Received: 22 July 2020 | Revised: 2 December 2020 | Accepted: 22 December 2020

DOI: 10.1111/grow.12468

ORIGINAL ARTICLE

growth and change WILEY

Internal and external constraints of the Cuban production sector

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Abstract

This paper aims to explain the growth of the Cuban production sector between 1975 and 2014 by considering both demand and supply factors simultaneously. The research provides new empirical data on this topic through the application of a simultaneous equation model that considered the effect on the product of internal and external constraints most relevant to the Cuban economy, and the impacts of these over time. Its results confirm that the growth of the Cuban production sector was primarily limited by two factors: On the one hand, an overly centralized regulatory framework that reduces the global efficiency of the Cuban economy; and, on the other hand, a foreign exchange deficit that restricts its import capacity and the sustained growth of the Cuban capital stock. Therefore, the Cuban production sector's growth could be fostered by both a greater decentralization of its regulatory framework and the implementation of industrial and commercial policies geared to make Cuban exports more competitive.

1 | INTRODUCTION

This paper is presented to encourage and channel further academic reflection on the growth of the Cuban production sector.[1] The gross domestic product modelling proposed is based on the hypothesis that the growth of the Cuban economy has been hampered by simultaneous supply and demand

Some data that support the findings of this study—estimation of the cost of U.S. embargo—are available from *Instituto Nacional de Investigación Económica* but restrictions apply to the availability of these data, and so are not publicly available. This data set is, however, available from the authors upon reasonable request and with permission of *Instituto Nacional de Investigación Económica*. The rest of data sets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

constraints; the former due to an overly centralized regulatory framework and the latter due to lack of access to foreign currency.

The empirical analysis is based on a system of equations using production function expanded to include institutional factors (approximated by a synthetic index) and the cost of the U.S. Embargo as well as two equations that approximate the transmission channels between domestic supply constraint and foreign demand.

The availability of statistical data was a determining factor in our decision to study the period 1975 to 2014. The scope is the productive sphere of the economy, a choice made for the more direct link between the constraints analysed and the development of this sphere, its higher capacity to generate economic surplus and the methodological change adopted in 2004 to compute the value of the nonproductive sector. Cuba changed that year its accounting policy for nonproductive-related services from one of cost-based analysis to one of price-based estimates.[2] In spite of that sharp change, the nonproductive sector is more stable in Cuba because it does not depend so much on the ideology and political preferences of the incumbent government and the specific stage the economic cycle is going through.

The paper is structured as follows: Section 2 contains a description of the theoretical framework and empirical evidence regarding Cuba's economic growth during the years considered in this paper. Section 3 analyses the principal structural constraints affecting Cuba's economic growth, and the channels of interaction among these. Section 4 contains an empirical analysis, that employs 3SLS estimations to model the evolution of the growth of the Cuban production sector during the years studied and Section 5 includes the principal conclusions and economic policy implications derived from the empirical analysis.

2 | THEORETICAL FRAMEWORK AND PRIOR EMPIRICAL EVIDENCE

The economic growth of nations, differing national incomes and factors determining these is a recurring theme in economic science and literature. In the 1930s, based on the static equilibrium work done by John Maynard Keynes, economists like Harrod and D. Domar extended the analysis of the instability of capitalism to the long-term.

The postulates critical of neoclassical thinking would not come until the 1970s. Consideration of historical and cultural contexts of nations was then one of the main concerns of New Institutional Economics.[3] Within the literature on economic growth, the two institutional reforms receiving the greatest attention have been clearly been Foreign Direct Investment (FDI) and open access to private property ownership. However, the results on FDI are far from conclusive. Caves (1974) or Borensztein et al. (1995) confirm its positive effects on GDP growth, while other papers, such as Girma (2002) or Heijs (2006), question the existence of any FDI impact. According to Heijs, growth is subject to the minimum absorption capacity of destination countries. Studies on growth due to property privatizations are equally inconclusive. While papers by Khan and Reinhart (1990), Plane (1997), and Boubakri and Cosset (1998) praise private property as a superior and more productive model, others by Holland (1972) or Cook and Uchida (2003) affirm that publicly owned property is the more equitable of the two models. The number of empirical studies regarding the impact of regulatory frameworks on economic growth has risen since the Fraser Institute published the Economic Freedom Index. Høj et al. (2006), Arnold et al. (2008), and Alesina et al. (2005) comprise only a few of the studies that have examined the benefits of regulatory restrictions and the promotion of an institutional framework favouring free markets and competition.

However, Kaldor and Thirlwall question the exogenous nature of production factors and affirm that growth is created by demand. Their work applies the Harrod foreign trade supermultiplier and the

idea of circular cumulative causation developed by G. Myrdal and A. Hirschman, which emphasizes the role of exports in the economic growth of nations. According to Thirlwall (1979), the sustainable growth rate with long run balance of payments equilibrium is determined by the ratio of export growth rate to income elasticity of demand for imports. This came to be known as Thirlwall's Law.

The empirical evidence for balance-of-payments-constrained growth models resoundingly corroborates the validity of Thirlwall's Law. Its relevance for developed economies can be found in works such as those of McCombie and Thirlwall (1994), Atesoglu (1997) and Hieke (1997). Meanwhile, the work of Moreno-Brid (1998), Moreno-Brid and Perez (1999), Lopez and Cruz (2000), Holland et al. (2002), Yongbok (2006), Arevilca and Risso (2007), Carvalho and Lima (2009), Ahmad et al. (2011), Aricioglu et al. (2013), and Bastos et al. (2017), among others, has focused on external growth constraints in developing economies.

The demand-side approach developed by Thirlwall led to further studies by Grossman and Helpman (1991), Ethier and Markussenn (1991), Aw et al. (1998) and others, all of which applied combined supply and demand factors to explain growth. More recently, studies by Guisán and Padrao (2001) and Yifu Lin and Yongjun (2002) have approximated the interactions between supply and demand factors using multiequation models.

In the case of Cuba, decades would pass before economic growth analyses gained a central role in national economic studies, due to economic and social development being the first items on the political and academic agenda. The first empirical analysis based on the Cobb – Douglas production functions can be found in González (1989). Since that time, several works have modelled the Cuban GDP with the inclusion of new determining factors such as human capital (Mendoza, 2003) and structural change (Torres, 2007).

Doimeadios (2007) and Palacios (2013), two of the main references for this research paper, have analyzed the effect of the regulatory framework on the Cuban GDP. On the demand side, Mendoza and Roberts (2000), Cribeiro and Triana (2005), Alonso and Sánchez (2005), Vidal and Fundora (2008), Fugarolas and Mañalich (2009) and Quiñones and Mañalich (2010) have contrasted the external constraint affecting the long-term growth of the Cuban economy.

