Ca' Foscari University of Venice

Department of Economics

Working Paper

Roberto Roson

Education, Labor Force Composition, and Growth A General Equilibrium Analysis

ISSN: 1827-3580
No. 07/WP/2022

Working Papers
Department of Economics
Ca' Foscari University of Venice
No. 07/WP/2022
ISSN 1827-3580

Education, Labor Force Composition, and Growth
A General Equilibrium Analysis

Roberto Roson
Ca' Foscari University of Venice; Loyola Andalusia University; GREEN Bocconi University Milan

Abstract

We propose, in this paper, a novel approach to modelling education and human capital formation in a computable general equilibrium model. Rather than adopting microeconomic-based assumptions of human capital formation, the method is based on an empirical relationship between labor force composition and expenditure in education services. After realizing a set of econometric estimates, we found some robust relationship between workers' shares in the labor force and educational expenditure, in real terms and per capita. To assess the implications of these findings, we simulate, in a conventional CGE model for Ethiopia, the impact of an increase in public expenditure devoted to education. Our 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
Education expenditure, Human capital, Labor productivity, CGE models, Economic growth

JEL Codes
C68, D58, E27, I20, J24, O11, O15, O41

Address for correspondence:
Roberto Roson
Department of Economics
Ca' Foscari University of Venice
Cannaregio 873, Fondamenta S.Giobbe
30121 Venezia - Italy
e-mail: roson@unive.it

The Working Paper Series
is available only on line
(http://www.unive.it/pag/16882/)
For editorial correspondence, please contact:
wp.dse@unive.it

Department of Economics
Ca' Foscari University of Venice
Cannaregio 873, Fondamenta San Giobbe
30121 Venice Italy
Fax: ++39 041 2349210

Education, Labor Force Composition, and Growth

A General Equilibrium Analysis

Roberto Roson[1]

ABSTRACT

We propose, in this paper, a novel approach to modelling education and human capital formation in a computable general equilibrium model. Rather than adopting microeconomic-based assumptions of human capital formation, the method is based on an empirical relationship between labor force composition and expenditure in education services. After realizing a set of econometric estimates, we found some robust relationship between workers' shares in the labor force and educational expenditure, in real terms and per capita. To assess the implications of these findings, we simulate, in a conventional CGE model for Ethiopia, the impact of an increase in public expenditure devoted to education. Our 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

Education expenditure, Human capital, Labor productivity, CGE models, Economic growth.

JEL CODES

C68, D58, E27, I20, J24, O11, O15, O41.

---

[1] Ca' Foscari University Venice; Loyola Andalusia University; GREEN Bocconi University Milan. E-mail: roson@unive.it.

1. Introduction and Motivation

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, to (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).

Whereas the role of human capital and education in economic development is well understood, both conceptually and theoretically, empirical studies on the field are lacking. This should not come as a surprise, since measuring the stock of human capital, and assigning a value to it, looks practically impossible. Paul Krugman (2013), in its critique of endogenous growth theory, states that "too much of it involved making assumptions about how unmeasurable things affected other unmeasurable things.".

Another major limitation of most of the 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 input-output 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, 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 are adequate, and empirically robust, to capture the dynamics of macro aggregates.

Cloutier, Cockburn, and Decaluwé (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 example of CGE-based "theory with numbers" is provided by Verbic, Majcen, and Cok (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).

We propose in this paper an alternative approach. Rather than inserting microeconomic-based assumptions of human capital formation inside a CGE setting, we look for an empirical relationship between labor force composition and expenditure in education services. To this end, we take advantage of the labor classification available in the latest GTAP dataset release, which distinguishes five categories of workers, instead of the usual skilled / unskilled partition. We also use data from GMig2, to get average salaries and the number of employed people. This makes it possible to conduct econometric estimates, based on a cross-sectional data set.

We found some empirically robust relationships between workers' shares in the labor force and educational expenditure, in real terms and per capita. To assess the implications of these findings, we simulate. in a conventional CGE model for Ethiopia, the impact of an increase in public expenditure devoted to education. Our 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 Ethiopian economy.

2. Assessing the link between education expenditure and growth

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

We take a macroeconomic perspective, and 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 to this purpose. Unfortunately, those more substantial data lack the country coverage we need, as they mainly focus on developed countries, whereas our primary interest is simulating the impact of educational expenditure on economic development. Furthermore, a side benefit of this strategy is consistency with the model parameters and format.

We explore 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 constant employed labor force in physical terms (men, hours, etc.), this shift would increase labor productivity in the aggregate. Moreover, underemployment in agriculture is a typical characteristic of poorer countries, so understanding how workers could be pulled out of agriculture and introduced into more productive sectors is of fundamental relevance.

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 we use here, can capture supply-demand interactions in the identification of market equilibria. For instance, a better educated work force could affect the relative competitiveness, comparative advantage, terms of trade and ultimately the industrial structure of an economy.

Parameters of our CGE model are calibrated based 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 as cross-section observations in a series of regressions. We therefore consider 141 observations, corresponding to the countries and regions in the GTAP10 database.

The set of regressions we present are meant to detect a relationship between expenditure in education and shares of workers in the five different labor categories considered in the GTAP data base, namely:

- 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) was obtained from the total wages data in the value added of the GTAP national accounts, divided by the average wage levels, estimated in GMig2.

