Econometric Estimation of the Capital Stock and the Production Function: The Case of the Bahamas, Barbados, Jamaica, and Suriname

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Gerardo Reyes-Tagle

IDB

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Abstract

Most studies of total factor productivity (TFP) and long-term production functions use capital stock time series obtained from ad hoc estimates of the rate of depreciation and the initial capital stock. This paper introduces a methodology that allows the simultaneous econometric estimation of the capital stock, the production function parameters, the rate of depreciation, and the initial capital stock. The proposed methodology, using the underlying cost function to the production function, allows for the incorporation of information about the relative prices of the factors of production and the possibility of having variable depreciation rates over time. The proposed methodology is applied to the case of the Bahamas, Barbados, Jamaica, and Suriname for the period 1989–2019 using national accounts data published by the statistical services of these countries.

JEL Classification: C01, C36, D24, E23, O47, O54
Keywords: Cobb-Douglas, TFP, capital stock

Acronyms

GDP	Gross domestic product
GMM	Generalized method of moments
IMF	International Monetary Fund
PIM	Perpetual inventory method
PWT	Penn World Table
TFP	Total factor productivity

1

Introduction

In its most basic concept, total factor productivity (TFP) can be defined as the portion of output that cannot be explained by the number of inputs used in production. The ratio gives us information about how much progress the economy of a country is making, relative to the number of hours worked by the workforce and the number of machines or equipment used by the economy. As the economy becomes more efficient in the mix of units of labor per unit of machines, that is what we understand as improvements in TFP.

Many economies in the Latin American and Caribbean (LAC) region experienced a deep economic downturn because of the COVID-19 pandemic. Rising concerns over the impact of the growth slowdown have produced an increasing number of papers centering on the long-term consequences of a global impact such as the global economic crisis of 2008 or the most recent health crisis. In the process, researchers have been paying keen attention to the issues of severe slowdown in growth and productivity in middle-income countries.

This paper contributes to the literature using a novel methodology for the estimation of capital stock and TFP without resorting to long time series of gross domestic product (GDP) and gross fixed investment as traditional methods do. This methodology is applied to the Caribbean countries in a standardized form. Caribbean countries do not in general have reliable national accounts for years before 1990 and the reliability of the national account decreases the further back in time one goes.

Traditional methods of measuring TFP rely on non-econometric ad hoc assumptions about the depreciation rate and the initial value of the capital stock; hence, the estimation of TFP becomes a highly subjective procedure. The methodology proposed in this paper removes the subjectivity of the estimation process and estimates the initial capital stock and the depreciation rate by standard econometric techniques. The estimation procedure estimates these parameters along with the other parameters of the underlying production function, namely the elasticity of factor substitution and the TFP parameter.

An economy grows in proportion to its capacity to produce more. In that sense, capital stock, labor force, and TFP are key economic aggregates used in the estimation of long-term production functions that define a country's potential GDP. Estimating TFP is an important tool in assessing a country's past and potential economic performance and its estimation depends heavily on the measurement of the capital stock.

However, the direct measurement of the capital stock is a difficult task.[1] For starters, national accounts generally do not report series for capital stock, so it is usually estimated through the perpetual inventory method (PIM). The PIM consists of using the following equation that describes the accumulation of capital:

$$K_t = (1 - \delta_t)\, K_{t-1} + I_t \qquad (1)$$

or its alternative form:

$$K_t = \left\{\Pi_{j=0}^{t}\left(1-\delta_t\right)^j\right\}K_0 + \sum_{i=0}^{t-1}\left\{\Pi_{j=0}^{t}\left(1-\delta_t\right)^j\right\} I_{t-i} \qquad (2)$$

where K_t is the unobserved capital stock at the end of year t; K_0 is the unknown stock at the end of the initial period; δ_t is the rate of depreciation of assets or consumption of capital during the year t; and I_t is the flow of gross fixed investment in period t.

In an International Monetary Fund (IMF) working paper by Thacker, Acevedo, and Perrelli (2012), the physical capital stock for a selected list of Caribbean countries is constructed using investment data from Penn World Table (PWT) and applying the PIM. Average depreciation is assumed to be 6 percent per year over the period. However, given that the region suffers from the recurrence of natural disasters that may destroy the capital stock, the time series is adjusted for years in which there were major hurricanes that inflicted considerable damage to the islands.

In the case of Barbados, a study by Dowling et al. (2016) uses data for capital stock from PWT. In a related study published by IMF (2010), El-Masry and Shui assume a share of labor income in total Value Added of 65 percent and the capital stock was estimated according to the PIM assuming a constant depreciation rate of 5 percent per year and using investment data for the period 1980–2010.

The common denominator of these studies is that the depreciation rate is assumed to be constant, and it is not estimated by econometric methods. Instead, depreciation rates are defined in an ad hoc manner, by weightings of hypothetical sectoral depreciation rates, or by reference to studies of similar countries or previous studies.

Something similar happens with the calculations of the initial capital stock (K_0). In all these studies, K_0 is estimated not through an econometric method but by making assumptions about the capital/product ratio for the initial year or alternatively using the implied balance of long-term conditions associated to the PIM and defined in the following equation:

$$K_0 = I_1 / (g + \delta) \qquad (3)$$

where "g" is the equilibrium long-term GDP growth rate.

Based on ad hoc estimates of the capital stock, the authors mentioned above, using

[1] Capital stock is the value sum of many different capital goods produced at different times. The aggregation of all these different goods is a difficult task. Most developing countries do not publish series on the capital stock. In the case of the Bahamas, Barbados, Jamaica, and Suriname, there are no official series on the capital stock in their national accounts.

the Cobb-Douglas production function as a theoretical frame of reference, estimate the elasticity of capital and the elasticity of labor. The Cobb-Douglas production function has the following specification:

$$Y_t = A\ K_{t-1}\alpha L_t^{(1-\alpha)} \qquad (4)$$

where "A" and "α" are the parameters of the production function with returns to scale constant and equal to 1.[2] The parameter "A" corresponds to the TFP and "σ" corresponds to the elasticity of the capital factor of the Cobb-Douglas production function.

The use of econometric techniques, such as cointegration for the estimation of the elasticity of the capital, is also used as an alternative to TFP estimation. Based on a sample of 13 EU countries for the period 1995–2016, Borović, Rebić, and Tomaš (2020) estimate the TFP for the selected countries to determine the existence of cointegration between the TFP and its main drivers. Ladu (2008) looks at the economic performance of European regions' economies and computes the TFP using a panel cointegration approach. However, these studies, like the others, calculate the capital stock independently of the production function used in the estimation of the elasticity of capital. Therefore, they introduce a level of subjectivity in the estimation process of the elasticity of capital.

To remedy these shortcomings, this document introduces a methodology that allows for simultaneously estimating parameters that define K_0, δ, and the parameters of the production function (A and α). This methodology was introduced by Nadiri and Prucha (1993) and Prucha (1995) to estimate a time-varying depreciation rate in the context of a production function. Our methodology extends the results of Prucha to the case of the underlying "cost function," the dual of the production function. It allows for incorporating into the estimation process information about relative prices of the factors of production. Our methodology allows the introduction of the relative prices of production factors to the simultaneous econometric estimation of the unobserved capital stock and the underlying parameters of the production function. It also allows the use of shorter time series for GDP and fixed investment since the initial capital stock is estimated as an additional parameter of the econometric estimation process.

This paper has seven sections, the first of which is the present introduction. Section 2 presents the methodology used for the simultaneous estimation of the parameters that define the capital stock and the production function. Section 3 presents a short review of the data used in the study. Section 4 presents the set of simultaneous equations together with the specification of time-varying depreciation rates used for the estimation in Eviews using the generalized method of moments (GMM). Section 5 presents the estimation results of capital stock and Cobb-Douglas production function parameters for the Bahamas, Barbados, Jamaica, and Suriname. In Section 6, the results of Section 5 are used to estimate the evolution of the TFP for the period 1989–2019. Finally, Section 7 presents some conclusions and suggestions for future research.

[2] Public capital is not considered an independent factor of production in the Cobb-Douglas specification due to lack of data on its factor cost.

2

Methodology

The simultaneous econometric estimation of the capital stock together with the parameters of the production function corresponds to a problem of estimation with non-observable variables. In our case, this is equivalent to an iterative process in which one defines initial values for the depreciation rate and the capital stock in the initial period and from these values capital stock time series are estimated by the PIM. The production function parameters are then estimated from the capital stock and the time series of the labor force. Repeating this process for different values of the rate of depreciation and initial capital stock, one can estimate the parameters of the production function together with the depreciation rate and the stock of initial capital under standard econometric estimation methods.

The methodology to be used is a modification of the method suggested by Prucha (1995) to estimate a constant rate of depreciation. Modifications to Prucha's method essentially consist of modifying the specification of the estimation model for one that allows the characterization of time-varying depreciation rates and using the cost of production function (dual) rather than the underlying production function (primal).

