Pollution in Small Island Developing States: An overlapping generations model of the Caribbean economies

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Abstract

International development agencies argue that human capital accumulation and demographic dynamics are crucial elements to attain a sustainable economic development in a finite world. The question of economic development is particularly important for Caribbean Small Island Developing States (SIDS) which were defined, at the Earth summit held in Rio de Janeiro in 1992, as a group of developing countries facing specific social, economic and environmental vulnerabilities. We develop a simple overlapping generations model with migration and intergenerational transfers in an economy where production is responsible of pollution. In line with the literature on migration, we find a potential positive impact of remittances and migration on the economic development of these countries, under some conditions. However, if these conditions are not respected, then migration could lead to an economic disadvantage. Moreover since growth is responsible of pollution, there is an ambiguity on the migration's effect on pollution emissions. Finally, by means of a numerical analysis, we evaluate the economic results in three different Caribbean islands: Barbados, Jamaica as well as Trinidad and Tobago. We show, that these islands have different economic paths due to their human capital accumulation.

Keywords: Migration, Demographics, Overlapping Generations Model, Caribbean, Small Island Developing States

JEL classification: Q01, F24, J24

1. Introduction

Many intrinsically related determinants of welfare and development exist, including social and economic status, education, health, and physical and environmental exposures. Development agencies as the World Bank, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the United Nations Childrens Fund (UNICEF) and others have argued that human capital accumulation through, education and demographic transition could trigger sustainable economic development in a finite world (World Bank (2007), UNESCO, UNDP, UNFPA, UNHCR, UNIECF, UN Women, WB (2016), Bocquenet et al. (2016)). In order to draw qualitative conclusions regarding the impact of these socio-demographic variables on economic growth, researchers have built models including one or several aspects of the problem. In overlapping generations (OLG) models there is, on the one hand, a vast literature dealing with the link between economic growth and the demographic structure (Schoonbroodt and Tertilt (2014), Del Rey and Lopez-Garcia (2016), Cardia and Michel (2004), Docquier et al. (2007)). On the other hand, contributions by among others Constant et al. (2014), Jouvet et al. (2000), Pautrel (2009), Jouvet et al. (2010), Mariani et al. (2010), Aloi and Tournemaine (2011), examine the link between economic growth, demographic changes and environmental impacts. Therefore, it is widely acknowledged that to understand the roots of sustainable development in a finite world, it is useful, if not necessary, to study the interplay between economic activities, the environment, and the demography. These questions are especially important in Caribbean Small Islands Developing States (SIDS), where there are numerous physical constraints and economic backwardness.

Indeed, at the Earth summit held in Rio de Janeiro in 1992, the United Nations (UN) defined the Caribbean SIDS as a group of developing countries facing specific social, economic and environmental

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vulnerabilities (UN-OHRLLS (2015))[1]. With some exceptions, there is also a strong consensus in the literature on the economic vulnerability and the ecological fragility of SIDS, even compared to other developing states (Adrianto and Matsuda (2004), Guillaumont (2010), Guillaumont et al. (2009), van der Velde et al. (2007), Briguglio and Galea (2003), Briguglio et al. (2009), Briguglio (2003, 1998, 1995)). This results, among other things, from structural challenges such as their small size – which makes it difficult for them to achieve economies of scale in the production chain – and their limited availability of natural resources – which forces them to import most of the raw materials. Further, the remoteness and the insularity imply an extra cost for international trading. Finally, these economies are characterized by an increased vulnerability to extreme events and growing climate change effects. Because of these similar constraints in their development, these countries can be studied as a unique group, even if some of them are continental states such as Suriname or Guyana when others are non-independent states as Puerto Rico or the British Virgin Islands. Nevertheless, for the sake of homogeneity, we focus only on independant islands that have comparable characteristics regarding demography and economic structures. Tables 1 and 2 display the main characteristics in terms of demographic dynamics and economic growth of the selected islands.

The first part of our work is to link economic growth to demographic dynamics in Caribbean SIDS. Various features characterize these islands. First a rapid demographic transition, second a negative migratory sold and finally a strong heterogeneity in the scale of these phenomena in the different territories. The demographic transition in this area started soon after the movement of independence in the 1960s. The mean number of children per woman in the Caribbean area decreased from 5.3 in 1960 to 2.83 in 1990, and it is now at 2.4. Over the same period, the life expectancy at birth in the area increased from 52 years to 67.7 years, reaching 72.4 in 2010. According to Guzmán et al. (2006), demographic transition will represent an economic opportunity for the area, thanks to the increase in the productive capital per person. The migratory sold is negative in most of the islands (-3.51 in 2012 in Jamaica for example) and it can be seen as a positive thing since it amplifies the effect of the demographic transition and leads to others economic advantages (e.g. remittances). However the emigration tends to decrease over time while immigration from the diaspora increases (United nations, Department of Economic and Social Affairs (2015)), which means than on the one hand in some countries the migration effects tend to decrease, and on the other hand it remains an important feature.

Several authors such as Connell and Conway (2000) or Thomas-Hope (1992) study the impact of migration and remittances or return migration, in particular in the island economies. There is a debate on the effect of migration for the developing economies. First, contributions, by among others Beine et al. (2006) or Docquier et al. (2008), defend the idea that brain drain and migration in general could enhance economic development through an increase of the mean human capital in the domestic country. In fact, individuals migrate to build up their revenues, knowing that the probability of migration is higher for skilled individuals, the possibility of migration create an incentive to educate. Then if the proportion of new skilled individuals staying in the domestic country – because of the barriers to migration (e.g. cost or procedures) – is large enough, the mean level of human capital increases. Second, return migration, i.e. the movement of immigrants back to their countries of origin, constitutes another source of gain from migration for the domestic countries, because of the induced cash flows from the rest of the world. Finally, another channel which migration can enhance economic development are remittances, defined as transfers of money between migrants and their family in the domestic area. These cash transfers can promote economic growth especially if they are used to increase the investments in human capital through an informal loan between family members (Poirine (1997)) or the capital stock with important savings in the domestic country (Osili (2007)). However, most of the time, remittances and return migration are used to fund consumption and then unproductive investments. Therefore, according to some economists, it is not possible to rely on them to trigger the economic development of a country. These economists have developed many pejorative labels to qualify insular economies such as "Remittances societies" (Frucht (1968), Hill (1977)). Besides, two other empirical studies focus on the impact of remittances in the independent states of the Caribbean and both of them conclude that this kind of transfer does not

[1]There are 23 countries or territories in this group: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, British Virgin Islands, Cuba, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Montserrat, Netherlands Antilles, Puerto Rico, Saint-Kitts and Nevis, Saint-Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago and United States Virgin Islands.

impact long-term growth but long term consumption (Mishra (2006), Lim and Simmons (2015)). One should finally note that in these developing states, family solidarity is an important characteristic and can replace the access to credits through cash flows that help to finance education or consumption during old age. Moreover, solidarity can take the form of an accorded time to long term care for example (Mizushima (2009)). Although, even if migration decreases in some islands as Trinidad and Tobago, intergenerational transfers can still occur and matter in the understanding of saving decisions, education choices and natality.

