RESEARCH ARTICLE

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General Equilibrium Effects of Investments in Education and Changes in the Labor Force Composition

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ABSTRACT

In this paper, a novel approach to modelling education and human capital formation in a computable general equilibrium model is proposed. Rather than adopting microeconomic-based assumptions of human capital formation, the method is based on an empirical relationship between labor force composition and expenditure on education services. It is found some robust correlation between workers' shares in the labor force and educational expenditure, in real terms and per capita. To assess the implications of these findings, the impact of an increase in public expenditure devoted to education is simulated in a conventional CGE model for Ethiopia. The simulation results highlight the existence of a multiplicative effect, such that the overall increase in the supply of education services, in the final equilibrium state, is more than three times larger than the initial demand push. This comes associated with a positive supply shock, entailing gains in productivity, income, and welfare, as well as changes in the structure of the economy.

Keywords: CGE Models, Economic Growth, Education Expenditure, Human Capital, Labor Productivity.

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I. Introduction

Long-term economic growth is driven by changes in endowments of primary resources and productivity. Human capital is one key resource, affecting income, consumption levels, and welfare, both directly, and indirectly, through its impact on productivity. Endogenous growth theory postulates that the enhancement of a nation's human capital will lead to economic growth by means of the development of new forms of technology and efficient and effective means of production (Romer, 1984). Whereas physical capital stock varies over time because of real investments, like purchases of machinery and infrastructure, human capital varies because of investments in education. The latter should be interpreted in a broad sense, much beyond schooling. Education expenditure is a kind of investment because people and resources involved in education are subtracted, albeit temporarily, from (other) productive purposes (or leisure). Furthermore, the cost of education is born, under the expectation of higher income in the future (e.g., higher wages).

One major limitation of most studies related to education and growth is their aggregate nature. The typical approach involves considering a single production function (of value added), and a closed economy, with no trade. However, trade may be relevant, because knowledge transmission may be related to the technology embodied in the traded products. More importantly, the structure of an economy matters. Sectors are linked through trade interdependencies. The supply of education services is determined by some production technique. Different industries have different degrees of intensity of human capital, such that any increase in its stock entails a change in the relative competitiveness of sectors, terms of trade, and factor returns.

In this respect, computable general equilibrium (CGE) models are, possibly, an appropriate empirical tool to analyze the structural change processes, associated with investments in education. CGE are calibrated models, solidly based on official national accounts, which consider both market interdependencies and the circular flow of income in the economy.

Nonetheless, modelling education in a CGE framework remains challenging because, among other things, national accounts are not sufficiently informative about the process of human capital creation, accumulation, and employment. For this reason, the few examples of education-oriented CGE analysis one could find in the literature are based on a hybrid approach, whereby micro-economically formulated education investments, often having weak empirical support, are combined with data-intensive CGE settings.

For example, Jung and Thorbecke (2003) appraise the impact of public education expenditure on human

capital, the supply of different labor skills, and its macroeconomic and distributional consequences, in a multisector, dynamic CGE model. Intertemporally, the model adjusts through changes in the stock of physical capital and the stock of human capital. The supply of educated labor is determined by agents' maximization of their lifetime utility from consumption. It is assumed that agents are identical except for their availability of education facilities. In a period *t*, an agent (representative of a broad aggregate of households) selects one between the following two options: getting a higher-level education in period t to earn higher expected wage incomes from period (*t+1*) or continuing to work without a higher level education and earn the wage incomes for the same education level afterwards. This study is an example of how theoretical models from microeconomics are combined within a CGE macroeconomic framework. It remains to be seen, however, if the life cycle approach applied to representative agents in the model is adequate, and empirically robust, to capture the dynamics of macro aggregates.

Cloutier *et al.* (2008) present a CGE model for Vietnam, where education allows workers to "migrate" from one category to another, by attaining a certain training level. To maximize their income, households modify the equilibrium proportion of skilled and unskilled labor that they possess, by adjusting their level of education investment, subject to imperfect transformation between skilled and unskilled workers.

An even more striking hybrid of CGE modelling with microeconomic theory is proposed by Verbic *et al.* (2009). Their model SIDYN 2.0 is a dynamic endogenous-growth general equilibrium model of the Slovenian economy, where (representative) households and firms make their decisions under the assumption of an infinite horizon with perfect foresight (rational forward-looking expectations).

An alternative approach is proposed in this paper. Rather than inserting microeconomic-based assumptions of human capital formation inside a CGE setting, the work is based on an observed empirical relationship between labor force composition and expenditure on education services. To this end, the labor classification available in the latest GTAP dataset release is considered, which distinguishes five categories of workers, instead of the usual skilled/unskilled partition. Data from GMig2 is also used, to get average salaries and the number of employed people.

