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Education and Poverty in Vietnam: a Computable General Equilibrium Analysis

Marie-Hélène Cloutier
John Cockburn
Bernard Decaluwé

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Cloutier : Université de Montréal, Département d'économique, Pavillon Lionel-Groulx C-7081, 3150 rue Jean-Brillant, Montréal (Québec) Canada H3T 1N8
marie-helene.cloutier@umontreal.ca
Cockburn : Corresponding author. Poverty and Economic Policy (PEP) Research Network, CIRPÉE and Université Laval, Département d'économique, Pavillon J.-A.-DeSève 2156, 1025 avenue des Sciences-Humaines, Québec (Québec) Canada G1V 0A6 ; Telephone : 1-418-656-2131, ext. 2756; Fax: 1-418-656-7798
jcoc@ecn.ulaval.ca
Decaluwé: Poverty and Economic Policy (PEP) Research Network, CIRPÉE and Université Laval, Département d'économique, Pavillon J.-A.-DeSève 2180, 1025 avenue des Sciences-Humaines, Québec (Québec) Canada G1V 0A6
bdec@ecn.ulaval.ca

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Abstract:
Education is often promoted as the solution to poverty in the developing world. Yet, fiscal discipline has led to reductions in public spending on education. We examine the poverty impacts of a cut in public subsidies to higher education, accompanied by corresponding tax cuts, in a general equilibrium framework applied to Vietnam. This policy is shown to have strong and complex impacts through various channels: a direct increase in the private costs of higher education, a reduction in education investments, a shift in the economy's skills mix in favor of unskilled workers, a rise in the vague premium for skilled workers, education and consumer price changes, etc. When all of these contrasting impacts are taken into account, we find that a higher education subsidy cut reduces welfare and increases poverty in Vietnam. While rural and agricultural households would benefit from this reform, urban and non-agricultural households would lose out.

Keywords: Computable general equilibrium model, public expenditures, education, Vietnam, welfare, poverty

JEL Classification: C68, H42, H52, I21, I32, J24, O53

1 Introduction

Despite a relatively high incidence of poverty (36%), Vietnam has generally succeeded in providing widespread access to social services such as education and health. However, since the political and economic reform program (renovation or *doi moi*) was launched in 1986, the quantity and quality of public services has been deteriorating and school fees have been introduced in some cases (UNDP (2001)). Presently, Vietnam is still in the heart of this reform program and has also committed itself to fight poverty. The Vietnamese government is therefore facing a big challenge: to promote equity while simultaneously encouraging economic growth.

Education has the potential to contribute to both of these objectives as a source of human capital accumulation to spur growth and to allow the poor to escape poverty. Conversely, reductions in public spending on education seem likely to have strong negative effects by increasing the cost of education, reducing education investment and increasing the skills premium, which generally favors the non-poor, in the labor market. Yet, little is known about the actual impacts, notably taking into account the powerful general equilibrium effects, of such a widespread policy on education choices, the skilled wage gap and, ultimately, income distribution. Our goal is to identify the likely winners and losers and poverty impacts of a reduction in public spending on education in Vietnam with particular attention to understanding the mechanisms underlying these impacts.

We choose to focus our analysis on education as an investment, as described in human capital theory, and to neglect, at this stage, the direct utility provided by education as a consumption good[1]. Human capital theory, developed by Schultz (1961, 1971) and Becker (1975),

[1] We neglect the consumption motive despite the fact that it can also be a plausible, but partial, explanation of education demand. This view states that, in addition to the investment motive, education provides utility in itself

stipulates that education and training contribute to the creation of human capital, or labor productivity, just as investment in technology increases physical capital productivity. Individual benefits from education take the form of higher remuneration, whereas social benefits materialize as a higher growth rate. Consequently, modeling of education requires the specification of two production functions: a production function for final goods, in which human capital is a crucial input, and a production function for human capital.

A first specification for the production of final goods, going back to Lucas (1988), assumes that production is a function of physical capital and aggregated "efficient labor units" (h) possessed more or less abundantly by workers in the economy. Education contributes to the accumulation of h where each unit of h is remunerated at a same rate. A second specification[2] assumes distinct categories of workers having different skill levels and receiving different wages. Production is thus a function of capital and of these types of labor[3]. Education generally allows workers to "migrate" from one category to another by attaining a certain predetermined training level[4]. This type of specification has the advantage of allowing analysis of wage distribution since remuneration of each labor category depends on its relative scarcity.

Production of the "human capital" output depends on the different inputs intervening in the production process of skills. Among them are individual effort or time invested in education[5],

(eg: general knowledge, increased leisure value, etc.). Like all other consumer goods, its demand then depends on its own price (including direct and indirect costs), the prices of all other goods and household income. See, for example, Kodde and Ritzen (1984) and Belfield (2000).

[2]See, for example, Cahuc and Michel (1993, 1996) as well as Heckman et al. (1999)

[3]According to Chiswick and Chiswick (1987), empirical evidence supports the adoption of a constant elasticity of substitution (CES) function.

[4]The role of education is modeled differently in Jacobs (2007). Education allows two different types of agents (high ability and low ability) to accumulate human capital at different rates, the high ability type having a comparative advantage in learning. Moreover, due to imperfect substitution in labor demand, units of human capital are remunerated at the type-specific wage rate.

[5]See Heckman et al. (1999), Glomm and Ravikumar (2001), Docquier and Michel (1999), Asselin (1996).

initial human capital level and public spending in this sector[6]. Time spent at school has an opportunity cost, which is generally represented as foregone labor earnings, except in the case of Glomm and Ravikumar (1992) who consider it as a leisure loss. Demand for education is therefore an investment decision involving a trade-off between the costs (opportunity costs, school fees, the cost of school material and uniforms or clothing, transport, additional living expenses if schooling implies living away from home, etc.) and benefits (in terms of higher future wages) of an additional year of study.

Two of the most frequently used partial equilibrium analysis of public policies impacts are *benefit incidence analysis* and *behavioral approaches*. Benefit incidence analysis[7] assumes that benefits to the consumer of a public service is equivalent to the cost per user of furnishing this service. These benefits are assigned to users ordered according to some welfare measure, which makes it possible to evaluate whether they are progressive or regressive. Although this technique is widely used, criticisms are also numerous. There are strong reasons to believe that public spending is not distributed evenly and does not benefit each user to the same degree. Moreover, this approach does not take account of individual reactions to policy changes.

Behavioral approaches, developed by Gertler et al. (1987) and many others, analyze changes in policies over time or in space to econometrically estimate the effects of public spending on monetary and non-monetary welfare measures while controlling for other factors likely to influence these measures. They find that beneficiaries and non-beneficiaries significantly adapt many aspects of their behavior to changes in public spending. But these approaches are limited by probable estimation biases resulting from endogeneity and omitted

[6]In a dynamic context, authors also account for the depreciation rate of human capital (Lucas (1988)) representing obsolescence of knowledge.

[7]This methodology, initially proposed by Meerman (1979) and Selowsky (1979), is described in detail in Van de Walle (1996).

variables[8].

Furthermore, we believe that education policies have important general equilibrium impacts, in particular through their impacts on relative wages of skilled and unskilled workers, which have clear poverty implications. For this reason, partial equilibrium analysis does not adequately reflect the magnitude and even the direction of actual impacts. In order to be able to capture these effects, Heckman et al. (1999) suggest a general equilibrium analysis. In this study, a computable general equilibrium (CGE) model is proposed[9].

There are only a handful of existing CGE studies linking education policies and households welfare, poverty, or inequality level. Savard and Adjovi (1998) introduces externalities from public spending on education in a static model while Lofgren and Robinson (2004) specifies the impact of government spending on total factor productivity growth in a recursive model. In both papers, there are no attempt to model household investment or consumption behavior with respect to education, nor the resulting impacts on the labor market. The policy impact on households is thus only indirectly channelled via the production level in the economy.

A more elaborate approach is adopted by Agénor et al. (2002), Agénor et al. (2004), Bourguignon et al. (2004), and Logfren and Diaz-Bonilla (2006). It incorporates the impacts of education on the relative supply of skilled and unskilled workers in the economy and, as a consequence, on the wage premium. However, households are not allowed to modify their endowments in the different type of labor as a result of getting education, which seriously limits the impact of policy reforms on the labor markets and the analysis of the distributive effects of education on households. Furthermore, the skill acquisition function does not follow

[8]Endogeneity would cause problems in cases where the design of a public program was based, in part, on the welfare measure used for analysis. Omitted variable bias would occur if a variable, which is not included in the regression, is correlated with both the design of the public policy and with the welfare measure.

[9]For a description of the essential features of CGE models, see Decaluwé and Martens (1988) or Shoven and Whalley (1984).

from an explicit modelling of household behavior, nor does it reflect human capital theory.

In a recursive dynamic CGE model where the labor market is segmented into skilled and unskilled workers, Agénor et al. (2002) impose an *ad hoc* skill acquisition function that depends on the relative expected wages of skilled and unskilled workers, government capital stock in the education sector, and the average level of wealth of each unskilled worker. Only urban workers have the possibility to acquire skills. Consequently, any simulation of a change in the amount of public capital in education has only an indirect impact (through urban-rural migration) on rural households[10]. Acquiring skills does not allow a household to change its labor supply composition.

Agénor et al. (2004) also develop a recursive macroeconomic framework. In each period, raw labor can be transformed into educated labor through a production function that is assumed to depend on the quantity of raw labor and the stock of public capital in education in the previous period. Interestingly, this function accounts for a congestion effect. There is only one aggregate household and thus the change in the labor composition in the economy is also the change in the labor composition of the aggregate household. Modifications in this aggregate household's consumption and price level are applied to a household survey (using an estimated partial elasticity) to analyze poverty effects.

In a different spirit, Bourguignon et al. (2004) developed an economy wide model to capture the relationship between several of the Millenium Development Goal (MDG) objectives. An implementation of this approach is provided by Logfren and Diaz-Bonilla (2006) for Ethiopia. They endogenize some aspects of student behavior. For example, the drop out,

[10]Even if it is an established fact that a majority of education institutions are located in urban areas, it would be false to pretend that none exists in rural areas. Furthermore, since a student who lives in a rented room and studies in urban areas during the week can still be considered part of a rural household, to require migration as a prerequisite for education could lead to false conclusions.

repeat and graduation rates are all linked to several indicators: quality of education, wage incentives, the mortality rate, the size of the infrastructure capital stock, etc. Even if they fail to develop a rigorous theoretical framework justifying their formulation of student behavior, this approach is very interesting and offers the advantage of linking the performance of the education system to the labor market with a possible feedback impact on wage differentials and household income.