3 | STRUCTURAL CONSTRAINTS ON CUBA'S GROWTH

An analysis of Cuba's economic reality suggests the existence of structural constraints on both supply and demand sides. On the one hand, an overly centralised regulatory framework may have affected the country's economic efficiency and limited expansion of Cuban production. On the other hand, in Cuba's case, the deficit of foreign currency, inherent to open underdeveloped economies, combined with a production sector highly dependent on the import of supplies and technology (ONEI, 1988) may have limited long-term economic growth. A summarized explanation of the arguments supporting this hypothesis is provided below.

3.1 | The regulatory framework as a supply constraint of Cuban economic growth

Since the Revolution, Cuba's national debate on the role that monetary and trade relations should play in its national economic planning has moved to a gradual acceptance of a more flexible regulatory framework, that is not without constraints, and is subject to changing levels of centralisation.

If Cuba's response to the declining efficiency and stagnation in the mid-1980s was to recentralise the economy by applying its *Proceso de Rectificación de Errores* (Error Correction Process), the gravity of the 1990s crisis forced the Cuban government to introduce an urgent program of reforms to liberalise and decentralise economic sectors formerly subject to central planning. The measures adopted included an end to the foreign trade monopoly, encouragement of Foreign Direct Investment (FDI), reorganisation of the agricultural and livestock sectors (through the creation of cooperatives and the reopening of free markets), government authorisation of self-employment, extension of the *Programa de Perfeccionamiento Empresarial* (Enterprise Optimisation Programme) to the civil sphere of the economy, and an adaptation of State planning that placed more emphasis on financial components and less on material components. Not only did this change of direction announced in the early 1990s receive little or no follow-up in the next decade, it was partially reversed by the centralisation of foreign currency operations and the creation of a single-till system, the recentralisation of foreign trade, the reorganisation of FDI, new restrictions on self-employment, the elimination of business funding, and the loss of financial autonomy reflected in the new regulation passed on the Enterprise Optimisation Programme (Decree Law No. 281 of 2007). The appointment of Raúl Castro in early 2008 brought yet another turn in the winding path of Cuba's economic model, which culminated in the 6th Congress of the Cuban Communist Party (CCP) and the opening of a new process of economic decentralisation, ratified in the 7th Congress of the CCP.

An initial indicator of the positive correlation between decentralisation and efficiency is found in empirical studies based on growth accounting as applied to the Cuban economy (Doimeadios, 2007; Medonza, 2003; Palacios, 2010). The authors cited above concur that Cuba's economic recovery in the 1990s was due to improved total factor productivity (TFP), not to the expansion of productive factors.

3.2 | Balance of payments equilibrium as a demand constraint of Cuban economic growth

As a small open economy lacking foreign currency reserves and with limited access to international capital markets, Cuba has been highly sensitive to the performance of its export industries. Its greatest economic growth periods have always coincided with expanding export opportunities, such as those grasped when it instituted national structural reforms to facilitate foreign trade, joined COMECON, and entered the Bolivarian Alliance for the Peoples of America (*ALBA*). In contrast, Cuba's negative growth rates in the early 1990s and the recession of 2009 were primarily due to external shocks: the demise of the USSR and the international economic crisis.

Figure 1 shows the parallel development of Cuban GDP, imports and exports between 1975 and 2014.

Foreign trade flows show an evident correlation with the evolution of the GDP of the Cuban production sector, an initial indication that the balance of payments equilibrium may have been limiting economic growth during the period studied. As far as the Cuban external sector is concerned, two particularities have to be borne in mind due to their remarkable effect: the U.S. embargo and the monetary and exchange rate duality. Since the beginning of the 1960s, Cuba's external balance has hardly been affected by the U.S. imposition of a trade and financial embargo that, to some extent, explains why Cuba embraced the socialist model and redirected its economic relations towards the socialist block. Since then, a progressive concentration of economic relations in favour of this block was initiated, with stable and preferential commercial and financial conditions.[4] The transformation of the political and economic structures came to establish a single party system and the social ownership of the means of production, represented through the direct control of the State and central planning, became the

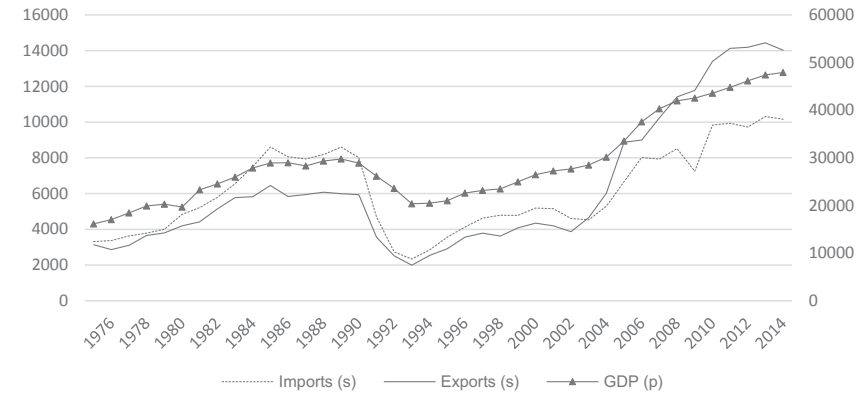

FIGURE 1 GDP and exports and imports of goods and services in Cuba 1975–2014[a]. *Source:* Prepared by the author, based on ONEI and Cuban *National Institute* of Economic Research (INIE, for its Spanish acronym) data.
[a]GDP, exports and imports are at constant 1997 prices

main mechanism for allocating resources. From the very beginning, the model prioritised the development of a new social conscience, in which moral stimuli became a priority to the detriment of material ones, thereby promoting, for most of the period, a political subjectivity that identified private property, free markets, the United States and imperialism as the main enemies of Cuban socialism. During this first stage, the Cuban government strived for building an identity that was closely linked to the definition of its own economic and political model and the defence of national sovereignty, jeopardised by U.S. imperialism and its multiple attempts to destabilise the Cuban project.