After having tested alternative functional forms, we found that the best performing relationship (not only in terms of general fitting, but also regarding economic interpretation and theory) is the linear logarithmic one, that is between the logarithm of the labor category share and the logarithm of total (private, public, by firms) real expenditure in education (l_ES). The latter is estimated by dividing total output value of the education services industry by an industry-specific index of labor cost, which is the main factor in the production of education services. We present our findings in the following Tables 1-5.

Table 1. OLS regression results for dependent variable tech_aspros (log. share)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	4.67994	0.173078	27.04	<0.0001	***
l_ES	0.690144	0.0500326	13.79	<0.0001	***

Mean dependent var	2.349860	S.D. dependent var	0.686635
Sum squared resid	27.86381	S.E. of regression	0.447727
R-squared	0.577856	Adjusted R-squared	0.574819
F(1, 139)	190.2712	P-value(F)	8.24e-28
Log-likelihood	−85.75943	Akaike criterion	175.5189
Schwarz criterion	181.4164	Hannan-Quinn	177.9154

Table 2. OLS regression results for dependent variable clerks (log. share)

	Coefficient	Std. Error	t-ratio	p-value	
const	3.52901	0.196271	17.98	<0.0001	***
l_ES	0.381019	0.0567369	6.716	<0.0001	***

Mean dependent var	2.242601	S.D. dependent var	0.582219
Sum squared resid	35.83156	S.E. of regression	0.507721
R-squared	0.244969	Adjusted R-squared	0.239537
F(1, 139)	45.09842	P-value(F)	4.41e-10
Log-likelihood	−103.4902	Akaike criterion	210.9804
Schwarz criterion	216.8779	Hannan-Quinn	213.3770

Table 3. OLS regression results for dependent variable service_shop (log. share)

	Coefficient	Std. Error	t-ratio	p-value	
const	4.25657	0.175943	24.19	<0.0001	***
l_ES	0.486519	0.0508606	9.566	<0.0001	***

Mean dependent var	2.613975	S.D. dependent var	0.584004
Sum squared resid	28.79368	S.E. of regression	0.455136
R-squared	0.396972	Adjusted R-squared	0.392634
F(1, 139)	91.50343	P-value(F)	5.74e-17
Log-likelihood	−88.07375	Akaike criterion	180.1475
Schwarz criterion	186.0450	Hannan-Quinn	182.5440

Table 4. OLS regression results for dependent variable off_mgr_pros (log. share)

	Coefficient	Std. Error	t-ratio	p-value	
const	5.36928	0.161477	33.25	<0.0001	***
l_ES	0.797769	0.0466788	17.09	<0.0001	***

Mean dependent var	2.675836	S.D. dependent var	0.732991
Sum squared resid	24.25349	S.E. of regression	0.417715
R-squared	0.677560	Adjusted R-squared	0.675240
F(1, 139)	292.0882	P-value(F)	5.62e-36
Log-likelihood	−75.97629	Akaike criterion	155.9526
Schwarz criterion	161.8501	Hannan-Quinn	158.3491

Table 5. OLS regression results for dependent variable ag_othlowsk (log. share)

	Coefficient	Std. Error	t-ratio	p-value	
const	1.99967	0.143411	13.94	<0.0001	***
l_ES	−0.483834	0.0414564	−11.67	<0.0001	***

Mean dependent var	3.633203	S.D. dependent var	0.520139
Sum squared resid	19.13013	S.E. of regression	0.370981
R-squared	0.494931	Adjusted R-squared	0.491297
F(1, 139)	136.2097	P-value(F)	2.30e-22
Log-likelihood	−59.24691	Akaike criterion	122.4938
Schwarz criterion	128.3913	Hannan-Quinn	124.8904

The most relevant result is that workers' shares are all increasing with education expenditure, except for agricultural and low skilled. The marginal change (positive or negative) is always decreasing, because of the strict concavity (convexity) of the logarithmic relationship. This confirms the intuition that more educated workers may find jobs in sectors with higher wages and productivity, moving out of sectors like Agriculture, or Constructions. The larger marginal gain is observed in the category where returns of investments in human capital are likely to be larger (officials and managers).

Therefore, with more spending in education, the composition of the labor force would change. Even if the amount 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, Figure 1 show the estimated composition of the labor force, as a function of real education expenditure per capita, in the range of values of our cross-section data set.