Although they also do not allow households to modify the composition of their labor endowment, Jung and Thorbecke (2001) and Dabla-Morris and Matovu (2002) improve on the previous group of papers by using a production function of human capital based on explicit household optimization.

In a sequential dynamic CGE model for Tanzania and Zambia, Jung and Thorbecke (2001) consider three types of labor differentiated by skills. They specify a constant return to scale production function of skilled labor that depends on public expenditures in education and the opportunity cost of acquiring more skills. This opportunity cost is defined as the effort provided (or time invested) in education by the household multiplied by the wage it would obtain if it chose not to invest in further education. Households choose the effort level through the maximization of the present value of their income while taking into account wage differentials (present or expected), the unemployment rate and the interest rate. As mentioned previously, the model still has one important drawback: the proportion of household endowments in the different labor categories is constant, precluding any behavioral response[11].

Dabla-Morris and Matovu (2002) construct a dynamic CGE with overlapping generations and heterogeneous agents for Ghana in which the modeling of the household decision is ex-

[11] Households can decide to get more education and this contributes to increase the quantity of skilled workers in households and in the economy in general. However, the endowment in skilled labor rises in the same proportion in *all* household groups. Thus, highly educated households will always remain the most educated.

tremely rigorous and closely related to human capital theory. All households value family consumption and the human capital of their offspring. Altruistic parents choose the time their child spends in school based on a careful cost-benefit analysis. On one hand, schooling increases the child's human capital and future earnings on the labor market, as well as the utility of the (altruistic) parent. On the other hand, given fixed and variable costs for different levels of education, schooling lowers household income, and thus consumption. The scale of the benefits from education depends on school quality and child ability. The fraction of the population falling in 17 different skill-types is endogenized by taking into account household schooling decisions in each period. The model has nonetheless two important limitations in relation to poverty analysis. First, household groups are only differentiated by their level of human capital (parents' and child's combined), which implies that it is impossible to see if some unrelated (to education) characteristics of the households explain skill acquisition behavior and only aggregate poverty measures can be analyzed. Second, there is only one representative firm and thus only a single aggregate demand for labor – instead of sectoral labor demands differing according to the sectoral intensities in the different types of labor – influences the wage premium. This is an important weakness in that poverty effects are generally driven primarily through the income channel, which is mediated by household factor endowments and sectoral factor demands.

Finally, Zhai and Hertel (2006) developed an economywide model for China where education expenditure affects the production of human capital, its distribution among different household groups and the skill composition of each household. Each household is endowed with different categories of workers distinguished by their total years of schooling. Education results in a greater supply of skilled labor and lesser supply of unskilled labor and in an improved mobility of labor in rural areas. Simultaneously for each skill level, more education yields, in a linearly increasing manner, an improvement in labor productivity. Nevertheless, the authors assume that private and public expenditures in education are made in equal proportions and thus private decisions regarding skill acquisition are not the result of household investment choices.

To our knowledge, no authors have analyzed the impact of public expenditures in education using a CGE model that incorporates: 1) a relative supply of skilled and unskilled labor, and a wage differential, that are endogenous to the level of schooling; 2) several household groups with differential endowments in multiple labor types and thus a differentiated impact of education on the composition of these household labor endowments; 3) a production function for skills or human capital that is endogenously derived from household (investment) optimization relating to education.

In order to capture the general equilibrium effects on income distribution of changes in education policies in Vietnam, we develop a static CGE model that incorporates all three above-mentioned elements. Household education investment decisions are modeled in detail. The model accounts for direct and opportunity costs of education as well as public spending on education. It renders household endowments of skilled and unskilled workers endogenous in the spirit of human capital theory. A simulation is run in order to analyze the impacts of a reduction in public spending on education on the Vietnamese economy and, in particular, on poverty. In a more general manner, we aim to reach a better global understanding of the link between public spending in education and poverty in order to be able to learn lessons transferable to other countries. Furthermore, through the innovative integration of education in this model, this paper contributes to poverty and income distribution analysis.

In the next section, the theoretical model used is described with emphasis on how education and related household decisions are integrated into the CGE framework. Section 3 presents an analysis of the distributive consequences of a simulated reduction in public spending on education. We conclude and put our results in perspective in section 4.

2 The Model

The general structure of the model is based on an archetypal static CGE model designed by Cockburn et al. (2007). The Vietnamese economy is represented as a small open economy, i.e. taking international prices as given. The model includes five production sectors (agriculture, industry, services, low and high education), two labor categories or education levels (skilled and unskilled)[12] and four household groups (rural agricultural, rural non agricultural, urban agricultural[13] and urban non agricultural). Disaggregation of representative households into more than one category allows us to observe the distinct way in which each of them are affected by the shock and, consequently, to analyze welfare and poverty impacts[14].

The proposed model allows adjustments in household skilled and unskilled labor endowments meaning that they are specific to each category of households. Household decisions concerning education follow a pure investment motive and are modeled in a relatively simple manner. In order to maximize their income, households modify the equilibrium proportion of skilled and unskilled labor that they possess by adjusting their equilibrium level of education investment. Note that the model determines an equilibrium *flow* of education investments and amount of time devoted to education that is required to maintain an optimal mix in the household's *stock* of skilled and unskilled workers. So, by reducing its equilibrium education investments, the household would reduce the share of skilled workers in its equilibrium labor

[12] We choose to consider two distinct labor categories instead of a continuum of human capital levels *à la Lucas (1988)* in order to have two different wages (see section 1) influencing household decisions.

[13] This category is composed of agricultural workers who live in the outside edges of cities and work in proximate fields.

[14] The analysis must however be limited to intergroup comparison. It is a recognized weakness since the model supposes stability of income distribution within each household category. A solution to this problem would necessitate microsimulation techniques (see Cockburn (2001)), which go beyond the scope of this paper.

endowment. Education investment decisions then influence household income and consumption, as well as total production in the economy,

which is a function of human capital (see section 2.4). Household demand for education depends on the relative wages of skilled and unskilled workers, the opportunity cost of schooling, as well as the direct cost of education.

The Vietnamese education system includes five levels: a) preschool; b) primary; c) lower secondary; d) upper secondary; and e) post-secondary education. There is also a parallel system of professional education offered by various institutions and accessible after primary or lower secondary school. The education system in our model is segmented in two: basic education (a and b) and higher education (c, d, e, and professional training). Only higher education allows workers to become skilled. Instead of specifying a production function for human capital (see section 1), we assume that households must buy or "consume"[15] a predetermined amount of higher education units in order to possess more skilled labor. All education is assumed to be public, as semi-public and private schools remain quite rare in Vietnam. The value of education produced and consumed is partly paid by the government (public spending on education) and partly paid by households (direct cost of education).

In order to simplify the presentation, we do not present all model equations[16]. Emphasis will be put on equations introduced in order to model education.

[15] "Consumption of education" refers to the action of buying units of schooling and thus investing in education.
[16] The complete list of equations is available in annexe 1.

2.1 Households

In typical static CGE models (without education), each household possesses fixed endowments of skilled and unskilled labor, capital and land[17]. Household income is composed of returns on factors of production (labor, capital and land) and transfers (governmental or others). Households thus have no control over their income. Consumption choices in order to maximize utility are the only household decisions to be modeled. In some cases, an endogenous labor supply equation is also included to introduce a labor-leisure trade off.

As education investments are taken into account in our model, households makes an additional decision: the proportion of its adult members in each labor category (skilled and unskilled). Households can modify their shares of skilled and unskilled labor by changing their level of higher education investments. Investment in basic education is assumed to be fixed[18]. The household decision is therefore modeled in two stages[19]: (i) Income maximization; (ii) Utility maximization.

2.1.1 Income maximization

As education investments only affect utility through their impacts on net income (YH_h), household h chooses the volume of skilled (LS) and unskilled (LU) labor in order to maximize income (net of spending on education), subject to imperfect transformation between skilled and unskilled labor. The total number of workers and students in each household h

[17] In recursive dynamic CGE models, endowments generally increase at an exogenous given rate, generally equal to the population growth rate. However, except in the MAMS framework discussed in section 1, there is no relationship between education and accumulation of skilled labor.

[18] Since attendance rates in primary school in Vietnam are more than 90% (Nguyen (2002)), it is reasonable to treat this as an exogenous variable. In other contexts, the model could be easily modified to allow endogenous basic education investments.

[19] Household decisions concerning education and consumption are assumed "separable" as in Heckman et al. (1999), Bouzahzah et al. (2002).

being fixed in the short term, this can also be understood as a choice of the optimal shares of skilled and unskilled workers.

This total number of workers and students is not directly observed, but the initial value of remunerated labor is. Estimates from the literature of the returns to higher education can then be used to estimate the wage gap between skilled and unskilled workers. Hence, the constrained maximization of net income can be expressed as

$$\begin{aligned}\max_{\delta_h^s} \; YH_h \;&=\; Wu\,(1-\delta_h^s)\,\overline{L}_h + Ws\,(1-e)\,\delta_h^s\,\overline{L}_h - Pc_{edh}\,\overline{CED}_{h,\,edh}\,e\,\delta_h^s\,\overline{L}_h \\ &\quad + \text{non labor income} - \text{cost of basic education} \qquad (1)\end{aligned}$$

$$\text{s.t.} \;\; \overline{L}_h \;=\; b_h^l \left\{ \beta_h^l \left[(1-\delta_h^s)\,\overline{L}_h\right]^{\kappa^l} + (1-\beta_h^l)\,\left[\delta_h^s\,\overline{L}_h\right]^{\kappa^l} \right\}^{1/\kappa^l}, \qquad (2)$$

where δ_h^s is the share of skilled workers in household h's total potential labor supply (including students), e is the share of active life that must be devoted to higher education by a skilled worker, β_h^l is the CET share parameter reflecting the household-specific shares of unskilled labor, b_h^l is the CET scale parameter and κ^l is a parameter of transformation between skilled and unskilled labor.

In equation 1, income from unskilled labor is represented by $Wu\;(1-\delta_h^s)\;\overline{L}_h$, i.e. the product of the unskilled wage index (Wu) and the volume of unskilled labor in the household. Similarly, income from skilled labor, $Ws\,(1-e)\,\delta_h^s\,\overline{L}_h$ is the product of the skilled wage index (Ws), the volume of skilled labor in the household, and the proportion of a skilled worker's active life not spent in higher education $(1-e)$.