Countries	**Natural Balance**[a] (total per 1000 pop.)			**Migratory sold** (percent)		
	1972	1992	2012	1972	1992	2012
CSS[b]	24,07	16,92	9,71	-5,78	-4,13	-1,78
A&B[c]	20,38	11,8	10,41	-4,28	4,13	-0,06
Bahamas	20,16	17,97	9,45	0,5	-0,15	2,6
Barbados	10,49	6,04	1,84	-2,25	-1,24	0,77
Cuba	20,37	8,73	3,01	-2,11	-1,12	-0,71
Dom. Rep.[d]	29,98	22,74	15,51	-1,49	-1,93	-1,51
Haiti	21,24	23,31	16,82	-1,8	-1,9	-1,46
Jamaica	26,06	17,77	10,88	-5,35	-4,54	-3,51
St-V& G.[e]	30,26	17,37	9,53	-9,51	-8,04	-4,57
St. Lucia	28,93	19,74	8,71	-9,06	-3,39	0,02
T& T.[f]	19,15	11,01	5,64	-3,03	-2,58	-0,37
USA[g]	6,2	7,3	4,5	1,35	1,78	1,59
UK[h]	2,9	2,6	3,9	0,19	0,36	1,41
Spain	11,3	1,6	1,1	0,28	0,82	-1,27
France	5,6	3,9	3,9	1,52	0,52	0,5

Table 1: Caribbean SIDS: Demographic dynamics

Countries	**GDP per capita** (constant 2010 US$)			**Remittances** (Percent of GDP)	
	1972	1992	2012	1992	2012
CSS[b]	5972.94	5863.1	8892.13	2.32	5.31
A&B[c]	–	10902.73	13000.8	0.64	1.73
Bahamas	18437.73	20635.08	22029.97	–	–
Barbados	–	12405.21	15959.32	2.78	2.8
Cuba	2472.03	3289.24	6006.05	–	–
Dom. Rep.[d]	1895.35	2769.58	5630.94	3.07	7.03
Haiti	–	–	698.81	–	20.43
Jamaica	5383.15	4563.42	4827.01	6.11	14.65
St. V & G[e]	2318.68	3753.03	6290.22	0.73	4.49
St. Lucia	–	5636.93	6782.13	0.43	2.29
T&T[f]	7516.46	6522.32	16680.79	0.12	0.49
USA[g]	24760.15	36566.17	49481.16	0.03	0.04
UK[h]	19151.01	28245.08	39225.08	0.17	0.19
Spain	14978.69	23079.74	29414.99	0.42	0.16
France	21741.18	33271.13	41227.18	0.37	0.85

Table 2: Caribbean SIDS: GDP per capita
Source: World Development Indicators, World Bank

[a]Natural Balance is define as the number of births minus the number of deaths in a year
[b]Caribbean Small States
[c]Antigua and Barbuda
[d]Dominican Republic
[e]Saint-Vincent and the Grenadines
[f]Trinidad and Tobago
[g]United States of America
[h]United Kingdom

In the second part of our analysis we assess the economic development of Caribbean islands and the associated environmental issues. Indeed, these economies face several challenges related to catastrophic events, climate change and the preservation of endemic ecosystems. But there is more to include in our analysis because of the insularity and resource – and land – scarcity, which would require the efficient use of natural assets. It goes without saying that preserving natural resources from mismanagement and overuse is a daunting task for several reasons. First, in many developing countries, inefficient governance and informal dumping or recycling lead to inadequate environmental policies of waste management (Barton et al. (2008), Wilson et al. (2006), Thonart Philippe et al. (2005)). A review of this topic has been done by Mohee et al. (2015) for SIDS. Second, the close interaction between ecosystems implies that pollutants may easily travel through all the natural environment, ecosystems and vital stock of water. For example, the proximity of waste facilities and their lack of efficiency are directly responsible of soft water contamination and coasts degradation through anthropogenic seafloor debris. This pollution is a crucial issue for marine ecosystems, although they are important for tourism and represent one of the main assets of the area (Debrot et al. (2014)). Therefore, in addition to the health impact of pollution, production externalities may occur between sectors. Domestic waste is not the only source of pollution in the Caribbean. In fact agricultural use of pesticides and fertilizers were considered as the main local pollution source between 1980 and 2000 (Rawlins et al. (1998)). Even if the management of agricultural pollution has improved since the 1990s, the pollutants tend to accumulate in the sea (this is due to the oceanographic features of the Caribbean region), and are still impacting the health of the inhabitants (Ross and de Lorenzo (1997)). The management of local pollution is then crucial to protect the environmental quality in this region. We are well aware of the importance of global environmental threats for these islands – especially the threats from the climate change effects – however, in this work we focus on the local emissions of pollution from domestic production which is a non negligible source of desutility.

All these stylized facts point to the necessity to describe these economies by giving a proper account of their demographic dynamics, economic characteristics, and environmental issues altogether. However, to the best of our knowledge, there is no work that analyzes economic growth and anthropogenic pollution while dealing with demographic dimension through migration and natality. The idea for this article arises from the need to fill this gap in the literature. To do so, we develop a two-stage approach. First, we build an OLG model of a closed-economy in order to study how domestic production and remittances impact growth and pollution. Though simple, this model provides us with some insights. On the one hand we highlight the usual trade-off between present and future consumption. On the other hand we show the conditions of the choice between savings, natality and education – in order to receive remittances from the next generation – to finance the consumption during old age. Depending on the expected return from the intergenerational transfers, parents do not make the same investments in education. Thus, in the line with Beine et al. (2006) or Docquier et al. (2008) we find a positive impact of migration on education investments, natality and then on human capital stock and production. However the consumption is exclusively produced by the local representative firm which is responsible of some emissions of pollution that create a desutility. Then two effects appear on the utility, first migration boosts consumption and thus utility, but at a cost of an increase of the pollution stock which is an externality. This last effect is diminished through the reduction of the population size induced by a higher migration. The effect of migration on utility is then ambiguous and is studied in the first part of our work.

Second, as an illustration of the model, we conduct a numerical analysis for three islands – Barbados, Jamaica as well as Trinidad and Tobago – and we introduce shocks to simulate an environmental policy or different migration intensities. This second part of our analysis is a preliminary work that allows us to test the model and the impact of the parameters on the results regarding the environmental impact. The idea here, is to confirm the tractability and the consistency of the model to study the Caribbean SIDS with regard to possible values for the parameters, and especially the environmental features.

The rest of this paper is structured as follows. In section 2 we describe the OLG model. Sections 3 and 4 highlight key results through the analysis of the equilibrium and the numerical simulations. The last section draws conclusions and defines a roadmap for future research work.

2. The Model

To analyze the trend of capital intensity in SIDS with migration and intergenerational transfers, we present an overlapping generations (OLG) model, with discrete time indexed by $t = 0, 1, 2, ..., +\infty$ [2]. OLG models are extensively described in De La Croix and Michel (2002) and are really convenient to study intergenerational transfers as in Del Rey and Lopez-Garcia (2016) or Thibault (2008). They are widely used in the studying of migration and remittances (Docquier et al. (2008), de la Croix et al. (2007), Beine et al. (2001), Marchiori et al. (2008)). We use a simple model as in Constant (2015), Constant et al. (2014) in which we focus on households' behavior toward savings, consumption and education. In order to have a convenient model, we do not scrutinize the supply side and the pollution changes are kept as simple as possible.

