is a small exporter for virtually all its export commodities, including the important case of electricity exports to Thailand, where electricity from Lao sources represent just a few percentage points of all electricity consumed in Thailand. The elasticities of supply of imports to Laos were assumed to be infinite and import prices were thus set exogenously. All elasticities of substitution within the CES production functions are assumed to be 0.5, except for the paddy production industry where this elasticity is set at 0.25, reflecting the empirical observation of low elasticities of supply response in this industry. The Armington elasticities of substitution in demand between imports and domestically produced goods were set equal to 2 for all commodities.

5. Simulations and results

5.1. The shocks

Three forms of uncertainty arise in specifying the distributional impacts of the public spending made possible by the NT2 revenues. First, the magnitude of total revenues derived from the project and their distribution over time both depend on demand for the electricity produced, especially demand from Thailand, and are therefore uncertain. Second, even if adherence to the planned pattern of expenditures from these revenues was assumed, their distributional impact would still not be clear. For example, 'education' and 'health' make up more than half of the official proposed expenditures, but there is scope for a wide range of distributional outcomes to be consistent with these broad categories of expenditure. Third, as discussed above, the possibility exists that the marginal expenditures – the true incremental expenditures actually financed by these revenues – may be different from the official expenditures, because some of the official expenditures may have occurred anyway.

Accordingly, we design a set of stylized shocks that recognizes the uncertainty regarding the true distributional impacts of the spending. First, the magnitude of the shock to total spending is set at US$50 million per year. This amount is intermediate between the US$30 million per year estimated for the early years of project operation and US$100 million in later years. All simulations reported in this paper are based on this increase in total government spending. Second, consistent with this total level of expenditure, we consider a set of expenditure shocks, allocated across households, covering a wide range of distributional possibilities. The simulations will determine the extent to which the effect of the expenditures on poverty incidence is sensitive to these distributional assumptions.

We simplify the marginal government expenditures arising from the project inflows, treating them as lump-sum income transfers to individual households. Of course, actual expenditures seldom, if ever, take this heavily simplified form, but this stylized treatment allows us to focus on the distributional characteristics of the marginal expenditures. In this treatment,

[5] The population sizes of the two major categories are not the same, but *within* each of the two categories the population sizes of the 100 sub-categories are the same.

Table 5
Summary of assumed distribution of marginal expenditures.

	Within regions		
	Progressive	Neutral	Regressive
Between regions			
Pro-rural	SIM 1	SIM 2	SIM 3
Neutral	SIM 4	SIM 5	SIM 6
Pro-urban	SIM 7	SIM 8	SIM 9

Note: 'Region' refers to rural vs. urban. 'Between regions' refers to the assumed bias in the distribution of marginal expenditures between rural and urban regions, as follows. 'Pro-rural' means that all marginal expenditures go to the rural region. 'Neutral' means distribution between rural and urban regions according to population shares. 'Pro-urban' means that all marginal expenditures go to the urban region. 'Within region' refers to the assumed bias in the distribution of marginal expenditures across households within rural and urban regions, as follows. 'Progressive' means that within each region marginal expenditures are allocated in inverse proportion to income per person. 'Neutral' means allocation in proportion to population, independently of income. 'Regressive' means allocation in direct proportion to income per person.

when the government receives income from the project, it distributes it directly to households in lump-sum form with the distribution across households depending on two criteria:

(i) whether the household is rural or urban and
(ii) the household's pre-transfer income.

We explore simple rules for applying these two criteria to determining the distribution of benefits across households and explore the extent to which the poverty-reducing power of the project depends on these rules, taking account of the 'Dutch disease' arguments. Because the commodity and factor price effects referred to above could be important for the ultimate poverty impact of the spending, and are central to the 'Dutch disease' phenomenon, the analysis necessarily involves general equilibrium issues.

Table 5 summarizes the nine simulations performed. First, we consider three forms of *urban–rural bias*:

Pro-rural – all marginal expenditures go to rural households.
Neutral – marginal expenditures are divided in proportion to population.
Pro-urban – all marginal expenditures go to urban households.

