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1. Introduction

Undoubtedly, Haiti has endured incredible hardship and, despite its resilience, the country's social and economic structures have not created an environment for prosperity. Consequently, statistics are usually grim, starting with Haiti's GDP per capita of US$761 for 2017. Of Haiti's population of 10.8 million, 58.6 percent are considered poor based on the national poverty line and the most recent estimate. Haiti is also extremely unequal; based on the 2012 household survey data, Haiti has a Gini coefficient of 0.610, which has remained constant since 2001 (ECVMAS, 2012).

In this paper, we first assess the historical evolution of total factor productivity in Haiti and then consider alternative scenarios related to accelerating growth. Specifically, we focus on issues of intertemporal coordination between population growth, TFP (Total Factor Productivity), capital accumulation, foreign debt, output, and consumption. To that end, we developed a model of the Ramsey-Cass-Koopmans type.[1] This class of models are the workhorse of most contemporary work in modeling the long and very long term growth of countries (Barro and Sala-i-Martin 2004 and Acemoglu 2009). In doing so, we make two contributions to the empirical economic analysis of developing countries such as Haiti: (a) we estimate Haiti's capital stock and perform a growth accounting exercises using data that

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[1] It is interesting to note that most of the empirical work using this framework sets out closed economy steady-state models, thus missing some very basic features of developing countries such as Haiti: they are small open economies; have quite limited absorptive capacity for new capital; can be credit constrained in international financial markets; and, last but not least, they are usually far from the steady state. Thus, transitional dynamics starting from actual initial conditions matters, and matters a lot (Mercado and Cicowiez, 2013).

goes back to the 1950s; and (b) we built a 2016 macro consistent dataset and use it to calibrate a long-run growth model for a small open economy such as Haiti.

In outline, we proceed as follows. In Section 2, we assess the long-term growth performance of Haiti. In addition, we perform a growth accounting exercise that singles out the contribution of factor accumulation and technical progress to explain Haiti GDP (and GDP per capita) performance between 1970 and 2013. In Section3 we use a (very) long-term growth model to assess the impact of TFP growth and improved absorptive capacity in selected macro variables. Finally, we conclude in Section 4.

2. Historical Trends in Total Factor Productivity

Total Factor Productivity

In this section, we estimate Total Factor Productivity (TFP) growth in Haiti through a conventional growth accounting exercise (Hulten, 2010). In a typical growth accounting exercise, the “residual” TFP is estimated as the difference between actual and estimated GDP growth as a consequence of factor accumulation. Besides, we tested several specifications related to the (a) definition of skill and unskilled labor, (b) inefficiencies in the capital accumulation process, and (c) natural disasters.

Firstly, we provide a brief description of the growth accounting method. The objective of growth accounting is to decompose the economic growth rate of a country into contributions from different factors: capital accumulation, labor force growth, and technical progress. It is an empirical tool that requires specific assumptions for the interpretation of economic data. In its most basic version, an aggregate Cobb-Douglas production function serves as a framework. Mathematically,

(1) $$Y_t = A_t \cdot K_t^{\alpha} \cdot L_t^{1-\alpha}$$

where Y_t is output, K_t is capital stock, L_t is (employed) labor force, A_t is total factor productivity, and α is the capital income share. By assumption, output changes can only be caused by changes in the capital stock, the labor force, or the total factor productivity; i.e.,

(2) $$\frac{\Delta Y}{Y_t} = \frac{\Delta A}{A_t} + \alpha \frac{\Delta K}{K_t} + (1-\alpha)\frac{\Delta L}{L_t}$$

where the three terms on the right-hand side refer to the growth contribution of TFP, capital accumulation and (employed) labor force growth, respectively. In our estimations, we use an extended growth accounting equation in order to (a) focus on GDP per capita, and (b) account for outmigration. Specifically, and regarding (b), we adjust the contribution of labor force growth using the labor force participation rate. Mathematically, we estimate the following equation:

(3) $$\frac{Y_t}{N_t} = \frac{A_t \cdot K_t^{\alpha} \cdot L_t^{1-\alpha}}{N_t}$$

$$y_t = \frac{A_t \cdot K_t^{\alpha} \cdot L_t^{1-\alpha}}{N_t} \frac{L_t^{\alpha}}{L_t^{\alpha}}$$

(4) $$y_t = A_t \cdot k_t^{\alpha} \cdot f_t$$

(5) $$\frac{\Delta y}{y_t} = \frac{\Delta A}{A_t} + \alpha \frac{\Delta k}{k_t} + \frac{\Delta f}{f_t}$$

where N_t is population, $y_t = \frac{Y_t}{N_t}$, $k_t = \frac{K_t}{L_t}$, and $f_t = \frac{L_t}{N_t}$.

In our calculations, α is 0.35 and is obtained from the national accounts as the share of gross operating surplus in value added. In turn, the growth rate of GDP per capita and factor inputs can be computed empirically. Then, the contribution of TFP to growth can be calculated from equation (5) as a "residual" or difference between the actual growth rate of GDP per capita and the part of the growth rate that can be "accounted for" by the growth rate of capital stock per worker and labor force participation rate.