In a new attempt to overthrow Castro's regime, in October 1992 G. H. B. Bush's administration passed the Cuban Democracy Act (also known as the Torricelli Act), which prohibited U.S. companies in third countries from trading with Cuba and third country ships touching port in Cuba from entering U.S. territory within a term of 180 days (except those with a Secretary of the Treasury permit), thereby reducing Cuban exports and increasing the cost of Cuban imports. In March 1996, the 104th U.S. Congress passed the Cuban Liberty and Democratic Solidarity Act (also known as the Helms-Burton Act), tightening the conditions to invest in Cuba.[5] President Barack Obama's arrival in the White House in 2009 was a real turning point, lifting, and easing the travel and remittance restrictions passed by the G. W. Bush administration and supporting the normalization of Cuba-U.S. relations. However, the U.S.'s next president, Donald Trump, decided to re-tighten the U.S. position regarding Cuba. To this effect, the first package of measures announced in June 2017 was completed in April 2019 with the ending of Title III of the Helms-Burton Act, the prohibition of cruise ship visits to Cuba, the limitation of remittances to 1,000 dollars per person, the restriction of travel for non-family reasons, and the prohibition of financial transactions with companies linked to the Cuban army.

Thus, the meaningful impact of the U.S. embargo on Cuban GDP is beyond doubt. Two of the most relevant attempts to assess the real cost of the U.S. Embargo on Cuba are Aguilar (1998), who estimated a total cost of more than 67 billion dollars by 1995; and more recently in 2012, the INIE, which developed a new methodology that enabled the annual cost to be estimated and different types of impacts to be identified: productive, financial technological, less revenues from exports, higher cost of transport, and Cuban brain drain. According to these official data, the accumulated cost until 2018 exceeded 134 billion dollars (MINREX, 2018).

A second problem for Cuba's external sector derives from the economic duality in force since September 1993, when the possession and use of the dollar in economic activities was legalised by the Cuban government. Although this decision was initially aimed at preventing the Cuban peso from

becoming strongly devalued along with the subsequent social costs, the existence of two currencies and two kinds of exchange rates for so long has in fact been the cause of some of the major problems of the current Cuban economy, such as the segmentation of the productive system; the increase in social inequality; the distortion of microeconomic indicators (prices, costs, profits, competitiveness, and so on); an economically unfounded exchange rate for the business sector that subsidizes imports and worsens external disequilibrium; and the shift of high-skilled workers into low-skilled activities but with greater access to foreign currency.

3.3 | Interaction of structural constraints with Cuba's economic growth

The empirical evidence and the bibliographical analysis provided above would appear to suggest the possible existence of structural constraints to Cuban economic growth (on both supply and demand sides); but, do these constraints have any kind of interaction over time?

Figure 2 illustrates the potential flows of transmission between the two constraints.

The potential efficiency gains from regulatory framework changes could be affecting both supply and demand constraints. On the one hand, more efficient use of production resources would bring the economy closer to its production possibility frontier and serve to relax the effect of external constraint on Cuba's economic growth by improving the competitiveness of exports and leading to more sustainable economic growth (as shown in Figure 2, internal to external constraint flows).

Regulatory improvements could initiate a virtuous circle by positively affecting the foreign currency volumes of a country with scant possibilities of access to international credit and the need to import the great majority of its capital goods. The influx of foreign currency from export sales would provide a greater margin for the import of goods and equipment and expand economic production capacity (as shown in Figure 2, external to internal constraint flows). Higher investment in capital assets would have a positive impact on production growth, thus, validating, in Cuba's case, the concept of circular cumulative causation cited in the works of Harrod, Kaldor, and Thirlwall.

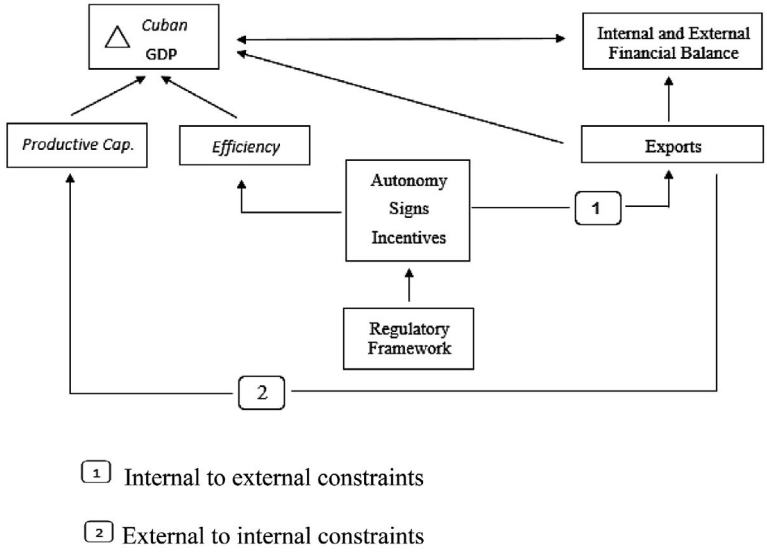

FIGURE 2 Flow of structural constraints on Cuba's economic growth. 1 Internal to external constraints. 2 External to internal constraints. *Source:* Prepared by the author

However, as we have seen in the previous epigraph, the relation between the Cuban regulatory framework and external constraint has also operated in the opposite way. In that vein, the U.S. embargo has reinforced the need for a centralized and vertical direction (Torres, 2016), in legitimizing measures and regulations that, despite affecting efficiency, were more aligned with the government's ideology. Therefore, while economic factors help us understand the level of centralization of the Cuban economy, political factors (ideology, political preference for direct control…) are crucial for a more complete understanding of the Cuban regulatory framework. Indeed, both factors (economic and political) should not be considered as totally independent, since the implementation of more decentralized measures has also altered both the collective imagination of the Cuban society and some governmental narratives.

Figure 3 shows the interdependence of goods and services exports and gross capital formation when both of these variables are applied.

The positive correlation reflected between the two variables strengthens the argument represented in Figure 2, according to which external economic constraint lead to internal constraint for economies lacking access to foreign currency for the import of capital assets.

4 | EMPIRICAL ANALYSIS

4.1 | The model

The existence of direct and indirect effects interacting over this period increases the possible endogenous nature of some of the variables used in the analysis. In addition to joint consideration of the factors and constraints of supply and demand that are potentially significant in the evolution of the Cuban GDP, the modelling of this based on the equations described below represents a possible solution to the problem of simultaneity.

$$\ln Y_t = \beta_0 + \beta_1 \ln K_t + \beta_2 InH_t + \beta_3 DI_t + \beta_4 \ln EMB + e_t \tag{1}$$

$$\ln K_t = \alpha_0 + \alpha_1 \ln K_{t-1} + \alpha_2 \ln X_{t-1} + u_t \tag{2}$$

FIGURE 3 Export of goods and services and Gross Capital Formation in the production sector 1975–2014 (at constant prices)[a]. *Source:* Prepared by the author, based on ONEI data (1988). [a](p) denotes main axis variable; (s) denotes secondary axis variable

$$\ln X_t = \lambda_0 + \lambda_1 \ln Y_t + \lambda_2 GPTP + \lambda_3 TOT_t + v_t \quad (3)$$

In the first equation, the GDP, represented by Y, is expressed as a Cobb-Douglas function of the traditional production factors (capital and labour); a synthetic index, represented by DI, approximating the principal changes in Cuba's regulatory framework in recent decades, and a variable that approximates the cost of the U.S. embargo (EMB). Despite its relevance, economic duality cannot be included in the econometric analysis due to the lack of data.

