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Vijay P. Ojha and **Joydeep Ghosh**

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Centre for International Trade and Development
School of International Studies
Jawaharlal Nehru University
India

Optimizing Public Expenditure Allocations between Secondary and Higher Education : A CGE Approach

Vijay P. Ojha[1]

Joydeep Ghosh[2]

Abstract

With a view to define a balance in the allocation of public expenditure across secondary education and higher education, we compare, in this paper, the relative contributions of public expenditures on secondary and higher education to growth as well as equity, employing a computable general equilibrium (CGE) model of India. Our policy simulations show that reducing allocations for secondary education and correspondingly increasing allocations of public education expenditure for higher education, produce monotonically decreasing growth and equity outcomes, if expansion of higher education does not foster technological progress. On the other hand, if higher education is well integrated with technological innovation, the former can become a powerful engine of inclusive growth. However, the growth and equity outcomes are not monotonically increasing with respect to expenditures on higher education when the latter is closely linked with technological innovation. Further, when higher education is a facilitator of technological innovation, the optimal allocation proportion for higher education in public educational spending is most likely to be within the range 40%-50%.

[1] Contact details of the corresponding author : Vijay P. Ojha, Guest Professor, Centre for International Trade and Development, JNU, New Delhi – 110067, India. Email: **vpojha@gmail.com** Tel. +91 9871256407, +91 120 3004364

[2] The co-author , Joydeep Ghosh is a Research Analyst at the International Food Policy Research Institute (IFPRI), New Delhi, India – 110001, India . Email : j.ghosh@cgiar.org

1. Introduction

The pivotal role played by education-based human capital in fostering economic growth has its origins in modern growth theory of the 1980s and 1990s which includes both the endogenous growth models (Romer, 1986, 1990; Lucas, 1988; Aghion and Howitt, 1998), and the extended neoclassical growth models (Mankiw, Romer & Weil, 1992; Nonneman & Vanhoudt, 1996). Specifically, the impact of various types or levels of education on economic growth has been intensively studied by several authors using the econometric methodology. Based on their findings, these studies could be divided in two disparate groups: one, in which there exists between higher education and economic growth either an insignificant relationship or one of reverse causality while primary and secondary levels of education have a positive and statistically significant causal effect on income growth (Pereira & St. Aubyn, 2007; Self & Grabowski, 2004; Self & Grabowski, 2003; Petrakis & Stamatakis, 2002; Asteriou & Agiomirgianakis, 2001), and, two, in which higher education has a significantly positive impact on economic growth, whereas primary and secondary education have insignificant - sometimes even negative - effects on growth (Kimenyi, 2011; Gyimah-Brempong, Paddison & Mitiku, 2006; Lin, 2004, Tilak, 2003; Agiomirgianakis, Asteriou & Monastiriotis, 2002; Chatterji, 1998)

Fortunately, the two dichotomous views emerging from these papers have not turned into an unending and irresolvable debate. Infact, in the copious literature on the linkage between higher education and economic growth, the seemingly divergent results get eminently reconciled by intuitively appealing and empirically plausible explanations of them offered by several researchers (Kimenyi, 2011; Gyimah-Brempong, Paddison & Mitiku, 2006; De Meulemeester and Rochat, 1995). According to these authors, higher education *per se* provides only a necessary but not a sufficient condition for income growth. Arguably, higher education has a significantly positive impact on economic growth when sufficiency is satisfied, but has an insignificant effect on income growth when sufficiency is unfulfilled. Whether the sufficiency condition is satisfied or not cannot be decided *a priori*; it has to be an empirical issue. And, the empirical evidence can go either way, as it does across different studies. So, what are the factors which make for sufficiency ? Evidently, very many. As pointed out by Gyimah-Brempong *et al* (2006), there prevails multiple indirect channels through which higher education stimulates income growth, such as, reducing social conflicts and strengthening social cohesion, enhancing political stability, increasing awareness about good health, boosting technological innovation and adoption. Influenced by the writings of Benhabib & Spiegel (1994), Hansen & Lehmann (2006), Bloom, Canning

& Chan (2002), and Fleisher, Li & Zhao, (2010), we identify the last one as the most proximate consequence of investment in higher education, without undermining its other impacts, for the purpose of this study.

The reconciliation in the debate over the relative growth impacts of primary and secondary education on one hand, and higher education, on the other hand, arguably in favor of the latter because of its virtuous spin-offs in terms of technological progress notwithstanding, a perpetual policy dilemma of how to define a balance in the allocation of public expenditure across primary/secondary education and higher education remains largely unexamined in the literature on the nexuses between the levels of education and economic growth.

In this paper, we analyze the relative efficacies of public expenditures on secondary and higher education in terms of inclusive growth, using a computable general equilibrium (CGE) model of India, with a view to compare policies for allocating public education expenditure across the different levels of education. A CGE model is ideally suited for tracing the economywide impact of a policy shock through the series of interlinked responses by economic agents that change the commodity and factor demands, their relative prices, and thereby the factor and personal incomes in a market economy. In our study, which aims at simultaneously determining the growth and distributional outcomes of public expenditures at different educational levels in a market-based economic system, the selection of a CGE model as the methodological tool is thus obvious. Typically, a CGE model is employed to build alternative policy scenarios. Prior to that, it is usually run first to outline what could be called the 'no-policy' or 'benchmark' scenario, but is conventionally referred to as the baseline or business-as-usual (BAU) scenario, against which the subsequent runs called the counterfactual policy scenarios are evaluated.

In this paper, three alternative policy scenarios with two variants each are developed. In all the three scenarios, the public education expenditure is augmented by 30% of the amount prevailing in the BAU scenario, but there are increasing allocations of this additional expenditure going into higher education in the successive scenarios. While in the first variant, the increases in expenditure on higher education have no impact on the rate of technological progress over time (which is provided for exogenously in the BAU scenario), in the second variant, they are allowed to expedite technological progress.

A caveat is worth mentioning at this stage. That is, in a tripartite skill classification of labor – skilled, semi-skilled and unskilled – the corresponding levels of education or lack of it are higher, secondary, and primary clubbed together with the non-educated respectively. We refrained from defining primary-educated labor as a distinct category (which could accord with, say, 'low semi-skilled labor') because it offered some respite in the ardous task of working through an already complex system of equations, and, because productivity and wage levels of primary-educated labor are not significantly higher compared to the non-educated labor in India. In any case, even the finest possible classification of labor skills cannot do away with heterogeneity of productivity levels within any particular skill category[3]. Instead, it will aggravate unnecessarily the computational burden and, at the same time, create interpretational difficulties. In short, a three-way classification of skills adopted in this paper is an optimal trade-off between complexity and practicality.

The rest of the paper is organized as follows. Section 2 presents a description of the model structure followed by a brief discussion on how the model works. Section 3 describes the main features of the BAU scenario. In section 4 we report the results of the two triplet policy scenarios in comparison with the BAU scenario. Section 5 concludes and suggests policy implications of the results.

2. Model structure

Our model is sequentially dynamic. That is, it is solved annually. Hence it consists of two interlinked parts : the intra-year multisectoral neoclassical type price driven CGE model, wherein each period, the economy begins with given endowments of physical capital and labor of three different types – unskilled (non-educated), semi-skilled (secondary-educated) and skilled (higher-educated), and the inter-year sub-model, in which stocks of physical capital and labor of three different types are updated. There is precedence for this kind of modeling in other earlier works on linkages between human capital and economic growth, such as, Ojha, Pradhan and Ghosh (2013) and Jung and Thorbecke (2003).

Physical capital is augmented by the exogenously given investment expenditure undertaken in the previous year's base CGE model. Likewise, labor stocks of different skill levels are augmented by the additional supply of skilled and semi-skilled labor, which in turn are functions of public education expenditure incurred at the two respective levels of education, and the workers' wage at a given skill level relative to workers' wage at the next lower level of skill in the previous period. There is a time lag associated with learning or acquisition of skills as the potential worker departing from the unskilled

[3] For instance, the skilled labor category encompasses a vast spectrum of workers ranging from graduates to doctorates and other highly qualified professionals

labor force pool has to spend some time in the educational pipeline before entering the pool of semi-skilled or skilled labor as the case maybe. Accordingly, an appropriate structure of lags has been built into the labor stock updating equations of our intertemporal sub-model. Finally, the incremental supply of unskilled labor is obtained residually from the total increase in labor force, which in turn is given by the increase in population multiplied by the labor participation rate. (The complete set of equations for the inter-year sub-model and intra-year CGE model described below are provided in Appendix A. Computationally, the model has been solved using the GAMS software with its PATH solver.)

