SCALING UP INFRASTRUCTURE SPENDING IN THE PHILIPPINES: A CGE TOP-DOWN BOTTOM-UP MICROSIMULATION APPROACH

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Abstract

In this paper we use a top-down bottom-up microsimulation CGE model with endogenous labour supply and unemployment to explore the impact of scaling up infrastructure in the Philippines. In the context of the debate on the importance of scaling up infrastructure to stimulate growth, some analysts raise concerns on the negative macroeconomic impact (Dutch disease effect). This study aims to provide some insight into this debate by extending the analysis with the inclusion of distributional impact evaluation. We draw from the infrastructure productivity literature to postulate positive productive externalities of new infrastructure and Fay and Yepes (2003) for operating costs associated with new infrastructure. We investigate two fiscal tools and foreign aid to fund the new infrastructure and operation and maintenance costs. The distributional analysis is performed with FGT indices and growth incidence curves. Our results reveal positive poverty reduction and differences between funding schemes with foreign aid providing the most equitable option and the value added tax, the strongest poverty reduction.

JEL codes: C68, D68, E62, F35, H54.

Keywords: Investment externalities, foreign aid, fiscal reforms, poverty, CGE, microsimulation.

Introduction

Since Aschauer (1989) and Munnell (1990) stressed the important role of the public sector in funding infrastructure to stimulate economic development, a vast literature has dealt with this issue. Theoretical models and empirical studies have attempted to shed some light on this relationship. Some authors believed that a decline in productivity would be induced by slow expansion of the public infrastructure investment (Bergman and Suan 1996; and Binder and Smith 1997). In policy circles, this role was much less popular in the context of reforms and structural adjustment programs of the mid eighties and nineties. For many international institutions and developing countries the focus was directed at liberalizing trade, improving macroeconomic balances and reacting to various external shocks. With improvements on these grounds but with sluggish results for poverty reduction in many countries, the end of the nineties saw major changes in development strategies by international financial institutions (IFI), development partners and governments of developing countries.

According to Estache (2007), infrastructure seems to be returning to the agenda of development economists. The interest of the economists is the result of a change in focus from governments of developing countries, IFI's and multi- and bilateral donor agencies bringing infrastructure back to the top of the agenda. The Asian Development Bank organized a major conference on Infrastructure Development, Private Solutions for the Poor in October 2002 in Manila. This conference dealt with important issues such as making infrastructure projects pro-poor, increasing private sector participation to scale up infrastructure and strengthening and increasing pro-poor public-private infrastructure partnerships. This conference built on the May 2000 conference organized by the Department for International Development (DFID-UK) and

the World Bank. The World Bank's world development report published in 2001 is an important illustration of this change, as is the implementation of the Poverty Reduction Strategy programs. More recently the Asian Development Bank (2009) published a report on investing in sustainable infrastructure to improve lives. Since the turn of the century, poverty has been at the centre of the development strategies. In many countries, growth is constrained by infrastructure bottlenecks in a large number of developing countries and this is reflected in many investment climate surveys in which infrastructure ranks as the top priority (Estache 2007).[1]

Governments of developing countries and various development partners have been investigating the determinants of poverty and the most efficient roads out of poverty. One important determinant of poverty reduction is the improvement of productivity. On the one hand, education has received much attention in terms of improving workers' productivity and significant investments have been made and major reforms have been implemented to improve the education of workers in developing countries. More and more analysts have raised the issue of faltering or obsolete infrastructure in developing countries as a stumbling block for growth. In many countries, infrastructure growth has not followed the economic and demographic growth and in some instances the infrastructure was not even maintained. This situation has led many analysts to return to the literature linking public expenditure to infrastructure. These stakeholders have argued that major investments to scale up infrastructure levels would transform their role from a constraint to an engine for growth and indirectly would contribute in the long run to reducing poverty.

Some authors, such as Gupta et al. (2006), Foster and Killick (2006) and Mckinley (2005), have suggested that scaling up aid could have negative macroeconomic consequences

[1] Estache (2007) provide an interesting survey of the state of infrastructure for development and review the main issues at stake for policy makers of developing countries and donor agencies.

among which the spreading of the Dutch disease due to the risks of appreciation of the real exchange rate. It is important to note that scaling up infrastructure is a subset of scaling up aid in general. These conclusions have been challenged by others in empirical studies such as Berg et al. (2007) for five Sub-Saharan African countries, Li and Rowe (2007) for Tanzania and Mongardini and Rayer (2009) for a panel of 28 Sub-Saharan African countries. Although this shows that the matter has not been settled, the concern for the risks associated with large scaling up of aid (for infrastructure or other expenditures) continues to prevail in many policy circles. A fair amount of authors have investigated the impacts or challenges of scaling up aid to achieve the Millennium Development Goals (MDG), namely Bourguignon and Sundberg (2006) and Hailu (2007). Others argue that significant infrastructure scaling-up will result in inflation and loss of competiveness. There is also an important body of literature on public investment dealing with eviction of private investment. Finally, some authors have raised concerns over the excessive burden created with the scaling-up of infrastructure on operation and maintenance costs (O&M).

In a recent comprehensive report sponsored jointly by the African Development Bank, the World Bank and the Agence Française pour le Développement, edited by Foster and Briceño-Garmendia (2010), it was found that half of Africa's improved growth was generated by infrastructure. In the report, the authors argue that improved infrastructure will accelerate urbanization, which has been the engine for growth in many countries and will also improve regional integration. They focus on the potential for contribution to the growth of various forms of infrastructure such as information and communication technologies, electricity, transportation (in a broad sense), water, irrigation and sanitation. They further decompose the contribution of roads, railway, ports and airports. They also investigate the impact on poverty, the role of

institutions and the various function options available. The main contribution of this report is to provide a price tag for upgrading infrastructure in Africa in terms of what would be needed to achieve optimal growth rates. This price tag is estimated at 93 billion per year, of which one third is required for operation and maintenance.

In this paper we provide a comparative analysis of funding mechanisms to finance the new infrastructure and operation and maintenance costs. As described in Adam and Bevan (2006) Levy (2007) and Estache et al. (2007), the literature shows that infrastructure investment can contribute to the so-called Dutch disease (i.e., in which a booming sector adversely affects performance in that country's other economic sectors—in particular, the non-booming tradable sector). In their 2006 paper, Adam and Bevan show that the negative economic effect can be attenuated if non-tradable sectors also benefit from infrastructure investment externalities. They construct an aggregated model to verify this and apply it to Ugandan data. We extend this idea by dropping the dichotomous classification of sectors as tradable and non-tradable and we also introduce an additional element by imposing increases in public expenditure to maintain and repair the new public infrastructure as in Estache et al. (2007). These increases will be included in the government budget constraints while funding options will be investigated through fiscal policy and foreign aid. We further build on the work of these last authors by introducing a distributional impact analysis with poverty indices and growth incidence curves. For this purpose, a CGE micro-simulation model is required and we use a CGE top-down/bottom-up micro-simulation approach.

The paper is structured as follows: we present the CGE top-down/bottom approach in the context of CGE microsimulation approaches, then set forth our model and resolution strategy and

present our simulations, followed by an examination of macro and distributional analysis. We close the paper with our concluding remarks and possible extensions.

The CGE microsimulation approaches

Three main approaches have been used to link macro reforms to changes in income distribution and poverty. The first and most commonly used one is the representative household approach (CGE-RH), the second one is the Top-down, layered or micro-simulation sequential approach (CGE-MSS) and the third is usually referred to as the CGE integrated multi-household (CGE-IMH) (see Davis 2009 for a detailed description of these approaches).