Second, we consider three forms of *distributional bias* within regions:

Progressive – marginal expenditures are allocated in inverse proportion to income.
Neutral – marginal expenditures are allocated independently of income.
Regressive – marginal expenditures are allocated in proportion to income.

Simulation 1 is presumably the most 'pro-poor' allocation of marginal expenditures and Simulation 9 is presumably the most 'pro-rich'. It is not clear how the others should be ranked in this respect. We will explore this issue by determining how the nine possible combinations of marginal expenditure allocations implied by this classification each affect poverty incidence, along with other variables of interest.

5.2. Model closure

Since real household consumption expenditure is chosen as the basis for welfare measurement, the macroeconomic closure must be made compatible with both this measure and with the single-period horizon of the model. This is done by ensuring that the full economic effects of the shocks are channeled into current-period household consumption and do not leak in other directions, with real-world inter-temporal welfare implications not captured by the welfare measure. The choice of macroeconomic closure may thus be seen in part as a mechanism for minimizing inconsistencies between the use of a single-period model to analyze welfare results, and the multi-period reality that the model depicts.

To prevent inter-temporal and other welfare leakages from occurring, the simulations are conducted with balanced trade (exogenous balance on current account), *including* the capital inflows. This means that the capital inflow is fully absorbed. Balanced trade means that the change in the value of net exports (gross exports minus gross imports) is equal to the magnitude of the capital inflow. This ensures that the potential benefits from the inflow do not flow to foreigners through a current account surplus, or that increases in domestic consumption are not achieved at the expense of borrowing from abroad, meaning a current account deficit in excess of the magnitude of the capital inflow. For the same reason, real government spending on each good is fixed exogenously. The government budget deficit is held fixed in nominal terms, meaning that the magnitude of the receipt of revenues from abroad is exactly matched by the total magnitude of government

transfers to households. This is achieved by endogenous across-the-board adjustments to the sales tax rate, so as to restore the base level of the budgetary deficit. Finally, household nominal savings are fixed exogenously for each household. The combined effect of these features of the closure is that the full effects of changes in policy are channeled into household consumption and not into effects not captured within the single-period focus of the model.

5.3. Results

Table 6 summarizes the short-run macroeconomic effects of the capital inflow, transferred to households according to the simple rules outlined above. In this table, as in Table 7 below, the results refer to the percentage change in the variable shown, relative to its base level.

The capital inflow is equivalent to just under 1% (0.91%) of GDP, but real GDP is virtually unaffected by the inflow, because the capital inflow has no short-run effect on production capacity within Laos. Our macroeconomic closure ensures that the capital inflow is reflected in increased household consumption. Real household consumption increases by about 1.27% in

Table 6
Simulated changes in major macroeconomic variables (per cent change from base).

Between region	Pro-rural			Neutral			Pro-urban		
Within region	Progressive	Neutral	Regressive	Progressive	Neutral	Regressive	Progressive	Neutral	Regressive
	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9
Real GDP	0.016	0.016	0.016	0.017	0.017	0.018	0.019	0.020	0.021
Real household consumption	1.271	1.270	1.268	1.273	1.272	1.271	1.279	1.279	1.279
Export volume index	−4.381	−4.355	−4.299	−4.408	−4.384	−4.333	−4.481	−4.465	−4.427
Import volume index	1.328	1.339	1.361	1.318	1.327	1.347	1.288	1.294	1.310
GDP price index	2.815	2.804	2.774	2.843	2.829	2.793	2.920	2.900	2.848
Consumer price index (CPI)	2.418	2.410	2.386	2.444	2.433	2.403	2.515	2.497	2.451
Terms of trade	1.13	1.12	1.10	1.13	1.13	1.11	1.15	1.15	1.14
Real exchange rate	−2.74	−2.73	−2.70	−2.76	−2.75	−2.72	−2.84	−2.82	−2.77
Real factor returns									
Wage	0.014	−0.013	−0.067	−0.028	−0.050	−0.092	−0.146	−0.155	−0.161
Agric. capital	−0.430	−0.492	−0.652	−0.490	−0.551	−0.700	−0.659	−0.716	−0.837
Non-agric. capital	0.058	0.170	0.428	0.188	0.292	0.522	0.555	0.635	0.784
Land	−0.140	−0.223	−0.420	−0.225	−0.302	−0.482	−0.460	−0.525	−0.653

Source: Authors' calculations.
Note: See notes to Table 5. All simulations are based on an increase in total government expenditure of US$50 million per year.