In practice, the inputs of the production function are notoriously hard to estimate accurately. In Haiti, a direct application of the perpetual inventory method (PIM) to estimate capital stocks from investment data yields implausible results – specifically, the growth rate for the capital stock is too high when compared to other developing countries.[2]

[2] In essence, the PIM argues that the stock of capital is the accumulation of the stream of past investments. Mathematically,

$$K_t = \sum_{i=0}^{t-1} I_{k,t-i}(1-\delta_k)^i + K_0(1-\delta_k)^t$$

Consequently, and following the related literature, we extended the PIM to account for natural disasters and inefficiencies in the capital accumulation process – i.e., the degree to which investment is lost in the accumulation process, or conversely the loss of capital that is due to poor investment technology. Specifically, our estimates for the capital stock consider the following adjustments:

- 15 percent of gross private investment is lost while gelling into capital due to inefficiencies;
- 30 percent of gross public investment is lost while gelling into capital due to inefficiencies;
- annual losses from natural disasters are assumed equal to 3.8 percent of GDP per year and are accounted for as disinvestment; and

Overall, Haiti's capital-to-GDP ratio should not be different from other low-income countries by several orders of magnitude. Needless to say, applying these corrections reduces capital stock estimates (see below). Besides, we also extended equation (5) by considering labor quality as proxied by education as an additional input into the production function. Mathematically,

(6) $$\frac{\Delta y}{y_t} = \frac{\Delta A}{A_t} + \alpha \frac{\Delta k}{k_t} + (1-\alpha)\frac{\Delta h}{h_t} + \frac{\Delta f}{f_t}$$

where $H_t = h_t \cdot L_t$ is the capital stock defined as the product between raw labor L_t and its average qualification level h_t; in turn, $h_t = \frac{H_t}{L_t}$

Table 2.1 presents the main findings from our growth accounting exercise for the period 1970-2013 and various sub-periods corresponding to structural breaks in the GDP growth rate. Overall, between 1970 and 2013, GDP per capita grew at an average annual rate of -0.6 percent. Interestingly, Table 2.1a shows that capital accumulation had a substantial (positive) contribution to growth in Haiti. For example, in the first specification (i.e., without adjustments for natural disasters and inefficiencies in investment), capital accumulation

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where K_t is the aggregate physical capital stock value in year t, I_{kt} is the value of investment at constant prices, δ_k is the depreciation rate, and K_0 is the initial stock of capital. The PIM requires data on the assets service life or accumulation period and depreciation patterns.

made a positive contribution to growth in GDP per capita of one percent. Consequently, growth in TFP made a 1.5 percent negative contribution to growth in GDP per capita (-0.6 = 0.9 – 1.5). Moreover, 1970-1978 is the only period with sustained growth in GDP per capita. In fact, TFP grew at 1 percent between 1970 and 1978. In later periods, TFP decreased between 1.6 and 2.9 percent per year. Therefore, the decrease in GDP per capita and the negative estimates for TFP growth during 1979-2013 suggest an extremely low capital efficiency. On the one hand, this could reflect that Haiti suffers from insufficient and poor infrastructure (Singh and Barton-Dock, 2015). On the other hand, it may be the case that we are overestimating the size of the capital stock and consequently underestimating the social (and private) return on investment. Hence, and as described above, adjustments were made in the estimation of the capital stock. In the period 1970-1993, outmigration outpaced the increase in the economically active population -- the latter was driven by an increase in life expectancy and a decrease in the fertility rate. Consequently, panels (a) and (b) in Table 2.1 show a negative growth contribution by the participation rate for the periods 1970-1978 and 1979-1993.

In our second specification (see Table 2.1b), the contribution of capital accumulation to growth in GDP per capita decreases. By the same token, the negative growth contribution of (residual) TFP is reduced. Table 2.1b shows that capital accumulation explains 0.7 percent instead of 0.9 percent when adjustments of the capital stock estimates are considered. Thus, TFP still shows a strong negative contribution to GDP per capita growth. In contrast, for the most recent sub-period 1994-2013, capital accumulation makes a negative contribution to growth in GDP per capita; specifically, -0.2 percent instead of 0.6 percent. Naturally, the negative contribution of TFP is reduced during the same period.

In addition, adjustments for the change in the skill composition of the working population were also considered (see Table 2.1c). Specifically, we expanded the growth accounting equation showed above to include human capital accumulation as measured by the increase in the literacy rate and the average years of schooling. Of course, increasing the skill level of the workforce has a positive contribution to GDP per capita growth. Therefore, the negative contribution of (residual) TFP has to be even higher, about -2 percent.

Table 2.1a: growth accounting GDP per capita, 1970-2013

Period	Annual growth rate of y	Annual growth rate of A	Contribution of k*	Contribution of f**
1970-1978	2.3%	1.3%	1.2%	-0.2%
1979-1993	-2.3%	-2.9%	1.3%	-0.7%
1994-2013	-0.6%	-1.6%	0.6%	0.5%
1970-2013	-0.6%	-1.5%	0.9%	0.0%

Table 2.1b: growth accounting GDP per capita, 1970-2013 adjusted for natural disasters and inefficiencies in investment

Period	Annual growth rate of y	Annual growth rate of A	Contribution of k*	Contribution of f**
1970-1978	2.3%	0.5%	1.9%	-0.2%
1979-1993	-2.3%	-2.9%	1.2%	-0.7%
1994-2013	-0.6%	-0.9%	-0.2%	0.5%
1970-2013	-0.6%	-1.3%	0.7%	0.0%

Table 2.1c: growth accounting GDP per capita, 1970-2013 adjusted for natural disasters, inefficiencies in investment, and change in the skill composition of the working population

Period	Annual growth rate of y	Annual growth rate of A	Contribution of k*	Contribution of f**	Contribution of h***
1970-1978	2.3%	0.0%	1.9%	-0.2%	0.6%
1979-1993	-2.3%	-4.0%	1.2%	-0.7%	1.2%
1994-2013	-0.6%	-1.4%	-0.2%	0.5%	0.5%
1970-2013	-0.6%	-2.0%	0.7%	0.0%	0.8%

*Contribution of K = alpha * Annual growth rate of K, with alpha = 0.35.
**Contribution of f = (1-alpha) * Annual growth rate of L/N, the participation rate.
***Contribution of h = (1-alpha) * Annual growth rate of H/L, the human capital per worker.
Source: Authors' elaboration.

To summarize, we have shown that in Haiti, and for the period 1973-2013, the contribution of technological progress to growth has been negative. Moreover, this finding is robust to different specifications of the growth equation. Specifically, the TFP contribution to growth in GDP per capita lies between -1.3 and -2 percent. However, and perhaps making this growth accounting exercise rather atypical, our decomposition analysis is attempting to account for a long-run decrease in GDP per capita. Certainly, the negative trends for GDP per capita and TFP growth are explained by factors that we do not explore here. For instance, institutional and political factors have not been mentioned so far. In fact, only natural disasters and inefficiencies in the capital accumulation process have been mentioned. Surely, those three elements have a significant role to play in explaining Haiti's historic economic trajectories. In sections 3, we study what would be the impact of attaining positive TFP growth as observed during the seventies.