Without going into a complete review of these approaches, we wish to highlight a few of their drawbacks in order to situate the contribution of the Top-down/bottom-up approach. First, despite extensive applications for distributive analysis, the CGE-RH has been strongly criticized for its lack of ability to capture intra group change in Distribution (see Savard (2005) and Robilliard et al. (2008) for an elaboration of this critique). For the second approach, the CGE-MSS, the main drawback is that it does not fully take into account the feedback effect of household behaviour being modelled in the micro-simulation module. In fact, when micro-household behaviour aggregates perfectly, this approach implicitly integrates the feedback effect. However, when household behaviour does not aggregate perfectly, the aggregation error is lost in the process.[2] The interesting question is to know the size of this aggregation error. If the

[2] For a detailed discussion on aggregation of micro household behaviour to a representative household, the reader can consult Deaton and Muelbaueur (1980). Bourguignon and Savard (2008) also describe this problem. In fact, the micro household functions do not aggregate perfectly if they exhibit heterogeneity for fixed (or endogenous) shares of consumption, savings or taxation. Since these shares are generally calibrated to reproduce the reference period in micro household models, the aggregation of micro behaviour functions do not scale up to a representative agent. In other words, the equilibrium consumption level of the representative agent is not equivalent to the aggregated consumption level of households in a micro-household model with the same functional forms. In addition, when a worker has the option of working or not working, we have a discrete regime switching function, and aggregation conditions disappear completely (Bourguignon et al. 2005). (A more complete discussion is provided in the appendix.)

aggregation error is small, not taking into account the aggregation error is unlikely to bias results, but if the error is relatively large, there is a likelihood of biasing the results by not taking into account the feedback effect. This critique of the CGE-MSS approach has been highlighted in two literature reviews of macro-micro modelling for poverty analysis (Hertel and Reimer (2005) as well as Bourguignon and Spadaro (2006)). The third approach is the CGE-IMH, which is theoretically sound but presents a few challenges. First, it requires significant data treatment to balance out each household account and reconcile micro-household data with the national account data of the SAM. Large models with non linear functions can lead to difficulty of resolution. These problems are raised in Rutherford et al. (2005), Chen and Ravallion (2004) and Bourguignon and Savard (2008).

To circumvent these problems, we apply a more flexible variant of the CGE-IMH that draws from the CGE-MSS approach. The basic idea is to push the CGE-MSS approach further by taking into account the feedback effect of the micro-household module. This allows taking into account the aggregation error of the micro-household model back into the CGE macro module. We refer to this approach as the "Top-down/bottom-up" (CGE-TD/BU) approach. The approach provides greater flexibility for modelling household behaviour compared to the CGE-IMH approach, but introduces a bi-directional link between the two CGE modules and household micro-simulation modules to obtain a convergent solution between the two modules. The main drawback of the approach is that convergence is not guaranteed and must be verified for each simulation. The approach allows the modeller to use the exact income and expenditure structure found in the household income and expenditure surveys, since perfect coherence between micro and macro data is not required. Another advantage is that there is no limit to the level of disaggregation in terms of production sectors and the number of households to be included in the

model and finally, and most importantly, the degree of freedom in choices of functional forms used to reflect the micro-economic heterogeneity of household behaviour is much higher in this approach.[3]

The basic idea of the approach is to use the CGE model to generate a price vector (including wage rates) and a household micro-simulation (HHMS) model, to compute the response of household behaviours (consumption and labour supply) to these price changes. These micro-household responses are re-aggregated and the variations of these vectors are then fed back into the CGE model and we iterate until convergence. We will detail the procedure in the subsequent section.

The model

The basic model used for the analysis and the algorithm used for its resolution are presented in detail in Bourguignon and Savard (2008). We provide a summary of the model's hypothesis and present modification that we adapted from Estache et al. (2007) to capture the productivity of scaling up infrastructure investment and the operation and maintenance cost of the new infrastructure. We start with the CGE module for which we present the general model and move on to the special features to address the infrastructure externalities and the funding of operation and maintenance costs. We follow the presentation with a description of the microsimulation module and complete the presentation with an examination of the resolution process.

The CGE module

The CGE model is disaggregated into 20 sectors and comprises 873 equations. The bottom part of the overall macro/micro model is based on all of the 39,520 households from the

[3] It draws this advantage from the EGC-MSS approach.

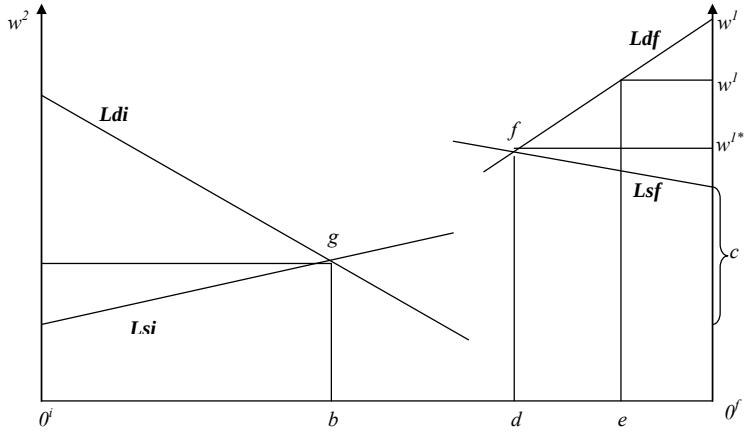
Family Income and Expenditure Survey (FIES). Production is determined through a 3-tier system: the total production of the branch (*XS*) is made up of a fixed share between value-added (*VA*) and intermediate consumptions (*CI*). *VA* is a combination of composite labour (*LD*) and capital (*KD*), which are related with a Cobb-Douglas function. Producers minimize their cost of producing *VA* subject to the Cobb-Douglas function. We introduce an externality parameter into this function, which we describe in more detail below. Optimal labour demand equations are derived from this process. Labour is then decomposed into formal and informal labour, and the choice of combinations between these two factors is determined by a constant elasticity of substitution (CES) function.[4] We assume that capital is not mobile between sectors, as it is quite difficult in the short to medium term to convert capital in order for it to be used in another production sector. Intermediate consumptions are linked by a fixed share assumption.

The labour market is quite original with respect to most macro/micro models. Our dual labour market is not perfectly segmented. The nominal wage in the formal market is exogenous and it is also above the natural market wage;[5] hence, we have an excess supply of labour on this market. Workers choose to offer their labour on the markets or stay unemployed based on their reservation wage and on the prevailing wages on the two labour markets. The informal nominal wage is flexible to clear this market.[6] The labour market mechanisms implemented are found in the CGE modelling context in Fortin et al. (1997), Devarajan et al. (1999), Agénor et al. (2003) and Stiefel and Thorbecke (2003), among others. All these applications with endogenous labour supply and unemployment are conducted with the CGE-RA approach. Let us provide a graphic

[4] Workers on the formal market are mostly skilled workers while workers on the informal market are mostly unskilled.
[5] We can also state that a minimum wage for private sector formal sector workers was set at 250 in 2001, which represented approximately 4.80$ US. A salary grid is also in place for this segment of the labour market.
[6] Further details concerning the labour market will be given in the micro household module.

representation of the labour market (it is similar to the model presented in Thomas and Vallée (1996)):

Graph 1 : Labour market representation



On the left hand side we have the informal sector wage and on the right hand side, the formal sector wage. The total labour available in the economy is measured by the distance 0^i-0^f. Moving from 0^i to 0^f we have the supply of labour on the informal market (*Lsi*) and from point 0^f towards 0^i we have the labour supply on the formal market (*Lsf*). On the left hand side we have the aggregate labour demand of the informal sector depicted by (*Ldi*) and on the right hand side, the aggregate labour demand in the formal sector (*Ldf*). The exogenous formal wage is w^1, and w^{1*} represents the equilibrium wage on the formal market if the nominal wage was not fixed. Employment in the formal sector is measured by the distance 0^f - *e*. When $w^1 > w^{1*}$ we have rationing on this market. The workers rationed out are not forced into unemployment as they can decide to supply their labour on the informal sector market if their reservation wage is inferior to the nominal informal wage. The rationed unemployed are measured by the distance e – d and the waiting unemployment, by the distance b – d. Further details are provided in the microsimulation module.

