Human Capital Formation and the Linkage between Trade and Poverty: The Cases of Costa Rica and Nicaragua*

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Abstract

We combine different analytical instruments to assess the impact of human capital and trade policies on macroeconomic aggregates and poverty, and how both sets of policies complement each other in Costa Rica and Nicaragua. We use a top-down approach –i.e. a dynamic CGE model and microsimulations– to assess the effects of two FTAs: DR-CAFTA and EU-CAAA on production and poverty. Moreover, we use a human capital satellite model to evaluate the impact of human capital formation. Combining the satellite model with the CGE model and the microsimulations, we construct a rich analytical framework to assess the direct effect of each set of policies on poverty and how these policies complement each other. We find that human capital policies have a significant and permanent effect on growth and this is associated with poverty reductions. On the other hand, the static efficiency changes associated with trade liberalization have positive but small growth and poverty effects.

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1 Introduction

Costa Rica and Nicaragua have engaged in important trade negotiations in the past 15 years. After negotiating several Free Trade Agreements (FTAs) with minor commercial partners (e.g. Mexico, Canada, Chile), Nicaragua ratified a FTA with the United States (US) in 2006 and Costa Rica in 2008 (DR-CAFTA). Moreover, both countries together with El Salvador, Guatemala and Honduras started negotiations with the European Union on an EU-Central America Association Agreement (EU-CAAA) in 2007. Combined, the US and EU represent the highest share of trade flows for both countries and thus, both FTAs are expected to have a significant economic impacts. In addition to trade reforms, both countries have been actively attracting Foreign Direct Investment (FDI) and pursuing competitiveness reforms to strengthen their integration with global markets. The main challenge of these policy efforts is to foster economic growth, improve living standards and reduce poverty.

Central America is characterized by widespread poverty and high levels of income inequality. Although Costa Rica has lower poverty levels, in the last two decades these have remained almost unaltered while income distribution has worsened. In the case of Nicaragua, poverty rates are among the highest in Latin America, while income distribution is highly unequal (Francois *et al.*, 2008). Thus, it is important to estimate the poverty effects of trade policy in both Central American countries. The main feature of FTAs is the change in relative prices of final goods and factors, associated with the reduction or elimination of tariffs and other trade barriers. It has been widely acknowledged that trade reform is in aggregate beneficial for households (the country's aggregate welfare). Notwithstanding, it is also asserted that particular groups can be negatively affected by increased trade openness. The final outcome of an FTA depends on the general equilibrium adjustments and resource reallocations resulting from relative price changes. As well as the dynamic effects created by FDI inflows, increased productivity and innovation derived from higher exposure to international markets and ideas.

Human capital formation has long been regarded as an important source of economic growth (Lucas, 1988; Barro and Sala-i-Martin, 1995). In their recent survey, Hanushek and Woessman (2008) find that there are strong empirical links between human capital formation and economic growth, particularly when the quality of education is accounted for. Thus, it is expected that educational policies that increase the quantity and quality of schooling can foster growth in both Central American countries. In turn, higher growth rates have a large potential to reduce poverty rates. Moreover, a labor force with higher human capital can act as a positive complementary effect to enhance the benefits of the recent trade liberalization process in Costa Rica and Nicaragua.

The main objective of this study is to estimate the impact of trade and human capital formation on poverty, and assess the complementarities between both sets of policies. To achieve this goal we use several methodologies. First, we build a dynamic Computable General Equilibrium (CGE) model and use it to analyze the macroeconomic effects of two FTAs (DR-CAFTA and EU-CAAA). Secondly, using a "top-down" approach, we assess the microeconomic effects on households when the macro policies are implemented. Finally, we implement a human capital satellite model and use it to assess the effects of human capital policies on labor efficiency and labor supply by different skill types. We then interlink the satellite model with the CGE model to interact trade and human capital policies at the macro level. The combination of these methodologies enables use to conduct a rich analysis of each policy (education and trade), their interactions and complementarities.

With respect to the macro component, this paper builds on previous studies that estimated the macroeconomic effects of both FTAs. In Francois *et al.* (2008) the economic implications of DR-CAFTA were assessed, while Rivera and Rojas-Romagosa (2007) studied the effects associated with different prospective scenarios for EU-CAAA.

The "top-down" methodology takes a two-step approach where changes in factors and final goods prices and quantities are first estimated through a Computable General Equilibrium (CGE) model and then mapped into the welfare function of each household using detailed household income and expenditure data.[1] With this methodology we can assess the poverty effects of both DR-CAFTA and the forthcoming EU-CAAA on two Central American countries: Costa Rica and Nicaragua.

Recent household surveys for Costa Rica and Nicaragua provide detailed micro information on the income sources and expenditures of a representative sample of households.[2] When this micro data is adequately organized, we can map changes in final goods and factor prices to the real income of each household. Using this real income information and the existing poverty line estimations published by national statistics agencies, we can estimate the changes in headcount poverty ratios, the poverty gap and the Foster-Greer-Thorbecke index for each country.

To address the issue of human capital formation a satellite model is constructed following a revised version of the model by Jacobs (2005). In this model, improvements in school attainment are linked to changes in labor efficiency and labor supplies of different skill groups. The revised version includes the use of qualitative measures of schooling –by means of test scores– to assess the impact of educational policies. This allows us to incorporate into the model the latest findings by Hanushek and Woessman (2008), who show the importance of cognitive skills (i.e. the quality dimension of schooling) to assess the impact of human capital on growth and productivity.

Given the relative abundance of low-skill labor in both countries, it is expected that better export market access to the US and the EU increases the production and trade in low-skill intensive activities. The expansion of these sectors will increase the demand for low-skill workers and this is reflected in higher wages and better employment opportunities. Since the region is also characterized by a large informal sector which consists mainly of low-skill workers, a larger labor demand related to higher trade volumes can also facilitate the inclusion of these low-skill workers into the formal sector.[3] Moreover, human capital investments in both countries are far behind international standards. This situation constrains the possibilities to create skill improvements that can take advantage of higher value added productive activities linked to international trade and foreign direct investment.

Our CGE results show that Costa Rica and Nicaragua can expect production and consumption increases from DR-CAFTA. These benefits are also present after the implementation of an Association Agreement with the European Union, although at a lower level. The CGE framework, however, only simulates static efficiency changes as a result of lower trade barriers. Thus, the positive changes from

[1] This methodology is now a standard feature of trade and poverty analysis. See for instance Cogneau and Robilliard (2000); Bourguignon and da Silva (2003); Löfgren *et al.* (2003); Winters *et al.* (2004).

[2] More precisely, the most recent expenditure and income surveys will be used for this study. These surveys are more comprehensive and capture more information than the (annual) household surveys.

[3] For instance, Sauma and Sánchez (2003) indicate that in the case of Costa Rica, trade liberalization helped to create more "formal" jobs and thus reduce poverty rates. Evidence suggests an inverse relationship between formal work and poverty in Costa Rica.

the trade policies we report can be regarded as a lower-bound for the potential benefits of the trade agreements. If dynamic efficiency gains are considered, then the benefits can be higher.[4]

The main driver of economic growth in the analysis is provided by the upgrading of human capital through educational policies. The results from the satellite model show that these policies create significant dynamic efficiency gains. For instance, the baseline growth rate is increased by around 0.6% in Costa Rica and 1% in Nicaragua when we link the labor supply and efficiency changes from the satellite model into the CGE model. Thus, both Costa Rica and Nicaragua experience higher growth and welfare effects when labor efficiency improves through human capital policies. However, there are significant short-term costs associated with the educational policies. In a first stage, the supply of low and high-skill workers is reduced (since students stay longer in school) but later on the human capital accumulation process starts and labor efficiency and wages begin to grow steadily over time. This process yields significant medium and long-term returns from education.

As a consequence of the different growth patterns produced by both policies, poverty impacts of FTAs are positive, but small. Human capital policies, on the other hand, yield stronger poverty reductions. Therefore, the poverty reduction we observe in our integrated scenario –where both trade and educational policies interact– is a direct outcome of human capital improvements in both countries. Our microsimulation results using the household surveys show that the most important income source for poor families in both countries is low-skill wages. Therefore, much of the poverty reduction after the implementation of education policies derives from the significant growth in low-skill wages. Finally, poverty and other macroeconomic variables do present positive but relatively small complementarity effects when both trade and educational policies are jointly implemented.

[4] Francois *et al.* (2008) and Rivera and Rojas-Romagosa (2007) estimate some of these dynamic efficiency gains.

2 Initial economic conditions in Costa Rica and Nicaragua

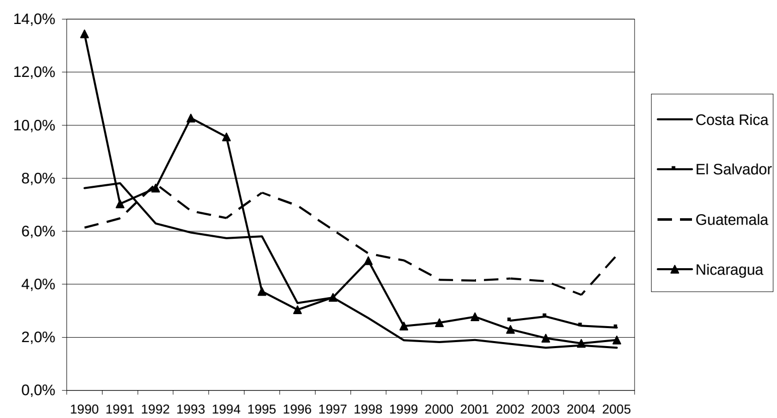
In this section we review the initial economic and social conditions in both countries. We start with an overview of the main macroeconomic and social indicators, continue with the latest trade policies implemented in recent years, and finish with an outlook of the human capital characteristics and policies for both countries.

2.1 Trade and development in Costa Rica and Nicaragua

One of the most meaningful changes experienced by Costa Rica, Nicaragua, and Central America in general during the last two decades has been the consolidation of market liberalization policies and trade openness. The countries have been deliberate in opening their economies, establishing measures to accelerate it through unilateral import tariff cuts, policies to attract Foreign Direct Investment (FDI), and the implementation of Free Trade Agreements (FTAs).

For instance, trade-weighted average tariffs in both countries have been steadily declining since the 1980s (Figure 1). During the last decade, in particular, trade policy in Costa Rica and Nicaragua has been based on FTAs. Currently, both countries have signed FTAs with Canada, Mexico, Chile, the Dominican Republic, United Sates and some Caribbean countries. In addition, investment agreements have been ratified with an important group of countries, European as well as Latin American.

Figure 1: Central America, effective average nominal tariff rates$^{1/}$, 1990-2005



Notes: 1/ Defined as the ratio of collected import duties to total imports
Source: World Development Indicators

Table 1 presents economic growth indicators. The average growth rate for Central America during the present decade has been 3,9%, while Costa Rica and Nicaragua grew at 4.6% and 3.4% respectively. GDP per capital reached US$6,581 in Costa Rica and US$1,167 in Nicaragua in year 2008, after an average growth rate of 2,7% and 2.0% for the period 2000-2008, respectively.

Table 2 shows the productive structure of Costa Rica and Nicaragua. It points to a very significant role for the service sector in Costa Rica, with a relatively high agricultural participation in Nicaragua. The volume of trade with respect to GDP is high in both countries, which highlights the importance

Table 1: GDP Indicators

	GDP (US$ million) 2008	GDP Growth 2000-2008	GDP per Cápita (Current US$) 2008	Per Cápita Growth 2000-2008
Costa Rica	29,834.4	4.7%	6,581.4	2.7%
Nicaragua	6,627.3	3.4%	1,168.9	2.0%
Central America	112,114.9	4.0%	3,005.6	1.9%

Source: CEPAL (2009), Consejo Monetario Centroamericano

of external demand for both economies. Costa Rica has a significant share of its industrial exports classified as high-technology products.

Table 2: Productive structure

	Agriculture (% of GDP)	Industry (% of GDP)	Services (% of GDP)	Merchandise trade (% of GDP)	High-tech exports (% manufact.exports)
Costa Rica	8.4	28.8	62.8	86.7	36.8
Nicaragua	19.5	31.1	56.1	66.0	6.1

Source: World Development Indicators, The World Bank

Costa Rica experienced an important structural change in its productive and trade sectors since the middle of the 90s, driven by FDI growth (Monge-González *et al.*, 2009). The country has a trade structure with a higher level of technological sophistication. Exports and imports of industrial goods represent the highest share of trade, particularly medium and high technology intensive goods. On the other hand, Nicaragua's exports depend mainly on primary and natural resource based goods, while its imports are less technology intensive. The trade structure of the country has not changed, with the exception of other products like mining, that have increased their participation (Table 3).

Table 3: Trade structure by industry and technology classification, 1995 and 2007/2008

	Costa Rica				Nicaragua			
	Exports		Imports		Exports		Imports	
	1995	2008	1995	2008	1995	2007	1995	2007
Primary Goods	58.3%	23.9%	10.7%	9.9%	64.0%	62.6%	23.9%	19.1%
Industrial Goods	36.4%	75.5%	87.4%	89.5%	34.0%	31.8%	75.2%	79.8%
Based on Natural Resources	15.6%	16.3%	23.6%	22.7%	14.2%	23.4%	19.4%	25.1%
Low Technology	10.8%	14.1%	16.1%	14.9%	12.0%	2.8%	13.2%	15.7%
Medium Technology	7.1%	17.6%	36.3%	29.7%	2.9%	4.8%	30.5%	25.0%
High Technology	2.9%	27.6%	11.6%	22.2%	4.8%	0.8%	12.1%	14.1%
Others	5.3%	0.6%	1.9%	0.6%	2.0%	5.6%	0.9%	1.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Own elaboration with data from CEPAL (2009)

The United States and the European Union are the most important trade partners of Costa Rica. Table 4 shows which goods are the main source of trade between Costa Rica an these regions. Industrial goods exports are the largest to the US market, with a higher share of products classified as diffusers of technical progress.[5] These same industrial goods account for around 60% of Costa Rican exports to other markets. On the other hand, primary agricultural goods represent almost 60% of external sales to the European Union, and around 30% of exports to the USA. Industrial imports from all trading partners are significant, whereas more technology advanced goods are imported from the EU and other markets. The United States is the main import source of traditional industrial goods and products with economies of scale

Table 4: Costa Rica: Trade by main partners and product categories, 2008

	United States		**European Union**		**Others**	
	US$ 000	% of total	US$ 000	% of total	US$ 000	% of total
Exports						
Agriculture	1,077,692	29.1	952,022	56.1	190,449	4.4
Mining	395	0.0	0	0.0	6,277	0.1
Energy	644	0.0	0	0.0	0	0.0
Traditional industrial goods	821,495	22.2	199,800	11.8	1,413,642	32.7
With economies of scale	300,827	8.1	72,785	4.3	754,290	17.4
Durable goods	13,788	0.4	5,056	0.3	76,921	1.8
Diffusers of technical progress	1,492,051	40.2	465,762	27.5	1,886,965	43.6
Others	860	0.0	1,109	0.1	644	0.0
Total	3,707,752	100.0	1,696,534	100.0	4,329,188	100.0
Imports						
Agriculture	496,321	8.5	18,428	1.1	221,521	2.9
Mining	10,771	0.2	588	0.0	42,387	0.5
Energy	4,841	0.1	537	0.0	580,562	7.5
Traditional industrial goods	904,850	15.5	209,822	12.2	1,613,189	20.9
With economies of scale	1,648,528	28.3	453,130	26.4	2,791,887	36.1
Durable goods	233,624	4.0	79,302	4.6	816,891	10.6
Diffusers of technical progress	2,440,826	41.8	942,437	55.0	1,607,620	20.8
Others	92,974	1.6	9,823	0.6	54,859	0.7
Total	5,832,735	100.0	1,714,067	100.0	7,728,916	100.0

Source: CEPAL (2009)

Nicaragua's trade with the US and the EU is more balanced in terms of industrial and primary goods (Table 5). Exports to other markets (specially to the Central American region) are more concentrated on primary goods. As indicated before, the trade structure of Nicaragua is composed of low technology intensity goods, especially in terms of its exports. More advanced goods are imported from the EU and other regions.

It is important to highlight that Costa Rica and Nicaragua have distinct economic and social characteristics, as shown by their different production and trade patterns. Costa Rica has a medium-income GDP per capita level, and a more dynamic and diversified economy. This difference can be better understood by observing the education and human development indicators. As shown in Table 6, Nicaragua has low literacy rates, education expenditures, and lower enrollment rates. Costa Rica shows better performance indicators. This differentiation introduces comparative issues that would help understand from two different perspectives the role played by trade on growth and poverty.

The Central America region has low-income country characteristics, while poverty rates are relatively lower for Costa Rica, and significantly high for Nicaragua. In addition, poverty rates are higher for people without a formal occupation. Even when unemployment is around 5% in both countries and

[5] This is mainly related to the operations of Intel Corporation in Costa Rica beginning in the late 1990s.

Table 5: Nicaragua: Trade by main partners and product categories, 2007

	United States		European Union		Others	
	US$	% of total	US$	% of total	US$	% of total
Exports						
Agriculture	59,313	34.0	171,111	53.1	165,735	81.4
Mining	3,119	1.8	0	0.0	8	0.0
Energy	0	0.0	0	0.0	0	0.0
Traditional industrial goods	82,922	47.5	131,073	40.7	31,472	15.5
With economies of scale	17,881	10.2	16,742	5.2	5,490	2.7
Durable goods	692	0.4	135	0.0	147	0.1
Diffusers of technical progress	10,314	5.9	2,899	0.9	699	0.3
Others	287	0.2	195	0.1	106	0.1
Total	174,529	100.0	322,155	100.0	203,655	100.0
Imports						
Agriculture	20,054	1.6	75,008	12.0	6,735	0.8
Mining	1,598	0.1	528	0.1	74	0.0
Energy	353,419	27.7	3,108	0.5	29,620	3.5
Traditional industrial goods	304,541	23.9	121,478	19.4	166,966	19.9
With economies of scale	354,308	27.8	173,734	27.8	217,199	25.9
Durable goods	56,851	4.5	28,038	4.5	166,499	19.8
Diffusers of technical progress	184,962	14.5	187,279	30.0	247,358	29.4
Others	235	0.0	35,571	5.7	5,498	0.7
Total	1,275,968	100.0	624,744	100.0	839,949	100.0

Source: CEPAL (2009)

Table 6: Education and human development

	HDI Rank*	Adult Literacy Rate (% aged 15 and above)	Net Primary Enrollment Rate (%)	Net Secondary Enrollment Rate (%)	Public Expenditure in Education (% of GDP)	Researchers in R&D (per million people)
	2008	2008	2005	2005	2005	2005
Costa Rica	50	95.8	99.7	67.6	4.9	533
Nicaragua	120	80.1	84.1	43.0	3.1	73

* Human Development Index among 176 countries

Source: Human Development Report, UNDP and World Development Indicators, The World Bank

expected to increase between 0,6% and 0,7% in year 2009 (ECLAC, 2009), there are relatively high under-employment conditions tied to a significant informal sector economy, particularly in Nicaragua (Table 7).

These characteristics imply that with this low human capital profile –together with the absence of major natural resource endowments– low-skill labor is a relatively abundant factor in Nicaragua, and less in Costa Rica. The subsequent high sub-utilization rates of labor imply that workers could be drawn to the formal sector with the improved labor opportunities expected from DR-CAFTA and EU-CAAA.

2.2 Trade policy in Central America

Both DR-CAFTA and EU-CAAA are steps forward in the global integration process of Costa Rica and Nicaragua. The agreements will not only consolidate trade and investments with the US and EU, but

Table 7: Poverty and labor conditions

	Poverty headcount	Poverty headcount*	Poverty non-employed	Worker Sub-Utilization**	Gini Coefficient
	1990-2003	2008	2008	2008	2008
Costa Rica	22.0%	18.6%	20.0%	13.4%	0.51
Nicaragua	47.9%	46.0%	62.0%	33.7%	0.57
Central America	44.5%	52.8%	51.9%	30.7%	0.57

* 2005 for Nicaragua
** Unemployment plus Under-Employment
Source: UNDP (2006), ECLAC (2009), Rivera and Rojas-Romagosa (2007)

create a business platform in the region, to attract more companies and investors interested in entering both markets. Most importantly, there would be a more solid integration of a regional Central American market of almost 40 million people.

Depending on the final outcome of a Free Trade Agreement (resulting basically from the political bargaining of interest and pressure groups), a group of "winners" and "losers" will emerge. These groups, however, might not be the expected winners and losers, in terms of their success or failure to influence the FTA agreement. Instead, the impact of an FTA will depend significantly on the starting point of an economy, and the particular characteristics of its productive sectors. The ensuing results will then depend on the structure, level of development, stage of competitiveness and dynamics of the different sectors within the economic system of a country (Condo *et al.*, 2005).

Less competitive business (or even entire industries) will either have to upgrade to compete, or be forced to move to other activities that offer the opportunity to create wealth. This is the resource reallocation and efficiency gains logic of international trade. If the production capacity and human resources can be upgraded or reallocated successfully, trade liberalization under DR-CAFTA and EU-CAAA can become a success as companies become competitive and workers share in the benefits of growing and thriving businesses.

However, there are political, economic and social risks that must be recognized and mitigated. Basically, the difficulties lie in the ability of the countries to manage the transformation process. Upgrading competitive capacity and shifting factors of production into other areas is time and resource consuming and requires much investment. Fiscal and institutional constraints in the countries could limit the ability to invest in many critical areas that would help facilitate and smooth the transformation.

Under the US Caribbean Basin Trade Partnership Act (CBTPA)[6] and the Generalized System of Preferences (GSP), many exports from Costa Rica and Nicaragua already enter the United States duty-free. DR-CAFTA consolidated these benefits and made them permanent.[7] More than 80 percent of US tariff codes (consumer and industrial products) exported to Central America enter duty-free

[6] Enacted in May 2000 as part of the Trade and Development Act. The CBTPA enhanced the 1984 Caribbean Basin Initiative (CBI) benefits.

[7] The United States and five Central American countries, El Salvador, Guatemala, Honduras, Nicaragua and Costa Rica, concluded negotiations on the US-Central American Free Trade Agreement (DR-CAFTA) in January 2004. The agreement was signed on May 2004, and ratified by the US House of Representatives on July 27, 2005. The agreement has been ratified by all country partners. The Dominican Republic was included into the Agreement on August 2004, named afterwards DR-CAFTA.

immediately since the ratification of the agreement, while 85 percent will be duty free within five years. All remaining tariffs will be eliminated within ten years.

Close to 98 percent of all goods produced in Central America enter the US market duty-free. The Central American countries also accorded substantial market access across their entire services regime (i.e. banking, insurance, telecommunications), subject to very few exceptions. Regarding agriculture, DR-CAFTA opened the market widely, with the elimination of almost 100 percent of import tariffs. The only excluded products are sugar in the US, white corn in all Central American countries, potatoes and onions in Costa Rica. The sensitive agricultural products of Central America (rice, beans, poultry, beef and pork meat, dairy products) obtained protection with long tariff phase-out periods.

The European Union (EU) and five Central American countries, El Salvador, Guatemala, Honduras, Nicaragua and Costa Rica, started negotiations of an EU-Central America Association Agreement (EU-CAAA) in June 2007.[8] Under the Generalized System of Preferences (GSP plus), many exports from Central America already enter the European Union duty-free. Notwithstanding, many agricultural goods face important tariff and non-tariff barriers in the EU market, particularly bananas and sugar, two export commodities with significant comparative advantages in Central America.

The Association Agreement could consolidate GSP plus benefits and make them permanent, so that an important amount of products made in Central America could enter the EU market duty-free immediately upon ratification of the agreement. However, the recent experience with EU negotiated FTAs (with Chile, Mexico, and South Africa, for instance) suggests that many "sensitive" sectors, mainly EU agricultural goods with high protection, would be excluded from any agreement.

Tables 4 and 5 shows the relative importance of trading partners for Costa Rica and Nicaragua before the implementation of both FTAs.

2.3 Human capital, trade and growth

Many of the economy-wide effects of increased trade openness are dynamic in nature. While an improvement in the allocation of resources is the main static effect of liberalization, most of the expected gains from increased trade are dynamic. These include more and cheaper inputs and final products, pro-competitive effects associated with increasing returns to scale and the erosion of market power, among others (Francois *et al.*, 1996). In order to assess the wider impact of trade liberalization it is important to take into account the potential impact of changes in key variables related to growth, like human capital accumulation, foreign investment growth, and technology upgrading.[9]

The impact of trade on poverty would depend on changes and adjustments of several variables that affect productivity and consumption. According to Winters *et al.* (2004), the impact is related to growth outcomes, household consumption changes, labor market adjustments (employment and wages), and fiscal impacts (public expenditure and income redistribution). Human capital investment is generally regarded as a key determinant of the impact of trade liberalization on growth and poverty. Reina and Zuluaga (2008) present a literature review with evidence of a strong link between increased trade, human

[8] An Association Agreement goes beyond the standard Free Trade Agreement approach. It incorporates political and institutional agreements between the Parties, and a development aid component. The EU-CAAA is expected to be ratified in 2010.

[9] See for example Edwards (1993), Barro and Sala-i-Martin (1995), Easterly (2001), Helpman (2004), Aghion and Howitt (2009).

capital formation and growth. From a theoretical perspective, there are at least three mechanisms through which education investments may affect economic growth:

- Education increases the human capital inherent in the labor force, which increases labor productivity and thus transitional growth towards a higher equilibrium level of output (Mankiw *et al.*, 1992).
- Education may increase the innovative capacity of the economy, and the new knowledge on new technologies, products and processes promotes growth (Lucas, 1988; Romer, 1990; Aghion and Howitt, 1998).
- Education may facilitate the diffusion and transmission of knowledge needed to understand and process new information and to adapt successfully new technologies, which again promotes economic growth (Helpman, 2004; Benhabib and Spiegel, 2005; Aghion and Howitt, 2009).

One particularity of education, from an economic perspective, is the presence of increasing returns and externalities. A direct consequence of this is the tendency of variables to gain more advantage when they move ahead, or to fall further behind when they go back. Increasing returns are then a form of positive feedback (see Arrow, 2000). Existing literature points towards an intergenerational effect of literates influencing education decisions of younger cohorts, and the contribution of a more educated population to economic growth.[10] Moreover, Heckman (2000) argues that early investments in human capital for children have a larger payoff than interventions at a later stage, which aim to close the gap between troubled and regular students.

It is after Lucas (1988) that linking education and economic growth was theoretically encouraged in the economic literature. However it was Romer (1990) who first emphasized a crucial aspect of knowledge (i.e. education and ideas): it can be compared to a public goods and regarded as a non-rivalry good. This roughly means that the use of knowledge by one party does not preclude or make more costly its use by another party. Thus, knowledge has a big potential to foster long-run progress in a country.

It is well documented that workers in cities earn a substantial wage premium, and there is mounting evidence that this premium is not due just to selectivity, but reflects the notion that cities foster the accumulation of human capital (Glaeser and Maré, 2001; Gould, 2007). Economic progress encourages education as well. A country with a healthy economic growth is likely to impact positively the family budget which also helps to support children education (Hanushek and Kimko, 2000).

Many indicators (of the quantitative efficiency) of the system are consistent with this perspective. Among them, the primary completion rate (PCR), which records the graduates from the sixth grade, and the graduate enrollment rate (GER) are regularly selected as the key output indicators to analyze an education system and its impact on growth and poverty. These two output indicators are, however, a quantitative measure of school achievements (coverage), but are not accurate indicators of learning outcomes. It is common practice to use school attainment (years) as a measure of human capital. School attainment as a rough measure of individual skill has been verified by several studies of labor market outcomes (Hanushek, 2007).

However, this variable is only a quantitative indicator that does not include the quality of the education that is provided. Moreover, it assumes that every year of schooling is "homogeneous," that

[10] See for instance Durlauf (1996).

is, produces the same output (like skill formation or completion rates) in every country or time period. Recent research show, contrary to this view, that the quality (more than the quantity) of education has an important impact on productivity and national growth rates (Hanushek and Kimko, 2000; Glewwe, 2002). Differences in cognitive achievement have also an impact on labor market outcomes. For instance, Murnane *et al.* (2000) present evidence on the causality between cognitive skills and future earnings (through higher wages).