.Consider a production function characterized by the following relation,

$$Y_t = F(K_{t-1}, L_t, \theta) \qquad (5)$$

where Y_t represents the GDP; K_{t-1} is the capital stock at the end of period t-1; L_t represents the labor force at the end of the period t; and θ represents the vector of unknown parameters associated with the production function F. In the specific case of the Cobb-Douglas production function with constant returns to scale, the expression (5) becomes

$$Y_t = A\, K_{t-1}^{\alpha}\, L_t^{\beta}$$

where $\theta = [A, \alpha, \beta]$

According to the principle of duality, the maximization of profits has its dual equivalent in the minimization of factor costs. Therefore, expression (5) has its dual equivalent in the following cost function,

$$Y_t = C(q_t, w_t, Y_{t,} \theta) \quad (7)$$

where q_t is the relative price of capital factor in relation to the GDP deflator; w_t is the relative price of labor in relation to the GDP deflator; and θ is the same vector of parameters associated with the production function. In the specific case of the function of Cobb-Douglas production with constant returns to scale equal to 1, expression (7) becomes

$$Y_t = A^* \ q_t^{\alpha/(\alpha+\beta)} w_t^{\beta/(\alpha+\beta)} Y_t^{1/(\alpha+\beta)} \quad (8)$$

where: $A^* = \left\{(\alpha+\beta)/\left[A \ \alpha^{\alpha}\beta \ \right]\right\}^{(1/(\alpha+\beta))}$

Using Shephard's lemma, we obtain expressions for the demand equations for the factors of production K_{t-1} and L_t from the cost function in (7).

$$K_{t-1} = \partial \ C(q_t, w_t, Y_{t,} \theta) \ / \ \partial \ q_t \quad (9)$$

$$L_t = \partial \ C(q_t, w_t, Y_{t,} \theta) \ / \ \partial \ w_t \quad (10)$$

In the case of the Cobb-Douglas production function, expressions (9) and (10) are equivalent to:

$$K_{t-1} = \left[A^*\alpha \, / \left(\alpha+\beta\right)\right] \ q_t^{-\beta/(\alpha+\beta)} w_t^{\beta/(\alpha+\beta)} Y_t^{1/(\alpha+\beta)} \quad (11)$$

$$L_t = \left[A^*\beta \, / \left(\alpha+\beta\right)\right] \ q_t^{\alpha/(\alpha+\beta)} w_t^{-\alpha/(\alpha+\beta)} Y_t^{1/(\alpha+\beta)} \quad (12)$$

The system of simultaneous equations represented in (11) and (12) allows one to estimate the technical parameters [A, α, β] of the Cobb-Douglas production function. However, the variable K_{t-1} and q_t are not explicitly observable but can be derived from the following equations

$$K_t = \left\{\Pi_{j=0}^{t} \ \left(1-\delta_t\right)^j\right\} K_0 + \sum_{i=0}^{t-1} \ \left\{\Pi_{j=0}^{t} \ \left(1-\delta_t\right)^j\right\} I_{t-1} \quad (13)$$

$$p_t^* \ Y_t = \ q_t^* \ K_{t-1} + w_t^* \ L_t \quad (14)$$

Equation (13) is the alternative version of the PIM, which allows us to express K_{t-1} as a function of the time series I_t, and the parameters K_0 and β.

$$p_t^* \ Y_t = \ q_t^* \ K_{t-1} + w_t^* \ L_t \quad (15)$$

The other non-observable variable, q_t is obtained from expression (14) that corresponds to the distribution of the current product, $p^* Y_t$ between the wage bill $w_t^* L_t$ and the operating surplus $q_t^* K_{t-1}$,

$$qt = [Y_t - w_t \ L_t] \ / \ K_{t-1} \quad (16)$$

where $q_t = q_t^* \ / \ p_t^*$ and $w_t = w_t^* \ / \ p_t^*$

Replacing expressions (15) and (16) in equations (11) and (12) and assuming constant returns to scale equal to 1 for the production function (α + β = 1), we obtain a system of equations with all its variables observable and therefore amenable for econometric estimation of its corresponding parameters A, α, K_0 and $\underline{\delta}$.

$$G_t\left(I_t, \ K_0, \ \underline{\delta}\right) = A^* \ \alpha \ \left\{\left(\left[Y_t - w_t \ L_t\right]\right) \ / \ G_t\left(I_t, \ K_0, \ \underline{\delta}\right)\right\}^{-(1-\alpha)} w_t^{(1-\alpha)} Y_t \quad (17)$$

$$L_t = A^* \ (1-\alpha) \ \left\{\left[Y_t - w_t \ L_t\right] / \ G_t\left(I_t, \ K_0, \ \underline{\delta}\right)\right\}^{\alpha} w_t^{-\alpha} Y_t \quad (18)$$

where: $A^* = 1 \ / \ [A \ \alpha^{\alpha} \ (1-\alpha)^{(1-\alpha)}]$

The system of equations (17) and (18) encompasses the information of the relative prices of the factors of production as well as the series of gross investment in a single frame of reference, allowing the simultaneous econometric estimation of the technical parameters of the production function and the parameters for the PIM.

However, the system of equations presents a practical problem for the traditional econometric packages. The problem originates in the time-varying nature of expression $G_t(I_t, K_0, \underline{\delta})$. It is time varying because one of the arguments (series I_t) changes in each period. If we take the expression of $G_t(I_t, K_0, \underline{\delta})$ (13) for the first periods we get

$K_0 = K_0$
$K_1 = (1 - \delta_1) K_0 + \delta_1$
$K_2 = (1 - \delta_1)(1 - \delta_2) K_0 + (1 - \delta_1) I_1 + I_2$
$K_3 = (1 - \delta_1)(1 - \delta_2)(1 - \delta_3) K_0 + (1 - \delta_1)(1 - \delta_2) I_1 + (1 - \delta_2) I_2 + I_3$

We can infer that the number of arguments for the time series I_t changes for each item in the series K_t. To solve this problem and to allow the system of equations (17) and (18) to be estimated with traditional econometric packages, it is necessary to transform the time series I_t in a set of dummy variables that will be equal to the number of available observations.

To achieve this transformation, we use the methodology introduced by Prucha (1997) and Hernández and Mauleón (2002). For simplicity, we assume that the rate of depreciation is constant to facilitate understanding of the method to be used for the estimation of the system of equations. However, the method can be generalized for the case of time-varying depreciation rate.

First, we define the following dummy variables as a function of the time series of gross investment I_t and each of them with dimension ((N + 1) x 1), where N is the number of observations.

$DI =_1 (0, I_1, I_2, I_3, \ldots, I_N)^T$
$DI_2 = (0, 0, I_1, I_2, \ldots, I_{N-1})^T$
.. ..
$DI_N = (0, 0, 0, 0, \ldots 0, I_1)^T$

Next, we define the vector of depreciation rates

$$\Delta = [1, (1-\delta), (1-\delta)^2, (1-\delta)^3, \ldots\ldots\ldots\ldots, (1-\delta)^{N-1}, (1-\delta)^N]^T \qquad (19)$$

From the auxiliary variables DI_1, DI_2, ...DI_N and the vector of depreciation rates □□ we can express the series of capital stock in matrix form

$$\begin{bmatrix} K_0 \\ K_1 \\ K_2 \\ . \\ . \\ . \\ K_{N-1} \\ K_N \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & \cdot\ \cdot & 0 & 0 \\ I_1 & 0 & 0 & \cdot\ \cdot & 0 & 0 \\ I_2 & I_1 & 0 & \cdot\ \cdot & 0 & 0 \\ . & . & . & . \ . & . & . \\ . & . & . & . \ . & . & . \\ . & . & . & . \ . & . & . \\ I_{N-1} & I_{N-2} & I_{N-3} & \cdot\ \cdot & I_1 & 0 \\ I_N & I_{N-1} & I_{N-2} & \cdot\ \cdot & I_2 & I_1 \end{bmatrix} \begin{bmatrix} 1 \\ (1-\delta) \\ (1-\delta)^2 \\ . \\ . \\ . \\ (1-\delta)^{N-1} \\ (1-\delta)^N \end{bmatrix} + K_0 \begin{bmatrix} 1 \\ (1-\delta) \\ (1-\delta)^2 \\ . \\ . \\ . \\ (1-\delta)^{N-1} \\ (1-\delta)^N \end{bmatrix} \qquad (20)$$

With this new characterization

$K_t = G(DI_1, DI_2, DI_3, \ldots, DI_N, K_0, \delta)$

and its structure G (.) that no longer depends on time, the number of variables is the same for each period and its parameters can be estimated as a system of simultaneous equations by traditional econometric packages.

In the case of time-varying depreciation rates, the vector Δ in (19) becomes,

$$\Delta = [1, (1-\delta_1), (1-\delta_1)(1-\delta_2), (1-\delta_1)(1-\delta_2)(1-\delta_3)^3, \ldots\ldots\ldots\ldots, (1-\delta_1)\ldots(1-\delta_{N-1})^{N-1} (1-\delta_N)^N]^T$$

3

Data Sources

The data used in the estimation were taken from the national accounts published by the statistical service of each country. Time series for the period 1989–2019 for each country were identified for the following variables:

a. Real Gross Value Added in millions of constant national currency
b. Nominal Gross Value Added in millions of current national currency
c. Real Gross Fixed Investment in millions of constant national currency
d. Employment in thousands of workers employed
e. Wage bill in millions of current national currency
f. Operating surplus in millions of current national currency