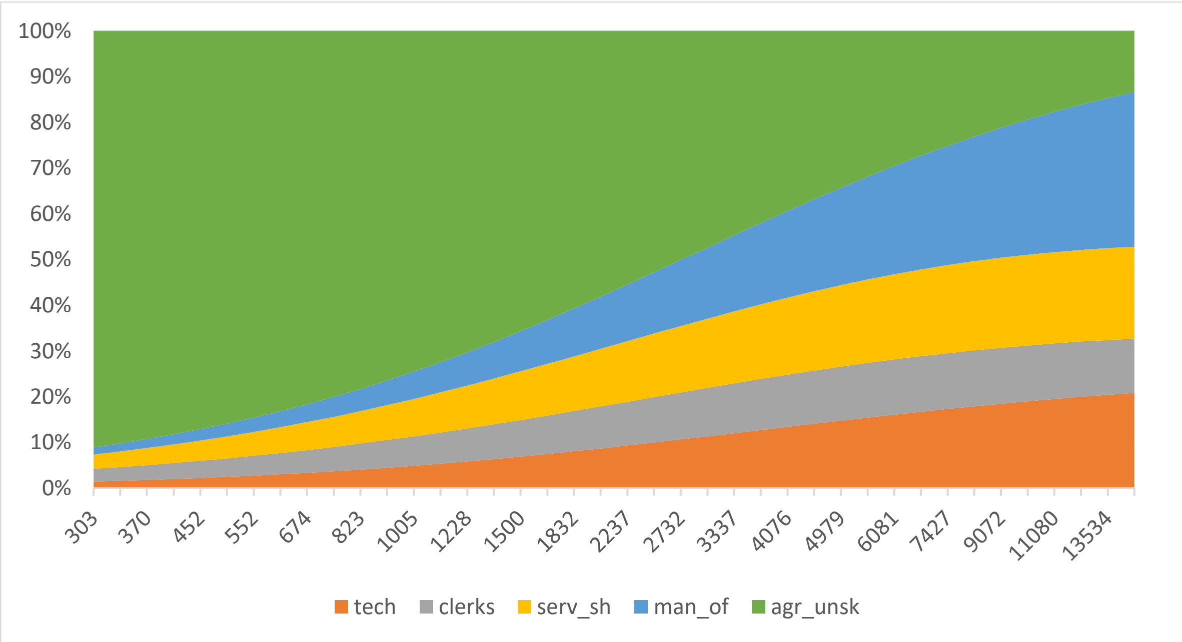

Figure 1. Estimated labor force composition as a function of real education expenditure per capita

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 produced by the regressions, which is necessary to ensure that total shares sum up to unity. This makes some components stabilizing at higher levels of expenditure, and in one case (clerks) sightly decreasing near the right end.

The impact magnitude of more expenditure in education depends, in a country, on some of its specific characteristics. In our setting, the estimated impact depends on the (degree of) inverse correlation between relative wages and the distribution of labor category shares. To see this, consider the bar graph shown in Figure 2. Here we display, with the blue bars, the relative wages of the various categories (simple mathematical average across all countries) and, with the red bars, the shares (averages, multiplied by 3, to easy the visual comparison). Labor categories are ordered from left to right, in terms of increasing wages.

Figure 2. Relative wages vs. labor shares, globally

We should expect a bigger effect of additional investment in education when lower wages are associated with larger labor shares. Especially, when a country is characterized by very low wages in agriculture (and low-skilled) and many workers in this category, which is typical of most developing countries. This would correspond to some kind of "crossing" between the two distributions of bars in Figure 2.

These conditions may or may not be fulfilled in the various countries. Consider, for instance, the case of Ethiopia. We calculated, by applying our regression results, the estimated increase in labor force, in terms of efficiency units (or, total labor productivity), consequent to a 10% expenditure increase in education. For Ethiopia, this would amount to +3.46%. Figure 3 help us to understand what drives this outcome.

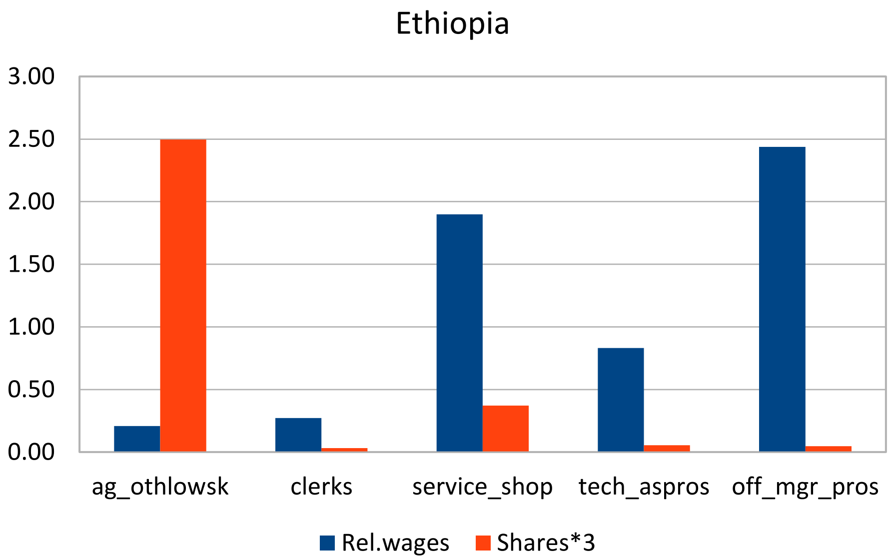

Figure 3. Relative wages vs. labor shares, Ethiopia

The picture looks quite different in many developed countries. For United States, for example, we found the effect to be only +0.78%. Figure 4 highlights that this would be primarily due to the relatively small share of agriculture, but also because of the wages in this category not being very low.