Hanushek and Woessman (2008) show that cognitive skills (in combination with traditional quantitative measures) increase the explanatory power of human capital with respect to economic growth, income distribution and wage determination. Moreover, Hanushek and Woessman (2009a) provide evidence that the robust association between cognitive skills and economic growth reflects a causal effect of cognitive skills and supports the economic benefits of education policy. For the case of Latin America, Hanushek and Woessman (2009b) show that the staggering low levels of cognitive skills in the region, can explain a great deal of the comparative low growth levels of the Latin American countries in the past 40 years. The authors argue that school attainment is associated with economic growth only insofar as it produces strong cognitive skills, an area where Latin America has important weaknesses.

The quantity and quality of education are therefore key issues to incorporate when assessing the potential impacts of education policies on trade openness (in this case, Free Trade Agreements) and growth outcomes. We will argue below that Nicaragua's human capital investment is far behind international standards, a situation that limits the creation of capacities and skills improvement to take advantage of higher value added productive activities linked, for instance, to international trade and foreign direct investment. On the other hand, notwithstanding the relative advantage of Costa Rica in terms of years of schooling, the analysis shows that the country still lags behind leading nations in terms of education quality. This leaves broad possibilities for policy actions to enhance human capital and economic growth.

2.4 Education quality in Nicaragua and Costa Rica

Improving the quality of education is still the major challenge confronted by the education systems of Latin America and the Caribbean (UNESCO and LLECCE, 2008b). In the case of Nicaragua, the task is more stressing, since limited access to education and low completion rates (quantity) are still important barriers to development. According to World Bank (2008), lack of education constitutes one of the main determinants of poverty in Nicaragua. It is estimated that less than 70% of population between 15 and 19 years attained complete primary education (UNESCO and LLECCE, 2008a). The Ministry of Education (MINED) reports an 80.3% primary school completion rate (Ministerio de Educación de Nicaragua, 2007). However, less than 40% of students complete primary education without repetition.

Despite some progress in recent years, Nicaragua is likely to meet less than half of the Millennium Development Goals (MDGs) set for 2015. In the case of MDG-2 (a net primary enrollment rate of 100% for year 2015), the country is on track, but unlikely to achieve the goal, notwithstanding the advances reported by Ministerio de Educación de Nicaragua (2008). Currently, the net enrollment rate in primary education is 84.1%. The forecast for 2015 is 87% (World Bank, 2008).

Regarding secondary education, Ministerio de Educación de Nicaragua (2007) reports a 65.7% approval rate, while 43.12% of students complete it without repetition. In year 2007, only 32% of the population aged between 20 and 29 year graduated from high school (UNESCO and LLECCE, 2008a). Therefore, there is also broad space for improvements in secondary education.

Recent estimations indicate that a worker in Nicaragua earns 10% more for each additional year of schooling received. Returns to primary and secondary education have been increasing in the last decade. It is estimated that workers require at least 11 years of education to achieve an income level above the poverty line (World Bank, 2008). Trejos and Gindling (2004) argue that one of the most important determinants of income inequality in Nicaragua, relative to other Central American countries, is the limited access to education. Quality is a central issue, as well. The possibility of increasing labor productivity depends on education quality improvements (World Bank, 2008; Guevara, 2004). For instance, using household survey data, Gutierrez *et al.* (2008) report a decrease of -26% in labor productivity (output per worker) between 2001 and 2005. In presence of more average years of education of the labor force, and a negative Total Factor Productivity (TFP) rate for the same period, the quality of education appears as a possible explanation for this outcome.

From a policy perspective, it seems clear that the improvement of education coverage and quality are key objectives of the Ministry of Education (MINED, 2007b). The final policy outcome in terms of a more productive labor force appears as a key performance indicator for the medium and long term.

Compared to Latin American standards, Costa Rica has made important advances regarding education access in the last decades. Literacy rate is almost 100% while more than 93% of population between 15 and 19 years has completed primary education (UNESCO and LLECCE, 2008a). According to the Ministry of Planning (MIDEPLAN), the net enrollment rate in primary education is 100.7% and 68.9% in secondary education, with completion rates of 89.3% and 79.4%, respectively (SIDES, 2009). However, in recent years secondary school attendance has decreased significantly. Close to 12.5% of secondary students leave high school before completion (Programa Estado de la Nación, 2008). Moreover, it is estimated that only 69% of enrolled students complete secondary studies without repetition (SIDES, 2009).

Secondary education is a central concern of current policy. Indeed, government officials included secondary education promotion as a key component of the National Development Plan for year 2006-2010 (MIDEPLAN, 2006). The main instrument of education promotion has been *Avancemos*, a conditional cash transfer program that aims to support low income students and thus help them complete secondary education. The main objective is to increase the completion rate by 4.2% of 2006 level, in year 2010.

According to Gindling and Trejos (2005), one of the most important determinants of rising inequality in Costa Rica during the 1990s (the period of major trade liberalization measures) was the presence of increasing returns of education, that is, the earning differences between more- and less-educated workers. Driven by trade liberalization and foreign direct investments attraction, the productive structure of Costa Rica has changed significantly in the last two decades. The demand for high skilled workers has increased, as well as their relative wages compared to low skilled workers (Sánchez, 2004). Multinational companies (MNCs) and exporting firms have created a labor demand for more qualified workers, therefore increasing education returns (Monge-González *et al.*, 2009). Gindling (2007) indicates that 90% of household income inequality is explained by labor income, while inequality in education access accounts for an important part of wage dispersion.

Table 8 describes the education level of the labor force for both countries. In terms of education quantity, the Costa Rican labor force is generally more skilled than in Nicaragua. In spite of this, Nicaragua has made advances in recent years to reduce the non-educated workers share and increase all education levels of the employed people. Projections for year 2015 suggest a similar tendency.

Table 8: Education level of the labor force: Projections for 2015

	Costa Rica		**Nicaragua**	
	2006	2015	2006	2015
No Education	2.5	1.8	14.4	8.4
Incomplete Primary	12.5	8.7	23.1	15.4
Primary	28.6	22.8	14.7	12.2
Incomplete Secondary	20.7	24.7	23.4	28.4
Secondary	13.9	15.1	11.1	16.7
University	21.8	26.9	13.2	19.0

Source: Trejos (2008)

Table 9 describes data from the Second Regional Comparative and Explanatory Study (SERCE). These data evaluates student performance in Latin America, following a similar methodology to the PISA (Programme for International Student Assessment) report by OECD (2007). The SERCE gives insight into the learning acquired by Latin American and Caribbean Third and Sixth Grade Primary Students in the areas of Mathematics, Language (Reading and Writing) and Natural Science during their school trajectory. The assessment is based on test scores with an scale of 500 (mean) and 100 (standard deviation) points (UNESCO and LLECCE, 2008a).

Table 9: SERCE tests: Student performance in mathematics and reading tests

	Mathematics		**Reading**	
	Mean Score	Std.Dev.	Mean Score	Std.Dev.
Argentina	513.0	7.7	506.5	9.6
Brasil	499.4	11.6	520.3	11.4
Chile	517.3	8.1	546.1	8.4
Colombia	492.7	9.4	514.9	10.9
Costa Rica	**549.3**	**7.4**	**563.2**	**6.2**
Cuba	637.5	21.7	595.9	13.0
Ecuador	459.5	9.9	447.4	9.2
El Salvador	471.9	7.4	484.2	7.8
Guatemala	455.8	5.7	451.5	6.6
Mexico	541.6	10.3	529.9	9.4
Nicaragua	**457.9**	**5.0**	**472.9**	**5.3**
Panama	451.6	6.3	472.1	7.2
Paraguay	468.3	8.4	455.2	8.7
Peru	490.0	10.6	479.3	5.2
Dominican Rep.	415.6	4.0	421.5	6.4
Uruguay	578.4	7.9	542.2	7.2
Latin America	506.7	5.3	513.0	5.2

Source: UNESCO and LLECCE, 2008b

With regard to changes in the quality of education –as measured by standardized test scores– Costa Rica shows scores above the Latin American averages, while Nicaragua ranks below regional average both in mathematics and reading skills tests. It is noticeable the dispersion of test scores from the highest and lowest percentiles.

Table 10: PISA tests: Student performance in mathematics and reading

	Mathematics		**Reading**	
	Mean Score	Std.Dev.	Mean Score	Std.Dev.
Australia	519.9	88.0	512.9	93.7
Austria	505.5	98.1	490.2	108.2
Belgium	520.3	106.1	500.9	110.0
Canada	527.0	85.8	527.0	96.3
Czech Republic	509.9	103.2	482.7	111.3
Denmark	513.0	84.8	494.5	89.3
Finland	548.4	80.9	546.9	81.2
France	495.5	95.6	487.7	104.0
Germany	503.8	99.1	494.9	111.9
Greece	459.2	92.3	459.7	102.7
Hungary	490.9	91.0	482.4	94.4
Iceland	505.5	88.0	484.4	97.0
Ireland	501.5	82.0	517.3	92.4
Italy	461.7	95.8	468.5	108.8
Japan	523.1	91.0	498.0	102.4
Korea	547.5	92.6	556.0	88.3
Luxembourg	490.0	93.4	479.4	100.2
Mexico	405.7	85.3	410.5	95.7
Netherlands	530.7	88.6	506.7	96.6
New Zealand	522.0	93.3	521.0	105.2
Norway	489.8	91.6	484.3	105.1
Poland	495.4	86.5	507.6	100.2
Portugal	466.2	90.7	472.3	98.8
Slovak Republic	492.1	94.5	466.3	105.1
Spain	480.0	88.9	460.8	88.8
Sweden	502.4	89.7	507.3	98.2
Switzerland	529.7	97.4	499.3	94.1
Turkey	423.9	93.2	447.1	92.9
United Kingdom	495.4	88.9	495.1	101.9
United States	474.4	89.7	na	na
OECD average	497.7	91.5	491.8	99.1
Latin American Countries				
Argentina	381.3	101.1	374	124
Brazil	369.5	92.0	393	102
Chile	411.4	87.4	442	103
Colombia	370.0	88.0	385	108
Uruguay	412.5	121.2	413	121

Source: OECD (2007)

The SERCE report found a positive correlation between the average scores of a given country and its per capita Gross Domestic Product (GDP). Another relevant finding is that the higher the income distribution inequality, the lower the average student performance in Latin American countries. Therefore, SERCE scores change offer a good picture of how the improvement of education quality could impact growth in the region.

SERCE reports scores for sixth grade students, while PISA evaluates 15-year old students skills. In spite of this difference, both reports are helpful for comparisons of Latin American countries included in both studies. A clear result is that PISA's standards are more rigorous than SERCE's (Table 10). Latin American countries are far from developed countries standards reported by PISA and obtained much lower scores compared to those of SERCE (in all cases more than 100 score points less). Furthermore, Hanushek and Woessman (2009b) argue that the average achievement of Latin American students on international cognitive skills tests is substantially lower than in East Asia and close to Sub-Saharan Africa.

2.5 Early childhood development policies in Nicaragua and Costa Rica

Development academics and practitioners acknowledge the important role of Early Childhood Development (ECD) interventions such as health and nutrition interventions, conditional cash transfer (CCT) programs, and nurseries and preschool facilities, on cognitive development and children welfare, education performance, and labor productivity, among other key development variables (Glewwe *et al.*, 2001; Gould *et al.*, 2009; Paxson and Schady, 2007; Hoddinott *et al.*, 2009).

In the case of education, available studies for developing countries indicate that ECD interventions make a difference in terms of school attainment, intellectual achievements and education investment returns in general (UNESCO and LLECCE, 2008b; UNESCO and LLECCE, 2008a; Grantham-McGregor *et al.*, 2007; Glewwe, 2002; Instituto Nacional para la Evaluación de la Educación, INED, 2008). The existing evidence supports interventions to improve young children's developmental outcomes before they enter school to enhance their performance and achievement while in school and beyond (Young and Richardson, 2007).

In order to increase skill levels, higher investment in education is required. Some studies have found that ECD interventions in Nicaragua could made important contributions to achieve a better education performance and higher returns on education investments. For instance, Macours *et al.* (2009) evaluate the impact of a randomized cash transfer program in rural Nicaragua, finding significant effects on cognitive outcomes, especially language.[11] Another conditional cash transfer program, *Red de Protección Social*, is evaluated by Maluccio and Flores (2004). The authors find that the program had positive effects on a broad range of indicators and outcomes, like increased household expenditures on food, reducing primary school desertion, and improving the health care and nutritional status of children under age 5.

Verdisco *et al.* (2007) evaluate the Comprehensive Childcare Program in Nicaragua (PAININ), which introduced a comprehensive ECD model in Nicaragua that consolidated services previously provided separately (e.g., preschool education; weighing and referral/counter-referrals to the health care system) and integrated them with new services (e.g., early childhood education). The authors find important impacts of the program on schooling and education performance, among other variables.

By looking at how the Early Childhood Environment affects outcomes of individuals later on in life, Gould *et al.* (2009) provides further evidence of investments in the early stages of a child's development having long-term payoffs. Heckman (2000) argues that early investments in human capital for children have a larger payoff than interventions at a later stage, which aim to close the gap between troubled students and regular students.

A vast body of research has demonstrated that children who participate in well-conceived ECD programs tend to be more successful in later school. It is well documented by medical and educational research that the brain is almost entirely developed by the time a child enters school, and it is estimated that half of all intellectual development potential is established by the age of four. Therefore, poorly

[11] The program, known as Atención a Crisis, makes sizeable payments, equivalent to about 15 percent of per capita expenditures for the average recipient household.

developed children could hardly reach their full intellectual potential, maintaining the intergeneration cycle of poverty (Galliani, 2007).

Regarding ECD interventions in Costa Rica, one of the oldest and most important programs is the CEN-CINAI. The program started in 1950 with the establishment of the country's Complementary Food Program through an agreement between the Ministry of Health and UNICEF. This program includes three types of centers: the Child Care Centers (CINAI) which provide child day care for twelve hours per day, the Education and Nutrition Centers (CEN) which operate eight hours a day in the morning and afternoon and the Education and Nutrition Centers and School Lunch Programs (CENCE), which also provide services to rural communities without school lunch programs. By 2007, there were 609 centers, of which 558 were CEN and 51 CINAI World Bank and Inter-American Development Bank (2008).

The CEN-CINAI's main goal is to allow poor and vulnerable children to develop normally. The program provide to children the opportunity to develop their psychomotor, cognitive and social skills, prepare children for high performance during the school life, promote the participation of the family and the community in education and nutrition issues and enable children's mothers to participate in the labor market. This kind of programs should be reinforced and upscaled in order to reach a wider group of households, particularly the poorer ones.

3 Analytical instruments and methodology

In this section we explain each of the analytical instruments that are employed in the analysis. This includes the use of three different economic methodologies. Later on, these instruments are used to simulate different policy scenarios and are mixed to analyze how trade policies interact with human capital policies and how this interaction affects poverty and the main macroeconomic indicators.

3.1 Trade and poverty evaluation using a top-down approach

The first analysis takes a two-step approach for which changes in factors and goods prices are estimated through a recursively dynamic multi-country CGE model and then mapped into the income and expenditure disaggregations of individual households using recent household survey data for Costa Rica and Nicaragua. In this way, the macroeconomic effects of FTAs are used to assess the potential impacts on poverty and income distribution from trade agreements alone. The methodology to assess the household-specific impact of trade reforms has been developed in Bourguignon *et al.* (2003).

3.1.1 Dynamic CGE model

To obtain the macroeconomic effects of both trade agreements we construct our own multi-country recursive dynamic CGE model. This model is written in GAMS using the MPSGE application developed by Rutherford (1995; 1999).This application translates the GTAP database and standard model into a GAMS version, i.e. GTAPinGAMS. Furthermore, Rutherford uses the MPSGE programming language, which allows to handle CGE models in a consistent and compact format.

There has been a long debate among CGE modelers and trade economists concerning the use of recursive against fully dynamic optimization models. A recursive model is based on a set of simplifying assumptions concerning investment decisions (i.e. fixed capital accumulation or savings rates) and this highly simplifies the modeling and the computational complexities. On the other hand, the use of CGE models is justified as a way to model structural changes in the economy that require a micro consistent optimization process by firms and consumers. Assuming that agents are myopic in their investment decisions goes against this particular strength of CGE modelling. However, the use of recursive dynamic models is a practical way to look at the dynamic impact of changes in tariffs and other forms of taxation of final goods, which do not rely crucially on the capital accumulation adjustment path. In our case, we want to focus on the growth path of the Central American countries –since this is very relevant for poverty changes– but we are less interested in assessing the dynamic evolution and adjustment path of the capital stocks. Although capital accumulation is relevant for growth, it is not directly relevant for poverty changes, since most poor households rely on low-skill labour or public transfers as their main income source. Therefore, the use of a dynamic optimization framework that yields a more accurate description of the evolution of capital is not very relevant for our current purposes, while it greatly complicates the modelling and simulation tasks. Under these circumstances, we rely on the use of a recursive dynamic model.

In order to move from the static GTAPinGAMS model to our dynamic recursive CGE model, several steps had to be taken. We describe them below:

- As a starting point we use the GTAPinGAMS static model developed by Rutherford (2005). This static CGE model is based on the standard GTAP general equilibrium model (Hertel and Tsigas, 1997), with some modifications. In particular, it has a different final consumption demand and investment demand systems. While both models use the same GTAP database.
- The first modification done was to adapt the GTAPinGAMS program to read the most recent GTAP database: GTAP7.[12] In this latest version of the database, most of the Central American countries can be separated. This was not possible with the former GTAP6 version of the database, where CA was included only as an aggregated region. Now we can separate Costa Rica (CRC), Guatemala (GUA), Nicaragua (NIC) and Panama (PAN), while the other countries (i.e. El Salvador, Honduras and Belize) are aggregated in the region RCA.
- The second modification was to transform the GTAPinGAMS static model into a recursive dynamic CGE model. This was done base on the insights by Paltsev (2004). In short, a recursive dynamic model solves the model period by period and links each period using exogenously determined growth rates and capital accumulation rates. The resulting growth path in the main economic variables: consumption, production, trade and prices is taken to be the baseline scenario. The way in which this dynamic calibration was done is explained in the following section.
- Finally, the model is used to estimate the macroeconomic impacts of both FTAs: DR-CAFTA and EU-CAAA. The resulting dynamic path from these simulations is then compared with the baseline scenario to assess the dynamic effects. The CGE evaluation of both FTAs is based on previous work. For DR-CAFTA our simulations are based on the changes in tariffs and quotas outlined in Francois *et al.* (2008), while we use Rivera and Rojas-Romagosa (2007) for the expected outcomes of EU-CAAA. The results of these simulations are explained in section 4.4.

3.1.2 Dynamic calibration

There is no standard way to calibrate a recursive dynamic model. The calibration decisions are based on the baseline assumptions of the model and the questions that the model is built to answer. For the purposes of this study, which relates changes in trade and educational policies on poverty, we are not directly concerned with the dynamic adjustment of physical capital nor on demographic transitions. It is known that economic growth changes demographic patterns –e.g. richer countries tend to have lower fertility rates and population growth than developing countries. Moreover, human capital growth is also intertwined in this relationship, with a more educated population also likely changing its demographic patterns. Despite these interrelations, we want to keep the model tractable and therefore, we assume that capital and population are growing at the same rate, such that capital per worker is constant. This allows us to focus on the human capital changes that are fed into the CGE model from the satellite model.

In general, the capital accumulation process is defined in the following equations:

[12] For a complete explanation and documentation of this database see Narayanan and Walmsley (2008).

$$K_{t+1} = (1-\delta)\,K_t + I_t \tag{1}$$
$$K_{t+1} = (1+g_K)\,K_t \tag{2}$$

where K_t and I_t are the (physical) capital stock and the investment values in period t, while δ is the depreciation rate of capital. Combining both equations we obtain the investment level I_t and the investment growth rate g_I:

$$I_t = (\delta + g_K)\,K_t \tag{3}$$
$$g_I = \frac{I_{t+1}}{I_t} - 1 = g_K \tag{4}$$

It follows from this equations that we can either fix investment growth (which is equivalent to fixing the savings rate when there are no international capital flows) or the capital growth rate. In our case, we follow the second option.

Regarding demographic trends, assuming a constant population growth is translated into a constant increase in both skill types L and H. In our baseline scenario –without any educational policies– the composition of total labour between both skill types is also held constant. This is not the case for our counterfactual simulations with educational policies. In these scenarios the skill level of the population is upgraded and the skill composition of the working force changes accordingly. However, the total number of workers is constant in all scenarios for most of the years in the simulations. The only exception is related to the transitional decreases in the working population that are associated with the opportunity costs of staying longer in school to accumulate more human capital. Therefore, our first calibration assumption is that population (low and high skill labour alike) and capital have an annual growth rate of 3% in developing countries and 2% in developed countries.

The second assumption is that the remaining production factors: land and natural resources, do not grow. This follows from the physical limitations of both productive factors to expand. In a strict sense, land refers to pastures and arable land that are used in the agricultural sector, while natural resources is a fixed factor in the production of certain sectors. For example, oil and mineral reserves are a fixed factor in mining sectors. This second assumption implies, hence, that there is no expansion in the agricultural frontier[13] and that new natural resources are not discovered.

However, we do allow for changes in the efficiency of land usage. When labour and capital endowments are increasing and land is kept constant, land becomes a relatively scarce resource and land rents experience a substantial rise. In turn, land is used intensively in the agricultural sector and this increase in land rents produces a spike in the relative price of agricultural products. Yet, we do not observe significant increases in agricultural prices over time, even when the endowments of labour and capital have been steadily increasing. Therefore, there has to be another mechanism at work that prevents the relative price of agricultural products to increase. One explanation is that TFP growth in agriculture is higher than in the rest of the economy. This hypothesis has been confirmed for OECD countries by

[13] This is a very plausible case for Costa Rica, where the protection of national parks has set an effective limit to the expansion of arable land. For Nicaragua is can be possible to still expand the agricultural frontier further, but this is rather uncertain and we do not have sufficient information to make a robust assumption in this regard.

Kets and Lejour (2003). They estimate that TFP growth in agriculture in the period 1970-1990 was 2.7%, while it was lower for manufacturing (1.95%) and services (0.42%). When these differentiated TFP sectoral growth rates are introduced into a CGE model, changes in agricultural prices are not significantly different from the price changes for other sectors (see for example Lejour *et al.*, 2006). However, we did not find such sectoral TFP estimates for Latin America or other developing countries. The only reference found was to agricultural TFP growth from Avila and Evenson (2004). They find that on average for the years 1961 to 2001 agriculture TFP grew by 1.5% in Costa Rica and 1.6% in Nicaragua. Since we do not have disaggregated sectoral TFP growth data for non-agicultural sectors, we use a 1.5% increase in land efficiency use into our model. This gives a productivity increase in the agricultural sector and thus, agricultural goods prices are not increasing significantly in relation to other sectors. Thus, using the above information for OECD countries and for agricultural productivity changes, our third calibration assumption is that land efficiency is has a 1.5% annual growth rate in developing countries and 2% for developed countries.

Finally, our fourth and last assumption is about aggregated productivity increases that provides an economy-wide growth path. These productivity changes are calibrated as total factor productivity (TFP) growth rates in the baseline scenario. Following historic data for Costa Rica[14] and OECD countries[15] we assume that TFP is growing at an annual rate of 1% for all regions. This does not imply that the sources of TFP growth are the same for all regions. For developed countries these TFP increases are mostly associated with R&D activities and innovation processes. In the case of developing countries, they are associated with technological catch-up processes and efficiency improvements in the production process.

3.1.3 Microsimulations using household-level data

For the top-down microsimulations, we use the most recent expenditure/income surveys for Costa Rica in 2004 (INEC-CR, 2006) and for Nicaragua in 2005 (INEC-Nicaragua, 2006).

The second step in the macro-micro top-down approach consists in translating the macro results from the CGE model to the disaggregated household data available from national surveys. There are three main mechanisms through which changes in trade policy can affect household income (Bourguignon and da Silva, 2003). First, changes in aggregate goods and factor prices directly affect the expenditure and income levels of individual households. Of these, the change in wages and food prices are usually the most important to assess poverty effects. Secondly, changes in employment levels induced by the economy-wide adjustments that follow from FTAs directly affect household income. Sometimes, this can be the single most important factor for a household to be lifted out of poverty. Finally, government transfers to poor individuals may also be affected by trade agreements through tariff revenue changes. This is also true for private transfers and financial gains in non-poor households, which can induce significant poverty effects.

This study focus mainly on the first mechanism: economy-wide price changes. As a starting point, it is assumed that the labor market adjustments are made via changes in wages and not through changes in existing employment levels. When the economy is not in full employment it can be expected that wages will not vary much, but employment levels will increase in response to a rise in the labor demand.

[14] Rodríguez-Clare *et al.* (2004) and Jiménez *et al.* (2009).

[15] Lejour *et al.* (2006)

In the CGE model it is assumed that the governmental budget is adjusted to compensate for potential tariff revenue losses and therefore, transfers to households are also assumed to remain constant.

Using this approach, therefore, the main effect of the FTAs on individual households is represented by the change in the price of the goods consumed and the variation in the factor prices (i.e. wages, capital and land rents). The overall welfare effects for an individual household are then a combination of both price effects. For example, if the price of the bundle of goods consumed by a specific household increases more than the price of its factor endowments, it is likely that its real income diminishes.[16]

The macro CGE price changes are mapped into household expenditure and income data following the GTAP 7 sectors and factor aggregations. This procedure is achieved in two steps. First, all expenditures are aggregated into the 57 GTAP sectors and for both FTAs the expenditures are further aggregated to match the particular sector dimension of each simulations. The second step consists in aggregating each household's income into four GTAP factors: low-skill labor, high-skill labor, capital and land. An additional income category consists of financial gains and transfers.

With the income and expenditure data classified by the GTAP sectors, the income composition by household is constructed. To summarize the results, the expansion factors to obtain the whole population information are used and then, this population is divided by percentiles. Thus, each percentile is a representative figure of each income level. The results for Costa Rica are shown in Figure 2. The income composition of the low-income families consists mainly of low-skill labor, and to a lesser extent capital and transfers. On the contrary, for the high-income households' high-skill labor, capital rents, and financial gains are the most significant.

This figure provides important information to evaluate the potential poverty impacts. First, capital represents a constant fraction of household income, irrespective of the income level.[17] It is important to notice that the constant share of capital among income levels does not mean that the absolute levels of capital are equal among different household, only the relative fraction. Thus, high-income households will have higher capital gains compared to poorer households, but it will represent the same fraction of their total income.

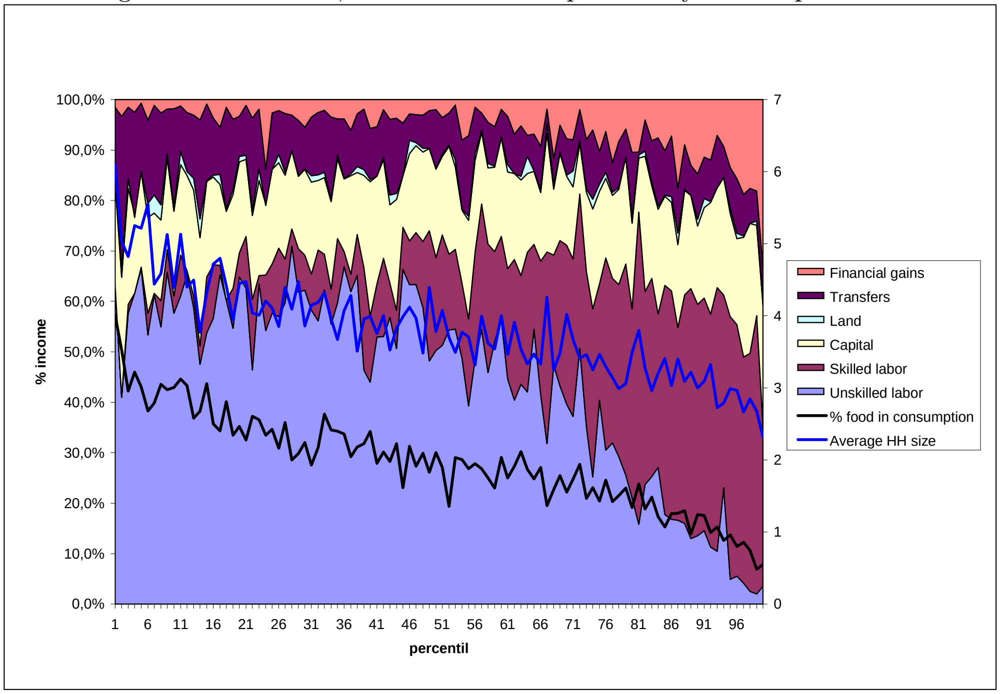
With respect to poverty, the changes in low-skill labor earnings are a key issue. This follows from the fact that for the lowest two quintiles of the population, low-skill labor represents more than half of its income. Moreover, given the relative importance of food consumption for the poorest household, the relative price of food is also a key factor that affects poverty.