The Bahamas

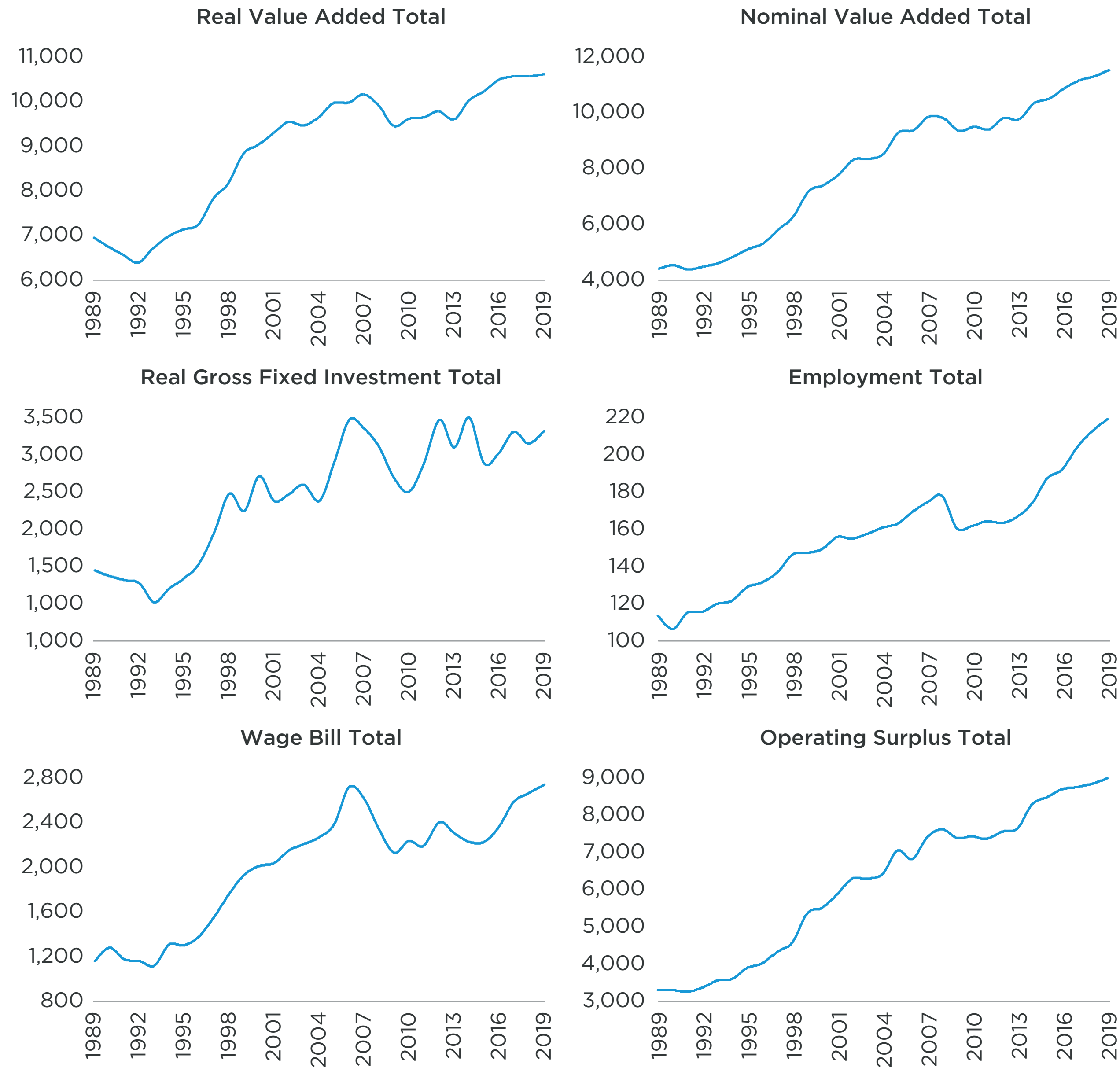
Data for the Bahamas has been obtained from the national accounts report[3] published by the Department of Statistics. The base year for the national accounts is 2012 and the time series cover the period 1989–2019. Value Added figures have been used instead of GDP to deduct indirect taxes on production. In Figure 1, time series are expressed in millions of Bahamian dollars except Employment, which is expressed in thousands of employees.

Operating Surplus was obtained as the difference between Nominal Value Added and the Wage Bill. Two additional variables were derived from these time series: (i) Potential Real Value Added and (ii) Capital Utilization. Potential Real Value Added is obtained using the Hodrick-Prescott filter with Lambda = 100. The Capital Utilization factor is obtained as the ratio between Real Value Added and Potential Real Value Added. The values of each time series are presented in the Appendix.

[3] https://www.bahamas.gov.bs/wps/wcm/connect/a0afefb1-1e86-4b16-953a-c91f0909322a/National+Accounts+Annual+Report+2019.pdf?MOD=AJPERES.

FIGURE 1

The Bahamas (in millions of 2012 B$ and thousands of employees)



Source: National Accounts Bahamas Department of Statistics.

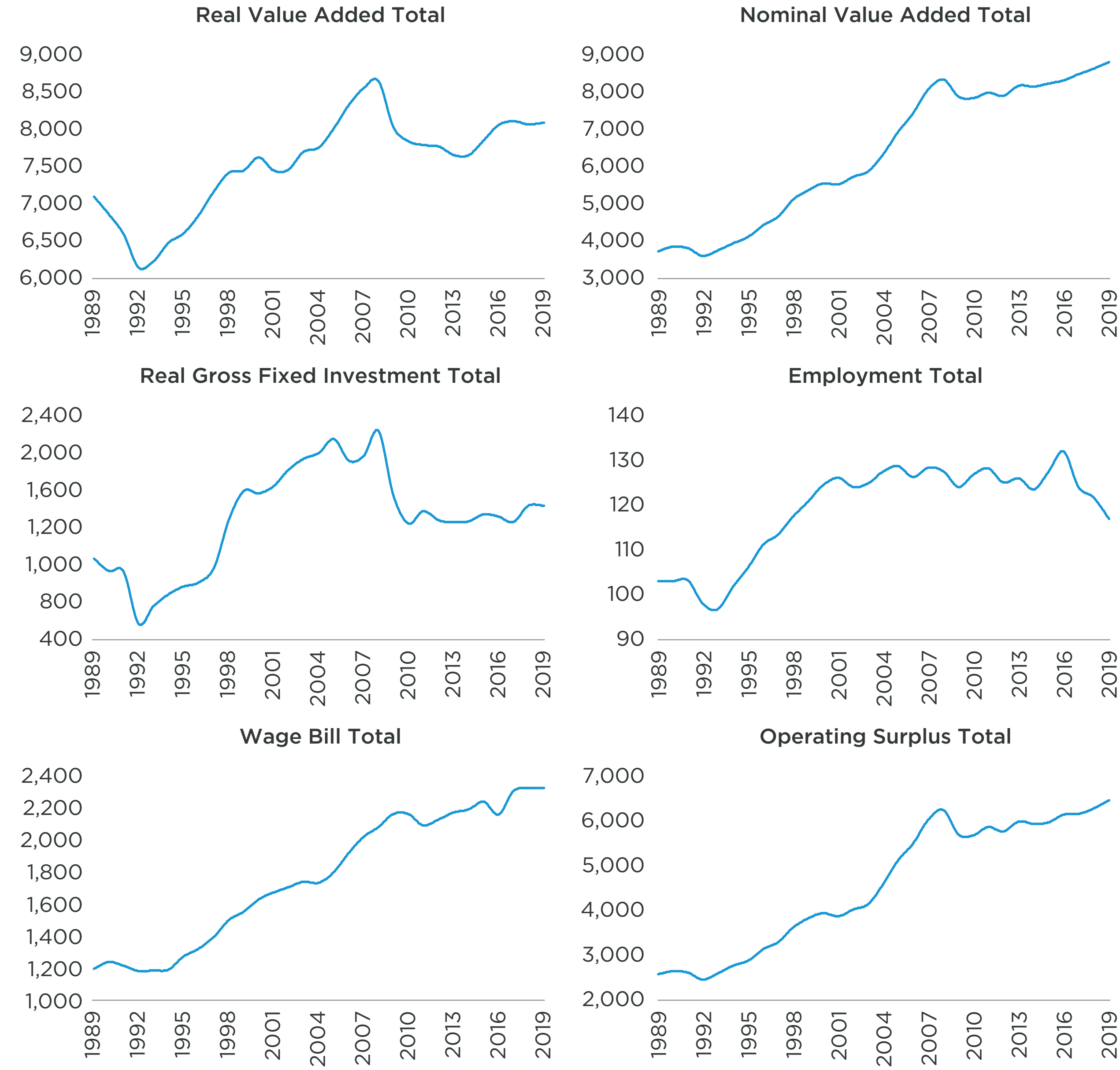
Barbados

Data for Barbados has been obtained from the national accounts report[4] published by the Barbados Statistical Service and the Central Bank of Barbados. The base year for the national accounts is 2010 and the time series cover the

[4] http://www.centralbank.org.bb/research-publications/statistics/statistics-news/article/9679/gross-domestic-product-gdp-2018.

FIGURE 2

Barbados (in millions of 2010 BB$ and thousands of employees)



Source: National Accounts Barbados Statistical Service and Central Bank of Barbados.

period 1989–2019. Value Added figures have been used instead of GDP to deduct indirect taxes on production. In Figure 2, time series are expressed in millions of Barbadian dollars except Employment, which is expressed in thousands of employees.

Operating Surplus was obtained as the difference between Nominal Value Added and the Wage Bill. Two additional variables were derived from these time series: (i) Potential Real Value Added and (ii) Capital Utilization.

Potential Real Value Added is obtained using the Hodrick-Prescott filter with Lambda = 100. The Capital Utilization factor is obtained as the ratio between Real Value Added and Potential Real Value Added. The values of each time series are presented in the Appendix.

Jamaica

Data for Jamaica has been obtained from the national accounts report[5] published by the Statistical Institute of Jamaica (STATIN). The base year for the national accounts is 2007 and the time series cover the period 1989–2019. Value Added figures have been used instead of GDP to deduct indirect taxes on production. In Figure 3, time series are expressed in millions of Jamaican dollars except Employment, which is expressed in thousands of employees.

Operating Surplus was obtained as the difference between Nominal Value Added and the Wage Bill. Two additional variables were derived from these time series: (i) Potential Real Value Added and (ii) Capital Utilization. Potential Real Value Added is obtained using the Hodrick-Prescott filter with Lambda = 100. The Capital Utilization factor is obtained as the ratio between Real Value Added and Potential Real Value Added. The values of each time series are presented in the Appendix.

Suriname

Data for Suriname has been obtained from the national accounts report[6] published by the General Bureau of Statistics of Suriname. The base year for the national accounts is 2007 and the time series cover the period 1989–2019. Value Added figures have been used instead of GDP to deduct indirect taxes on production. In Figure 4, time series are expressed in millions of Suriname dollars except Employment, which is expressed in thousands of employees.

Operating Surplus was obtained as the difference between Nominal Value Added and the Wage Bill. Two additional variables were derived from these time series: (i) Potential Real Value Added and (ii) Capital Utilization.