The precursor models for our base CGE model are a standard CGE model (Robinson, Yunez-Nauda, Hinojasa-Ojeda, Lewis, Devarajan, 1999) and three India-specific CGE models by Mitra (1994), Ojha and Pradhan (2006), and Ojha, Pradhan and Ghosh (2013). In developing our own model, the approach has been eclectic, keeping in mind the focus of the paper and institutional features peculiar to the Indian economy. Moreover, the database has been revised, extended and updated as far as possible to meet the requirements of the present exercise.

Our model is based on the following 16-sector disaggregation of the Indian economy : agriculture, mining, fossil fuels, electricity, energy intensive industries, machinery, construction, other intermediates, consumer goods, other manufacturing, land transport, railways, other transport, medical and health services, education and research, services. Each sector produces its gross domestic output through a nested structure of leontief or constant elasticity of substitution (CES) aggregation functions of the factors of production which include intermediate inputs, capital, and labor of three different skill levels. (A diagrammatic representation of the nested production structure is given in Figure A.1). Substitution between skilled and semi-skilled labor are captured at the lowest level in a CES aggregator (Nest I) which produces what is referred to as "skilled-labor-composite". The latter, in turn, combines with unskilled labor in a CES function (Nest II) further up in the production structure, to form "composite labor". Above this nest, is the CES aggregator (Nest III) for value added which brings together composite labor and capital. At the top level of the production structure, gross domestic output is produced with the help of a leontief aggregator (Nest IV) for value-added and intermediates, signifying zero substitution between them. Producers in each sector behave as profit maximizers operating in perfectly competitive markets. They, therefore, take factor and tax inclusive output prices as given and generate demands for factors in consonance with cost minimization.

For international trade, the small-country assumption is made for all imports and exports. This implies that India is a price-taker and can import as much as it wants. Additionally, Armington assumption of imperfect substitutability between imported and domestic varieties of a good is made. Domestic absorption is met with composite output resulting from a CES aggregation of domestic sales of domestic output and imports. For exports, a downward sloping world demand curve is assumed. Moreover, a constant elasticity of transformation (CET) function is employed to distribute domestic output between domestic markets and foreign markets. It follows that the optimal ratio of imports to domestic sales and exports to domestic sales are determined by first order conditions based on respective relative prices.

Aggregate capital stock is fixed within a period, but is mobile across sectors so that there is a single market clearing return for capital which equates the sum of sectoral demands for capital to its given aggregate supply. Wages too adjust freely to equilibrate the demand and supply of labor which is fixed within a period, but movable across sectors, for each of the three types of labor.

Factor incomes emerge straight away in a CGE model as factor prices multiplied by the respective factor demands, but to address distributional issues the functional income distribution must be translated into a personal or a household income distrbution, within the CGE model. The translation of factor incomes into household incomes within a CGE model are typically guided by the sort of data that is made available in the Social Accounting Matrix (SAM) for the country under consideration. In case of India, almost all available SAMs (Pal, Pohit and Roy, 2012; Ojha, Pal, Pohit and Roy, 2009; Pradhan, Saluja and Singh, 2006) map the factor incomes generated in the Indian economy onto nine socio-economic groups: rural non-agricultural self-employed, rural agricultural labor, other rural labor, rural agricultural self-employed, other rural households, urban self-employed labor, urban salaried labor, urban casual labor, and other rural households. Households earn their income by vending the factors of production they own : labor (of three types) and capital. Initial values for the labor and capital endowment shares across the nine household groups were taken from Ojha, Pal, Pohit and Roy (2009) ; these initial shares were then adjusted for overall consistency within our own 16-sector 2006-07 SAM.

After deducting savings and direct taxes paid to the government, the households allocate their consumption expenditure across the 16 commodities through the Stone-Geary linear expenditure system (LES). To these sectoral consumption demands are added investment demands, government final demands, and, finally, intermediate demands based on leontief input-output coefficients and domestic output levels, to obtain sector-wise aggregate demands. For equilibrium in goods market aggregate demands are equated to composite goods supplies. Government is not an optimizer, but uses its taxes, transfers and expenditures as exogenous policy instruments.

Market clearing *relative* prices for commodities and factors of production (capital and labor of three different skill types) are determined within the CGE model in a Walrasian fashion. The consumer price index, which is normalized to unity, plays the role of a numeraire. Finally, the model is made to follow an investment-driven macro closure, in which the aggregate investment is exogenously fixed, and aggregate savings (i.e., the sum of household, government, corporate and foreign savings) adjusts to maintain the saving-investment equality.

2.1 How the model works

The nested production structure of our CGE model is particularly apposite for capturing productivity growth resulting from a boost in public expenditure on education. Additional investment in education leads to an increase in the supply of semi-skilled and skilled labor which in turn leads to an increased value for composite labor, resulting ultimately in higher value-added. Note that in the process of reallocation of labor of different skill levels over a period of time, there may be trade-offs involved. For example, an increase in supply of skilled and semi-skilled labor would entail a decrease of unskilled labor (when additional investment is made in education, as in policy scenarios 1(a) and 1(b), developed later in section 4), or, there may be an increase in the supply of skilled labor along with a decrease in supply of semi-skilled and unskilled labor (when higher education is increasingly prioritised over the secondary education, as in policy scenarios 2(a), 2(b), 3(a), 3(b) of section 4). The consequent net impacts of such trade-offs on composite labor and thereby on value-added (GDP) would most likely be favourable in the long-term, but may in certain cases be adverse in the short or medium term (as in policy scenario 3(a)).

The sectoral impact of an increase in educational investment would typically be an enhancement in the sectoral GDP shares of the skill intensive sectors, such as, ‘health’ ‘education’ and ‘other services’. As the structure of production shifts towards skill-intensive sectors, there is a relative decline in demand for non-educated labor. Further, enhancing investment in education leads to an increase in both demand and supply of secondary-educated and higher-educated labor. In case of the former, the demand-generating effect is weaker than the supply-augmenting effect, while, in case of the latter, the opposite is true. Hence, wages would fall for non-educated labor and secondary-educated labor, but, would rise for higher-educated labor. It follows that, wage inequality across the three labor types would most probably accentuate, and so would the personal income inequality because of the virtually monotonic relationship between it and the wage inequality. In short, with increased investment in education, the resulting growth is likely to be disequalizing, and the inequality would further sharpen if the additional investment is concentrated towards higher education .

However, when higher education facilitates technological innovation, adoption and diffusion, we capture the ensuing effects in our model through uniform total factor productivity (TFP) growth in all sectors. This provides equal scope for growth in all sectors. The growth pattern in this case would not reflect any bias towards sectors with higher capital intensity and/or skill intensity. Indeed, sectors which have a high share of unskilled labor in their primary input use, such as, 'agriculture', 'construction', 'consumer goods', and 'land transport' are likely to improve their shares in GDP (as compared to the two previous cases of expansion in higher education without any technological spillovers). And sectors which use more of capital and/or semi-skilled and skilled labor in their production process – e.g., 'health', 'education', 'other services', 'machinery' and 'energy-intensive industries', – suffer relative losses in their respective GDP shares. This would give fillip to the demand for unskilled labor, and dampen the demand for capital, skilled and semi-skilled labor in relative terms. There would, hence, be an increase in the relative wages of unskilled labor, and a decrease in the relative return to the other factors of production. Wage inequality and, consequently, personal income inequality, would then significantly decline. Hence, growth impelled by the spread of innovation-boosting higher education is likely to be substantially equalizing.