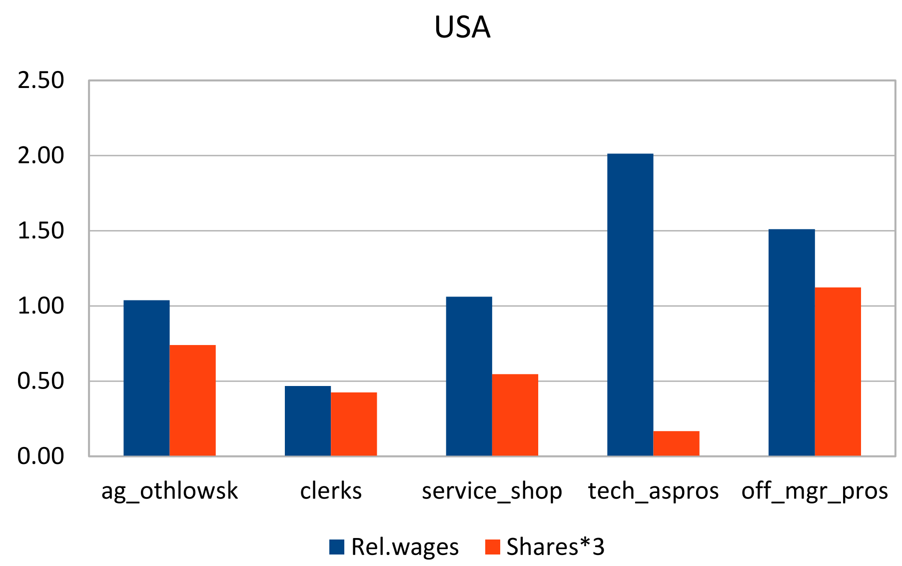

Figure 4. Relative wages vs. labor shares, United States

3. Simulating the multiplicative effects of educational investments

We demonstrated in the previous section the existence a robust, empirical relationship between investments in education and composition of the labor force. We also ascertained that more education entails, 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.

However, the impact of higher educational expenditure goes much beyond the 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.

A general equilibrium framework is therefore needed to account for all these systemic effects. To this end, we consider here a counterfactual simulation experiment, 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).

We employ this model to simulate the long run impact of a 10% increment in the demand for educational services, realized by the public sector in Ethiopia. The case of Ethiopia is especially interesting, 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 Figure 5.

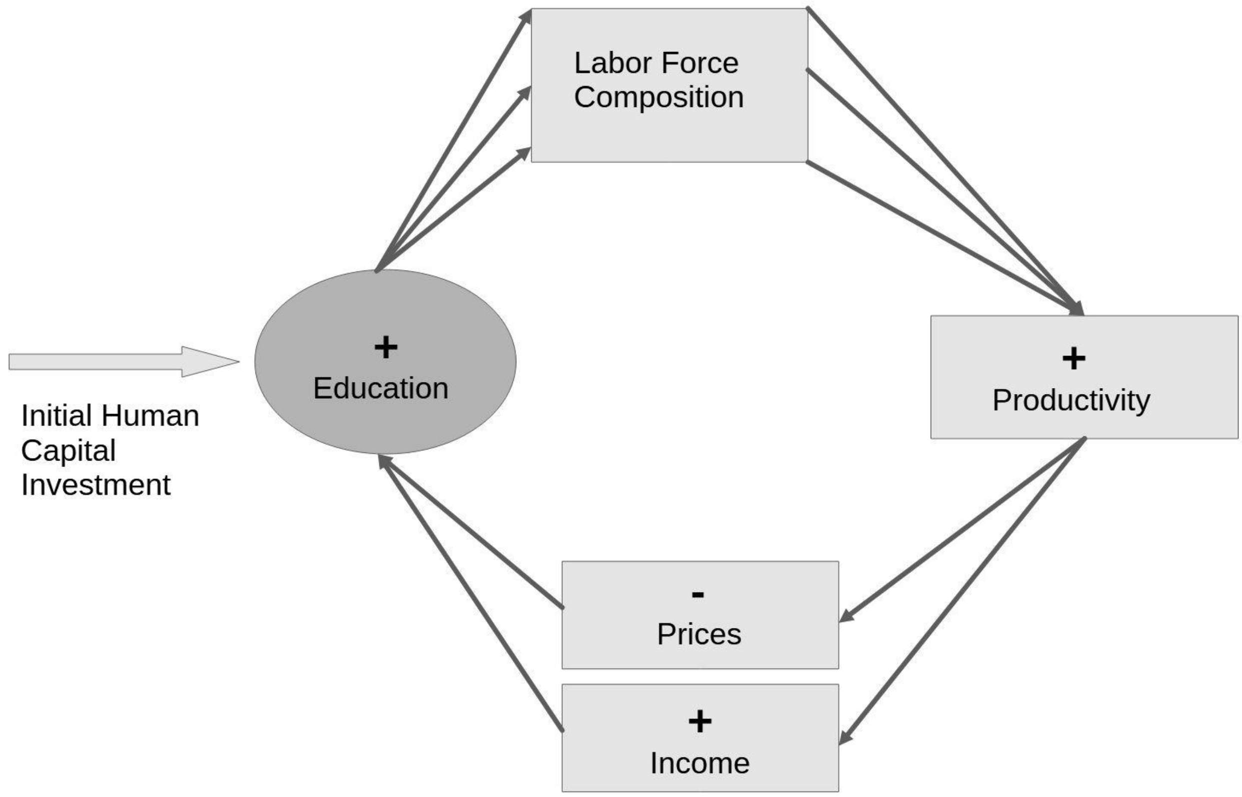

Figure 5. The multiplicative process of increased investments in education

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", with the exception of agricultural and others 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.