Some empirically robust correlation is found between workers' shares in the labor force and educational expenditure, in real terms and per capita To assess the implications of these findings, the impact of an increase in public expenditure devoted to education is simulated in a conventional CGE model for Ethiopia. The simulation results highlight the existence of a multiplicative effect, such that the overall increase in the supply of education services, in the final equilibrium state, is more than three times larger than the initial demand push. This comes associated with a positive supply shock, entailing gains in productivity, income, and welfare, as well as changes in the structure of the economy.

The paper is organized as follows. Some evidence about the empirical correlation between the production of education services and the composition of the labor force is presented in section two. Section three introduces the numerical simulation experiment, conducted with a conventional, comparative static CGE model. Section four discusses the interpretation and implications of the findings. Some conclusions complete the paper.

II. The Link Between Education Expenditure and Labor Force Composition

I start this section with a disclaimer. An empirical assessment of the causality between expenditure on education services, human capital accumulation, labor productivity, and growth is an extremely complex endeavor, which I refrain to tackle here entirely. Rather, an analysis is presented, which is instrumental to the subsequent application into a computable general equilibrium model.

A macroeconomic perspective is taken, which mainly use data already available for the calibration of the CGE model parameters. Other data sources on education, possibly richer in terms of information and detail, are available (e.g. OECD, 2021), and could have been used for this purpose. Unfortunately, those more substantial data lack the needed country coverage, as they mainly focus on developed countries. Furthermore, a side benefit of our strategy is the consistency with the model parameters and format.

It is explored how changes in human capital investments affect the employment structure and, indirectly, aggregate productivity. The intuition is that more educated workers can find employment in industries where they can get higher wages, reflecting higher marginal productivity. Even with a constantly employed labor force in physical terms (men, hours, etc.), this shift would increase labor productivity in the aggregate.

Of course, sectoral employment is not only a matter of supply but also of demand. In this respect, a general equilibrium model, like the one used here, can capture supply-demand interactions in the identification of market equilibria. For instance, a better-educated workforce could affect the relative competitiveness, comparative advantage, terms of trade, and ultimately the industrial structure of an economy.

The parameters of the CGE model are calibrated on the GTAP global Social Accounting Matrix (Aguiar *et al*., 2019), version 10. These data, complemented with other sources, like GMig2 (Walmsley *et al*., 2013;

Aguiar, 2020), are utilized here to highlight the existence of an empirical correlation between shares of workers' categories and expenditure on educational services.

The five different labor categories considered in the GTAP database are:

- Technicians and associated professionals ("tech_aspros")
- Clerks ("clerks")
- Service and shop workers ("service_shop")
- Officials and managers ("off_mgr_pros")
- Agricultural and low-skilled ("ag_othlowsk")

The shares of people (or, equivalently, days worked) were obtained from the total wages data in the value added of the GTAP national accounts, divided by the average wage levels, estimated in GMig2.

The country-level shares of workers are contrasted with a measure of total (private, public, by firms) real expenditure on education. The latter is estimated by dividing the output value of the education industry by a specific index of labor cost, which is the main production factor.

Fig. 1 presents five correlograms, one for each labor category, together with their interpolating regression lines. There are 141 points in each diagram, corresponding to the countries and regions in the GTAP database.

The graphs highlight a clear positive correlation between real per-capita expenditure on education and labor shares in four out of five cases, the only exception being "Agricultural and low-skilled", where the correlation is negative. Furthermore, the top-level occupations of technicians, professionals, officials, and managers are found to be the most reactive ones to changes in educational expenditure. Confirming the intuition, it is generally found that countries spending more on education are characterized by a higher quality mix of workers in their labor force.

Therefore, with more spending on education, the composition of the labor force would change. Even if the number of physical labor units would stay the same, the move towards sectors offering higher wages implies an expansion of labor supply in terms of efficiency units or, equivalently, an increment in labor productivity.

To better appreciate the findings, Fig. 2 shows the estimated composition of the labor force, as a function of real education expenditure per capita, in the range of values of the data set, from the minimum to the maximum.

The most evident effect of increased spending is on the share of agricultural and low-skilled workers, with the green area characterized by a semi-sigmoid shape, initially concave, then convex. This effect is due to the rescaling of estimates, which is necessary to ensure that total shares sum up to unity. This makes some components stabilize at higher levels of expenditure, and in one case (clerks) slightly decrease near the right end.

III. Simulating the Multiplicative Effects of Educational Investments

The previous section demonstrated the existence of a robust, empirical relationship between investments in education and the composition of the labor force. More education would entail, through a change in the labor supply mix, an increase in total labor productivity or, equivalently, in the stock of human capital, expressed in efficiency units.