The external constraint to Cuban growth is estimated in Equation 2, which expresses the evolution of capital stock as a function of export performance and capital stock of the previous year.

Equation 3 adds the demand factors commonly used in export modelling, such as terms of trade (TOT) or growth of principal trading partners (GPTP) and supply factors, approximated by the GDP.

4.2 | Data

The data sets used in the empirical analysis were constructed using aggregated annual production sector data for 1975–2014.

The dependent variable corresponds to GDP constant prices based on 1997 data (ONEI, several years). The methodological change introduced in GDP measurement by the Cuban government required our correction of the original data set for the 2007–2014 period in order to exclude outliers from the sample. The following steps have been taken to reduce the bias and give the time series greater consistency:

- The scope of the study has been limited to the production sector so that a more homogeneous series can be constructed using the official data for a longer time period (1975–2006).
- GDP values for the production sector for 2007–2014 have been corrected by applying (starting 2006), the growth rates obtained using the new methodology to the GDP value of the preceding year, which reduced the sector's growth rate as of 2007 from 3.8% to 1.9%.

The explanatory variables included in the model and the methodology and data used to measure them are set out below.

4.2.1 | Stock of physical capital (K)

One advantage to examining the national accounts of a planned economy like Cuba's is the availability of official data up to 1989 on accumulation funds and fixed capital stock, listed by sector (calculated using the physical assets inventory method) which enabled us to obtain the capital stock of the production sector between 1975 and 1989.

Capital stock for the 1990–2014 period has to be estimated. The most used estimation method is the Perpetual Inventory Method (PIM), developed by Benhabib and Spiegel (1994).

$$\mathrm{K}_t = \sum_{i=1}^{6} \mathrm{K}_{it} = \sum_{i=1}^{6} \left[\mathrm{K}_{i0} (1-\delta_i)^t + \sum_{t=1}^{t} \mathrm{I}_{it} (1-\delta_i)^{t-q} \right] \quad (4)$$

where δ_i is the rate of linear depreciation of sector i,[6] I_{it} and K_{it} represent Gross Fixed Capital Formation in constant prices for 1997 and capital stock for sector i in year t (ONEI, several years).

However, in the case of Cuba, an added difficulty in estimating capital stock is determining the impact that the disintegration of the Socialist bloc in the late 1980s may have had on depreciation assumptions. Until that time, the accumulation model of the Cuban economy was strongly affected by its membership in Council for Mutual Economic Assistance (COMECON). The disintegration of the Socialist bloc marked the end of guaranteed supply of production and machinery supplies and revealed a tremendous technological obsolescence of installed capacity with respect to the capitalist supply. In this context, the constant depreciation between 1990 and 2014, of the capital stock accumulated during the COMECON period (assumed in Equation 4) would no longer be a reasonable assumption. It could, therefore, be expected that the loss of economic value due to the technological obsolescence of the said capital, combined with repair and maintenance problems (this latter caused by the lack of spare parts and technical assistance), would increase over time for the stock accumulated during Cuba's membership in the socialist bloc. Aimed at including these specific characteristics of the Cuban economy, the following adaptation of Equation 4 is proposed, in which capital stock is estimated assuming rising depreciation of the capital stock accumulated up to 1989 starting with 1990, and assuming constant depreciation of the capital stock generated with the new investments:

$$\mathrm{K}_t = \sum_{i=1}^{6} \mathrm{K}_{it} = \sum_{i=1}^{6} \left[\left[\mathrm{K}_{it-1} - \sum_{j=1}^{t-2} \mathrm{I}_t (1-\delta_i)^{t-1-j} \right] (1 - t\delta_i) + \sum_{j=1}^{t-1} \mathrm{I}_t (1-\delta_i)^{t-j} \right] \tag{5}$$

where $\mathrm{K}_{it-1} \geq \sum_{j=1}^{t-2} \mathrm{I}_t (1-\delta_i)^{t-1-j}$

In Equation 5, depreciation of the capital stock accumulated during Cuba's membership in COMECON shows linear growth over time (t1989 = 1). Based on this, the capital stock accumulated between 1990 and 2014 is estimated.

Figure 4 shows the estimations of capital stock between 1975 and 2014, applying both depreciation assumptions.

The estimates used in Equation 5 reflect the decapitalisation of the Cuban economy following the disintegration of the Socialist bloc, which has been cited in literature as one of Cuba's principal structural problems since that time (Carranza & Monreal, 2000; Gonzalez, 1995).

4.2.2 | Human capital (H)

Given that the high education levels of Cuban workers is one of the calling cards of the Cuban Socialist model, it appears reasonable to consider the quality of work in their estimation.

In recent decades, the measurement of the effect of a more highly skilled labour force on economic growth has been addressed by numerous authors (A.W. Lewis; J. Arrow; Z. Griliches; J. Mincer; R. Lucas; P. Romer). The mean years of schooling of the working population is among the proxies most frequently employed for measurement. Barro and Lee (1993) estimate the mean years of schooling for different economies based on the perpetual inventories method, as applied to student enrolment rates at different educational levels. In the present study, the number of occupied workers (ONEI, several years) is multiplied by the mean years of schooling per year, as obtained from Mendoza (2003), Barro and Lee (2010), and UNDP (2017).

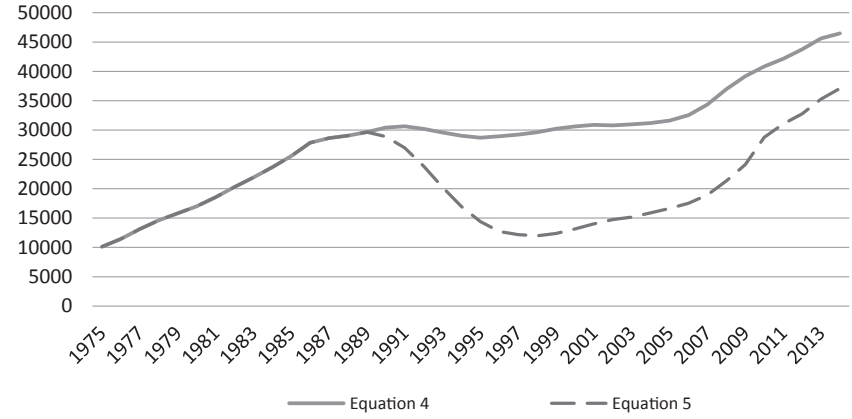

FIGURE 4 Cuba's capital stock 1975–2014 (different depreciation assumptions). *Source:* Prepared by the author, based on ONEI data (1988)

4.2.3 | Economic decentralisation composite indicator (ED)

As we have previously seen, one of the variables that could explain the behaviour of Cuban GDP is the regulatory framework or, more specifically, the level of centralisation of the Cuban economy. In order to capture its evolution and assess the dynamics of centralisation-decentralisation, a composite index is constructed, based on the Principal Components Analysis.