In the CGE module, we only have one representative household and its income is composed of wage payments (from the two labour categories), capital payments, dividends and transfers from other agents. As opposed to what we would find in the CGE-IMH approach, labour endowment is endogenous (as stated above) although this is only factored in the micro module. At an aggregate level (CGE module), workers can move in and out of unemployment as well as between the formal and informal markets but these movements will be computed in the micro module and transferred into the CGE module in the resolution procedure.

The key assumptions to capture the impact of infrastructure spending rely on their positive externalities and the government budget constraint. We focus on a few key equations to capture the positive productivity externalities of infrastructure and the budget constraint of the government to fund operation and maintenance costs. A complete description of the model can be found in Estache et al. (2007). This first equation (1.1) is the government budget constraint (equation 1.1), which will spend part of its income (Yg) on public services or expenditures (G) and the other part on government savings (Sg), which will be used entirely for public investment.

$$1.1 \quad Sg = Yg - G$$

We assume that G is exogenous and Sg is implicitly exogenous as it is equal to public investment, which is exogenous. Hence, to fund new public infrastructure, the government will need an endogenous source of revenue such as a tax instrument, or a foreign transfer (aid). We introduce an additional assumption, namely that an increase in public infrastructure investment will generate higher operation and maintenance costs for the government. We draw this assumption from the estimations of Fay and Yepes (2003).[7]

[7] We used the average of road, electricity, water, sanitation and telecommunications infrastructure, which provides for a ω value of 1.03.

The externality equation (1.2) is the other important assumption, given its role in increasing the total productivity of factors and operating in the value added equation (1.3). For this, we draw on the vast literature linking public infrastructure to private sector factor productivity, such as that modelled by Dumont and Mesplé-Somps (2000) in a CGE context—although our externality function does not use the private investment. This function was also used in Estache et al. (2008). The function defining the externality is the following:

$$1.2 \quad \theta_i = \left(Itp / Itpo \right)^{\xi_i}$$

where θ_i is the externality or sectoral productivity effect, which is a function of the ratio of new public investment (*Itp*) over past public investment (*Itpo*) with a sector-specific elasticity (ξ_i)[8]. The externality variable is introduced into the following value added (Va_i) equation:

$$1.3 \quad Va_i = \theta_i A_i Ld_i^{\alpha_i} Kd_i^{1-\alpha_i}$$

where A_i is the scale parameter, Ld_i, the labour demand, Kd_i, the capital demand, and α, the Cobb-Douglas parameter. Hence, an increase in θ_i represents a Hicks neutral productivity improvement, like the one modelled in Yeaple and Golub (2007).[9] With this formulation, the infrastructure investment can act as a source of comparative advantage because the function is sector specific. The commodity market is balanced by adjusting the market price of each commodity. The current account balance is fixed; accordingly, the nominal exchange rate varies to allow the real exchange rate to clear the current account balance. The GDP deflator is used as the numeraire in the model. We also assume in a standard manner that the Philippines is a small open economy. Armington's (1969) assumption for the demand of imported goods (imperfect

[8] The values for this parameter were constructed using a combination of information from Estache et al. (2008) and Harchaoui and Tarkhani (2003). In general, the values of our parameters are conservative with respect to this literature, ranging from 0.01 to 0.038. See table A.1 in the appendix for specific parameter values.

[9] This formulation is also commonly used in the literature estimating parameters of the externalities of public infrastructure on total factor productivity such as Ashauer (1989), Gramlich (1994) and Dessus and Herrera (1996), among others.

substitution with constant elasticity of substitution function (CES)) and constant elasticity of transformation (CET) functions are used to model for export supply.[10]

The household micro-simulation module (HHMS)

The construction of the micro household module (HHMS) relies on data from the FIES-1997 and on three rounds of the Labour Force Survey (LFS) between 1997 and 1998.[11] The household module (HHMS) comprises a representation of the households' income structure and expenditure behaviour as well as their labour supply decision. Household consumption is modelled with a linear expenditure demand system (LES). We use the calibration method proposed by Dervis et al. (1982). Savings and income tax rates are calibrated according to the observed data in the survey. All transfers received and paid are exogenous. We consider the capital endowment as fixed according to the level observed in the FIES-1997.

On the income side, we consider the capital endowment as fixed to the level observed in the Family Income and Expenditure Survey (FIES-1997). In the household survey, we have information on the head of household sector of activity, and the amount of non-wage income. This allows for a mapping of the sector of origin for individual household capital income. Based on information of the FIES and labour force survey (LFS), we classified the wage earners into formal and informal workers according to the category of work specified in the survey.[12]

Our labour market mechanism is described below. This labour market hypothesis is drawn from the Roy (1951) model, which was revisited by Heckman and Sedlacek (1985) and further

[10] The complete set of equations and variables can be provided upon request.

[11] Interestingly, the FIES 1997 and LFS 1997-1998 are implemented from that same master survey. Over 93 percent of households in the FIES 1997 are present in the three rounds of the LFS surveys used. This information from the LFS essentially was used for the econometric estimation in combination with the FIES 1997. For further information on the construction of the data base and combination procedures from the two compatible data sources, the reader can consult Savard (2006).

[12] The information on the type of work performed by the head of the household is very precise, with a decomposition of 200 types of work categories. Given the rich set of information, it is relatively easy to classify the workers as formal and informal workers.

enriched by Magnac (1991). We selected the non competitive version of the models presented by Magnac (1991), as it includes a formal and informal market with unemployment. The formal market in non competitive; it has a rigid nominal wage and workers face a cost of entry to access this market. The fixed formal wage is above the market equilibrium wage, which will create excess supply on this market. The rigid wage can reflect various interventions on the labour market such as labour union contracts, efficiency wages and regulated wages.[13] The labour supply model is estimated with the two-step Heckman procedure—more details on model and the results of the estimation results can be found in Bourguignon and Savard (2008). The estimated model allows us to compute the worker specific cost of entry, the reservation wage and the potential wage. Each of these elements is used in constructing our labour supply in the micro household module described hereafter.

The main feature of the module is the introduction of an endogenous labour supply, but it also serves to compute changes in income, consumption and welfare change at the household level. We introduce mobility between the three statuses of workers and potential workers, namely informal work, formal work and unemployment. The transformation at the micro level allows us to compute changes in labour supply to the informal sector and unemployment from the HHMS module. Let us describe how we go from the econometric model to our HHMS module to construct our two labour supplies.

For the first step, for the formal market, we construct two queues. The first concerns the formal sector workers that can be laid off in the context of a decrease in formal labour demand generated by the CGE module and the second concerns unemployed and informal market workers that supply their labour to the formal market. This queue will be used when the formal

[13] In the Philippines, formal wages are fixed by regional wage boards. For further information the reader can consult the web page of the National Wage and Productivity Commission (http://www.nwpc.dole.gov.ph/).

labour demand increases in the CGE module. We assume that firms have perfect knowledge of the workers' productivity (implicitly their potential wage).