Admittedly, these findings are nothing new. For instance, Griliches (1997) reviews the literature on the relationship of economic growth to the education levels of the labor force. More recently, Dissou *et al.* (2016) assess the growth implications of alternative methods of financing education and develop a multisector endogenous growth model with human capital accumulation. Where the literature is silent is on the second-order, structural adjustment processes, triggered by a varying composition of the labor force. Indeed, the impact of higher educational expenditure goes much beyond the direct labor productivity gains. Increased investments in education imply changes in the final demand, with consequences for the productive structure of an economy. Higher labor productivity would benefit labor-intensive industries, especially those intensive in skilled labor. The positive supply shock would change relative prices, trade flows, and ultimately real income and welfare.

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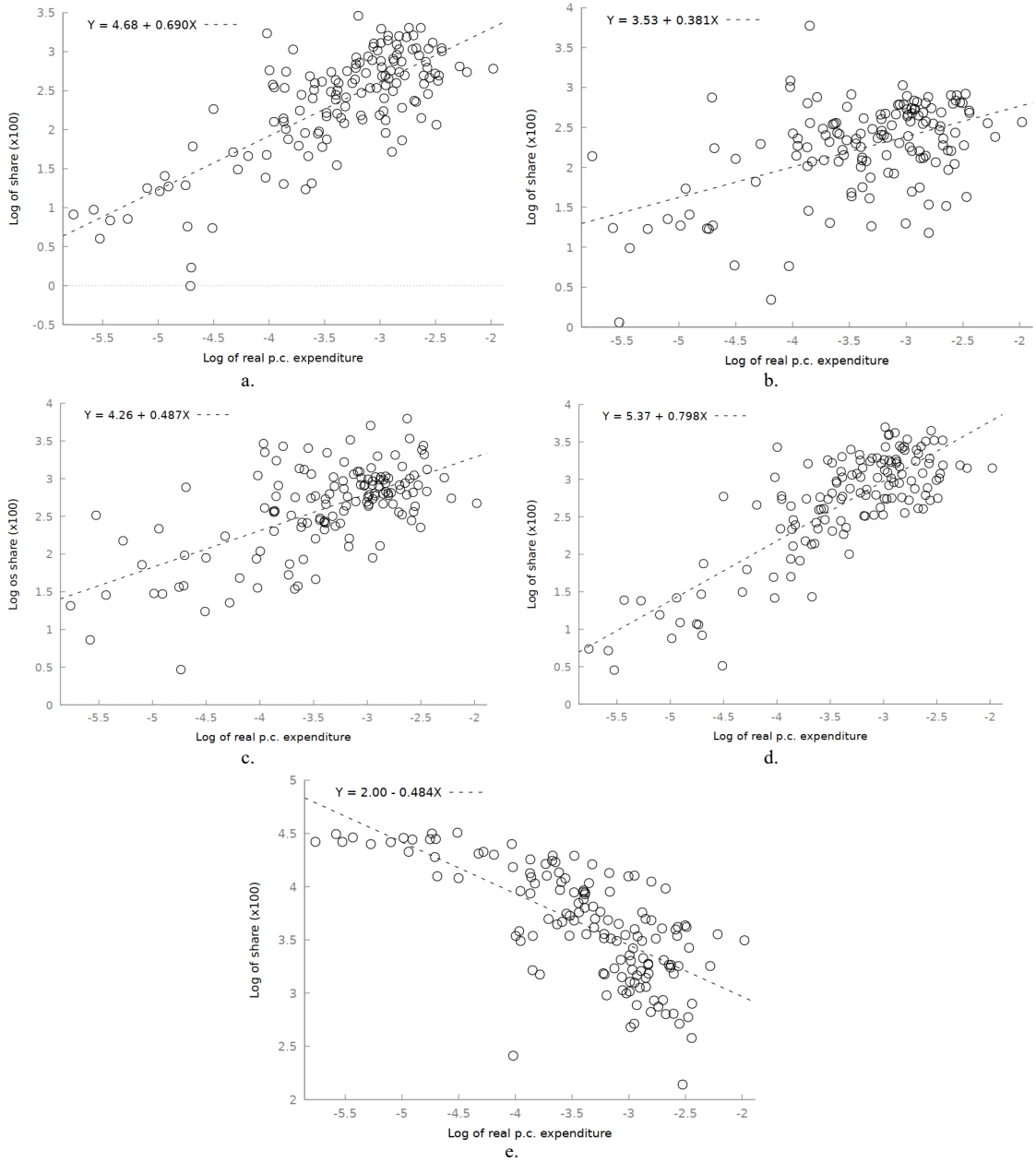

Fig. 1. Five correlograms displaying expenditure levels and labor shares (in logarithms): a) Technician and associated professionals; b) Clerks; Service and shop workers; d) Officials and managers; e) Agricultural and low skilled workers.