3. The Impact of Productivity Gains in the Long Run[3]

In this section, we assess the (very) long-run impact of the increased in TFP derived in Section 2. To that end, we use a long-run growth model with a single sector that focuses on the macro requirements and the consequences of sustained growth in key economic variables.

Growth Model and Data

The objective of the model and simulations presented here is to provide a basic, rough, and stylized framework in order to obtain orders of magnitude of the growth potential for the main macroeconomic aggregates of Haiti. Hence, in no way the model aims to fully capture the dynamics of development of the Haitian economy. This model is a streamlined and consistent framework to consider questions such as the following: What very long run growth rates of output and consumption could be achieved by the Haitian economy based on different levels of population and TFP growth? What would be the consequent requirements in terms of capital accumulation and foreign debt? What impact would have on those dynamics changes in financing conditions or international aid? How would be, from a very stylized point of view, the transitional dynamics of the main macroeconomic stocks and flows starting from the current situation until achieving steady-state levels of very long rung growth?

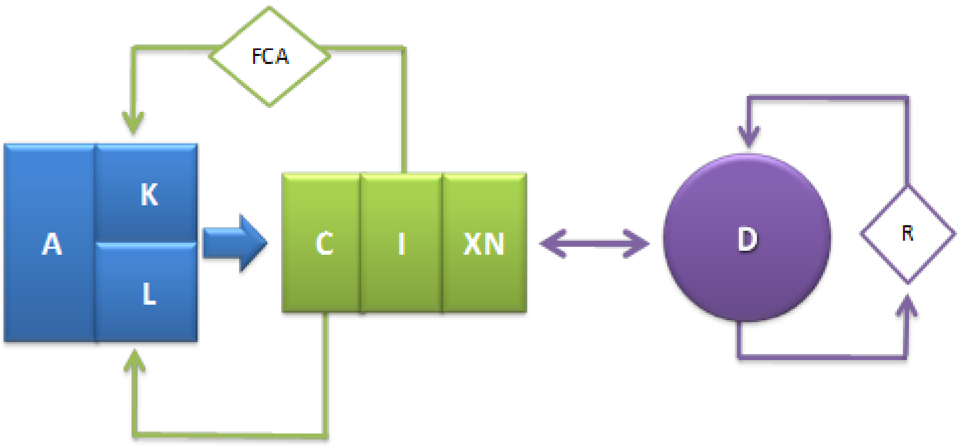
Figure 3.1 shows the main features of our growth model; it shows that the stock of factors of production (capital (*K*), labor (*L*) and technology (*A*)) generates a flow of output. In turn,

[3] The model used in this section is based on Mercado and Cicowiez (2013).

part of this output is consumed (*C*) by the workforce, and the part that is not consumed (i.e., saved) is invested in physical capital (*I*). As will be explained, investment is mediated by an absorptive capacity function (*G*), which determines the proportion of investment that can be transformed effectively in increases in the stock of physical capital. The expansion of the stock of physical capital helps to increase output in the next period, and so on. In an open economy, a share of output takes the form of net exports (*XN*) (i.e., the difference between exports and imports), and its sign means either an increase or a decrease in foreign debt (*D*), whose dynamics also depends on the international interest rate (*R*).

In Appendix B, we provide additional details for our growth model.

Figure 3.1: the growth model in a snapshot



Source: Authors' elaboration.

In mathematical terms, our model can be presented as follows.

Production Function

Output Y_t is produced using physical capital K_t and labor L_t as inputs, given the stock of technology A_t (equation (3.1)). The production function is Cobb-Douglass with constant returns to scale (i.e., factor shares add up to one), and technical change increases the efficiency of labor (i.e., it is labor augmenting, or Harrod-neutral). Mathematically,

(3.1) $$Y = K_t^{\alpha}(A_t \cdot L_t)^{1-\alpha}$$

where

Y_t = output

K_t = physical capital

L_t = labor

A_t = stock of technology

α = capital share

Physical Capital Accumulation

The accumulation of physical capital is given by equation (3.2). In general, it is not feasible to increase the capital stock in large proportions within a given period of time, particularly in a developing country such as Haiti. In fact, this is consistent with our previous discussion regarding inefficiencies in investment (see Section 2). Thus, from a modeling perspective, it is necessary to constrain how much investment can be transformed into effective additions to the capital stock within a single time period. To that end, we implement the concave absorptive capacity function shown in equation (3.3).[4] Figure 3.2 shows some examples; the forty-five degree line represents the case of perfect absorption, while the other two lines show functions with different asymptotic value parameters (μ=0.5 and μ=1). In the figure, we can see that, when μ=0.5, increases of the physical capital stock beyond 50% within a year will likely be impossible, no matter how much investment is made since the absorptive capacity of the economy would be saturated.