[5] https://statinja.gov.jm/NationalAccounting/Annual/NewAnnualGDP.aspx.

[6] https://statistics-suriname.org/bruto-binnenlands-product/.

FIGURE 3

Jamaica (millions of 2007 J$ and thousands of employees)

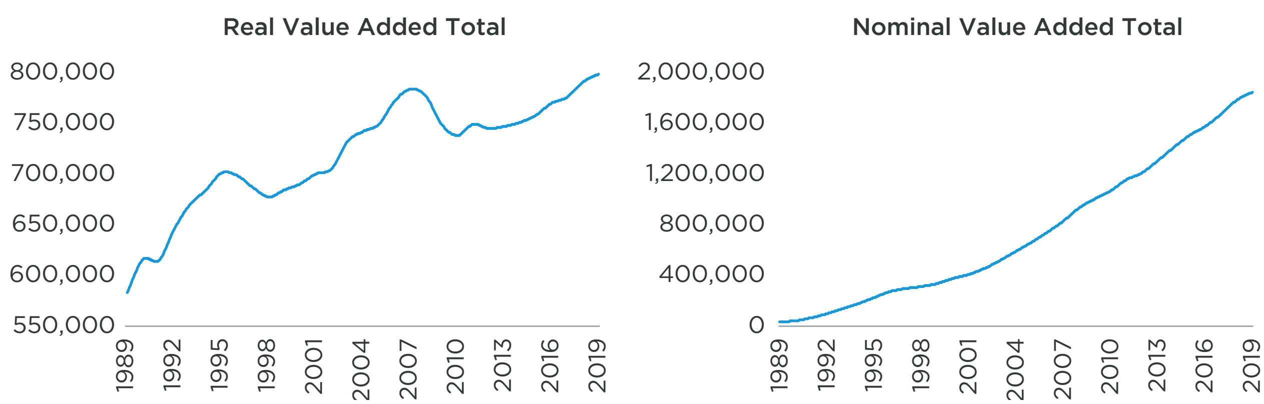


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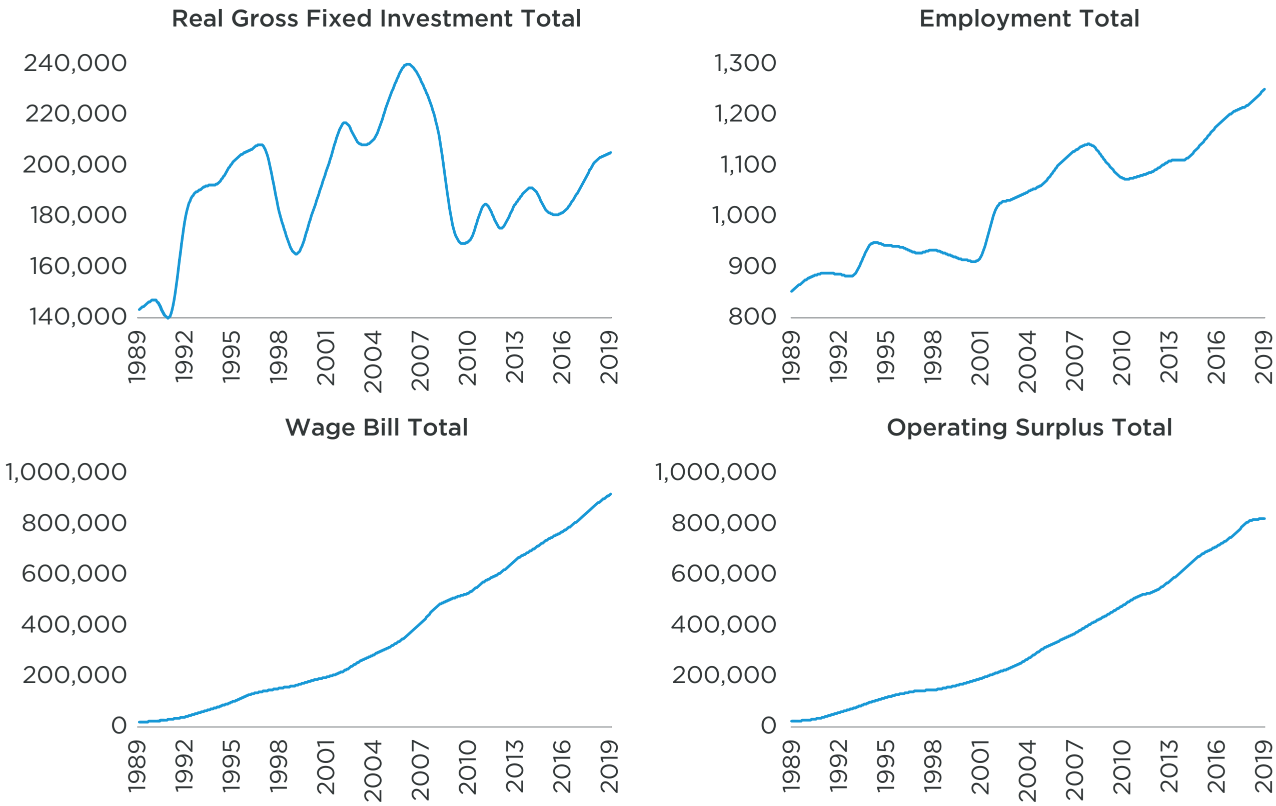
FIGURE 3

Jamaica (millions of 2007 J$ and thousands of employees) *(continued)*



Source: National Accounts Statistical Institute of Jamaica (STATIN).

FIGURE 4

Suriname (millions of 2007 S$ and thousands of employees)

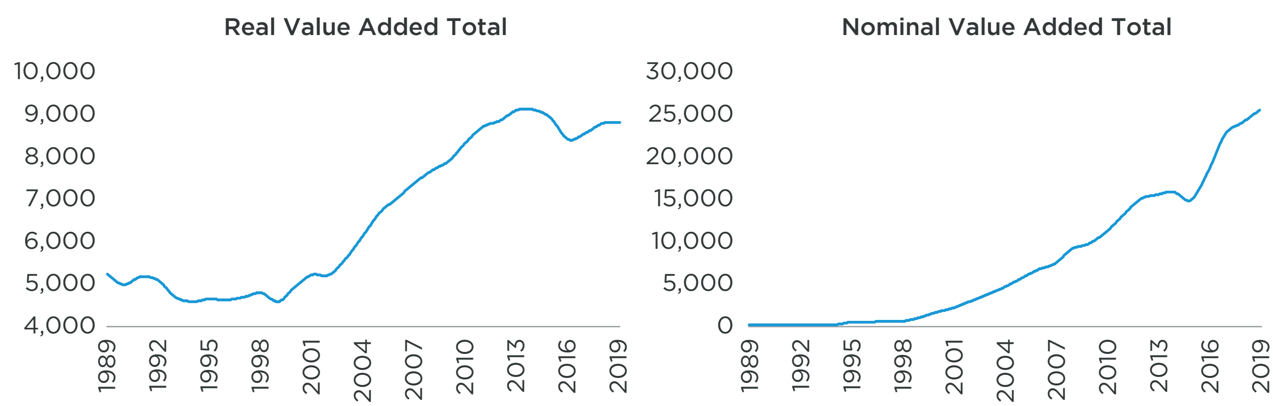


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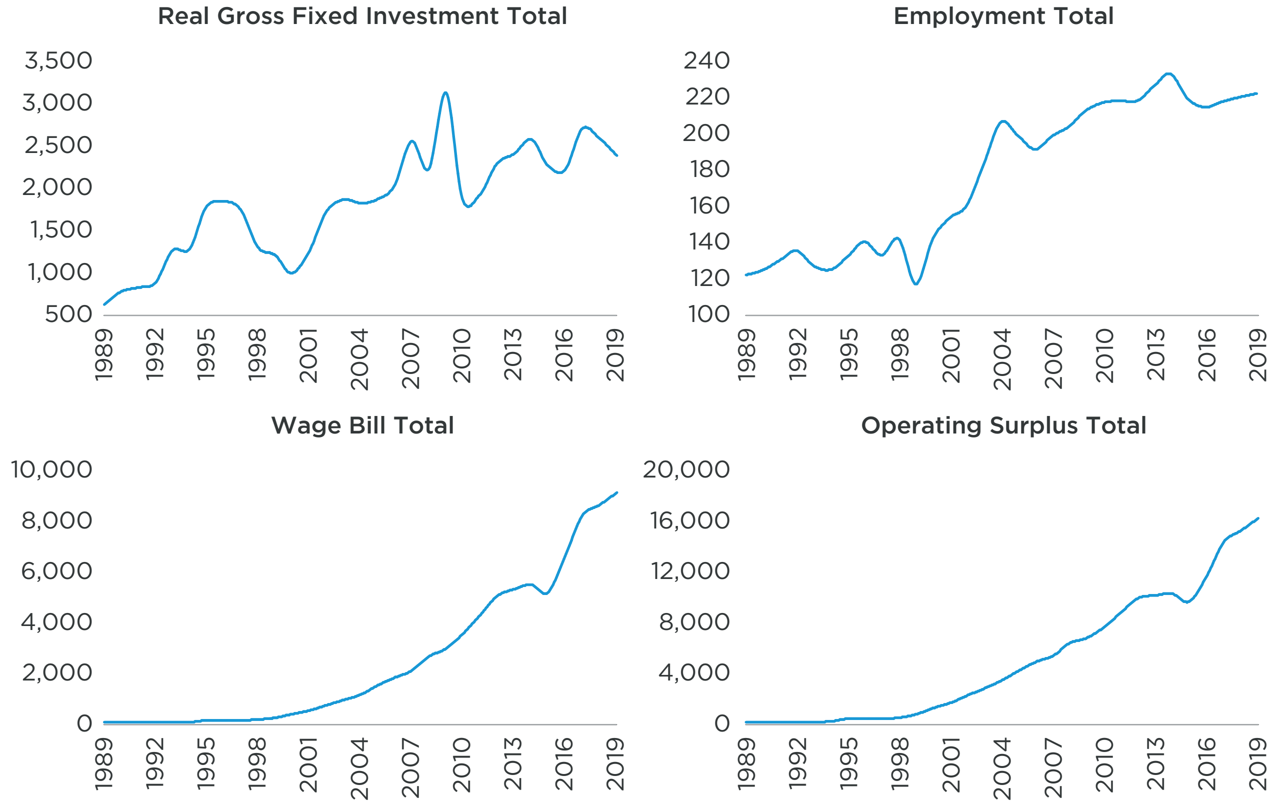
FIGURE 4

Suriname (millions of 2007 S$ and thousands of employees)



Source: National Accounts Suriname General Bureau of Statistics.