2.1. Production and Environment

Production of the composite good is carried out by a representative firm in our economy. The output is produced according to a constant returns to scale technology:

$$Y_t = AK_t^{\alpha} \left(L_t h_t\right)^{1-\alpha} \tag{1}$$

where K_t is the aggregate stock of physical capital, L_t is the aggregate labor supply to production, h_t is the mean human capital, $A > 0$ measures the technology level, and $\alpha \in (0, 1)$ is the share of physical capital in the production. Defining $y_t \equiv \frac{Y_t}{L_t h_t}$ as the output per unit of efficient labor and $k_t \equiv \frac{K_t}{L_t h_t}$ as the capital to labor ratio, we have the following production function per unit of efficient labor:

$$y_t = Ak_t^{\alpha} \tag{2}$$

The government collect revenues through a tax rate $\tau \in (0, 1)$ on production, which is the source of pollution. The tax revenue is used to finance pollution abatement m_t, with $m_t = \tau Y_t$, in order to correct the environmental externality. The firm profit is:

$$\Pi_t = A(1-\tau)K_t^{\alpha} \left(L_t h_t\right)^{1-\alpha} - w_t h_t L_t - R_t K_t \tag{3}$$

where w_t is the wage for a unit of efficient labor and R_t the interest rate of capital.

Assuming that the capital fully depreciates in one period, we have:

$$w_t = A(1-\alpha)(1-\tau)K_t^{\alpha} \left(L_t h_t\right)^{-\alpha} = A(1-\alpha)(1-\tau)k_t^{\alpha} \tag{4}$$
$$R_t = A\alpha(1-\tau)K_t^{\alpha-1} \left(L_t h_t\right)^{1-\alpha} = A\alpha(1-\tau)k_t^{\alpha-1} \tag{5}$$

The production sector generates a stock of pollution whose evolution is given by:

$$Z_{t+1} = \Omega Y_t + (1-a)Z_t - m_t \tag{6}$$

with Ω, the emissions of pollution from the production, a the natural absorption rate of pollution and m_t the cleanup effort which is equal to τY_t. We can also define $z_{t+1} \equiv \frac{Z_{t+1}}{L_{t+1}h_{t+1}}$ as the stock of pollution per unit of efficient labor:

$$z_{t+1} = (\Omega - \tau)Ak_t^{\alpha} \frac{L_t h_t}{L_{t+1}h_{t+1}} + (1-a)z_t \frac{L_t h_t}{L_{t+1}h_{t+1}} \tag{7}$$

[2] Each period is assumed to last twenty to thirty years

2.2. Family's behavior

Households live three periods, childhood, adulthood, and old age. At $t+1$, a new generation of $n_t N_t$ homogenous agents is born, where n_t is the growth rate of the adult generation between period t and $t+1$. As in De La Croix and Doepke (2003) the value of n_t is chosen by the adults of period t, knowing that raising n_t children takes a franction σn_t of time, with $\sigma \in [0,1]$. Let us denote the probability of migration by $p \in [0,1]$. Migration implies that only $(1-p)n_t N_t$ children stay in the domestic country after childhood, the others $pn_t N_t$ children migrate to countries where wages are higher.

Individual born in $t-1$ cares about her adult consumption level c_t, her old-age consumption level d_{t+1} and suffers from the stock of pollution when she is old, Z_{t+1}. We assume here that the vulnerability to pollution increases with age and that the individuals do not suffer from the stock of pollution when they are young.

During childhood, individuals are reared by their parents and do not make any decisions. When adult, if they stay in the domestic territory, they supply inelastically one unit of labor remunerated at wage w_t per unit of human capital h_t and have children. They allocate their income to consumption c_t, savings s_t and children education $n_t e_t$. Besides, they transfer a part γ of their revenue to their parents. Agents who have migrated send the same part γ of their revenue to their parents, but they can have a higher wage abroad which is proportional to the domestic one: $w_t^F \equiv \varepsilon w_t$, where $\varepsilon \geq 1$ is the net premium to the migration. Cashflows from the migrants are remittances in our economy, while transfers from domestic workers are simply intergenerational transfers. We assume that the migrants are not economically active in the domestic country, except for the remittances sent to their parents. Therefore in this paper, we do not study the decision of migration by the children or the remittances level, but only the trade-off of the parents between savings and children education, knowing that a part of the children will leave the country with a probability p and will remit more.

Finally, when old, agents only consume their savings remunerated at the rate $R_{t+1} = 1 + r_{t+1}$ and the "intergenerational transfers" sent by their children, wherever they live. That said, there are two trade-offs in this model, the first one with regard to present versus future consumption. In addition, they have to choose between savings or transfers (through human capital investments and the number of children) to finance their consumption when old. Besides, they suffer from the environmental externality due to the stock of pollution Z_{t+1}, with respect to the weight of pollution in the preferences $0 > \phi \geq 1$.

The evolution of the size of the adult generation is represented by this equation:

$$N_{t+1} = n_t N_t (1-p) \tag{8}$$

And we note the population growth[3] as :

$$g^N = \frac{N_{t+1} - N_t}{N_t} = n_t(1-p) - 1 \tag{9}$$

The preferences of the agents are represented by this utility function:

$$U(c_t, d_{t+1}, Z_{t+1}) = \ln(c_t) + \beta \left[\ln(d_{t+1}) - \phi \frac{Z_{t+1}^2}{2} \right] \tag{10}$$

The two budget constraints for an adult born in $t-1$ are:

$$c_t + s_t + n_t e_t = w_t h_t (1 - \gamma - \sigma n_t) \tag{11}$$

$$d_{t+1} = s_t R_{t+1} + n_t \gamma (1 - p + p\varepsilon) w_{t+1} h_{t+1} \tag{12}$$

Human capital of her child h_{t+1} depends on the total investments in education e_t and her own human capital h_t:

$$h_{t+1} = \theta h_t^{1-\mu} e_t^{\mu} \tag{13}$$

[3]Note that there is demographic growth only if $n_t(1-p) > 1$

where $\theta > 0$ is the efficiency of human capital accumulation and $0 > \mu > 1$ represents the efficiency of education. Note that in our model, corner solutions are indeed possible since there are two different forms of investments. But we choose not to pay attention to corner solutions because $e_t = 0$ would bring the stock of human capital to 0. Then we set the condition: $e_t > 0$.

Three approximations in our model must be discussed. First, we do not introduce the return migration during old-age. Secondly, islands here are small closed economies only open to emigration, there are no imports, exports or capital flows between the rest of the world and the domestic economy. We are well aware that these countries present a high degree of economic openness. Nevertheless the current model offers a tool to study the domestic production as a source of pollution and the impact of migration on consumption that comes from the domestic firms. Moreover, we limit our analysis to local pollution which is mainly related to domestic production or consumption. The third limit and the most important, concerns the similarity between the relative proportion in the revenue of the intergenerational transfers from the migrants and the non-migrants. For the sake of simplicity, we suppose that the proportion of revenue sent to the parents is the same, regardless of the location of the children. The amount and the motives of remittances from migrants are well-studied in the economic. However, to the best of our knowledge, there is no study that allow us to evaluate the amount of intergenerational solidarity in Caribbean islands knowing that there are several forms of solidarity. Among others, it could be through private cash transfers, payment of services or long-term care given by the children to the parents. Thus, we make the assumption, that the term γ include remittances for migrants and cash transfers or time for non-migrants. Indeed, γ can be seen as a amount of time that is not spent at work, and then not only as a part of revenues that is spent to the parents.