The volume of remunerated (active) skilled workers is represented by $(1-e)\;\delta_h^s\;\overline{L}_h$ and the volume of higher education students is $e\;\delta_h^s\;\overline{L}_h$. This specification implies a long-term equilibrium where a household must, year after year, have e% of its skilled workers in higher education in order to maintain its desired proportion (δ_h^s) of skilled labor. In other words, to increase its endowments in skilled labor by $\Delta\delta_h^s$, household h must increase the number of units of higher education it "consumes" by $e\,\Delta\delta_h^s\,\overline{L}_h$ and, at the same time, increase the amount of time it invests in higher education. This situation implies that the opportunity cost of education is $Ws\,e\,\delta_h^s\,\overline{L}_h$.

Household *net* income also depends on the amount that households spend on their investment in higher education: $Pc_{edh}\,\overline{CED}_{h,\,edh}\,e\,\delta_h^s\,\overline{L}_h$. Higher education has a fixed direct unit cost (including school fees, transportation, materials, etc.), $\overline{CEDT}_{h,\,edh}$, that varies between household groups (e.g. costs may be higher in rural areas because of greater transportation costs)[20]. Part of this total cost is paid by an exogenous public subsidy $(\overline{TED}_{edh})$, which is assumed to be the same for all households. The direct unit cost to households of higher education, $\overline{CED}_{h,\,edh}$, represents the difference between the total unit cost and the public subsidy:

$$\overline{CED}_{h,\,edh} \;=\; \overline{CEDT}_{h,\,edh} - \overline{TED}_{edh} \tag{3}$$

Consequently, a reduction (increase) in the public subsidy leads to an increase (decrease) in the private direct unit cost of higher education $(\overline{CED}_{h,\,edh})$. Education costs are indexed by the price of higher education, Pc_{edh}, which captures changes in the production costs of higher education and changes in the demand for higher education.

The imperfect substitution between skilled and unskilled labor (equation 2) also plays an essential role in modeling education investments. Without this constraint, households would specialize entirely in one or the other type of labor. The ease with which households can change their skill mix (see equation 4) depends on the transformation parameter κ^l from the

[20]Unit costs are equal to total costs divided by the corresponding volume of students, i.e. the total number of students multiplied by the average skilled wage rate in the base year.

(CET) function[21].

When choosing its share of skilled labor (δ_h^s), the household analyzes the trade off between the benefits of possessing more educated labor (higher wage rate) and the opportunity and direct costs of higher education. The choice function resulting from labor income maximisation is:

$$\frac{\delta_h^s}{(1-\delta_h^s)} = \Bigg(\overbrace{\underbrace{\frac{Ws}{Wu}}_{\text{skills premium}} - \underbrace{\frac{e\,Ws}{Wu}}_{\text{opportunity cost}} - \underbrace{\frac{Pc_{edh}\,CED_{h,edh}\,e}{Wu}}_{\text{direct cost and price of education}}}^{\text{net gain}}\Bigg)^{\tau^l}\left[\frac{\beta_h^l}{1-\beta_h^l}\right]^{\tau^l} \quad (4)$$

So, if the benefits of possessing more skilled labor (the skill wage premium) exceed the total (opportunity and direct) cost of education, we would expect households to increase their share of skilled labor through increase investments in education. If the benefits are inferior to the costs, households would reduce their share of skilled labor and education investments. The extent of their reactions will depend on their initial skills mix and the elasticity of transformation between skilled and unskilled labor $\tau^l = 1/(\kappa_l - 1)$.

Once the optimal share of skilled labor (δ_h^s) is determined, the household supplies $(1 - \delta_h^s)\,\overline{L}_h$ of unskilled labor and $(1-e)\,\delta_h^s\,\overline{L}_h$ of skilled labor, while the rest of the skilled labor, $e\,\delta_h^s\,\overline{L}_h$, attends higher education. When public spending on education falls, if all households decide to reduce their investment in higher education, there would be, on the one hand, an increase in the supply of unskilled labor supply of $\Delta\delta_h^s$ and a decrease in the supply of skilled labor of $\Delta(1-e)\,\delta_h^s$ so that total labor supply would increase by $\Delta e\,\delta_h^s$.

[21] The value for κ^l was chosen to be 1.5. Sensitivity analysis reveals that values between 0.5 and 10 do not change the direction of results and only slightly affect their amplitude. Parameters, b_h^l and β_h^l, are calibrated on Vietnamese data (see section 2.7).

2.1.2 Utility maximization

Having determined their optimal labor skill mix, households then choose their consumption of all goods (other than basic and higher education, which do not provide any direct utility to households[22]) in order to maximize their utility subject to the budget constraint resulting from income maximization. A "Stone-Geary" utility function is adopted, giving rise to a linear demand system.

2.2 Government

Government behavior is relatively simple. Its income comes from taxes and from transfers from the rest of the world. Government allocates this income between spending on public services (education and others), transfers to households and firms, and savings[23]. Education in Vietnam represents 15% of public spending, of which a little more than half is allocated to higher education (57.3%).

Public spending on higher education is endogenous, as it depends on household demand for higher education. In effect, the government subsidizes a fixed amount for each unit of higher education "consumed" by households. Public spending on higher education (G_{edh}) is thus defined as follows:

$$Pc_{edh}\, G_{edh} \quad = \quad Pc_{edh}\, \overline{TED}_{edh} \sum_{h} e\, \delta_h^s\, \overline{L}_h \tag{5}$$

Public spending on education therefore reduces the direct cost of higher education and thus provides households with incentives to invest further. Basic education is also publicly subsi-

[22]Integration of leisure and a direct impact on utility of education in this model would be interesting extensions. If education directly generated utility, education and leisure would become substitutes and time would be allocated between labor, leisure and education.

[23]Savings are negative in the case of a budget deficit.

dized but, since demand by households is assumed to be fixed, the volume of public spending on basic education is also exogenous.

In order to maintain public savings (current budget surplus) fixed during our simulations, government income and consumption (other than spending on higher education) are fixed and the sales tax, which influences consumption prices, is allowed to adjust endogenously.

2.3 Factors of Production

There are three production factors: capital, land and labor. Land is sector-specific (immobile) and exclusive to agriculture. Because our central focus, education, is a long term phenomenon, capital is assumed to be mobile among sectors, which implies that there is a single rate of return on capital for all sectors in the economy.

Labor is segmented between unskilled labor (not having completed lower secondary) and skilled labor (having completed at least lower secondary). Workers are assumed to be mobile among sectors of activity so that wage rates are the same in all sectors for a given skill category. The skills premium is determined by changes in the demand for each category of labor and their respective supplies. As we have seen, the supply of skilled and unskilled labor is determined by household education investment decisions. So, a fall in the relative supply of skilled labor is expected to lead to an increase in the skills premium.

2.4 Production

All sectors are assumed to use a constant returns technology under perfect competition. Output is a Leontief combination of value-added and intermediate consumption, while value-added is a constant elasticity of substitution (CES) function of composite labor and capital. Composite labor is itself a CES function of skilled and unskilled labor. Under these conditions, it is clear that changes in public spending on education will influence value added and total output in the economy through its impacts on the share of skilled and unskilled labor supply, as well as the corresponding changes in the share of (inactive) students in higher education.

2.5 Equilibrium and closure conditions

Equilibrium in each market is reached through price adjustments. Wages are the equilibrating variables on the labor market as specified in section 2.3. The public deficit and current account balance are maintained fixed through endogenous variations of the sales tax rate and the general price index.

The last constraint concerns the savings-investment equilibrium. Real investment (volume) is fixed and financed by the savings of households, firms, government (public surplus), and the rest of the world (current account balance). Equilibrium is attained through endogenous variation in firm savings.

2.6 Welfare and Poverty Effects

Equivalent variations (EV) are used to measure welfare impacts. Education influences household welfare through its impacts on net (of spending on higher education) income and consumer prices.

Poverty analysis requires observations of expenditures at the household level. Base year values are obtained from a representative household survey discussed below. After the simulations, changes in net income[24] of the different household groups in the CGE model are applied

[24] These changes are equivalent to the variations in total expenditures since average savings and income tax

to all households in corresponding groups.

We use two absolute poverty lines: one for urban households and

the other for rural households. They represent the real cost of a basket of goods deemed necessary for a minimal quality of life[25] in both areas. When running simulations, the consumer price indices (CPI) of rural and urban households evolve differently according to their respective consumption patterns. These variations in the CPI of rural and urban households are applied to their respective poverty lines, which means that the poverty lines are endogenous[26]. Poverty is measured by the standard FGT indices (Foster et al. (1984)). Initial FGT poverty indices are calculated using base-year total consumption per capita for each household. The new FGT indices are then calculated using the new poverty lines and levels of total consumption per capita. Finally, FGT indices are compared before and after the simulations. Gini indices, computed using DAD software (Duclos et al. (2001) and Duclos and Araar (2006)) are compared in the same manner.

2.7 Data

Calibration of our model is based on a year 2000 SAM for Vietnam constructed by Tarp et al. (2002). Poverty analysis is based on data from the 1997-98 Vietnam Living Standard Survey (VLSS) of more than 6000 households (Government Statistical Office (2000)). Rural, urban and nationwide poverty lines were calculated so as to reproduce official poverty headcounts. The nationwide poverty line that satisfies this criterion is 1,877,000, which is close to the official poverty line of 1,789,871 Vietnam Dong (around 120$US) per person computed by the

rates are fixed.

[25]A minimum consumption of 2100 calories per day and per person, plus a minimum non-food consumption (accommodation, clothing, etc.) allowance is assumed.

[26]See Decaluwé et al. (1999, 2005).

Government Statistical Office (GSO) of Vietnam in collaboration with the World Bank (Viet Nam's Government-Donor-NGO (1999), Australian Agency for International Development (2002)).

The ratio of skilled to unskilled wage indices captures the initial returns to education. In this model, this must be somewhere between the returns to completing lower secondary school and the returns to completing university, i.e. between 7% and 94% based on a Mincer equation analysis (Mincer (1988)) performed by Nguyen (2002). A return to education of 25% is assumed. We normalize Ws at unity and thus Wu equals 0.8.

The value of governmental and household expenditures on higher education are obtained from the SAM. Given that a skilled worker must spend 15% of her/his active life in higher education[27], the volume of students in higher education at any given time is, on average, 15% (the parameter "e" in our model) of the volume of skilled workers in each household group. The public (unit) subsidy is equal to total public spending on higher education divided by the volume of students. Private unit costs are specific to each household category and equal to their reported private spending on higher education divided by the volume of students in this category. The total unit cost of education is the sum of these two.