We simulate this process 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]).

Figure 6 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 in the public sector.

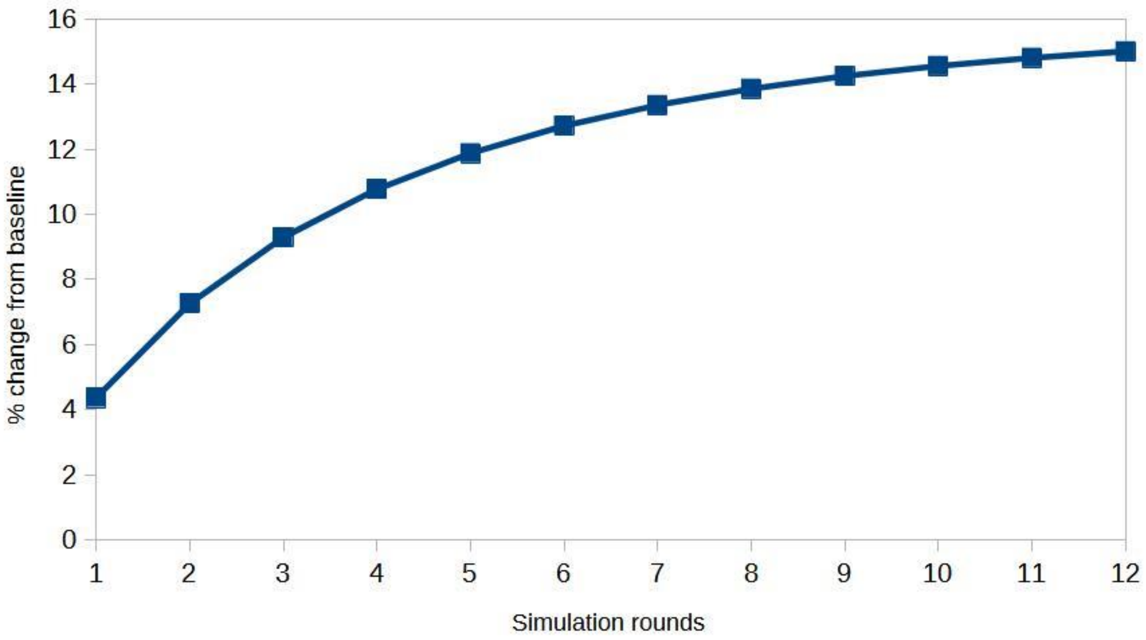

Figure 6. Iterative convergence of Education industry output (% change)

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

Real GDP increases by 1.57%, whereas the equivalent variation, an aggregate monetary measure of welfare impact, amounts to 789 million of 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.[2]

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

Figure 7 displays the percentage change in the price of primary resources in the Ethiopian economy, whereas Figure 8 shows the corresponding price changes for the eleven industries considered in the model.

[2] Contrary to other CGE models, balanced trade is not an equilibrium condition in the GTAP model. For an illustration of the rather peculiar treatment of international financial flows, see Corong et al. (2017).

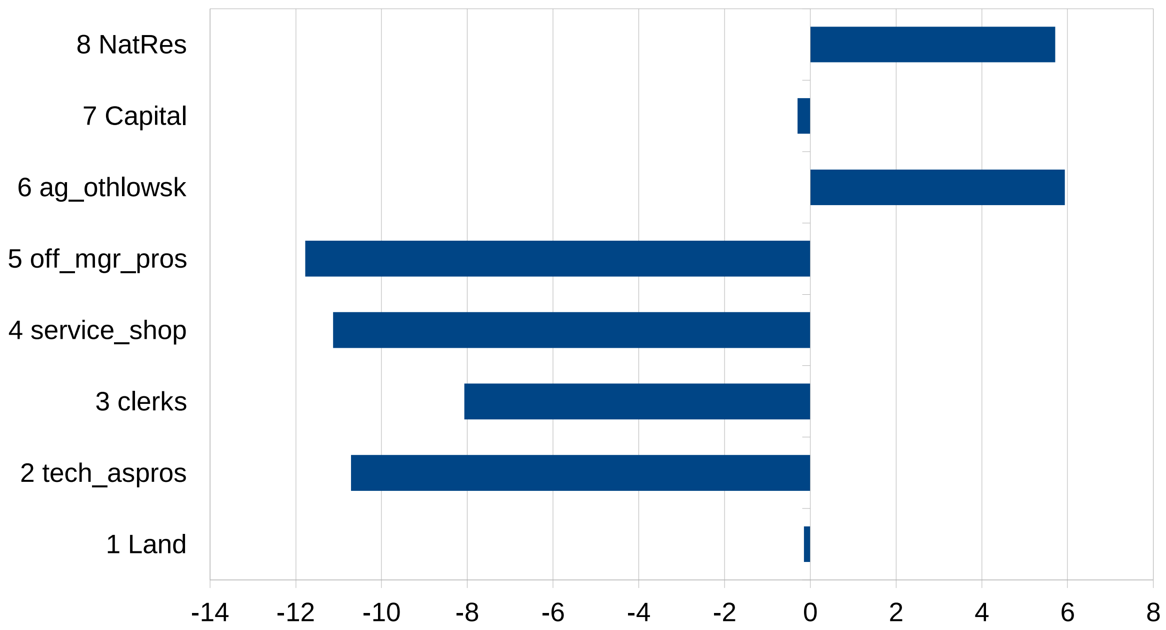

Figure 7. Variation in the price of primary factors (% change)