The consumer program is summarized by:

$$\max_{c_t,s_t,e_t} U(c_t, d_{t+1}, Z_{t+1}) = \ln(c_t) + \beta \left[\ln(d_{t+1}) - \phi \frac{Z_{t+1}^2}{2}\right] \tag{14}$$

$$s.t\, c_t + s_t + n_t e_t = w_t h_t (1 - \gamma - \sigma n_t)$$

$$d_{t+1} = s_t R_{t+1} + n_t \gamma (1 - p + p\varepsilon) w_{t+1} h_{t+1}$$

$$h_{t+1} = \theta h_t^{1-\mu} e_t^{\mu}$$

$$Z_{t+1} = (\Omega - \tau) Y_t + (1 - a) Z_t$$

The first order condition (FOC) of the household's problem with respect to s_t shows the following standard relationship between adult consumption and old consumption:

$$\frac{1}{c_t} = \frac{\beta R_{t+1}}{d_{t+1}} \tag{15}$$

Similarly, the FOC of the household's problem with respect to education suggests that the remuneration from education and savings should be equal on the equilibrium, it leads to:

$$\frac{1}{c_t} = \frac{\beta \gamma \mu (1 - p + p\varepsilon) w_{t+1} h_{t+1}}{e_t d_{t+1}} \tag{16}$$

Finally, the FOC of the household's problem with respect to n_t the number of children leads to:

$$\frac{1}{c_t} = \frac{1}{\sigma w_t h_t + e_t} \frac{\beta \gamma (1 - p + p\varepsilon) w_{t+1} h_{t+1}}{d_{t+1}} \tag{17}$$

Combining equations (16) and (17) leads us to the optimal choice of education, which is just a part $\frac{\mu\sigma}{1-\mu}$ of the income:

$$e_t^* = \frac{\mu \sigma w_t h_t}{1 - \mu} \tag{18}$$

Substituting education into equation (17) and combining with equation (15) leads to a relation between the future prices of the factors of production :

$$R_{t+1} = \frac{\theta\gamma(1-\mu)(1-p+p\varepsilon)}{\sigma}\frac{w_{t+1}h_{t+1}}{w_t h_t} \tag{19}$$

Defining x_t as the income allocated to future consumption and according to the value of education given by equation (18) we obtain:

$$x_t = s_t + \frac{\sigma w_t h_t}{1-\mu} n_t \tag{20}$$

Finally, using equations (19) and (18) we can rewrite the budget constraints as:

$$c_t = w_t h_t(1-\gamma) - x_t \tag{21}$$

$$d_{t+1} = x_t R_{t+1} \tag{22}$$

Replacing (21) and (22) in the FOC (15) we obtain a new expression of x_t:

$$x_t = \frac{\beta(1-\gamma)}{1+\beta} w_t h_t \tag{23}$$

However the respective shares of investments in human capital or savings in the funding of the future consumption are undetermined. Therefore, we need to introduce the market clearing conditions (MCC) and the prices of the factor (given by equations (4) to (5)) in order to define the optimal choices of savings and natality. The market clearing conditions are given by the equations bellow:

$$K_{t+1} = s_t N_t \tag{24}$$

$$L_{t+1} = N_{t+1} = n_t N_t (1-p) \tag{25}$$

$$h_{t+1} = \theta e_t^{\mu} h_t^{1-\mu} = \theta \left(\frac{\mu w_t \sigma}{1-\mu}\right)^{\mu} h_t \tag{26}$$

We deduce from the MCC that:

$$k_{t+1} = \frac{K_{t+1}}{h_{t+1}N_{t+1}} = \frac{s_t}{(1-p)n_t h_{t+1}} \tag{27}$$

Moreover from equation (19) and the factor prices (equations (4) and (5)) we have:

$$k_{t+1} = \frac{\alpha w_t h_t \sigma}{h_{t+1}(1-\alpha)(1-\mu)\gamma(1-p+p\varepsilon)} \tag{28}$$

Therefore we can find a relationship between s_t and n_t:

$$n_t = s_t \frac{(1-\alpha)(1-\mu)\gamma(1-p+p\varepsilon)}{\alpha w_t h_t \sigma (1-p)} \tag{29}$$

Replacing expression (29) in x_t gives the optimal choices for savings and natality:

$$s_t^* = \frac{\beta\alpha(1-p)(1-\gamma)}{(1+\beta)[\alpha(1-p)+(1-\alpha)\gamma(1-p+p\varepsilon)]} \tag{30}$$

$$n_t^* = \frac{\beta(1-\gamma)(1-\alpha)(1-\mu)\gamma(1-p+p\varepsilon)}{\sigma(1+\beta)[\alpha(1-p)+(1-\alpha)\gamma(1-p+p\varepsilon)]} \tag{31}$$

The interpretation of e_t^* and s_t^* – given by equations (18) and (30) – is intuitive. The education expenditures increase with the income $w_t h_t$, the efficiency of education μ and the opportunity cost of rearing a child σ. The amounts of savings increase with respect to the income $w_t h_t$, the preference for the future β and the share of capital in the production, α. Savings decrease with the probability of migration p, the transfers ratio γ, and the premium for migration ε. Then when the gain from investment of human capital increase, households will save less in order to raise the education expenditures. However the interpretation of n_t^* and its impact on demographic growth is not simple. First, the number of children per household is constant over time and is increasing with respect to β, p and ε. The natality is negatively correlated to σ and α. More interestingly, the impact of the transfer ratio γ on n_t is ambiguous and depends of the condition bellow:

$$\gamma < \frac{\sqrt{\alpha(1-p)}\left[\sqrt{\alpha(1-p)+4(1-\alpha)(1-p+p\varepsilon)}-\sqrt{\alpha(1-p)}\right]}{2(1-\alpha)(1-p+p\varepsilon)} \tag{32}$$

The growth of the number of adults is given by equation (9) and it is increased by all the factors which are positively correlated to n_t, except for p which has an ambiguous effect on demographic growth. Indeed, p boosts the natality and then increases the number of children but in the same time it decreases the number of adults who will stay on the territory at the next period. These two effects are competing, and then in some cases an increase of migration could lead to a growth of the population size, if the increase of the number of children is higher than the decrease of the number of adults through migration. These effects depend of the condition bellow:

$$\frac{\partial g^N}{\partial p} > 0 \iff \frac{1-p}{1-p+p\varepsilon} > \frac{\alpha(\varepsilon-1)}{\gamma(1-\alpha)} \tag{33}$$

3. Equilibrium

3.1. Intertemporal equilibrium

The market-clearing conditions for capital and the efficient units of labor were given respectively by the equation (24) and the combination of equations (25) and (40). The values of s_t, n_t and e_t are given by the optimal choices of the households in equations (30), (31) and (18). The wage and the rate of interest correspond respectively to (4) and (5). After some computations, we can deduce the intertemporal equilibrium.