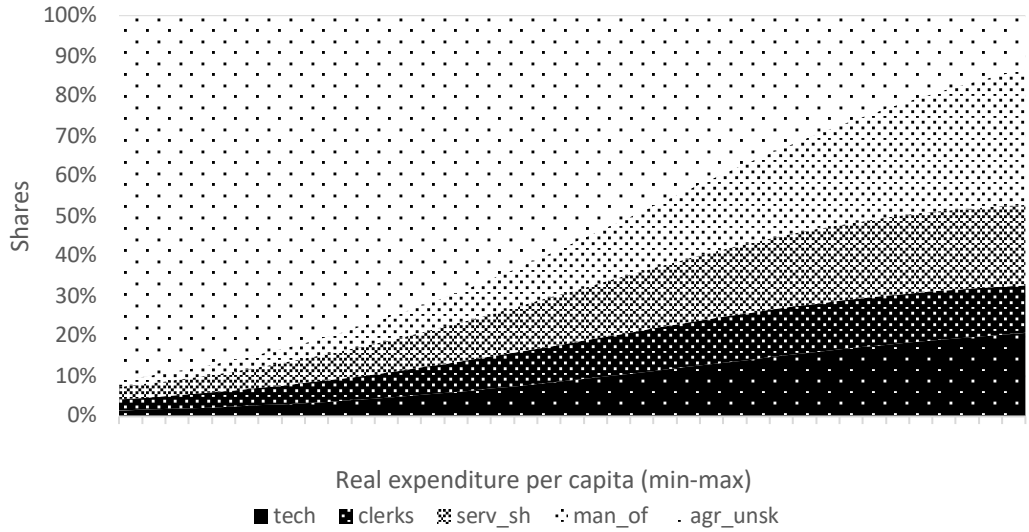

Fig. 2. Estimated labor force composition as a function of real education expenditure per capita.

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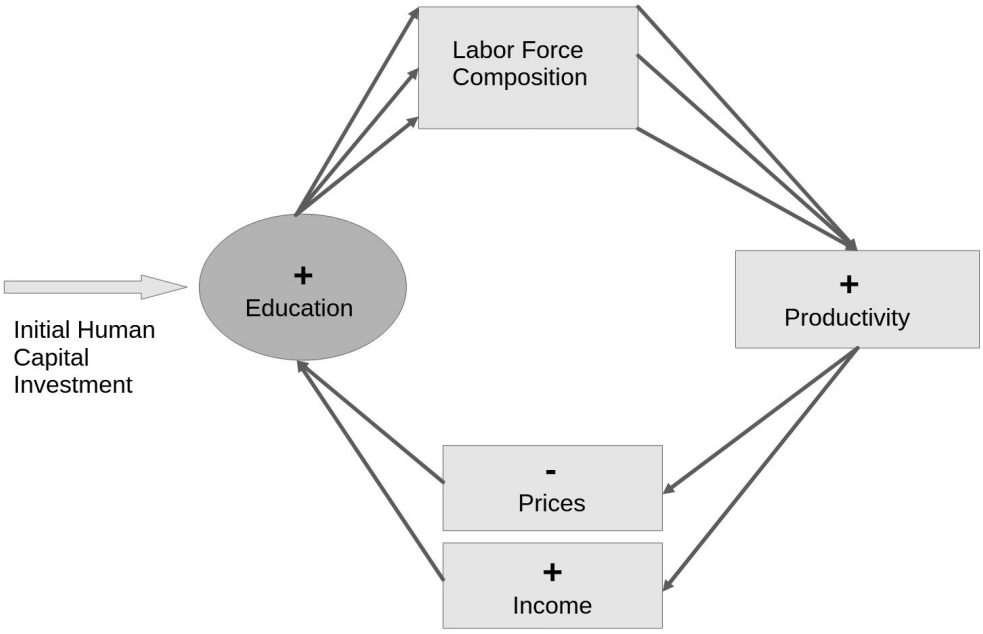

Fig. 3. The multiplicative process of increased investments in education.

A general equilibrium framework is therefore needed to account for all these systemic effects. To this end, a counterfactual simulation experiment is considered here, realized with the standard, comparative static, GTAP model (Corong *et al*., 2017). This is a widely diffused, and extensively tested, Computable General Equilibrium model, with parameters calibrated on a global Social Accounting Matrix for the year 2014 (Aguiar *et al*., 2019). This model is employed to simulate the long-run impact of a 10% increment in the demand for educational services, supposedly realized by the public sector in Ethiopia. Since final demand is not exogenous in the CGE (contrary to the standard input-output model) the additional expenditure is obtained through an endogenous budget adjustment.

Ethiopia is an especially interesting case test, for two reasons. First, it is a developing country, with a relatively large agricultural sector, and a high share of unskilled workers. Second, Education is one industry in this country, where the most education-sensitive category of workers, that is, officials, managers, and professionals ("off_mgr_pros"), accounts for as much as 45% of the value added, and 50% of total salaries. Evidently, teachers are included in this category.