3. The baseline scenario

A SAM provides a snapshot of all the transactions in an economy at a given point of time. It also proxies for the benchmark equilibrium dataset needed for a CGE model. We constructed a 16-sector SAM for the Indian economy for the year 2006-2007 (hereinafter referred to as the year 2007) out of the 35-sector SAM for that year by Pal, Pohit and Roy (2012) by reaggregating their sectors but disaggregating their single labor into three different skill types of labor. As the required time-series and/or cross-sectional data for econometrically estimating the full set of parameters for a CGE model rarely exist, its parameterization is usually done by utilizing the information provided in a SAM, with supplementation by other sources which include independent but relevant econometric estimates – for our model these sources were, mainly, Upender (2009) and Stern (2009). Specifically, given the SAM dataset and elasticity coefficients of the production and aggregation functions, their shift and share parameters are calibrated in such a manner that the base-year CGE model solution replicates the SAM values. (The shift and share parameters along with the substitution elasticities of the production functions are shown in Table A.2). Finally, using a time series of exogenous variables and the inter-year sub-model, a sequence of equilibria for the time span, 2007-2030, is generated as the base-line scenario. Of the 24-year time period, the first five years, 2007-2012, is treated as the period to which historical validation applies, and the subsequent 18-year prospective period, 2013-2030, is the reference period for the policy experiments performed in the next section.

GDP growth in the 24-year time period, 2007-2030, declines from 7.51 percent per annum in the sub-period 1 (SP1), 2007-2012, to 5.18 percent per annum in sub-period 2 (SP2), 2013-2020, and rises again to 6.35 percent per annum in sub-period 3 (SP3), 2021-2030. The fluctuations in GDP growth after 2012 are accounted for mostly by the growth pattern of the three skill types of labor, as physical capital and TFP grow at constant rates through the 18-year prospective period (Table 2). On the one hand, decline in the employment of unskilled labor tends to dampen GDP growth; on the other hand, rise in the employment of skilled and semi-skilled labor is instrumental in enhancing GDP growth. While the former tendency is dominant, growth retards, but, ultimately, the latter propensity overtakes and growth accelerates. In short, growth in public education expenditure allocated across secondary and higher education in 70:30 proportions in the baseline scenario has its payoff in terms of growth enhancement in the long term, but not necessarily in the short-term.

The sectoral distribution of growth emerging in the BAU scenario is one in which skill-intensive manufacturing and services sectors expand their GDP shares, while those of the unskilled-labor-intensive sectors contract (Table A.1). This pattern of economic development in India is in concurrence with the findings of other analysts, such as, Kochhar, Kumar, Rajan, Subramanian & Tokatlidis (2006) and Bosworth, Collins & Virmani, (2007). This developmental pattern also has its ramifications for wage and income inequalities.

The skill intensive bias in the growth pattern of the Indian economy leads to notable inequality-augmenting outcomes. All the three indicators of inequality: (i) factor income shares (in GDP at factor cost) of the four primary factors of production, (ii) wage inequality ratios of four paired combinations of the four factors – W3/W1, W2/W1, W3/W2, W3/WK, and (iii) standard deviation of personal incomes (SDPI) across the nine household groups, show an almost steady rise in inequality over the three sub-periods (Table 6).

In short, the average growth rate of real GDP of 6.18 percent with increasing income inequality over the 24-year period in the BAU scenario is accounted for by three key growth drivers : (ii) physical capital investment, (ii) human capital investment, and (iii) gains in TFP. As we have seen above, TFP improvement is inequality-reducing. Even physical capital investment is inequality-mitigating[4]. But, human capital investment (especially investment in higher education) is inequality-augmenting, because it encourages a skill-intensive pattern of economic development. Curiously, it turns out to be the overriding force in the growth process of the Indian economy, causing growth to go hand in hand with a worsening income distribution. It is noteworthy that our BAU scenario of disequalizing growth is consistent with several other (non-CGE) studies analyzing the post-liberalization inequitable growth process of the Indian economy that have found human capital accumulation to be a key contributor to growth as well as its attendant inequity (Cain, Hasan, Magsombol, & Tandon, 2009; Pieters, 2009; Kijima, 2006; Kochhar *et al* , 2006) .

4. Policy scenarios

In line with the central objective of this paper to compare policies for different allocations of education expenditure across secondary and higher education, we develop three policy scenarios with two variants each for the period 2013-2030. In all the three scenarios, the public education expenditure is increased by 30% of the amount prevailing in the BAU scenario, but there are increasing allocations of this additional expenditure going into higher education in the successive scenarios. While in the first variant, the increases in expenditure on higher education have no impact on TFP growth over time, in the second variant, they accelerate the rate of growth in TFP. The source of finance is additional income tax in all the six policy scenarios which are summarized in Table 1.

Our simulations are designed for examining the consequences of the hypothesis that increased investment in higher education is not always productivity enhancing. If the thrust of higher education is not felt on technological innovation and adoption, it may produce only minor favorable impacts on

[4] We conducted two policy experiments, not reported in this paper, for increased physical capital investment with our model, and found them to be growth enhancing and also mildly inequality reducing.

growth and some adverse effects on income distribution. On the other hand, if educational policy proactivley attunes higher education toward yielding a technological dividend, there may be larger benefits on account of both growth and income distribution. Scenarios 1(a), 2(a), 3(a) are meant to capture the impacts for the former kind of policy, while scenarios 1(b), 2(b), 3(b) would assess the outcomes for the latter policy variant.

Table 1 : The Policy Scenarios

	Increase in education expenditure *w.r.t.* BAU Scenario	Secondary education / Higher education allocation ratio	Average annual increase in TFP *w.r.t.* BAU Scenario	Source of Finance
	(*in percent*)		(*in percentage points*)	
Scenario 1(a)	30.00	70 / 30	0.00	Additional income tax
Scenario 2(a)	30.00	60 / 40	0.00	Additional income tax
Scenario 3(a)	30.00	50 / 50	0.00	Additional income tax
Scenario 1(b)	30.00	70 / 30	0.10	Additional income tax
Scenario 2(b)	30.00	60 / 40	0.14	Additional income tax
Scenario 3(b)	30.00	50 / 50	0.19	Additional income tax

4.1 Policy scenarios 1(a), 2(a), 3(a)

The results in scenario 1(a) of a 30% increase in public education expenditure, with allocation proportions between secondary and higher education maintained at 70:30 as in the BAU scenario, are a substantiation of the expected outcome from additional investment in education outlined in section 2.1 on how the model works. For the 18-year period, there is an average annual decline in the usage of unskilled labor by 0.63%, but there is an average annual increase in the employments of semi-skilled labor and skilled labor by 1.29% and 1.94% respectively (Table 5). The resulting gains in GDP are on an average by 0.70% (Table 4). However, the difference in GDP gains over the medium run (SP2) and the long run (SP3) is noteworthy. In the medium run GDP increases by only 0.12%. while in the long run it increases by 1.12%. Further, it may be noted that these GDP gains arise even though the enhanced spending on higher education does not induce any TFP improvement.

As argued above, the increase in public spending on education orients the structure of production toward skill-intensive sectors sharpening the wage inequality and thereby the personal income inequality. Indeed, inequalities in scenario 1(a) show clear signs of aggravation. The factor income share of unskilled labor in 2030 decline significantly from 0.22 in BAU to 0.21 in this scenario. For semi-skilled labor factor income share in 2030 remains unchanged as compared to BAU scenario. However income share of skilled labor in that year rises from 0.19 in BAU scenario to 0.20 in this scenario. All the four wage inequality ratios increase steadily over the 18-year period, 2013-2030. SDPI also rises throughout the 18-year period. In 2030, it is 13277.57 in this scenario as compared to 12899.91 in BAU scenario (Table 6).

The income tax rate, which is made endogenous, increases to finance the additional human captal investment. This induces a restructuring of the saving-investment balance in the economy. With income growing in the economy, tax base for income and other taxes broaden leading to a rise in the government savings to GDP ratio and a decline in the household savings to GDP ratio. Ratios of foreign savings to GDP also decline marginally. There is thus no deterioration in either the fiscal balance or the external balance.