First for the scenario (decrease in labour demand), the least productive workers based on their potential wage computed from the estimated model will be laid off. We will describe how their destination will be determined below. For the scenario in which the formal labour demand increases, workers from the informal sector and from the unemployed are ranked with the most productive workers placed in front of the queue. To be included in the queue, two conditions from our econometric model must be satisfied by workers. The first one is that the formal wage minus the cost of entry into the formal sector is greater than the reservation wage of the worker. The second condition is that the formal wage minus the cost of entry must be higher than the informal wage.[14] The workers satisfying these two conditions are then ranked based on their potential wage. We now have a queue from which formal sector firms can recruit the most qualified workers when the CGE model generates an increase in formal labour demand.

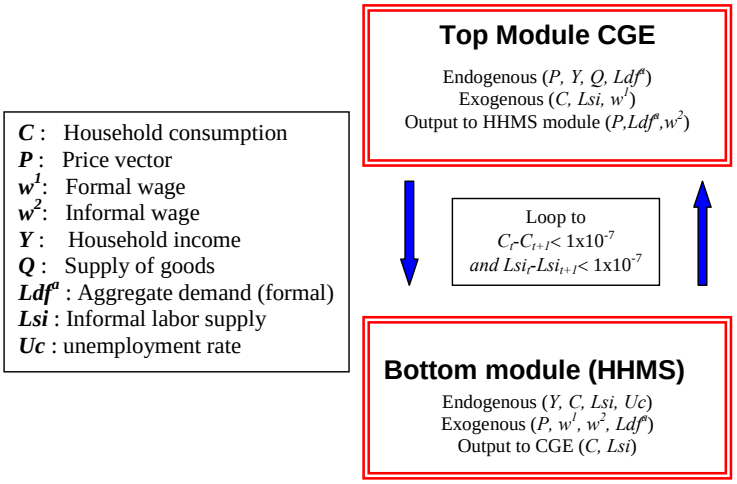
For the first scenario (decrease in formal labour demand), we must determine the destination of the workers losing their formal sector job, between the informal sector and unemployment. The destination of laid off workers depends on the reservation wage of the workers compared to the prevailing informal sector wage. If the reservation wage is above the informal wage the workers become unemployed, and if it is lower they supply their labour to the informal market. The reservation wage check with the informal sector wage is not only applied to laid off workers in the formal sector but also to active informal sector workers and the unemployed. The change in informal wage can modify the status of either type of workers or potential workers. This procedure will give us new labour endowments in the micro module to compute the new income

[14] The cost of entry represents various items such as search time, human capital investment, networking, etc. This cost is specific to workers and is estimated. For details on this procedure to obtain this cost, the reader can consult Bourguignon and Savard (2008).

level, expenditure and change in welfare. The final step in the micro module consists in computing the variation for the aggregate labour supply in the informal sector and the variations of the aggregate consumption that will be used to link back to the CGE module.

Resolving the model is done by iterating between the two modules (CGE top module and HHMS bottom module). Hence, we build on the CGE-MSS approach by integrating the feedback effect of the micro module back into the CGE module. This top to bottom and bottom to top resolution process is performed until convergence and is equivalent to a cobweb type of resolution of market equilibrium. Performing this bi-directional link is equivalent to including all 39,520 households of the survey into the model.[15]

Figure 1: Resolution procedure of the TD/BU approach



The Top Down loop presented in Figure 1 is implemented in the following way. The simulation is performed in the CGE module and we use the variation of prices and the variation of formal labour demand from this module to feed into the HHMS module. First the variations of price vector (goods and services and factor prices) and the aggregate change in the formal labour demand. As explained in the previous sub-section this change and the variation of the informal

[15] See Bourguignon and Savard (2008) for formal proof of this equivalence.

wage allows us to determine the labour endowment of workers. Once this is done, we can determine the new income and consumption level of each household. At the end of this step we aggregate consumption level for all households as well as the labour supply decision for workers supplying their labour to the informal sector. These figures allow us to extract variations for these two variables. These variations are then applied into the CGE module in which aggregated consumption and informal labour supply is exogenous. We repeat this loop until converging results are obtained for these two variables.[16] We know that there exist conditions that satisfy the stability of the cobweb resolution approach and these conditions are also present for the resolution of the TDBU approach. Our application of the CGE-TDBU approach to the Philippines is programmed into the GAMS software. Our top EGC-module has 873 equations and endogenous variables and the bottom household micro-simulation module has 829,920 equations with 829,920 endogenous variables.

The simulations

In order to analyze the macro and distributional impact of scaling up infrastructure investment and different funding mechanisms, we apply two types of infrastructure investments, a non productive one and a productive one.[17] These simulations are well justified in the context of the economic crisis and the large debate on scaling up infrastructure and developing countries described in the introduction. We perform an increase of 30 percent of public investment on infrastructure with respect to the level of investment at the reference period. To fund the increase

[16] Convergence is generally obtained between 10 and 12 loops. Given the small number of iterations required, modellers do not have to program their model to have the loop automated. A sequential resolution of each loop can be performed without any problem. Various methods can be used to implement an automated iteration process in GAMS.

[17] The non productive investment is used mainly to isolate the productivity effects from other effects of the simulations. It is not meant to represent a specific type of non productive investment such as monuments.

in infrastructure, we use three methods; the first one consists in raising the value added tax and in the second, income tax is used and finally foreign aid is used. It is important to highlight that the effective tax rates observed in the SAM are relatively small at the reference period (between 2 and 3% for the two weighted average tax rates). Hence, the increase in these taxes required to fund the program is large in percentage change but not in nominal terms. The increases necessary for the three funding schemes are presented in Table A.3 in the appendix.

Productive externalities will contribute to increased economic activity, which will increase government revenues. Hence, the funding requirements are not equal to the direct investment and operation and maintenance costs. This comparative analysis allows us to highlight the most efficient funding mechanism and to explore the effect on different macroeconomic and sectoral variables in addition to the distributional impact.

Impact analysis of the scenarios

In this section, we concentrate on the macroeconomic variables and to simplify the presentation, we highlight only a few sectoral effects for three funding options for each type of investment. We concentrate our sectoral impact analysis on the key variables contributing to welfare changes for households, namely rental rate of capital and market prices. We will undertake the comparative analysis between funding options throughout the section. We focus on the productive options with a brief comparative analysis with the non productive one at the end of the section. When looking at results, it is important to keep in mind that our current account balance is fixed.[18]

Before moving on to the specific simulations, we can extract a few general comments from our results. First, the impact of our scenarios on GDP and most macro variables are relatively modest. This

[18] The current account is balanced by adjusting the nominal exchange rate. Finally, in the tables, we present the nominal exchange rate. But this rate can also be interpreted as the real exchange rate because our price index is exogenous. So the variation in the nominal exchange rate is equivalent to the variation in the real exchange rate.

comes from the fact that in nominal terms, the 30% increase in public investment is not large compared to size of the economy (0.48%). However, this is not an important issue as we are mostly interested in the comparative analysis between the different scenarios. The second point is that all simulations produce a positive impact on GDP, although the non productive simulations produce a very small impact. This positive effect comes in part from the productivity gains of the infrastructure but also from the economic activity generated by these investments.[19] The positive effect helps create employment in the construction sector and in the public services to operate and maintain this new infrastructure. The sectors supplying goods and services more intensively to these two sectors will benefit the most and workers operating in these sectors will also benefit the most. The expansion of the construction sector and public services creates employment directly and indirectly with the increase in the informal wage (see the impact described in the HHMS module previously). This effect is possible with the presence of unemployment in the model. Hence, these new workers contribute to increasing GDP.