3 Results

We simulate the impacts on household welfare and poverty in Vietnam of a 50% reduction in the public subsidy for higher education[28]. If behavior were to stay unchanged, this would lead to a 50% decrease in public spending on higher education. However, as we will see that

[27] Average 8 years for higher education / 53 years of active adult life between beginning higher education at age 11 and retiring on average at age 64.

[28] The simulation can also be interpreted as the introduction of, or the increase in, user (tuition) fees.

households respond by reducing their demand for higher education, public spending falls even more.

As illustrated in figure 1, the impacts of this policy change on household welfare, poverty and inequality are complex with important general equilibrium effects that are missing in standard benefit incidence analysis. We focus on the education investment decision, households income, and the poverty impacts.

3.1 Impacts on education investments and the skills mix

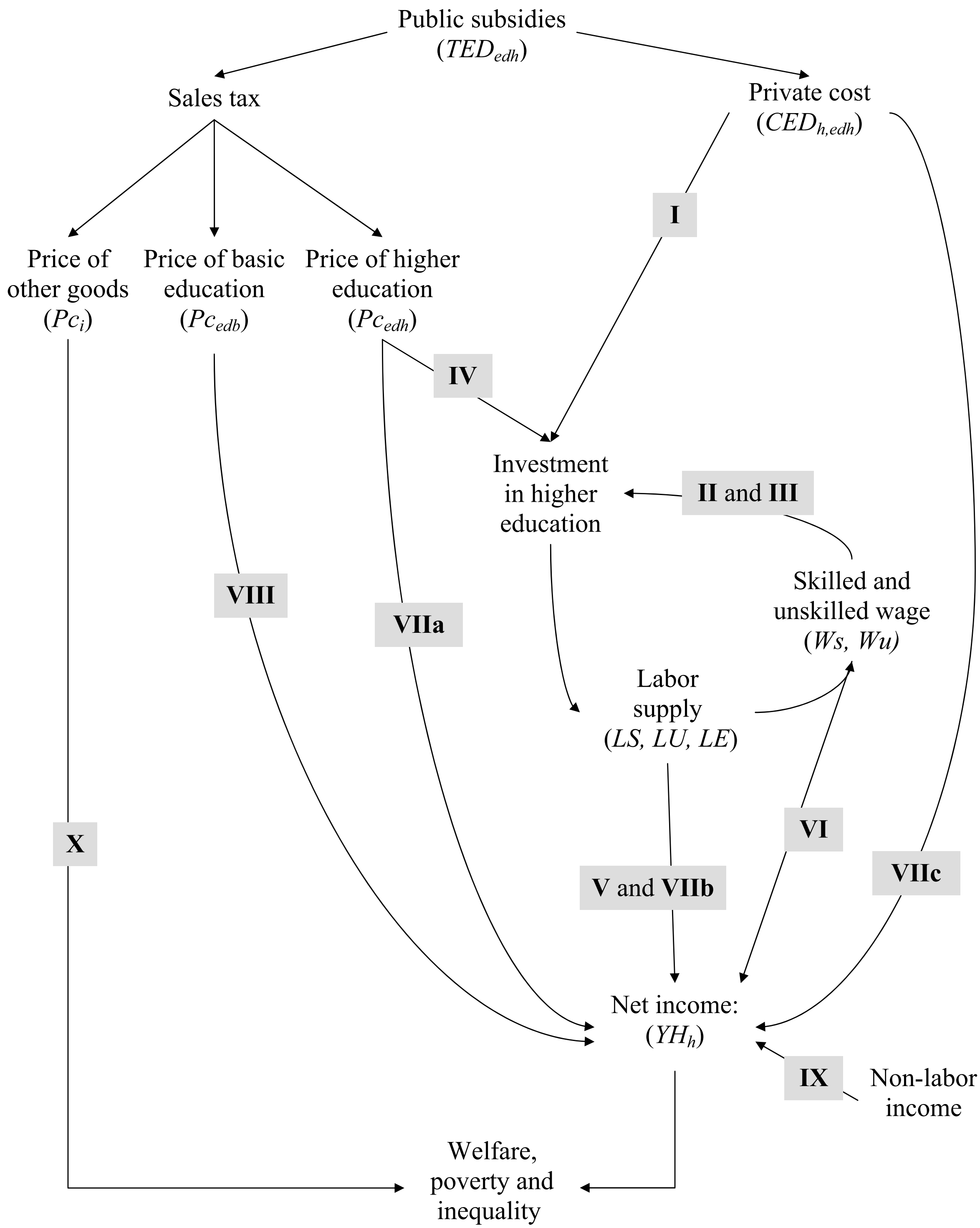
Education investments are governed by equation 4 with four main channels of impact.

"Direct cost" effect (I): Following equation 3, a 50% reduction in the public subsidy $(\overline{TED}_{edh})$ increases the private direct cost per unit of higher education $(\overline{CED}_{h,edh})$ by the same amount for each student. This directly reduces the net gain to education investments in equation 4. The fall in education investments then sets in motion general equilibrium effects that feed back into the other three channels of impact.

"Skills premium" effect (II): Households respond to the increase in private direct costs by decreasing their investment in higher education, which in turn reduces their supply of skilled labor and time spent in higher education. Since the total labor endowment of households is fixed, there is a commensurate increase in their supply of unskilled labor. The resulting fall in the supply of skilled labor and rise in the supply of unskilled labor in the economy leads to an increase in the skill wage premium. This increases the net gain of higher education, somewhat offsetting the "direct cost" effect.

"Opportunity cost" effect (III): The increase in the skills premium simultaneously raises the opportunity cost of higher education. This cost increases proportionately less than

Figure 1: Welfare, poverty and inequality impacts of a reduction in public spending on education



the skills premium as the share of active life spent in higher education (e) is necessarily less than one, but its impact is to reduce net gains to higher education, further reinforcing the "direct cost" effect.

"Price of education" effect (IV): A fourth channel of impact on the net gain in equation 4 is the price of higher education. This can be expected to change as a result of the compensatory sales tax, the above-mentioned changes in wage rates, the fall in the demand for higher education, as well as other general equilibrium supply and demand effects. The direction of this impact is hard to predict a priori.

Note that all other general equilibrium effects are also taken into account in the model and the final results we obtain. For example, reduced spending on education subsidies allow the government to also reduce sales taxes, which brings down consumer prices. However, these are second order effects that are not of direct interest to our analysis.

We first examine the overall simulation results ("All" column in table 1), before examining how specific household groups are affected. The public subsidy is cut 50% from 0.78 (block A of table 1) to 0.39 (block B). As total unit costs are assumed to be fixed, the private unit cost thus increases by the same absolute amount, going from 0.76 (block A) to 1.15 (block B). This results in an increase of 0.06 in the direct cost of education element in equation 4 (an increase from 0.11 to 0.17, see block C and D). Our results also indicate that the subsidy cut leads to a small increase in both the skills premium and opportunity cost components of the net gains from education. This is due to the fact that households reduce their education investments and, consequently, their supply of skilled labor (compare blocks E and F), as we will see shortly. Finally, the price of higher education increases very slightly (0.02%). The "price of education effect" is integrated into the direct cost results in table 1, as the two impacts are multiplicative and cannot be separated. The net impact of these four channels is a 4.2 percent reduction in the net gain from education (block D), as the increase in direct and opportunity costs outweigh the increase in the skills premium. Note that a partial equilibrium analysis would have overstated the impact on net gains by roughly 100% by capturing only the 0.06 increase in direct costs and neglecting the countervailing impact of the increase in the skills premium. Households react to the fall in net gains by reducing their education investments, which translates into a 4.01% reduction in the volume of both students and skilled labor, as well as a 1.27% increase in the supply of unskilled labor (block F). The reduction in the volume of students leads to a 0.15% increase in the total labor supply in the economy. On the factor market, the fall in the relative supply of skilled versus unskilled workers leads to a decrease in the unskilled wage rate of 0.32% and an increase in skilled wage rate of 3.30% (not shown).

Our results also indicate that the impacts of the subsidy cut on education investments differ between household groups. Although all household groups experience the same 0.03 absolute increase in net gains [29], it is the percentage change in net gains that drive household decisions on their optimal skills mix (equation 4). Percentage net gain variations differ according to the initial levels of these gains for each household group. The percentage fall in net gains are greatest for rural and agricultural households which, due to their higher initial direct education costs, have a lower initial level of net gains from higher education. Greater travel costs in rural and agricultural areas are one possible explanation for their higher unit costs of education [30].

[29] We assume that all household groups experience the same subsidy cut of 0.39 and thus all share the same absolute increase of 0.06 in the direct cost of education component of net gains. Furthermore, the skills premium and opportunity costs components are identical, as all household groups face the same wage rates and have the same share of active life required for higher education (blocks C and D).

[30] Although this is a simplifying assumption, relaxing it would only increase the disadvantage of rural and agricultural households. Nguyen (2002) reports higher per student public spending in urban and non agricultural areas such as the Red River delta (Hanoi) and the south east (Saigon), particularly for upper secondary school. To take this fact into account, we would have had to attribute lower public subsidies per student to rural households. Thus, the private cost share of those households would have been even higher and the reduction in their net gain to education would also have been greater.