The demand push initiated by the public sector triggers a multiplicative expansion in the production of education services, through a process, which is graphically exposed in Fig. 3.

The initial demand push stimulates an increase in the production of education services. With more education provided, the composition of the labor force would change, with an increase in all categories, most notably in the "off_mgr_pros", except for agricultural and other low-skilled workers ("ag_othlowsk"). This would generate productivity gains, especially in those industries, like Education, which are intensive in skilled labor. More human capital resources for the economy would then bring about lower prices and higher income, which boost the demand for education services, among others, thereby further changing the composition of the labor force, and so on. The income effect may be especially relevant for those consumption items, like education, having high-income elasticity.

This process is simulated with the GTAP standard model, through a series of iterative simulations. The model is set to consider two regions (Ethiopia and Rest of the World), eleven industries (Grains and Crops [GrainsCrops], Meat and Animal Products [MeatLstk], Extraction [Extraction], Processed Food [ProcFood], Textiles and Apparels [TextWapp], Light Manufacturing [LightMnfc], Heavy Manufacturing [HeavyMnfc], Utilities [Util_Cons], Transport and Communication [TransComm], Education [Education], Other Services [OthServices]), and eight primary factors (in addition to the five labor categories: Land [Land], Capital [Capital], Natural Resources [NatRes]).

Fig. 4 shows how the production output of the Education industry progressively converges to a value of +15%, because of the cumulative process described above, starting from the +4.36%, induced by the +10% expansion of demand by the public sector.

Labor supply, in efficiency units, for the category officials and managers ultimately increases by 17.24%. Technicians and professionals rise by 15.57%, service and shop workers by 12.41%, and clerks by 10.77%. Agriculture and other non-skilled workers decrease by -2.65%.

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Real GDP increases by 1.57%, whereas the equivalent variation, an aggregate monetary measure of welfare impact, amounts to 789 million US$ (1.42% of the baseline GDP).

Physical capital supply is unchanged, but capital returns get higher, because of complementarity with labor. This attracts investments from abroad, but, at the same time, more savings (a constant share of national income in the model) are generated. The net effect is an outflow of funds, reflected by a surplus in the trade balance. Indeed, and contrary to other CGE models, balanced trade is not an equilibrium condition in the GTAP model, see Corong *et al*. (2017).

The additional expenditure, due to the +10% consumption of education services, is partly compensated by the generally decreasing prices of products and services. In the final equilibrium state, total public expenditure grows by only 2.27%.

Fig. 5 displays the percentage change in the price of primary resources in the Ethiopian economy, whereas Fig. 6 shows the corresponding price changes for the eleven industries considered in the model.

Relative prices (salaries) for most labor categories (except agriculture and low-skilled) diminish, primarily because of increased supply. For the other resources, which are in fixed supply, variations are driven by the demand. Demand will be higher because of increased output in some industries, but at the same time substitution effects are at work. For instance, replacing capital with cheaper labor.

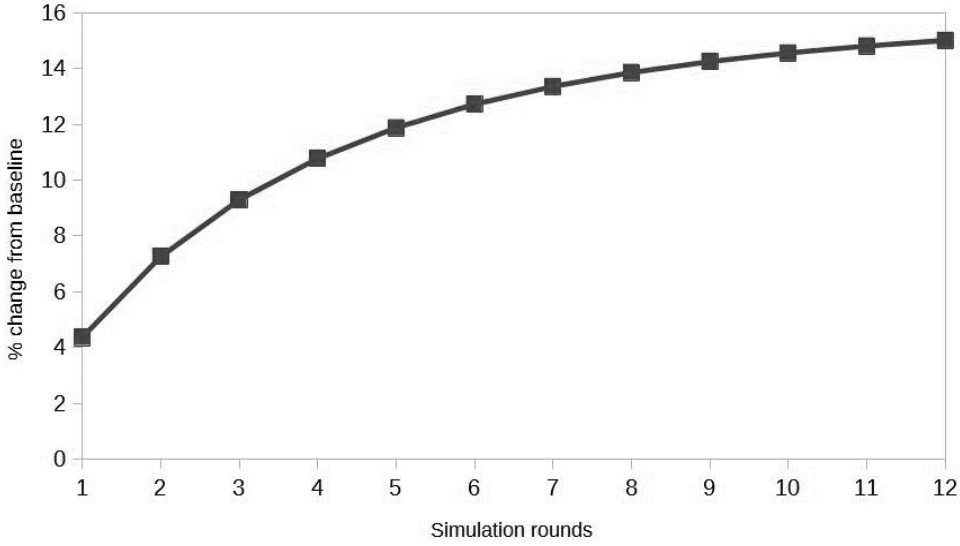

Fig. 4. Iterative convergence of Education industry output (% change).