Table 1: Macroeconomic results
Variations are presented as percentage changes

			Value added tax		Income tax		Foreign Aid	
Variables	Definition	Base	Non productive investment	Productive investment	Non productive investment	Productive investment	Non productive investment	Productive investment
Yh	Household income	86476.9	0.15	0.74	0.17	0.75	0.14	0.73
Sh	Household savings	9651.8	-2.2	-3.24	-1.98	-2.99	-3.41	-4.21
w2	Informal Wage	0.5	0.43	0.98	0.49	1.05	0.39	0.94
Yg	Government income	20367	3.94	3.94	3.94	3.94	3.94	3.94
Ye	Firms' income	26172.9	-0.14	0.52	-0.17	0.49	-0.17	0.51
Sg	Government savings	1337	30,00	30,00	30,00	30,00	30,00	30,00
G	Government expenditure	16818.8	2.38	2.38	2.38	2.38	2.38	2.38
It	Private investment	23161.2	-1.23	-0.54	-1.86	-1.07	-1.54	-0.82
Se	Firms' savings	7810.5	0,00	0.95	-0.31	0.9	-0.3	0.92
ui	Unemployment rate	16.8	-1.05	-1.95	-1.14	-1.95	-0.9	-1.84
e	Nominal exchange rate	1	0.69	0.39	0.06	-0.13	-1.2	-1.18
GDP	Gross domestic product	104510.7	0.16	0.79	0.17	0.8	0.15	0.79

[19] This is precisely the objective of many stimulus plans implemented in a large number of countries during the latest economic crisis.

* Values computed by the author

The impact on the aggregate household is positive for all simulations and we observe an eviction effect of private investment in all scenarios. The reduction for unemployment rate is present across the board and the increase in nominal informal wage is also a uniform result. The increase in government income is the same in all simulations as this is implicitly directly tied to the simulated increase in public investment and the operation and maintenance cost associated with the investment. Other variables such as nominal exchange rate, firms' income and savings exhibit qualitative and quantitative differences.

Investment funded by the value added tax

In this simulation, the increase in investment by the government is funded by a uniform increase in the effective value added tax. At the reference period, the value added tax (VAT) is not uniform and the differentiated structure remains after simulation. We hold exogenous the other public expenditures made by governments but assume, as was explained earlier, that the new investment will require some new operational expenditure. The required tax increase is 0.7 percentage points or a rate of 3.2% up from 2.5%. The first observation is that this option seems to favour households over firms, because the informal wage increases (+0.98%) and the average rental rate of capital increases by only 0.63%. Since firms' income originate essentially from capital income and for households it is a mixture of the two sources, the households come out winners. The increase in informal wage originates from pressure for labour demand in public services (+1.87 from table 2) that must grow to meet the operational needs created by new investment and the expansion of the construction sector (+1.81%) to build the new infrastructure. Given the capital/labour ratio of these two sectors, their expansion produces more pressure on demand for labour versus capital.

The increase in household income is +0.74% and is explained by the reduction in unemployment and increase in nominal informal wage. The total private investment falls (-0.54%), which is one of the strongest impacts at the macro level, and this illustrates a form of eviction of private investment. The

nominal exchange rate increases by 0.39%, which represents a depreciation of the real exchange rate. Price effects are generally increasing for most sectors with the strongest increase in the logging and timber sector. The real estate sector benefits from the strongest decrease.

Investment funded by income tax

For the income tax funding option, we let the household income tax rate adjust from the reference situation. This pushes the effective income tax rate from 2.2% to 3.0% (a 37% increase). The macro results are quite similar to the previous simulation with main differences observed for the nominal exchange rate, with an appreciation of the rate at -0.13% compared to depreciation at 0.39% in the previous simulation. In this case, we have a very slight Dutch disease effect. The total investment decreases more (-1.07%) compared to the previous simulation (-0.54%). The slightly stronger negative impact on firms' income is at the source of this difference. The other macro level results largely resemble the VAT-funded scenario.

Table 3: Sectoral results: rental rate of capital
Variations are presented as percentage changes

			Value added tax		Income tax		Foreign Aid	
Variables	**branches**	**Reference**	**Non productive investment**	**Productive investment**	**Non productive investment**	**Productive investment**	**Non productive investment**	**Productive investment**
r (rental rate of capital)	Palay & corn	1	-0.76	2.13	-0.49	2.36	-0.16	2.66
	Fruit & vegetable	1	-1.24	0.17	-1.16	0.24	-0.34	0.94
	Coconut	1	-0.45	1.68	-0.34	1.79	-1.05	1.16
	Livestock	1	-0.71	1.66	-0.87	1.49	0.79	2.92
	Fishing	1	-0.5	0.92	-0.57	0.84	-0.33	1.07
	Other agriculture	1	-0.11	0.79	-0.29	0.65	-1.15	-0.09
	Logging & timber	1	1.3	4.33	0.79	3.9	1.03	4.09
	Mining	1	0.33	1.14	-0.06	0.81	-2.49	-1.25
	Manufacturing	1	-0.1	-0.26	-0.04	-0.2	-1.46	-1.4
	Rice manufacturing	1	-0.26	0.86	-0.05	1.03	0.09	1.15
	Meat industry	1	-0.01	-0.32	-0.19	-0.49	1.12	0.62
	Food manufacturing	1	-1.41	-1.82	-1.2	-1.64	-0.87	-1.38
	Electricity, gas & w ater	1	0.32	-0.39	0.49	-0.27	0.65	-0.11
	Construction	1	2.03	2.62	1.96	2.56	2.9	3.34
	Commerce	1	-0.18	0.67	-0.14	0.7	-1,00	-0.02
	Trans. & comm.	1	0.55	0.98	0.16	0.67	0.82	1.22
	Finance	1	0.5	1.3	0.72	1.48	0.07	0.94
	Real estate	1	-0.48	-0.55	-1.33	-1.31	0.34	0.14
	Services	1	0.07	0.14	0.51	0.52	0.09	0.17

* Values computed by the author

For rental rate of capital, the qualitative effects are the same as in the previous simulation with a weighted average increase being slightly weaker (0.60% compared to 0.63%). Some sectors exhibit stronger increases or decreases whereas for others it is the opposite. Evidently, the market price variations are quantitatively small for most sectors and qualitative differences are observed in six sectors with the largest gap for the service sector passing from a 1.4% increase for the VAT scenario to a 0.18% decrease in this case. These stronger differences at the market price will have an impact on household welfare for the poverty analysis.

Investment funded by foreign aid

At the macro level, the main difference is observed for the nominal exchange rate, which is not surprising insofar as the current account balance is fixed and an increase in foreign aid requires an appreciation of the exchange rate to balance out. As in the previous simulation, we observe a slight Dutch disease effect for this simulation. The unemployment rate decreases less compared to the previous two simulations. Other macro results are almost identical to the other simulations.