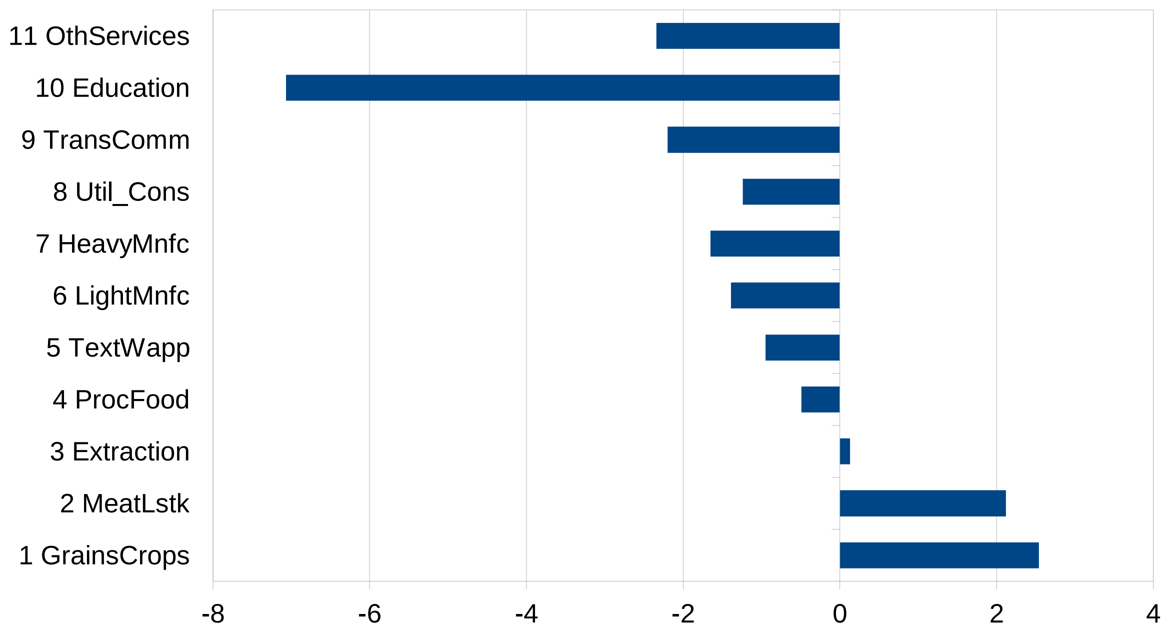

Figure 8. Variation in the price of produced goods and services (% change)

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.

The most significant price drop is detected for 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 Figure 8, presenting the estimated variations in output volumes, for the various industries.

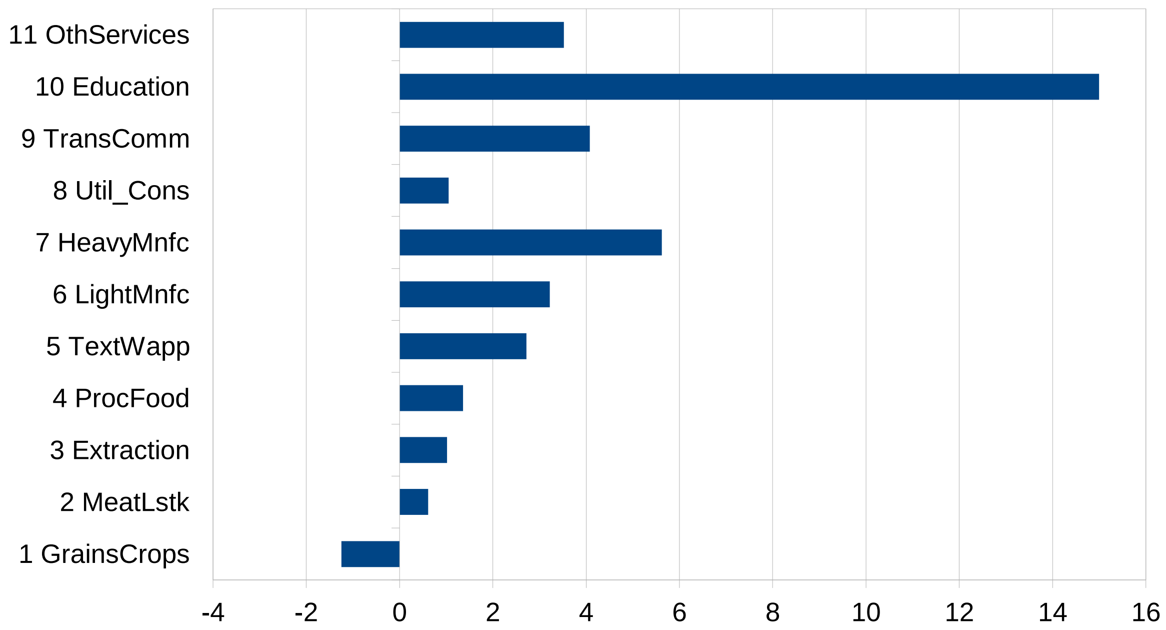

Figure 9. Variation in the quantity of produced goods and services (% change)

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 the fall in relative competitiveness.