(3.2) $\dot{K}_t = G_t - \delta \cdot K_t$

(3.3) $G_t = \mu \cdot K_t \left(1 - \left(1 + \frac{\varepsilon \cdot I_t}{\mu \cdot K_t}\right)^{-\frac{1}{\varepsilon}}\right)$

where

δ = rate of depreciation of the physical capital stock

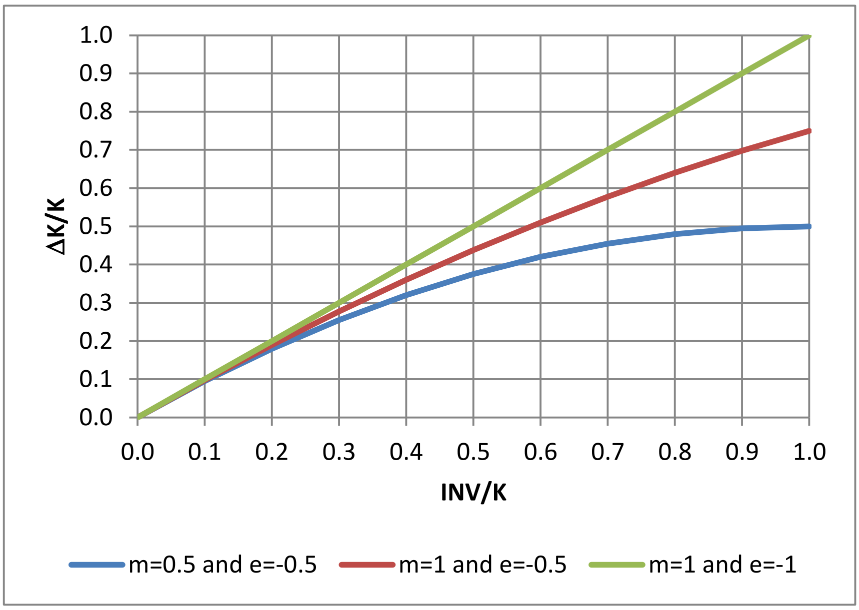
G_t = absorptive capacity

μ; $\mu \geq 0$= parameter that controls the asymptotic value of G_t

[4] This function was first introduced by Kendrick and Taylor in their pioneering dynamic multi-sectoral growth model (Kendrick and Taylor, 1970; Mercado et al., 2003); for a discussion and its parametrization see Mercado and Cicowiez (2013).

$\varepsilon; -1 \leq \varepsilon \leq 1$ = parameter that controls the curvature absorptive capacity function

Figure 3.2: absorptive capacity function



Source: Authors' elaboration.

Foreign Debt Accumulation and Foreign Debt Constraint

The foreign debt D_t stock evolves according to equation (3.4), where the term $r \cdot D_t$ represents interest payments.[5] However, given our model parameterization (specifically, see the rate of time preference and the elasticity of intertemporal substitution in Table 3.1 below), assuming that Haiti has an unrestricted access to foreign borrowing would imply that the debt stock D_t grows indefinitely. Consequently, we impose an upper bound to the debt-to-output ratio, an indicator commonly used to characterize the debt burden of a given country (see equation (3.5)). In our model, a large inflow of foreign grants can be rationalized as foreign borrowing at (very) low interest rate. In other words, although Haiti receives significant amounts of foreign funds regardless of its country risk premium, we assume that lenders do impose rationing by quantity. Technically, the model will display two

[5] Strictly speaking, D_t should account for the resident's stock of net assets. However, here it is interpreted in a more restricted way as the country's foreign debt.

different intertemporal dynamics, depending on whether the foreign debt constraint is binding or not.[6]

(3.4) $\dot{D}_t = r \cdot D_t - NX_t$

(3.5) $\frac{D_t}{Y_t} \leq \chi$

where

r = international interest rate

NX_t = net exports

χ = upper bound to the debt-to-output ratio

Intertemporal Welfare

Thus far, we presented the production and accumulation equations that characterize the dynamics of the economy. Now, we need an optimization criterion to consider the intra- and inter-temporal tradeoffs implicit in the many possibilities of allocation of resources in this economy. To that end, and following the standard procedure in growth models, we set as the optimization criterion the maximization of an additively separable inter-temporal welfare function W of the form shown in equation (3.6).[7]

(3.6) $W = \int_{t=0}^{\infty} \frac{\left(\frac{C_t}{L_t}\right)^{1-\theta} - 1}{1-\theta} \, e^{nt} \; e^{-\rho t} \; dt$

where

ρ = rate of time preference

n = labor force/population growth rate

$1/\theta$ = elasticity of intertemporal substitution

[6] See Mercado and Cicowiez (2013) for details and mathematical derivations.

[7] Thus, utility derives from consumption through a constant elasticity of substitution function. This functional form, together with the Cobb-Douglass form for the production function, ensures that the "canonical" form of the Ramsey-Cass-Koopmans model has a steady state.

Resource Constraint

Finally, a resource constraint establishes that within each time period output has to be equal to the sum of consumption, investment, and net exports (equation (3.7))

(3.7) $Y_t = C_t + I_t + NX_t$

In order to operationalize our growth model for Haiti, we need a consistent dataset similar to a (macro) social accounting matrix. Besides, we need estimates for the parameters that describe the inter-temporal welfare function.

For the production function in equation (3.1), we need (a) labor and capital share parameters, (b) labor and (initial) capital stocks, and (c) TFP growth rate. For labor and capital shares, they can be directly estimated from national accounts data, under the assumption that the social marginal products can be measured by observed factor prices. In fact, these shares are reported in a section of the national income and product accounts (NIPA) often referred to as the “functional distribution of income”. In our case, we computed labor and capital shares from the Haiti 2013 Social Accounting Matrix (SAM) described in Cicowiez and Filippo (2018), built using the supply and use tables for the same year as its main source of data. It is worth mentioning that our estimate for α takes into account the presence of a large number of non-salaried workers (i.e., “mixed income” within the NIPA), particularly in the agricultural sector. Overall, our 44.4 percent capital share is consistent with those reported by Gollin (2002) for a set of developing countries.

For capital stock and TFP growth, we used the results from the growth accounting exercise for Haiti in Section 2. Specifically, we implemented the perpetual inventory method (PMI) using NIPA data on investments as its main source of data. In addition, we considered the impact of natural disasters and inefficiencies in the accumulation process when implementing the PIM for Haiti. It is interesting to note that inefficiencies in the capital accumulation process are captured in our long-term growth model through the absorptive capacity function described in equation (3.3). In short, for K_0 we used the capital-to-GDP ratio of 2.5 estimated in Section 2. For the TFP, we estimated a growth rate of one percent during the 70s. However, for periods other than the 70s, the estimated TFP growth rate is negative. Thus, our base case assumes a TFP growth rate of 0.28 percent, consistent with a

GDP growth rate of 1.5 percent. Finally, the size of the labor stock was estimated using census (population size) and household survey data (participation rate).