Table 2 : Growth rates of selected variables of the BAU scenario

Period	Total Factor Productivity (TFP) (*exogenous*)	Physical capital investment expenditure (*exogenous*)	Public Education Expenditure (*exogenous*)	LS_1	LS_2	LS_3	GDP
2007-2030	*2.00*	*6.19*	*4.24*	*4.03*	*1.48*	*2.02*	*6.18*
2007-2012 (SP1)	*2.00*	*11.61*	*4.85*	*6.83*	*0.90*	*0.59*	*7.51*
2013-2020 (SP2)	*2.00*	*4.00*	*4.00*	*4.36*	*1.63*	*2.09*	*5.18*
2021-2030 (SP3)	*2.00*	*4.00*	*4.00*	*2.37*	*1.64*	*2.07*	*6.35*

Table 3 : GDP in BAU and policy scenarios in selected years

	GDP (in billion Rupees)	*percentage diff. from BAU*					
Year	BAU	Sco. 1(a)	Sco. 2(a)	Sco. 3(a)	Sco. 1(b)	Sco. 2(b)	Sco. 3(b)
2013	62282.01	*0.05*	*0.05*	*0.05*	*0.14*	*0.17*	*0.20*
2020	95978.43	*0.45*	*0.23*	*-0.04*	*1.24*	*1.33*	*1.29*
2030	159042.69	*1.69*	*1.09*	*0.71*	*3.53*	*3.66*	*3.61*

Table 4 : GDP in policy scenarios in different periods

	average percentage diff. from BAU					
Period	Sco. 1(a)	Sco. 2(a)	Sco. 3(a)	Sco. 1(b)	Sco. 2(b)	Sco. 3(b)
2013-2030	*0.70*	*0.43*	*0.09*	*1.65*	*1.76*	*1.70*
2013-2020 (SP2)	*0.12*	*0.01*	*-0.11*	*0.55*	*0.62*	*0.63*
2021-2030 (SP3)	*1.16*	*0.76*	*0.24*	*2.53*	*2.67*	*2.56*

Table 5 : Labour stock in policy scenarios in different periods

	average percentage diff. from BAU								
	Scos. 1(a) and 1(b)			Scos. 2(a) and 2(b)			Scos. 3(a) and 3(b)		
	LS_1	LS_2	LS_3	LS_1	LS_2	LS_3	LS_1	LS_2	LS_3
2013-2030	*-0.63*	*1.29*	*1.94*	*-0.34*	*-1.01*	*4.66*	*0.01*	*-2.96*	*5.94*
2013-2020 (SP2)	*-0.29*	*0.37*	*0.32*	*-0.17*	*-0.38*	*1.11*	*0.04*	*-0.92*	*0.99*
2021-2030 (SP3)	*-0.90*	*2.02*	*3.25*	*-0.47*	*-1.52*	*7.49*	*-0.01*	*-4.58*	*9.91*

Table 6 : Inequality Indicators : Factor income shares, wage ratios, and SDPI's for BAU and policy scenarios

Year 2013							
	BAU	Sco. 1(a)	Sco. 2(a)	Sco. 3(a)	Sco. 1(b)	Sco. 2(b)	Sco. 3(b)
YL1	0.24	0.24	0.24	0.24	0.24	0.24	0.24
YL2	0.29	0.29	0.29	0.29	0.29	0.29	0.29
YL3	0.17	0.18	0.18	0.18	0.18	0.18	0.18
YK	0.30	0.29	0.29	0.29	0.29	0.29	0.29
W3/W1	8.99	9.19	9.19	9.19	9.19	9.19	9.19
W2/W1	4.58	4.61	4.61	4.61	4.61	4.61	4.61
W3/W2	1.96	1.99	1.99	1.99	1.99	1.99	1.99
W3/WK	9.62	9.83	9.83	9.83	9.83	9.82	9.82
SDPI	5099.56	5123.94	5123.94	5123.94	5117.85	5119.42	5120.59
Year 2020							
	BAU	Sco.1(a)	Sco.2(a)	Sco.3(a)	Sco. 1(b)	Sco. 2(b)	Sco. 3(b)
YL1	0.23	0.22	0.22	0.21	0.23	0.24	0.24
YL2	0.32	0.32	0.32	0.32	0.32	0.32	0.32
YL3	0.18	0.19	0.20	0.21	0.18	0.17	0.17
YK	0.27	0.27	0.26	0.26	0.27	0.27	0.27
W3/W1	9.09	9.16	9.90	9.93	7.48	7.86	8.29
W2/W1	6.11	6.16	6.52	6.59	5.95	6.11	6.38
W3/W2	1.66	1.74	1.87	1.96	1.58	1.67	1.77
W3/WK	15.69	15.88	15.97	16.11	15.59	15.76	16.01
SDPI	7890.54	7914.66	7941.45	7981.51	7898.74	7926.49	7961.32
Year 2030							
	BAU	Sco.1(a)	Sco.2(a)	Sco.3(a)	Sco. 1(b)	Sco. 2(b)	Sco. 3(b)
YL1	0.22	0.21	0.21	0.20	0.26	0.25	0.26
YL2	0.33	0.33	0.33	0.33	0.32	0.34	0.33
YL3	0.19	0.20	0.22	0.23	0.16	0.15	0.15
YK	0.26	0.26	0.24	0.24	0.26	0.26	0.26
W3/W1	10.14	10.25	10.83	10.97	9.98	10.05	10.26
W2/W1	6.57	6.58	6.67	7.10	6.08	6.65	7.07
W3/W2	1.38	1.42	1.58	1.86	1.04	1.16	1.36
W3/WK	20.58	20.61	21.06	22.28	16.81	17.83	18.12
SDPI	12899.91	13277.57	13391.16	13639.91	12596.45	12641.03	12784.13

Note : YL_1: Factor income share for unskilled labor, YL_2: Factor income share for semi-skilled labor,
YL_3: Factor income share for skilled labor, YK: Factor income share for capital,
W_1: Wage rate for unskilled labor, W_2: Wage rate semi-skilled labor,
W_3: Wage rate for skilled labor, W_K: Wage rate for capital,
SDPI : Standard deviation of personal incomes

In scenario 2(a), the share of higher education in the additional educational expenditure increases from 30 to 40%, and correspondingly the share of secondary education declines from 70% to 60%. Utilisation of unskilled labor and semi-skilled labor decline by 0.34% and 1.01% respectively, but there is a large increase of 4.66% in the utilisation of skilled labor (Table 5). The resulting impact on composite labor and thus on GDP gains (*w.r.t.* baseline scenario) is still positive but smaller than that in the previous scenario. Infact, as shown in Table 4, in the medium term (SP2) there is hardly any increase in GDP. Most of the increase in GDP comes about in the long term (SP3). The effect on income distribution is also adverse in comparison to baseline as well as the previous scenario. The factor income shares change in favor of skilled labor and against unskilled labor and capital. Wage inequality ratios rise systematically over the 18-year period. So does the SDPI (Table 6). Hence, enhanced spending on higher education at the cost of secondary education spending in scenario 2(a) leads to a clearly inferior outcome *vis-à-vis* scenario 1(a) in term of both growth and income distribution if higher education is not simultaneously catalyzing growth in TFP.

There is no evidence of a worsening of internal fiscal balance or external balance in scenario 2(a), as there is tad rise in government savings to GDP ratio, while both foreign savings relative to GDP and household savings relative to GDP decline slightly.

In scenario 3(a), the share of additional investment in education accruing to higher education is increased further to 50% , leaving only 50% for secondary education. With the employment of unskilled labor remaining more or less unchanged, the trade-off in the reallocation of labor operates between semi-skilled labor and skilled labor. Employment of the latter rises by 5.94%, while that of the former declines by 2.96% (Table 5). The net impact on GDP is marginal. It increases on an average by only 0.09% w.r.t. baseline scenario. Indeed, in the medium term there is a GDP loss of 0.11%, which is outweighed by a gain in GDP in the long term of 0.24% (Table 4). All the inequality indicators point to a worsening income distribution as compared to the BAU and the two previous scenarios (Table 6).

Overall for the 18-year period, 2013-2030, even scenario 3(a) does not show any siginificant deterioration for the fiscal balance or the external balance, as the ratios of government savings, household savings and foreign savings with respect to GDP remain more or less unchanged in comparison to those in the BAU scenario.