Table 7
Simulated changes in industry outputs (per cent change from base).

Between region	Pro-rural			Neutral			Pro-urban		
Within region	Progressive	Neutral	Regressive	Progressive	Neutral	Regressive	Progressive	Neutral	Regressive
	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9
Crops	0.08	0.03	−0.07	0.02	−0.02	−0.11	−0.16	−0.18	−0.22
Livestock	0.10	0.13	0.17	0.15	0.16	0.19	0.27	0.27	0.25
Forestry	−1.92	−1.91	−1.89	−1.93	−1.92	−1.90	−1.98	−1.96	−1.92
Mining	−3.14	−3.15	−3.19	−3.20	−3.22	−3.25	−3.39	−3.40	−3.42
Food	0.17	0.20	0.25	0.23	0.25	0.28	0.39	0.38	0.36
Textile	−1.30	−1.29	−1.28	−1.36	−1.34	−1.33	−1.50	−1.49	−1.48
Wood	−3.08	−3.07	−3.03	−3.10	−3.09	−3.05	−3.16	−3.14	−3.11
Chemicals	−3.58	−3.61	−3.66	−3.68	−3.70	−3.74	−3.94	−3.95	−3.97
Minerals	−0.07	−0.06	−0.05	−0.07	−0.07	−0.05	−0.07	−0.07	−0.06
Metals	−2.38	−2.40	−2.42	−2.45	−2.46	−2.47	−2.65	−2.65	−2.62
Other manuf.	−0.32	−0.30	−0.18	−0.34	−0.32	−0.20	−0.40	−0.37	−0.25
Elect./water	−0.99	−0.98	−0.96	−0.96	−0.94	−0.90	−0.87	−0.83	−0.73
Construction	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.04
Transport	0.71	0.71	0.73	0.71	0.72	0.73	0.72	0.73	0.74
Post and comm.	−0.14	−0.11	0.03	−0.11	−0.05	0.12	−0.02	0.11	0.35
Trade	0.06	0.07	0.10	0.07	0.08	0.11	0.11	0.12	0.14
Banking	−0.35	−0.33	−0.26	−0.34	−0.32	−0.26	−0.33	−0.31	−0.25
Estate	0.13	0.16	0.24	0.20	0.22	0.28	0.40	0.40	0.39
Government	0.13	0.16	0.23	0.14	0.16	0.22	0.16	0.18	0.20
Other services	0.90	0.98	1.17	0.89	0.97	1.18	0.86	0.96	1.22

Source: Authors' calculations.
Note: See notes to Table 5. All simulations are based on an increase in total government expenditure of US$50 million per year.

each simulation, reflecting the fact that household consumption is about 72% of GDP. The absorption of the foreign exchange is accompanied by a contraction in exports and expansion of imports, causing a moderate improvement in the terms of trade.

The real exchange rate listed in Table 6 is measured here as the average purchaser price of traded goods (the eleven industries listed as 'crops' to 'other manufacturing' in Table 7) using total purchases as weights relative to the average purchaser price of the nine industries 'electricity and water' to 'other services', weighted similarly. The real exchange rate appreciates significantly in each simulation (the negative sign indicates a decline in the P_t^T/P_t^N price ratio), consistent with the 'Dutch disease' analysis. Real wages rise only in the most pro-poor allocation (Simulation 1). Moving across the table, the declines in real wages become progressively larger. This outcome is a consequence of the spending patterns of poor rural households at one extreme and rich urban households at the other. Poor rural households purchase goods and services that are more labor-intensive and more land-intensive, bidding up real wages and real returns to land. Rich urban households purchase more capital intensive goods and services, bidding up returns to capital.