For the intertemporal welfare function in equation (4.6), we need estimates for the elasticity of intertemporal substitution (EIS) and the rate of time preference. The EIS reflects the sensitivity of consumption (and therefore savings) to changes in intertemporal prices (i.e., the consumption interest rates), with higher values indicating greater sensitivity. In Ogaki et al. (1996), the EIS is estimated for 85 countries, including Haiti. In turn, the rate of time preference or, equivalently, the discount factor, describes the preference for present consumption over future consumption. In this case, we do not have estimates for Haiti. Thus, based on a literature review, we assign a value of 0.03 to ρ.

In the model (and in reality), external imbalances are matched with changes in the stock of foreign assets. In calibrating the model, we assume that Haiti is a relatively impatient country. Specifically, we assume a rate of time preference and an elasticity of intertemporal substitution equal to 0.03 and 0.43, respectively. Besides, we impose an upper limit to the debt-to-GDP ratio that can be considered as a real-world restriction as imposed by the Debt Sustainability Framework of the IMF/WB. Most importantly, our long-run baseline scenario assumes that the annual growth rate for TFP is 0.28 percent, which is consistent with the long-run GDP growth rate of 1.5 percent discussed above. Table 3.1 shows all model parameters and initial conditions.

Table 2.1: Haiti growth model parameterization

Symbol	**Description**	**Value**	**Source**
θ	inverse elast of intertemporal subst	2.2990	Reinhart et al. (1996)
ρ	rate of time preference	0.0300	literature review
α	capital share	0.4440	Social Accounting Matrix in XXX
n	labor force/population growth rate	0.0100	UN (2015) for period 2015-2050
g	total factor productivity growth rate	0.0028	based on TFP growth rate during the 70s
δ	capital depreciation rate	0.0500	literature review
μ	asymptotic value absorptive capacity fn	0.5000	literature review
ε	curvature absorptive capacity fn	1.0000	literature review
r	foreign interest rate	0.0300	literature review
Y_0	GDP in 2013 (mill gourdes)	364,526	National Accounts
K_0	capital stock in 2013 (GDP share)	2.5	Section 2
L_0	labor force in 2013 (# persons)	4,489,196	World Bank WDI
D_0	foreign debt stock in 2013 (GDP share)	18.4	World Bank WDI

Source: Authors' elaboration.

Scenarios

In this section, we present illustrative simulations related to the questions regarding the very long-run growth dynamics raised in the introduction to this paper. Each simulation includes 150 periods, which can be interpreted as annuals. From a mathematical point of view, our intertemporal growth model is a system of differential equations that presents what is known as a "two point boundary value problem". Thus, its numerical solution requires the simultaneous imposition of initial and terminal conditions. In this application, initial and terminal conditions sufficient to solve it are given by the values 5.1 and 10 of the capital stock in efficiency units, respectively.[8] In gourdes of 2013, the initial value for the capital stock is the one estimated in Section 2. In turn, the terminal value is obtained from analytically solving the steady-state of the model with optimal control techniques.

Now, we turn to assessing long-run growth scenarios for Haiti. First, we present a base case, parameterized according to the data in Table 2.1 above, with a TFP growth rate equal to 0.28 percent, a population growth rate equal to one percent, and international interest rate equal to three percent. In the simulations, under these assumptions, the economy converges to its steady-state in about 100 periods or years.

In addition, the steady state growth rate and capital-to-output ratio are 1.5 percent and 4, respectively. Thus, we see that the starting capital-to-output ratio of 2.5 -- derived in Section 2 after introducing adjustments related to natural disasters and inefficiencies in investment -- is well below its steady-state value of 4.

Next, we assess the following three non-base scenarios:

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[8] In efficiency units, given our assumption of Harrod-neutral technical change, each variable X_t is expressed as $x_t = \frac{X_t}{A_t L_t}$, where A_t and L_t are the efficiency parameter in the production function and the labor force, respectively. Also, note that the steady state conditions that are used as terminal conditions for the simulations were analytically derived from the first order conditions of the model. In doing so, we considered the corresponding transversality conditions assuming that (a) $r > n + \lambda$ to avoid an unbounded welfare intertemporal integral, and (b) $r \leq \rho + \lambda\theta$ to avoid an accumulation of foreign assets that would violate our assumption that Haiti is a small open economy.

- tfpgrw = increase in TFP growth by 0.5 percentage points, based on the TFP growth rates achieved by other developing countries CGE simulations reported in the previous section; and
- debconst = decrease in the foreign financing constraint, from 60 to 30 percent of output.
- abscap = improvement in absorptive capacity, by increasing the value of the μ parameter to 1; i.e., doubling the parameter that defines the asymptotic value in the absorptive capacity function.