It follows that, increasing allocations of the additonal educational investment toward higher education *vis-à-vis* secondary education in the absence of any induced technological improvement lead to smaller GDP gains and sharper income inequalities. Scenario 1(a) which allocates only 30% of the additional public education spending to higher education (and remaining 70% to secondary education) is the best, followed by scenario 2(a) in which higher education gets 40% share, and, lastly, there is scenario 3(a) in which the share of higher education is 50%.

4.2 Policy scenarios 1(b), 2(b), 3(b)

In the second variant of the three policy scenarios discussed above – i.e., scenarios 1(b), 2(b) and 3(b) – higher education policy is assumed to be so focused as to lead to an acceleration of technological progress (Grossmann, 2007; .Eid, 2012). In the absence of any precise empirical estimate for the impact of higher education expenditure on the rate of technological progress in India, we resorted to using the econometric estimate of the proportion of higher-educated workers in the population on TFP growth provided by Fleisher *et al* (2010) for a comparable country, namely, China. Since, the effects of expenditure on higher education education in our model also are basically transmitted through an increase in the proportion of higher-educated workers in the population, the estimate of Feisher *et al* (2010) could easily be adapted for use in our simulations. The customized estimates for the average annual increase in TFP growth for increased allocations of additional educational expenditure going into higher education as against secondary education are given in Table 1.

In scenario 1(b), the increase in educational spending is allocated between secondary and higher education in the ratio 70:30 as in scenario 1(a), but the augmented investment in higher education stimulates an average annual increase in TFP growth of 0.10 percentage point. This results in a significant improvement in GDP gains. In scenario 1(a) the average annual increase in GDP for the 18-year period was 0.70%, while in this scenario it is 1.65%. Further, as shown in Table 4, the improvement in GDP gains is larger in the long run (SP3) than in the short run (SP2).

With TFP improvement impacting all sectors equally in scenario 1(b), the skill-intensive bias featured in the growth pattern of the scenarios 1(a), 2(a) and 3(a) stands corrected, and there is therefore a more balanced growth across all sectors including the unskilled labor intensive ones in this scenario. Income inequality in this scenario 1(b) thus shows distinct signs of mitigation. The factor income share of unskilled labor in 2030 rises markedly from 0.22 in BAU (and 0.21 in scenario 1(a)) to 0.26 in scenario 1(b). At the same time, income shares of both semi-skilled labor and skilled labor decline – that of the former marginally, while that of the latter substantially. All the four wage inequality ratios increase consistently over the 18-year period, 2013-2030. SDPI rises marginally in the medium run but, declines eventually in the long run. In 2030, it is 12596.45 in this scenario as compared to 12899.91 in BAU scenario (Table 6).

In scenario 2(b), the increase in public spending on education is allocated between secondary and higher education in the 60:40 proportions as in scenario 2(a). However, unlike in scenario 2(a), in this scenario expansion in higher education induces an average annual increase in TFP growth of 0.14 percentage point, which makes all the difference to the growth and distributional outcomes. In comparison to scenario 2(a), there is a large increase in GDP gains in this scenario. In scenario 2(a) the average gain in GDP over the 18-year period was 0.43%, while in this scenario the average gain is 1.76% (Table 4). In income distribution also there comes about a substantial improvement in this scenario – both when compared to BAU and *vis-à-vis* scenario 2(a). In general, the factor income shares of skilled labor decline, while those of semi-skilled and unskilled labor rise. The other two inequality indicators – wage inequality ratios and SDPIs – show a consistent decline throughout the 18-year period (Table 6).

In scenario 3(b), the additional public expenditure on education is allocated between secondary and higher education in the 50:50 proportions as in scenario 3(a), and over and above there is simultaneous increase in TFP growth of 0.19 percentage point due to the resulting augmentation in higher education. Both growth and distributional outcomes in this scenario are vastly superior in comparison to those in scenario 3(a). Average GDP gains over BAU increase from 0.09% in scenario 3(a) to 1.70% in scenario 3(b). In the medium run, there was a GDP loss of 0.11% in scenario 2(a), which converts into a GDP gain of 0.62% in this scenario (Table 4). In the long run there are even greater gains for GDP – i.e., of 2.67% in this scenario as against 0.24% in the scenario 3(a). Income inequality is much less acute in scenario 3(b) in comparison to scenario 3(a), as shown by all the inequality indicators. Income shares for unskilled labor increase at the cost of those for skilled labor. Moreover, wage inequality ratios and SDPIs are consistently lower in the former scenario (Table 6).

At the same time, in a comparison across the three scenarios, 1(b), 2(b) and 3(b), we find that scenario 2(b) shows better results than scenario 1(b) in terms GDP gains, but worse results for income distribution. However, in scenario 3(b) the GDP gains are marginally smaller than those in scenario 2(b), while inequality worsens in comparison to the latter scenario (Table 6).

The saving-investment readjustment process in this set of three scenarios – 1(b), 2(b) and 3(b) - work essentially in the same manner as in the previous set of three scenarios - (1(a), 2(a) and 3(a) . That is, government savings to GDP ratio rise because of the increase in the income tax rate and the broadening of the tax base, but the household savings to GDP ratio decline. On foreign savings to GDP ratio, there is hardly any impact. Evidently, there is no deterioration in the internal fiscal balance or the external balance resulting from the enhanced public spending on education.

Finally, in a comparison of our two triplet scenarios, it is worth noting that while in the scenarios 1(a), 2(a) and 3(a), the growth and equity outcomes are monotonically decreasing with respect to expenditures on higher education, in the scenarios 1(b), 2(b) and 3(b), the reverse is not true. That is, the growth and equity outcomes in the latter set of three scenarios are not monotonically increasing with respect to expenditures on higher education. The monotonicity in the latter case is lost due to the coexistence of TFP growth and higher education, which makes them joint determinants of the consequences for growth and income distribution.

5. Conclusions and policy implications

While the linkage between human capital formation and economic growth is by now well established, the issue of how to define a balance in the allocation of resources between secondary and higher education remains a contentious one. There are two aspects of this education policy debate in India. One aspect of this debate is about shifting of the expenditure burden of higher education from the public sector onto the private sector using the argument that the limited fiscal capacity of public sector if unduly stretched to finance the expansion of higher education would *crowd out* the 'more important' secondary education. This argument is not entirely justified as it is based on two questionable but somewhat related assumptions, namely, more financial resources for investing in both secondary and higher education are not fiscally manageable, and, secondary education is more beneficial for growth and equity than higher education - and yet it seems to have dominated recent policymaking for higher education in India (Tilak, 2013; Tilak, 2007).

Our policy scenarios show that additional public spending financed through increased income taxes may not be fiscally disruptive. Moreover, secondary education does not necessarily foster growth and equality more strongly than higher education. On the contrary, it is possible to reap larger benefits for growth and income distribution through increased allocations for higher education in additional public education spending upto a point, provided higher education is conducive to innovation. In other words, our scenarios incorporate and examine equally the second aspect of the secondary vs. higher education debate - which in our view is the kernel of the debate – that is, how to circumvent the trade-off between secondary and higher education while investing in education.

Scenarios 1(a), 2(a) and 3(a), clearly demonstrate that reducing allocations for secondary education and correspondingly increasing allocations of public education expenditure for higher education, produce monotonically decreasing growth and equity outcomes, if expansion of higher education does not catalyze TFP growth. Interestingly, these scenarios do seem to reflect fairly accurately the current crisis prevailing in higher education in India. As pointed out by Krishna (2013), the root cause of this crisis lies in the extremely weak link between higher education and research and development (R&D) in India. According to him, almost 85% of the Indian universities remain mere teaching institutions that have not yet integrated teaching with research which has the potential of fostering all-round economic development. Under such circumstances, spread of higher education produces only minor GDP growth gains and that too with a likely deterioration in income distribution. It is not surprising then that expanding higher education at the cost of secondary education generates inferior outcomes in terms of both growth and income distribution.