Table 1: Structure and impacts on education and labor

	Rural	Agricultural	Non agricultural	**Urban**	Agricultural	Non agricultural	**All**
Share of population	**76.0**	58.8	17.2	**24.1**	2.9	21.1	**100.0**
***A) Higher education costs:* Base**							
Private unit cost	**1.26**	1.53	0.94	**0.54**	1.49	0.51	**0.76**
Public subsidy	**0.78**	0.78	0.78	**0.78**	0.78	0.78	**0.78**
Total unit cost	**2.04**	2.32	1.73	**1.32**	2.27	1.29	**1.54**
Private cost share	**61.58**	66.14	54.56	**40.66**	65.51	39.23	**49.22**
***B) Higher education costs:* After simulation**							
Private unit cost	**1.65**	1.92	1.33	**0.93**	1.88	0.90	**1.15**
Public subsidy	**0.39**	0.39	0.39	**0.39**	0.39	0.39	**0.39**
Total unit cost	**2.04**	2.32	1.73	**1.32**	2.27	1.29	**1.54**
Private cost share	**80.77**	83.07	77.28	**70.31**	82.76	69.61	**74.53**
***C) Benefits and costs of higher education:* Base**							
Skill premium	**1.25**	1.25	1.25	**1.25**	1.25	1.25	**1.25**
Opportunity cost	**0.187**	0.187	0.187	**0.187**	0.187	0.187	**0.187**
Direct cost	**0.24**	0.29	0.18	**0.10**	0.28	0.10	**0.14**
Net gain	**0.83**	0.78	0.89	**0.96**	0.78	0.97	**0.92**
***D) Benefits and costs of higher education:* After simulation**							
Skill premium	**1.30**	1.30	1.30	**1.30**	1.30	1.30	**1.30**
Opportunity cost	**0.194**	0.194	0.194	**0.194**	0.194	0.194	**0.194**
Direct cost	**0.31**	0.36	0.25	**0.18**	0.35	0.17	**0.22**
Net gain	**0.79**	0.74	0.85	**0.93**	0.75	0.93	**0.89**
Δ Net gain	**-4.32**	-4.66	-4.03	**-4.08**	-4.61	-3.66	**-4.20**
***E) Distribution of labor within households:* Base (%)**							
Unskilled labor	**87.25**	89.25	83.79	**60.00**	87.76	56.79	**75.92**
Skilled labor	**10.84**	9.14	13.78	**34.00**	10.40	36.73	**20.47**
Total labor	**98.09**	98.39	97.57	**94.00**	98.16	93.52	**96.39**
Students	**1.91**	1.61	2.43	**6.00**	1.84	6.48	**3.61**
***F) Distribution of labor within households:* Percentage change (%)**							
Δ Unskilled labor	**0.83**	0.75	0.98	**2.17**	0.84	2.41	**1.27**
Δ Skilled labor	**-5.67**	-6.21	-5.06	**-3.26**	-6.04	-3.17	**-4.01**
Δ Total labor	**0.11**	0.10	0.13	**0.21**	0.11	0.22	**0.15**
Δ Students	**-5.67**	-6.21	-5.06	**-3.26**	-6.04	-3.17	**-4.01**

Notes: The specifications for “skills premium”, “opportunity cost”, “direct cost” and “net gain” are provided by equation 4.

In addition to the percentage change in net gains, the percentage impacts on the optimal skills mix and consequent education investments of each household group depend on the initial skills mix, as reflected in the parameter β_h^l (equation 4). The lower the initial share of skilled labor, the greater the percentage increase in skilled labor supply and students and the smaller the percentage decrease in unskilled labor supply. As it is the rural and agricultural households that have the lowest initial shares of skilled labor – as well as the greatest percentage reduction in net gains from higher education – they also have the largest percentage increase in skilled labor and the smallest percentage fall in unskilled labor supply (block F). In contrast, urban and non-agricultural households post the smallest percentage fall in skilled labor supply and students (education investments).

We thus conclude that a subsidy cut would reduce the net gains from higher education. This would lead to a shift in Vietnam's skills mix in favor of unskilled workers, which would further accentuate the wage gap in favor of skilled workers. Rural and agricultural households post the greatest percentage reductions in the net gains from higher education and in skilled labor supply, but the smallest percentage change in unskilled labor supply.

3.2 Impacts on household incomes

Our ultimate concern is the impact of the higher education subsidy cut on income distribution and poverty. To understand these impacts, we must first study the household income and consumer price effects. Here, we can identify six main channels of influence, of which the first five involve household net income, whereas the final one concerns consumer prices: skills mix, wage rates, cost of higher education, non-labor income, cost of basic education, and consumer prices (other than education).

To first trace out the five income channels, let us approximately decompose the change in net income by taking the total differential of equation 1:

$$\begin{aligned}
\Delta YH_h \approx\ & \left.[Ws\,(1-e)\ -\ Wu]\,\Delta\delta_h^s\,\overline{L}_h\right\}\text{Skills mix effect} \\
& \left.+\Delta Wu\,(1-\delta_h^s)\,\overline{L}_h+\Delta Ws\,(1-e)\,\delta_h^s\,\overline{L}_h\right\}\text{Wage effect} \\
& \left.\begin{aligned}
& -\Delta Pc_{edh}\,CED_{h,\,edh}\,\delta_h^s\,e\overline{L}_h \\
& -Pc_{edh}\,\Delta CED_{h,\,edh}\,\delta_h^s\,e\,\overline{L}_h \\
& -Pc_{edh}\,CED_{h,\,edh}\,\Delta\delta_h^s\,e\,\overline{L}_h
\end{aligned}\right\}\text{Cost of higher education effect} \\
& +\Delta\ \text{non labor income} - \Delta\ \text{cost of basic education.}
\end{aligned} \tag{6}$$

Percentage changes in net income components are reported in table 2. We discuss each effect separately.

Skills mix (V): As noted in the preceding section, the net impact of the cuts in public subsidies is a reduction in the net gains from and, consequently, the investments in higher education. At the new equilibrium, this results in a shift in the household optimal skills mix in favor of unskilled workers relative to skilled workers and students (i.e. a reduction in δ_h^s). The impact of this skills mix shift on household income depends crucially on the share of time spent in higher education (e, which we assume to be 15% of active life[31]) and the gap between skilled and unskilled wage rates ($Ws - Wu$, which we assume to be 20%). We can rewrite the expression for the skills mix effect as: $[(1-e)(Ws-Wu) - e\ Wu]\ \Delta\delta_h^s\ \overline{L}_h$. On one hand, a reduction in the share of skilled workers reduces household income by the amount of the wage premium ($Ws - Wu = 1 - 0.8 = 20\%$) that these workers would have earned over their working life ($1-e$). On the other hand, household income is increased by the (unskilled) wages these workers earn during the share of their active life ($e = 15\%$) that they would have

[31] See section 2.7.

Table 2: Income channels

	Rural	Agricultural	Non agricultural	**Urban**	Agricultural	Non agricultural	**All**
Skill mix effects							
$(1-e)(Ws\,-\,Wu)\,\Delta\delta_h^s\,\overline{L}_h$	**-0.10**	-0.09	-0.13	**-0.17**	-0.11	-0.18	**-0.13**
$(-e)\,Wu\,\Delta\delta_h^s\,\overline{L}_h$	**0.07**	0.06	0.09	**0.12**	0.08	0.13	**0.09**
Wage effect							
$\Delta\,Wu\,(1-\delta_h^s)\,\overline{L}_h$	**-0.19**	-0.18	-0.20	**-0.12**	-0.20	-0.11	**-0.16**
$\Delta\,Ws\,(1-e)\,\delta_h^s\,\overline{L}_h$	**0.30**	0.24	0.41	**0.88**	0.30	0.94	**0.55**
Total	**0.11**	0.06	0.22	**0.76**	0.10	0.82	**0.39**
Cost of higher education effect							
$-\Delta\,Pc_{edh}\,CED_{h,\,edh}\,e\,\delta_h^s\,\overline{L}_h$	**-0.00**	-0.00	-0.00	**-0.00**	-0.00	-0.00	**-0.00**
$-Pc_{edh}\,\Delta\,CED_{h,\,edh}\,e\,\delta_h^s\,\overline{L}_h$	**-0.62**	-0.50	-0.87	**-1.83**	-0.62	-1.96	**-1.13**
$-Pc_{edh}\,CED_{h,\,edh}\,e\,\Delta\,\delta_h^s\,\overline{L}_h$	**0.11**	0.12	0.11	**0.08**	0.14	0.08	**0.09**
Total	**-0.51**	-0.38	-0.76	**-1.75**	-0.48	-1.88	**-1.04**
Other income effects							
Δ non-labor income	**0.17**	0.18	0.15	**0.18**	0.17	0.19	**0.17**
Δ cost of basic education	**0.00**	0.00	0.00	**0.00**	0.00	0.00	**0.00**
Change in net income							
$\Delta\,YH_h$	**-0.24**	-0.16	-0.41	**-0.83**	-0.22	-0.89	**-0.50**

previously spent in school. The lost wage premium is slightly greater than the reduced opportunity costs, such that the net effect is slightly negative.

Wage rates (VI): At the same time, wage rates themselves vary as a result of the change in the skills mix of labor supply[32]. As we noted earlier, skilled wages increase by 3.30%, whereas unskilled wages decline by 0.32%. Thus, the initial endowments of households in these two types of labor determine the differential effect on incomes through this channel.

[32] There are also general equilibrium demand effects on wage rates as consumption patterns adjust to the subsidy cut and its impacts on the economy, but these are of much smaller magnitude.

Cost of higher education (VII): The cost of higher education is affected in a number of ways. The strongest impact is a reduction in net income through the subsidy cut itself and the corresponding increase in the unit higher education costs (CED). Second, the reduction in higher education investments, i.e. the reduction in δ_h^s, directly reduces education costs for households and thus increases net income. Finally, there is a very small increase in the price of higher education through general equilibrium effects discussed earlier, which reduces net income.

Non-labor income (VIII): Changes in household incomes and factor prices lead to small general equilibrium increases in the returns to capital and to land. Indeed, in reaction to the subsidy cuts, households reorient their consumption away from higher education and increase their demande for capital-intensive industrial goods and land-intensive agricultural goods.

Cost of basic education (IX): A final, minor, impact on household net incomes results from changes in the cost of basic education. As the volume and unit cost of basic education are assumed to be constant, this is purely the result of a reduction in the price of basic education. Indeed, basic education is relatively intensive in unskilled labor, for which the wage rate falls.

The combined impact of these various income effects is an average 0.50% reduction in net income (see 2). Urban non-agricultural households lose by far the most, whereas agricultural households, particularly in rural areas, lose least. To understand these impacts, we decompose the contributions of the above-mentioned effects to the change in net income. To do so, we express each of these effects as a share of initial income.

As we noted above, the shift toward unskilled labor is income-reducing for all household groups given that the wage premium for skilled workers more than offsets the opportunity cost of the extra share of active life they must devote to higher education. In table 2, we see that this channel accounts only for a small part of the decrease in average net income (0.04% = 0.13% - 0.09%). As we can see from the expression in equation 6, the skills mix effect is strictly proportional to the absolute variation in skilled workers ($\Delta\delta_h^s\overline{L}_h$), where the rest of the expression (in square brackets) is identical for all household groups. Given the much higher initial level of skilled workers in urban non-agricultural households (block E of table 1) – and despite their slightly lower percentage variations (block F) – they have the largest absolute change in skilled workers and thus have a slightly more negative skills mix effect than the other household groups.