Table 4: Sectoral results: rental rate of capital
Variations are presented as percentage changes

			Value added tax		Income tax		Foreign Aid	
Variables	**branches**	**Reference**	**Non productive investment**	**Productive investment**	**Non productive investment**	**Productive investment**	**Non productive investment**	**Productive investment**
Pq (market price)	Palay & corn	**1.01**	**-0.09**	**1.65**	**-0.24**	**1.52**	**-0.21**	**1.55**
	Fruit & vegetable	**1.02**	**0.25**	**0.77**	**-0.55**	**0.1**	**-0.19**	**0.4**
	Coconut	**1.02**	**0.62**	**1.61**	**0.01**	**1.11**	**-0.45**	**0.71**
	Livestock	**1.01**	**0.45**	**1.33**	**-0.31**	**0.68**	**0.17**	**1.09**
	Fishing	**1.01**	**0.19**	**0.81**	**-0.24**	**0.43**	**-0.16**	**0.51**
	Other agriculture	**1.03**	**0.57**	**0.76**	**0.06**	**0.33**	**-0.6**	**-0.23**
	Logging & timber	**1.01**	**1.12**	**2.38**	**0.46**	**1.83**	**0.32**	**1.71**
	Mining	**1.01**	**0.69**	**0.42**	**0.08**	**-0.09**	**-1.07**	**-1.06**
	Manufacturing	**1.08**	**0.83**	**0.4**	**0.07**	**-0.23**	**-0.61**	**-0.8**
	Rice manufacturing	**1,000**	**0.16**	**1.27**	**-0.11**	**1.04**	**-0.2**	**0.97**
	Meat industry	**1.01**	**0.7**	**0.91**	**-0.15**	**0.19**	**0.21**	**0.5**
	Food manufacturing	**1.03**	**0.47**	**0.47**	**-0.24**	**-0.12**	**-0.37**	**-0.24**
	Electricity, gas & water	**1.01**	**0.97**	**-0.02**	**0.25**	**-0.63**	**0.05**	**-0.79**
	Construction	**1.01**	**1.13**	**0.82**	**0.52**	**0.31**	**0.33**	**0.15**
	Commerce	**1.05**	**1.02**	**0.8**	**0.06**	**-0.01**	**-0.39**	**-0.38**
	Trans. & comm.	**1.01**	**1.08**	**0.68**	**0.18**	**-0.07**	**-0.03**	**-0.25**
	Finance	**1.05**	**2.2**	**1.92**	**0.35**	**0.37**	**-0.18**	**-0.08**
	Real estate	**1,000**	**0.03**	**-0.68**	**-0.61**	**-1.23**	**0.19**	**-0.54**
	Services	**1.04**	**2.1**	**1.4**	**0.2**	**-0.18**	**0.32**	**-0.09**
	Public services	**1,000**	**0.51**	**0.5**	**0.17**	**0.23**	**0.05**	**0.12**

* Values computed by the author

The differences between sectors are also more pronounced for this scenario. The market price and rental rate of capital are more sensitive to this funding scheme and we have many qualitative changes compared to the first two scenarios. The differences are greater when we compare these results with the VAT scenario. These stronger price differences should have a distributional impact on the income side (rental rate of capital) and on the consumption side (market prices).

Comparing productive and non productive infrastructure

For the non productive investment scenarios, we note a weaker positive effect on GDP, household income and firms' revenues. This is not surprising as we built in this difference. As for productive investment, the funding schemes do not produce much difference on macro variables. For the private

investment eviction effect, it almost doubled in the non productive investment scenarios compared to productive investment.

For price variations (market price and rental rate of capital) the effects are quite different between the productive and non productive ones. For the VAT funding option the rental rate of capital variations are very different. Nine out of nineteen sectors exhibit a qualitative change. For all agricultural sectors, the difference is strong, ranging from 0.9% improvement for other agriculture to a 2.89% improvement in the palay and corn sector. The pattern of differences between the income tax scenarios is similar to that of the VAT simulations. The productive foreign aid simulation produces closer results between the two scenarios, in which only five sectors exhibit qualitative differences. Moreover, the quantitative gap between the productive and non productive scenarios is weaker. As for market price variations, we observe many differences between non productive and productive options with five (VAT) to eight (foreign aid) qualitative differences. There is no clear trend that can be observed, either.

Before moving on to the distributional impact of our policies, we can summarize the key effects that will play an important role in changes in poverty indices and affect the welfare of household through the distribution of income. This first scenario will have a tendency to favour sectors in which initial VAT rates were lower, and households that consumed a lower share of goods and services with high VAT rates at the reference period. For the workers and owners of capital, those active in the sectors with higher VAT rates will experience a stronger negative impact. Moving on to the income tax scenario, on the income side, we will have a stronger negative impact on households that pay income tax, but the price effect of this simulation is different from the previous one in which the price of goods consumed by households with higher income decreases more compared to the first scenario. The price effect could dominate the income effect. The last simulation will produce a price and income effect via the appreciation of the exchange rate given the fixed current account. This will favour consumers of imported goods on the price side and on the income side, the non tradable sectors will be favoured and hence capital owners in these sectors will benefit the most. The final effects are a combination of these more direct effects and indirect effects captured by all assumptions and interactions in the model. It is also important to note that contrary

to many CGE microsimulation models, we capture discrete changes in income and not only marginal changes in income with workers moving in and out of unemployment. This can produce unusual distributional effects. For example, a relatively rich household at the reference period can become unemployed after simulation and lose a large portion of its income.

Distributional analysis

For the distributional analysis, we apply poverty indices and compute growth incidence curves. The diagnostic of poverty changes is based on the most commonly used indices in the context of macro-micro modelling. The poverty index chosen is the additively decomposable Foster, Greer and Thorbecke (FGT, 1984) P_α.[20] To complete the distributional analysis, we computed the growth incidence curve (GIC) proposed by Ravallion and Chen (2003).

Poverty analysis

We use the change in households' welfare measured by the equivalent variation to measure the impact of the policy on each household. This approach has the advantage of taking into account the price and income effect simultaneously. This approach is quite standard in the context of macro-micro CGE analysis. The CGE top-down/bottom-up model generates post simulation changes in welfare at the household level that are used for poverty analysis. Target groups are defined independently of the CGE modelling exercise and poverty analysis can be performed for the base period and after simulations. For our application, we decomposed households based on the education level of the household head.

The first point we can make is that poverty impacts are relatively small. As we have highlighted, in the macro analysis, this comes from the relatively small nominal increase in

[20] FGT poverty indices are interesting within the framework of this analysis and make it possible to measure the proportion of the poor among the population but also of this poverty depth and severity. For detailed information on the FGT index family, see Ravallion (1994).

public investment, but we can still draw interesting conclusions on relative impact between productive and non productive investments and between the three funding schemes. Starting at the national level, we observe a decrease in poverty only for the VAT scenario when considering the non productive investment. This reduction is almost the same for the three poverty indices ranging from -0.26% for the headcount index (FGT-0) to -0.30% for poverty severity (FGT-2). The income tax and foreign aid scenarios for non productive investment produce an increase in poverty. This increase is over up to 1.33% for the poverty severity for the income tax option and 0.88% for the poverty severity of the foreign aid. This is interesting insofar as the GDP and aggregate household income increased in both those scenarios. This illustrates the importance of using a microsimulation approach to conclude on the distributional and welfare impact of such reforms. The option generating the most negative results for poverty is the income tax option.

The productive investments produce a similar pattern insofar as the best option is the VAT, which produces reductions in poverty ranging from -0.86% for the headcount index to -1.57% for the severity index. The least positive option is the income tax option with poverty reduction around 0.2% for all three indices. This result is not surprising insofar as the households absorb fully and directly the funding option as a negative income effect. The foreign aid option provides an intermediary option with reductions of 0.41% for the headcount index and a drop of 0.60% for the severity index.