The above spending story carries over to Table 7, which shows changes in industry outputs. The output of crops rises in Simulations 1, 2 and 4 (the most pro-poor patterns of marginal expenditures) but decline in all others. The greater the pro-rich bias in expenditures, the greater the decline in the output of crops. Rich households spend a small proportion of their incomes on staple foods such as crops. The reverse outcome occurs with livestock.

Table 8 shows the estimated changes in rural and urban poverty incidence and inequality. It should be recalled that for internal consistency within model, the database for calculations of poverty and inequality is the 2002–03 LECS survey, summarized in Table 3, above. The method of calculating changes in poverty incidence is illustrated by Fig. 1, which reproduces the result for rural households in Simulation 1. The *ex ante* distribution of real expenditure per capita within rural areas, based on the 2002–04 LECS survey data (see Table 4), is shown by the solid curve. The *ex post* distribution, generated by Simulation 1 with the model and after re-sorting households according to real expenditures per capita, is shown by the dashed curve.

The vertical line depicts the official poverty lines for rural areas. The intersection of this poverty line with the *ex ante* and *ex post* distributions indicates the headcount measure of poverty incidence (37.6 and 34.7%, respectively). The difference between the two headcount measures (*ex post* minus *ex ante*) is the estimated impact of the transfers – a reduction in rural poverty incidence of 2.9%. Since Simulation 1 entails transfers that are biased towards the poorest rural households, it is not surprising that rural poverty incidence falls and urban poverty incidence is affected only slightly. The effect on urban poverty is not zero. There is a small positive effect because some of the goods and services purchased by the urban poor increase in price as a result of the spending of the rural poor and this effect outweighs the increase in real wages that also occurs.

Finally, Table 9 facilitates a fuller understanding of the reasons for the changes in urban and rural poverty. This analysis helps avoid the 'black box' character of many, if not most, general equilibrium studies. Consider the urban household on the threshhold of the urban poverty line (top half of the table). Because the base level of poverty incidence in urban areas is 19.7%, the poverty line approximately coincides with the expenditure level of the urban household in the 20th centile (household group U20). If this poverty-threshhold urban household becomes better off, we expect urban poverty incidence to decline, and vice versa. The advantage of doing this is that the sources of the change in the real expenditures of this household can be decomposed in detail, facilitating a deeper understanding of the economic reasons for a change in urban poverty incidence. A similar exercise can be undertaken for the rural household on the threshold of the rural poverty (bottom half of the table) which, because initial rural poverty incidence is 37.6%, corresponds to household R38.

The basis for the decomposition is as follows. We focus on the sources of changes in the real expenditure of a particular household, say household h, arising from some external shock. Upper case Roman letters, like Z, will denote levels of variables and lower case Roman letters, like z, will denote their proportional change, so that $z = dZ/Z$. The levels of nominal income and nominal expenditure of household h will be denoted Y_h and E_h, respectively. Let the proportional change in the nominal expenditure of household h, be $e_h = \tilde{e}_h + p_h$, where $\tilde{e}_h$ is the proportional change in the household's real expenditure and $p_h = \sum_{i=1}^{I} \varepsilon_h^i p^i$ is the proportional change in a consumer price index specific to household h, with $\varepsilon_h^i = E_h^i/E_h$ denoting

Table 8
Simulated changes in poverty incidence and inequality.

Between region	Pro-rural			Neutral			Pro-urban		
Within region	Progressive	Neutral	Regressive	Progressive	Neutral	Regressive	Progressive	Neutral	Regressive
	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9
Poverty incidence (*ex post* level minus *ex ante* level %)									
Urban	0.36	0.37	0.38	−0.12	−0.08	0.08	−0.54	−0.42	−0.21
Rural	−2.86	−2.77	−2.21	−2.62	−2.54	−1.98	−0.34	−0.35	−0.36
Total	−2.01	−1.94	−1.53	−1.96	−1.90	−1.44	−0.39	−0.37	−0.32
Gini index (*ex post* level minus *ex ante* level %)									
Urban	0.13	0.13	0.12	−0.27	−0.09	0.17	−1.36	−0.69	0.31
Rural	−1.13	−0.60	0.35	−0.80	−0.41	0.29	0.14	0.13	0.12
Total	−0.92	−0.67	−0.16	−0.73	−0.49	−0.05	−0.17	0.02	0.27

Source: Authors' calculations.
Note: See notes to Table 5. Initial (*ex ante*) values in 2002–03 were: poverty incidence – urban 19.7%; rural 37.6%; total 33.5%. Gini coefficient – urban 34.8%; rural 30.3%; total 32.6%. All simulations are based on an increase in total government expenditure of US$50 million per year.