Potential Real Value Added is obtained using the Hodrick-Prescott filter with Lambda = 100. The Capital Utilization factor is obtained as the ratio between Real Value Added and Potential Real Value Added. The values of each time series are presented in the Appendix.

4

Estimation with Time-Varying Depreciation Rate

The PIM usually assumes a constant depreciation rate through the estimation period. This assumption generates a smoother capital stock time series. However, smooth capital stock time series are not realistic, especially when considering small economies where natural disasters and capital stock utilization generate volatilities on real GDP growth rates and hence of TFP levels. One way to avoid this shortcoming is introducing a time-varying depreciation rate.

Changes in the depreciation rate allow a better estimation of TFP than using a constant rate. If the depreciation rate stays constant, during a natural disaster, for example, TFP will be overestimated since the estimated capital stock does not reflect the changes in the depreciation rate due to the natural disaster occurring in a given year.

This section presents the results of the estimation of the model of simultaneous equations deduced in expressions (11) and (12) with constant returns to scale and time-varying depreciation rate.

$$K_{t-1} = \left[A^{*}\alpha\right] q_t^{-(1-\alpha)} w_t^{-(1-\alpha)} Y_t \tag{21}$$

$$L_t = \left[A^{*}(1-\alpha)\right] q_t^{\alpha} w_t^{-\alpha} Y_t \tag{22}$$

For simplicity we use the logarithmic version with constant returns to scale version of expressions (21) and (22):

$$\log(K_{t-1}) = \log\left(\left[A^{*}\alpha\right]\right) - (1-\alpha)\log(q_t) + (1-\alpha)\log(w_t) + \log(Y_t) \tag{23}$$

$$\log(L_t) = \log\left(\left[A^{*}(1-\alpha)\right]\right) + \alpha\log(q_t) - \alpha\log(w_t) + \log(Y_t) \tag{24}$$

Since log (K_{t-1}) is not observable, equation (23) has been reversed to obtain the following system of equations:

$$\log(Y_t) = -\log([A^*\alpha]) + (1-\alpha)\log(q_t) - (1-\alpha)\log(w_t) + \log(K_{t-1}) \quad (25)$$

$$\log(L_t) = \log([A^*(1-\alpha)]) + \alpha\log(q_t) - \alpha\log(w_t) + \log(Y_t) \quad (26)$$

with:

$A^* = 1 / [A\ \alpha^{\alpha}\ (1-\alpha)^{(1-\alpha)}]$
$K_{t-1} = G_t(I_t, K_0, \delta)$
$K_0 = [\ Y_{1990} / (A\ L^{(1-\alpha)})\ ]^{(1/\alpha)}$
$q_t = [Y_t - w_t L_t] / G_t(I_t, K_0, \delta)$

To introduce a time-varying depreciation rate we assume the following deprecation rate vector:

$\Delta = [1, (1-\delta_1), (1-\delta_1)(1-\delta_2), (1-\delta_1)(1-\delta_2)(1-\delta_3)^3, \ldots\ldots\ldots\ldots, (1-\delta_1)\ldots(1-\delta_{N-1})^{N-1} (1-\delta_N)^N]^T$

In this case, we assume that δ_τ is proportional to the capital utilization ratio:

$$\delta_\tau = \delta_* \text{ KUTIL(t)}$$

where KUTIL(t) is defined as the ratio between Real Value Added and Potential Value Added.

KUTIL(t) = RVA(t)/RVAPOT(t)

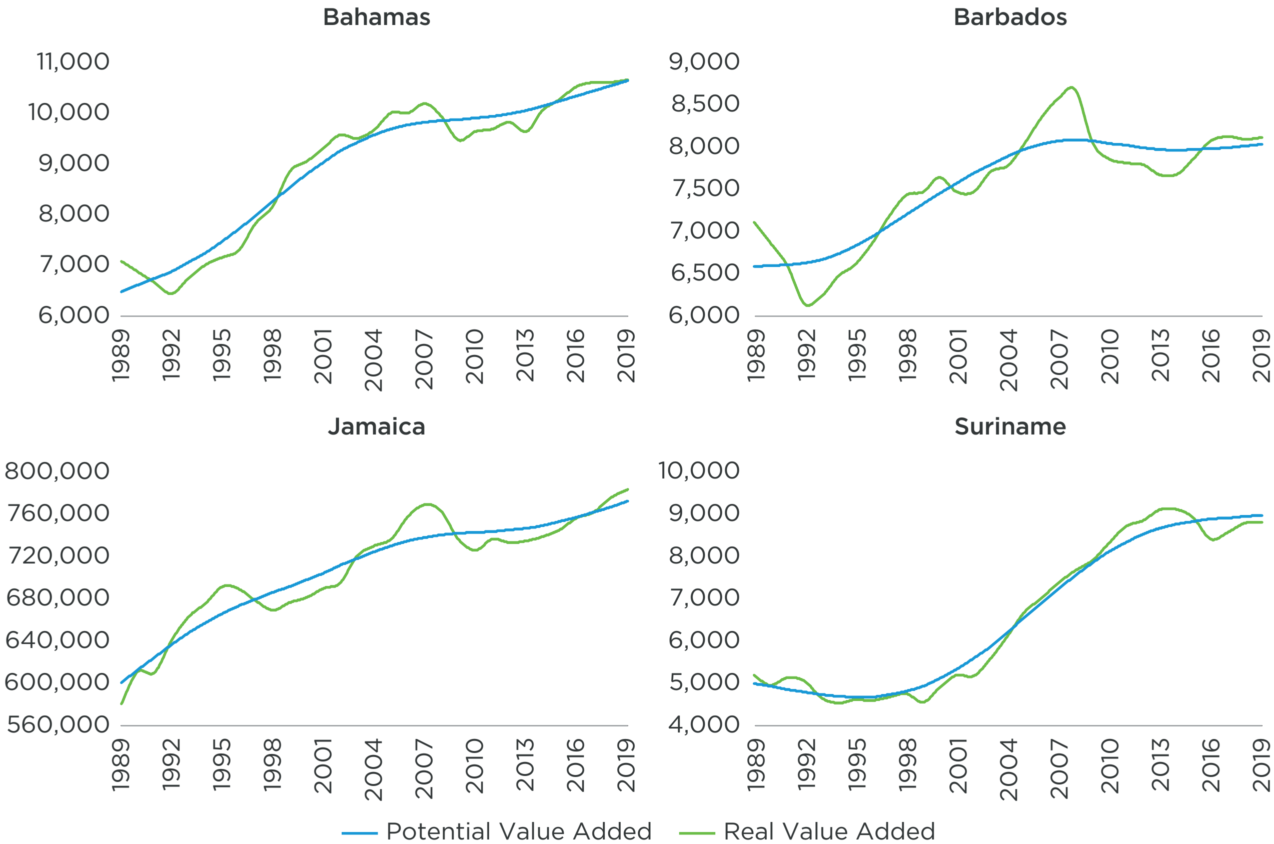
The constant parameter δ is the average depreciation rate for the estimation period. The actual depreciation rate δ_τ oscillates around the average depreciation rate. The greater the utilization of the capital stock the greater the depreciation rate. This oscillation is proportional to the business cycle of the economy.

Potential Value Added is obtained as the Hodrick-Prescott filter (HP) of Real Value Added. The time series for the relative price of the labor production factor, w(t) was obtained dividing the average wage (total wage bill/ number of employees) by the Value Added Deflator. The time series for the relative price of capital production factor, q(t) was obtained parametrizing the identity qt = $[Y_t - w_t L_t] / G_t(I_t, K_0, \delta)$ into the estimation procedure.

The values of the Potential Value Added together with the observed Real Value Added for each of the four Caribbean countries are presented in Figure 5.

FIGURE 5

Potential Value Added and Real Value Added (millions of constant national currency)



Source: National accounts and authors' calculations.

5

Estimation Results

Parameters

The system of simultaneous equations in (25) and (26) together with the definition of the time-varying depreciation rate vector has been estimated by the generalized method of moments (GMM) in Eviews. The results of the estimation for the four Caribbean countries are presented in Table 1.

The instrumental variables used for the estimation were the lagged variables of the original time series used in the simultaneous systems of equations. The parameter values were used to calculate time series for capital stock, depreciation rate, and TFP.

Capital Stock

The evolution of the capital stock and the corresponding capital-output ratio for the period of estimation were obtained from the estimated parameters of the Cobb-Douglas production function. For comparison purposes we have included the capital stock estimated in PWT. We have used different scales for PWT's capital stock time series to account for the different units used by the national accounts of each country and the units used by PWT (millions of US$).

The evolution of the capital stock for each of the four Caribbean countries is presented in the Figure 6. The values of the capital stock time series for each country are presented in the Appendix.