Definition 1. *Given the initial conditions $K_0 \geq 0$, $L_0 \geq 0$ and $h_0 \geq 0$, the intertemporal equilibrium is the sequence (K_t, L_t, h_t, Z_t) such that the following system is satisfied for all $t \geq 0$:*

$$\begin{cases} K_{t+1} &= \frac{\alpha\beta A(1-\alpha)(1-\gamma)(1-\tau)(1-p)}{(1+\beta)[\alpha(1-p)+\gamma(1-\alpha)(1-p+p\varepsilon)]} K_t^{\alpha} L_t^{1-\alpha} h_t^{1-\alpha} \\ L_{t+1}h_{t+1} &= \frac{\beta(1-\gamma)(1-\alpha)(1-\mu)\gamma(1-p+p\varepsilon)}{\sigma(1+\beta)[\alpha(1-p)+\gamma(1-\alpha)(1-p+p\varepsilon)]}\theta\left[\frac{\mu A\sigma(1-\alpha)(1-\tau)}{1-\mu}\right] K_t^{\alpha\mu} L_t^{1-\alpha\mu} h_t^{1-\alpha\mu} \\ Z_{t+1} &= (\Omega-\tau)AK_t^{\alpha}\left(L_t h_t\right)^{1-\alpha} + (1-a)Z_t \end{cases} \tag{34}$$

The system (34) can be rewritten in terms of capital to efficient unit of labor ratio k_t:

$$\begin{cases} k_{t+1} &= \frac{(A\alpha\sigma(1-\tau))^{1-\mu}}{\theta(1-\alpha)^{\mu}(1-\mu)^{1-\mu}\gamma(1-p+p\varepsilon)} k_t^{\alpha(1-\mu)} \\ z_{t+1} &= (\Omega-\tau)Ak_t^{\alpha}\frac{L_t h_t}{L_{t+1}h_{t+1}} + (1-a)z_t\frac{L_t h_t}{L_{t+1}h_{t+1}} \end{cases} \tag{35}$$

We define g_t^{Lh} and g_t^K, respectively as the growth of the stocks of efficient units of labor and physical capital in this economy.

$$\begin{aligned} g_t^{Lh} &= \frac{L_{t+1}h_{t+1}}{L_t h_t} \\ &= \frac{\beta(1-\gamma)(1-\alpha)(1-\mu)\gamma(1-p+p\varepsilon)}{\sigma(1+\beta)\left[\alpha(1-p)+\gamma(1-\alpha)(1-p+p\varepsilon)\right]}\theta\left[\frac{\mu A\sigma(1-\alpha)(1-\tau)}{1-\mu}\right] K_t^{\alpha\mu} L_t^{-\alpha\mu} h_t^{-\alpha\mu} \\ &= \frac{\beta(1-\gamma)(1-\alpha)(1-\mu)\gamma(1-p+p\varepsilon)}{\sigma(1+\beta)\left[\alpha(1-p)+\gamma(1-\alpha)(1-p+p\varepsilon)\right]}\theta\left[\frac{\mu A\sigma(1-\alpha)(1-\tau)}{1-\mu}\right] k_t^{\alpha\mu} \end{aligned}$$

$$
\begin{aligned}
g_t^K &= \frac{K_{t+1}}{K_t} \\
&= \frac{\alpha\beta A(1-\alpha)(1-\gamma)(1-\tau)(1-p)}{(1+\beta)\left[\alpha(1-p)+\gamma(1-\alpha)(1-p+p\varepsilon)\right]} K_t^{\alpha-1} L_t^{1-\alpha} h_t^{1-\alpha} \\
&= \frac{\alpha\beta A(1-\alpha)(1-\gamma)(1-\tau)(1-p)}{(1+\beta)\left[\alpha(1-p)+\gamma(1-\alpha)(1-p+p\varepsilon)\right]} k_t^{\alpha-1}
\end{aligned}
$$

Because of the accumulation of human capital, there is no steady state in this economy but a balanced growth path.

Definition 2. *A balanced growth path (BGP) is an equilibrium satisfying* ***Definition*** *1 and where the stock of physical and efficient units of labor grow at the same constant rate* $g^{BGP} = g_t - 1 = g_t^K - 1 = g_t^{Lh} - 1$. *On the balanced growth path,* $k_t = k^{BGP}$ *is constant.*

Proposition 1. *According to the definition 2 there is a unique locally stable equilibrium, for which the values of k and g are:*

$$
k^{BGP} = \left[\frac{(A\alpha\sigma(1-\tau))^{1-\mu}}{\theta(1-\alpha)^{\mu}(1-\mu)^{1-\mu}\gamma(1-p+p\varepsilon)}\right]^{\frac{1}{1-\alpha+\alpha\mu}} \tag{36}
$$

$$
g^{BGP} = \frac{\beta(1-p)(1-\gamma)(1-\tau)}{(1+\beta)\left[\alpha(1-p)+\gamma(1-\alpha)(1-p+p\varepsilon)\right]} \left[\frac{(A\alpha)^{\mu}(1-\alpha)^{1-\alpha-\mu}}{[\theta\gamma(1-p+p\varepsilon)]^{\alpha-1}} \left(\frac{\sigma}{1-\mu}\right)^{(1-\mu)(1-\alpha)}\right]^{\frac{1}{1-\alpha+\alpha\mu}} \tag{37}
$$

To prove the stability of the equilibrium we define the function $f(k_t) = k_{t+1}$.

$$
\lim_{k_t \to 0} f'(k_t) = +\infty
$$

$$
\lim_{k_t \to +\infty} f'(k_t) = 0
$$

$$
\lim_{k_t \to +\infty} f(k_t) = +\infty
$$

The function $f(k_t)$ is concave and there are two points such as $k_{t+1} = k_t$, which are $k_t = 0$ and $k_t = k^{BGP}$ satisfying $0 < f'(k^{BGP}) < 1$. Therefore, it exists a unique non-trivial equilibrium locally stable and the model shows a regular convergence.

On the BGP, the pollution stock per unit of efficient labor is constant, such as $z_{t+1} = z_t$ in equation (7). The stock of pollution increases monotonically on the BGP unless the effort of abatement is sufficient to overcome the pollution impact of production, i.e. $\Omega = \tau$. In this case, the stock level will decrease over time with a rate depending on the natural absorption of pollution, a. Then, we define z^{BGP} as:

$$
z^{BGP} = \frac{(\Omega-\tau)A\left(k^{BGP}\right)^{\alpha}\left(g^{BGP}\right)^{2}}{g^{BGP}-(1-a)} \tag{38}
$$

Finally, we conduct a comparative statics analysis in order to evaluate the effect of the different parameters on the growth rate and the ratio of capital to unit of efficient labor. First, we investigate how the growth of the economy, g^{BGP}, responds to a change in the different parameters of the model.

Proposition 2. *On the BGP, under conditions the economic growth,* g^{BGP}, *is positively impacted by:*

- *The technology factor* A
- *The preference for the future* β
- *The efficiency of human capital accumulation* θ

- *The net gain to migration ε:*

$$\frac{\partial g^{BGP}}{\partial \varepsilon} > 0 \iff \varepsilon < \frac{(1-p)(1-\mu\gamma)}{\mu\gamma p}$$

- *The level of intergenerational transfers γ:*

$$\gamma < \frac{\alpha\mu}{1-\alpha} \Rightarrow \frac{\partial g^{BGP}}{\partial \gamma} > 0$$

- *The probability to migrate p:*

$$\frac{\partial g^{BGP}}{\partial p} > 0 \iff \frac{\gamma(1-p+p\varepsilon)}{1-p} < \frac{\alpha}{1-\alpha}\left[\frac{(1-\alpha)(1-p)(\varepsilon-1)+(1-p+p\varepsilon)(1+\beta)(1-\alpha(1-\mu))}{\alpha\mu(\varepsilon-1)(1-p)+(1-p+p\varepsilon)(1-\alpha(1-\mu))}\right]$$

And g^{BGP} is negatively correlated to the tax level.