On the other hand, if higher education is well integrated with R&D, the former can become a more potent driver of inclusive growth than secondary education, as shown by scenarios 1(b), 2(b) and 3(b). Each of these scenarios show a large improvement for growth as well as equity when compared to the corresponding scenario in the previous variant with no technological spillovers from the expansion of higher education. Furthermore, in a comparison across the scenarios 1(b), 2(b) and 3(b), we find that progressively increasing allocations of additional public spending on education toward higher education do not lead to monotonically better outcomes for growth and equity. Scenario 2(b), with 60:40 public spending allocation proportions for secondary and higher education, exceeds scenario 1(b), in which the allocation proportions are 70:30, in terms of growth performance, but churns out a mildly more unequal income distribution in comparison to the latter scenario. Scenario 3(b) with 50:50 public education expenditure allocation ratios for secondary and higher education, however, produces slightly smaller GDP gains and somewhat greater income inequality. In other words, even when higher education is closely bound up with technological innovation and adoption, the optimal allocation proportion for higher education in public educational spending is most likely to be within the range 40%-50%.

That our simulations as they stand are only suggestive is obvious. They have been deliberately and modestly designed to be so. The underlying objective is to underscore, what we may call, the *lower bound* in educational policy efforts – represented by scenarios 1(a), 2(a) and 3(a) – and, at the same time, inform policymakers about the direction in which lies the scope for improvement – as shown by the scenarios 1(b), 2(b) and 3(b). And, the broad policy conclusion which emerges is that enhanced allocations for higher education in public education expenditure are rewarding in terms of inclusive growth only if there is an increase in R&D intensity associated with the spread of higher education. India's developmental achievements through innovation in knowledge intensive sectors notwithstanding, there remains enormous potential for amplifying the thrust of higher education on innovation in non-tertiary sectors, such as, various types of manufacturing and agriculture. The government of India is already active in this policy area as is evinced, inter alia, in the work being done by National Knowledge Commision (Government of India, 2007). But there is a long tortuous road ahead, before the goalpost of inclusive growth is reached.

Finally, two limitations of this study which could stimulate future research deserve a mention. First, in our latter set of triplet scenarios. higher education is assumed to spur uniform TFP improvement across all sectors. Second, the technological progress facilitated by the spread of higher education is necessarily of the Hicks-neutral type. In reality, technological innovation is not likely to be occuring evenly and simultaneously across all sectors. Instead there would be dissimilar TFP growth rates across sectors materializing presumably in response to imperfect market signals and to extant policy priorities, which could well be warped in favor of capital and/or skill intensive sectors in an economy like India with abundance in unskilled labor. Moreover, real world is replete with examples of non-neutral technologies – ones that are biased in favor of capital and skilled labor rather than unskilled labor. In other words, these two assumptions do not square well with reality, and yet we have employed them. The aim is to set a benchmark against which plausible real-world policies for promoting neutral and non-neutral technological progress selectively in certain sectors can be compared, thus, providing motivation for future research to identify key sectors and the type of technological progress therein that would enhance both growth and its inclusiveness.

Appendix A

CGE Model Equations

<u>Nested Production Structure</u>

Nest I

$$SLC_i = as_{3i} \left[\lambda_{3_i} LL2_i^{\rho_{3i}} + (1-\lambda_{3_i}) LL3_i^{\rho_{3i}}\right]^{1/\rho_{3_i}} \quad (A.1)$$

$$LL2_i = LL3_i \left[\left(\frac{WLL3}{WLL2}\right) \left(\frac{\lambda_{3i}}{1-\lambda_{3i}}\right) \right]^{1/(1-\rho_{3_i})} \quad (A.2)$$

$$WSLC_i * SLC_i = WLL2 * LL2_i + WLL3 * LL3_I \quad (A.3)$$

Nest Ii

$$CL_i = as_{2i} \left[\lambda_{2_i} LL1_i^{\rho_{2i}} + (1-\lambda_{2_i}) SLC_i^{\rho_{2i}}\right]^{1/\rho_{2_i}} \quad (A.4)$$

$$LL1_i = SLC_i \left[\left(\frac{WSLC_i}{WLL1}\right) \left(\frac{\lambda_{2i}}{1-\lambda_{2i}}\right) \right]^{1/(1-\rho_{2i})} \quad (A.5)$$

$$WCL_i * CL_i = WLL1 * LL1_i + WSLC_i * SLC_i \quad (A.6)$$

Nest III

$$VA_i = as_i \left[\lambda_i CL_i^{\rho_{1i}} + (1-\lambda_i) K_i^{\rho_{1i}}\right]^{1/\rho_{1_i}} \quad (A.7)$$

$$CL_i = K_i \left[\left(\frac{WK_i}{WCL_i}\right) \left(\frac{\lambda_i}{1-\lambda_i}\right) \right]^{1/(1-\rho_{1i})} \quad (A.8)$$

$$PVA_i * VA_i = WLL1 * LL1_i + WLL2 * LL2_i + WLL3 * LL3_i + WK_i * K_i \quad (A.9)$$

Nest IV

$$VA_i = iva_i * X_i \qquad (A.10)$$

$$QINTA_i = inta_i * X_i \qquad (A.11)$$

$$PX_i * X_i * (1-exct_i) = PVA_i * VA_i + PINTA_i * QINTA_i \qquad (A.12)$$

$$PINTA_i = \sum_j PQ_j * a_{ji} \qquad (A.13)$$

Constant Elasticity of Transformation Function for Distibution of Domestic Output

$$X_i = cet_i \left[\lambda c_i EXP_i^{\rho c_i} + (1 - \lambda c_i) DS_i^{\rho c_i}\right]^{1/\rho c_i} \qquad (A.14)$$

$$EXP_i = DS_i \left[\left(\frac{PEX_i}{PD_i} \right) \left(\frac{\lambda_{c_i}}{1-\lambda_{c_i}} \right) \right]^{1/(1-\rho c_i)} \qquad (A.15)$$

$$PX_i * X_i = PEX_i * EXP_i + PD_i * DS_i \qquad (A.16)$$

$$PEX_i = PWE_i * ER \qquad (A.17)$$

$$EXP_i = exs_i * (pwes_i / PWE_i)^{\varepsilon_i} \qquad (A.18)$$

Armington Aggregation of Imports and Domestic Sales

$$Q_i = arm_i \left[\lambda a_i IMP_i^{\rho a_i} + (1 - \lambda a_i) DS_i^{\rho a_i}\right]^{1/\rho a_i} \qquad (A.19)$$

$$IMP_i = DS_i \left[\left(\frac{PM_i}{PD_i (1+salt_i)} \right) \left(\frac{\lambda_{a_i}}{1-\lambda_{a_i}} \right) \right]^{1/(1-\rho_{a_i})} \qquad (A.20)$$

$$PQ_i * Q_i = PM_i * IMP_i + PD_i * (1+ salt_i) * DS_i \qquad (A.21)$$

$$PM_i = pwm_i * (1 + tarf_i) * ER \qquad (A.22)$$

Incomes

$$Y_h = WLL3 * end_{h,LL3} + WLL2 * end_{h,LL2} + WLL2 * end_{h,LL2} + fk_h * WK * K \qquad (A.23)$$

$$YD_h = Y_h (1- inct_h) + fg_h * trnfg * PINDEX + trnfw_h * ER \qquad (A.24)$$

$$HS_h = sav_h * YD_h \qquad (A.25)$$

$$CORPDI = (1- corpt) * [fk_{corp} * \sum_i (WK_i * Ki)] + fg_{corp} * trnfg * PINDEX \qquad (A.26)$$

$$CORPSAV = CORPDI \qquad (A.27)$$

$$PUBDI = fk_{pub} * \sum_i (WK_i * Ki) \qquad (A.28)$$

$$\begin{aligned} TAXREV = & \sum_h inct_h * Y_h + \\ & corpt * [fk_{corp} * \sum_i (WK * \overline{K})] + \sum_i PX_i * X_i * exct_i + \\ & \sum_i PD_i * DS_i * salt_i + \sum_i IMP_i * pwm_i * ER * tarf_i \end{aligned} \qquad (A.29)$$

$$GREV = TAXREV + fk_{gov} * \sum_i (WK_i * K_i) + trnfw_{gov} * ER \qquad (A.30)$$