Table 9
Decomposition of simulated changes in expenditures of households on the poverty borderline.

Between region	Pro-rural			Neutral			Pro-urban		
Within region	Progressive	Neutral	Regressive	Progressive	Neutral	Regressive	Progressive	Neutral	Regressive
	SIM 1	SIM 2	SIM 3	SIM 4	SIM 5	SIM 6	SIM 7	SIM 8	SIM 9
Urban poor (U20)									
Labor income	473.41	465.95	449.81	469.76	462.82	448.02	459.49	454.02	443.01
Agric. capital income	79.67	75.72	66.27	76.80	73.01	64.22	68.76	65.41	58.46
Non-agric. capital income	134.88	141.70	156.98	144.99	151.07	164.00	173.33	177.30	183.62
Land income	39.98	38.00	33.28	38.55	36.65	32.25	34.55	32.87	29.38
Other income	0.00	0.00	0.00	522.20	407.13	231.92	1982.41	1545.51	880.33
Total income	727.95	721.37	706.34	1252.31	1130.66	940.40	2718.54	2275.10	1594.80
Saving	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumption	727.95	721.37	706.34	1252.31	1130.67	940.40	2718.54	2275.10	1594.80
Living cost	972.83	968.70	956.49	990.41	983.70	966.40	1040.24	1026.13	994.31
Real expenditure	-244.88	-247.32	-250.15	261.90	146.96	-26.00	1678.30	1248.97	600.49
Rural poor (R38)									
Labor income	413.10	406.59	392.50	409.91	403.86	390.95	400.96	396.18	386.57
Agric. capital income	227.28	216.00	189.06	219.10	208.26	183.19	196.16	186.59	166.76
Non-agric. capital income	384.78	404.23	447.83	413.63	430.95	467.83	494.45	505.80	523.82
Land income	114.05	108.41	94.93	109.97	104.55	92.00	98.55	93.76	83.82
Other income	2357.15	1663.66	718.38	1736.23	1225.41	529.13	0.00	0.00	0.00
Total income	3496.37	2798.89	1842.70	2888.84	2373.03	1663.09	1190.12	1182.32	1160.97
Saving	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumption	3496.37	2798.89	1842.70	2888.84	2373.03	1663.09	1190.12	1182.32	1160.97
Living cost	982.54	959.00	912.16	970.99	950.01	907.61	938.93	925.03	894.89
Real expenditure	2513.83	1839.89	930.55	1917.85	1423.01	755.49	251.19	257.29	266.08

Source: Authors' calculations.
Units: Million of Lao Kip, 2002 prices. *Note*: See notes to Table 5. All simulations are based on an increase in total government expenditure of US$50 million per year.

that household's expenditure share on commodity i, E_h^i denoting its nominal expenditure on commodity i and p^i denoting the proportional change in the consumer price of commodity i.

The absolute change in this household's nominal expenditure is now

$$dE_h = E_h e_h = E_h(\tilde{e}_h + p_h) = d\tilde{E}_h + E_h p_h = d\tilde{E}_h + \sum_{i=1}^{I} E_h^i p^i \tag{1}$$

That is, the change in nominal expenditure of the household is given by the change in its real expenditure plus the change in its true cost of living, the latter an expenditure weighted sum of the changes in the consumer prices that household actually faces, where the expenditure weights pertain to that particular household.[6] The change in nominal expenditure is also equal to the change in nominal income minus the change in saving, so that $dE_h = dY_h - dS_h$. Disregarding any changes in transfer income or direct taxes, for simplicity, the change in nominal income is equal to the change in nominal factor income, $dY_h = dY_h^f$.