First of all there are some intuitive results which are well described in the literature. A rise in the technological factor, A or the efficiency of human capital accumulation θ leads to an increase of the efficiency of the economy, and then to a stronger economic growth on the BGP. An increase of β, the preference for the future, results in higher investments for the future through human capital or savings and then in an increase of the economic growth.

However, the model gives us some insights of the effects of the demographic features such as the choice of natality and the human capital investments. First, the effect of ε the net gain to migration is not intuitive. There is a positive effect of ε according to a condition which is negatively correlated to the probability of migration p, the efficiency of education μ and the intergenerational transfer, γ. Despite the fact, that these three parameters are positively correlated to the gain from human capital investments for the parents. We might have thought that the return from migration and the return from education expenditures were positively correlated, but it appears that when the return from education increase through μ, γ or p, the condition for a positive effect of ε on the economic growth is more restrictive. Therefore it seems that it is difficult to have a positive effect of the human capital return and of the migration premium in the same time. Moreover, the effect of the intergenerational transfer is positively correlated to α the share of capital in the economy and to μ the efficiency of education.

Finally, the impact of the probability to emigrate for the children is not easy to interpret in terms of economic development because it results from different effects, especially on natality, the amount of savings and the population size when adult. Indeed, an increase of the probability to emigrate creates an incentive to have more children through the effect of the net gain to migration. However, because there are more adults who leave the territory at the next period it could leads to a decrease of the number of units of efficient labor and then of the economic growth. Moreover, the effect of migration on the capital stock is three-fold. First, by increasing the number of children, there is a rise in the rearing expenditures and thus a decrease of the amount of savings. Second in some cases, there is the negative effect of the reduction of the population size, and then of the contributors to the capital stock. However, in other cases, migration could lead to an increase of the units of efficient labor – thanks to the stronger natality – and then of the capital stock.

In conclusion, the effect of the parameters, γ, ε and p on the stock of units of efficient labor is higher than the loss due to the reduction of physical capital, if they respect the conditions described in proposition 2. However if these parameters are too large, the accumulation of productive capital is too slow and the economic growth is lessened on the BGP. The tax represents a loss in the economy and then lessens the part of revenue allocated to production.

Now, we consider the effects of the different parameters on the capital to units of efficient labor ratio, k^{BGP}.

Proposition 3. *On the BGP, there is a negative correlation between k^{BGP} and all the parameters, except A and σ which have a positive effect on k^{BGP}.*

The positive effect of A and σ results respectively from the increase of the production and from the decrease of the number of children due to the extra cost – i.e. the decrease of the next generation size. The negative impact of the other parameters is explained by the increase of the number of units of efficient labor in the economy – with respect to ε, θ, γ – or the negative effects of p which are two-fold, first an increase of the number of children and then a decrease of the amount of savings, second the effect on economic growth which is negative for certain values of p.

Through the analysis of k^{BGP} and g^{BGP} in equation (38), we can determine the interrelation between demographic parameters and the emissions of pollution per unit of efficient work on the BGP. k^{BGP} and g^{BGP} have a positive effect on pollution emissions, however the effect of g^{BGP} is greater. With propositions 2 and 3, we know that the parameters can have opposite effects on these two factors. When the parameters that control the gain from migration – i.e. γ, ε and p – are below the level defined by conditions of proposition 2, the growth rate is enhanced through the increase of human capital, as the emission of pollution. However in this situation there is a decrease of physical capital that leads to a reduction of emissions of pollution. If p, ε or γ, do not respect the conditions of proposition 2, the migration effect on g^{BGP} and k^{BGP} is negative, and then migration reduces pollution emissions. Moreover, there is an additional effect, from p which leads in some cases to a reduction of the population size and then of the production stock, which is responsible of pollution. Finally, migration has a positive effect on the pollution emissions, only if the human capital effect is greater than the physical capital impact and if the population is increasing with p. Thus, because of the impact of migration on the economy, we can link migration and pollution.

Caribbean states are developing economies. Thus it is necessary to scrutinize the path that leads to the BGP which describes the long-run behavior of the economy. The objective here is to characterize these paths and to evaluate the accuracy of the model to describe the reality. However, because of the difficulty to build careful parameters for the environmental features of the Caribbean, we choose to focus this first analysis on the economic achievement of the three islands and to evaluate the environmental features through the theoretical analysis.

4. Numerical analysis

This section is devoted to the transitional dynamics of three Caribbean SIDS: Barbados, Jamaica as well as Trinidad and Tobago. The proposed numerical analysis underlines the importance of the characteristics of the BGP for a long-run analysis. Prior to this, in order to evaluate the use of this model toward sustainable economic development we need to study the first periods of the simulation. Moreover, the model presented here is generic and can be used not only for small open island states but for any economy with emigration and pollution. In order to specify the conclusions of the model in the context of the Caribbean islands, we need to introduce the accurate parameters in regards to the demographic dynamics and the human capital formation. Therefore, the objective of this preliminary work is to compare the path of three different islands which present different features. Our objective being the evaluation of the impact of migration and natality, we construct the parameters according to a method which is given below.

Table 3 below reports the model's structural economic parameters, their respective economic interpretations, as well as the support range for credible values:

4.1. Structural parameter values estimation and calibration

The purpose of finding credible values for structural parameters is two-fold: first, it ensures that the model performs well along credible values with respect to the benchmark economy it seeks to replicate. Second, when the model proves to be able to match defining moments for the benchmark economy, it provides an adequate analytical framework, and thus predicts a set of relevant outcomes with respect to policy changes and instruments. As such, proper calibration can yield useful results for policymaking. Nonetheless, credible values for structural parameters are contingent upon available data. This is particularly the case for small emerging economies, such as the Caribbean.

Kydland and Prescott (1991) provide a comprehensive framework for discussing calibration in general equilibrium models. They insist on discipline as to how one chooses benchmark values for the structural

Economic Parameters	**Range**	Method
Preference factor for the future	$\beta \in [0,1[$	Calibration
Capital intensity in production	$\alpha \in [0,1]$	*idem*
Technology level	$A > 0$	*idem*
Emigration rate	$p \in [0,1]$	*idem*
Net gain to migration	$\varepsilon \in [0,1]$	*idem*
Education efficiency	$\mu \in [0,1]$	Estimation
Cost of rearing a child	$\sigma \in [0,1]$	*idem*
Efficiency of human capital accumulation	$\theta > 0$	*idem*
Share of income remitted	$\gamma \in [0,1]$	*idem*

Table 3: Parameters of the model

parameters. They insist for instance that for agent behaviour, values should be drawn from panel studies on households and firms, or by using long-run averages as a proxy for the steady-state. Finally, they also argue that econometric estimation of optimality conditions can provide suitable alternatives. However, such an undertaking can yield spurious estimations for the parameters of interest, as credible and estimated values can differ significantly from one another.

As far as emerging economies go, panel studies are not an option readily available. Furthermore, long-run averages work only as far as tractable specifications allow. We are left with econometric estimations of structural parameters, with all the challenges involved, as delineated in Favero (2001). As mentioned before in Kydland and Prescott (1991), a naive econometric specification may yield statistically robust but incoherent estimates for structural parameters. This is particularly the case for those parameters whose values are not well specified in the literature, or are specific to our model. In addition to those issues on data availability referred to earlier, these are the reasons why we focus on optimality conditions to derive our estimated structural parameters We focus in particular on equations (18), (40) and (29) to estimate those structural parameters of interest, gathered into the parameter set $[\mu, \theta, \sigma, \gamma]$ for those countries in the Caribbean with available data from 1970 to 2014.