Although they do pose methodological difficulties,[7] composite indices can synthesise a large volume of information and make it easier to interpret and compare complex and multidimensional phenomena (across individuals and across time). Generally speaking, composite indicators are constructed with the help of the following equation:

$$IC = \sum_{i=1}^{m} w_i X_{in} \tag{6}$$

where X_{in} represents each of the standardized individual indicators X_i, and w_i the weight assigned to the variable X_{in}.

The variables chosen to represent the level decentralisation in the analysis are the following:

- *Openness to Foreign Direct Investment*: passage of Law No.77 on FDI, which met the three priorities for which it was designed: new capital influx, technology transfer and access to new markets (Pérez, 2006). Because official data on FDI flows to Cuba are only available from 1994 to 2001, the *number of international economic ventures* is used as a proxy for the production sector's openness to FDI (Pérez et al., 2016)
- *Level of Managerial Autonomy*: the Enterprise Optimisation Programme was expanded in 1998 to include the civil sectors of Cuba's economy. Its purpose was to increase efficiency and provide greater guarantees of financial autonomy for businesses through decentralisation methods applied in the organisation of work, salaries and incentives, financial policies and investment. For this reason, the level of managerial autonomy is approximated by the *number of companies in the Enterprise Optimisation Programme* (Marquetti, 2006; Caminos, 2010; Juventud Rebelde, 2017).
- *Relevance of non-state forms of ownership (OWN)*: in 1993, Decree Law 141/93 regulated self-employment, in hopes of contributing to higher productivity by permitting thousands of the sector's

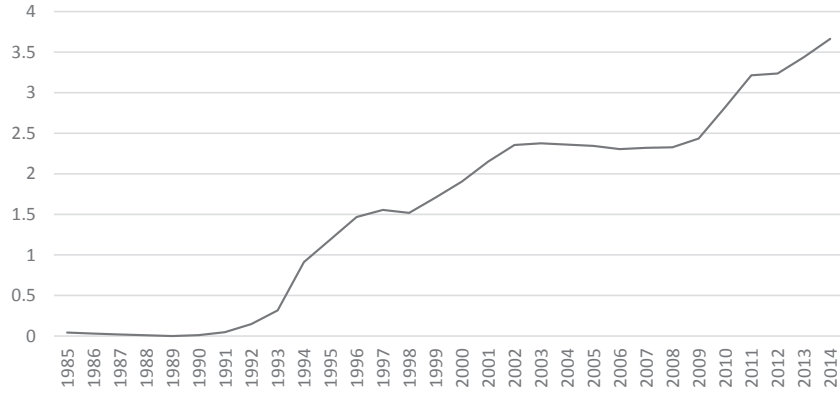

FIGURE 5 Economic decentralization index for Cuba's production sector from 1985 to 2014[a]. *Source:* Prepared by the author. [a]The index is not represented between 1975 and 1984 because it was constant and close to zero

underemployed workers to enter the private sector. This variable was estimated based on the *number of self-employed workers* in the productive sector (Economic Commission for Latin America & the Caribbean-ECLAC, several years; ONEI, several years)

- *Size of free markets (MAR)*: in September 1994 the government authorised the reopening of the Agricultural and Livestock Market. The incorporation of market mechanisms was meant to have two positive effects: higher production would bring in more than centralised prices, and the move from administrative price fixing to supply and demand policies would facilitate measurement of the key variables for good economic functioning and the proper allocation of resources. The proxy is *sales on the supply and demand markets*. It includes sales in the agricultural and livestock market, and sales made by the self-employed (ONEI, several years).

The aim here is to obtain an overview of the regulatory environment in Cuba between 1985 and 2014 by looking at the way in which the extent of decentralisation in the production sector has evolved (Figure 5). The principal components analysis was used to arrive at these estimates. This method involves linear combinations of the original variables in which the combinations are placed in decreasing order based on the amount of variance that they account for. In line with Freudenberg (2003), once the theoretical framework and the relevant variables have been defined, the next step is to standardize them and to proceed with a correlational analysis, since, if common factors exist, they will yield a higher intervariable correlation. To contrast the results, use has been made of the correlations matrix, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Barlett's test of sphericity. The results validate the use of the main components method to build the composite index, since 100% of the correlation coefficients exhibit an absolute value of over 0.5, the KMO coefficient is over 0.6 and the probability associated with the chi-square statistic of the Barlett's test is lower than 0.05 (see Appendix A).

The changes in this index show that the periods 1992–2003 and 2008–2014 appear as stages during which the regulatory framework was being decentralised and the years 2004–2007 being a time during which the decentralisation process was stopped and even lightly reversed.

4.2.4 | U.S. embargo (EMB)

This variable is based on data provided by the INIE. Given that annual data are not available for the period 1975–1984, the missing data are calculated as the average of the nearest 5-year period.

4.2.5 | Exports of goods and services (X)

This variable is in constant prices, obtained from Balance of Payments data included in Cuba's Statistical Yearbooks (ONEI, several years) and from information facilitated by the Institute for Economic Research. The economic performance of goods and services exports with respect to the Gross capital Formation shown in Figure 3 justifies inclusion of this variable, lagged one period, in Equation 2.

4.2.6 | Terms of trade (TOT)

This variable was constructed from ECLAC data (several years) and data supplied by INIE.

4.2.7 | Economic growth of principal trading partners (GPTP)

This variable is approximated by an index number that reflects GDP evolution of the Cuban economy's principal trading partners, with growth rate weighting of each country by its weight in Cuba's total exports[8] (base year 1974 = 100).

The series' stationarity is analysed using augmented Dickey-Fuller tests. The results are shown in Table 1.

The results of the augmented Dickey-Fuller tests show that all the series used for this econometric analysis are non-stationary and integrated of order 1, I(1); any cointegration relationship that may exist between them can, therefore, be analysed.