For the case of Nicaragua, the income composition is heavily skewed toward low-skill labor earnings. Figure 3 shows that low-skill labor represents around 70% of income for all families up to the last quintile, were its relative importance diminishes. On the other hand, high-skill labor income is only significant for the richest families. As with Costa Rica, capital rents represent a similar share of total income for all the population. However, land rents are more significant in Nicaragua, and contribute to almost 10% of total income of the poorest families. Finally, transfers are significant for all income levels.

[16] An alternative is to assume a different macroeconomic closure, where wages are fixed and employment levels change. In this case, the assignment of new jobs to specific households can be done using logistic regressions. These regressions provide the probability of each household to have an employed member.

[17] This follows the way the household divides own-activity income, assigning part of the revenues to capital gains and the rest to labor income. Thus, for the low-income individuals that work in independent activities, part of their income will be reported as capital rents and the rest as unskilled labor income.

Figure 2: Costa Rica, factor income composition by income percentile



Under these conditions, increases in inequality can be expected if the wages for high-skill wages increase relative to other income sources. However, the main concern for Nicaragua is the reduction of its high poverty levels and this can be achieved by an increase in the low-skill labor earnings, which is the main income source for most households. Moreover, the share of food consumption in total expenditure is also relatively high for most income levels, and therefore, changes in the relative prices of food are key to changes in poverty.

3.1.4 Poverty measurement

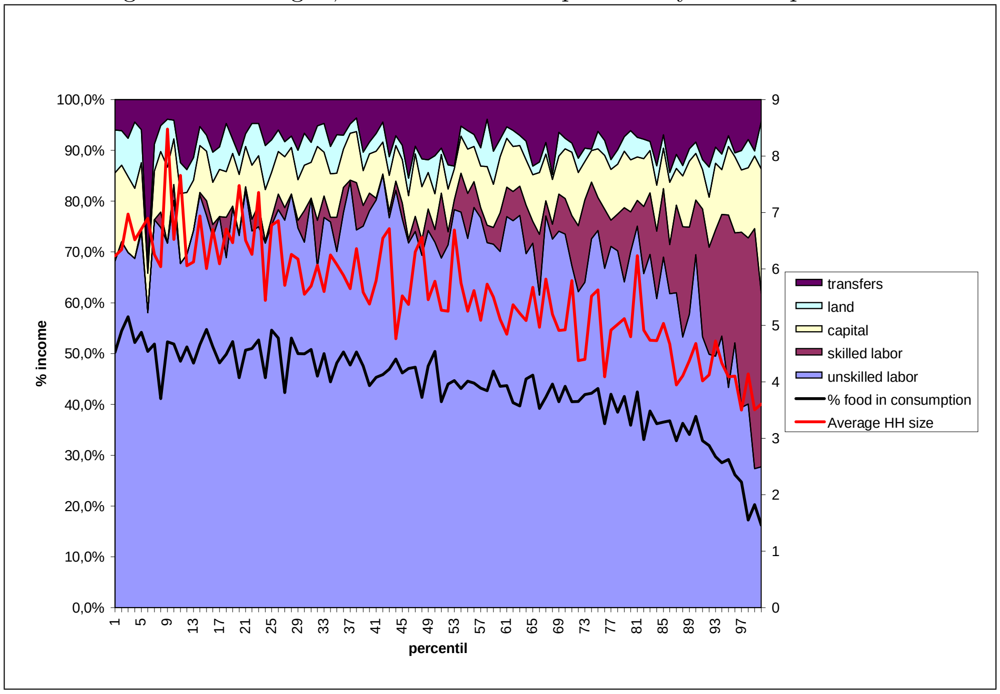
We use the Foster-Greer-Thorbecke $FGT(\alpha)$ indexes to measure poverty. These indexes are defined in discrete terms as:

$$FGT\left(\alpha\right)=\frac{1}{n}\sum_{h=1}^{q}\left(\frac{z-y_h}{z}\right)^{\alpha}$$

where n is total population, and q is the number of households h with income y that are below the poverty line z. There are three different indexes, which are determined by the value of α. When $\alpha=0$ we obtain the Head Count Poverty index. This is $FGT(0)=q/n$, which counts the number of poor individuals defined by q. For $\alpha=1$ the Poverty Gap index $FTG(1)$ captures the acuteness of poverty, since it measures the total shortfall of the poor from the poverty line. The Foster-Greer-Thorbecke $FGT(2)$ index is also known as the square poverty gap, since $\alpha=2$.

Finally, we use two poverty lines following the measures proposed by the World Bank. The first poverty line corresponds to the "$2 a day" measure, which captures relative poverty. While absolute

Figure 3: Nicaragua, factor income composition by income percentile



poverty is defined with a "$1 a day" poverty line.[18] We use the official values of both poverty lines taken from the statistical offices of Costa Rica and Nicaragua.

3.2 Assessing the impact of human capital policies

The implementation of human capital formation is evaluated through a satellite model based on Jacobs (2005) and Rojas-Romagosa (2009). Using five different skill-levels this model estimates the opportunity costs of increased years of schooling and the expected labor productivity increases by skill that are expected from higher school attainment. Both outcomes are then linked to the main CGE model to estimate the effect of higher school attainment on labor supply of different skills, wages, sectoral production and other relevant macroeconomic variables. In turn, these macroeconomic results are linked using the top-down approach to the micro model to evaluate the impact of the human capital policies on poverty.

For this paper, a revised version of the satellite model by Rojas-Romagosa (2009) is constructed. In particular, to adapt the model to developing countries, we change the skill classifications to have more detailed information for low skilled workers, which are relatively more important in countries like Costa Rica and Nicaragua. Thus, we use three low skilled and two high skilled sub-groups. In addition, the satellite model incorporates cognitive skills into the analysis. Using test score information for Costa Rica and Nicaragua, the impact of these quality indicators are incorporated to obtain a more robust indicator of the role of human capital on poverty.

[18] This poverty lines do not correspond exactly to the values of $1 and $2, but are periodically adjusted by country to account for PPP changes and other factors. For a recent review see Ravallion *et al.* (2008).

As surveyed by Hanushek and Woessman (2008), there are strong empirical links between human capital and economic growth. Thus, it is expected that increasing the quantity and/or quality of schooling in both Central American countries can positively impact economic growth and facilitate poverty reduction. Moreover, improving the human capital stock can also act as a complementary policy to recent trade liberalization processes in the region. Improving the skills of workers can enhance the potential benefits of increased trade openness.

3.2.1 Human capital satellite model

In the following section we explain how the satellite model is constructed and how it is employed to assess the macroeconomic impacts of different human capital policies.

Defining skill groups We define skill groups by school attainment, i.e. years of schooling. Thus, $L1$ corresponds to a first stage of primary education ($L1 < 6$ years), $L2$ is completed primary education ($L2 = 6$ years), and $L3$ is lower secondary education (6 years $< L3 \leq 9$ years) . We follow the standard convention to define high skill as workers with completed secondary education. Therefore, $H1$ corresponds to upper secondary education (9 years $< H1 \leq 12$ years), while $H2$ are workers with university studies ($H2 > 12$ years).

The initial number of workers in each skill group s is defined using the schooling ranges described above. However, to estimate the number of years of schooling in the population and the number of extra years needed to move from one skill group to the other, we use a fixed number of schooling year per skill group. In particular: $L1 = 3$, $L2 = 6$, $L3 = 9$, $H1 = 12$ and $H2 = 16$. This means that S, the required number of year to move from one skill group to the other is given by: $S_{L1L2} = 3$, $S_{L2L3} = 3$, $S_{LH} = 3$, and $S_{H1H2} = 4$.

This skill classification diverges from that of Rojas-Romagosa (2009) in the first and last classification. In particular, $L1$ is part of $L2$ there –since almost all of OECD workers have completed primary school– this moves the number of schooling year by type until $H2$ corresponds to workers in a second stage of tertiary education. The data for Costa Rica is taken from INEC CR (2008) and from INEC Nicaragua (2005) for Nicaragua.

Labour market dynamics The first building block in the satellite model (SM) is the evolution of the stock of workers over time and how changes in formal schooling are fed into the model. The number of workers is not only aggregated over the skill-types defined above, but also over cohorts. In this sense, the SM can be regarded as a stylized cohort model. Current formal education policies only affect the flow of each new cohort entering the labour market, but not those already working –this can only be achieved by on-the-job training. This dynamic process is bound to limit the changes in the stock of human capital and the potential impact of education policies.

Defining $NT_{sry} = \sum_s N_{ry}$ as the total number of workers, we have that over time N evolves by:

$$NT_{ry+1} = NT_{ry} + i_{ry} - o_{ry} \tag{5}$$

where i_{ry} is the inflow and o_{ry} is the outflow of workers. These variables, in turn, are determined by:

$$i_{ry} = \theta_r NT_{ry} \tag{6}$$
$$o_{ry} = \delta_r NT_{ry} \tag{7}$$

Labour force growth by region r is defined as $g_r = \theta_r - \delta_r$, where θ_r is the rate of inflow of new workers while δ_r is the rate of outflow of workers. The inflow (θ) and outflow (δ) rates are calibrated such that these match average population growth rates in each region over the period considered. The data on population growth are provided by the UN's World Population Prospects. We assume that g_r is constant over time, since we do not associate changes in g_r with any of the human capital policies we are assessing. Thus, the effort to calibrate time and skill-specific cohort differences over a long period of time (in the estimation of the model we work with $y \in [0, 40]$) is not justified. There are other cohort difference that are not captured. For instance, training on the workplace and the quality of education is not defined by cohort, but only in the aggregate, as explained below.

Educational attainment We proceed now to model the changes in formal schooling. There are two main components of formal education: the number of years of schooling (i.e. educational attainment) and the quality of schooling. We deal with the second part in the next section. Regarding educational attainment we begin by assuming that the current graduation rates are at their steady-state levels. This means that the composition of total investment between higher and lower education is constant. Since skills are constantly being upgraded over time, one can think of these steady-state graduation rates as the share of relatively higher educated with respect to relatively lower educated workers, and not in absolute terms.[19]

If we define η_{sry} as the graduation rates for skill s, region r and year y, then we have that the total inflow of workers with skill s into the workforce is: $i_{sry} = \eta_{sry}\theta_r NT_{ry}$. We assume that the outflow rates for each skill category are the same as for the total work force, hence: $o_{sry} = \delta_r NT_{ry}$. Data on graduation rates are taken from INEC CR (2008) for Costa Rica and INEC Nicaragua (2005) for Nicaragua. With this information we have a baseline time path of the composition of skills and we can model changes in educational policies as changing the graduation rates η.

It is important to note that current graduation rates *do not* reflect the current share of low to high-skill workers. For Costa Rica, we have $\frac{L}{H} = 1.86$, while for Nicaragua this value is 2.85. This reflects a higher low-skill abundance in Nicaragua when compared to Costa Rica. On the other hand the graduation rate aggregates for low-skill (η_{Lry}) and high-skill students (η_{Hry}) result in a ratio of $\frac{\eta_{Lry}}{\eta_{Hry}} = 1.01$ for Costa Rica and 2.11 for Nicaragua. Since $\frac{L}{H} > \frac{\eta_{Lry}}{\eta_{Hry}}$, these steady-state graduation rates are translated in our model into a slow adjustment process that upgrades the skill composition of the labour force over time, increasing the relative share of H in the workforce.

The importance of educational quality In a recent paper, Hanushek and Woessman (2008) argue that cognitive skills play a key role in understanding the relation between education and economic outcomes. It is common practice to use school attainment as a measure of human capital. However,

[19] Another alternative is to explicitly model the optimal decision of the households to invest in different human capital levels or skill-types. This requires the use of a dynamic optimization CGE framework. Constructing such a model, however, is beyond the scope of this study.

this variable only captures a part of human capital formation. This shortcoming is made clear by Hanushek and Woessman (2008) in the following equation:

$$H = \lambda F + \phi Q(S) + \delta A + \alpha X + \nu \tag{8}$$

where human capital H is determined by family inputs (F, the quantity and quality of formal education $Q(S)$, (where S is school attainment), individual ability A, and X which includes other relevant factors such as experience and health.

Hanushek and Kimko (2000) already emphasized that pure quantity measures of education are a very crude measure of skill. However, Hanushek and Woessman (2008) show that incorporating cognitive skills (based on test scores) in combination with traditional quantitative measures (i.e. using $Q(S)$ instead of only S) greatly increases the explanatory power of human capital with respect to economic growth, income distribution and wage determination. Moreover, the information contained in test scores indirectly includes the family inputs, individual abilities and other factors, all of which are not easily measured. Finally, there is significant country variation in these quality measures that can be used to assess changes in country-specific policies.

It is difficult to track the earnings effects of increased cognitive skills. This requires information on the test scores at the time of schooling, and later on data on labour earnings. However, US longitudinal data is available that can make this estimations possible. Reviewing these studies, Hanushek and Woessman (2008) find that a standard deviation in test scores increases future earnings by 12%. Moreover, they offer several reasons why this estimate can be considered as a lower bound. For instance, the skill-premium has increased over time and this is not captured by the time of the available longitudinal data. This value of 12% represents a significant increase from the previous value used in Jacobs (2005), which was based on a 8% value based on the survey by Krueger (2003).

The former studies where based on data for developed countries. For the case of developing countries we are not aware of any comparable estimations. However, we can expect a higher wage increase from increased cognitive skills in developing countries since high-skill labour is relatively scarce. Thus, we use a value of 20% efficiency increase associated with one standard deviation in test scores for Costa Rica and Nicaragua.

On-the-job training Workers can acquire human capital through schooling, but also by training at the workplace. This is modelled in Jacobs (2005) by simplifying the human capital production function used by Heckman *et al.* (1998):

$$H_{sabt+1} = H_{sabt} + \widetilde{A}_{sa} \left(I_{sa}\right)^{\alpha_s} \left(H_{sabt}\right)^{\beta_s} \tag{9}$$

where human capital H is indexed over skill type s, ability a, age b and time t; and on-the-job training (OJT) is defined by I. The parameters of this function are: $\widetilde{A}$,a productivity parameter related to the ability to learn, and α_s and $\beta_{s.}$ Implicitly, this function is assuming the human capital does not depreciate. This assumption is supported by the empirical observation that wages do not generally decrease nor is there substantial OJT at the end of working careers.

To aggregate between cohorts and skill groups Jacobs (2005) assumes that $\alpha_s = \beta_s = 1$ for all s. This implies that returns to OJT I_{sa} do not diminish with the human capital level. This allows to aggregate individuals (with different ability and ages) into:

$$H_{st+1} = H_{st}(1 + \widetilde{A}_s \chi_{st}) \tag{10}$$

where the weighted average fraction of time invested in OJT is: $\chi_{st} = \frac{\sum_{sa} I_{sa} H_{sabt}}{\sum_{sa} I_{sa}}$. Using (10) we obtain the growth rates of OJT (γ):

$$\gamma_s = \frac{H_{st+1} - H_{st}}{H_{st}} = \widetilde{A}_s \chi_{st} \tag{11}$$

Furthermore, it is assumed that the ability to generate human capital through OJT $\left(\widetilde{A}_s\right)$ is equal for all skills s and that the time devoted to OJT (χ_{st}) is independent of s and constant over time.[20] This allows to have a constant OJT growth rate γ for all skill types. However, we do allow γ to vary across regions. Therefore, γ_r is the key parameter in the model that summarizes the effects of OJT on human capital accumulation.

Efficiency units of labour To calibrate the value of γ we use the work by Mincer (1962) and Heckman *et al.* (1998). They estimate that the fraction of life-time human capital gathered through OJT (ω) is 50% and 23% respectively. Assuming that total working years is in average $T = 40$ we obtain that the number of efficiency units of labour NE_{rsT} for region r, skill s at year T is given by:

$$NE_{rsT} = (1 + \gamma)^T NE_{rs0} \tag{12}$$

Taking NE_{rs0} to be the human capital gathered through schooling before any work experience at $y = 0$, then we have:

$$NE_{rsT} = \omega NE_{rsT} + NE_{rs0} \tag{13}$$

Combining (12) and (13) we can calibrate γ as:

$$\gamma = \left(\frac{1}{1 - \omega}\right)^{1/T} - 1 \tag{14}$$

Using the estimates of Heckman *et al.* (1998) that $\omega = 0.23$ we get that $\gamma = 0.0066$. If we use $\omega = 0.5$ from Mincer (1962), then $\gamma = 0.0175$. Jacobs (2005) decided to use $\gamma = 0.01$, which implies that $\omega = 0.33$, i.e., OJT generates one third of life-time human capital. In our SM we assume that $\gamma = 0.01$, since we do not have any data or expectations that OJT is significantly different in developing countries.

Since on-the-job training (OJT) is a continuous process, the *initial* stock of human capital (expressed in terms of number of workers by school attainment) has to be updated to include the skills already obtained by the workers through past OJT.

[20] There is litte empirical evidence about the values of these parameters for different skill categories. Thus, for simplicity they are assumed equal.

Taken N_{rs0} as the number of workers at $y = 0$, we adjust this value to efficiency units of labour (NE) using the following equation:

$$NE_{rs0} = (1+\gamma)^{\overline{T}} N_{rs0} \tag{15}$$

where $\overline{T} = 20$ is the average working experience of the population and γ_{r0} is the initial value of gamma.

Dynamic evolution of human capital stocks To obtain an overall function of human capital accumulation, we combine the dynamic evolution of the labour market together with the human capital acquired through formal schooling and OJT. The following dynamic function determines how human capital stocks (defined as efficiency units of labour) evolve over time:

$$NE_{sry} = (1+\gamma-\delta_r) NE_{sry-1} + NET_{ry-1}\theta_r\eta_{sry}Q_{ry} \tag{16}$$

$$NET_{ry} = \sum\nolimits_s NE_{sry} \tag{17}$$

where NET_{ry} is the total labour supply in region r in year y,.and NE_{sry} is the number of efficiency units of labour indexed by the five different skill levels s. Equation (16) is the key equation of the SM and determines the evolution of human capital stocks over time. Equation (16) consists of four main components:

- First, it represents the dynamic evolution of the working force population as defined in section (3.2.1). Note that we are implicitly assuming that each cohort has the same OJT accumulation parameter γ and that differences in the quality of education (given by Q_{ry}) are also independent of cohort size.[21]

- Formal educational attainment is determined by the graduation rates parameter η_{sry}. The second term in equation (16) defines the new inflow of human capital by skill. First, $\theta_r NT_{ry-1}$ indicates the total number of new workers in year y, while η_{sry} indicates the fraction of that particular cohort that graduates in each skill-level. We have that $\sum_s \eta_s = 1$ when the composition of the labour force is not changing between skills, but $\sum\limits_s \eta_s < 1$ when there is a policy that increases schooling. In this case, students stay longer in school and do not join the work force immediately, and this process creates the indirect opportunity costs of higher schooling levels.

- Q_{ry} is a quality indicator of the new inflow of workers by region and year. We start with $Q = 1$ and indicate increases in the quality of education through $Q > 1$, which only affects the newly graduated workers and not the overall working force. Note that there is no need to have $Q(r)$ differences between countries at the initial year, since any quality differences between countries is implicit in the baseline wage differentials between those countries.

[21] In principle, there is not enough data to obtain time-specific past observations of quality (Q) and γ parameters that can be calibrated to obtain a present value of efficiency units of labour over different cohorts. However, assuming the educational quality has been increasing over time, then the presence of fatter cohorts with more work experience and OJT can be compensated with thinner cohorts with less OJT but higher Q.

- Finally, on-the-job training is determined in the first term of equation (16). The human capital stock of the former year is updated to include the growth rates γ of aggregate human capital due to OJT.

It is important to note that the accumulation process builds upon the acquired human capital of all the population. The efficiency units of newly graduated students are a fraction of the accumulated efficiency units of labour of previous years NET_{ry-1}, and not a fraction of the total raw number of workers in the that previous year: $\widetilde{NT}_{ry} = \sum_s \widetilde{N}_{sry}$, where $\widetilde{N}_{sry} = (1-\delta)\,\widetilde{N}_{sry-1} + \widetilde{NT}_{ry-1}\eta_{sry}$. In this sense, we can think of the human accumulation process embedded in equation (16) as general knowledge that is transmitted over time from older to younger cohorts, instead of job-specific knowledge that is not directly transferable to younger cohorts. This assumption is crucial to the results of the SM. When we used an accumulation process that does not accumulate over efficiency units, but over $\widetilde{NT}_{ry}$ (number of workers), the overall impact of our counterfactual simulations is greatly reduced. This is a direct consequence of the initial stock of human capital by new cohorts being sizable smaller and thus, the growth of human capital is much slower. Any policy changes that affect new cohorts (affecting for instance η and Q) takes much longer to have an impact on the overall stock of human capital. Moreover, even changes in the OJT parameter γ are also less influential since they are not transmitted to the human capital stock of new cohorts.

Disaggregated human capital production function Through the parameters in equation (16), namely: γ, η and Q, we can estimate how human capital policies affect the human capital accumulation process by each skill-type. To use these inputs into the core CGE model, however, we first need to aggregate the five skill types we have: $L1$, $L2$, $L3$, $H1$ and $H2$, into low-skill (L) and high-skill (H) aggregates This is the classification for which we have data in the core CGE model.[22]

Using the time path of the different skill types in efficiency units NET_{ry} from equation (16), we aggregate the five groups using a nested CES function, which is commonly used in CGE models. Then we have:

$$L_{ry} = A_{Lry}\left[\alpha_{L1ry}\left(N_{L1ry}\right)^{\rho_L} + \alpha_{L2ry}\left(N_{L2ry}\right)^{\rho_L} + \alpha_{L1ry}\left(N_{L3ry}\right)^{\rho_L}\right]^{\frac{1}{\rho_L}} \quad (18)$$

$$H_{ry} = B_y A_{Hry}\left[\alpha_{M1ry}\left(N_{H1ry}\right)^{\rho_H} + \alpha_{M2ry}\left(N_{H2ry}\right)^{\rho_H}\right]^{\frac{1}{\rho_H}} \quad (19)$$

where L_{ry} is aggregated low skill and H_{ry} is aggregated high skill; α_{sry} are the share parameters of each skill level $s = L1, L2, L3, H1, H2$, with $\alpha_{L1ry} + \alpha_{L2ry} + \alpha_{L3ry} = 1$ and $\alpha_{H1ry} + \alpha_{H2ry} = 1$. The elasticity of substitution between the two different low-skill workers is σ_L, with $\rho_L = 1 - \frac{1}{\sigma_L}$. In the same fashion, σ_H is the elasticity of substitution between the high skill groups. It is assumed that $\sigma_L = 5$ and $\sigma_H = 1.2$.[23]

A_{Lyr} and A_{Hyr} are general efficiency parameters that scale the embedded human capital levels (measured by schooling attainment) of each sub-skill group:

[22] This is the classification used in the GTAP database and we are restricted by this. Currently, the USITC is working on splitting the current two skills into five skills using ocupational-based data (Weingarden and Tsigas, 2009).

[23] Jacobs (2005) is assumed the following values: $\sigma_L = 3$ and $\sigma_H = 1.2$. We use a higher σ_L reflecting the different skill-type definitions we are using. Sensitivity analysis done in Rojas-Romagosa (2009) show that the key labor supply and efficiency changes do not change when these elasticities vary within sensible ranges.

$$A_{Lry} = \widetilde{A}_{ry} \frac{(3 * N_{L1ry} + 6 * N_{L2ry} + 9 * N_{L3ry})}{A_{Lr0}} \tag{20}$$

where $\widetilde{A}_{ry}$ is a general labour efficiency scale parameter applied to both skill levels and assumed equal to one in the baseline. A_{Lr0} is the value in $y = 0$. In a similar way, we define:

$$A_{Hry} = \widetilde{A}_{ry} \frac{(12 * N_{H1ry} + 16 * N_{H2ry})}{A_{Hr0}} \tag{21}$$

In addition, we introduce skill-biased technological change (SBTC) in the model through the parameter B_y in equation (19). We assume that B is growing at a constant rate of τ:

$$B_{y+1} = (1 + \tau) B_y \tag{22}$$

$$B_0 \equiv 1 \tag{23}$$

The SBTC growth parameter τ is calibrated to reflect the growing wage differential (Δ) between high-skill (H) and low-skill (L) workers, where $\Delta = \frac{dw_H}{w_H} - \frac{dw_L}{w_L}$. Jacobs (2004) summarizes empirical estimates for skill-biased technological change in the US, which generate a wage differential increase of approximately 3% per year. However, for European countries this number is substantially lower and in Jacobs (2005) he uses $\Delta = 1.5\%$. Log-linearizing the aggregate marginal rate of transformation between H and L, at constant relative supplies, we get:

$$\tau \equiv \frac{dB}{B} = \frac{\Delta}{1 - 1/\sigma} \tag{24}$$

Using an elasticity of substitution between L and H of $\sigma = 1.5$, then we get the calibrated value $\tau = 0.045$.[24]

Finally, we need to obtain the values for the share parameters (α_{sry}) from the disaggregated functions. However, these share are generally unknown. As explained in Jacobs (2005), these shares are estimated using Mincer rates of return (β) and the number of years required to move from one skill-level to the other (S). The resulting calibration equations are:

[24] In the SM, σ does not play an important role since the aggregation between our low and high skill categories is only done for descriptive reasons, but it is not used to create the linkage variables that are fed to the core CGE model. Moreover, τ is not changing between our baseline and policy counterfactuals, so its value does not change our results.

$$\alpha_{L1,ry} = \frac{1}{1+\exp\mu L1_{ry} + \exp\mu L1_{ry}\exp\mu L2_{ry}} \quad (25)$$

$$\alpha_{L2,ry} = \frac{\exp\mu L1_{ry}}{1+\exp\mu L1_{ry} + \exp\mu L1_{ry}\exp\mu L2_{ry}} \quad (26)$$

$$\alpha_{L3,ry} = \frac{\exp\mu L1_{ry}\exp\mu L2_{ry}}{1+\exp\mu L1_{ry} + \exp\mu L1_{ry}\exp\mu L2_{ry}} \quad (27)$$

$$\mu L1_{ry} = \beta_{L1L2,r} S_{L1L2} + (1-\rho_L)\ln\left(\frac{N_{ryL2}}{N_{ryL1}}\right) \quad (28)$$

$$\mu L2_{ry} = \beta_{L2L3,r} S_{L2L3} + (1-\rho_L)\ln\left(\frac{N_{ryL3}}{N_{ryL2}}\right) \quad (29)$$

$$\alpha_{H1,ry} = \frac{1}{1+\exp\mu H_{ry}} \quad (30)$$

$$\alpha_{H2,ry} = \frac{\exp\mu H_{ry}}{1+\exp\mu H_{ry}} \quad (31)$$

$$\mu H_{ry} = \beta_{H1H2r} S_{H1H2} + (1-\rho_H)\ln\left(\frac{N_{ryH2}}{N_{ryH1}}\right) \quad (32)$$

We assume that there is a country average Mincer rate of return, β, of 10% per year. Jacobs (2005) used a Mincer rate of return of 8%, following the empirical findings surveyed by Card (1994), Ashenfelter *et al.* (1999) and Harmon *et al.* (2003) for developed countries.[25] However, it is expected that these rates are higher for developing countries where high-skill workers are scarce (see for example World Bank, 2008). However, these Mincer rates of return have little impact on the overall results of the satellite model, since they only affect indirectly, the share parameters of the aggregated labor functions.