We derive our estimated results from a dataset built around data collected from the World Bank's World Development Indicators (WDI), as well as the University of Pennsylvania PWT. For those variables incorporated in the estimated equations, the dataset spans the period 1970-2014. We focus on three countries in the Caribbean for which data was available for the considered time period, namely Barbados, Jamaica as well as Trinidad and Tobago. The selected variable for Human Capital is derived from the Penn World Table (PWT) which is an index computed on the basis of returns to education and years in schooling. Both wages and savings are derived from transformed variables: in the neo-classical framework of our model, wages are the marginal product of labour, and as such they represent a constant fraction of output, which is proxied in our model by the real GDP per capita of the benchmark economy. The same goes for gross savings, which are proxied for the non-consumed fraction of output as well. Finally, private education spending is assumed to represent 20% of total public expenditure. All three variables are collected from the WDI World Bank database.

We use the transformed data in order to estimate our structural parameters using the following system of equations:

$$h_{t+1} = \theta e_t^{\mu} h_t^{1-\mu} \tag{39}$$

$$e_t = \frac{\mu}{1-\mu}\sigma w_t h_t \tag{40}$$

$$s_t = \frac{(1-\alpha)(1-\mu)\gamma(1-p+p\varepsilon)}{\alpha w_t h_t \sigma(1-p)} \tag{41}$$

Those estimated results prove to be statistically robust and significant.

Parameter β which denotes preference for the future is calibrated using the risk-free interest rate in the United States. There is a large consensus in the literature that the interest rate is a good proxy for households' discounting factor (or preference for the future). All three Caribbean countries are small, open economies, and we use the annual 4% interest rate in order to calibrate β. The value is calibrated so as to get an annual discount factor. The same can be said as the share of capital in output α at 1/3, which is the usual value used in the literature. Total Factor Productivity (TFP) is frequently used in the literature as a proxy for the technology level. In order to calibrate the technology level for each country, we use the long-run average real growth per capita in the United States at 2%, and multiply it by the PWT 1970 value for TFP in each country as a percentage of that in the United States. For instance, the value for Jamaica is 1.014 translates into a long-run average TFP growth rate of 1.14% in 1970.

Similar adjustments are carried out for the initial values for capital as well as output and efficient units of labor. Output is normalized to unity in 1970, and the capital stock is computed using capital-to-output ratio for the same year. The figures in table 4 report harmonised initial values for physical capital for comparison purposes. The same calibration is computed for efficient units of labor, which are derived from normalized output and capital. We use the Cobb-Douglas equation (1) to deduce L_0h_0 for a given K_0 and $y_0 = 1$. Finally, given that human capital is reported as an index in PWT, we retain the 1970 value for all three economies. We report all the economic parameters in table 4 below:

Parameters		**Barbados**	**Jamaica**	**Trinidad and Tobago**
Preference factor for the future	β	0.961	0.961	0.961
Capital intensity in production	α	1/3	1/3	1/3
Technology level	A	1.033	1.014	1.038
Education efficiency	μ	0.394	0.432	0.198
Efficiency of human capital accumulation	θ	4.409	4.826	2.98
Cost of rearing a child	σ	0.005	0.006	0.001
Emigration rate	p	0.081	0.251	0.161
Net gain to migration	ε	2.424	3.903	2.314
Share of income remitted	γ	0.201	0.104	0.114
Capital stock	K_0	2.025	0.477	1.641
Human capital stock	h_0	2.516	1.993	2.028
Efficient units of labor	L_0h_0	1.423	0.691	1.281

Table 4: Values of the parameters

4.2. Results

The economic results are given in the figures 1 to 7 in logarithmic values, and in the table 5. According to the model, the three economies are driven on the one hand by the amount of physical capital in the economy and on the other hand by the number of units of efficient labor. The respective weight of these two aspects will be given by the combination of the parameters in the equilibrium equation (equation (35)). In the three Caribbean economies studied in this article, it seems that the demographic growth governs the economic growth and that the capital stock in itself is decreasing over time.

The demographic features are directly dependent of the natality choices and the human capital investments. In the figure 1, we can see that the demographic growth is extremely strong in the three islands, especially in Trinidad and Tobago. This is due to the small cost of rearing a child – in table 4 – which enhances the incentive to have children, in order to increase the intergenerational transfers obtained from the progeniture. Indeed, with such a low cost of rearing a child it is optimal to increase the number of children even if it leads to a decrease of the investments in human capital per child and then of the human capital over time (figure 4)[4]. In our numerical analysis, we choose to have a coherent and rigorous method of estimation for the parameters values through an econometric estimation, however we are well aware that the values for σ are probably underestimated, especially for Trinidad and Tobago whom value is only 0.001. Then in the three islands, we observe a stronger demographic growth than in reality. Though, the model partly explains the effect of natality on the human capital investments.

[4]Note that the negative values are due to the logarithm, even if it is not possible to have an negative value for human capital

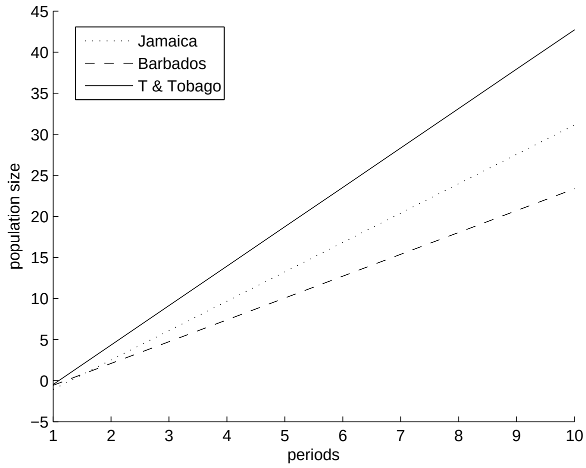

Figure 1: Evolution of the adult population

Indeed, there is a trade-off between the number of children and the amount of education expenditures per child. In the developing countries the effect of this trade-off could be explained by the theory developed in Becker (1981) which assumes that the fertility decline could occur only if the opportunity cost of raising children is stronger than the income effect from the children. The present model, allow us to evaluate the stage of development in these economies in 1970, and it seems that they were not on a path that leads to an increase of the human capital in the domestic population according to the natality feature.

According to the literature, migration could enhance this situation by creating an incentive to invest in human capital, however in our model, the cost of rearing a child is so small that it is not sufficient to insure a growth of human capital. Moreover, an increase of the probability to migration does not lead to a significant change of the economic achievement of these economies, but only of the consumption. The empirical results of our work are then in the line of Mishra (2006), Lim and Simmons (2015).

However, despite the diminution of human capital over time, the production is increasing because of the demographic growth, as well as the production per capita. This economic growth occurs despite the fact that the combination of parameters in the equation of savings (equation (30)) leads to a factor smaller than one, and then to a decrease of the capital per capita from one period to another. Here, because the number of units of efficient labor rises exponentially, the stock of capital will be increasing, as the production in equation (34). In table 5, the ratio of capital to units of efficient labor is extremely low in Barbados, Jamaica as well as Trinidad and Tobago. This is due to the demographic growth on the BGP. In the end, the only reason why there is an economic growth is due to the demographic features, and not to the savings amount.