4.3 | Estimation method and results

The empirical analysis is a two-stage process. The first step consists of estimating each equation individually using Ordinary Least Squares to test the robustness of the estimated parameters and confirm the presence of cointegration between variables. The second step consists of estimating the simultaneous equations model defined by Equations 1, 2, and 3 using 3SLS to consider both the internal and external constraints and their interaction over time.

Table 2 shows the results of the OLS estimate of Equations 1, 2, and 3.

The synthetic index of economic decentralisation shows high significance and positive effect, thereby suggestingthe importance of considering the regulatory framework when explaining the growth of the Cuban production sector. As far as the traditional factors of production are concerned, while the elasticity of physical capital is significant and with the expected sign,[9] in the case of human capital this elasticity becomes negative and significant at the 10% level. This apparently counterintuitive result makes sense when framed in the context of the years studied. In late 2010, for instance, after 17 years of steady economic growth and of having amply exceeded precrisis production levels, the Cuban government publicly recognised that there were still one million too many employees on the State payroll (one quarter of the working population), which gives some idea of the high levels of underemployment of the production sector during the entire period of the recovery. Another relevant result of this first estimation has to do with the parameter linked to the U.S. embargo, confirming its significant and negative impact on the growth of the Cuban production sector.

TABLE 1 Series stationarity tests, 1975–2014[a]

	t-statistic	Constant and trend	Lags
Ln Y	−1.760	Constant	1
Ln K	−2.004	Yes	1
Ln H	−2.270	Yes	0
DI	1.543	No	1
Ln EMB	0.608	No	0
Ln X	0.909	No	1
GPTP	0.932	No	1
TOT	−2.706	Constant	1
Δ Ln Y	−3.390*	No	0
Δ Ln K	−2.033**	No	1
Δ Ln H	−5.203*	Constant	0
Δ DI	−3.129**	Constant	0
Δ Ln EMB	−7.607*	No	0
Δ Ln X	−3.612*	No	0
Δ GPTP	−2.812*	No	0
Δ TOT	−5.502*	No	1
errorEq1	−2.908*	No	0
errorEq2	−1.820***	No	0
errorEq3	−3.428*	No	0

Abbreviations: DI, decentralization index; EMB, U.S. Embargo; errorEq1, estimated error of Equation 1; errorEq2, estimated error of Equation 2; errorEq3, estimated error of Equation 3; GPTP, Economic growth of principal trading partners; H, human capital; K, Stock of physical capital; TOT, Terms of trade; X, Exports of goods and services; Y, GDP.

[a]Logarithmic transformation is applied to the variables that are not indices in order to smoothen their behaviour.

*Stationary at a 99% confidence level.

**Stationary at a 95% confidence level.

***Stationary at a 90% confidence level.

Source: Prepared by the author.

On the other hand, the importance of lagged exports in the financing of investments and in the capitalisation of the Cuban economy suggested in Figure 3 is contrasted with the positive and significant effect of lagged exports in the modelling of capital stock.

The variables that have traditionally modelled exports, such as revenues of principal trading partners or changes in terms of trade are also significant and with the expected sign.

Next, the variables' cointegration is analysed using the methodology developed by Engle and Granger (1987), in which a cointegration vector can be found such that, when the model's variables are integrated in the same order, these variables can be combined in a lesser order.[10] In the case at hand, the results of the augmented Dickey-Fuller test shown in Table 1 indicate that the estimated residuals are stationary, which confirms the existence of a cointegration relationship between the model's variables[11] and rules out the possibility that the correlation could be the result of a spurious relationship between the variables.

Following this long-term estimate, given Granger's representation theorem (which states that if a vector of variables is CI (1,1), then, there is a valid error correction mechanism (ECM) for representing the data generation process) (Intriligator et al., 1996), an ECM model can be applied to the present

TABLE 2 OLS estimation of Equation 1, 2, and 3[a]

End.Var	Parameters	Obs	R^2	Prob (F-statistic)
Ln Y	5	40	0.845	0.000
Ln K	3	39	0.972	0.000
Ln X	4	40	0.939	0.000
	Equation 1	Equation 2		Equation 3
Ln K	0.558			
	(0.000)[b]			
Ln H	−0.310			
	(0.015)			
DI	0.156			
	(0.000)			
Ln EMB	−0.280			
	(0.001)			
Cons	11.718	0.448		−6.808
	(0.000)	(0.098)		(0.000)
Ln K (−1)		0.828		
		(0.000)		
Ln X (−1)		0.150		
		(0.000)		
Ln Y				1.415
				(0.000)
GPTP				0.012
				(0.000)
TOT				−0.165
				(0.133)

Abbreviations: DI, Decentralization index; EMB, U.S. Embargo; GPTP, Economic growth of principal trading partners; H, Human capital; K, Stock of physical capital; TOT, Terms of trade; X, Exports of goods and services; Y, GDP.

[a]SE corrected for heteroscedasticity (Huber-White).

[b]p-value shown in parenthesis.

Source: Prepared by the author.

analysis. By combining variables in levels with variables in first differences, this model makes it possible to link a long-term equilibrium analysis with the short-term adjustment pattern and estimate how quickly any departures from long-term equilibrium will be corrected.

The Engle-Granger two-step method, which involves including the estimated residuals, lagged one period, in the ECM model, can then be used.

$$\Delta \ln Y_t = \beta_1 \Delta \ln K_t + \beta_2 \Delta \ln H_t + \beta_3 \Delta DI_t + \beta_4 \Delta \ln EMB + \beta_5 errorEq1_{t-1} + e_t \tag{7}$$

$$\Delta \ln K_t = \alpha_1 \Delta \ln K_{t-1} + \alpha_2 \Delta \ln X_{t-1} + \alpha_3 errorEq2_{t-1} + u_t \tag{8}$$

The results obtained from the OLS estimation of Equations 7, 8, and 9 are shown in Table 3.

TABLE 3 Error correction mechanism[a]

End.Var	Parameters	Obs	R^2
Δ ln Y	4	39	0.557
Δ ln K	2	38	0.903
Δ ln X	3	39	0.613
	Equation 7	Equation 8	Equation 9
Δ ln K	0.748		
	(0.000)[b]		
Δ ln H	−0.486		
	(0.006)		
Δ DI	0.022		
	(0.714)		
Δ ln EMB	−0.097		
	(0.034)		
Δ ln K (−1)		0.992	
		(0.000)	
Δ ln X (−1)		0.080	
		(0.011)	
Δ ln Y			1.481
			(0.000)
Δ GPTP			0.009
			(0.121)
Δ TOT			0.413
			(0.070)
ErrorEq1 (−1)	−0.523		
	(0.013)		
ErrorEq2 (−1)		−0.308	
		(0.000)	
ErrorEq3 (−1)			−0.416
			(0.002)

Abbreviations: DI, Decentralization index; EMB, U.S. Embargo; GPTP, Economic growth of principal trading partners; H, Human capital; K, Stock of physical capital; TOT, Terms of trade; X, Exports of goods and services; Y, GDP.