Overall, the wage effect is positive, leading to a 0.39% increase in net income. Indeed, as the skilled wage rate increases (3.30%) much more than the unskilled wage rate declines (0.32%), net income gains from the increase in the skilled wage rate (0.55%) more than offset the losses (-0.16%) from the fall in the unskilled wage rate. Urban non-agricultural households, which have by far the highest share of skilled workers, benefit by far the most from this increase in the skills premium, whereas agricultural households, particularly in rural areas, benefit least.

The increase in the cost of higher education, which is mainly explained by the decrease in subsidy, has by far the greatest impact, reducing household net incomes by 1.04%. This impact is driven primarily by the direct impact of decreased subsidies, which reduces net incomes by 1.13%. On the other hand, the reduction in education investments leads to a decrease in the expenditure on higher education and thus an increase in average net income of 0.09%. Finally, the effect of the increase in the price of higher education is negligible. When we compare the cost of higher education effect across household groups, we note that urban non-agricultural households are dramatically more negatively affected. This result can be traced to the fact that it is urban non-agricultural households who have the highest shares of students and who, consequently, are most directly hit by the subsidy cuts, which reduces their net income by 1.96%. In addition, these households have the smallest percentage reduction in students and thus the smallest reduction in education investments.

The increase in non-labor income slightly offsets the impact of the increase in the cost of higher education on net incomes. Whereas non-agricultural households – both rural and urban – are the main beneficiaries of the increase in returns to capital, rural agricultural households gain most from the increase in the returns to land (not shown). This leads to a positive impact on net income through this channel of between 0.15% and 0.19% for all households.

The reduction in the price of basic education (0.32%) can be essentially traced to the 0.37% reduction in the sales taxes, which we will examine more closely in the following section. This impact is insignificant and varies little between household groups.

In conclusion, for all households, the direct impact of the subsidy cuts on the cost of higher education far outstrip the compensating gains through higher skilled wage rates and non-labor incomes. However, urban non-agricultural households are by far the biggest losers given their high initial share of students and despite the fact that they benefit most from the increase in the skill wage premium and non-labor incomes.

3.3 Welfare and poverty

As in many developing countries, poverty in Vietnam is principally a rural phenomenon and is particularly problematic in agriculture. The poverty rate in rural areas is 45% compare to 9% in urban areas (Vietnam's Government-Donor-NGO, 1999)). In terms of income distribution, we observe a higher Gini index, and therefore a more unequal distribution of total consumption, in urban areas (0.34) than in rural areas (0.27). Rural-urban divides in terms of education, as well as even larger differences in education within urban areas, play an important role in this respect. In this section, we explore the welfare and poverty impacts of the simulated cut in public subsidies to higher education.

Consumer prices (X): In addition to the income channels we have been exploring so far, the subsidy cut and the resulting shift in the economy's skills mix and wage premium also have general equilibrium effects on consumer prices. While we have already observed the changes in the cost of education, all other consumer prices are also affected. These results are primarily driven by the cost savings for government, which we assume to be transformed into a reduction in sales taxes and, consequently, in consumer prices. Note that cost savings come not only from the reduction in the rate of public subsidy, but also from the reduction in the volume of students. Obviously, there are other possible mechanisms through which government may adjust that would have different impacts on poverty overall and by household category.

Our simulations indicate that government cost savings are transformed into a 0.37% reduction in the sales tax rate (see Table 3), which is determined endogenously in order to keep the government deficit constant. This leads to a reduction in consumer prices, which, in itself, has a positive effect on welfare and poverty. Consumer prices reductions vary somewhat at the sectoral level as a result of general equilibrium production cost and consumer demand effects: 0.09% (services), 0.30% (agriculture) and 0.47% (industry). However, given that consumption patterns differ little between household groups, they all experience a reduction of roughly 0.37% in their non-education consumer price indices (CPI). Urban non-agricultural households, which we have already found to have the most negative net income effects, also benefit least from these cost savings given the higher share of services in their consumption basket.

We note that consumer prices fall more than net income for agricultural households (rural and urban), whereas the opposite is true for non-agricultural households, particularly in rural areas. Consequently, we find quite strong contrasts in their welfare effects. Indeed, we observe welfare gains for both agricultural household groups and welfare losses for their non-agricultural counterparts. As agricultural households are a minority in urban areas and a majority in rural areas, overall urban welfare falls whereas rural welfare increases. This result also reflects the fact that the welfare gains of agricultural households are particularly strong in urban areas, whereas the welfare losses of non-agricultural households are much greater in rural areas. Finally, the fall in the welfare of non-agricultural households outweighs the increase in the welfare of agricultural households such that welfare falls for the country as a whole.

Table 3: Impacts on welfare and poverty

	Δ % Sale taxes	Δ % Net income h	Δ % CPI h	Δ % Welfare (EV/Income) h	Δ % Poverty rates (P0) h	Δ % Poverty gap (P1) h	Δ % Poverty severity (P2) h	Δ Gini h
Rural	**-0.37**	**-0.24**	**-0.37**	**0.12**	**-0.72**	**-0.52**	**-0.63**	**-0.06**
Agricultural	-0.37	-0.16	-0.38	0.20	-1.02	-0.63	-0.75	
Non agricultural	-0.37	-0.41	-0.37	-0.04	0.90	0.17	0.19	
Urban	**-0.37**	**-0.83**	**-0.35**	**-0.35**	**1.41**	**1.61**	**2.07**	**-0.07**
Agricultural	-0.37	-0.22	-0.37	0.11	0.00	-0.62	-0.80	
Non agricultural	-0.37	-0.89	-0.35	-0.40	1.82	2.24	2.85	
All	**-0.37**	**-0.50**	**-0.37**	**-0.08**	**0.29**	**0.39**	**0.45**	**-0.31**

We also find highly contrasting poverty impacts of the cut in public subsidies to higher education. A substantial 0.72% reduction in the share of poor among rural households contrast with an even stronger 1.41% increase in the share of poor among urban households. Similarly contrasting results are found for the poverty gap and severity indices. Among urban and rural households, agricultural households benefit from the policy change in poverty terms. In contrast, there is a large increase in poverty among non agricultural households. Urban non-agricultural households are particularly affected, with an increase in the incidence of poverty of almost two percent. These results mirror the earlier welfare effects. Even though the poor are overwhelmingly located in rural areas, the increase in poverty among urban non agricultural households is sufficiently important to lead to an overall negative effect with poverty increasing in

the country as a whole.[33]

Distribution of income is unchanged, by definition, within households groups as we are in a representative household framework. Equality improves in both rural (0.06% reduction in the Gini coefficient) and urban (0.07% reduction) areas. This reflects the fact that real incomes increase for agricultural households, who have initially high poverty rates, and fall for the less poor non-agricultural households. The reduction in inequality for the country as

[33]Note that choosing a different compensation mechanism can lead to different welfare and poverty results without altering significantly the other main insights of the paper. For example, the choice of a compensatory income tax instead of a compensatory sales tax increases welfare and reduces poverty for all households except rural non-agricultural households. In effect, we observe a slightly more pronounced reduction in net gains, mostly due to a somewhat greater rise in direct costs (because of the lesser fall in consumer prices, especially for higher education). Households therefore invest less in higher education and the drop in skilled labor supply, as well as the increase in unskilled labor supply, are more important. As a result, the skilled wage rate rises less, the unskilled wage falls more and the increase in skills premium is similar. Mainly because the negative unskilled wage effect exceeds the positive skilled wage effect for most households, the ”before tax“ income decreases comparatively more than in the sales tax case. Yet, owing to the compensating fall in income tax rates, all households (except rural non agricultural households) benefit from an increase in their disposable income and, despite the lesser reduction in the CPI in the absence of the compensatory drop in sales tax rate, welfare therefore increases and poverty decreases for all households (except rural non agricultural households).

a whole (0.31%) is even greater, reflecting the fact that real incomes increase in the poorer, rural, areas and fall in the richer, urban, areas.

4 Conclusion

As Vietnam's government ponders further cuts to public spending on education, it has become urgent to fully understand the implications for Vietnam's economy, labor markets, income distribution and poverty. This paper presents a static CGE model that fully integrates household education decisions and labor skill acquisition. Households consider both the (direct and opportunity) costs and the benefits, in terms of higher wages, in determining their optimal investment in education and their optimal mix of skilled and unskilled labor. We use this model to evaluate the impacts of a reduction in public subsidies to higher education, paying careful attention to the numerous channels of impact. Simulation analysis presented in this work highlights lessons on education-poverty links in general and, more specifically, in the case of Vietnam.

The subsidy cut affect households through its impact on both incomes and consumer prices. The immediate impact is to increase the private cost of higher education and, consequently, reduced the net gains from investments in higher education. Our model confirms this effect, although it shows that a general equilibrium increase in the skills premium cuts the fall in net gains by more than half. Households react to falling net gains by reducing their higher education investments and reweighting their optimal skills mix in favor of unskilled workers, which is precisely the case of the increase in the wage premium paid to skilled workers. Although the absolute reduction in net gains are the same for all household groups, rural and agricultural households have the greatest percentage reduction in net gains given their low initial levels (due to observed higher costs of education). As a result of this and their low initial share of skilled labor, they also have the largest percentage reduction in skilled labor.

Our results also show that the subsidy cut has strong and complex impacts on household incomes. Overall, household incomes fall by 0.5%. This is primarily a result of the increase in the costs of higher education, which reduces household net-of-education-costs income by more than one percent, despite the reduction in the absolute number of students sent for higher education. This income loss is reinforced by the direct loss of income from having a lower share of skilled workers, who earn a skills premium during their working life, although this is almost entirely offset by the additional income these workers earn during the period they would have previously been attending school. Another important income effect comes through changes in wage rates. Here, the impact of the increase in skilled wages is found to be sufficient to offset the loss due to the fall in unskilled wages, such that the net effect is an average 0.39% increase in household income. An increase in non-labor income also serves to cushion the increased costs of education, increasing income by 0.17% on average. Changes in the price of education are found to play only a negligible role.

When we compare across households, it is clearly the urban non-agricultural households that are hardest hit by the direct increase in the private costs of higher education, given their much higher share of students. While this negative impact is partially offset by larger gains from the increase in the skills premium and non-labor income for these households, it is not enough as their incomes fall by 0.89%, as compared to 0.41% for rural non-agricultural households and roughly 0.20% for agricultural households in both rural and urban areas. Furthermore, urban non-agricultural households benefit least from the fall in consumer prices as the government transforms subsidy cuts into lower indirect taxes, although the differences here are minor.