Aggregated human capital production function We can then aggregate labor into a single labour variable using a CES function:

$$G_{ry} = A_{ry}\left[\alpha_{L,ry}\left(L_{ry}\right)^{\rho} + \alpha_{H,ry}\left(H_{ry}\right)^{\rho}\right]^{\frac{1}{\rho}} \quad (33)$$

where L_{ry} and H_{ry} are the stocks of labour from equations (18) and (19), with shares given by $\alpha_{L,ry} + \alpha_{H,ry} = 1$. A_{ry} is a general efficiency parameter and $\rho = 1 - \frac{1}{\sigma}$, where $\sigma = 1.5$ is the elasticity of substitution between both aggregated skill levels.[26] As done before, the share parameters α are calibrated using Mincer rates of return (β) between low and high skill education and the number of schooling year that takes to move from low to the high skill category is $S_{LH} = 3$. Then the estimation of the share parameters is done using these equations:

[25] Moreover, Harmon *et al.* (2003) find that each additional year of education on average approximately lowers the Mincer rate of return with 1%, hence we set $\pi = 0.01$.

[26] This value is the estimated elasticity of substitution between high-school and college graduates in the United States (Katz and Murphy, 1992; Heckman *et al.*, 1998), which has been recently validated by the work of Caselli and Coleman (2006).

$$\alpha_{Lry} = \frac{1}{1+\exp\mu} \tag{34}$$

$$\alpha_{Hry} = \frac{\exp\mu_{ry}}{1+\exp\mu} \tag{35}$$

$$\mu_{ry} = \beta_r S_{LH} + (1-\rho)\ln\left(\frac{H_{ry}}{L_{ry}}\right) - \rho\ln B_y \tag{36}$$

Using equation (33) we can obtain an aggregated labour efficiency parameter defined as:

$$\varepsilon_{ry} = \frac{G^S_{ry} - G^B_{ry}}{G^B_{ry}} \tag{37}$$

where G^S_{ry} is the aggregated labour for region r in year y for the counterfactual simulation S, while G^B_{ry} is the value of G in the baseline B. We use this summary variable to analyze in a simplified way the effects of each counterfactual simulation on labour efficiency. However, the linkage between the SM and the core CGE model is done using four variables, as explained in the next section.

3.2.2 Linkage variables

We incorporate into the core CGE model information from the disaggregated labour values L and H, which are are defined in equations (18) and (19). Moreover we divide the L and H changes into a volume parameter ($LSUP$) and a labour efficiency parameter ($LEFF$) . This division allows us to track changes in the relative supply of L and H and changes in the efficiency units of labour for each skill aggregation L and H. In total, we have now four linkage variables from the SM into the core GGE model. Note that using this formulation the aggregated labour variable G_{ry} is not relevant. Consequently the values of σ and the share parameters α_{Lry} and α_{Hry} do not affect our results.

The procedure to separate the human capital labour supply (volume) changes from the labour efficiency changes is the following. First, we use the number of workers as defined in $\widetilde{N}_{sry}$, which includes only the terms in equation (16) that are associated with volume changes, such that:

$$\widetilde{N}_{sry} = N^B_{sry-1}(1-\delta_r) + NT^B_{ry-1}\theta_r\eta_{sry} \tag{38}$$

$$\widetilde{NT}_{ry} = \sum\nolimits_s \widetilde{N}_{sry} \tag{39}$$

$$\widetilde{N}_{Lry} = \widetilde{N}_{L1ry} + \widetilde{N}_{L2ry} \tag{40}$$

$$\widetilde{N}_{Hry} = \widetilde{N}_{M1ry} + \widetilde{N}_{M2ry} + \widetilde{N}_{Rry} \tag{41}$$

where N^B_{sry} is the value of N in the baseline. We use N^B instead of $\widetilde{N}$ in equation (38) because we want to see changes in the composition of the workforce with respect to the baseline. On the other hand, using $\widetilde{N}$ creates a dynamic process where the changes in η's are accumulated over time and instead of seeing shifts between skill groups, we have overall changes in the number of workers with respect to the baseline.

We then estimate the volume change parameter $LSUP_{vfry,}$ where v indexes the counterfactual simulation and $f = L, H$. The volume changes are given by the following equations, where $\widetilde{N}^B_{sry}$ is the value of $\widetilde{N}_{sry}$ in the baseline:

$$LSUP_{vfry} = \frac{\widetilde{N}^v_{fry}}{\widetilde{N}^B_{fry}} \tag{42}$$

Secondly, we derive the labour efficiency change, which is given by the change in L_{ry} and H_{ry} when the volume change is not present. This pure efficiency-units value does not include the volume changes is defined as N^e_{sry}:

$$\begin{aligned} N^e_{sry} &= NE^B_{sry-1}(1 + \gamma_r - \delta_r) + NET^B_{ry-1}\theta_r\eta^B_{sry}Q^i_{ry} && (43) \\ L^e_{ry} &= A_{ry}\left[\alpha_{L1ry}\left(N^e_{L1ry}\right)^{\rho_L} + \alpha_{L2ry}\left(N^e_{L2ry}\right)^{\rho_L}\right]^{\frac{1}{\rho_L}} && (44) \\ H^e_{ry} &= B_y A_{ry}\left[\alpha_{M1ry}\left(N^e_{M1ry}\right)^{\rho_H} + \alpha_{M2ry}\left(N^e_{M2ry}\right)^{\rho_H} + \alpha_{Rry}\left(N^e_{Rry}\right)^{\rho_H}\right]^{\frac{1}{\rho_H}} && (45) \end{aligned}$$

where the new variables Q^i_{yr} is used to account for the accumulation of Q over the years: $Q^i_{ry} = (Q_r)^y$. The use of Q^i_{yr} –instead of its time unvarying equivalent– is required to adjustment the values of NE^B_{sry} that do not include the counterfactual higher values for Q_r. Therefore, the values for N^e_{sry} are including the effects of efficiency changes in Q_r into the baseline values of NE_{sry}, but do not include the volume changes associated with the parameters δ_r, θ_r and η_{sry}. Finally, the labour efficiency parameter $LEFF_{fry}$ is defined as changes in the L^e_{ry} and H^e_{ry} from each counterfactual simulation v with respect to the baseline values:

$$\begin{aligned} LEFF_{vLry} &= \frac{L^{ev}_{ry}}{L^B_{ry}} \\ LEFF_{vHry} &= \frac{H^{ev}_{ry}}{H^B_{ry}} && (46) \end{aligned}$$

Finally, $LSUP_{vfry}$ is multiplied by the labour supply time-path in the core CGE model, while $LEFF_{vfry}$ is going to be used as a labour efficiency parameter.

3.2.3 Human capital policy simulations

In this section we explain the policy simulations that are conducted for each country and the changes in labour efficiency that are derived from the application of these policies.

Simulation exercises Based on the state of education in Costa Rica and Nicaragua described in section 2.4, three simulation exercises are developed. In all cases, a what if policy scenario is formulated. The main data sources are the household survey of year 2008 in the case of Costa Rica INEC CR (2008), the eight population census of Nicaragua, published in year 2005 INEC Nicaragua (2005), and the SERCE report. The three exercises for Nicaragua are based on the following assumptions:

1. We do not think the achievement of the MDG-2 target is plausible. However, we simulate a significant progress by assuming that there is an 80% completion rate in primary education by 2015 and 90% by 2020.

2. The second target is another what-if scenarios when –on top of the increase in primary completion– secondary graduation rates[27] increase to 5 percentage points to reach 37% in 2010, with an additional 5% increase to reach 42% in 2015.

3. The final target for Nicaragua is an improvement in student performance measured by a half standard deviation increase in the SERCE scores (50 points).

In the case of Costa Rica, the three counterfactual exercises are based on the following assumptions:

1. The achievement of a 95% graduation rate of primary education by 2015 and 97.5% by 2020.

2. In addition to the primary graduation rates, the increase of the secondary graduation rates by 5% in 2010 reaching 55% and then another 5% increase to reach 60% in 2015. This requires an increase in all low-skill type graduation rates to produce a balanced increase in schooling attainment.

3. The final target is an improvement in student performance measured by a half standard deviation increase in the SERCE scores (50 points).

Labour efficiency results The results are divided between the school attainment goals, i.e., more years of schooling, and the quality of schooling goals as measured by standardized test scores. The last section presents the simulation results when both school attainment and quality are simultaneously achieved.

School attainment To simulate the accomplishment of the primary education goals, we change the graduation rates η_{sry} from equation (16). In particular, we decrease η_{L1ry} and increase η_{L2ry} by the same percentage. This percentage corresponds to the targeted graduation rates. However, there is a time lag that corresponds to the opportunity costs of remaining more years in school. This opportunity cost is considered to be the biggest cost associated with skill formation.[28] Therefore, although η_{L1ry} will be decreased in a certain year, it is not until 3 year later (i.e. $S_{L1L2} = 3$) that these students will graduate from primary school and thus, η_{L2ry} is increased accordingly.

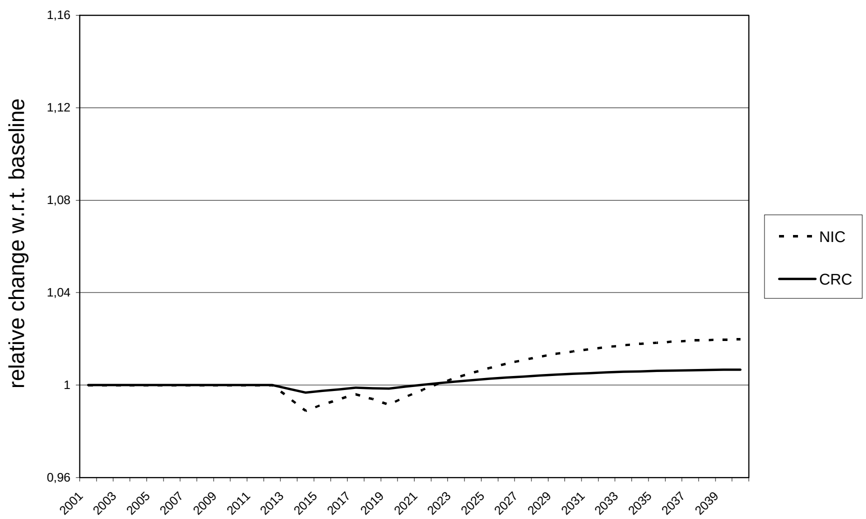
Figure 4 shows the changes in labour efficiency with respect to the baseline case. Until 2012 there are no changes, but then there is an initial decrease in labour efficiency. This decrease is determined by the opportunity cost of a fraction of the students remaining longer in school to move from skill level $L1$ to $L2$. This initial decrease is later compensated when these students with a higher level of education enter into the workforce and increase overall labour efficiency. Since the skill upgrade applies only to the new cohorts, the average skill level of the total workforce adjusts slowly. The primary school goals are much more ambitious in Nicaragua –e.g. starting at 67% of primary completion and moving up to 90% by 2020– than in Costa Rica, which starts at 90% and moves to 97.5% by 2020. Thus, Nicaragua

[27] Graduation rates are defined as the percentage of the population with ages between 20 and 29 that graduated from a specific educational level.

[28] The direct costs of schooling can also be incorporated in the analysis by taking data on expenditure by student by educational level, as done in Rojas-Romagosa (2009).

experiences a higher initial cost but also higher benefits later on. However, the overall benefits from achieving the primary goals are relatively modest. The increase in labour efficiency in Nicaragua is 2% with respect to the baseline. This is a consequence of low-skill labour being relatively abundant in both countries. Under these conditions, increase in the level of L have a lower effect on the aggregated function G than increases in the relatively less abundant high high-skill workers H.

Figure 4: Costa Rica and Nicaragua, changes in aggregate labour efficiency associated with the primary education goals

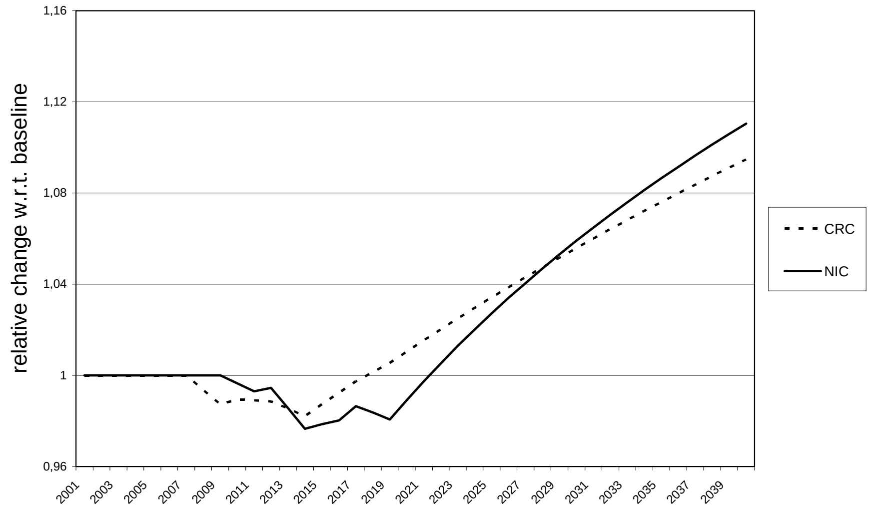


Accordingly, we use the same procedure to simulate the secondary education policies. However, here we need to smooth the pattern of school upgrading so we do not end up with unrealistic graduation rates for some skill levels. In particular, we have to increase the number of graduates in $L2$ and $L3$ in order to be able to increase the target rates for $H1$. In this sense, the goals for secondary education are more ambitious because they require an upgrade of $L3$ but also of the lower skill levels $L1$ and $L2$. Therefore, achieving the secondary school rates implies a much larger effort in terms of schooling attainment, which in turn is reflected in a larger initial opportunity costs of schooling and also, larger benefits when the more educated workers enter the labour market. These results are presented in Figure 5.

Here we observe again the same pattern of initial losses and later benefits. However, now the labour efficiency gains are much larger than for the primary education goals. This is a combination of higher schooling attainment by different skill groups –instead of just $L1$ and $L2$ as in the former simulation– and the increase in the number of high-skilled workers H, which is a scarce factor in both economies.

Quality of schooling To assess the impact of quality improvements in education, as measured by standardized test-scores we use the SERCE data. We estimate the effects of an increase of half standard deviation (50 points) in the test scores. This is translated, in turn, into a labour productivity increase of 10%. As explained in section 3.2.1 we take that one standard deviation increase in standardized test

Figure 5: Costa Rica and Nicaragua, changes in aggregate labour efficiency associated with the secondary education goals



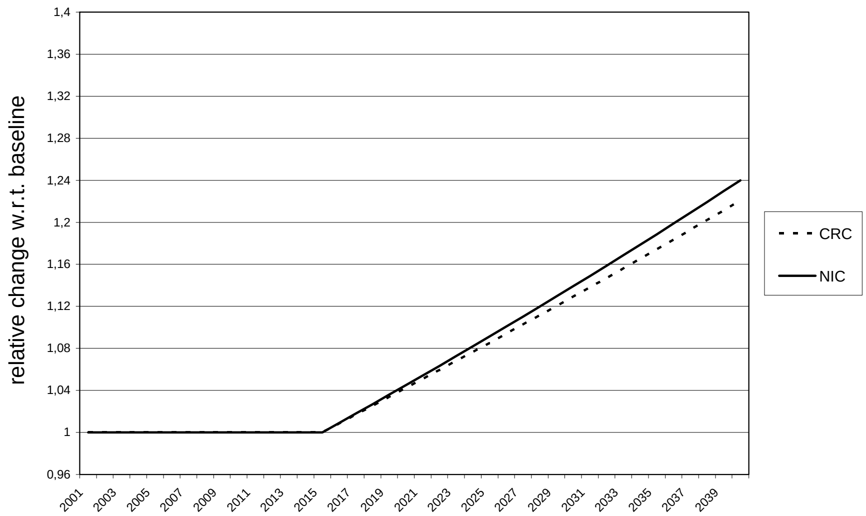
scores translates into a 20% increase in wages. Thus, a half standard deviation increase is equivalent to a 6% labor productivity increase.

Since these standardized tests are given to current students, an increase in the test performance only translates into new cohorts being more productive, but the human capital levels of the older cohorts already working are unchanged. Therefore, we use (16) and increase the quality parameter Q by 10% to reflect that the new cohorts entering the labour force have higher levels of cognitive skills and are more productive.

To achieve this quality increase, however, requires monetary investments and time. There is a huge literature that tries to link education expenditures with the quality of education. In the influential paper by Hanushek (1986), he concluded that there was no empirical relation between school expenditures and student performance. However, it is recognized that the majority of the studies he surveyed suffered endogeneity bias. A more recent literature uses exogenous variation from controlled or natural experiments. These new papers are surveyed by Webbink (2005) and he finds that resources and incentives can matter for achievements of students. However, the results vary by expenditure and incentives, making it extremely difficult to establish a clear relationship between concrete policy interventions and schooling achievements. For example, the cost-effectiveness of the policies is not yet established and it probably varies much between countries and educational systems. This lack of clear policy instruments that can be directly modeled to achieve the increase in schooling quality limits is a limiting factor in our analysis. Thus, for illustrative reasons we conduct a what-if experiment where the quality increase has already been reached in 2015. We show the changes in labour efficiency of this quality improvement in Figure 6.

Comparing these results with those of increased schooling attainment, it is clear that the economic benefits of improved schooling quality are much more significant. Labour efficiency increases by around 20% when test scores are improved. While the increase in labour efficiency is half that amount (around

Figure 6: Costa Rica and Nicaragua, changes in aggregate labour efficiency as a result of an improvement of half s.d. in SERCE test scores



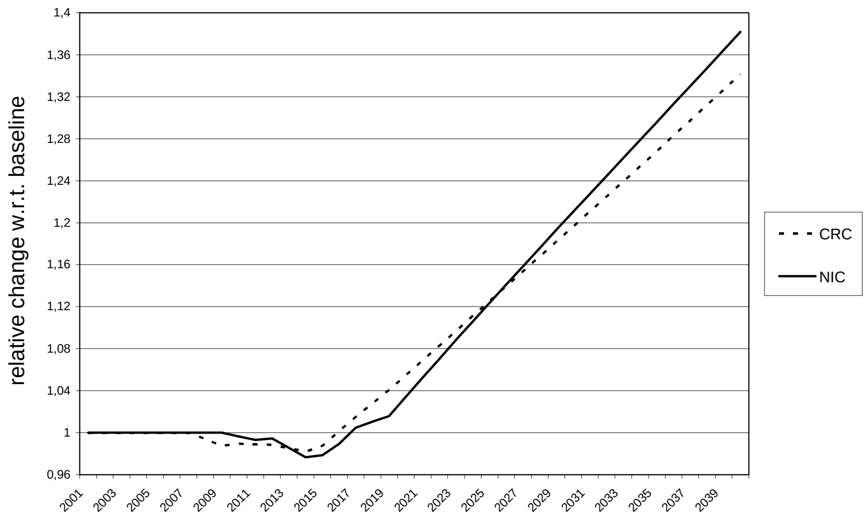
10%) when there is an increase in secondary school attainment. Therefore, these significant results are in line with the empirical findings by Hanushek and Woessman (2008) that cognitive skills have a significant impact on economic growth.

To put these results in perspective, it is useful to compare the SERCE results with those of the PISA study. As indicated before, PISA tests are more rigorous than SERCE's. The sample of Latin American countries included in both studies reveals a wide gap in the test results between developing and developed countries. Comparing the results of both tests we can also have an idea of the meaning of a half standard deviation increase. Taking into account that Costa Rica's scores reported by SERCE are higher than those of Latin American countries in the PISA study, an increase of half a standard deviation (50 points) of test scores would rank the country close to the level of European countries like Greece and Turkey. For the case of Nicaragua, such an improvement of 50 points would rank the country close to the test score levels of Brazil and Peru.

Cumulative results Finally, we run a simulation of the satellite model where all policy education goals are achieved. Thus, both primary and secondary school attainment and improved schooling quality are included in the overall labour efficiency gains. The results are shown in Figure 7. The end-result is a staggering 34% increase in labour efficiency in Costa Rica and 38% in Nicaragua by 2040. Although the educational goals we have modeled are ambitious, these results show the expected payoffs in terms of labour efficiency, which are translated into higher labour productivity and wages. The level of such increases can become a significant force to increase overall growth rates and significantly decrease poverty.

Until now we have used the labour efficiency changes (ε_{ry}) from the aggregated function G as defined in equation (37). This was done just to summarize the results from the satellite model for the different education policies. As explained before, we use instead four variables to link the satellite model results to the CGE model. These four variables are defined in equations (42) and (46). We present how each

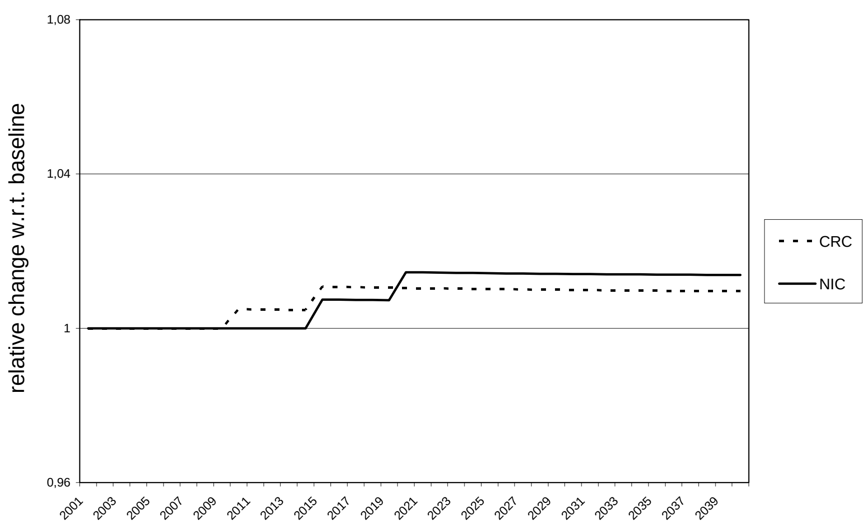
Figure 7: Costa Rica and Nicaragua, accumulative changes in aggregate labour efficiency when reaching both school attainment and quality goals



of these four variables change when we use the accumulated policy simulations where primary and secondary schooling are increased, as well as the overall quality of education. This is the simulation where all the education policies targets are reached.

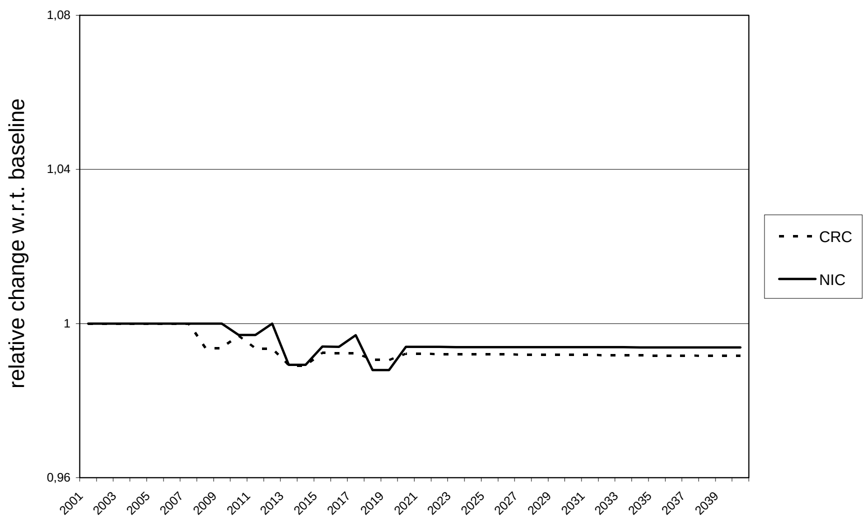
Figure (8) shows the changes in labour supply for the high-skill category H. We see that the supply of H is increasing in two steps and the change becomes permanent after 2020. This corresponds to the increase in high-school graduates in both countries.

Figure 8: Costa Rica and Nicaragua, high-skill labour supply changes with respect to baseline, simulation with all education policies



On the other hand, Figure (9) gives the same information but for the low-skill workers. The supply of L is increasing with the primary school goals, which increase the level of schooling within the low skill aggregate L.But this effect is counteracted by the movement of students from the L aggregate unto the H aggregate as more students are completing their secondary education. At the end, this second effect is stronger and after 2020 there is a permanent decrease in the supply of low-skill workers.

Figure 9: Costa Rica and Nicaragua, low-skill labour supply changes with respect to baseline, simulation with all education policies



The following figures presents the effects of achieving the educational goals on the labour efficiency measures for both skill types. Figure (10) shows a very significant increase in the efficiency of high-skill labour. For Costa Rica we have a 80% increase by 2040 and in Nicaragua it represents a 90% rise.

In the case of low-skill workers, the efficiency increase is also significant but of a lower magnitude (see Figure 11). Another difference is that there is an initial decrease in the efficiency levels. This is a consequence of the composition changes happening within the low-skill aggregate L.There is a movement of students from $L1$ to $L2$ to $L3$ that is consistent with an upgrading of skills from the primary and secondary education targets. This compositional changed in the transition period when there a less students graduating than in the steady-state provokes a decrease in the aggregate value of L.

These significant labour efficiency increases are a result of the dynamic accumulative process embedded in equation (16) .The driving force is the rise of educational quality represented by an increase in the parameter Q, which produces a higher level of human capital for the new cohorts. Given the dynamic process of labour inflow and outflow, higher Q levels are traduced into a slow but steadily increase in the overall human capital stock level of all cohorts. Moreover, the process is accelerated by the presence of on-the-job training (OJT), i.e., on each period the previous human capital stock is increased by the OJT parameter γ. Since human capital is a crucial determinant of the efficiency levels of both types of labour and labour is the main productive factor in the economy, we have a direct link between quality of education and economic growth. This follows the insights by Hanushek and Woessman (2008). In a broader sense, the particular accumulation dynamics of equation (16) , produces an endogenous growth

Figure 10: Costa Rica and Nicaragua, high-skill labour efficiency changes with respect to baseline, simulation with all education policies

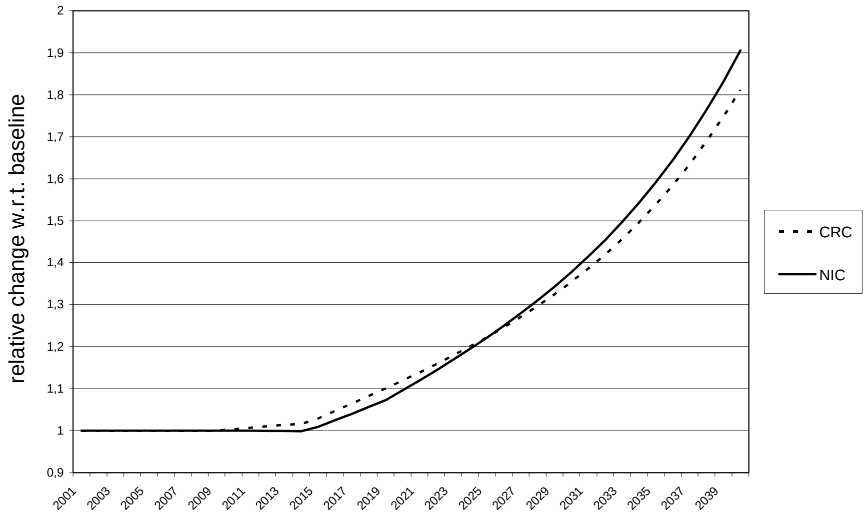
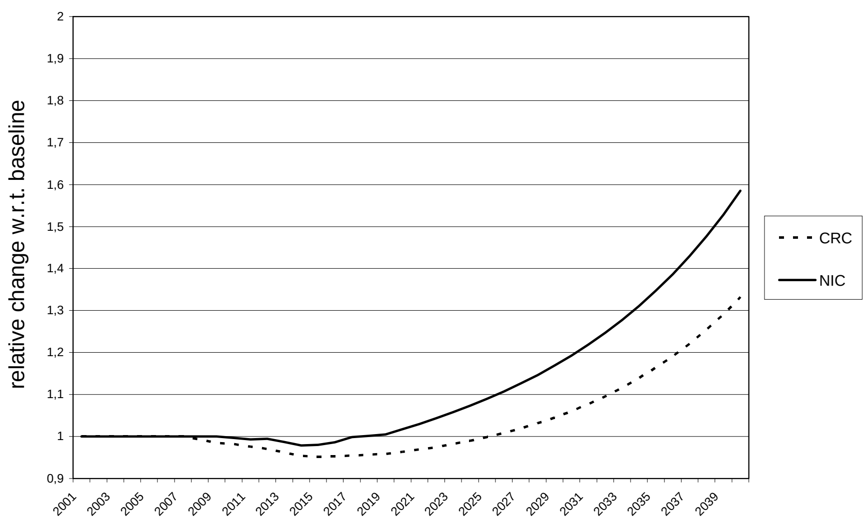


Figure 11: Costa Rica and Nicaragua, low-skill labour efficiency changes with respect to baseline, simulation with all education policies



process. This mechanism is one of the reasons why human capital formation has long been regarded as an important source of economic growth (Lucas, 1988; Barro and Sala-i-Martin, 1995).