TABLE 1

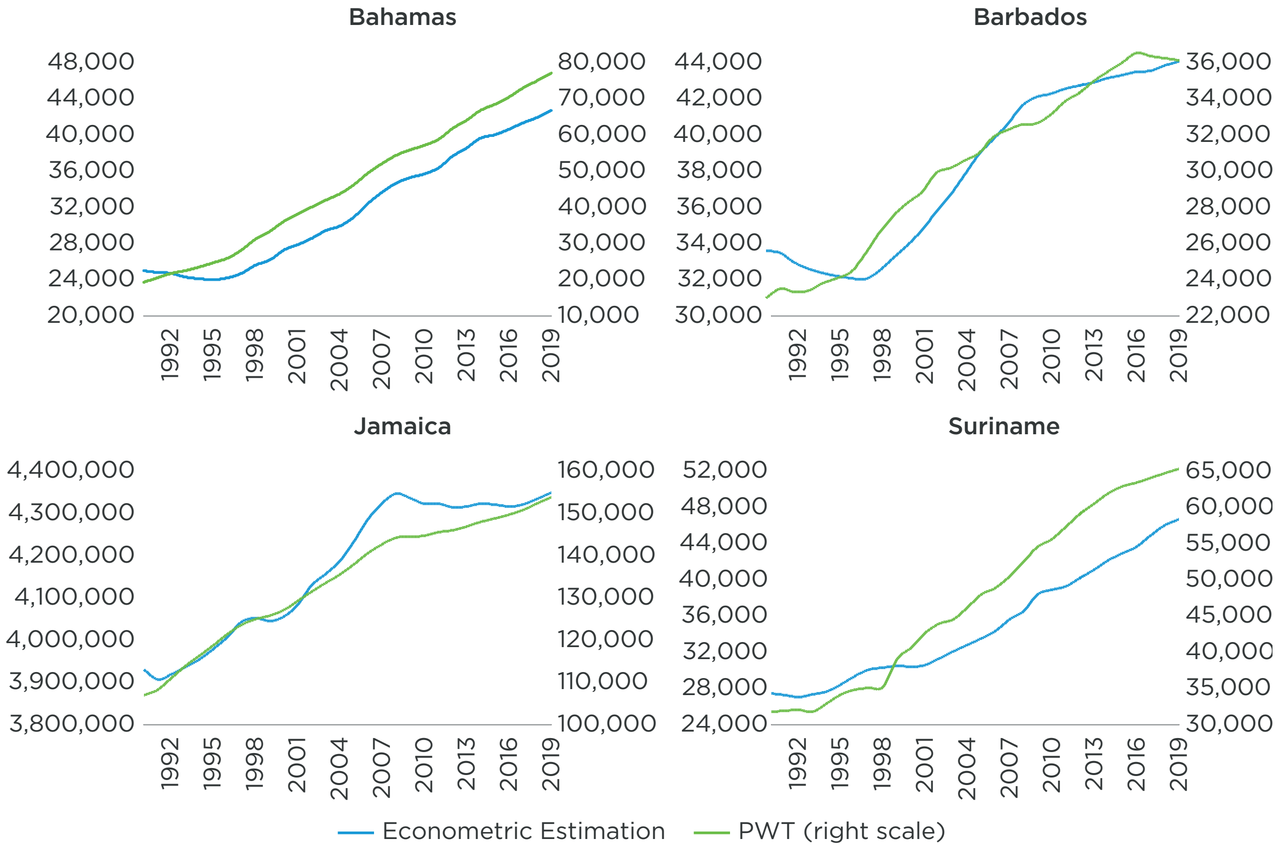
Estimation Results

Bahamas: Cobb-Douglas Time-Varying Depreciation Rate					Barbados: Cobb-Douglas Time-Varying Depreciation Rate				
Estimation Method: Generalized Method of Moments					Estimation Method: Generalized Method of Moments				
Date: 02/12/21 Time: 11:19					Date: 02/12/21 Time: 11:09				
Sample: 1991 2019					Sample: 1991 2019				
Included observations: 29					Included observations: 29				
Total system (balanced) observations 58					Total system (balanced) observations 58				
Kernel: Quadratic, Bandwidth: Fixed (3), No prewhitening					Kernel: Quadratic, Bandwidth: Fixed (3), No prewhitening				
Iterate coefficients after one-step weighting matrix					Iterate coefficients after one-step weighting matrix				
Convergence achieved after: 1 weight matrix, 11 total coef iterations					Convergence achieved after: 1 weight matrix, 14 total coef iterations				
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**		**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
α	0.753734	0.000586	1,285.99	0.00000	α	0.716888	0.000199	3,602.23	0.00000
A	1.030558	0.007647	134.77	0.00000	A	1.005037	0.009064	110.88	0.00000
δ	0.059242	0.000407	145.55	0.00000	δ	0.032435	0.000481	67.49	0.00000
Determinant residual covariance			0.000052		Determinant residual covariance			0.000028	
J-statistic			0.287963		J-statistic			0.299456	

Jamaica: Cobb-Douglas Time-Varying Depreciation Rate					Suriname: Cobb-Douglas Time-Varying Depreciation Rate				
Estimation Method: Generalized Method of Moments					Estimation Method: Generalized Method of Moments				
Date: 02/22/21 Time: 13:56					Date: 02/22/21 Time: 13:53				
Sample: 1991 2019					Sample: 1991 2019				
Included observations: 29					Included observations: 29				
Total system (balanced) observations 58					Total system (balanced) observations 58				
Kernel: Bartlett, Bandwidth: Fixed (1), No prewhitening					Kernel: Quadratic, Bandwidth: Fixed (3), No prewhitening				
Iterate coefficients after one-step weighting matrix					Iterate coefficients after one-step weighting matrix				
Convergence achieved after: 1 weight matrix, 26 total coef iterations					Convergence achieved after: 1 weight matrix, 20 total coef iterations				
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**		**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
α	0.494799	0.001580	313.18	0.00000	α	0.729136	0.000441	1,653.90	0.00000
A	10.830440	0.147983	73.19	0.00000	A	0.778720	0.003121	249.51	0.00000
δ	0.043254	0.000301	143.74	0.00000	δ	0.035800	0.000502	71.36	0.00000
Determinant residual covariance			0.000008		Determinant residual covariance			0.000449	
J-statistic			0.212283		J-statistic			0.299518	

FIGURE 6

Capital Stock (in millions constant national currency [left axis] and millions US$ 2017 PWT [right axis])



Source: Feenstra, Inklaar, and Timmer (2015) and authors' calculations.

6

Total Factor Productivity (TFP) Analysis

TFP is defined as the portion of output not explained by traditionally measured inputs of labor and capital used in production. In the case of the Cobb-Douglas production function, TFP is measured by the parameter "A" of the Cobb-Douglas specification:

$$Y_t = A\ K_{t-1}\alpha\ L_t^{(1-\alpha)}$$

Using Potential GDP as a parsimonious measure of output we can measure TFP from the following relationship:

$$A_t = Ypot_t \,/\, K_{t-1}^{\alpha}\ L_t^{(1-\alpha)}$$

where K_t and α are the capital stock and elasticity of capital estimated in previous sections. The evolution of A_t gives a measure of the evolution of TFP through time. Figure 7 presents the evolution of TFP for the four Caribbean countries. For comparison purposes the TFPs estimated in PWT are also included. In the case of the Bahamas and Suriname, there are only TFP time series for the period 1990–2014.

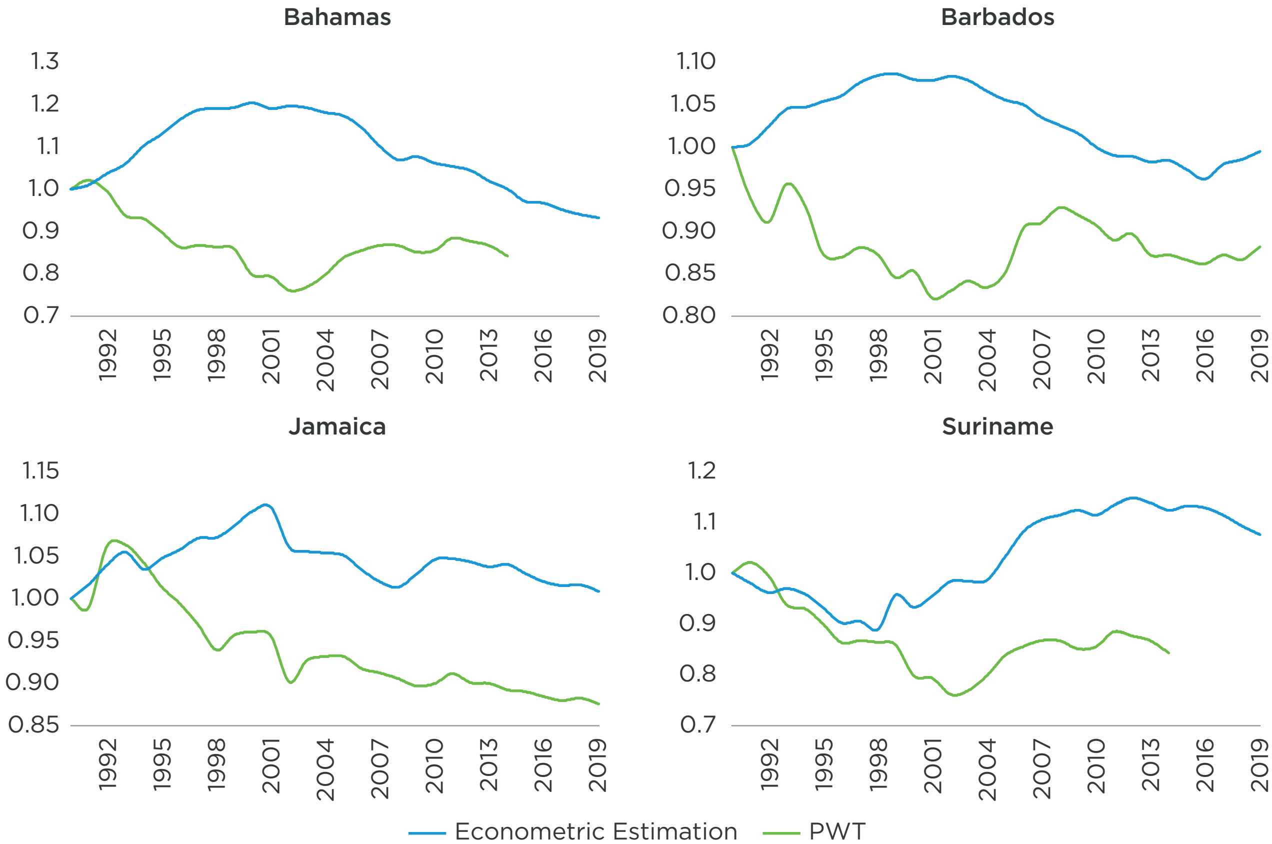
To make PWT's TFP comparable with our estimates,[7] we have equated both TFP indices to be equal to 1 in 1990. TFPs of PWT exhibit substantial differences with our TFPs obtained through econometric estimation.