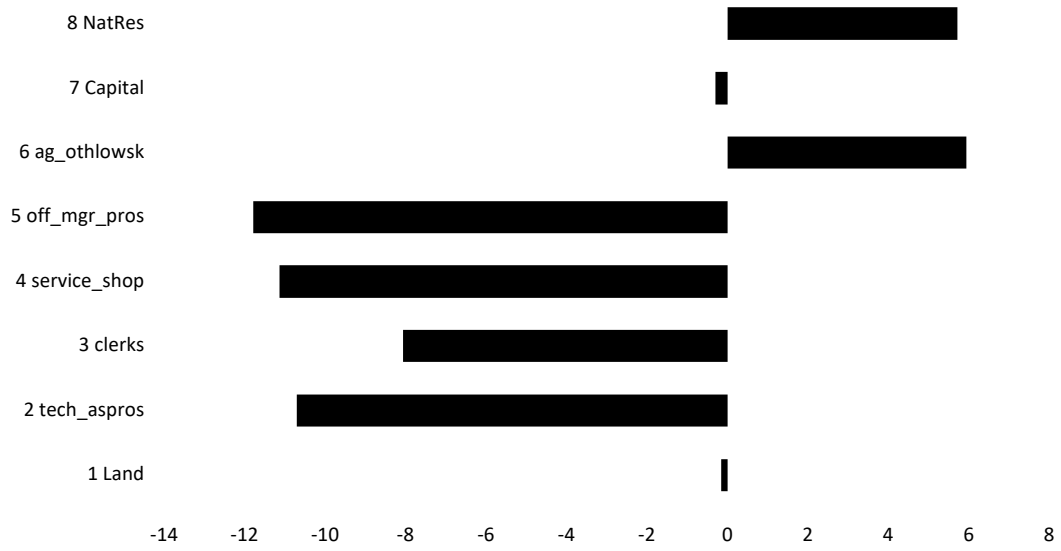

Figure 5. Variation in the price of primary factors (% change).

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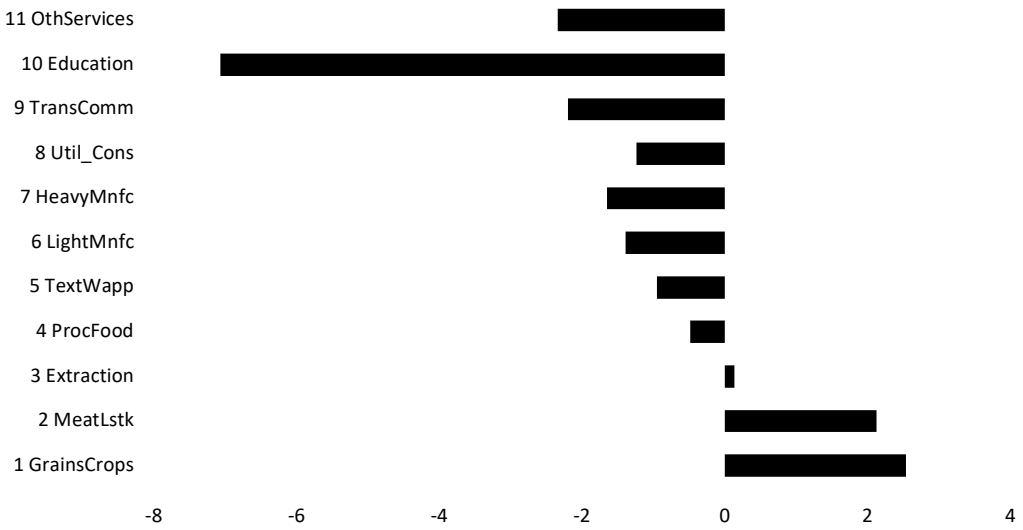

Figure 6. Variation in the price of produced goods and services (% change).

The most significant price drop is detected in the Education industry, which explains the magnitude of the multiplicative effect. Lower relative prices stimulate demand, and vice versa, but income effects are at work as well, depending on income elasticity. This combined effect can be appreciated from Fig. 7, presenting the estimated variations in output volumes, for the various industries.

The very large increase in the production of education services is followed, albeit at a distance, by output growth in all other industries, except "GrainsCrops". The latter result is easily interpreted. "GrainsCrops" is intensive in "ag_othlowsk" labor and, furthermore, has a low-income elasticity. Therefore, and contrary to "MeatLstk", income growth cannot compensate for the fall in relative competitiveness.

Fig. 8 presents the variations, expressed as differences in million US$, in the sectoral trade balances.