4 Economic and poverty impact of trade and human capital policies in Costa Rica and Nicaragua

The following analysis is done using the three different analytical instruments developed in the previous section. For instance, the macroeconomic effects of the FTAs are analyzed using our recursive dynamic CGE model with the GTAP7 database (section 3.1.1). The poverty impact of the FTAs is evaluated using the microsimulations (section 3.1.3). Finally, the macroeconomic effects of the human capital policies is evaluated using the human capital satellite model (section 3.2.1), together with the CGE model. Furthermore, by linking the CGE model, the top-down approach and the human capital satellite model we can evaluate the different interactions and complementarities of trade and human capital policies and their impact on poverty.

We start, however, with an overview of the initial trade conditions before the negotiation of the FTAs began and then, what was (or is being) negotiated for each FTA.

4.1 Preliminary trade conditions and FTA negotiations

As discussed in section 2.1, the United States and the European Union are key trade partners for Costa Rica and Nicaragua. Aggregated data indicate that both regions account for a significant share of both countries exports and imports. The trade relationship of Costa Rica is more important, while Nicaragua has other important trade partners besides the US and the EU (see Table 11).

Table 11: Costa Rica and Nicaragua, main trading partners, 2008

	Costa Rica		**Nicaragua**	
	Exports	Imports	Exports	Imports
United States	35.6%	40.3%	29.5%	20.7%
European Union	16.1%	8.5%	14.9%	6.3%
Central America	18.1%	6.0%	33.4%	22.4%
Others	30.2%	45.1%	22.3%	50.5%
Total	100%	100%	100%	100%

Source: PROCOMER, Central Bank of Nicaragua

The Dominican Republic-Central American Free Trade Agreement with the Unites States (DR-CAFTA) and the forthcoming Association Agreement between the European Union and Central America (EU-CAAA) are expected to create the conditions for the promotion of a more dynamic export sector in the region, and to build a solid base for a development path in Central America based on increasing foreign direct investments, the creation of productive linkages with local firms and the consolidation of clusters, the transfer of technology and human capital formation, and the reinforcement of regional integration strategies.

It is not easy to estimate the possible impacts of a Free Trade Agreement (FTA). Many factors and conditions are involved. The expected impacts of DR-CAFTA and EU-CAAA depend on the growth of employment, trade and investments, on dynamic effects resulting from increased competition within the integrated markets, greater investments and technology transfers, and the impact in international relations, including development cooperation, "agreement-pushed" domestic reforms, and CA global reputation.

4.1.1 DR-CAFTA negotiation

DR-CAFTA was ratified by almost all member countries in year 2005. The exception was Costa Rica. The Congress ratified the Agreement until 2008 after a referendum in September 2007. In general, DR-CAFTA is aimed at consolidating CBI market access benefits and extending it to previously excluded sectors. Furthermore, important provisions and legal requirements were included to improve investment opportunities in CA.

Almost no agricultural products are excluded from DR-CAFTA. Tariffs will be eliminated for all products, except sugar for the United States, fresh potatoes and fresh onions for Costa Rica, and white corn for the rest of Central America. More than half of current US agricultural exports to Central America will become duty-free immediately. Each Central American country will have a separate schedule of commitments providing access for US products. The United States will provide the same tariff treatment to each of the five countries, but will make country-specific commitments on tariff-rate quotas.

Sensitive sectors were granted special treatment (safeguards, protection from imported goods, specific schedules for tariff phase-out) under DR-CAFTA. To address asymmetrical development and transition issues, DR-CAFTA specifies rules for lengthy tariff phase-out schedules as well as transitional safeguards and tariff rate quotas (TRQs) for sensitive goods in Central America. Although almost all goods will attain immediate duty-free treatment, others will have tariffs phased out incrementally so that duty-free treatment is reached in 5, 10, 15, or 20 years. Duty-free treatment would be delayed and in some cases, the tariff reductions would not begin until 7 or 12 years into the agreement (see Table 12).

Table 12: Tariff Reduction Schedule for Sensitive Agricultural Products under DR-CAFTA

	Guatemala			Honduras			El Salvador			Nicaragua			Costa Rica		
Product	IT (%)	PP (yrs)	GP (yrs)	IT (%)	PP (yrs)	GP (yrs)	IT (%)	PP (yrs)	GP (yrs)	IT (%)	PP (yrs)	GP (yrs)	IT (%)	PP (yrs)	GP (yrs)
Beef*	n.a.	10	0	15	15	6	15	15	0	15	15	3	15	15	4
Pork	15	15	0	15	15	0	40	15	6	15	15	0	47	15	6
Poultry	164.4	18	10	164.4	18	0	164.4	18	10	164.4	18	10	151	17	10
Diary products	15	20	10	15	20	10	40	20	10	40	20	10	66	20	10
Yellow maize	n.a.	10	0	45	15	6	15	15	6	15	15	0	15	15	0
Beans	20	15	6	15	15	0	20	15	15	30	15	0	47	15	0
Fresh potatoes	15	15	0	15	15	0	15	13	0	15	15	0		Excluded	
Rice	29.2	18	10	45	18	10	40	18	10	63	18	10	36	20	10
Sorghum	0	0	0	15	15	0	15	15	0	20	15	6	15	15	0

*Beef products other than prime and choice cuts

IT: initial tariff; PP: phase-out period; GP: grace period; n.a.= not available

Source: CEPAL (2004)

On the other hand, textiles and apparel will be duty-free and quota-free immediately if they meet the agreement's rule of origin. The agreement's benefits for textiles and apparel will be retroactive to January 1st 2004. Some apparel made in Central America that contains certain fabrics from NAFTA partners (Mexico and Canada) will have duty-free access. A de minimis provision will allow limited amounts of third-country content to go into DR-CAFTA apparel, giving producers in both the US and Central America needed flexibility.

In addition, one of DR-CAFTA's main objectives is to implement a secure and predictable legal framework for investors. All forms of investment are protected under the agreement, including enterprises, debt, concessions, contracts and intellectual property. Pursuant to US Trade Promotion Authority, the agreement draws from US legal principles and practices to provide US investors in CA a basic set of substantive protections that Central American investors currently enjoy under the US legal system.

4.1.2 EU-CAAA negotiation

Central American and European Union countries announced at May 12, 2006, during the Fourth EU-Latin America Presidential meeting in Vienna, their intention to start a Free Trade Agreement (FTA) negotiation process. After several informal meetings, discussion events and preparation workshops, at a national and regional level, formal negotiations of an Association Agreement between the European Union and Central America (EU-CAAA) started in June 2007.[29] Currently, seven rounds of negotiations have been completed. The ratification of the Agreement is expectd in 2010.

Association Agreements negotiated by the EU are different to traditional FTAs. The Agreements comprehend not only economic (trade) issues, but additional components related to political dialogue and development cooperation. These are the previous steps to the consolidation of a Free Trade Zone between signatory countries. Central American integration strengthening would also be a key element. Indeed, the EU cooperation strategy for 2007-2013 includes regional integration as a key component for development assistance and resource allocation.

The Central American integration process has been reactivated in recent years. At present, 35 percent of trade is intraregional. The five members of the Central American Common Market (CACM) agreed in 1995 to reduce their common external tariff to a maximum of 15 percent. The region has one of the lowest average tariff rates of the world, as a result of a unilateral process of trade liberalization and a strong commitment to global integration. However, selected agricultural commodities are protected with tariffs that significantly exceed the 15 percent common external tariff ceiling (see Table 13). These specially protected commodities include dairy products, rice, sugar, and poultry. In addition, the use of non-tariff barriers has decreased significantly in recent years; although some of these barriers are still relevant.

4.2 Macroeconomic effects of the trade scenarios

Since the implementation of NAFTA in the early 1990s, CGE modeling has become the main empirical tool to assess the impact of free trade agreements. The considerable economy-wide effects expected from the policy shocks associated with trade openness require the use of general equilibrium analysis. Moreover, theoretical models and databases have been undertaking continual improvements over the years to match the extensive use of CGE models.

[29] Initial talks to pursue an FTA with the EU started years ago, during the first EU-LA Presidential Meeting at Rio de Janeiro, Brazil (1999). However, a cooperation agreement signed in year 1993 at San Salvador is perhaps the first moment when the idea of an Association Agreement started. The agreement idea was strengthened in 2002, at the Madrid Presidential Meeting.

Table 13: Main trade barriers in Central America

Average Tariffs (%)		Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica
Average nominal external tariff		7.1	6.9	7.1	5.1	7.1
	Capital goods	0	0	1	0	0
	Inputs	0	0	1	0	0
	Intermediate Goods	5 – 10	5 – 10	5 – 10	5	5 – 10
	Final Goods	15	15	15	15	15
Most Protected Industries (%)						
	Diary products (Milk)	15	40	20	40	65
	Corn (yellow)	5 – 35	0	20	0-30	1
	Rice	32	40	35	62	35
	Sugar	20	40	40	55	50
	Pork meat	15	40	15	15	48
	Chicken meat	15	20	50	170	150
Non-Tariff Barriers						
	Countervailing & anti-dumping	X	X	X	X	X
	Safeguards	X	X	X	X	X
	Non-automatic licensing		X		X	X
	SPS Prohibitions	X	X	X	X	X
	Tariff Rate Quotas	X	X	X	X	X
	Price Band Controls			X		

Source: Own elaboration with information from SIECA, www.sieca.org.gt

In this study we aggregate the GTAP7 database in 40 sectors and 9 regions: Costa Rica (CRC), Guatemala (GUA), Nicaragua (NIC), Panama (PAN), Rest of Central America (RCA), United States (USA), European Union (EU27), China (CHN), and Rest of the World (ROW). The sector aggregation was done considering the relevant exporting and importing sectors for Costa Rica, Nicaragua and Central America.[30]

4.2.1 Baseline case

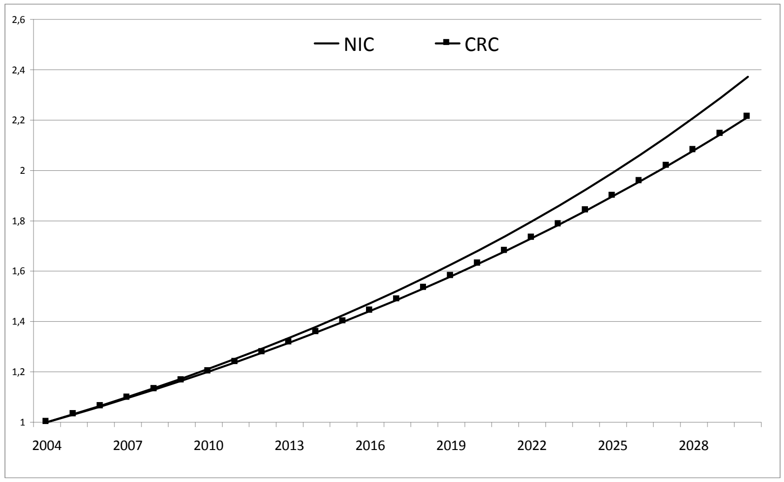
The baseline case takes 2004 as the starting point and it then applies the different growth rates explained in section 3.1.2. This simulation represents the business as usual scenario, which does not include the trade nor the human capital policy shocks. The growth path of GDP is described in Figure 8. For both countries, GDP growth is around 3% by year, which determines the exponential increase in GDP levels.

Analyzing changes in the productive sectors, the evolution is diverse among Costa Rica and Nicaragua. Agriculture and agricultural industries show continuous growth in both countries (dairy, traditional crops, cattle, sugar) with the exception of meat in Nicaragua. However, for both countries in most manufacturing sectors are growing faster than agriculture. In addition, the energy and services sectors show sustained growth along the projected period (Table 14).

In what follows, the results from the different scenarios are presented in a sequential way. First the ATC-protocol is implemented in 2005, together with the expansion of the EU from 25 to 27 members. Then DR-CAFTA is implemented starting in 2006 and 2008 in Nicaragua and Costa Rica, respectively. Finally, EU-CAAA is implemented in 2011 in both countries. We analyze each scenario below using sectoral production changes to see disaggregated effects and relative changes in private consumption. Changes in factor prices and final goods prices are analyzed when we discuss the poverty impacts of

[30] Sectoral definitions and groupings can be found in the Appendix

Figure 8: Costa Rica and Nicaragua, GDP growth path, relative changes with respect to base year



each scenario. While aggregated production (GDP) is analyzed in the next section when we simulate the human capital polices.

In our recursive dynamic model, there is no intertemporal optimization of consumption and investments, and thus, we cannot construct a strict welfare indicator. However, the changes in private consumption in real terms, is an indirect measure of the increase in household utility over time. In what follows, we use consumption as our main indicator of welfare improvements.

4.2.2 ATC-protocol scenario

The global liberalization of textile and clothing quotas at the beginning of 2005 under the Agreement on Textiles and Clothing (ATC-protocol) has already opened the US and EU markets for Chinese exports. This fact is very relevant for Central American textile and apparel (T&A) products and has already produced a significant increase of Chinese exports to the US and Europe. Hence, to assess the current international setting in the T&A sector, we eliminate the textile quotas for Chinese imports to the US and EU in 2005, as a pre-experiment condition in our baseline estimations. Subsequently, we use the updated database for our DR-CAFTA simulations.

Given the highly significant participation of China in the world market, we consider it necessary to include this event prior to our FTAs estimations, and this is a contribution of this paper with respect to previous CGE assessments. From Table 15 we observe that with the implementation of the ATC-protocol, the T&A sector shrinks in Costa Rica and Nicaragua, evidencing an important market share loss of Central American countries. The resource reallocation from T&A sector to other industries is important in both Central American countries. Many alternative industries grow significantly as a result, with a diversification of the productive structure. The impact on agriculture and agro-industries is diverse. In some cases activities grow while others shrink.

From Figure 9 we observe that the impact of the ATC-protocol implementation on consumption is significantly negative for Nicaragua with a reduction of more than 2% with respect to the baseline values. The importance of this single sector (T&A), which is based on maquila production, is evident

Table 14: Baseline scenario, sectoral growth rates, relative changes from base year

Code	Sector	Costa Rica 2010	Costa Rica 2020	Costa Rica 2030	Nicaragua 2010	Nicaragua 2020	Nicaragua 2030
PDR	Paddy_rice	0.20	0.58	0.98	0.15	0.43	0.75
WHT	Wheat	0.66	2.12	3.73	0.79	3.00	5.80
GRO	Other_cereal	0.23	0.65	1.06	0.16	0.47	0.84
V_F	Veg_fruits	0.18	0.50	0.83	0.17	0.48	0.84
OSD	Oil_seeds	0.18	0.50	0.83	0.18	0.50	0.82
C_B	Sugar_cane	0.13	0.38	0.68	0.13	0.39	0.70
PFB	Plant_fibers	0.20	0.58	1.00	0.17	0.51	0.91
OCR	Crops_nec	0.11	0.31	0.53	0.12	0.31	0.50
CTL	Cattle	0.16	0.47	0.85	0.08	0.24	0.42
OAP	Animprod_nec	0.16	0.47	0.82	0.15	0.43	0.74
RMK	Raw_milk	0.19	0.55	0.98	0.11	0.31	0.54
WOL	Wool	0.24	0.80	1.57	0.17	0.42	0.62
FRS	Forestry	0.11	0.30	0.48	0.14	0.33	0.45
FSH	Fishing	0.09	0.16	0.20	0.05	0.13	0.20
OMN	Minerals_nec	0.19	0.39	0.46	0.13	0.17	0.18
CMT	Meat	0.23	0.73	1.40	-0.01	-0.14	-0.40
OMT	Meatprod_nec	0.24	0.74	1.40	0.21	0.65	1.16
VOL	Veg_oils	0.27	0.87	1.73	0.23	0.66	1.14
MIL	Dairy	0.26	0.83	1.59	0.20	0.64	1.23
PCR	Proc_rice	0.24	0.71	1.27	0.22	0.68	1.29
SGR	Sugar	0.20	0.62	1.18	0.20	0.64	1.21
OFD	Foodprod_nec	0.21	0.60	1.00	0.20	0.63	1.20
B_T	Bev_tobacco	0.22	0.70	1.38	0.25	0.80	1.60
TEX	Textiles	0.34	1.18	2.44	0.11	0.30	0.48
WAP	Apparel	0.33	1.13	2.34	0.14	0.37	0.50
LEA	Leather	0.54	2.15	5.27	0.20	0.58	0.99
LUM	Wood_prod	0.25	0.75	1.29	0.18	0.52	0.86
PPP	Paper_prod	0.25	0.81	1.61	0.34	1.17	2.45
CRP	Chemical_pla	0.32	1.07	2.20	0.34	1.13	2.29
NMM	Minprod_nec	0.25	0.80	1.62	0.23	0.69	1.22
I_S	Ferrous_met	0.29	1.00	2.26	0.44	1.86	5.44
NFM	Metals_Nec	0.37	1.42	4.23	0.29	1.11	3.58
FMP	Metal_prods	0.30	0.99	2.01	0.40	1.38	2.95
MVH	Motor_veh	0.28	0.93	1.89	0.38	1.33	2.84
OTN	Trans_eq_nec	0.25	0.93	2.07	0.51	1.83	3.83
ELE	Electronic	0.08	0.21	0.33	0.57	2.17	4.96
OME	Machine_nec	0.12	0.41	0.83	0.47	1.75	3.86
OMF	Manufact_nec	0.26	0.77	1.28	0.61	2.82	9.57
SRV	Services	0.19	0.60	1.16	0.20	0.64	1.24
ENE	Energy	0.29	0.95	1.91	0.37	1.42	3.59

Source: Own elaboration

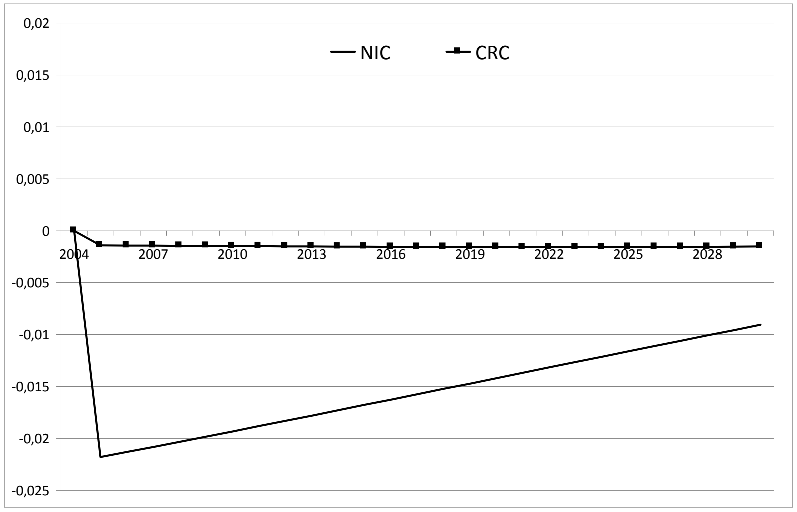
Table 15: ATC-protocol scenario, sectoral production changes w.r.t. baseline

Code	Sector	Costa Rica 2010	Costa Rica 2020	Costa Rica 2030	Nicaragua 2010	Nicaragua 2020	Nicaragua 2030
PDR	Paddy_rice	0.00	0.00	0.00	0.03	0.02	0.01
WHT	Wheat	0.01	0.01	0.01	0.09	0.05	0.03
GRO	Other_cereal	0.00	0.00	0.00	0.01	0.00	0.00
V_F	Veg_fruits	0.00	0.00	0.00	0.01	0.01	0.01
OSD	Oil_seeds	0.01	0.01	0.00	0.07	0.05	0.03
C_B	Sugar_cane	0.00	0.00	0.00	0.04	0.03	0.02
PFB	Plant_fibers	0.00	0.00	0.00	0.00	0.00	0.00
OCR	Crops_nec	0.00	0.00	0.00	0.08	0.05	0.04
CTL	Cattle	0.00	0.00	0.00	0.01	0.00	-0.01
OAP	Animprod_nec	0.00	0.00	0.00	-0.02	-0.01	-0.01
RMK	Raw_milk	0.00	0.00	0.00	-0.05	-0.05	-0.04
WOL	Wool	0.01	0.01	0.01	-0.36	-0.32	-0.27
FRS	Forestry	0.00	0.00	0.00	0.02	0.01	0.00
FSH	Fishing	0.00	0.00	0.00	0.02	0.01	0.00
OMN	Minerals_nec	0.01	0.00	0.00	0.01	0.00	0.00
CMT	Meat	0.00	0.00	0.00	0.06	0.04	0.01
OMT	Meatprod_nec	-0.01	0.00	0.00	0.00	0.00	0.00
VOL	Veg_oils	0.00	0.01	0.01	0.09	0.06	0.03
MIL	Dairy	0.00	0.00	0.00	0.07	0.06	0.04
PCR	Proc_rice	0.00	0.00	0.00	-0.01	-0.01	-0.01
SGR	Sugar	0.00	0.00	0.00	0.04	0.03	0.02
OFD	Foodprod_nec	0.00	0.00	0.00	0.05	0.04	0.02
B_T	Bev_tobacco	0.00	0.00	0.00	0.01	0.01	0.01
TEX	**Textiles**	**-0.10**	**-0.08**	**-0.07**	**-0.01**	**-0.02**	**-0.04**
WAP	**Apparel**	**-0.42**	**-0.40**	**-0.37**	**-0.58**	**-0.55**	**-0.52**
LEA	Leather	0.05	0.06	0.07	0.02	0.00	-0.01
LUM	Wood_prod	-0.03	-0.04	-0.04	0.02	0.00	-0.01
PPP	Paper_prod	0.00	0.00	0.00	0.08	0.07	0.05
CRP	Chemical_pla	0.01	0.01	0.01	0.07	0.05	0.03
NMM	Minprod_nec	0.01	0.01	0.01	0.07	0.05	0.03
I_S	Ferrous_met	0.04	0.04	0.04	0.10	0.10	0.08
NFM	Metals_Nec	0.05	0.05	0.05	0.34	0.29	0.21
FMP	Metal_prods	0.01	0.01	0.01	0.11	0.09	0.06
MVH	Motor_veh	0.00	0.01	0.01	0.10	0.09	0.06
OTN	Trans_eq_nec	0.02	0.02	0.02	0.14	0.10	0.07
ELE	Electronic	0.04	0.05	0.06	0.20	0.15	0.10
OME	Machine_nec	0.03	0.03	0.03	0.33	0.25	0.17
OMF	Manufact_nec	0.01	0.01	0.00	0.02	0.02	0.03
SRV	Services	0.00	0.00	0.00	0.03	0.03	0.02
ENE	Energy	0.00	0.01	0.01	0.06	0.05	0.05

Source: Own elaboration

for Nicaragua. In the case of Costa Rica the impact is also negative but close to zero. This reflects the small proportion of Costa Rican exports in the T&A sector.[31]

Figure 9: ATC scenario, consumption changes w.r.t. baselne



4.2.3 DR-CAFTA Scenario

Once we ran the scenario with the quota reduction to Chinese exports of T&A, we proceeded to estimate the impact of DR-CAFTA. This calculation is done by assuming a full liberalization of trade between the US and Central America in 2006 (for the case of Costa Rica in 2008), as well as free trade within CA. Thus, we reduce all tariffs between both regions to zero and eliminate all tariffs within CA; but keep the original tariffs with the other 7 regions. In accordance with the agricultural exclusions made in the agreement we do not remove the tariffs for sugar from CA to the US, and implement a phase-out period for sensitive goods from the US to CA using a GTAP7 classification adaptation (Table 16). In addition, some minor quotas across both regions and within CA were also eliminated.

In Table 17 we present the sectoral production changes for the DR-CAFTA scenario. First, we observe that most agriculture sectors are either slightly decreasing or remaining the same as in the baseline levels, for both Costa Rica and Nicaragua. However, there are some exceptions like raw milk and dairy products in both countries and oilseeds in Nicaragua. The production of the apparel sector falls significantly compared to the baseline, but less than in the previous scenario for the ATC-protocol, while the textile sector is experiencing a strong expansion. Since each scenario builds upon the last, this means that DR-CAFTA is partly compensating for the negative effects of the stronger Chinese competition in T&A markets. But it is also creating a specialization in the textile sector away from the apparel sector. On the other hand, many industrial sectors experience an increase in production with respect to baseline values, in both countries. In the case of the US (not reported), the only relevant

[31] In the case of Guatemala and the other Central American countries (El Salvador and Honduras), the impact of the ATC protocol on T&A production is very important. The impact of China's competition on these countries is stronger than in Nicaragua. These results are not presented here, but are available on request.

Table 16: Phase-out schedule for sensitive goods from DR-CAFTA, changes relative to base tariff by year

	Costa Rica					Nicaragua				
GTAP sector:	GRO	PDR	MIL	OMT	SGR	GRO	PDR	MIL	OMT	SGR
Description:	White Corn	Paddy Rice	Diary Products	Meat	Sugar	White Corn	Paddy Rice	Diary Products	Meat (Pork,	Sugar
Base Tariff	15.0	36.0	66.0	40.2	47.0	Excluded	63.0	40.0	90.0	55.0
Year 1	-6.7	0.0	0.0	0.0	-6.7	0.0	0.0	0.0	-2.2	-6.7
Year 2	-7.1	0.0	0.0	0.0	-7.1	0.0	0.0	0.0	-4.4	-13.3
Year 3	-7.1	0.0	0.0	0.0	-7.7	0.0	0.0	0.0	-6.7	-20.0
Year 4	-8.3	0.0	0.0	0.0	-8.3	0.0	0.0	0.0	-11.7	-26.7
Year 5	-9.1	0.0	0.0	-2.2	-9.1	0.0	0.0	0.0	-16.7	-33.3
Year 6	-10.0	0.0	0.0	-2.2	-10.0	0.0	0.0	0.0	-21.7	-40.0
Year 7	-11.1	0.0	0.0	-3.8	-11.1	0.0	0.0	0.0	-26.7	-46.7
Year 8	-12.5	0.0	0.0	-3.9	-12.5	0.0	0.0	0.0	-31.7	-53.3
Year 9	-14.3	0.0	0.0	-4.1	-14.3	0.0	0.0	0.0	-36.7	-60.0
Year 10	-16.7	0.0	0.0	-4.9	-16.7	0.0	0.0	0.0	-41.7	-66.7
Year 11	-20.0	-8.0	-10.0	-15.1	-20.0	0.0	-12.5	-10.0	-50.8	-73.3
Year 12	-25.0	-8.7	-11.1	-17.7	-25.0	0.0	-25.0	-11.1	-60.0	-80.0
Year 13	-33.3	-9.5	-12.5	-21.5	-33.3	0.0	-37.5	-12.5	-69.2	-86.7
Year 14	-50.0	-10.5	-14.3	-29.7	-50.0	0.0	-50.0	-14.3	-78.3	-93.3
Year 15	-100.0	-11.8	-16.7	-42.2	-100.0	0.0	-62.5	-16.7	-87.5	-100.0
Year 16		-20.0	-20.0	-50.0		0.0	-75.0	-20.0	-75.0	
Year 17		-25.0	-25.0	-100.0		0.0	-87.5	-25.0	-87.5	
Year 18		-33.3	-33.3			0.0	-100.0	-33.3	-100.0	
Year 19		-50.0	-50.0			0.0		-50.0		
Year 20		-100.0	-100.0			0.0		-100.0		

Source: own elaboration with information from Sánchez (2007) and DR-CAFTA Country Text Annexes

result is a reduction in the production of the T&A sector, but for the rest of sectors there are no significant changes.

The impact of DR-CAFTA on the GDP and consumption for the United States is negligible. In Figure 10 we show the consumption effects for Costa Rica and Nicaragua. For Costa Rica we see a significant increase of 1% after the implementation of the agreement, which gradually is reduced over time. For Nicaragua, the ATC protocol impacts are still observed before 2007. However, when DR-CAFTA is implemented consumption jumps 2% to offset the negative impact of the ATC protocol. Later on consumption continues growing to reach almost 0.5% in 2030.