Table 5: Poverty index results

Variations are presented as percentage changes

			Value added tax		Income tax		Foreign Aid	
Poverty index	Code-education	Base	Non productive investment	Productive investment	Non productive investment	Productive investment	Non productive investment	Productive investment
FGT-0	National	0.311	-0.26	-0.86	0.67	-0.19	0.49	-0.41
FGT-1	National	0.096	-0.27	-1.29	1.05	-0.20	0.68	-0.52
FGT-2	National	0.04	-0.30	-1.57	1.33	-0.22	0.88	-0.6
FGT-0	0	0.564	-0.36	-1.08	0.51	0.07	0.71	0.2
	1	0.501	-0.37	-0.89	0.31	-0.26	0.27	-0.61
	2	0.384	-0.29	-0.8	0.70	-0.26	0.3	-0.42
	3	0.317	0.35	-0.71	1.52	0.27	1.38	-0.30
	4	0.184	-0.34	-0.94	0.85	-0.33	0.2	-0.54
	5	0.092	-0.47	-0.83	1.58	-0.35	1.35	0.40
	6	0.021	-0.42	-0.42	-0.42	-0.42	3.54	-0.42
FGT-1	0	0.185	-0.19	-0.99	0.96	-0.05	0.92	-0.09
	1	0.168	-0.24	-1.19	0.94	-0.20	0.61	-0.50
	2	0.116	-0.30	-1.36	1.05	-0.23	0.62	-0.61
	3	0.090	-0.32	-1.37	1.15	-0.17	0.79	-0.51
	4	0.048	-0.31	-1.56	1.29	-0.22	0.71	-0.71
	5	0.022	-0.26	-1.65	1.60	-0.11	1.05	-0.57
	6	0.005	-0.49	-1.87	1.43	-0.24	1.51	-0.20
FGT-2	0	0.08	-0.25	-1.32	1.25	-0.09	1.14	-0.18
	1	0.075	-0.27	-1.48	1.23	-0.23	0.82	-0.58
	2	0.048	-0.32	-1.64	1.34	-0.26	0.82	-0.70
	3	0.035	-0.36	-1.66	1.41	-0.20	0.95	-0.64
	4	0.018	-0.31	-1.78	1.57	-0.23	0.93	-0.76
	5	0.007	-0.28	-2.01	1.92	-0.19	1.22	-0.78
	6	0.002	-0.38	-1.83	1.83	0.00	2.12	0.24

* Values computed by the author

Moving on to the decomposition analysis, we observe a relatively uniform qualitative impact across household types for non productive investment. We only observe two cases of qualitative differences, namely for the VAT simulation, in which the poverty headcount increases for group 3 where other households benefit from a reduction in poverty indices. The headcount for group 6 also varies in a different direction with a 0.42% reduction where other households experience an increase in poverty indices. For the VAT simulation, we can identify a weak trend favouring the most educated households. For the income tax option, the most educated groups (4, 5 and 6) have the largest poverty increase when using the poverty depth and severity indices. For the foreign aid funding scheme, the groups suffering the least are groups 1 and 2 for the three indices with one exception for FGT-0 where the most favoured group is group

4. The productive investment provides more interesting results. For the VAT option, the headcount index indicates that the least educated would be most advantaged, while the depth and severity indices reveal a more regressive option in which most educated households benefit the most.[21] In the second productive scenario, we cannot find a clear trend. Each indicator provides a different picture. The headcount index seems to favour the most educated and group 3 is faced with a 0.27% increase in poverty. In terms of the poverty depth (FGT-1) we observe the most positive effects for group 6, and the least poverty effect for 2 and 0; poverty severity favours group 2, 1 and 4, and groups 6 and 1 are the losers. For the foreign aid simulation, we seem to have a clearer winner with group 4 being top or second in terms of positive impact and group 0 being last or second to last for all indices. Interestingly, group 5 has the worst situation for the headcount index and the best when using the severity index.

When comparing each funding option we can clearly conclude that the VAT is the most favourable option both at the national level and when looking at household decomposition results. Moreover, all groups benefit for all indices. In addition, the poverty reduction impact is quite large given the weak changes in macro and sectoral variables. The foreign aid option also dominates the income tax option for the poverty depth and severity indices. For the headcount index, two groups (group 0 and 4) suffer more with the foreign aid compared to the income tax option. For the other groups, the foreign aid option is more favourable.

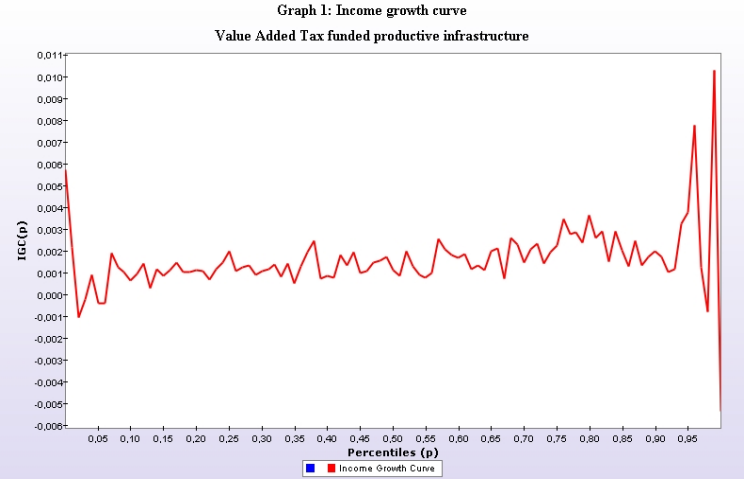
Comparing the micro distributional results with poverty results illustrates the importance of using a CGE microsimulation approach since the income tax option is the most favourable when looking at aggregate variables such as GDP, aggregate household income, informal wage and unemployment whereas it is the least favourable in terms of poverty impact.

[21] The poverty indices at the reference period reveal that the more educated the head of household, the lower the poverty indices.

Growth incidence curves

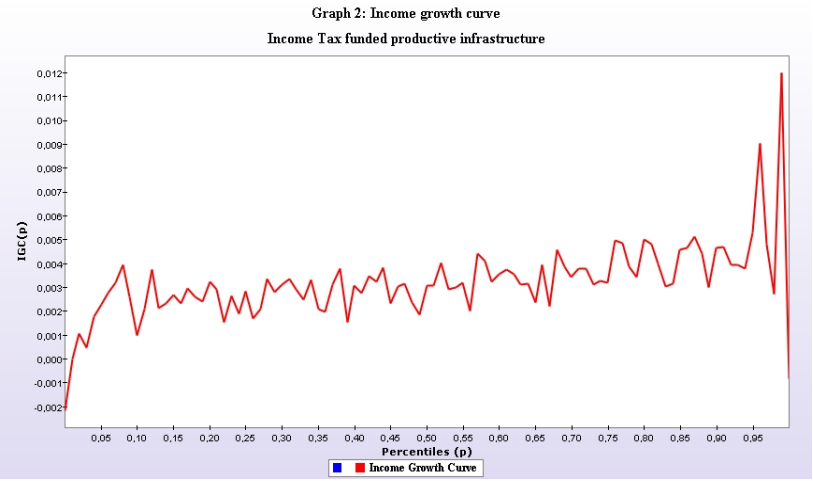
We computed the GIC for the three productive scenarios. A caveat must be highlighted for comparison of the two tools used. In the first case, households remain in the same group whereas for the GIC curves, a household in the top of the distribution can drop at the bottom and this is not fully captured given that the approach compares households at a specific rank and not the households before and after the simulation. The two tools are thus complementary.

It is interesting to note that in the first scenario (Value added tax), we observe in Graph 1 the largest gains at the two extremities of the distribution. If we remove the bottom and top two deciles, we note a slightly positive GIG. On average, the households below the 50th percentile seem to gain less compared to those above that level. This is consistent with the decomposition of poverty analysis in which more educated households seem to benefit the most.