Expenditures

$$C_{h,i} = minc_{h,i} + (\gamma_{h,i} / PC_i) * [(YD_h - HS_h) – (\sum_i PC_i * minc_{h,i})] \qquad (A.31)$$

$$INVDT_i = pukv_i * pubinv + prkv_i * prinv \qquad (A.32)$$

$$ID_i = ad_i * (pubinv + prinv) + cst_i \ ; \qquad (A.33)$$

$$AD_i = \sum_h C_{h,i} + ID_i + cg_i + \sum_j a_{ij} * QINTA_j \qquad (A.34)$$

$$GEXP = trnfg * PINDEX + \sum_i PC_i * cg_i \qquad (A.35)$$

Equilibria in Factor Markets

$$\sum_i LL1_i = LS_1 \qquad (A.36)$$

$$\sum_i LL2_i = LS_2 \qquad (A.37)$$

$$\sum_i LL3_i = LS_3 \qquad (A.38)$$

$$\sum_i K_i = \overline{K} \qquad (A.39)$$

Equilibria in Commodity Markets

$$Q_i = AD_i \qquad (A.40)$$

Savings and Investment

$$GS = GREV + PUBDI - GEXP \qquad (A.41)$$

$$FSD = \sum_i (pwm_i * IMP_i) + [fk_{row} * (WK * \overline{K})] / ER - \sum_i (pwe_i * EXP_i)$$

$$- \sum_h trnfw_h + trnfw_{gov} \qquad (A.42)$$

$$TS = \sum_h HS_h + CORPSAV + GS + FSD * ER \qquad (A.43)$$

$$TS = \sum_i PQ_i * ID_i \qquad (A.44)$$

$$PINDEX = \sum_i \alpha_i * PC_i \qquad (A.45)$$

$$RGDP = [\sum_i PVA_i * X_i] / PINDEX \qquad (A.46)$$

Inter-year Sub-model Equations

$$\overline{K}_{(t+1)} = \overline{K}_t * (1\text{-dp}) + \sum_i \text{INVDT}_i \quad (A.47)$$

$$MS_{mt} = \beta_1^m * (ged_{mt})^{\rho m} + \beta_2^m * (W_{m\,(t-1)} / W_{1\,(t-1)}) * [\,1 + G_{(t-1)}\,] \,/\, [\,1 + r_{(t-1)}\,] \quad (A.48)$$

$$ML_{3\,t} = MS_{3\,t-5} \quad (A.49)$$

$$ML_{2\,t} = MS_{2\,t-3} - MS_{3\,t-3} \quad (A.50)$$

$$ML_{1\,t} = n * \Delta P_t + \left(\sum_{l=1}^{3} dh_l\, LS_{l\,t}\right) - (ML_{2\,t} + ML_{3\,t}) \quad (A.51)$$

$$LS_{l\,(t+1)} = LS_{l\,t}\,(1 - dh_l) + ML_{l\,t} \quad ; \quad \text{for } l = 1,2,3\,. \quad (A.52)$$

Notations:

Endogenous variables

AD_i	aggregate demand
DS_i	domestic sales
$C_{h,i}$	consumption demand of commodity ‘i’ by household group ‘h’
CORPDI	private corporate sector disposable income
CORPSAV	private corporate sector savings
CL_i	composite labour
EXP_i	exports
ER	exchange rate
FSD	foreign savings in dollars
GREV	government (total) revenue
GEXP	government (total) expenditure
GS	government savings
G	growth rate of the economy (GDP)

HS_h	household savings by household group h
ID_i	real investment demand by sector of origin
$INVDT_i$	real investment by sector of destination
IMP_i	imports
K_i	demand for capital in sector i
LL1	demand for lablour level 1 (non-educated labour)
LL2	demand for lablour level 1 (secondary-educated labour)
LL1	demand for lablour level 1 (higher-educated labour)
LS_l	labour supply of educational level 'l' , l = 1,2,3.
MS_m	output flow of labour of educational level 'm' , m= 1,2,3.
ML_m	new labour supply of educational level 'm' , m= 1,2,3.
PQ_i	price of composite good
PD_i	price of domestic sales
PEX_i	export price in rupees
$PINTA_i$	aggregate intermediate input price for commodity i
PWE_i	export price in dollars
PM_i	import price in rupees (inclusive of tariffs)
PX_i	producer's price
PINDEX	overall price index
PVA_i	value-added price
PUBDI	public sector disposable income
Q_i	composite commodity
$QINTA_i$	quantity of aggregate intermediate input for production of one unit of commodity i
RGDP	real GDP
SLC_i	skilled labour composite
TAXREV	tax revenue of the government
WLL1	wage for labour of educational level 1 (non-educated labour)
WLL2	wage for labour of educational level 2 (secondary-educated labour)
WLL3	wage for labour of educational level 3 (higher-educated labour)
$WSLC_i$	wage for skilled labour composite

WCL_i	wage for composite labour
WK	rental rate for capital
X_i	gross domestic output in sector i
Y_h	income of household group h
YD_h	disposable income of household group h

Exogenous variables and parameters

as_i	shift parameter in production function for domestic output
$as2_i$	shift parameter in aggregation function for composite labour
$as3_i$	shift parameter in aggregation function for skilled labour composite
arm_i	shift parameter in Armington function for imports and domestic demand
a_{ij}	quantity of commodity i used as intermediate input in production of one unit of commodity j
α_i	weight in the price index (share of value added of commodity i)
β_1^m	responsiveness of output flow of labor of education level 'm' to the public education expenditure at level 'm'
β_2^m	responsiveness of output flow of labor of education level 'm' to the wage differential between labor of education levels 'm' and 'l'
cet_i	shift parameter in CET function for export demand and domestic demand
cg_i	real government consumption
corpt	corporate tax rate
cst_i	change in stocks in sector i
ad_i	share of investment by sector of origin
dh_l	depreciation rate of human capital
dp	depreciation rate of physical capital
$exct_i$	excise tax rate
exs_i	scale factor in the export demand function
ε_i	export demand elasticity

fg_h	share of government transfer to household group 'h'
fg_{corp}	share of government transfer to the corporate sector
fk_h	share of capital income to accruing to household group h
fk_{corp}	share of capital income accruing to corporate sector
fk_{pub}	share of capital income accruing to public sector
fk_{gov}	share of capital income accruing to government
fk_{row}	share of capital income accruing to rest of world (row)
ged_l	government education expenditure at education level 'l'
$\gamma_{h,i}$	marginal budget share of good 'i' for household group 'h'
$inct_h$	income tax rate for household group 'h'
iva_i	quantity of value-added per unit of output of commodity i
$inta_i$	quantity of aggregate intermediate input per unit of output of commodity i
λ_i	factor share parameter in production function for domestic output
$\lambda 2_i$	factor share parameter in in aggregation function for composite labour
$\lambda 3_i$	factor share parameter in in aggregation function for skilled labour composite
λa_i	share parameter in Armington function for imports and domestic demand
	λc_i share parameter in CET function for export demand and domestic demand
$minc_{h,i}$	minimum real consumption parameter for household group 'h'
n	labour participation rate
P	population
pwm_i	world price of imports in dollars
$pwes_i$	world price of export substitutes (in dollars)
prinv	total private real investment
pubinv	total public real investment
$prkv_i$	share of private investment by sector of destination
$pukv_i$	share of public investment by sector of destination
r	discount rate
ρ_{1i}	substitutability parameter in production function for domestic output
ρ_{2i}	substitutability parameter in aggregation function for composite labour
ρ_{3i}	substitutability parameter in aggregation function for skilled labour composite

ρ_{ai}	substitutability parameter in Armington function for imports and domestic demand
ρ_{ci}	substitutability parameter in CET function for export demand and domestic demand
ρ^m	‘efficiency’ of public education expenditure at level ‘m’
$salt_i$	sales tax rate
sav_h	savings-income ratio of household group ‘h’
$tarf_i$	import tariff rate
trnfg	real transfer from government
$trnfw_h$	transfer from rest of the world to household group ‘h’ in dollars
$trnfw_{gov}$	transfer from rest of the world to government in dollars