For the other Central America countries (not presented), DR-CAFTA also compensates for the consumption losses driven from higher competition from Chinese products in the US T&A market. Provided that the current CBI assures market access to many Central American products, in our baseline scenario, DR-CAFTA is more than compensating for the negative effects of the Chinese quota reduction in T&A.

4.2.4 EU-CAAA Scenario

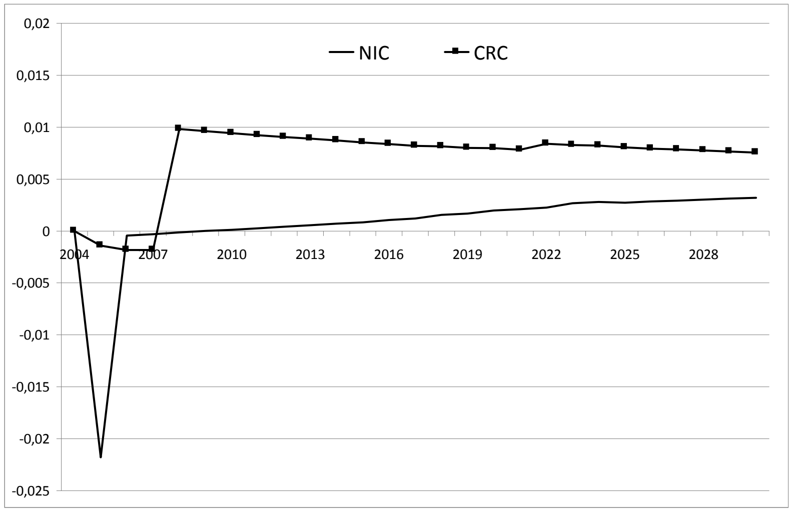
The EU-CAAA scenario is sequential with the other two trade policy shocks. Thus, we first include the application of the Agreement on Textiles and Clothing (ATC) protocol in 2005, which expands China's exports of apparel and textile products to the US and the EU, and increases competition with Central

Table 17: DR-CAFTA scenario, sectoral production changes w.r.t. baseline

		Costa Rica			Nicaragua		
Code	**Sector**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
PDR	Paddy_rice	-0.01	-0.02	-0.06	-0.04	-0.10	-0.13
WHT	Wheat	0.00	0.00	0.01	0.02	0.02	0.02
GRO	Other_cereal	-0.01	-0.02	-0.06	-0.01	0.00	0.01
V_F	Veg_fruits	0.00	0.00	0.00	-0.01	-0.01	-0.01
OSD	Oil_seeds	0.00	0.00	0.01	0.29	0.22	0.19
C_B	Sugar_cane	0.00	0.00	0.00	0.01	0.01	0.01
PFB	Plant_fibers	-0.01	-0.01	0.00	0.01	0.00	0.00
OCR	Crops_nec	-0.01	0.00	0.00	0.00	0.01	0.01
CTL	Cattle	0.00	0.00	0.00	-0.01	-0.01	0.00
OAP	Animprod_nec	0.00	-0.01	-0.02	-0.01	-0.01	-0.01
RMK	Raw_milk	0.10	0.07	0.04	0.04	0.03	-0.02
WOL	Wool	0.03	0.03	0.03	-0.15	-0.12	-0.08
FRS	Forestry	-0.01	0.00	0.00	0.00	0.00	0.00
FSH	Fishing	0.00	0.00	0.00	0.01	0.00	0.00
OMN	Minerals_nec	0.01	0.00	0.00	0.00	0.00	0.00
CMT	Meat	0.00	0.00	0.00	0.03	0.02	0.00
OMT	Meatprod_nec	0.00	-0.01	-0.03	0.00	-0.01	-0.02
VOL	Veg_oils	0.00	0.01	0.03	-0.14	-0.12	-0.11
MIL	Dairy	0.11	0.08	0.05	0.13	0.09	0.02
PCR	Proc_rice	-0.01	0.00	0.02	-0.12	-0.07	-0.03
SGR	Sugar	0.00	0.00	0.00	0.01	0.01	0.00
OFD	Foodprod_nec	0.00	0.00	0.01	0.01	0.04	0.05
B_T	Bev_tobacco	0.01	0.01	0.00	0.01	0.01	0.00
TEX	**Textiles**	**-0.06**	**-0.06**	**-0.05**	**0.47**	**0.42**	**0.37**
WAP	**Apparel**	**-0.35**	**-0.32**	**-0.29**	**-0.42**	**-0.37**	**-0.33**
LEA	Leather	0.07	0.08	0.10	-0.02	-0.02	-0.02
LUM	Wood_prod	-0.06	-0.06	-0.06	-0.02	-0.02	-0.02
PPP	Paper_prod	-0.01	-0.01	0.00	0.03	0.02	0.01
CRP	Chemical_pla	0.00	0.00	0.01	0.02	0.01	0.01
NMM	Minprod_nec	0.00	0.01	0.01	0.03	0.02	0.01
I_S	Ferrous_met	0.05	0.05	0.04	0.05	0.04	0.03
NFM	Metals_Nec	0.04	0.04	0.04	0.12	0.10	0.07
FMP	Metal_prods	0.01	0.01	0.01	0.04	0.03	0.02
MVH	Motor_veh	0.00	0.00	0.00	0.03	0.02	0.02
OTN	Trans_eq_nec	0.09	0.07	0.05	0.05	0.04	0.03
ELE	Electronic	0.00	0.02	0.03	0.00	-0.01	-0.01
OME	Machine_nec	0.25	0.23	0.21	0.33	0.27	0.22
OMF	Manufact_nec	0.02	0.01	0.01	-0.03	-0.02	0.00
SRV	Services	-0.01	-0.01	-0.01	0.01	0.01	0.01
ENE	Energy	-0.03	-0.03	-0.02	0.02	0.01	0.00

Source: Own elaboration

Figure 10: DR-CAFTA scenario, consumption changes w.r.t. baseline



American products. In the second sequential adjustment we apply the DR-CAFTA base case scenario implementation, as described in Section 4.2.3. The implementation of the EU-CAAA is assumed to begin in 2011.

The outcome of this scenario provides useful information, not only about the magnitude of the potential macroeconomic effects of EU-CAAA, but also about the comparative results between different prospective negotiation outcomes. However, since the agreement is still being negotiated we must assume the main negotiation outcomes. Thus, we simulate total liberalization: all tariffs and quotas between Central America and EU are eliminated, excluding two main sensitive sectors, sugar and bananas exports from Central America to the European Union. For these sectors, we assume that the negotiated tariffs decrease by 50%.

The sectoral production results are shown in Table 18. The changes resulting from EU-CAAA are different between Costa Rica and Nicaragua. For Costa Rica we observe a decrease in most agricultural production. However, the vegetable and fruits sector –where bananas are included– experiences a 5% increase by 2030. This reflects the decline in the EU tariffs for this product. On the other hand, we do not observe changes in the production of sugar cane or processed sugar after the EU tariff reduction. This is a reflection of a very high initial base tariff, which is still prohibitive after a 50% decrease. For Nicaragua we observe that some agricultural sectors are expanding, most prominently oil seeds. While other are decreasing and there is no change in the vegetable and fruits sector, since Nicaragua does not export many bananas.

For both countries we observe an increase in many agro-industrial and industrial sectors. The exceptions are textiles and apparel in both countries as a result of the ATC protocol. The electronics sector in Costa Rica also experiences an important production decrease.

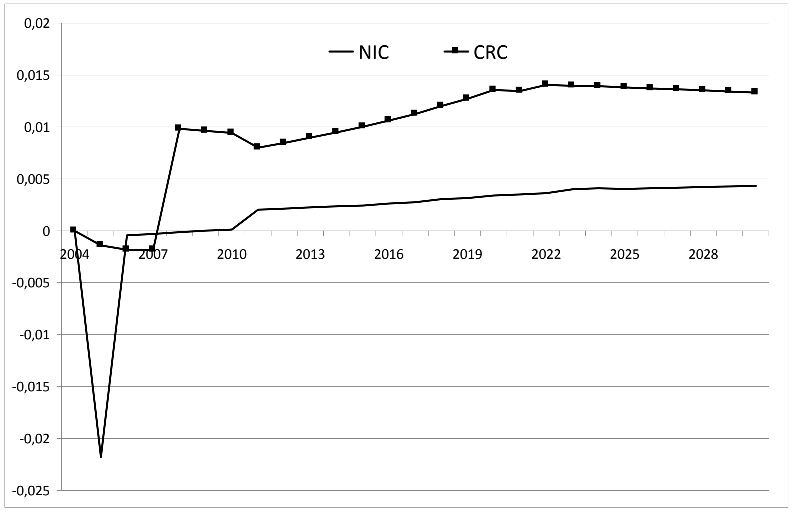
There is no significant impact of EU-CAAA on the EU macroeconomic indicators. This is a consequence of the very low share of Central American trade in terms of total EU trade. In Figure 11 we show the consumption changes after the implementation of the EU-CAAA.

Table 18: EU-CAAA scenario, sectoral production changes w.r.t. baseline

		Costa Rica			Nicaragua		
Code	**Sector**	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
PDR	Paddy_rice	-0.01	-0.05	-0.08	-0.04	-0.10	-0.13
WHT	Wheat	0.00	-0.13	-0.10	0.02	0.02	0.02
GRO	Other_cereal	-0.01	-0.04	-0.08	-0.01	0.00	0.00
V_F	Veg_fruits	0.00	0.06	0.05	-0.01	-0.01	0.00
OSD	Oil_seeds	0.00	-0.03	-0.03	0.29	0.22	0.19
C_B	Sugar_cane	0.00	0.00	0.00	0.01	0.01	0.01
PFB	Plant_fibers	-0.01	-0.03	-0.03	0.01	0.00	0.00
OCR	Crops_nec	-0.01	-0.03	-0.03	0.00	0.01	0.01
CTL	Cattle	0.00	-0.01	-0.01	-0.01	0.00	0.00
OAP	Animprod_nec	0.00	-0.02	-0.04	-0.01	-0.01	-0.01
RMK	Raw_milk	0.10	0.05	0.02	0.04	0.02	-0.02
WOL	Wool	0.03	0.02	0.02	-0.15	-0.11	-0.07
FRS	Forestry	-0.01	0.01	0.00	0.00	0.00	0.00
FSH	Fishing	0.00	0.00	0.00	0.01	0.00	0.00
OMN	Minerals_nec	0.01	0.01	0.00	0.00	0.00	0.00
CMT	Meat	0.00	-0.01	-0.01	0.03	0.02	0.00
OMT	Meatprod_nec	0.00	-0.02	-0.05	0.00	0.00	-0.01
VOL	Veg_oils	0.00	0.00	0.02	-0.14	-0.13	-0.12
MIL	Dairy	0.11	0.06	0.03	0.13	0.08	0.01
PCR	Proc_rice	-0.01	-0.01	0.02	-0.12	-0.07	-0.03
SGR	Sugar	0.00	0.00	0.00	0.01	0.01	0.01
OFD	Foodprod_nec	0.00	0.01	0.01	0.01	0.04	0.06
B_T	Bev_tobacco	0.01	0.01	0.01	0.01	0.01	0.00
TEX	**Textiles**	**-0.06**	**-0.03**	**-0.03**	**0.47**	**0.43**	**0.38**
WAP	**Apparel**	**-0.35**	**-0.30**	**-0.27**	**-0.42**	**-0.37**	**-0.32**
LEA	Leather	0.07	0.14	0.15	-0.02	-0.03	-0.02
LUM	Wood_prod	-0.06	-0.06	-0.08	-0.02	-0.02	-0.02
PPP	Paper_prod	-0.01	0.01	0.01	0.03	0.01	0.01
CRP	Chemical_pla	0.00	0.03	0.03	0.02	0.01	0.01
NMM	Minprod_nec	0.00	0.00	0.01	0.03	0.01	0.00
I_S	Ferrous_met	0.05	0.06	0.05	0.05	0.04	0.03
NFM	Metals_Nec	0.04	0.03	0.04	0.12	0.12	0.09
FMP	Metal_prods	0.01	0.02	0.02	0.04	0.02	0.02
MVH	Motor_veh	0.00	0.00	0.00	0.03	0.01	0.01
OTN	Trans_eq_nec	0.09	0.09	0.07	0.05	0.04	0.03
ELE	Electronic	0.00	-0.19	-0.18	0.00	-0.01	-0.01
OME	Machine_nec	0.25	0.31	0.27	0.33	0.28	0.23
OMF	Manufact_nec	0.02	0.02	0.01	-0.03	-0.03	-0.02
SRV	Services	-0.01	0.00	0.00	0.01	0.01	0.01
ENE	Energy	-0.03	-0.02	-0.02	0.02	0.01	0.00

Source: Own elaboration

Figure 11: EU-CAAA scenario, consumption changes w.r.t. baseline



We observe that the broad pattern of consumption is maintained, however, there is an increase of around 0.5% in consumption for Costa Rica –when compared to the DR-CAFTA scenario. For Nicaragua, there are almost no consumption changes. This is a consequence of the initial low levels of trade that Nicaragua has with the EU and that a potential export product such as sugar, still has prohibitive tariffs even with the 50% reduction we simulated.

4.2.5 Final remarks on the CGE simulations of trade policies

Costa Rica and Nicaragua can expect significant and lasting benefits from both FTAs. However, we are only considering here the static adjustments related to these agreements. We do not account for dynamic effects such as increased FDI inflows, trade facilitation mechanisms that can reduce international transportation costs nor productivity changes associated with increased trade flows. There is a large literature that relates trade with economic growth. Yet, there is a large debate about how to isolate the effect of trade liberalization from other economic policies that are usually carried out together. Thus, there is no empirical link between trade flows and TFP changes. Moreover, FDI inflows are extremely difficult to model in a dynamic recursive framework where investment is not optimally decided over time. To construct such a framework is beyond the scope of this study and therefore, we remain with our static effects. These can be considered to be a lower bound of the potential benefits of these FTAs.

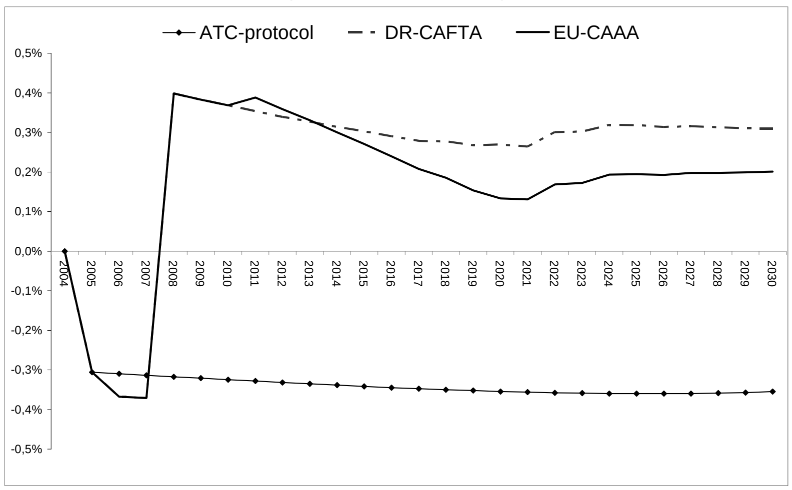
4.3 Poverty effects of the trade scenarios

This section presents the simulation results using the top-down approach, which combines the dynamic CGE model with the microsimulations using household survey data. As explained in section 3.1.3, these household surveys have data on both expenditures and incomes by household and by person. We use both changes in expenditures and incomes to estimate changes in real incomes.

The impact of FTAs on poverty depends on how factor and food products prices change as a result of trade agreements implementation. For poorer households, wages and food prices are the most relevant variables. Both in Costa Rica and Nicaragua, income of the poorest household depends significantly on low-skill workers wages, while food goods represent and important share of total consumption. These results were already presented in section 3.1.3. Therefore, we obtain the factor and final goods changes from each scenario in the CGE model. With this information we determine the impact of each scenario on poverty.

Following this methodology, we first analyze how wages for both skill types –high and low skill– change for each scenario. In Figure 12 we plot the dynamic path of low-skill wages for our three trade scenarios in Costa Rica. Is it important to remember that these trade scenarios are sequential, and thus, DR-CAFTA scenario includes both this agreement and the ATC-protocol, while the EU-CAAA scenario includes all the three trade shocks.

Figure 12: Costa Rica, changes in low-skill wages relative to baseline values

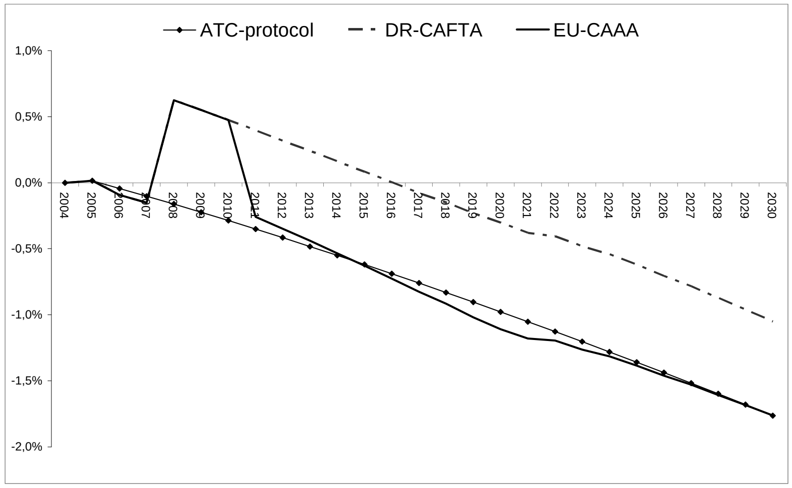


The wages of low-skill workers in Costa Rica experience an expected decrease after the implementation of the ATC-protocol, which represents more competitions from low-skill intensive goods from China. This initial decrease, however, is reversed after the DR-CAFTA agreement, where wages increase by 0.5%. The implementation of the EU-CAAA agreement also has a positive impact on low-skill wages, but it is about only 0.1%.

On the other hand, Figure 13 shows the changes in high-skill wages. In this case we see that all three trade scenarios decrease the wages of high-skill workers significantly. This are less intuitive results. The ATC-protocol is decreasing high-skill wages, while DR-CAFTA increases them by more than 0.5% but with the EU-CAAA returns wages to their ATC-protocol levels. In general, following standard trade theory, more competition with relatively skill abundant regions such as the EU and the USA is expected to hurt the wages of high-skill workers. However, in the case of Costa Rica, it seems that the T&A sector had an important component of high-skill factor content. This can be a consequence of Costa Rica competing in a specialized niche of the T&A market that does not rely entirely on cheap labour to be competitive.

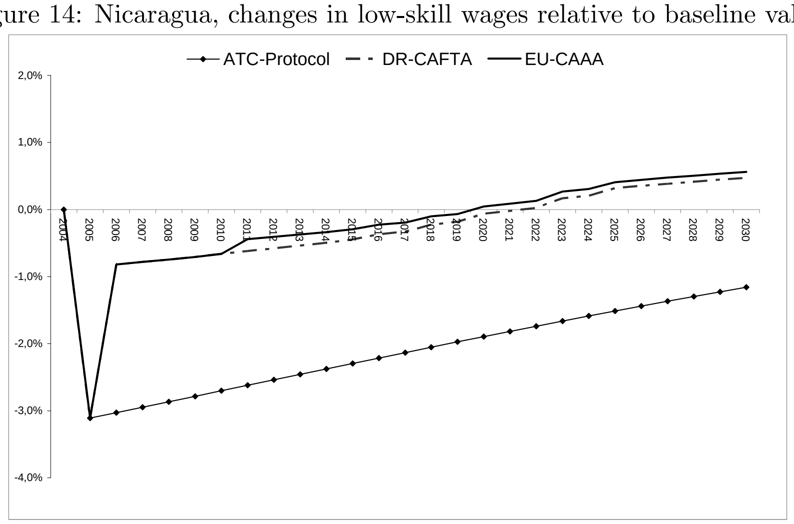
The wage results from our trade scenarios are very different for Nicaragua. Figure 14 we show the dynamic changes for low-skill wages and in Figure 15 for high-skill wages. For both types of wages we

Figure 13: Costa Rica, changes in high-skill wages relative to baseline values



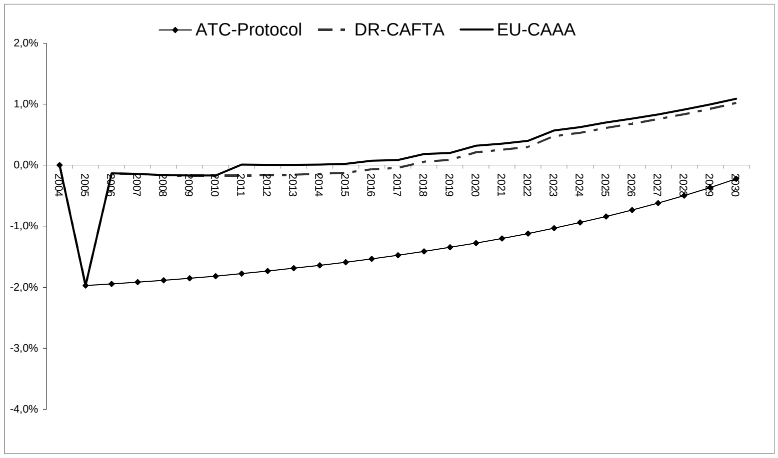
observe the same pattern. Wages decrease significantly with the ATC-protocol implementation in 2005 as the T&A sector contracts. In the medium term, wages increase for both high-skill workers as the economy adjusts its production to other sectors. When the DR-CAFTA is implemented we observe a one-time increase in the wages of more than 2% for low-skill workers and of less than 2% for high-skill workers. The EU-CAAA has a positive but small impact on wages for both for skill types. Thus, the reallocation of productive resources to different sectors after the trade shocks increases the demand for all workers irrespective of skill levels. This has a positive impact on wages. In this case, contrary to Costa Rica, the wage gap between skill levels is not changing.

Figure 14: Nicaragua, changes in low-skill wages relative to baseline values



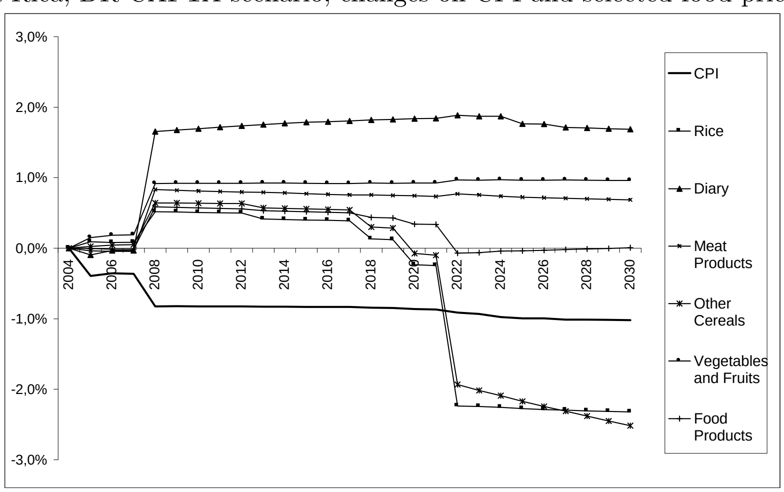
We analyze now the changes in final goods prices of the two trade agreements. In the case of DR-CAFTA, the decrease of general prices (CPI) compared to baseline values indicates an improvement in

Figure 15: Nicaragua, changes in high-skill wages relative to baseline values



real incomes for both countries. On the other hand, the changes in food prices are diverse. In Costa Rica, the prices of some agricultural products decrease, while others grow (see Figure 16).

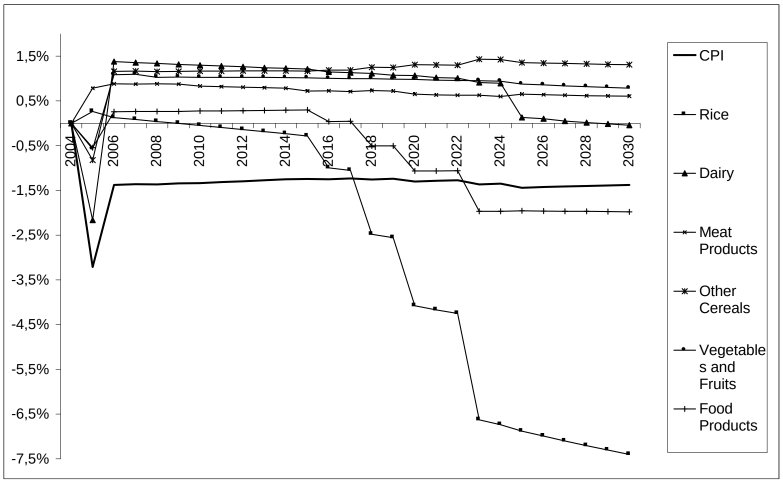
Figure 16: Costa Rica, DR-CAFTA scenario, changes on CPI and selected food prices w.r.t. baseline



It is important to recall that the productivity shocks and endowment growth rates influence the agricultural markets in the baseline, while the price shocks in the FTA are related to changes in tariffs. Tariffs changes can act through two channels on domestic prices. One is directly through foreign competition to lower prices and the other channel is through a reallocation of production to the export sector that can displace domestic production and increase prices. In both our FTA scenarios and in both countries, CPI is declining mainly because of changes in manufactured goods, which are imported at lower prices after the implementation of the agreements.

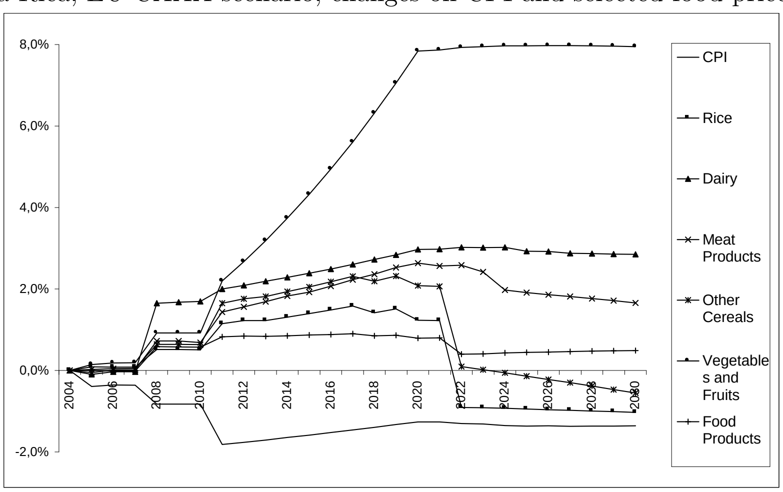
Figure 17 shows similar price effects for Nicaragua. Consumer prices fall below baseline levels for all the analyzed period, while in the case of food products most prices grow although others fall. The decrease is significant in the case of rice, which is an important consumption good for poor families.

Figure 17: Nicaragua, DR-CAFTA scenario, changes on CPI and selected food prices w.r.t. baseline



In Figure 18 we plot the price changes in Costa Rica after the implementation of the EU-CAAA. We observe that general prices (CPI) are decreasing further by around 1% compared to the DR-CAFTA scenario, while changes in food prices are again diverse. The most significant case is for the price of vegetables and fruits, which increase significantly. This is a result of bananas demand increase due to market liberalization in the EU and this concentrates production into this good and decreases the production of related goods and pushes their prices up.

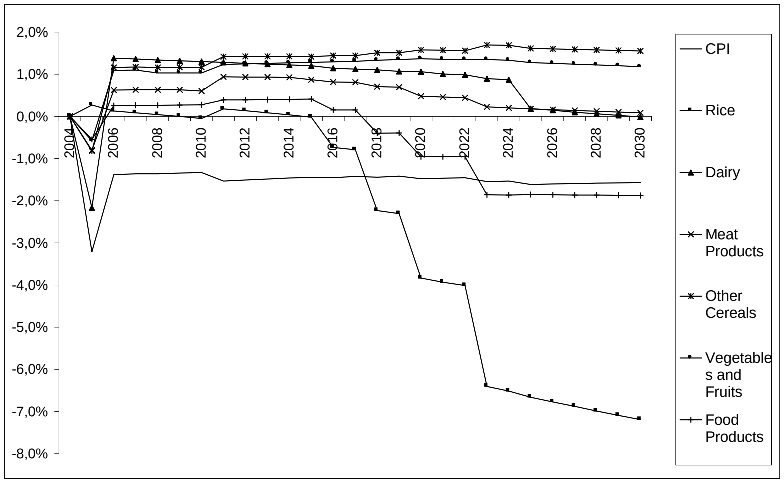
Figure 18: Costa Rica, EU-CAAA scenario, changes on CPI and selected food prices w.r.t. baseline



For Nicaragua, Figure 19 shows again the same pattern of price changes than the previous scenario. This is due to the small overall impact of the EU-CAAA agreement for Nicaragua.