[a]Constants are removed because of the lack of statistical significance.

[b]*p*-value shown in parenthesis.

Source: Prepared by the author.

$$\Delta \ln X_t = \lambda_1 \Delta \ln Y_t + \lambda_2 \Delta GPTP_t + \lambda_3 \Delta TOT_t + \lambda_4 errorEq3_{t-1} + v_t \quad (9)$$

Cointegration is confirmed by the error correction term in all the equations. The parameters for the estimated speed of adjustment indicate that temporary departures from long-term equilibrium are nearly adjusted in two or 3 years. Except for the parameters associated with the decentralization index and the terms of trade, the rest of the parameters keep the same sign and are also significant in the

short run, thereby confirming the robustness of the long run estimation and suggesting that decentralisation measures take longer to affect GDP.

After estimating each equation individually, this second part of the analysis takes the interaction and simultaneity of the specified equations into account. The first step is to verify that the model truly presents problems of simultaneity. Otherwise, it is preferable to perform equation estimations separately, using Ordinary Least Squares (OLS). To this end, the *Hausman test* is applied by rewriting the equations of the system in reduced form, and regressing by OLS the equation that models the behaviour of the variable posing simultaneity problems (in this case, the GDP). Below, is the equation resulting when the estimated values of the data set of GDP in Equation 1 are inserted in Equation 3, followed by OLS estimation.[12]

$$\ln X_t = \lambda_1 \ln Y_t + \lambda_2 GPTP_t + \lambda_3 TOT_t + \lambda_4 errorEq1 + v_t \tag{10}$$

The results of Table 4 show that the GDP estimation in Equation 1 is significant in Equation 10, which confirms the endogenous nature of this variable, and the need for simultaneous equations for the estimation of Cuban growth.

The most frequent solution to problems of endogeneity is simultaneous equation model estimation, or using instrumental variables (Greene, 1997). The Two Stage Least Squares (2SLS) method is for a specific estimation of instrumental variables in which each equation is estimated individually without considering the constraints defined in the rest of the model (Gujarati, 2005). Conversely, using the Three Stage Least Squares (3SLS) method, estimation of all equations in the model is performed simultaneously.

The method of estimation to be employed will ultimately be determined by the problem of identification. If equations are exactly identified, 2SLS can be applied, but for overidentified equations, the use of 3SLS is required. The rule applied in the analysis of identification of the equations of this model consists of comparing the number of endogenous variables of model (M), with the number of variables excluded in each of the equations, with respect to with the total exogenous and endogenous variables. In our case, the three equations that define the system are overidentified (since the number of variables excluded is greater than $M - 1$ in all equations of the system), due to which 3SLS estimation modelling is preferred. Table 5 shows the results of the 3SLS estimate of the model.

The model's ability to explain the evolution of the Cuban GDP for the period studied and the need for simultaneous consideration of the supply and demand constraints are proven by the high values of

TABLE 4 OLS Estimation of Equation 10[a]

	Coefficient	*t*-statistic
Ln Y	0.675[b]	134.49
GPTP	0.015[b]	1.814
TOT	−0.118	−1.661
errorEq1	0.863[c]	3.637
R^2	0.899	
Akaike (Schwars)	−0.490	(−0.321)

[a]SE corrected for heteroscedasticity (Huber-White).

[b]Significant at a 99% confidence level.

[c]Significant at a 95% confidence level.

Source: Prepared by the author.

TABLE 5 3SLS estimation of the system formed by Equation 1, 2, and 3[a]

End.Var	Parameters	Obs	RMSE	R^2	*p*-value
Ln Y	4	39	0.088	0.834	.000
Ln K_eq.5	2	39	0.057	0.972	.000
Ln X	3	39	0.133	0.940	.000
	Equation 1	Equation 2		Equation 3	
Ln K_eq.5	0.546 (0.000)[a]	–		–	
Ln H	−0.204 (0.237)	–		–	
DI	0.135 (0.000)	–		–	
Ln EMB	−0.271 (0.000)	–		–	
Cons	8.580 (0.000)	0.462 (0.077)		−7.754 (0.000)	
Ln K_eq.5(−1)	–	0.834 (0.000)		–	
Ln X (−1)	–	0.141 (0.000)		–	
Ln Y	–	–		1.520 (0.000)	
GPTP	–	–		0.011 (0.000)	
TOT	–	–		−0.159 (0.105)	

[a]*p*-value shown in parenthesis.

Source: Prepared by the author.

R^2, the significance (with the expected sign) of most of the variables considered and the endogenous nature of some of them. The stability of the empirical results supports their soundness.

The relevance of the regulatory framework in the equation that models GDP evolution again shows the positive effect of the decentralisation reforms on the economic growth of the Cuban production sector. In turn, the 3SLS estimation confirms the negative effect of the U.S. embargo and the difficulties involved in using one of the main strengths of the Cuban economy, its human capital, productively.

The results of the third equation suggest that Cuban exports are both income and price elastic since changes in the revenues of the principal trade partners have a significant and positive effect on Cuban exports and changes in prices (terms of trade) have a significant and negative effect.

Likewise, the significance and circular causality between the stock of physical capital, lagged exports and exports and GDP reinforces the assumption of simultaneity of endogenous and exogenous factors of Cuban growth on which the analysis is based.

Finally, a test can be run to see how solid the estimates are based on an analysis of their sensitivity to changes in the construction of factors of production. To this end, new alternative estimates can be calculated by employing constant capital depreciation assumptions for the whole period—as

estimated in Equation 4- and by substituting Human Capital by Labour, that is to say, without considering its education level (see Appendix B). Once again, the stability of the results of the new estimate is noteworthy, matching up with the main findings obtained from the preceding analysis (positive and significant effect of decentralization on the GDP and significant external constraint) and thus, underscoring the importance of taking factors and constraints specific to the Cuban economy into consideration when modelling its GDP. These final results confirm the appropriateness of assuming increasing depreciation of the capital stock (given that R^2 falls by 35 points when assuming constant depreciation of the capital stock) and the irrelevance in terms of GDP growth of expanding Cuban labour (even when education is not considered).

5 | CONCLUSIONS AND ECONOMIC POLICY IMPLICATIONS

The qualitative and quantitative analysis carried out in this paper suggests the importance of both institutional factors and external restraint in explaining Cuba's productive sector GDP over the past 40 years.