Thus, rearranging terms:

$$d\tilde{E}_h = dY_h^f - dS_h - \sum_{i=1}^{I} E_h^i p^i \tag{2}$$

The change in the household's real income is decomposable into three components: (i) the change in its nominal factor income, minus (ii) the change in its savings, minus (iii) the change in its true cost of living. Importantly, the change in nominal factor income is itself additively decomposable into its factor components, as identified in the model.

We can take the poverty-threshold rural household (household R38) under Simulation 1 (first column of Table 9) as an illustration of the method. All units are millions of kip at 2002 prices. The real expenditure of this household category rises by 2,514 (bottom row of Table 9) consistent with rural poverty incidence declining. Drawing on the decomposition, we can now study in detail why its estimated real expenditure rises by this amount. Income from the transfer rises by 2357. However, the spending of this transfer has general equilibrium effects on commodity prices, raising the cost of living, and also effects on factor incomes, operating through the responses of producers to the changes in commodity prices. Factor income (returns to labor, capital and land), rises by an additional 1139, within which increased payment to labor is the largest component. The increase in total income (3496) must now be set against the increase in the cost of living of 982. Recalling that household savings are held constant under the model closure, real expenditure rises by 3496 − 982 = 2514.

[6] It should be noted that real expenditures means expenditures measured at constant prices, defined here to mean base period prices. Thus, the levels of nominal and real expenditures in the base period are identical, meaning $E_h = \tilde{E}_h$.

From the changes in poverty incidence derived from the nine sets of simulations, one simple conclusion emerges. The most important characteristic of the marginal expenditures in so far as effects on poverty incidence are concerned, is its degree of rural bias. This is far more important than the within-region distribution. That is, whether the distribution within rural areas is progressive, neutral or regressive is far less important than its rural-urban bias. Among the pro-rural distributions even the most regressive distribution (Simulation 3) reduces total poverty incidence by four times as much as the most progressive of the pro-urban distributions (Simulation 7).

6. Conclusions

This study analyzes the effects on poverty incidence and other economic variables that arise from increases in public expenditures derived from natural resource revenues. The expenditures of interest are those financed by resource inflows to the government originating from outside the country, rather than from tax revenues collected within the country. We focus in particular on government expenditures financed by foreign exchange revenue inflows derived from the operation of natural resource projects such as the NT2 hydroelectric dam project in Laos. The analysis is conducted with a multi-sector/multi-household general equilibrium model of the economy of Laos.

The analysis distinguishes between the *official expenditures* that are officially said to be financed by the project and the *marginal expenditures* – the incremental expenditures actually made possible by the addition to government revenues. The marginal expenditures are those that occur with the new revenues but which would not have occurred in the absence of these revenues. The two might be different if some of the official expenditures would have been undertaken anyway, even in the absence of the new revenues. The analysis also takes account of the indirect distributional effects of absorption of foreign exchange revenues, operating through the 'Dutch disease' mechanism of real appreciation.

The official expenditures associated with the NT2 project are carefully targeted towards poor people within Laos. The present study analyzes the effects of a wide range of marginal expenditures, whose distributional characteristics may differ from those of the official expenditures. The aim is to assess how much the distinction between official and marginal expenditures matters for the poverty-reducing effects of the revenue inflow.

The results confirm that the new expenditures financed by natural resource projects can be expected to reduce poverty incidence within the country. Poverty incidence declines under the entire range of distributional assumptions that are considered. Nevertheless, the magnitude of the poverty reduction that occurs is highly sensitive to these distributional assumptions. By far the most important determinant of the poverty-reducing power of the government spending is the degree to which it is focused on rural rather than urban areas.

The results have implications for the poverty-reducing capacity of additions to government expenditures, such as those financed by new natural resource revenues. The results imply that it is appropriate to consider the government's full spending program and not just the expenditures officially claimed to be associated with the particular revenue inflow under consideration. The most important question is not which expenditures are officially associated with the new revenues. The more important and much more difficult question is what are the incremental government expenditures that are made possible by the new revenues and which would not have occurred without them.

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