Figure 10 presents the variations, expressed as differences in million US$, in the sectoral trade balances.

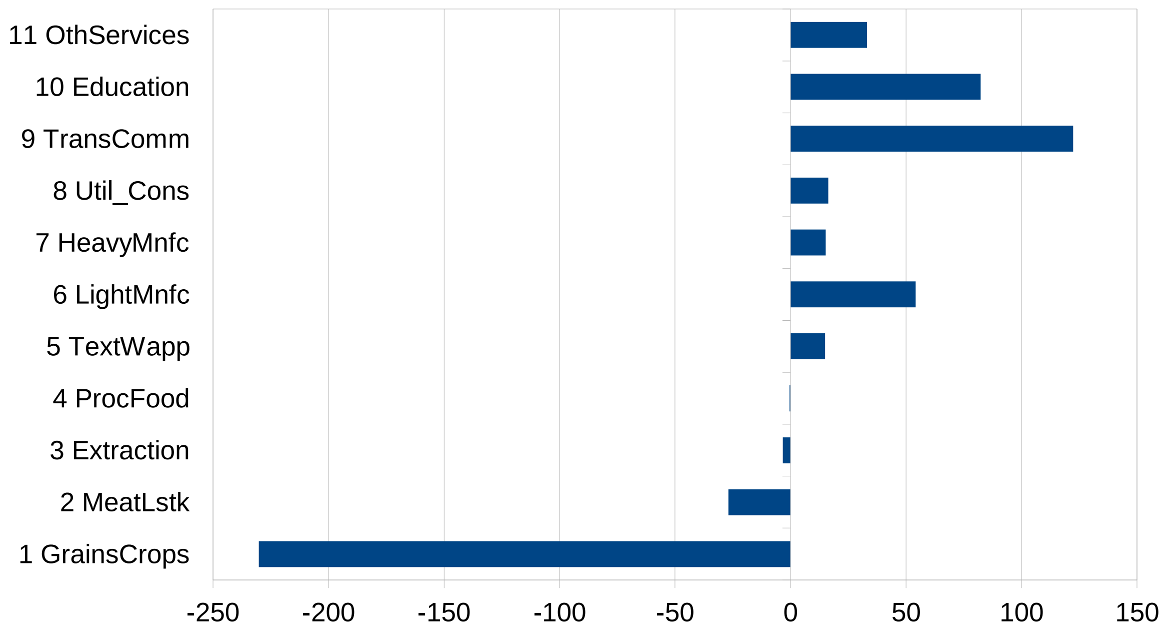

Figure 10. Variation in sectoral trade balances (change, million US$)

The results follow the changes in relative prices but, because of the Armington assumption of imperfect substitutability between domestic and imported products,[3] a key role is also played by the baseline trade shares, considered when 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 imports Grains and Crops, whose import share was already quite sizeable.

4. Discussion

The results illustrated above have been generated through a standard, comparative static 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 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, or closure rules, could be easily implemented. For example, the nominal or real wage can be taken as fixed, which is technically implemented in the model by swapping one exogenous variable (labor endowment) with one endogenous variable (wage), in a way that makes employment or unemployment levels variables. More elaborated treatments of the labor market are also possible. For example, the introduction of a positively sloped labor supply function (as, e.g., in Roson, 1998).

One issue with the setting adopted here is the actual existence of five, separated, labor markets. Therefore, the model not only individually determines employment or unemployment levels by category, but also calculates new wage differentials, after each iteration round or, more generally, after each external shock. 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.

We defend this choice with two arguments. First, the endogenization of the wage differentials would entail the introduction of new equations in the model system, whereas we would like to illustrate the general logic 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 Figure 7 indicate that the wage gap between agriculture/low-skilled and the rest of workers has narrowed. Consequently, we are overestimating somewhat the expansion in the total labor supply.

The variation in the composition of the labor force is determined, in our exercise, by changes in the overall educational spending. This association is based on an empirical correlation we detected between the mix of workers and the real output level of educational services. However, this correlation might well be driven by a third factor, like per capita income.

[3] Domestic and imported goods are aggregated by a CES production function, determining a composite good, available for domestic consumption.

In fact, economic development entails structural change, with a larger share of agriculture in the national income at earlier stages of development, and a larger share of services at some later stages. The different mix of the labor force may then simply reflect the various degrees of economic development, whereas lower or higher expenditure in education would merely depend on available income.

Furthermore, in our simplified 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 we are not considering 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".[4] Smith (1986), Abel and Deitz (2017), Livingstone (2018) discuss the phenomenon of overeducation and underemployment. McKee-Ryan and Harvey (2011) provide a comprehensive overview of underemployment research. This literature primarily focuses on individuals, whereas, to the best of our knowledge, no satisfactory macroeconomic analysis (theorical or applied) has been proposed so far. Therefore, given the current state of knowledge, accounting for underemployment in a general equilibrium model, like the one applied here, looks quite problematic.