We also have information on the changes on the prices of the other production factors: capital, land and natural resources. From 3.1.3 we know that these factors account for a relatively small amount of household income, and this is more pronounced for poorer household. Therefore, their effect on poverty

Figure 19: Nicaragua, EU-CAAA scenario, changes on CPI and selected food prices w.r.t. baseline



is very limited. However, we observe that for both FTAs and in both countries the prices of land, capital and natural resources are increasing. Thus, we can expect a positive impact on households that depend on these factor incomes.

Summing up on the changes on prices and wages, we can expect poverty to fall given the increase in low-skill wages in both countries. As mentioned before, the most important impact on poverty resulting from FTAs implementation would be the changes in wages, particularly those of low-skill workers. The results from the simulations indicate that both agreements (DR-CAFTA and EU-CAAA) have a positive impact on low-skill workers wages in Costa Rica. Whether small in magnitude, the agreements help to compensate for the decrease in low-skill workers demand resulting from ATC and China's impact on T&A markets.

However, the changes in relative food prices can have mixed effects on poverty. We observe that many agricultural goods have a relative price increase and this can have a negative impact on the expenditures –in real terms– of poor households, where food has a high percentage of their consumption basket.

We now can analyze how poverty is changing. As explained in section 3.1.3 we integrate these price and wage changes into the income and expenditure values of each household using the survey information. This allows us to translate the CGE macroeconomic shocks into the real income values of each household. For instance, real income is increasing with higher wages, but it is decreasing when the prices of final goods rises. The extent of the final goods impact depends on the weight of each specific product on the consumption basket of that particular household. Then we divide the real income of the household between the number of household members to obtain the real income by person. Finally, we compare this real income values with the specific poverty line to asses which people are considered to be relatively poor (if their income is below the $2 a day poverty line) and absolute poor (when income are below the $1 a day threshold).

The impact of all changes aforementioned on poverty in Costa Rica is described in Table 19. Our main indicator is the headcount poverty index, which is defined for $A = 0$ in the FGT index described in section 3.1.3. We also show information on the changes on the other FGT indexes for the poverty gap ($A = 1$) and the square of poverty gap ($A = 2$) in the Appendix. The poverty values for 2004 are those obtained directly from the households surveys and do not include any policy shock.

Table 19: Costa Rica, headcount poverty values for trade scenarios

	2004	2010	2020	2030
Baseline				
Relative poverty	19.6%	17.4%	16.2%	15.4%
Absolute poverty	4.0%	6.0%	5.7%	5.7%
ATC-Protocol				
Relative poverty		17.6%	16.3%	15.7%
Absolute poverty		6.0%	5.7%	5.7%
DR-CAFTA				
Relative poverty		17.4%	16.1%	15.3%
Absolute poverty		6.0%	5.7%	5.7%
EU-CAAA				
Relative poverty		17.4%	16.4%	15.5%
Absolute poverty		6.0%	5.8%	5.8%

Notes: Relative poverty is estimated with the $2 a day poverty line, while absolute poverty uses $1 a day.
The trade scenarios are sequential: DR-CAFTA includes ATC protocol and EU-CAAA includes all.
Source: Own elaboration.

The most significant poverty reduction is achieved in the baseline scenario. This is a direct consequence of the 3% growth rate that is obtained after the increases in TFP, land efficiency and the capital stock. These changes result in sustained labor demand increases to cope with the production expansion and this yields higher wages, while food prices are growing moderately.

Regarding our trade scenarios we observe only small deviations from this baseline poverty decrease. In particular, the impact of the ATC-protocol on poverty is slightly negative, but it is compensated with a poverty reduction of DR-CAFTA of about 0.4%. On the other hand, poverty rates increase slightly with EU-CAAA. The increase in some food prices is the main force driving this outcome. However, the impacts on poverty (positive and negative) are of a very small magnitude for both trade agreements.

For the case of Nicaragua, Table 20 shows again a general decrease in headcount poverty in the baseline case. This follows from the same reasons explained in the case of Costa Rica. However, in Nicaragua the negative impact of the ATC-protocol implementation is much higher, with poverty increasing by almost 2% in 2010. DR-CAFTA mitigates these effects and in 2030 the percentage of poor households returns to the baseline values. The EU-CAAA has a very small impact on poverty.

As mentioned before, the impact of Chinese competition in the T&A global market negatively affected the country's welfare. Both FTAs compensate these effects by increasing promote growth and consumption, which helps to reduce poverty. Wage increases and key food products price falls are reinforcing this outcome. Finally, we observed that the changes in both relative and absolute poverty are following the same pattern in each country.

4.4 Macroeconomic effects of human capital policies

This section links the human capital satellite model with the dynamic CGE model. As explained in section 3.2.1. the changes in human capital policies are fed into the CGE model using four linkage variables. These are the labour efficiency changes for low and high-skill workers and the labour supply

Table 20: Nicaragua, headcount poverty values for trade scenarios

	2004	2010	2020	2030
Baseline				
Relative poverty	39.4%	35.6%	32.5%	30.2%
Absolute poverty	16.9%	17.5%	15.2%	13.0%
ATC-Protocol				
Relative poverty		37.4%	33.7%	30.7%
Absolute poverty		18.7%	16.1%	13.8%
DR-CAFTA				
Relative poverty		36.3%	32.7%	30.0%
Absolute poverty		17.6%	15.5%	13.0%
EU-CAAA				
Relative poverty		36.3%	32.7%	29.9%
Absolute poverty		17.6%	15.5%	13.0%

Notes: Relative poverty is estimated with the $2 a day poverty line, while absolute poverty uses $1 a day.
The trade scenarios are sequential: DR-CAFTA includes ATC protocol and EU-CAAA includes all.
Source: Own elaboration.

changes for both skill types. Using these linkage variables we can analyze the macroeconomic impact of these policies.

Figure 20 depicts the impact of those human capital policies on consumption. In both countries consumption decreases with respect to their baseline levels until 2018, but then it starts increasing with rates superior not only to baseline but to all other simulation scenarios presented so far. The decrease of consumption is a direct consequence of the opportunity cost effect in education. This is, to increase the level of school attainment a fraction of the population has to stay longer at school and thus, the labour supply of workers is decreasing during this period. Yet, when these students with higher education enter into the labour market not only is labor supply increasing, but also labour efficiency is rising because the new worker cohorts have higher school attainment, but also higher quality of education. The remarkable effect is that consumption and growth levels have not only a positive effect but also experience a change in the growth rate.

In a broad sense, the human capital satellite model is creating an endogenous growth process, where shifts in the stock of human capital yield changes in the baseline growth rates. These results are in stark contrast with the more static –i.e. one-time– impact of the trade scenarios.

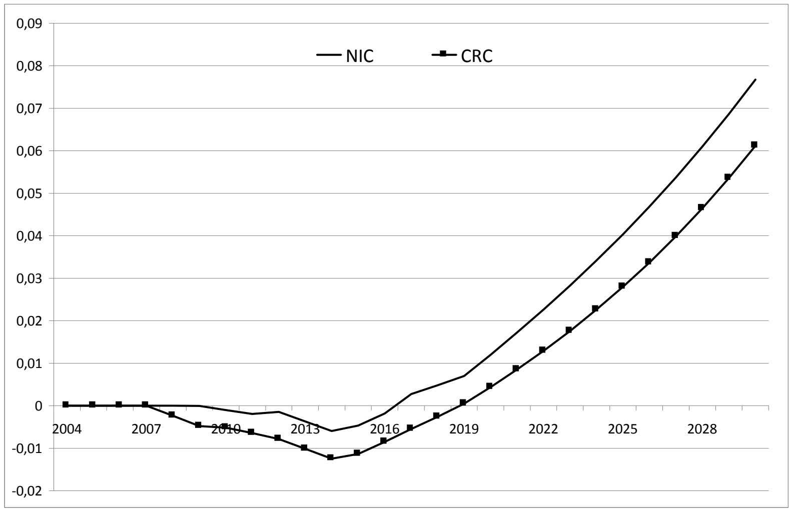
Due to the differences in human capital in Costa Rica and Nicaragua, the impact of education policies is stronger for the Nicaraguan economy. The higher impact is determined by the lower initial levels in Nicaragua and therefore the scope for improvement is wider.

The improvements in human capital for both countries promotes growth in practically all productive sectors by 2030 (see Table 21). However, production is stagnant or decreasing in the previous periods (i.e. 2010 and 2020) due to the initial opportunity costs of the human capital policies.

However, it is important to note that both Costa Rica and Nicaragua experience a relative increase in the manufacturing sector, with respect to agriculture. This outcome shows the impact of education policies on productive sectors which demand higher skilled workers.

The case of the T&A sector is illustrative. Trade policies partially compensated and in some cases reversed the negative shock from the ATC implementation. After integrating this impacts with human

Figure 20: Human capital scenario, consumption changes w.r.t. baseline



capital policies, the T&A sector grows in both countries. This result confirms that final impacts on growth as a result of human capital policies depend on the skill intensity of productive sectors.

However, we observe a significant increase in the production of the T&A sector for Nicaragua of around 33%. In the case of Costa Rica the T&A expansion is also positive but of a lower magnitude at around 12%. This results signals that although the T&A sector is considered to be based on low-skill labor on a global sense, in Costa Rica and Nicaragua it can also be employing middle and high-skilled workers. This result is also consistent with the wage changes we observed in the previous section when we analyzed the impact of the ATC-protocol.[32] Moreover, the services sector is also experiencing a significant impact, which is an expected result of a skill upgrading in the labor force.

It is worth mentioning that human capital policies outcomes are realized in the medium and long term. Therefore, the impact on production and other variables would be sustained as far as a continuous policy effort is institutionalized. In other words, the short-term costs outweigh the benefits, but on a broader perspective, these benefits impacts from human capital investments depend on its level of policy priority.

4.5 Poverty effects of human capital policies

Once again we follow the top-down approach and we plug the price and wage changes into the household budgets. As expected from the high growth rates produced by the human capital policies, we have a positive and very significant impact on wages in Costa Rica and Nicaragua. Figure 21 plots the wage changes for Costa Rica and Nicaragua for both skill types.

A first observation is that the wages of low-skill workers is increasing more than that for high-skill workers. This is a direct consequence of the skill upgrading of the labor force, which means that low-skill

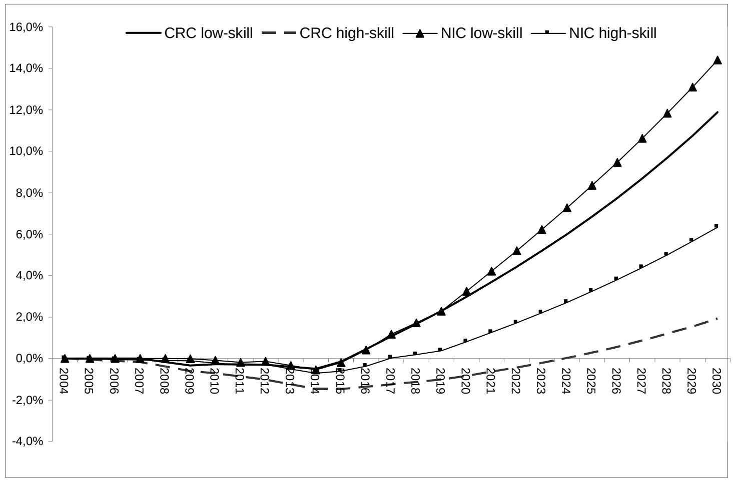
[32] Condo *et al.* (2004) indicate that the T&A sector in the region is diverse, with several segments along the value chain. This means that the expansion of the sector can occur at different segments that have a different low and high-skill factor content. Therefore, how this sector grows as a result of trade policies (particularly in Nicaragua) depends on how the supply of low and high skill workers evolves over time.

Table 21: Human capital scenario, sectoral production changes w.r.t. baseline

Code	Sector	Costa Rica 2010	Costa Rica 2020	Costa Rica 2030	Nicaragua 2010	Nicaragua 2020	Nicaragua 2030
PDR	Paddy_rice	0.00	0.00	0.02	0.00	0.00	0.01
WHT	Wheat	0.00	-0.01	-0.02	0.00	0.01	0.01
GRO	Other_cereal	0.00	0.00	0.01	0.00	0.01	0.03
V_F	Veg_fruits	0.00	-0.01	-0.01	0.00	0.00	0.02
OSD	Oil_seeds	0.00	-0.01	0.00	0.00	0.00	-0.01
C_B	Sugar_cane	0.00	0.00	0.03	0.00	0.00	0.03
PFB	Plant_fibers	0.00	0.00	0.00	0.00	0.01	0.05
OCR	Crops_nec	0.00	-0.01	0.00	0.00	0.00	-0.01
CTL	Cattle	0.00	0.00	0.03	0.00	0.00	0.01
OAP	Animprod_nec	0.00	0.00	0.02	0.00	0.01	0.04
RMK	Raw_milk	-0.01	0.00	0.04	0.00	0.01	0.08
WOL	Wool	0.00	0.00	0.02	0.00	0.03	0.25
FRS	Forestry	0.00	0.00	0.00	0.00	0.01	0.02
FSH	Fishing	0.00	0.00	0.00	0.00	0.00	0.00
OMN	Minerals_nec	0.00	0.00	0.00	0.00	0.00	0.00
CMT	Meat	0.00	0.00	0.03	0.00	0.00	0.01
OMT	Meatprod_nec	0.00	0.00	0.03	0.00	0.01	0.05
VOL	Veg_oils	-0.01	0.00	0.05	0.00	0.01	0.06
MIL	Dairy	-0.01	0.00	0.04	0.00	0.00	0.01
PCR	Proc_rice	0.00	0.00	0.03	0.00	0.00	0.03
SGR	Sugar	0.00	0.00	0.03	0.00	0.00	0.03
OFD	Foodprod_nec	0.00	0.00	0.03	0.00	0.01	0.06
B_T	Bev_tobacco	-0.01	0.00	0.06	0.00	0.01	0.08
TEX	Textiles	-0.01	-0.01	0.11	0.00	0.04	0.35
WAP	Apparel	-0.01	-0.01	0.12	0.00	0.04	0.33
LEA	Leather	-0.01	0.02	0.15	0.00	0.03	0.27
LUM	Wood_prod	-0.01	-0.01	0.07	0.00	0.02	0.08
PPP	Paper_prod	-0.01	0.00	0.08	0.00	0.03	0.20
CRP	Chemical_pla	-0.01	0.01	0.07	0.00	0.03	0.15
NMM	Minprod_nec	-0.01	0.00	0.06	0.00	0.02	0.12
I_S	Ferrous_met	-0.01	0.01	0.10	0.00	0.02	0.10
NFM	Metals_Nec	-0.01	0.01	0.10	0.00	0.04	0.26
FMP	Metal_prods	-0.01	0.01	0.08	0.00	0.03	0.19
MVH	Motor_veh	-0.01	0.00	0.06	0.00	0.03	0.18
OTN	Trans_eq_nec	-0.01	0.00	0.07	0.00	0.03	0.18
ELE	Electronic	0.00	0.00	0.02	0.00	0.04	0.22
OME	Machine_nec	-0.01	-0.01	0.05	0.00	0.05	0.27
OMF	Manufact_nec	-0.01	0.00	0.04	0.00	0.01	0.07
SRV	Services	0.00	0.01	0.07	0.00	0.02	0.14
ENE	Energy	-0.01	0.01	0.08	0.00	0.02	0.11

Source: Ow n elaboration.

Figure 21: Costa Rica and Nicaragua, human capital scenario, changes in wages w.r.t. baseline



labor supply is decreasing relative to high-skill supply. This supply effects produce a positive impact on the wages of low-skill relative to high-skill workers. In addition, both labor types are more efficient after the implementation of the human capital policies, and this creates the general increase in both wage types.

As mentioned before, the effects on production and consumption are present the medium term, when education levels and labor efficiency of the workforce improve. In the case of wages, a similar path is followed. In Costa Rica, low-skill workers start earning higher wages after a shorter period of time, compared to high-skill workers. Low-skill workers take advantage of better education and start working on better paid jobs, at the same time that labor demand is increasing due to economic growth.

With regard to prices changes, we observe a similar pattern than with the trade scenarios. Many agricultural goods prices are increasing relative to the rest of the economy and this increases the food expenditures for households. Thus, this effect can offset the positive poverty impact of higher low-skill wages.

In Table 22 we present the poverty results for the human capital scenario for Costa Rica. Here we observe that relative poverty is initially increasing in 2010, it is equal to the baseline value in 2020 and it decreases by 2030. Although the poverty reduction is less than 1%, it is expected that the increasing growth pattern of the human capital policies assures a steady decline of poverty over time, relative to the baseline scenario. In the case of absolute poverty, we see no changes until 2030 where there is a small reduction. The last scenario is analyzed in the following section.

Table 23 shows the poverty results for Nicaragua. In this case we observe that relative poverty experiences a slight increase in 2010 but then begins to decrease steadily after 2020. By 2030 relative poverty decreases more than 2% with respect to its baseline values. This decrease reflects the large wage rise produced by the skill upgrading of the working force. Moreover, these positive effects are also translated into changes in the absolute poverty level, which is reduced by more than 1%.

Even though the human capital policies are reducing poverty in both countries, the reductions are not consistent with the large increase in low-skill wages. To analyze this results we went deeper into the household income and expenditure information. There we found that negative savings –larger

Table 22: Costa Rica, headcount poverty values for human capital and integrated scenarios

	2004	2010	2020	2030
Baseline				
Relative poverty	19.6%	17.4%	16.2%	15.4%
Absolute poverty	4.0%	6.0%	5.7%	5.7%
Human capital policies				
Relative poverty		17.6%	16.2%	14.6%
Absolute poverty		6.0%	5.7%	5.6%
Integrated: Trade and HK policies				
Relative poverty		17.5%	16.3%	14.7%
Absolute poverty		6.0%	5.8%	5.7%

Notes: Relative poverty is estimated with the $2 a day poverty line, while absolute poverty uses $1 a day.
Source: Own elaboration.

Table 23: Nicaragua, headcount poverty values for human capital and integrated scenarios

	2004	2010	2020	2030
Baseline				
Relative poverty	39.4%	35.6%	32.5%	30.2%
Absolute poverty	16.9%	17.5%	15.2%	13.0%
Human capital policies				
Relative poverty		35.7%	32.1%	27.9%
Absolute poverty		17.5%	15.1%	11.7%
Integrated: Trade and HK policies				
Relative poverty		36.4%	32.4%	27.8%
Absolute poverty		17.6%	15.3%	11.7%

Notes: Relative poverty is estimated with the $2 a day poverty line, while absolute poverty uses $1 a day.
Source: Own elaboration.

expenditures than income– is a serious issue of the data. In general, we expect that some households have temporary higher expenses than income and that this is reflected in one-year period covered by the surveys. This gap can be financed through formal and informal sources and it is reflected in a positive debt for that particular household. It can also be financed by using past periods savings.

However, we observe abnormally high levels of negative savings, specially for Nicaragua. There we find that 36% of the population has negative savings. The corresponding value for Costa Rica is 18%. Another feature is that these negative savings are clustered prominently in lower income household. This is something that can also be expected given that these households have higher probabilities of insufficient income to cover current expenses. However, the concentration is very pronounced in Nicaragua. For instance, 75% of the people with negative savings are below the 50th income percentile, while 21% are in the lowest 10th income percentile. Figure 22 shows the distribution of savings for the upper half of the population when sorted by income levels. We observe that the large proportion of these households have no savings or slightly positive savings.

With 36% of households having negative savings, this means that most of these households are below the 50th income percentile. For instance, Figure 23 presents the distribution of savings among the household with incomes below the 10th percentile. It is clear from the graph that most of these extremely poor households have negative savings. Moreover, some households have abnormally large savings, if we compare it to the $1 a day poverty line.

Figure 22: Nicaragua, distribution of savings for households above the 50th income percentile

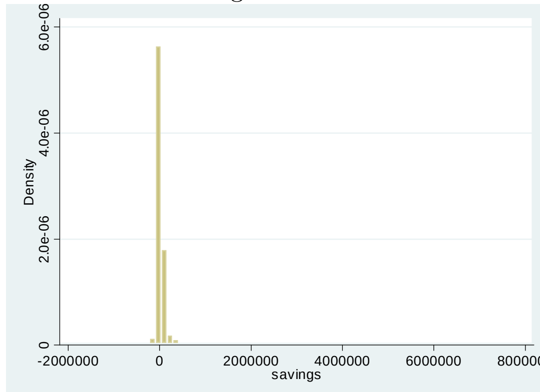
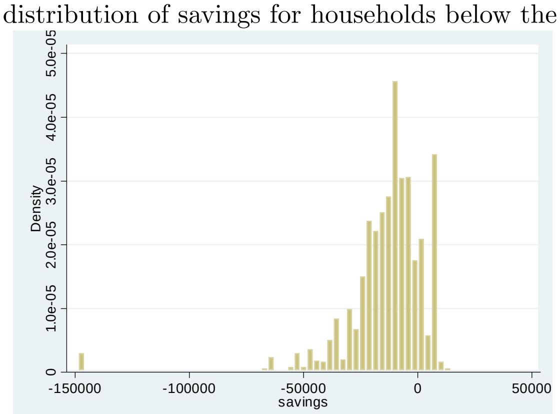


Figure 23: Nicaragua, distribution of savings for households below the 10th income percentile

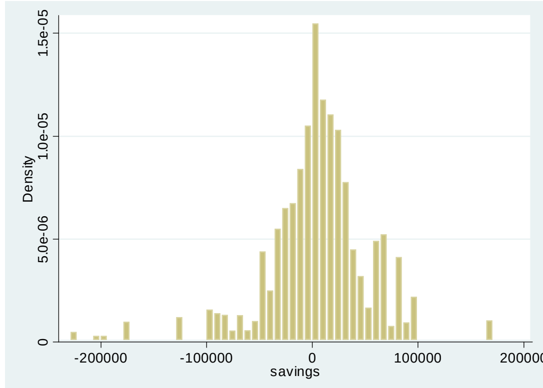


A partial explanation of these results is that the Nicaraguan survey is under-valuing the amount of foreign remittances to poor households. In our estimations of income composition in Figure 3 all transfers represent around 10% of income for the poorer households. However, in the study by the World Bank (2008) they estimate that remittances alone represent 22% of total income for the poorest 10% of household. Thus, part of these negative savings can be explained by missing remittances in the survey data.

Another explanation is that other income sources are being omitted. In particular, since low-skill wages represent more than 70% of income for the poorest households, is likely that this income source is also undervalued.

In any case, the very low levels of income for poor households in Nicaragua significantly weakens the link between higher wages and higher incomes. In the case of Costa Rica we have a similar difficulty, but here the negative savings is less pronounced. Less than 20% of the population have negative savings and this is not as concentrate on the poorer families as in Nicaragua. For instance, Figure 24 shows the distribution of savings among the poorest 10% of the population.

Figure 24: Costa Rica, distribution of savings for households below the 10th income percentile



We observe that the distribution is center around a zero-savings values, with a slightly majority of these poor households having positive savings. This results mimic the distribution of the whole population, with a large concentration of savings around zero.

4.6 Integrated approach: Complementary effects of trade and human capital policies

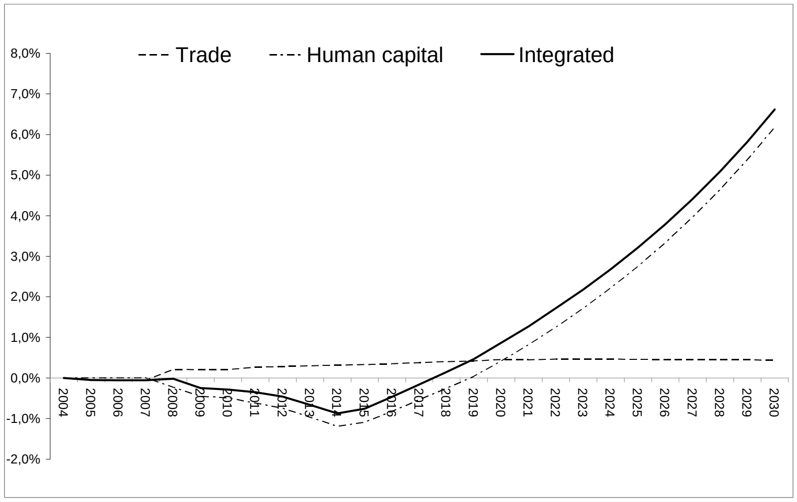
In this section we link the CGE model results, the top-down estimations and the human satellite model to evaluate the interactions and complementarities of trade and human capital policies. Using this integrated approach we can analyze the joint effects of trade and human capital policies on macroeconomic variables and poverty.

The main question we want to answer is: Does implementing both sets of policies jointly have a larger effect than applying them separately? We already now from the previous sections that consumption, production and wages are increasing when trade liberalization policies and human capital policies are implemented. With respect to poverty, we have that poverty is decreasing after upgrading human capital, but remains almost unchanged after the trade shocks. In what follows we analyze these variables again when both policies are simulated.

We start with production. Figure 25 plots the changes in production (GDP) with respect to the baseline for three scenarios for Costa Rica. The trade scenario refers to the implementation of all the trade shocks: ATC-protocol, DR-CAFTA and EU-CAAA. This is, the trade scenario corresponds to the EU-CAAA scenario where all these trade shocks are simulated sequentially. The human capital scenario is the simulation where we incorporate the three human capital targets: increased primary and secondary completion rates and higher quality of education. Finally, the integrated scenario is when we apply both trade and human capital policies simultaneously.

A first observation is that the impact of human capital policies are far more important that the effect from FTAs. This is determined by the labour efficiency increases in human capital, which produce an endogenous growth process that is changing the baseline growth rates in about 0.6%. On the other hand, trade liberalization is associated with the reduction in import tariffs and quotas, which produce only a one time efficiency shock, but are not associated with any changes in efficiency growth rates.

Figure 25: Costa Rica, GDP changes w.r.t. baseline for selected scenarios



Thus, we see that the trade shocks produce a scale increase in baseline production of about 0.5%. This does not mean that trade policies are less important in increasing GDP growth than human capital policies. In particular, our results are a reflection of the modeling strategy we used, where we do not have dynamic effects associated with trade shocks.

It is worth mentioning that trade policy can have important dynamic effects. These dynamic effects can be associated with different sources related to trade. For instance, investment growth through larger flows of FDI is regarded as one of the main dynamic effects associated with trade liberalization. In addition, there are productivity changes associated with the import of more and better intermediate inputs. Productivity can also increase when increased trade and capital flows promote technological transfers embedded in intermediate inputs or in FDI. Trade can also. increase internal market competition.

However, even when many of the economy-wide effects of trade policy are dynamic in nature, these mechanisms are very hard to incorporate into a CGE framework. As explained before, it is difficult to incorporate changes in FDI inflows without a fully dynamic optimization process where agents are maximizing over time consumption and savings. Moreover, there is not enough empirical evidence to link increased trade volumes with productivity changes that can alter the baseline growth rates.[33]

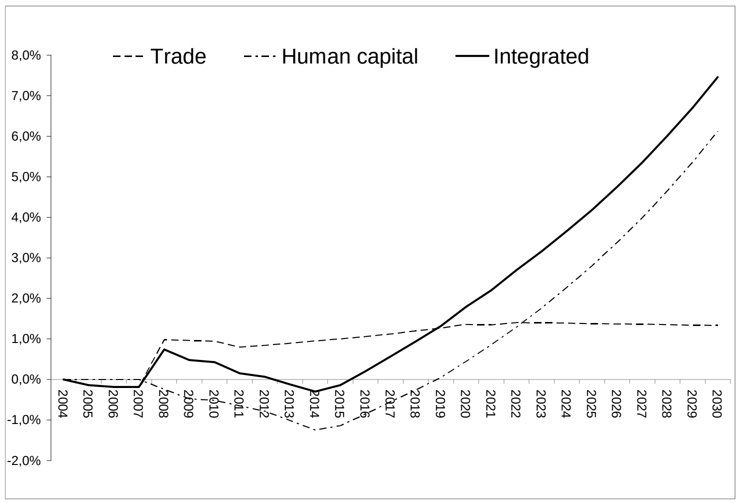
Given these limitation, our CGE model is accounting only for static efficiency effects. The main efficiency impact is the improvement in the allocation of resources after the import tariff and quota reductions. Therefore, our estimates can be regarded as the lower-bound impact of FTAs. Even when the magnitude of the FTAs effects with respect to the educational policies is small, they still represent a positive change in GDP.