Combining these income and consumer price effects, non-agricultural households experience a welfare loss and increase in poverty, particularly in urban areas, whereas agricultural households emerge as winners in welfare and poverty terms. At the same time this pro-rural pro-agricultural bias of subsidy cuts reduces inequality within and between the urban and rural regions. The negative impacts on urban non-agricultural households are sufficiently great that welfare falls and poverty increases for Vietnam as a whole.

We conclude that a cut in public subsidies to higher education in Vietnam would reduce the share of skilled labor, increase the skills wage premium, reduce welfare and increase poverty. While rural and agricultural households would benefit from this reform, urban and non-agricultural households would lose out.

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5 Annexe 1: Complete Mathematical Description

5.1 Symbols

5.1.1 Indices

5.1.1 Indices

Production

AGR	Agriculture
IND	Industry
SER	Services
EDB	Basic education
EDS	Higher education

Households

RF	Rural agricultural
RNF	Rural non agricultural
UF	Urban agricultural
UW	Urban non agricultural

Sets

I	Production sectors: AGR, IND, SER, EDB, EDS
$AGRS(I)$	Agricultural sector: AGR
$NAG(I)$	Non agricultural sectors: IND, SER, EDB, EDS
$SERV(I)$	Services sectors: SER, EDB, EDS
$GOOD(I)$	Goods sectors: AGR, IND
$NED(I)$	Non educational sectors: AGR, IND, SER
H	Households: RF, RNF, UF, UNF

5.1.2 Parameters

a_i^{ll}	Scale parameter (CES between skilled and unskilled labor)
α_i^{ll}	Share parameter (CES between skilled and unskilled labor)
δ_i^{ll}	Elasticity of substitution (CES between skilled and unskilled labor)
ρ_i^{ll}	Substitution parameter (CES between skilled and unskilled labor)
a_i^{kl}	Scale parameter (CES between labor and capital)
α_i^{kl}	Share parameter (CES between labor and capital)
δ_i^{kl}	Elasticity of substitution (CES between labor and capital)
ρ_i^{kl}	Substitution parameter (CES between labor and capital)

a^{cl}	Scale parameter (CES between composite factor and land)
α^{cl}	Share parameter (CES between composite factor and land)
δ^{cl}	Elasticity of substitution (CES between composite factor and land)
ρ^{cl}	Substitution parameter (CES between composite factor and land)
io_i	Coefficient (Leontief for total intermediate consumption)
v_i	Coefficient (Leontief for value added)
$aij_{j,i}$	Coefficient Input output
$\gamma_{h,ned}$	Marginal share of good NED in the demand function of household h
$\eta_{h,ned}$	Income elasticity of good NED for household h
$\varpi_{h,ned}$	Minimum consumption of good NED (demand function) of household h
ζ_h	Frish parameter (demand function) of household h
ϕ_h	Marginal propensity to save of household h
λ_h^l	Share of land income received by household h
λ^{lf}	Share of land income received by firms
λ^{lrow}	Share of land income received by the rest of the world
λ_h^r	Share of capital income received by household h
λ^{rf}	Share of capital income received by firms
λ^{rrow}	Share of capital income received by the rest of the world
b_h^l	Scale parameter (CET between skilled and unskilled labor)
β_h^l	Share parameter (CET between skilled and unskilled labor)
τ^l	Elasticity of transformation (CET between skilled and unskilled labor)
κ^l	Transformation parameter (CET between skilled and unskilled labor)
tm_i	Import tax rate for product i
tx_i	Sales tax rate for product i
tpx_i	Production tax rate for product i
tfk	Capital tax rate
tfl	Land tax rate
tyh_h	Income tax rate for household h
tyf	Direct income tax rate for firms
b_i^e	Scale parameter (CET between exports and domestic sales)
β_i^e	Share parameter (CET between exports and domestic sales)
τ_i^e	Elasticity of transformation (CET between exports and domestic sales)
κ_i^e	Transformation parameter (CET between exports and domestic sales)
a_i^m	Scale parameter (CES between imports and local product)
α_i^m	Share parameter (CES between imports and local product)
δ_i^m	Elasticity of substitution (CES between imports and local product)
ρ_i^m	Substitution parameter (CES between imports and local product)
μ_i	Value share of good i in total investment
ι_{serv}	Consumption share of service $serv$ in total public consumption
δ_i	Share of sector i in total value added
dvr	Share of firms' income distributed in dividends to the rest of the world
e	Share of a worker's active life time that must be spent in higher education in order to become skilled

5.1.3 Endogenous variables

Ws	Skilled wage index
Wu	Unskilled wage index
Wl_i	Composite labor wage index
Rk_i	Return index for capital in sector i
Rl	Return index for land
Rc	Return index for composite capital
P_i	Production price of product i
Pt_i	Production price of product i including taxes
Pv_i	Value added price in sector i
Pd_i	Domestic sales price of product i including taxes
Pl_i	Domestic sales price of product i excluding taxes
Pc_i	Consumption price of product i
Pm_i	Domestic price of imports i
Pe_i	Domestic price of exports i
$Pindex$	General price index
$Pinv$	Investment price index
Pg	Governmental consumption price index
XS_i	Production in sector i
VA_i	Value added in sector i (volume)
$DI_{i,j}$	Intermediate consumption of product i by sector j
CI_j	Total intermediate consumption by sector i
LDU_i	Demand for unskilled labor by sector i
LDS_i	Demand for skilled labor by sector i
CL_i	Composite labor in sector i
CF	Composite production factor (capital-land) in the agricultural sector
LA_h	Volume of active labor in household h
LE_h	Volume of student in household h
LU_h	Volume of unskilled labor in household h
LSA_h	Volume of active skilled labor in household h
LSP_h	Volume of potential skilled labor in household h
δ^s_h	Share of skilled workers in household h's total potential labor supply
$C_{ned,h}$	Consumption of good ned by households h (volume)
CTH_h	Total consumption of households h (value)
INV_i	Investment in product h (volume)
IT	Total investment (value)
DIT_i	Intermediate demand for product i
G_{edh}	Public consumption in higher education (volume)
CTG	Total public consumption (value)
$CTGvol$	Total public consumption (volume)
D_i	Demand for local product i
Q_i	Demand for composite product i
ED_{edh}	Higher education demand by household h
$STUD_{edh}$	Higher education demand by households and government
M_i	Imports of product i
EX_i	Exports of product i

YH_h	Income of household h
YDH_h	Disposable of household h
YF	Firms income
YG	Government income
SH_h	Savings of household h
SF	Firms savings
$DIVROW$	Dividends and other capital income received by the rest of the world
TI_i	Indirect tax income
TIM_i	Imports tax income
TIE_i	Exports tax income
$TCAP$	Capital tax income
$TLAND$	Land tax income
DTH_h	Tax income from direct income tax for household h
DTF	Tax income from direct firms income tax
NU	Adjustment variable for firms saving
ADJ	Adjustment variable for sales tax
EV_h	Equivalent variation of household h
$LEON$	Verification variable for Walras's law
Ω	Objective variable

5.1.4 Exogenous variables

$\overline{L}_h$	Total adjusted labor volume of household h
$\overline{KS}$	Capital volume
$\overline{SG}$	Current deficit (public savings)
$\overline{G}_{edb}$	Public consumption of basic education (volume)
$\overline{G}_{ser}$	Public consumption of services (volume)
$\overline{ED}_{edb,h}$	Demand for basic education of household h
$\overline{TED}_{h,edh}$	Public subsidy in higher education for household h
$\overline{CEDT}_{h,edh}$	Total direct unit cost of higher education for household h
$\overline{CED}_{h,edh}$	Direct unit cost of higher education supported by household h
$\overline{LAND}$	Land demanded by the agricultural sector
$\overline{ITVOL}$	Total investment (volume)
$\overline{Pwm}_i$	Rest of the world import price for product i (foreign currency)
$\overline{Pwe}_i$	Rest of the world export price for product i (foreign currency)
$\overline{Er}$	Nominal exchange rate
$\overline{CAB}$	Current account balance (foreign trade)
$\overline{DIV}_h$	Dividends and other capital income received by household h
$\overline{TG}_h$	Government transfers to household h
$\overline{TGF}$	Government transfers to firms
$\overline{TROW}_h$	Transfers from ROW to household h
$\overline{TFROW}$	Transfers from ROW to firms
$\overline{TGROW}$	Transfers from ROW to the government

5.2 Equations

5.2.1 Production

Sector i production function

$$XS_i = VA_i/v_i$$

Value added in non agricultural sectors

$$VA_{nag} = a^{kl}_{nag}\Big\{\Big[\alpha^{kl}_{nag}CL_{nag}{}^{-\rho^{kl}_{nag}}\Big] + \Big[(1-\alpha^{kl}_{nag})KD_{nag}{}^{-\rho^{kl}_{nag}}\Big]\Big\}^{-1/\rho^{kl}_{nag}}$$

Value added in the agricultural sector

$$VA_{agr} = a^{cl}\Big\{\Big[\alpha^{cl}CF^{-\rho^{cl}}\Big] + \Big[(1-\alpha^{cl})\overline{LAND}^{-\rho^{cl}}\Big]\Big\}^{-1/\rho^{cl}}$$

Composite production factor (labor-capital) in the agricultural sector

$$CF = a^{kl}_{agr}\Big\{\Big[\alpha^{kl}_{agr}CL_{agr}{}^{-\rho^{kl}_{agr}}\Big] + \Big[(1-\alpha^{kl}_{agr})KD_{agr}{}^{-\rho^{kl}_{agr}}\Big]\Big\}^{-1/\rho^{kl}_{agr}}$$

Total intermediate consumption of sector i

$$CI_i = io_i XS_i$$

Intermediate demand for product i by sector j

$$DI_{i,j} = aij_{i,j}CI_i$$

Demand for land by the agricultural sector

$$\overline{LAND} = \Big\{\Big[(1-\alpha^{cl})Rc\Big]/\Big[\alpha^{cl}Rl\Big]\Big\}^{\delta^{cl}}CF$$

5.2.2 Labor Demand

Composite labor

$$CL_i = a^{ll}\Big\{\Big[\alpha^{ll}_i LDNQ_i{}^{-\rho^{ll}}\Big] + \Big[(1-\alpha^{ll})LDQ)_i{}^{-\rho^{ll}}\Big]\Big\}^{-1/\rho^{ll}}$$