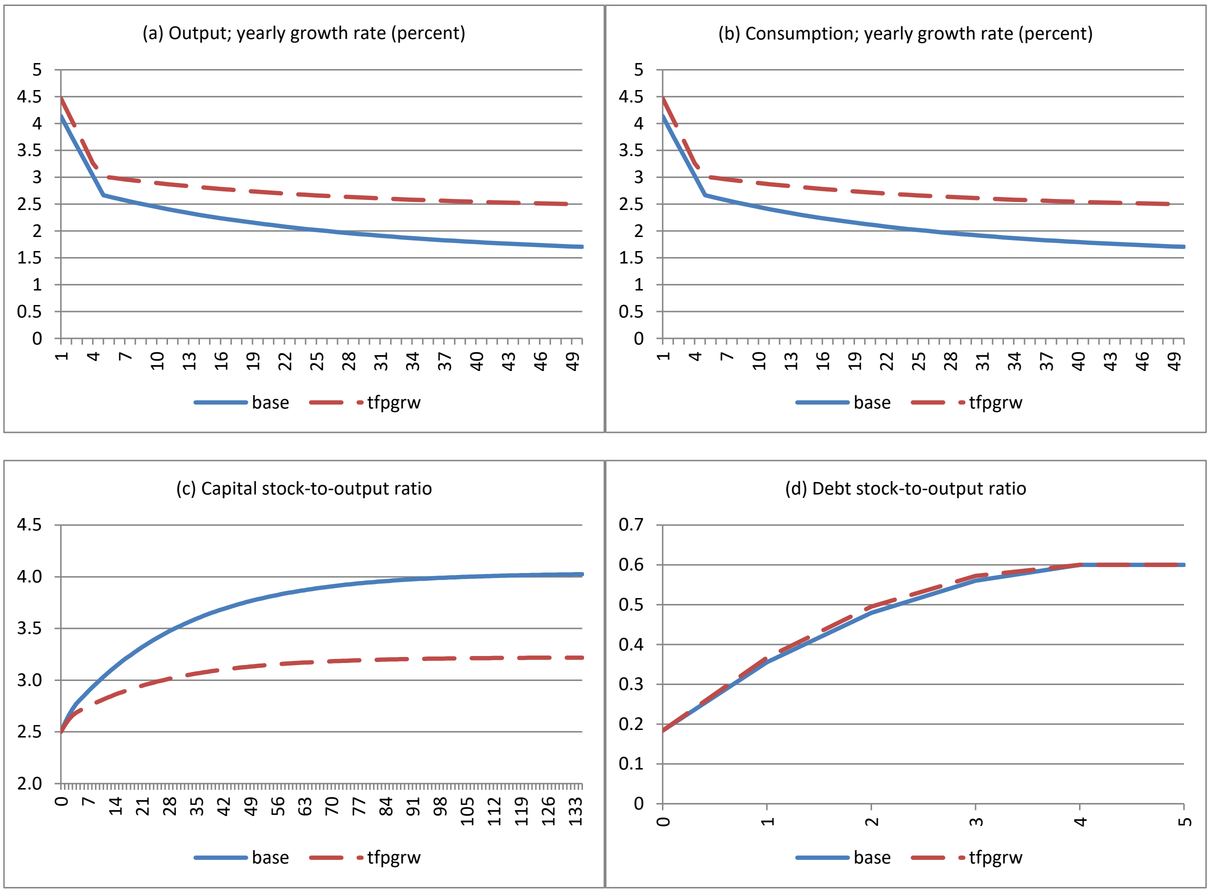
In order to obtain our results, we run the model for 150 periods. However, in what follows we report the results for the first 50 periods, which are enough to show the transitional dynamics from the initial conditions shown in Table 2.1 to the steady state. As expected, we see that the economy converges asymptotically to the steady state. The transition is monotonic. The growth rate is positive and decreases over time towards zero if k<kss. Similarly, the rate of per-capita consumption growth $\frac{c_{t+1}}{c_t}$ (i.e., in efficiency units) is positive and decreasing over time and converges monotonically to zero. Alternatively, the steady state growth rate of per capita output is equal to growth rate of technological change. For each non-base simulation, we report figures for the yearly growth rate for output consumption and the capital-to-output and debt-to-output ratios.

In Figure 3.1 (see panels a and b), we can see that the increase in TFP growth implies an increasing divergence between the base and non-base levels of output and consumption (i.e., the growth rate is higher under tfpgrw). For example, when TFP growth increases from 0.28 percent (base scenario) by half percentage point (tfpgrw scenario), after 35 periods this results into a difference of about 20 percent in output and consumption per capita. Alternatively, in the base and tfpgrw scenarios, it would take Haiti more than 250 and about 129 periods to reach the current level of Dominican Republic GDP per capita, respectively. (In 2013, the per capita GDP at PPP of Haiti and Dominican Republic were $1,684 and $12,325, respectively.)

In terms of the capital-to-output ratio, we see an inverse relationship with TFP growth. Of course, this reflects the well-established result that, the higher the TFP growth, the lower the savings and investment effort required to attain a given level of welfare. In panel (d) of

Figure 3.1, we show the dynamics of the debt stock-to-output ratio. In all cases, we see that the credit constraint is reached relatively quickly; this result reflects that the effective rate of time discount of Haiti is greater than the interest rate. In other words, Haiti is a relatively "impatient" country.