	Barbados	Jamaica	Trinidad and Tobago
k^{bgp}	6.2442e-004	2.2021e-004	4.2440e-005
g^{bgp}	24.8271	54.9964	179.3690

Table 5: Values of capital to units of efficient labor ratio and growth on the BGP

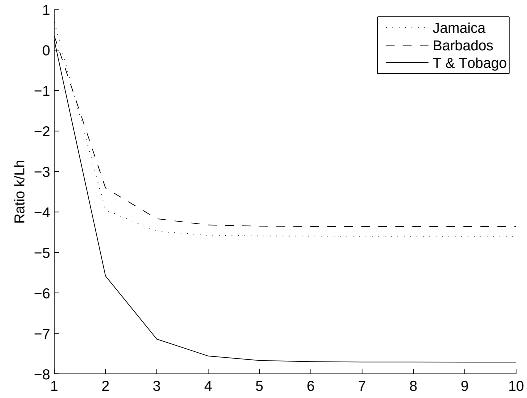

Figure 2: Capital to unit of efficient work ratio

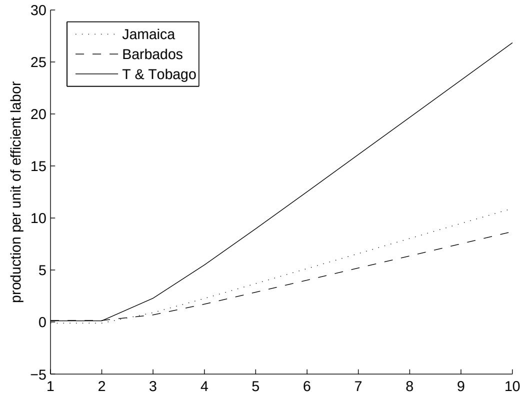

Figure 3: Production per unit of efficient work

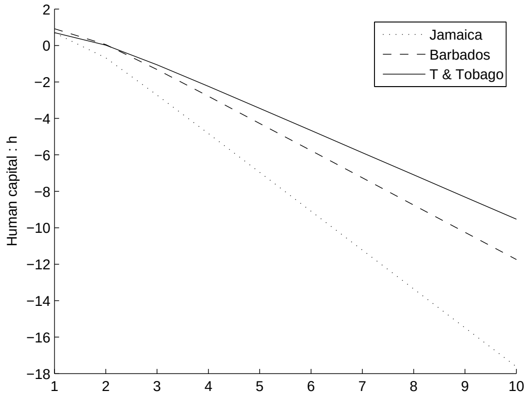

Figure 4: human capital evolution

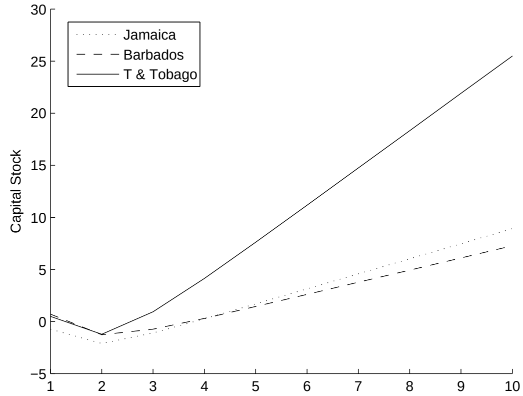

Figure 5: Capital stock

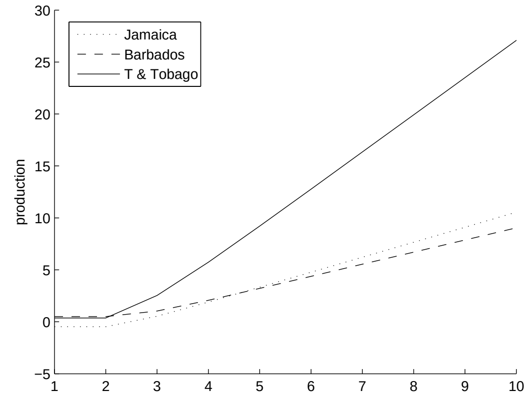

Figure 6: Production of the economy

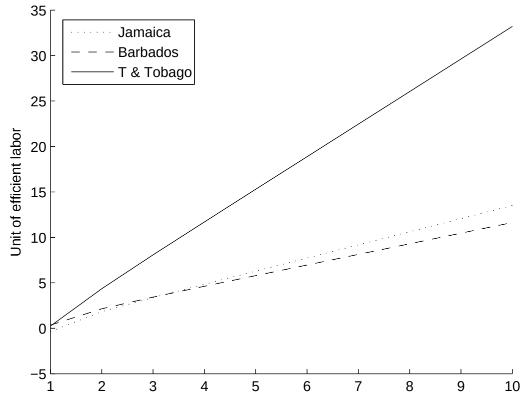

Figure 7: Stock of units of efficient work

5. Conclusion

In this paper, we develop a simple overlapping generations model, to explain the process of the interplay between economic activities, pollution emissions and investments in human and physical capital, according to the demographic structure of island economies. The analytical results, allow us to bring out the role of migration to explain choices of the parents in terms of natality, education and savings, knowing that intergenerational transfers are included in the budget constraint. These transfers are a key feature of our explanation of natality. Indeed, with the possibility to receive transfers and especially remittances from migrants, there is a stronger incentive to have children when there is a probability of migration. Migration can then lead to an increase of the size of the population through an increase of the number of children. In the same time, it is important to introduce the negative effect of migration on the size of the next adult generation. This two opposite effects can result respectively in an increase of the economic growth and in a reduction of the number of units of efficient labor. Moreover, if the incentive to have children is large, the amount of savings can be very low. In that case, there is a compensation of the reduction of the savings by the size of the next adult generation which is the source of the capital stock. Then, the long-term economic growth per capita is sustained exclusively by the demographic growth. Thus, we establish three conditions under which it is possible to have a gain from migration in terms of economic development. These conditions concern the probability, the net gain to migration and the intergenerational transfers.

Moreover, the model allow us to link the impact of remittances on pollution emissions, through two effects, the economic growth one with a higher number of units of efficient labor and the physical capital one. In fact, by enhancing the growth, intergenerational transfers contribute to the emissions of pollution. This is particularly true, if the net gain to migration is large, since the related remittances directly boost the consumption of the elderly, without reducing the consumption of the adult. However, migration reduces pollution through the effect on physical capital accumulation. Moreover, by reducing the population size, probability of migration has a really strong effect on the production stock and then on the pollution.

In the second part of this paper we develop a careful numerical analysis, with an econometric estimation of the parameters for three islands, Barbados, Jamaica as well as Trinidad and Tobago. This exercise allow us to evaluate the stage of development of these islands, which seem to be on a path where there is not human capital accumulation. However, this result must be lessened by the analysis of the parameter σ which is the opportunity cost of the children. Here we found extremely low values which explain most of the demographic feature in our economies.

Though general, the model developed here, can be useful to describe important features of the Caribbean SIDS, especially regarding the path that leads to the BGP. In a future work it will be necessary to study the different islands to build accurate environmental parameters. However, the present work shows that, depending on the parameters of the studied economy, the implementation of an environmental tax could be linked to the level of emigration. Then further considerations on the impact of remittances can be useful in order to build a more efficient environmental policy.

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