Demand for composite labor in non agricultural sectors

$$CL_{nag} = (a_{nag}^{kl})^{(\alpha_{nag}^{kl}-1)} \left\{ \left[(\alpha_{nag}^{kl} Pv_{nag})/Wl_{nag} \right]^{\sigma^{kl}} \right\} VA_{nag}$$

Demand for composite labor in the agricultural sector

$$CL_{agr} = (a_{agr}^{kl})^{(\alpha_{agr}^{kl}-1)} \left\{ \left[(\alpha_{agr}^{kl} Pv_{agr})/Wl_{agr} \right]^{\sigma^{kl}} \right\} CF$$

Demand for unskilled labor

$$LDNQ_i = \left\{ \left[\alpha_i^{ll}/(1-\alpha_i^{ll}) \right]^{\sigma_i^{ll}} \left[Ws/Wu \right]^{\sigma_i^{ll}} \right\} LDQ_i$$

5.2.3 Labor Supply

Choice function of higher education by household h

$$LSP_h = \left\{ \left[Ws\,(1-e) - CED_{h,edh}\, Pc_{edh}\, e \right]^{\tau^l} \left[\beta^l/(1-\beta^l) \right]^{\tau^l} \right\}$$

Transformation of unskilled into skilled labor (and vice-versa)

$$\delta_h^{nq} = 1 - \delta_h^s$$

Active (composite) labor supply by household h

$$LA_h = \delta_h^{nq} \overline{L}_h + \delta_h^s (1-e) \overline{L}_h$$

Unskilled labor supply by household h

$$LU_h = \delta_h^{nq} \overline{L}_h$$

Volume of potential skilled labor of household h

$$LSP_h = \delta_h^s \overline{L}_h$$

Active skilled labor supply by household h

$$LSA_h = \delta_h^s (1-e) \overline{L}_h$$

Volume of student in household h

$$LE_h = \overline{L}_h - LA_h$$

Unit cost of higher education “consumed” by household h

$$CED_{h,\,edh} = \overline{CEDT}_{h,\,edh} - \overline{TED}_{h,\,edh}$$

5.2.4 Income and Savings

Income of household h (net of investment in higher education)

$$\begin{aligned} YH_h \; = \; & Wu\,\delta_h^{nq}\,\overline{L}_h + Ws\,(1-e)\,\delta_h^s\,\overline{L}_h - CED_{h,\,edh}\,PC_{edh}\,e\delta_h^s\,\overline{L}_h \\ & + \lambda_h^r \sum_i Rk_i\,KD_i + \lambda_h^l\,Rl\,\overline{LAND} + \overline{DIV}_h + Pindex\,\overline{TG}_h \\ & + \overline{Er}\,\overline{TROW}_h - \overline{ED}_{h,\,edb}\,PC_{edb} \end{aligned} \tag{7}$$

Disposable income of household h

$$YDH_h = YH_h - DTHh$$

Firms income

$$YF = [1 - tfk - \sum_h \lambda_h^r] \sum_i Rk_i\,KDi + \overline{Er}\,\overline{TFROW} + Pindex\,\overline{TGF}$$

Government income

$$\begin{aligned} YG \; = \; & \sum_i TI_i + \sum_h DTH_h + \sum_i TP_i + \sum_i TIM_i + DTF + \overline{Er}\,\overline{TGROW} \\ & + TCAP + TLAND + ADJ \sum_i (Pd_i D_i + Pm_i M_i) \end{aligned}$$

Household h's savings

$$SH_h = \phi_h YDH_h$$

Firms' savings

$$SF = YF - \sum_h \overline{DIV}_h - DTF - \overline{Er}\,DIVROW$$

Dividends distributed by firms to ROW

$$DIVROW = NU\,dvr\,YF$$

Government's savings

$$SG = YG - CTG - \sum_h Pindex\,\overline{TG}_h - Pindex\,\overline{TGF}$$

5.2.5 Taxes

Indirect tax income for product i

$$TI_i = tx_i(P_i\, XS_i - Pe_i\, EX_i) + tx_i(1 + tm_i)\overline{Er}\ \overline{Pwm}_i M_i$$

Production tax income from sector i

$$TP_i = tpx_i\, Pt_i\, XS_i$$

Import tax income from sector i

$$TIM_i = tm_i\, \overline{Er}\ \overline{Pwm}_i\, M_i$$

Capital tax income

$$TCAP = tfk\, \sum_i Rk\, KD_i$$

Land tax income

$$TLAND = tfl\, Rl\, \overline{LAND}$$

Income from direct households h's income tax

$$DTH_h = tyh_h\, YH_h$$

Income from direct firms' income tax

$$DTF = tyh\, YF$$

5.2.6 Demands

Total consumption of household h

$$CTH_h = YDH_h - SH_h$$

Consumption of composite good ned of household h

$$C_{ned,\,h}\;Pc_{ned} = \varpi_{ned,\,h} Pc_{ned} + \gamma_{ned,h}[CTH_h - \sum_{ned} \varpi_{ned,h} Pc_{ned}]$$

Higher education "consumption" (volume) of household h

$$ED_{edh,h} = CED_{edh,\,h} LE_h$$

Higher education "consumption" (volume) of the government

$$G_e dh = \sum_h \overline{TED}_{edh,\,h}\; LE_h$$

Demand for higher education by households and the government

$$STUD_{edh} = \sum_h ED_{edh,h} + G_{edh}$$

Total public consumption (value)

$$CTG = \sum_{serv} G_{serv}\; Pc_{serv}$$

Total public consumption (volume)

$$CTGVOL = CTG/Pg$$

Investment in the composite good i

$$INV_i = \mu_i\; Pc_i\; IT$$

Total investment (volume)

$$\overline{ITVOL} = IT/Pinv$$

Intermediate demand for composite good j by sector i

$$DIT_i = \sum_j DI_{i,j}$$

5.2.7 Prices

Value added price in sector i

$$Pv_i = \left[P_i XS_i - \sum_j Pc_j DI_{i,j}\right] / VA_i$$

Return rate index of capital in non agricultural sectors

$$Rk_{nag} = \left[Pv_{nag} VA_{nag} - Wl_{nag} CL_{nag}\right] / KD_{nag}$$

Return rate index of capital in the agricultural sector

$$Rk_{agr} = \left[Rc\, CF - Wl_{agr} CL_{agr}\right] / KD_{agr}$$

Mean return rate index of the composite production factor in the agricultural sector

$$Rc = \left[Pv_{agr} VA_{agr} - Rl\, \overline{LAND}\right] / CF$$

Mean wage index for composite labor in sector i

$$Wl_i = \left[Wu\, LDNQ_i + Ws\, LDQ_i\right] / CL_i$$

Domestic price (including taxes) of product i

$$Pd_i = Pl_i\,(1 + tx_i)$$

Local price for imports i

$$Pm_i = (1 + tx_i)(1 + tm_i)\overline{Er}\;\overline{Pwm}_i$$

Local price for exports i

$$Pe_i = \overline{Er}\;\overline{Pwe}_i$$

Consumption price of composite good i

$$Pc_i = \left\{(1 + adj)[Pd_i D_i + Pm_i M_i]\right\} / Q_i$$

Production price of sector i

$$P_i = [Pl_i D_i + Pe_i EX_i] / XS_i$$

Production price of sector i (including taxes)

$$Pt_i = P_i/(1 + tpx_i)$$

Investment price index

$$Pinv = \prod_{good} (Pc_{good}/\mu_{good})^{\mu_{good}}$$

Public consumption price index

$$Pg = \sum_{serv} Pc_{serv}\, cg_{serv}$$

General price index

$$Pindex = \sum_i Pv_i\, \delta_i$$

5.2.8 International Trade

Relation between domestic sales (D) and exports (EX)

$$XS_i = B_i^e \Big\{ \Big[\beta_i^e EX_i^{\kappa_i^e} \Big] + \Big[(1 - \beta_i^e) D_i^{\kappa_i^e} \Big] \Big\}^{1/\kappa_i^e}$$

Export supply of sector i

$$EX_i = (Pe_i/Pl_i)^{\tau_i^e} \Big[(1 - \beta_i^e)/\beta_i^e \Big]^{\tau_i^e} D_i$$

Relation between imports and local production

$$Q_i = A_i^m \Big\{ \Big[\alpha_i^m M_i^{-\rho_i^m} \Big] + \Big[(1 - \alpha_i^m) D_i^{-\rho_i^m} \Big] \Big\}^{-1/\rho_i^m}$$

Imports demand for product i

$$M_i = (Pd_i/Pm_i)^{\sigma_i^m} \Big[(1 - \alpha_i^m)/\alpha_i^m \Big]^{\sigma_i^m} D_i$$

Current account balance

$$\begin{aligned} \overline{CAB} \quad = \quad & \sum_i \overline{Pwm}_i\, M_i + DIVROW - \sum_i \overline{Pwe}_i\, EX_i - \sum_h \overline{TRH}_h \\ & - \overline{TFROW} - \overline{TGROW} \end{aligned}$$

5.2.9 Equilibrium and Closures

Domestic absorption (goods)

$$Q_{good} = \sum_h C_{good,h} + DIT_{good} + INV_{good}$$

Domestic absorption (higher education)

$$Q_{edh} = DIT_{edh} + STUD_{edh}$$

Domestic absorption (basic education)

$$Q_{edb} = DIT_{edb} + \sum_h \overline{ED}_{edb,h} + \overline{G}_{edb}$$

Unskilled labor market equilibrium

$$\sum_h LU_h = \sum_i LDNQ_i$$

Skilled labor market equilibrium

$$\sum_h LSA_h = \sum_i LDQ_i$$

Investment-Savings equilibrium

$$IT = \sum_h SH_h + SF + Pindex\,\overline{SG} + \overline{Er}\,\overline{CAB}$$

5.2.10 Other

Equivalent variation (using the composite good providing utility)

$$\begin{aligned} EV_h \quad = \quad & \left[\prod_{ned}(Pco_{ned}/Pc_{ned})\right]^{\gamma_{ned,\,h}}\left[CTH_h - \sum_{ned}\varpi_{ned,\,h}Pc_{ned}\right] \\ & \left[CTHO_h - \sum_{ned}\varpi_{ned,\,h}Pco_{ned}\right] \end{aligned}$$

Verification of Walras' law

$$LEON = Q_{ser} - \sum_h C_{ser,\,h} - DIT_{ser} - G_{ser}$$

Objective function

$$OMEGA = 1000$$