The results follow the changes in relative prices but, because of the Armington assumption of imperfect substitutability between domestic and imported products, a key role is also played by the baseline trade shares, considered when the parameters of the model are calibrated. Consequently, and despite the large drop in the domestic price for Education, this industry is not the one getting the largest gain in net exports (accruing instead to Transport and Communication). This is due to the rather negligible volume of exports in the base data. On the other hand, Ethiopia starts to massively import Grains and Crops, whose import share was already quite sizeable.

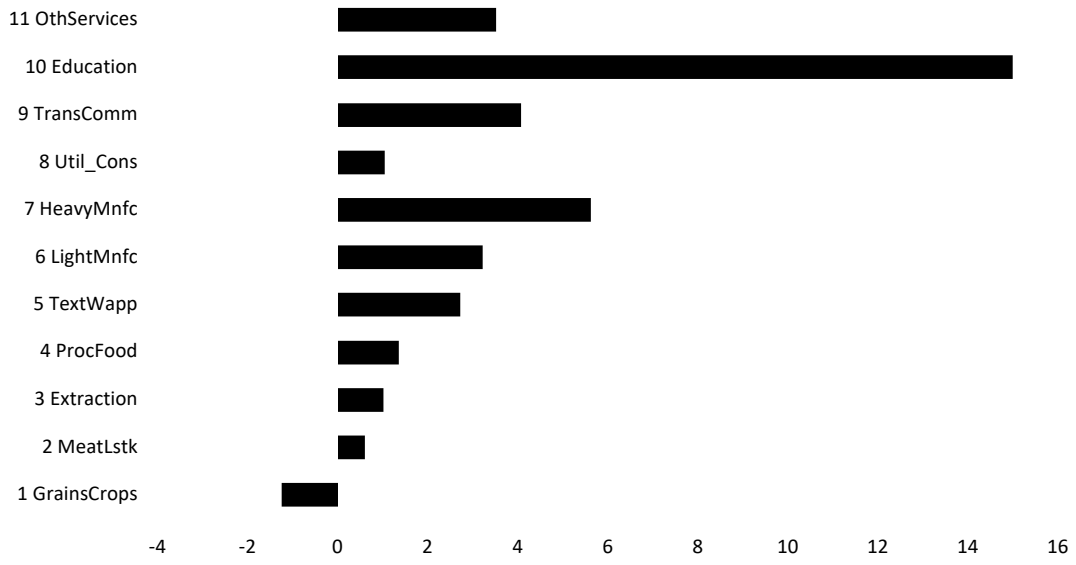

Figure 7. Variation in the quantity of produced goods and services (% change).

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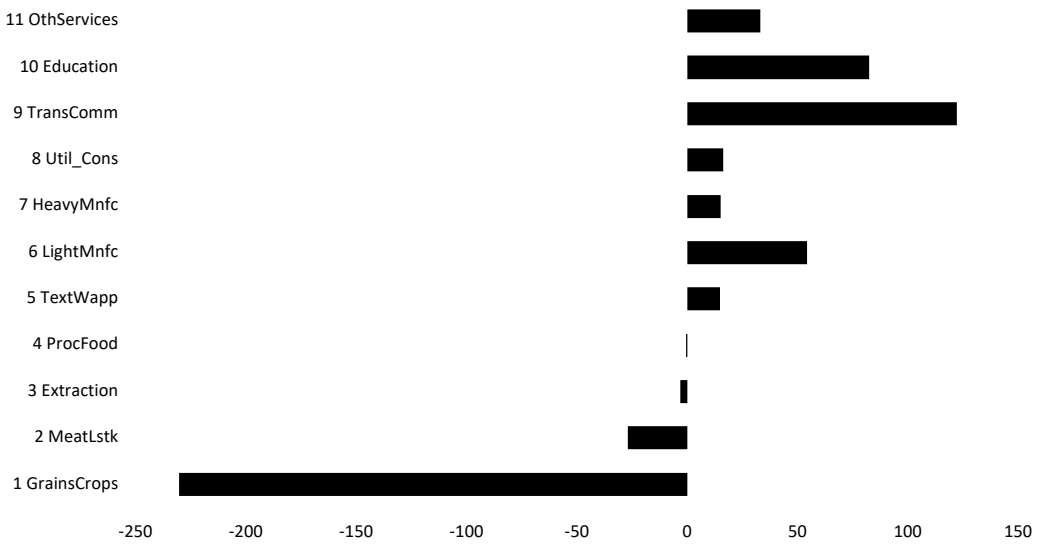

Figure 8. Variation in sectoral trade balances (change, million US$).

IV. Discussion

The results illustrated above have been generated through a standard CGE model, which uses a conventional set of closure rules. For instance, most primary resources, including labor, are assumed to be perfectly mobile domestically (implying a single domestic market, and a single equilibrium price), but not internationally mobile.

The simulation undertook is a comparative static one, therefore – by construction – it abstracts from the time dimension. Consequently, it is not known how much time would be required for the structural effects to fully unfold.