The striking differences between the TFP estimates of PWT and our econometric estimation are explained mainly by the differences on the capital stocks estimates of both methodologies. A higher capital stock growth produces a lower TFP. PWT tends to overestimate the capital stock because of lower depreciation rates.

[7] PWT estimates TFP using constant 2017 US$ for GDP and capital stock.

FIGURE 7

Total Factor Productivity (index 1990 = 1)



Source: Feenstra, Inklaar, and Timmer (2015) and authors' calculations.

In the case of the Bahamas, between 1989 and 2019 the capital stock grew 340.8 percent according to PWT, while the econometric estimation generates only 69.5 percent growth. In the case of Barbados, PWT estimates a capital stock growth of 49.4 percent, while the econometric method estimates 27.1 percent. For Jamaica, PWT estimates for the same period a capital stock growth of 42.9 percent, while the econometric method estimates only 10.3 percent. In the case of Suriname, PWT estimates growth of 104.5 percent, while the econometric method estimates 67.5 percent growth.

7

Conclusions and Suggestions for Further Research

The econometric method presented in this work removes the subjectivity associated with traditional methods of estimating capital stock and TFP. In addition, long-term series for investment and Value Added associated with the PIM are no longer needed as the initial capital stock is just one more parameter to be estimated by the econometric method. National accounts' long-term time series are usually prone to errors, especially in Caribbean countries where statistical services have only recently been strengthened.

This new methodology generates time series for the capital stock and TFP associated with the Cobb-Douglas production function, but it could be applied to other production functions like constant elasticity substitution (CES) or any other specification of the production function.

The econometric method allows the estimation of capital stock under the assumption of time-varying depreciation rates and different specifications of the production function. The case of varying depreciation rates over time is of relevance when it comes to incorporating the effect of natural disasters such as earthquakes, hurricanes, or the El Niño phenomenon.

Natural disasters are a common occurrence in Caribbean countries. In these cases, the impact of natural disasters is reflected in destruction of capital stock that translates into a sudden increase of the rate of depreciation. The possibility of including these changes in the depreciation rate enhances the accuracy of the proposed methodology. The application of time-varying depreciation rates could easily be extended to other Latin American countries.

Another area of application of the new methodology is in the estimation of dynamic production functions associated to real business cycle (RBC). In these cases, the potential GDP can be estimated in terms of the Cobb-Douglas production function or any other specification of the underlying technology in which the evolution of the capital stock and the TFP play an important role. The business cycle will be the difference between the observed output and the potential GDP. The RBC methodology can be used as the building block of the supply component of a dynamic general equilibrium model.

The methodology presented in this document can be extended to the estimation of sectoral capital stocks. The extension of the methodology to multiple sectors enables the analysis of TFP evolution at the sectoral level. This is of special relevance when implementing multisectoral dynamic general equilibrium models. The use of multisectoral models allows for the tracking of the impact of shocks that are focused on a given sector of the economy. The recent COVID-19 pandemic is a good example of a shock concentrated in the tourism sector.

Alternative specifications of the production function can be used to add more flexibility to the definition of the production technology. The same applies to the specification of the time-varying depreciation rate. Dummy variables can be used to account for natural disasters.

References

Borović, Z., M. Rebić, and D. Tomaš. 2020. Total Factor Productivity Drivers in the Selected EU Countries: Cointegration Approach. *Zb. rad. Ekon. fak. Rij.* 38(1): 295–315. Available at https://doi.org/10.18045/zbefri.2020.1.295.

Dowling, T., N. Mwase, J. Gold, and E. Moreno. 2016. Data Issues and Post-Crisis Growth in Barbados. Washington, DC: International Monetary Fund, Western Hemisphere Department.

Feenstra, R. C., R. Inklaar, and M. P. Timmer. 2015. The Next Generation of the Penn World Table. *American Economic Review* 105(10): 3150–3182. Available at www.ggdc.net/pwt.

Hernández, J. A. and I. Mauleón. 2002. On the Econometric Estimation of a Variable Rate of Depreciation. Working Paper WP-AD 2002–07. Las Palmas de Gran Canaria: University of Las Palmas.

IMF. 2010. Barbados: 2010 Article IV Consultation—Selected Issues. Washington, DC: International Monetary Fund, Western Hemisphere Department.

Ladu, M. G. 2008. Total Factor Productivity Estimates for a Sample of European Regions: A Panel Cointegration Approach. Working Paper, Department of Economics. Essex, England: University of Essex.

Nadiri, M. I. and I. R. Prucha. 1993. Estimation of the Depreciation Rate of Physical and R&D Capital in the US Total Manufacturing Sector. NBER Working Paper Series. Working Paper 4591. Cambridge, MA: National Bureau of Economic Research.

Prucha, I. R. 1995. On the Econometric Estimation of a Constant Rate of Depreciation. *Empirical Economics* 20: 299–302.

Prucha, I. R. 1997. Estimation of a Variable Rate of Depreciation: A Dummy Variable Approach. *Structural Change and Economic Dynamics* 3: 319–325.

Thacker, N., S. Acevedo, and R. Perrelli. 2012. Caribbean Growth in an International Perspective: The Role of Tourism and Size. IMF Working Paper WP/12/235. Washington, DC: International Monetary Fund, Western Hemisphere Department.

Appendix: Country Data

TABLE A1

Data for the Bahamas

Year	Real Value Added	Nominal Value Added	Real Gross Investment	Employed	Wage Bill	Capital Stock	TFP
1989	6,943.00	4,379.20	1,404.33	112.49	1,136.45	25,158.66	1.101
1990	6,733.76	4,489.34	1,330.78	105.48	1,253.13	24,943.86	0.994
1991	6,551.51	4,338.86	1,276.26	114.28	1,144.33	24,761.77	1.003
1992	6,368.50	4,435.41	1,232.83	114.70	1,131.40	24,620.28	1.031
1993	6,688.64	4,573.72	989.51	118.95	1,095.47	24,211.79	1.054
1994	6,954.84	4,808.28	1,167.79	120.30	1,274.76	23,990.94	1.096
1995	7,103.02	5,081.61	1,301.02	127.44	1,267.37	23,930.33	1.123
1996	7,234.69	5,288.44	1,487.63	129.76	1,349.31	24,080.27	1.158
1997	7,796.60	5,771.60	1,905.17	135.26	1,523.39	24,584.35	1.181
1998	8,125.30	6,218.20	2,405.56	144.36	1,725.02	25,549.81	1.185
1999	8,811.00	7,147.20	2,175.59	145.35	1,888.14	26,155.25	1.187
2000	9,008.40	7,365.10	2,629.70	147.21	1,966.93	27,190.72	1.199
2001	9,275.00	7,744.90	2,312.91	153.31	1,992.34	27,842.52	1.184
2002	9,510.70	8,268.60	2,396.06	152.69	2,103.92	28,534.07	1.191
2003	9,447.50	8,312.50	2,510.91	154.97	2,154.48	29,342.40	1.188
2004	9,619.30	8,496.70	2,307.35	158.34	2,216.97	29,893.98	1.174
2005	9,943.00	9,252.80	2,813.19	160.53	2,335.82	30,879.50	1.168
2006	9,951.90	9,339.10	3,358.60	166.51	2,661.47	32,364.02	1.139
2007	10,136.90	9,814.80	3,250.50	171.49	2,556.47	33,624.71	1.097
2008	9,880.70	9,750.70	3,005.66	174.92	2,289.12	34,622.12	1.064
2009	9,419.30	9,314.40	2,611.00	157.81	2,082.50	35,266.65	1.070
2010	9,584.40	9,463.30	2,419.30	159.33	2,186.48	35,653.08	1.056
2011	9,625.60	9,363.50	2,778.43	161.55	2,146.80	36,374.83	1.047
2012	9,760.67	9,760.67	3,360.03	160.65	2,352.80	37,617.55	1.038
2013	9,579.09	9,729.20	3,001.62	164.00	2,254.09	38,484.14	1.014
2014	10,001.52	10,311.97	3,394.15	171.28	2,178.62	39,616.01	0.994
2015	10,214.89	10,480.95	2,788.80	183.92	2,179.28	40,048.02	0.964
2016	10,458.07	10,830.23	2,932.50	188.36	2,309.98	40,565.15	0.960
2017	10,544.81	11,108.87	3,204.46	200.16	2,526.23	41,327.38	0.946
2018	10,547.13	11,260.66	3,047.44	208.26	2,607.42	41,910.93	0.933
2019	10,591.21	11,495.09	3,218.04	214.89	2,682.51	42,644.59	0.925

Source: Department of Statistics of the Bahamas, Central Bank, and authors' calculations.