Figure A.1 : Nested Production Structure

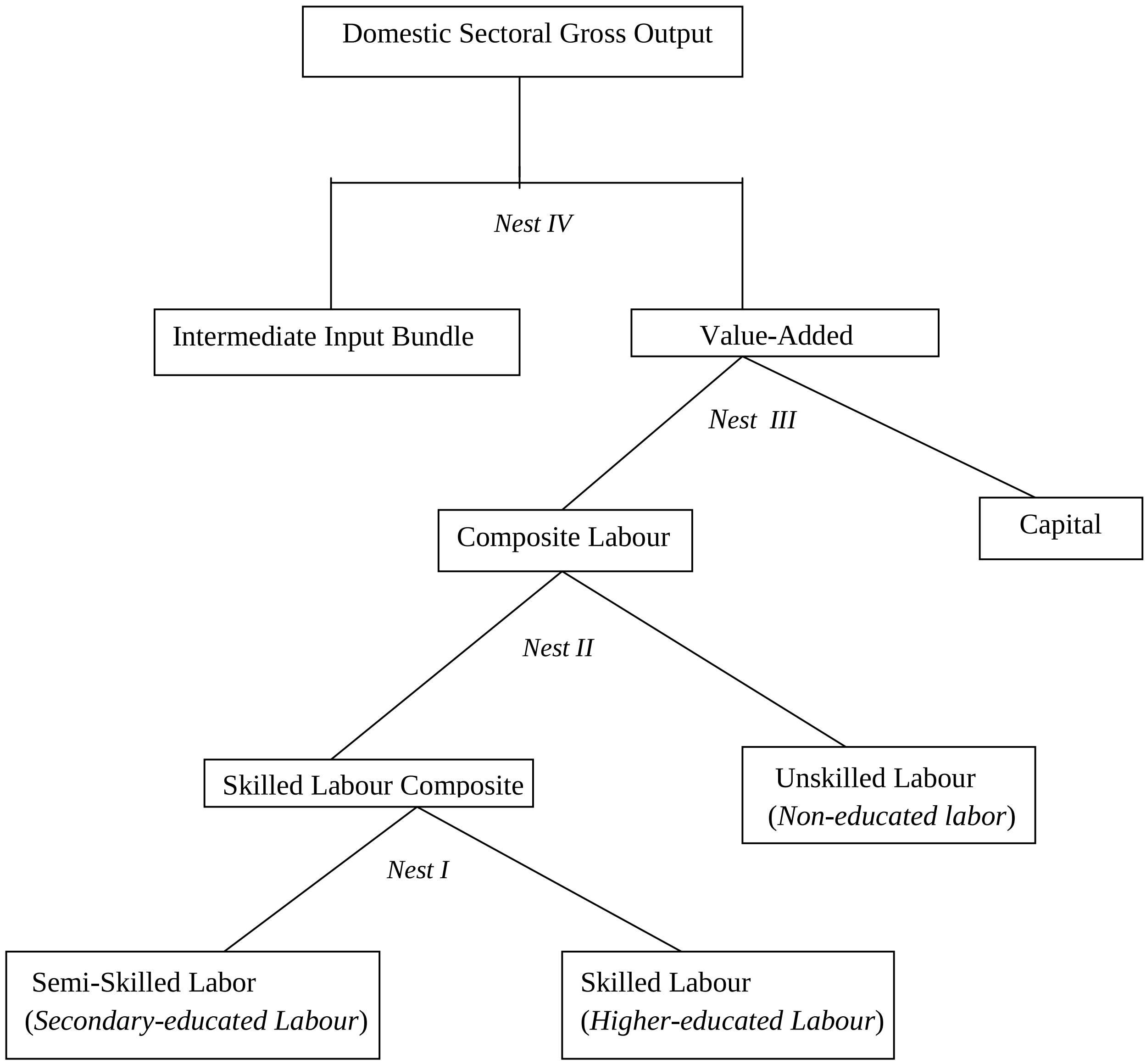

Table A.1 : Sectoral shares of GDP (at factor cost) in the baseline scenario

	SP1		SP2		SP3	
	2007	**2012**	**2013**	**2020**	**2021**	**2030**
Agriculture	0.239	0.211	0.211	0.210	0.210	0.207
Mining	0.018	0.013	0.013	0.013	0.013	0.013
Fossil Fuels	0.009	0.007	0.007	0.006	0.006	0.006
Electricity	0.012	0.013	0.013	0.014	0.014	0.015
Energy Intensive Industries	0.041	0.031	0.031	0.029	0.030	0.027
Machinery	0.016	0.017	0.017	0.018	0.018	0.019
Construction	0.077	0.069	0.067	0.059	0.058	0.047
Other Intermediates	0.007	0.005	0.005	0.005	0.005	0.006
Consumer Goods	0.055	0.055	0.056	0.057	0.057	0.058
Other Manufacturing	0.022	0.018	0.018	0.016	0.015	0.014
Land Transport	0.044	0.046	0.046	0.048	0.048	0.049
Railways	0.009	0.009	0.009	0.009	0.009	0.010
Other Transport	0.004	0.004	0.004	0.004	0.004	0.005
Health	0.016	0.020	0.020	0.022	0.022	0.024
Education and Research	0.027	0.036	0.036	0.039	0.039	0.043
Other services	0.404	0.446	0.447	0.451	0.452	0.457

Table A.2 : Shift and share parameters and the Substitution elasticities of the production functions within the nested production structure

Nest I				
	Shift parameter	**Share parameter of semi-skilled labor**	**Share parameter of skilled labor**	**Substitution Elasticities within Nest I**
Agriculture	1.020	0.999	0.001	0.670
Mining	1.836	0.772	0.228	0.670
Fossil Fuels	1.708	0.836	0.164	0.670
Electricity	1.986	0.659	0.341	0.670
Energy Intensive Industries	1.616	0.873	0.127	0.670
Machinery	1.629	0.868	0.132	0.670
Construction	1.889	0.739	0.261	0.670
Other Intermediates	1.707	0.837	0.163	0.670
Consumer Goods	1.738	0.823	0.177	0.670
Other Manufacturing	1.486	0.915	0.085	0.670
Land Transport	1.695	0.842	0.158	0.670
Railways	1.704	0.838	0.162	0.670
Other Transport	1.725	0.829	0.171	0.670
Health	1.909	0.273	0.727	0.670
Education and Research	1.909	0.273	0.727	0.670
Other services	1.887	0.741	0.259	0.670

Nest II				
	Shift parameter	**Share parameter of skilled labor composite**	**Share parameter of unskilled labor**	**Substitution Elasticities within Nest II**
Agriculture	1.332	0.027	0.973	0.530
Mining	1.759	0.138	0.862	0.530
Fossil Fuels	2.103	0.575	0.425	0.530
Electricity	1.941	0.775	0.225	0.530

Energy Intensive Industries	2.099	0.571	0.429	0.530
Machinery	2.099	0.573	0.427	0.530
Construction	1.792	0.151	0.849	0.530
Other Intermediates	1.984	0.271	0.729	0.530
Consumer Goods	1.987	0.272	0.728	0.530
Other Manufacturing	2.103	0.526	0.474	0.530
Land Transport	2.116	0.495	0.505	0.530
Railways	2.116	0.496	0.504	0.530
Other Transport	2.117	0.500	0.500	0.530
Health	1.620	0.920	0.080	0.530
Education and Research	1.619	0.921	0.079	0.530
Other services	1.928	0.778	0.222	0.530
Nest III				
	Shift parameter	**Share parameter of composite labor**	**Share parameter of capital**	**Substitution Elasticities within Nest III**
Agriculture	1.790	0.543	0.457	0.780
Mining	1.642	0.290	0.710	0.960
Fossil Fuels	1.143	0.063	0.937	0.960
Electricity	1.460	0.167	0.833	0.910
Energy Intensive Industries	1.726	0.330	0.670	0.910
Machinery	1.782	0.386	0.614	0.819
Construction	1.645	0.713	0.287	0.910
Other Intermediates	1.681	0.309	0.691	0.910
Consumer Goods	1.793	0.443	0.557	0.910
Other Manufacturing	1.786	0.401	0.599	0.910
Land Transport	1.804	0.537	0.463	0.590
Railways	1.790	0.427	0.573	0.590
Other Transport	1.799	0.565	0.435	0.590
Health	1.876	0.576	0.424	0.590

Education and Research	2.827	0.600	0.400	0.590
Other services	2.178	0.527	0.473	0.590

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