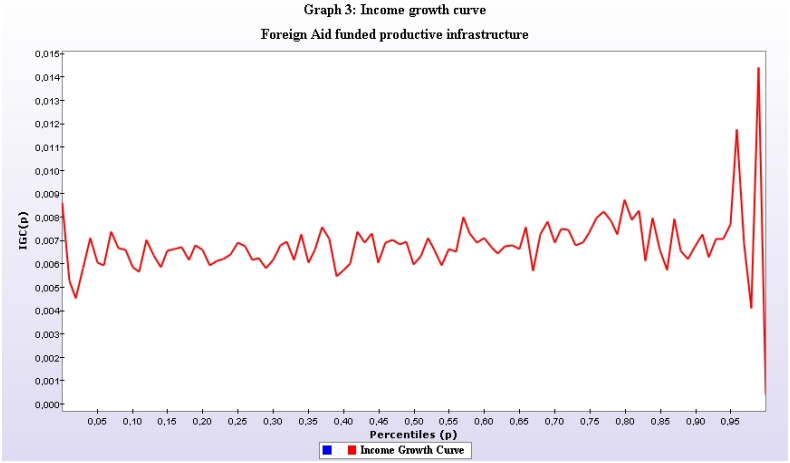


Moving on to the income tax funding option, we have a clearer positively sloped GIC compared to the previous one, in which we needed to exclude the extreme deciles. In this case, the bottom 5 percent are clearly losers compared to the rest of the distribution with the exception of the top decile, which also seems to be a looser.

Income tax



The foreign aid scenario presents a much more horizontal or proportional impact compared to the previous two scenarios. The bottom part of the distribution is similar to the VAT option and the top of the distribution is similar for the three scenarios.



In this context, no option seems to exhibit pro-poor features, with the third one looking to be the closest to that option and the income tax being the most favourable to the households in the top half of the distribution. When comparing with the FGT indices, we had the VAT as being the most interesting option, followed by the foreign aid and finally the income tax options. In the case of the GIC, if the objective is to choose the least regressive option, one would prefer the foreign aid option follow by the VAT and the income tax as the least preferred option.

Conclusion

In this paper we present the main steps to implementing a variant of the CGE integrated multi-household approach that offers more flexibility compared to the standard version of this approach, namely introducing endogenous labour supply and unemployment into the model. We also illustrate how to exploit this modelling exercise to analyze the distributional impact of scaling up infrastructure investment on macroeconomic, sectoral variables in the Philippines. The approach allows us to capture numerous issues surrounding infrastructure expansion among which are productivity externalities, job creation, relative price changes, investment eviction issues, Dutch disease, funding issues, fiscal constraints and distributional analysis. We build on the models presented in papers such as Adam and Bevan (2006) and Estache et al. (2008) by introducing rigorous distributional analysis. Our macro results are different than those of these authors given the presence of unemployment, which contributes to attenuating or reversing the Dutch disease effect that is also softened with the production externality assumption. We also present a framework that allows the analyst to conclude on the poverty impact of such programs and identify the most favourable funding option based on our two distributional indices (FGT and GIC). As in Estache et al. (2008), we do not observe strong differences at the macro level when comparing funding options to scale up infrastructure but our poverty analysis has clearly allowed us to rank the performance of each funding option in which the VAT is clearly more favourable followed by the foreign aid option and finally the income tax option.

In our analysis, our static modelling framework does not allow us to fully capture the negative impact of the private investment eviction issue. Another issue is that the returns on investment in infrastructure might come in the medium to long term. To improve the analysis on this front, a sequentially dynamic framework would be a more appropriate tool. In our future

research we will extend this model in this direction. The major challenge for this work program will be to introduce a capital reallocation mechanism at the micro level (this challenge is also discussed in Davis (2009)). To our knowledge, only one set of authors (Annabi et al. (2005)) applied a dynamic CGE microsimulation model, but they failed to rigorously capture the distributional factor growth issue as stated in Davis (2009). The uniform redistributed capital growth underestimated the distributional impact of the growth elements in the model and this issue needs to be resolved along the lines suggested by Davis (2009) in further research.

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Appendix Externality parameter

Table A.1 Externality elasticities by sector

branches	ξ value
Palay & corn	**0,01**
Fruit & vegetable	**0,015**
Coconut	**0,019**
Livestock	**0,011**
Fishing	**0,012**
Other agriculture	**0,018**
Logging & timber	**0,003**
Mining	**0,027**
Manufacturing	**0,038**
Rice manufacturing	**0,01**
Meat industry	**0,025**
Food manufacturing	**0,025**
Electricity, gas & water	**0,039**
Construction	**0,021**
Commerce	**0,022**
Trans. & comm.	**0,018**
Finance	**0,013**
Real estate	**0,027**
Services	**0,01**

Table A.2: Educational code definition

Education Code	Level of education
1	Elementary (not graduated)
2	Elementary graduate
3	1st to 3rd Year High school
4	High School Graduate
5	College Undergraduate
6	At least College graduate
0	Not reported or no grade

Table A.3: Funding scheme tool variations

		Value added tax		Income tax		Foreign Aid	
		Non productive investment	Productive investment	Non productive investment	Productive investment	Non productive investment	Productive investment
Level	Base	2,45%	2,45%	2,19%	2,19%	2272	2272
Level	After simulation	3,28%	3,16%	3,17%	3,00%	11142	9909
Variation	Variation	33,80%	28,80%	43,80%	37,17%	390,40%	336,14%

Appendix

According to Deaton and Muellbauer (1980), the aggregation problem is defined as the passage from the microeconomic behaviour of consumers (or workers) to the aggregate demand (labour supply) analysis. Or as Preston (1959) states, the aggregation problem is tied to the link between micro and macro theory and therefore differences that can occur between large models (microsimulation models) with smaller models (macro models) relying on aggregated variables and parameters. This is exactly the problem at hand with linking CGE models with microsimulation models. To respond to this problem, a few decades back, Gorman (1953) demonstrated that using or assuming the same marginal consumption and saving propensities was sufficient to solve this problem and obtain perfect linear aggregation. According to Deaton and Muellbauer (1980), this solution is extremely restrictive since it imposes linear and identical Engal curves for all households in a microsimulation model. Moreover, this assumption is incompatible with empirical analysis of household consumption behaviour. The second problem is linked to the household specific labour supply. Deaton and Muellbauer (1980) present the conditions for aggregation of labour supply with the following cost function:

$$(1.1)\quad c(u, w, p) = wT + \mu = Y,$$

Where u is the utility level, w, the wage, p, the price level of goods, T, time endowment for work, μ, the non work income or transfer from other agents and Y, the income of the worker. In this context, leisure is treated as a good with price w. Perfect linear aggregation is possible if the cost function has the following form:

$$(1.2)\quad c_h(u_h, w, p) = \alpha_h(w, p) + u_h b(w, p)$$

The average leisure must be a function of the average income, $\overline{Y}$, of the wage, w and of prices, p. We can see that the problem is tied to the demand for goods. Indeed, it is plausible that prices

are the same for all consumers; however, w varies between households given specific characteristics and is indexed with h, and the function $b(w,p)$ will be specific for each household. Therefore, the marginal consumption share will be household specific for good i, $\partial \log b / \partial \log p_i$ will also be indexed with h. In this case, perfect aggregation is impossible. To obtain perfect aggregation, the derivative of the labour income with respect to non labour income, μ and the derivative between labour income and time endowment are identical for all workers. According to Heckman, Lochner and Taber (1998), the worker specific labour supply is one of the most important factors in explaining the differential distributional impact of policy reform.