TABLE A2

Data for Barbados

Year	Real Value Added	Nominal Value Added	Real Gross Investment	Employed	Wage Bill	Capital Stock	TFP
1990	6,856.66	3,863.31	1,002.34	102.85	1,232.02	32,991.48	1.020
1991	6,589.60	3,805.20	994.71	102.95	1,210.75	32,917.29	1.024
1992	6,148.84	3,618.37	532.12	97.76	1,176.95	32,457.76	1.045
1993	6,229.25	3,761.34	690.70	96.60	1,178.31	32,164.43	1.066
1994	6,475.71	3,934.84	796.38	101.50	1,186.97	31,957.36	1.069
1995	6,597.99	4,126.49	865.18	105.83	1,265.63	31,820.25	1.075
1996	6,845.04	4,437.42	896.22	110.83	1,313.45	31,697.49	1.082
1997	7,169.74	4,669.03	1,025.81	113.04	1,393.55	31,678.55	1.098
1998	7,416.80	5,112.58	1,453.99	117.08	1,499.15	32,071.72	1.107
1999	7,452.95	5,367.66	1,710.05	120.25	1,549.16	32,721.48	1.109
2000	7,625.41	5,553.87	1,690.88	124.00	1,627.68	33,324.12	1.102
2001	7,450.68	5,528.87	1,748.69	125.70	1,672.20	34,006.99	1.101
2002	7,459.95	5,730.66	1,896.84	123.66	1,703.58	34,830.91	1.106
2003	7,692.57	5,882.74	1,990.59	124.38	1,738.61	35,703.82	1.101
2004	7,759.12	6,324.75	2,043.10	126.95	1,736.06	36,605.41	1.088
2005	8,016.51	6,925.82	2,167.01	128.30	1,802.86	37,575.64	1.077
2006	8,319.74	7,415.69	1,979.30	125.82	1,919.18	38,289.77	1.071
2007	8,552.58	8,072.30	2,016.64	127.84	2,020.51	38,987.22	1.057
2008	8,646.74	8,334.14	2,235.96	127.02	2,083.71	39,867.05	1.046
2009	8,028.28	7,866.30	1,668.34	123.52	2,166.21	40,245.98	1.036
2010	7,842.32	7,842.32	1,421.64	126.40	2,164.29	40,392.15	1.020
2011	7,790.24	7,973.09	1,533.67	127.73	2,095.46	40,649.54	1.010
2012	7,771.01	7,900.76	1,448.17	124.59	2,131.64	40,812.19	1.009
2013	7,658.04	8,169.94	1,430.93	125.52	2,177.75	40,968.23	1.002
2014	7,659.20	8,147.89	1,441.95	123.07	2,197.65	41,128.97	1.004
2015	7,846.35	8,222.92	1,504.62	127.03	2,244.02	41,316.53	0.993
2016	8,052.08	8,317.63	1,482.83	131.52	2,163.90	41,443.66	0.981
2017	8,103.40	8,482.76	1,435.08	123.52	2,313.32	41,513.12	0.999
2018	8,070.63	8,618.49	1,581.91	121.28	2,328.62	41,735.93	1.005
2019	8,086.85	8,808.09	1,581.98	116.48	2,328.17	41,952.17	1.015

Source: Barbados Statistical Service (BSS), Central Bank, and authors' calculations.

TABLE A3

Data for Jamaica

Year	Real Value Added	Nominal Value Added	Real Gross Investment	Employed	Wage Bill	Capital Stock	TFP
1990	610,265.00	35,968.00	147,154.00	877.20	15,732.00	3,927,182.00	10.859
1991	609,860.00	52,695.00	142,005.00	888.35	22,316.00	3,903,142.00	11.034
1992	639,544.00	87,608.00	181,712.00	886.35	35,828.00	3,914,956.00	11.287
1993	661,687.00	121,052.00	190,891.00	887.02	53,153.00	3,932,500.00	11.458
1994	674,108.00	162,011.00	192,524.00	944.85	70,810.00	3,950,281.00	11.242
1995	690,596.00	205,277.00	201,110.00	942.77	95,957.00	3,973,889.00	11.376
1996	687,879.00	245,187.00	205,192.00	939.32	119,829.00	4,003,179.00	11.490
1997	676,591.00	267,155.00	205,579.00	926.67	133,428.00	4,036,132.00	11.639
1998	668,405.00	285,739.00	178,813.00	933.30	145,294.00	4,044,514.00	11.652
1999	674,961.00	307,382.00	165,004.00	923.73	157,873.00	4,038,545.00	11.803
2000	680,201.00	342,980.00	180,984.00	913.63	177,199.00	4,049,002.00	11.983
2001	688,913.00	373,881.00	199,306.00	919.38	190,619.00	4,076,738.00	12.040
2002	693,562.00	417,036.00	215,942.00	1,014.65	211,147.00	4,120,405.00	11.525
2003	718,990.00	477,534.00	207,894.00	1,031.67	248,613.00	4,149,482.00	11.476
2004	728,509.00	543,265.00	210,494.00	1,046.51	281,091.00	4,179,113.00	11.454
2005	735,020.00	611,694.00	227,216.00	1,062.61	310,495.00	4,223,966.00	11.414
2006	756,328.00	682,640.00	238,743.00	1,099.73	351,484.00	4,274,242.00	11.230
2007	767,251.00	767,251.00	231,392.00	1,125.47	404,676.00	4,313,060.00	11.085
2008	760,976.00	866,620.00	213,124.00	1,137.41	466,989.00	4,334,014.00	11.009
2009	735,021.00	928,792.00	174,909.00	1,102.07	496,814.00	4,322,715.00	11.178
2010	724,472.00	990,133.00	170,404.00	1,071.59	520,717.00	4,310,268.00	11.365
2011	734,800.00	1,067,912.00	184,289.00	1,076.07	563,366.00	4,309,861.00	11.371
2012	731,119.00	1,124,402.00	175,160.00	1,086.34	598,989.00	4,301,591.00	11.337
2013	732,757.00	1,214,714.00	185,032.00	1,106.01	648,256.00	4,303,616.00	11.275
2014	736,967.00	1,305,747.00	190,625.00	1,108.56	687,433.00	4,310,767.00	11.301
2015	743,373.00	1,393,901.00	181,443.00	1,138.80	726,063.00	4,307,698.00	11.191
2016	754,511.00	1,465,100.00	181,576.00	1,174.50	762,886.00	4,303,165.00	11.083
2017	759,637.00	1,548,639.00	190,001.00	1,201.00	806,416.00	4,307,139.00	11.032
2018	773,517.00	1,656,167.00	200,896.00	1,215.10	859,865.00	4,319,666.00	11.034
2019	781,024.00	1,714,513.00	204,639.00	1,244.90	904,040.00	4,334,812.00	10.957

Source: Statistical Institute of Jamaica (STATIN), Central Bank, and authors' calculations.

TABLE A4

Data for Suriname

Year	Real Value Added	Nominal Value Added	Real Gross Investment	Employed	Wage Bill	Capital Stock	TFP
1989	5,206.93	4.09	615.03	121.45	0.84	27,555.62	0.967
1990	4,964.17	4.70	762.33	123.91	0.96	27,325.73	0.774
1991	5,137.49	5.57	810.27	129.21	1.14	27,102.58	0.759
1992	5,064.02	7.87	860.40	134.53	1.61	26,938.33	0.745
1993	4,664.60	20.75	1,240.51	126.53	4.26	27,229.09	0.751
1994	4,548.74	103.03	1,268.71	124.55	21.25	27,553.30	0.742
1995	4,619.51	364.84	1,747.26	131.83	75.83	28,326.21	0.721
1996	4,609.60	412.59	1,823.21	139.44	86.63	29,152.33	0.698
1997	4,673.57	444.51	1,728.51	132.47	94.54	29,850.49	0.700
1998	4,758.18	500.60	1,283.22	141.09	108.15	30,078.36	0.688
1999	4,560.61	868.77	1,191.14	116.45	191.18	30,276.29	0.740
2000	4,892.55	1,500.93	980.60	141.89	337.40	30,220.27	0.722
2001	5,189.49	2,035.37	1,227.50	152.79	468.68	30,394.61	0.739
2002	5,185.79	2,836.91	1,695.37	159.53	671.00	31,080.05	0.762
2003	5,598.48	3,626.78	1,847.40	182.07	883.48	31,868.07	0.761
2004	6,126.54	4,469.87	1,807.93	205.06	1,124.29	32,548.76	0.763
2005	6,664.80	5,577.08	1,845.97	198.06	1,451.97	33,206.84	0.800
2006	7,000.20	6,596.26	2,006.47	190.66	1,781.63	34,003.61	0.838
2007	7,351.40	7,346.62	2,535.00	197.93	2,063.02	35,298.15	0.855
2008	7,657.42	8,955.28	2,210.17	202.54	2,618.73	36,223.83	0.864
2009	7,887.76	9,681.80	3,099.30	211.60	2,947.33	38,016.40	0.870
2010	8,294.79	11,038.28	1,857.00	216.07	3,490.14	38,478.16	0.863
2011	8,692.71	13,010.20	1,896.50	217.16	4,255.67	38,934.85	0.879
2012	8,828.17	14,869.15	2,274.23	217.21	5,004.27	39,761.39	0.890
2013	9,080.47	15,403.21	2,387.63	225.27	5,297.51	40,653.07	0.882
2014	9,083.38	15,749.33	2,550.64	231.89	5,490.07	41,691.28	0.871
2015	8,884.59	14,771.85	2,250.81	218.16	5,169.27	42,436.57	0.876
2016	8,390.63	18,178.96	2,193.77	213.71	6,592.89	43,190.41	0.874
2017	8,538.48	22,539.24	2,676.80	216.50	8,226.82	44,381.45	0.864
2018	8,758.76	23,902.17	2,560.91	219.25	8,652.58	45,381.26	0.846
2019	8,782.26	25,401.37	2,368.18	220.87	9,144.49	46,153.71	0.834

Source: General Bureau of Statistics of Suriname (ABS), Central Bank, and authors' calculations.

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