Regarding human capital policies, the results for Costa Rica are consistent with recent studies that find a strong correlation between human capital investments, productivity and economic growth (Jiménez *et al.*, 2009).

[33] Cross-country estimates of trade and growth indicate that there is a strong link between trade, more investment and growth (Helpman, 2004). However, Rodríguez and Rodrik (2001) have critisized the empirical studies that associate trade with growth. They argue that these studies do not properly isolate the effects of trade liberalization from other policy changes.

Turning back to our main question. There are no complementary effects in production between trade and human capital policies. In other words, the increases in GDP attained separately with both sets of policies are the same as when both policies are jointly implemented. For the case of consumption we do observe some positive complementarity effects, but they are small and represent an increase of 0.1% . In Figure 26 we have plot the changes in consumption for Costa Rica and we observe the same pattern as for GDP.

Figure 26: Costa Rica, consumption changes w.r.t. baseline for selected scenarios



With respect of sectoral production changes, Table 4 in the Appendix shows that the integrated scenario is producing an acceleration in the agricultural decline in Costa Rica with production increasing in both manufacturing and services.

When we analyze wages we find that there are no complementarity effects for low-skill wages (see Figure 27), but we do observe a large complementarity effect for high-skill wages. In Figure 28 we observe that high-skill wages are declining for the trade scenario and increasing in the human capital scenario, but in the integrated scenario wages are even slightly higher than in the human capital scenario, reflecting a complementarity effect of almost 2 percentage points. This means that the implementation of human capital policies completely offsets the wage losses associated with the trade shocks and even have a higher effect than when only the education changes are simulated. This is a remarkable result and points to an important interaction of both policy sets for high-skill workers and those productive sectors that use relatively more of this factor.

Finally, for the case of poverty we do not observe any complementarity effects either. In the trade scenario we have an increase in relative poverty of 0.1% with respect to the baseline (see Table 19). For the human capital scenario we have a relative poverty decrease of 0.8% (see Table 22), while in the integrated scenario relative poverty is decreasing by 0.7% (see Table 22). Thus, both effects are the same for the separate and the joint simulations. This is the case also for absolute poverty.

For Nicaragua we perform the same analysis starting with production. In Figure 29 we observe the same relation between a static efficiency effect of the trade shocks and a dynamic efficiency impact of

Figure 27: Costa Rica, low-skill wage changes w.r.t. baseline for selected scenarios

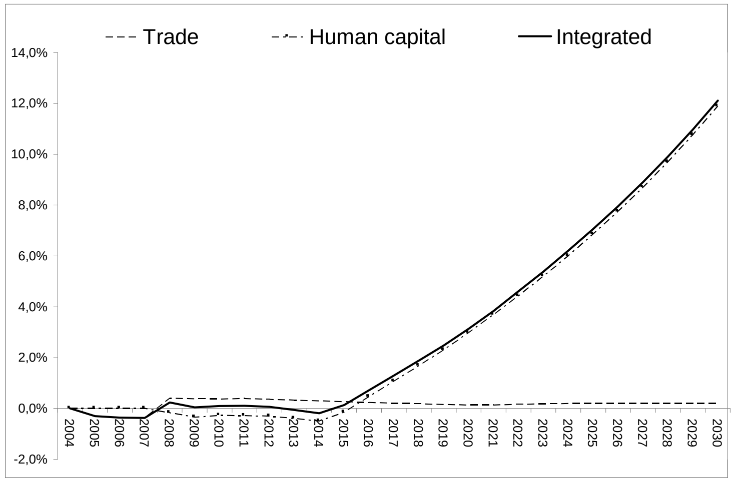
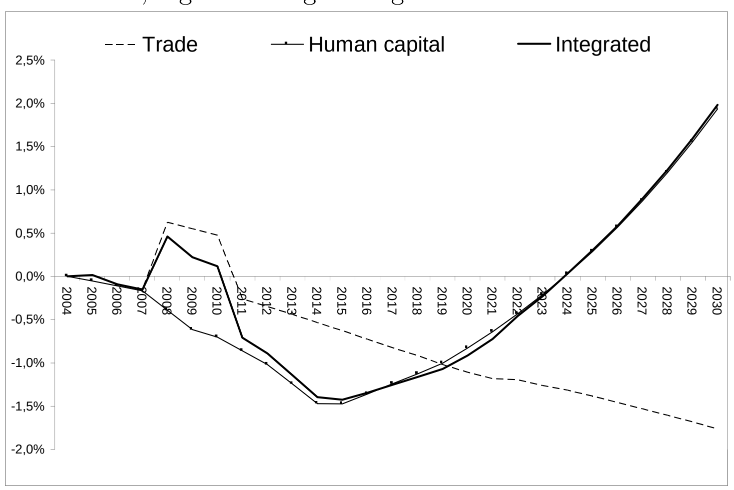


Figure 28: Costa Rica, high-skill wage changes w.r.t. baseline for selected scenarios

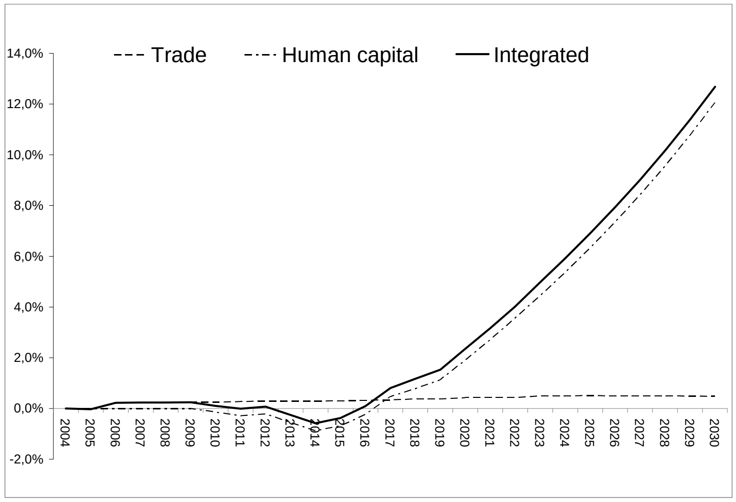


the human capital policies on GDP. Yet, the upgrading of skills through educational policies in the human capital scenario produces a shift in the growth rate from around 3.6% in the baseline, to 4.6% . This is 1% increase is much larger than for Costa Rica (0.6%) and reflects that the initial lower levels of human capital in Nicaragua provide much opportunities for improvement. Moreover, for Nicaragua we do have a small complementarity effect of 0.2%. For consumption (not reported) we find again the same pattern by with no complementarity effect.

Sectoral production changes for Nicaragua in the integrated scenario are shown in Table 4 of the Appendix. We observe that the pattern of overall production increase is also present with this scenario, where all sectors are increasing but manufacturing is growing faster than the rest of the economy.

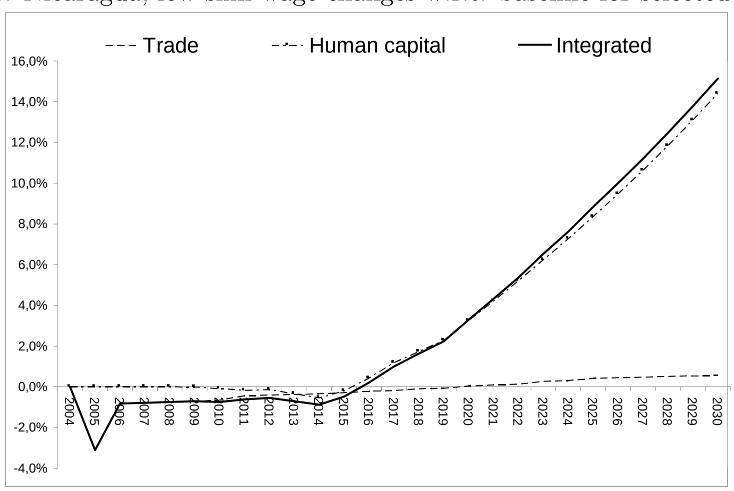
When we analyze wages in Figures 30 and 31 we find very similar results as for production and consumption. However, for low-skill wages we find a small negative complementarity effect of -0.2%,while for high-skill wages the complementarity effect is positive but again relatively small at 0.2%.In the case

Figure 29: Nicaragua, GDP changes w.r.t. baseline for selected scenarios



of low-skill wages, the decrease is comparatively smaller since wages in 2030 are increasing by more than 14% in the integrated scenario. This is double the effect than for high-skill wages.

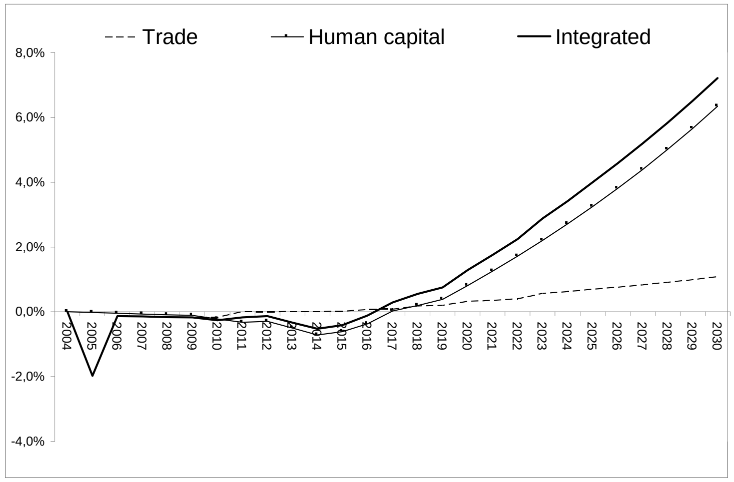
Figure 30: Nicaragua, low-skill wage changes w.r.t. baseline for selected scenarios



Finally, we analyze the complementarity effects for poverty in Nicaragua. Using the information on poverty changes by scenario from Tables 20 and 23 we find that there is a small negative complementarity effect of -0.2% for relative poverty. In particular, relative poverty is falling by 0.3% after the trade shocks and is further decreasing by 2.3% after the educational policy shock, however, the integrated scenario reports a relative poverty decrease of 2.4%.In other words. For the case of absolute poverty there is a zero complementarity effect.

To sum up this section, we find that the answer to our main question is that there are positive but small complementarity effects. The only exception is the positive and large complementarity effect for

Figure 31: Nicaragua, high-skill wage changes w.r.t. baseline for selected scenarios



high-skill wages for Costa Rica. These wages where decreasing as a result of the trade shocks, but when human capital policies where introduced the tendency was completely reversed and high-skill wages where increasing, even slightly more than with the human capital scenario.

The lack of strong complementarity effects in most of our main variables can be a result of comparing two different policy shocks. Human capital policies have a dynamic efficiency effect, while trade policies only a static efficiency impact. Another explanation can be related to the setup of the CGE model. The initial input-ouput coefficients in the economy are set fixed in the base year and thus, the production technology in each sector is also fixed. This means that changes in the quantity and quality of the production factors are reflected in sectoral production and trade changes, but not in how each sectors combines the different factors. In a setting where the production technology is changing a human capital upgrade can result in different input-output coefficients that alter the patterns of production and trade. This effects are not present in CGE models.

5 Conclusions and policy recommendations

The impact on poverty is given by three different mechanisms: a) changes in goods and factor prices through the FTAs, which affect the income and expenditure of households; b) direct changes of education policy on employment and wages; and c) the complementarities between trade and education policies.

With respect to the trade liberalization policies, the general results from our simulations show that DR-CAFTA has stronger effects on production, consumption, and poverty than EU-CAAA. In addition, the EU-CAAA results in more significant macroeconomic improvements for Costa Rica, since this country has higher trade flows with the European Union than Nicaragua. However, the impact of both FTAs yields only a static efficiency improvement that translates into a one-off increase in the baseline levels of consumption and production.

The main driver of economic growth in the analysis is provided by the upgrading of human capital through educational policies. These policies result in an endogenous growth process where the growth rate is increased by around 0.6% in Costa Rica and 1% in Nicaragua when compared to the baseline growth rates for both countries. Thus, both Costa Rica and Nicaragua experience higher growth and welfare effects when labor efficiency improves through human capital policies. In a first stage, low and high-skill workers receive lower salaries (compared to baseline levels) but when these initial opportunity costs are taken and the human capital accumulation process starts, wages begin to grow steadily. Under these circumstances, the long run impact of human capital policies continues beyond 2030 –our simulations final year– and we can expect that poverty reduction also follow a steady decline over time.

As a consequence of the different growth patterns produced by both policies, poverty impacts of FTAs are positive, but small. Human capital policies, on the other hand, yield stronger poverty reductions. Therefore, the poverty reduction we observe in our integrated scenario –where both trade and educational policies interact– is a direct outcome of human capital improvements in both countries. Much of this outcome derives from low-skill wages growth. High-skill labor and other production factors also experience a sizeable increase, but these factors are much less important as an income source for poor households.

Finally, poverty and other macroeconomic variables do present positive but relatively small complementarity effects when both trade and educational policies are implemented jointly. The only exception being the high-skill wages in Costa Rica, where educational policies completely offset the negative impact caused by the trade shocks. A possible explanation for this lack of stronger policy complementarity is that the magnitude of the human capital shocks are completely dominating the much lower trade effects. In a framework where both sets of policies have dynamic effects on growth rates we expect the results to be different.

Two main policy implications result from our analysis. First, in our study, we show that human capital accumulation is crucial in the process of economic growth and poverty reduction. Therefore, improvements in education should be part of an integrated approach for development policy design. Human capital investments, moreover, should be a policy priority, irrespective of its interactions with other public policies. However, the downturn from human capital policies is that they are a long-term investment. The initial opportunity costs associated with students staying longer in school outweigh the economic benefits in the short run. This can create problems in a political economy setting where the policymaker is confronted with several investment choices with different short and long term returns, but worries only for her short-term electoral performance.

For instance,. Jiménez *et al.* (2009) argue that human capital formation in Costa Rica was severely affected from the economic crises of 1980-82. The recovery of human capital investments levels took almost two decades after that negative shock. They conclude that economic growth in the following years depends on more investments in education, since total factor productivity growth in the last two decades has been mainly driven more by capital and labor accumulation (growth of labor units) than human capital accumulation.

In the case of Nicaragua, the World Bank (2008) argues that education investments are a key condition to improve labor productivity and enhance growth. They find that job creation and higher wages can improve living conditions and development opportunities, particularly for the poorest households. These potential medium and long term impacts of education investments on economic returns imply that policy efforts should be prioritized. Guevara (2004) argues that education investments require a sustained effort, if the current state of human capital in Nicaragua is to be effectively improved.

Therefore, Costa Rica and Nicaragua should strengthen education policies in order to create conditions for growth and poverty reduction. Education policies should be one of the highest priorities in both countries. The results from our satellite model and CGE model clearly state that the quantity and (most importantly) the quality of education matters crucially for economic growth.

Secondly, we find that FTAs are having a positive impact on production and consumption, and on a lower extent, on poverty reduction. These positive results can be considered as a lower-bound of possible trade effects, since we are not considering the dynamic effects from trade that can foster economic growth in the lung run. In this context, the attraction of FDI, for instance, and competitiveness enhancing policies (i.e. through technology improvements and infrastructure modernization) are a critical conditions to achieve these dynamic efficiency benefits.

For Costa Rica and Nicaragua, FTAs represents a series of opportunities that can be exploited, but also a series of critical challenges. Given the importance of US and EU trade and investment in the region, in addition to the huge size differences between countries and regions, the agreements will have significant sectoral and economy-wide effects.

A key factor will be the scope and depth of the complementary policies associated with FTAs implementation. For instance, after analyzing the Mexican experience with NAFTA, Lederman *et al.* (2005) conclude that FTAs offer great opportunities for Latin American countries, but without complementary policies, there is no guarantee that the agreements can increase growth. Thus, the full potential of trade liberalization depends on complementary policies, when we take complementary policies in a broad sense and define them as productivity enhancing policies. Competitiveness is built upon the productivity of the leading firms and industries within the economy.

Education is regarded by the World Economic Forum as one of the pillars of competitiveness, together with infrastructure, macroeconomic stability, technological readiness, and innovation, among other drivers of growth. These pillars are key determinants of productivity growth. Trade policy effectiveness depends on the country conditions in those areas. Education is certainly a key component of the growth equation. Schwab and i Martin (2009) indicate that education in Costa Rica is a competitive advantage, but requires more educational investments in order to catch up with leading innovation-driven economies. Meanwhile Nicaragua has made advances with primary education coverage, but the quality of education and enrollment rates in secondary and tertiary education represent competitive disadvantages that limit growth.

The governments of both countries have a role in adjusting policy to improve the countries' ability to compete and benefit from trade liberalization. The main concern in this respect, is the absence of long-term development strategies in Costa Rica and Nicaragua. In some way, FTAs have been seen as "substitutes" of such strategies. The key point is how governments create and implement a competitiveness enhancing long term strategy. This requires more investment in human capital. Integrated with FTAs, human capital accumulation are both growth engines that can create new development opportunities.

Costa Rica and Nicaragua can expect positive and lasting benefits from both FTAs, but these benefits can be multiplied if both countries can put in place the infrastructure, human capital, and institutional capacity necessary to participate successfully in world markets. DR-CAFTA and EU-CAAA establish a clear direction and powerful driver for leaders and policy makers to make much-needed political and financial investments toward truly competitive and successful societies.

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6 Appendix

Table A 1: GTAP sectors and own sectoral aggregation

	GTAP Code	GTAP Description	Own Code	Own aggregation
1	PDR	Paddy rice	PDR	Paddy rice
2	WHT	Wheat	WHT	Wheat
3	GRO	Cereal grains nec	GRO	Cereal grains nec
4	V_F	Vegetables, fruit, nuts	V_F	Vegetables, fruit, nuts
5	OSD	Oil seeds	OSD	Oil seeds
6	C_B	Sugar cane, sugar beet	C_B	Sugar cane, sugar beet
7	PFB	Plant-based fibers	PFB	Plant-based fibers
8	OCR	Crops nec	OCR	Crops nec
9	CTL	Bovine cattle, sheep and goats, horses	CTL	Bovine cattle, sheep and goats, horses
10	OAP	Animal products nec	OAP	Animal products nec
11	RMK	Raw milk	RMK	Raw milk
12	WOL	Wool, silk-worm cocoons	WOL	Wool, silk-worm cocoons
13	FRS	Forestry	FRS	Forestry
14	FSH	Fishing	FSH	Fishing
15	COA	Coal	ENE	Energy
16	OIL	Oil	ENE	Energy
17	GAS	Gas	ENE	Energy
18	OMN	Minerals nec	OMN	Minerals nec
19	CMT	Bovine meat products	CMT	Bovine meat products
20	OMT	Meat products nec	OMT	Meat products nec
21	VOL	Vegetable oils and fats	VOL	Vegetable oils and fats
22	MIL	Dairy products	MIL	Dairy products
23	PCR	Processed rice	PCR	Processed rice
24	SGR	Sugar	SGR	Sugar
25	OFD	Food products nec	OFD	Food products nec
26	B_T	Beverages and tobacco products	B_T	Beverages and tobacco products
27	TEX	Textiles	TEX	Textiles
28	WAP	Wearing apparel	WAP	Wearing apparel
29	LEA	Leather products	LEA	Leather products
30	LUM	Wood products	LUM	Wood products
31	PPP	Paper products, publishing	PPP	Paper products, publishing
32	P_C	Petroleum, coal products	ENE	Energy
33	CRP	Chemical, rubber, plastic products	CRP	Chemical, rubber, plastic products
34	NMM	Mineral products nec	NMM	Mineral products nec
35	I_S	Ferrous metals	I_S	Ferrous metals
36	NFM	Metals nec	NFM	Metals nec
37	FMP	Metal products	FMP	Metal products
38	MVH	Motor vehicles and parts	MVH	Motor vehicles and parts
39	OTN	Transport equipment nec	OTN	Transport equipment nec
40	ELE	Electronic equipment	ELE	Electronic equipment
41	OME	Machinery and equipment nec	OME	Machinery and equipment nec
42	OMF	Manufactures nec	OMF	Manufactures nec
43	ELY	Electricity	SRV	Services
44	GDT	Gas manufacture, distribution	SRV	Services
45	WTR	Water	SRV	Services
46	CNS	Construction	SRV	Services
47	TRD	Trade	SRV	Services
48	OTP	Transport nec	SRV	Services
49	WTP	Water transport	SRV	Services
50	ATP	Air transport	SRV	Services
51	CMN	Communication	SRV	Services
52	OFI	Financial services nec	SRV	Services
53	ISR	Insurance	SRV	Services
54	OBS	Business services nec	SRV	Services
55	ROS	Recreational and other services	SRV	Services
56	OSG	Public Administration, Defense, Education, He	SRV	Services
57	DWE	Dwellings	SRV	Services

Table A 2: Costa Rica, alternative poverty measures for all scenarios

	2004		2010		2020		2030	
FGT index:	**A=1**	**A=2**	**A=1**	**A=2**	**A=1**	**A=2**	**A=1**	**A=2**
Baseline								
Relative poverty	6.4%	3.0%	6.9%	4.0%	6.6%	4.0%	6.6%	4.7%
Absolute poverty	1.3%	0.6%	2.4%	1.5%	2.4%	2.0%	2.7%	4.3%
ATC-Protocol								
Relative poverty			6.9%	4.0%	6.6%	4.0%	6.6%	4.7%
Absolute poverty			2.4%	1.5%	2.4%	2.0%	2.7%	4.4%
DR-CAFTA								
Relative poverty			6.9%	4.0%	6.5%	4.0%	6.5%	4.7%
Absolute poverty			2.4%	1.5%	2.4%	2.1%	2.7%	4.4%
EU-CAAA								
Relative poverty			6.9%	4.0%	6.6%	4.2%	6.7%	5.1%
Absolute poverty			2.4%	1.5%	2.5%	2.5%	2.8%	5.6%
Human capital policies								
Relative poverty			6.9%	4.0%	6.6%	4.0%	6.3%	4.6%
Absolute poverty			2.4%	1.5%	2.4%	2.0%	2.6%	4.6%
Integrated: Trade and HK policies								
Relative poverty			6.9%	4.0%	6.6%	4.2%	6.4%	5.1%
Absolute poverty			2.4%	1.5%	2.5%	2.4%	2.8%	6.0%

Notes: Relative poverty is estimated with the $2 a day poverty line, while absolute poverty uses $1 a day.
The trade scenarios are sequential: DR-CAFTA includes ATC protocol and EU-CAAA includes all.
Source: Own elaboration.

Table A 3: Nicaragua, alternative poverty measures for all scenarios

	2004		2010		2020		2030	
FGT index:	**A=1**	**A=2**	**A=1**	**A=2**	**A=1**	**A=2**	**A=1**	**A=2**
Baseline								
Relative poverty	15.8%	8.3%	15.6%	9.2%	14.0%	8.1%	12.7%	7.2%
Absolute poverty	5.2%	2.4%	6.5%	3.8%	5.6%	3.2%	4.9%	2.8%
ATC-Protocol								
Relative poverty			16.5%	9.7%	14.6%	8.5%	13.0%	7.4%
Absolute poverty			7.0%	4.0%	5.9%	3.4%	5.1%	2.9%
DR-CAFTA								
Relative poverty			15.9%	9.3%	14.1%	8.1%	12.6%	7.2%
Absolute poverty			6.7%	3.8%	5.7%	3.2%	4.8%	2.8%
EU-CAAA								
Relative poverty			15.9%	9.3%	14.1%	8.1%	12.6%	7.2%
Absolute poverty			6.7%	3.8%	5.6%	3.2%	4.8%	2.8%
Human capital policies								
Relative poverty			15.7%	9.2%	13.8%	8.0%	11.6%	6.6%
Absolute poverty			6.5%	3.8%	5.5%	3.2%	4.5%	2.6%
Integrated: Trade and HK policies								
Relative poverty			15.9%	9.3%	13.9%	8.0%	11.5%	6.5%
Absolute poverty			6.7%	3.8%	5.6%	3.2%	4.4%	2.6%

Notes: Relative poverty is estimated with the $2 a day poverty line, while absolute poverty uses $1 a day.
The trade scenarios are sequential: DR-CAFTA includes ATC protocol and EU-CAAA includes all.
Source: Own elaboration.

Table A 4: Integrated trade and human capital scenario, sectoral production changes w.r.t. baseline

Code	Sector	Costa Rica 2010	Costa Rica 2020	Costa Rica 2030	Nicaragua 2010	Nicaragua 2020	Nicaragua 2030
PDR	Paddy_rice	-0.01	-0.05	-0.06	-0.04	-0.10	-0.12
WHT	Wheat	0.00	-0.14	-0.11	0.01	0.03	0.04
GRO	Other_cereal	-0.01	-0.04	-0.06	-0.01	0.01	0.04
V_F	Veg_fruits	0.00	0.06	0.04	-0.01	0.00	0.02
OSD	Oil_seeds	0.00	-0.04	-0.02	0.29	0.22	0.17
C_B	Sugar_cane	-0.01	0.00	0.03	0.01	0.01	0.04
PFB	Plant_fibers	-0.01	-0.03	-0.02	0.01	0.01	0.05
OCR	Crops_nec	-0.01	-0.04	-0.03	0.00	0.00	0.00
CTL	Cattle	0.00	-0.01	0.02	-0.01	0.00	0.02
OAP	Animprod_nec	0.00	-0.02	-0.01	-0.02	0.00	0.03
RMK	Raw_milk	0.09	0.05	0.05	0.04	0.03	0.05
WOL	Wool	0.03	0.02	0.03	-0.16	-0.09	0.17
FRS	Forestry	-0.01	0.01	0.00	0.00	0.01	0.02
FSH	Fishing	0.00	0.00	0.00	0.01	0.00	0.00
OMN	Minerals_nec	0.01	0.01	0.00	0.00	0.00	0.00
CMT	Meat	0.00	0.00	0.02	0.03	0.02	0.01
OMT	Meatprod_nec	-0.01	-0.02	-0.03	0.00	0.00	0.03
VOL	Veg_oils	-0.01	0.00	0.07	-0.14	-0.12	-0.07
MIL	Dairy	0.11	0.06	0.07	0.13	0.08	0.02
PCR	Proc_rice	-0.01	-0.01	0.05	-0.12	-0.07	0.00
SGR	Sugar	-0.01	0.00	0.03	0.01	0.01	0.04
OFD	Foodprod_nec	-0.01	0.01	0.04	0.01	0.05	0.12
B_T	Bev_tobacco	0.01	0.01	0.06	0.01	0.02	0.08
TEX	Textiles	-0.07	-0.04	0.08	0.46	0.49	0.88
WAP	Apparel	-0.36	-0.30	-0.18	-0.42	-0.35	-0.10
LEA	Leather	0.06	0.16	0.33	-0.03	0.01	0.25
LUM	Wood_prod	-0.07	-0.07	-0.01	-0.02	-0.01	0.06
PPP	Paper_prod	-0.02	0.01	0.09	0.03	0.04	0.21
CRP	Chemical_pla	-0.01	0.03	0.10	0.02	0.03	0.16
NMM	Minprod_nec	0.00	0.01	0.07	0.03	0.03	0.13
I_S	Ferrous_met	0.04	0.07	0.16	0.05	0.06	0.13
NFM	Metals_Nec	0.03	0.04	0.15	0.12	0.17	0.38
FMP	Metal_prods	0.00	0.02	0.10	0.04	0.06	0.21
MVH	Motor_veh	-0.01	0.00	0.07	0.03	0.04	0.19
OTN	Trans_eq_nec	0.08	0.09	0.15	0.05	0.07	0.21
ELE	Electronic	0.00	-0.19	-0.16	0.00	0.03	0.20
OME	Machine_nec	0.24	0.30	0.34	0.33	0.35	0.58
OMF	Manufact_nec	0.01	0.02	0.05	-0.03	-0.01	0.05
SRV	Services	-0.01	0.01	0.08	0.01	0.03	0.15
ENE	Energy	-0.04	-0.01	0.06	0.02	0.03	0.11

Source: Ow n elaboration.