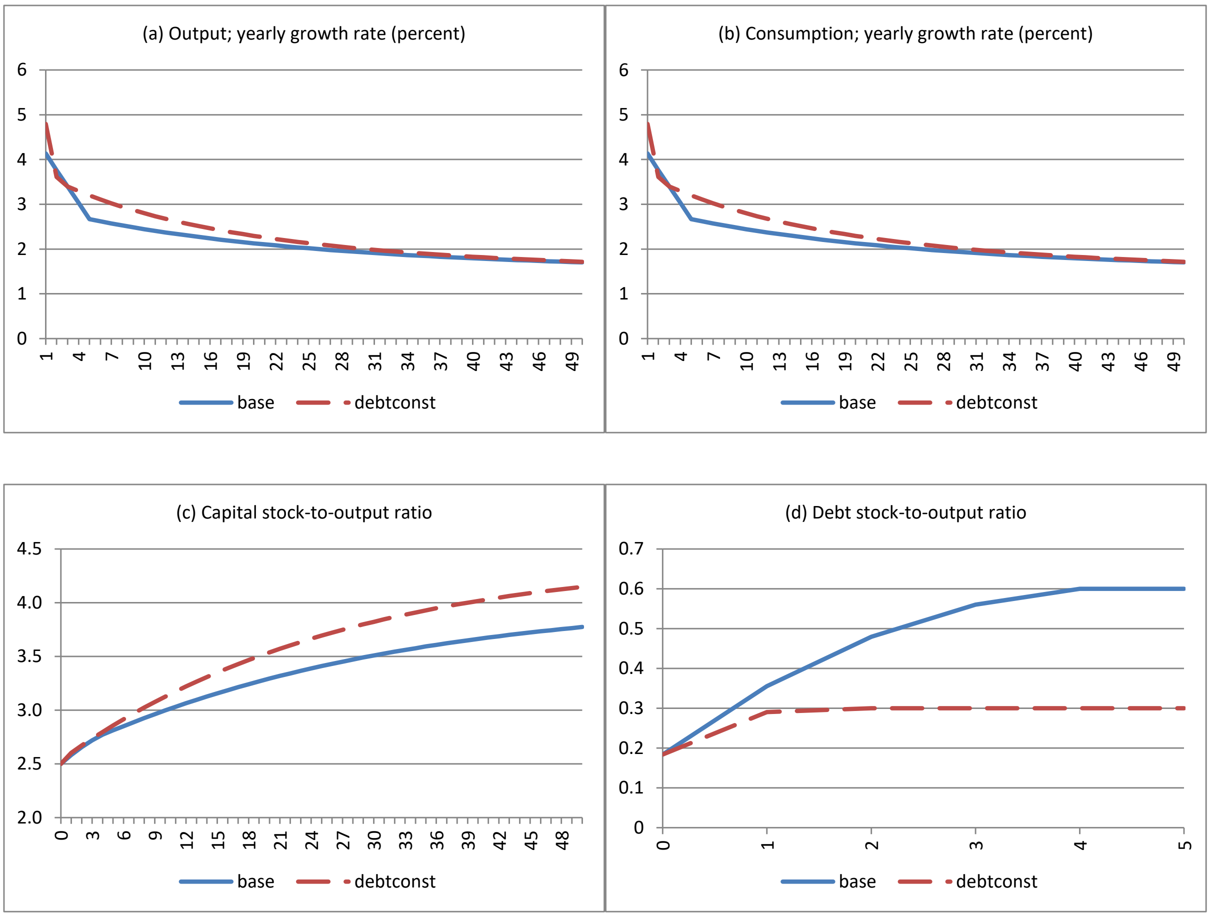
Figure 3.1: results for the TFP growth scenario



Source: Authors' calculations based on simulation results.

Next, we explore the results from the other non-base scenario. In Figure 3.2 we show the results of tightening the constraint on the debt stock-to-output ratio, from 60 to 30 percent. In principle, this scenario could be interpreted, in a rough manner, as a decrease in foreign aid and/or international remittances from migrants. In fact, according to recent projections, it is expected that foreign aid to Haiti will decrease during 2016-2020 relative to the amounts registered during 2010-2015 (Filippo, 2017). As a result of the shock, the effort required in terms of domestic savings and investment increases, which is reflected in a higher capital-to-output ratio (see panel c). Interestingly, the increase in capital accumulation reflects the need to increase the domestic production capacity given the tightened constraint to finance imports from the rest of the world. Also, driven by the larger capital stock, the growth rates of income and consumption are a bit higher during the transitional dynamics. In fact, since it is an “impatient” country, while the constraint is not binding, it will borrow more from abroad in order to have a high level of consumption early on.

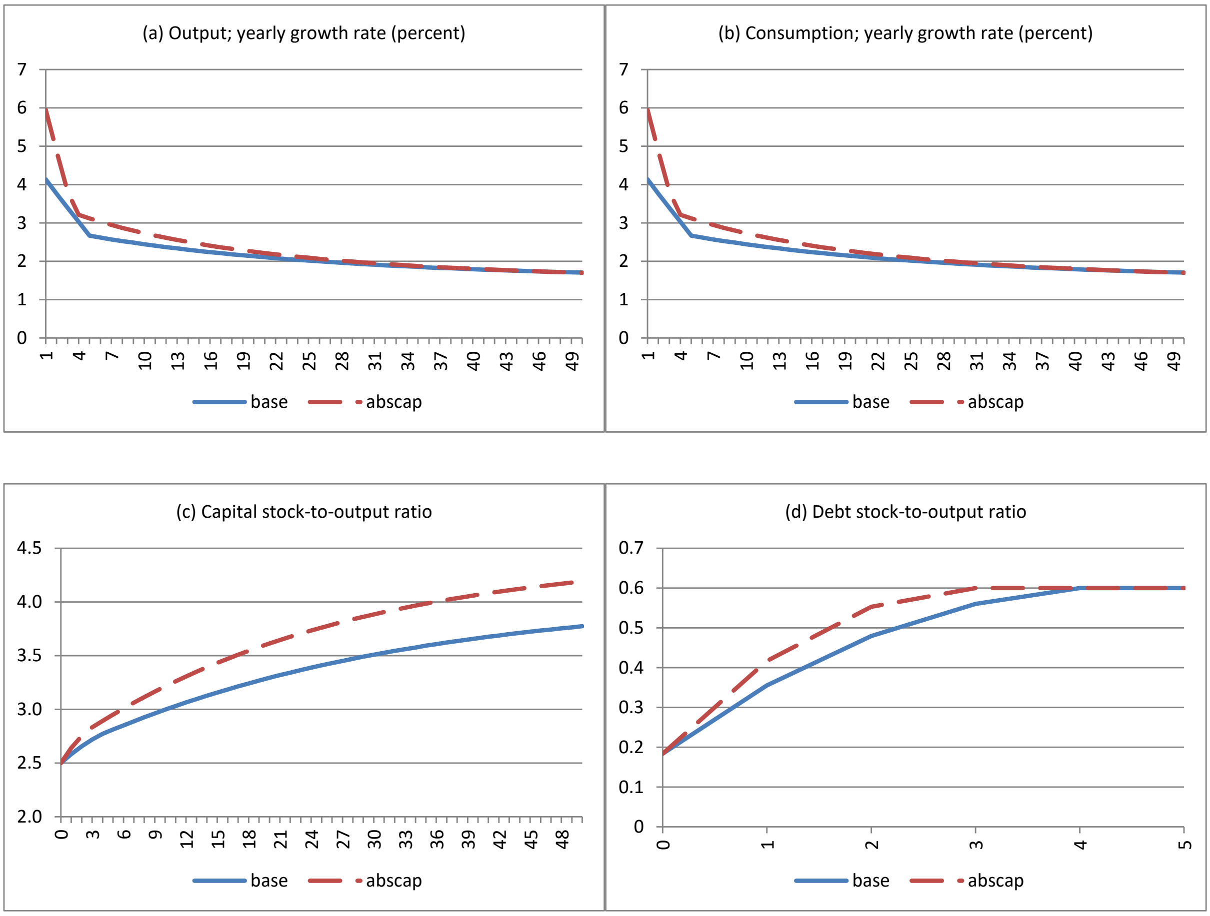
Figure 3.2: results for the debt constraint scenario



Source: Authors’ calculations based on simulation results.