The five labor categories are treated independently, that is, as separate resources. This means that it would be impossible – say – for a technician to work as a clerk. Furthermore, the supply of all primary factors (including labor in the various categories) is assumed as given. The supply curves are therefore vertical, such that the model replicates the employment levels observed in the calibration year, in all cases. However, alternative assumptions could be easily implemented, including fixed nominal or real wages, or a wage curve (as, e.g., in Roson, 1998).

Because of the existence of five, separate, labor markets, the model calculates new wage differentials. For the sake of simplicity, these updated differentials have not been considered in the exercise described above when the labor supply in efficiency units is recomputed.

This choice can be defended with two arguments. First, the endogenization of the wage differentials would entail the introduction of new equations in the model system, whereas the general logic is illustrated here through a relatively simple, standard reference model, without introducing new equations or assumptions. Admittedly, however, a properly reconfigured model would have allowed identifying the counterfactual equilibrium in one step, avoiding the iterative approximation.

Second, the direction of change of the differentials is ambiguous ex-ante. This is because any increase (decrease) in factor supply would come associated with an increase (decrease) in demand. Nonetheless, the results shown in Fig. 5 indicate that the wage gap between agriculture/low-skilled and the rest of the workers has narrowed. Therefore, the expansion in the total labor supply is somewhat overestimated.

The variation in the composition of the labor force is determined, in the exercise, by changes in the overall educational spending. This association is based on an empirical correlation detected between the mix of workers and the production of educational services. However, this correlation might well be driven by a third factor, like per capita income. More generally, a serious assessment of the relationship between education expenditure and the composition of the labor force would require a fully-fledged econometric estimation, possibly using panel data, as well as more sophisticated techniques (SUR, IV, etc.). This kind of analysis is beyond the scope of this paper, both because of limitations in the quality of data, and the need to get results at the aggregate level, directly employable in a CGE setting.

A direct link is established between investments in education and labor supply in the various categories. An intermediate step is therefore being skipped because more education would first determine attainment levels in the active population, and, subsequently, people with different qualifications would fill in vacancies for the diverse workplaces. This means that it is not considered a possible mismatch between educational attainments and work profiles, requested by the labor market. The mismatch between

occupation and skill, or qualification, is one dimension of what is known as "underemployment" (Smith (1986), Abel & Deitz (2017), Livingstone (2018), McKee-Ryan & Harvey (2011)).

Given the limitations above, and possibly others, one could legitimately ask if the insights obtained from the numerical exercise are still trustworthy and sufficiently general. I believe they are, to the extent they are correctly interpreted. Indeed, the main insight obtained is the existence of a multiplicative propagation mechanism of investments in education, not its precise quantification (in the spirit of the so-called "theory with numbers"). Nonetheless, the results suggest that the order of magnitude of these second-order, general equilibrium effects is quite sizeable, especially for a developing country, such as Ethiopia.

On the other hand, the findings rest on two critical hypotheses, which are quite robust. The first one is that better quality jobs are available when people get more educated, which is intuitive and realistic. The second one is that the technology for educational services is intensive in skilled labor. In this case, a simple analysis of the industrial cost structure could confirm this assumption.

Of course, much research work lies ahead. The link between education expenditure and the composition of the workforce should be better understood and estimated, possibly by expressing microeconomic results in terms of macroeconomic aggregates. Mismatches and underemployment could be introduced in general equilibrium models. The dynamics of the processes should be better specified. When these and other advances will be achieved, computable models will give more reliable results, yet the overall qualitative picture coming out from our analysis will not likely change in any substantial way.

V. Conclusion

To get more education you need more educated people. To get more educated people you need more education. In this paper, this virtuous circle is examined, with the help of an applied general equilibrium model.

The work makes two important contributions to the literature. First, the issue of human capital formation is studied from a macroeconomic perspective. The assumption about the existence of a hyper-rational, forward-looking representative agent, to model consumption of (investment on) educational services, is avoided. Instead, the analysis relies on an observed relationship between expenditure on education and the supply of workers, in five distinct categories. Although much could be done to better estimate this link, its consideration in an empirical macroeconomic model provides a much more solid and reliable base, rather than abstract microeconomic theory.

The second contribution comes from framing (possibly for the first time) the analysis inside a general equilibrium system. In this way, it is possible to ascertain how an education-induced change in labor supply would affect the relative competitiveness of the various industries, as well as trade and demand patterns. This is very relevant in this context since the industry of education services turns out to be among the most favored ones by the variation of relative prices. All in all, this generates a multiplicative effect for investments in human capital, making their social return remarkably high, especially in developing countries such as Ethiopia.

Acknowledgment

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Conflict of Interest

The author declares that he does not have any conflict of interest.

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