To sum up, and given all the weaknesses listed above, one could legitimately ask if the insights obtained from our numerical exercise are still trustworthy and sufficiently general. Despite all caveats and limitations in the data and estimation techniques, we believe they are. Indeed, there are two critical hypotheses driving our results, which are quite robust. The first one is that better quality jobs are available when people get more educated. This is quite 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 (as obtainable, for instance, from a national input-output table) will confirm this hypothesis.

Of course, much research work lies ahead. The link between education expenditure and composition of the work force 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 we believe that the overall qualitative picture coming out from our analysis will not likely change in any substantial way.

5. Concluding remarks

To get more education you need more educated people. To get more educated people you need more education. In this paper, we have examined this virtuous circle, 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, on the basis of some empirically validated relationships. We avoid assuming the existence of a hyper-rational, forward-looking representative agent, to model consumption of (investment in) educational services. Instead, we rely on an observed relation between expenditure in education and supply of workers, in five distinct categories. Although much could be done to better estimate this link, its employment in an empirical macroeconomic model provides a much more solid and reliable base, rather than that of hypotheses borrowed from abstract microeconomic theory.

[4] Not the only one. For instance, another dimension is related to time devoted to work forcibly inferior to the desired level, like constrained seasonal or part-time work (Bell and Blanchflower, 2021).

The second contribution we see comes from framing (we believe 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 one of the most favored by the variation in relative prices. All in all, this generates a multiplicative effect for investments in human capital, making their social return remarkably high, especially in development countries such as Ethiopia.

Acknowledgements

The development of this paper greatly benefitted from several discussions and suggestions provided by Wolfgang Britz. The econometric results have been obtained and employed in a parallel study, committed the European Commission Joint Research Centre.

References

Abel, J. R., Deitz, R. (2017). Underemployment in the early careers of college graduates following the Great Recession. In *Education, skills, and technical change: Implications for future US GDP growth* (pp. 149-181). University of Chicago Press.

Aguiar, A., Chepeliev, M., Corong, E., McDougall, R., & van der Mensbrugghe, D., (2019). The GTAP Data Base: Version 10. *Journal of Global Economic Analysis*, Volume 4, No. 1, pp. 1-27.

Aguiar, A. (2020). Updating GMig2 to GTAP 10. https://www.gtap.agecon.purdue.edu/resources/download/9605.pdf.

Bell, D. N., Blanchflower, D. G. (2021). Underemployment in the United States and Europe. *ILR Review*, 74(1), 56-94.

Britz, W., Roson, R. (2019). G-RDEM: A GTAP-Based Recursive Dynamic CGE Model for Long-Term Baseline Generation and Analysis, *Journal of Global Economic Analysis*, Volume 4, No. 1, pp. 50-96.

Britz, W., Roson, R. (2021). Simulating long run structural change with a dynamic general equilibrium model. *Int. J. Computational Economics and Econometrics*, Vol. 11, No. 4, pp. 368-405.

Cloutier, M. H., Cockburn, J., Decaluwé, B. (2008). Education and poverty in Vietnam: a computable general equilibrium analysis. Cahier de recherche/Working Paper 08-04, Cirpée.

Corong, E. L., Hertel, T. W., McDougall, R., Tsigas, M. E., van der Mensbrugghe, D. (2017). The standard GTAP model, version 7. *Journal of Global Economic Analysis*, *2*(1), 1-119.

Jung, H. S., Thorbecke, E. (2003). The impact of public education expenditure on human capital, growth, and poverty in Tanzania and Zambia: a general equilibrium approach. *Journal of Policy Modeling*, 25(8), 701-725.

König, M., Loibl, W., Haas, W., Kranzl, L. (2015). Shared-socio-economic pathways. In *Economic evaluation of climate change impacts* (pp. 75-99). Springer, Cham.

Krugman, P. (2013). "The New Growth Fizzle". *New York Times* (August 18, 2013).

Livingstone, D. W. (2018). *The education-jobs gap: Underemployment or economic democracy*. Routledge.

McKee-Ryan, F. M., Harvey, J. (2011). “I have a job, but...”: A review of underemployment. *Journal of Management*, *37*(4), 962-996.

Organisation for Economic Co-operation and Development (OECD). (2021). *Education at a glance 2021: OECD indicators*. Paris: OECD. https://doi.org/10.1787/b35a14e5-en .

Romer, P. M. (1994). "The Origins of Endogenous Growth". *The Journal of Economic Perspectives*. 8 (1): 3–22. https://doi.org/10.1257/jep.8.1.3 .

Roson, R. (1998) “Wage Curves and Capital Mobility in a General Equilibrium Model of Italy” in A.Fossati and J.Hutton (eds), *Policy Simulations in the European Union*, Routledge.

Smith, H. L. (1986). Overeducation and underemployment: An agnostic review. *Sociology of Education*, 85-99.

Verbic, M., Majcen, B., Cok, M. (2009). Education and economic growth in Slovenia: a dynamic general equilibrium approach with endogenous growth. MPRA Paper No. 17817.

Walmsley, T., Aguiar, A., Hussein, Z., Parsons, C. (2013). The GMig2 Data Base: Extending GTAP 8 to Include Global Bilateral Migration, Wages and Remittances. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4044 .