Lastly, we examine the effect of a substantial improvement in the absorptive capacity of capital, which could be interpreted as a significant improvement in physical and institutional infrastructure or management capacity (see Figure 3.3). In this case, the transitional dynamics show a higher growth rate. In other words, with an improvement in the absorptive capacity as defined above, Haiti can accumulate capital faster and thus reaches its steady-state in a shorter period of time, and with a higher capital-to-output ratio.

Figure 3.3: results for the absorptive capacity scenario



4. Concluding Remarks

In this study, we presented a simple and highly stylized model to perform basic counterfactual exercises on the very long-term growth of the Haitian economy. Indeed, with a relatively simple structure, the model allows to perform a series of counterfactual exercises in an orderly and consistent manner. Model simulations can accommodate changes in the following exogenous variables and parameters: population growth, TFP growth, international interest rate, absorptive capacity of the capital, intertemporal discount rate, intertemporal elasticity of substitution, and GDP shares of labor and capital. In this paper, we have presented some possible exercises, but a number of extensions or combinations among them would not be difficult to implement.In a recent study, Cavallo and Powell (2018) find that countries in Latin America and the Caribbean should focus on factors that accelerate investment and enhance productivity growth. By doing so, countries in the region will achieve a more encouraging economic outlook in the medium and long term. More specifically, the authors suggest that the reduction of economic frictions and distortions, tax reforms that promote growth of more productive economic units, and emphasis on efficient and sustained public capital expenditures are key ingredients of the appropriate growth policy.

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Appendix A: The Complete Model in Efficiency Units[9]

In this appendix, we show all model's variables and equations transformed into their intensive form[10], and we eliminate time subscripts to save notation.

A.1) Max $W = \int_{t=0}^{\infty} \frac{c^{1-\theta}-1}{1-\theta} e^{-vt} \; dt$

subject to the accumulation equations

A.2) $\dot{k} = g_k - \gamma_k k$ A.3) $\dot{h} = g_h - \gamma_h h$ A.4) $\dot{d} = \varphi d - nx$

and the resource and foreign debt constraints

A.5) $y = c + i_k + i_h + nx$

A.6) $\frac{d}{y} \leq \chi$

given the production function

A.7) $y = k^{\alpha} \, h^{\beta}$

and the concave absorptive capacity functions

A.8) $g_k = i_k \left(1 + \frac{1}{m_k} \frac{i_k}{k}\right)^{-1}$ A.9) $g_h = i_h \left(1 + \frac{1}{m_h} \frac{i_h}{h}\right)^{-1}$

and where

[9] This appendix draws heavily from Mercado and Cicowiez (2013).

[10] Given the assumption of Harrod-neutral technical change, each variable X_t is transformed such that

$$x_t = \frac{X_t}{A_t L_t}$$

where A_t and L_t are the efficiency and the stock of labor respectively. By the same token, each variable $\dot{X}_t$ becomes

$$\dot{x}_t + x_t \,(n + \lambda)$$

where n is the population growth rate and λ is the growth rate of the efficiency of labor. Finally, the expression

$$\left(\frac{C_t}{L_t}\right)^{1-\theta}$$

becomes $c_t^{1-\theta} A_0^{1-\theta} e^{\,\lambda\,(1-\theta)t}$, where A_0 is not relevant since it's a constant.

A.10) $v = \rho - n - (1-\theta)\lambda$

A.11) $\gamma_k = \delta_k + n + \lambda$

A.12) $\gamma_h = \delta_h + n + \lambda$

A.13) $\varphi = r - n - \lambda$

with initial conditions

A.14) $k_0 = \bar{k}$

A.15) $h_0 = \bar{h}$

A.16) $d_0 = \bar{d}$

and transversality conditions

A.17) $\lim_{t\to\infty} \mu_1 \, k \;\; e^{-vt} = 0$

A.18) $\lim_{t\to\infty} \mu_2 \, h \;\; e^{-vt} = 0$

A.19) $\lim_{t\to\infty} \mu_3 \, d \;\; e^{-vt} = 0$

and where, from A.7, A.8 and A.9, we have the following derivatives:

A.20) $\frac{\partial y}{\partial k} = \alpha k^{\alpha-1} h^{\beta}$

A.21) $\frac{\partial y}{\partial h} = \beta h^{\beta-1} k^{\alpha}$

A.22) $\frac{\partial g_k}{\partial i_k} = \left(1 + \frac{1}{m_k}\frac{i_k}{k}\right)^{-2}$

A.23) $\frac{\partial g_h}{\partial i_h} = \left(1 + \frac{1}{m_h}\frac{i_h}{h}\right)^{-2}$

3.24) $\frac{\partial g_k}{\partial k} = \frac{1}{m_k}\left(\frac{i_k}{k}\right)^2 \left(1 + \frac{1}{m_k}\frac{i_k}{k}\right)^{-2}$

3.25) $\frac{\partial g_h}{\partial h} = \frac{1}{m_h}\left(\frac{i_h}{h}\right)^2 \left(1 + \frac{1}{m_h}\frac{i_h}{h}\right)^{-2}$

In addition, given the model calibration, we assume that condition $r < n + \lambda$ applies, otherwise the intertemporal welfare integral will be unbounded; and condition $r \leq \rho + \lambda\theta$ applies also, otherwise the country would eventually accumulate enough assets to violate the small economy assumption.