The equation-based modelling enables correction of the problem of endogenous variables of the model, and inclusion, for the first time, of the simultaneous effect of supply and demand constraints on the evolution of Cuba's GDP. The results obtained also confirm the interactions between internal and external constraints that limited Cuba's economic growth during the period studied. This suggests that the relaxing of internal constraint could positively affect growth in two ways: on the one hand, a direct effect on the product, due to improved economic efficiency, and on the other, the effect of relaxing the external constraint due to the higher competitiveness of Cuban exports. This correlation would confirm the validity, in the case of Cuba, of the concept of circular cumulative causation developed by authors like Harrod, Kaldor and Thirlwall, according to which exports would cause a virtuous circle of sustained long-term growth. Likewise, the expansion of Cuban exports would also have a twofold impact on Cuban GDP: the shift of Cuban aggregate demand to the right given that net exports are one of the four components of aggregate demand, and the subsequent expansion of capital stock since exports are a crucial source to finance new investments in Cuba.

Given that the previous results derive from the analysis of the productive sphere, it is worth noting some aspects of the Cuban nonproductive sector that could affect the potential growth of the overall economy. One factor to bear in mind has to do with the large size of the nonproductive sector (due to the political preferences of the Cuban model and its commitment with full employment) and with how such oversize has limited wage rises; thereby contributing to the shift of high-skilled workers into low-skilled activities but with greater access to foreign currency. Nevertheless, in line with the main conclusion of the Lewis Model (Lewis, 1954), the excess supply of labor in the nonproductive sphere can also represent an opportunity for Cuban long-term economic growth, since the potential expansion of the productive sector could employee underemployed workers (both from the productive and nonproductive sector) without significantly altering the supply of the origin activities (due to the lower productivity of underemployed workers) or triggering wage pressures that could reduce future surplus and investments.

The analysis suggests two possible approaches for stimulating the growth in the Cuban production sector: one revolves around greater decentralisation of the regulatory framework, while the other focuses on industrial, commercial and institutional policies designed to boost the competitiveness of Cuban exports and increase the foreign exchange availability.

Regarding the current economic decentralization process now underway in Cuba, the analysis supports some of the principal conclusions reached in the 6th and 7th CCP Congress, which include: the

need to pare down state employment rolls, facilitate full implementation of non-state owned property, promote the separation of state and business functions, incentivise production through the expansion of free markets , form closer connections between work and income, and eliminate state subsidies to Cuban enterprise, leading to greater financial restraint of the same.

While the flexibilization (or elimination) of the U.S. embargo would have a positive impact on Cuba's GDP by reducing the cost of transport and credits and boosting FDI inflows and Cuban exports, among other effects, such a decision depends solely on the U.S. administration. Thus, the Cuban government should carry out measures aimed at relaxing external constraint such as: theimplementation of import substitution and exports promotion programs, facilitating Cuba's return to the capital markets (such as the agreements reached with the Paris Club[13]), promoting FDI and self-employment, creating a new wage framework for foreign companies,[14] ending the economic duality, and regulatory changes that enabled the productive investment of remittances. Taking the interconnection between internal and external constraints into account, the previous measures could become essential in the event of a new tightening of the U.S. embargo or the political collapse of Venezuela and the end of subsidised oil.

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ENDNOTES

[1] Assumed as correct the production sector provided by National Office of Statistics (ONEI): Agriculture and Livestock; Mining and Energy; Manufacturing; Tourism and Trade, Transport and Communications and Construction.

[2] Due to this decision, in 2004 the aforementioned sector registered 84% growth, and between 2003 and 2004, the GDP figures for this sector leapt from 11.6% to 31.3% (Office of National Statistics of Cuba-ONEI for its Spanish acronym, 1988).

[3] This laid the foundations for later work on the role of institutional infrastructure and economic growth: Hall and Jones (1999), Acemoglu et al. (2001) and Rodrik et al. (2004).

[4] Mesa-Lago (1993) estimates that, between 1960 and 1990, Cuba received credits from the socialist area accounting for $ 25,279 million and under favourable conditions.

[5] According to the new law, those executives of foreign companies who made transactions with the nationalized American properties would be sanctioned.

[6] Depreciation rates taken from ONEI (1988), the latest data available.

[7] Including the results' sensitivity to weightings, to the aggregation criteria used, and to the choice to include or exclude variables from the statistical analysis.

[8] The indicator refers only to growth registered by trade partners accounting for more than 2% of Cuba's export trade in each of the years considered (ONEI, 1988).

[9] It is similar to values estimated in the economic growth literature.

[10] The cointegration methodology developed by Engle and Granger is used here because there are some problems with the generation of nearly singular matrixes when Johansen's test is applied to small samples (Matesanz, Fugarolas and Candaudap, 2007).

[11] For the cointegration test, the values for the t-statistic are compared with the critical values calculated by Engle and Yoo (1987), since, in this case, the Dickey-Fuller and MacKinnon (1996) critical values are not directly derived from an underlying stochastic process but are instead the result of a series that is constructed after the model's parameters have been estimated.

[12] Application of Hausmann test (for further details see Pindyck y Rubinfeld, 1991).

[13] Under this restructuring agreement, fourteen out of the twenty members of the Paris Club forgiven about 80% of the Cuban debt and extended the payment due to 18 years. As a result, Cuban foreign debt has decreased from $35,000 million in 2001 to $15,000 million in 2016.

[14] Since joint companies assume the work cost in convertible pesos and Cuban workers receive a salary for the same amount in Cuban pesos, there is an important margin to reduce work costs for these kinds of companies that would make exports more competitive in the international markets.

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How to cite this article: Palacios Cívico JC. Internal and external constraints of the Cuban production sector. *Growth and Change*. 2021;00:1–26. https://doi.org/10.1111/grow.12468

APPENDIX A.

Principal component analysis

TABLE 6 Correlations matrix

Variables	AUT	MAR	OWN	FDI
AUT	1.000[a]	0.757[a]	0.776[a]	0.693[a]
MAR	0.757[a]	1.000[a]	0.862[a]	0.957[a]
OWN	0.776[a]	0.862[a]	1.000[a]	0.731[a]
FDI	0.693[a]	0.957[a]	0.731[a]	1.000[a]

Note: Determinant: 0.005.

AUT the level of managerial autonomy; MAR the expansion of free markets; OWN represents the expansion of non-State forms of ownership and FDI the extent of openness to Foreign Direct Investment.

[a]Significant at a 99% confidence interval.

Source: Prepared by the author.

TABLE 7 KMO and Barlett test

Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy	0.658	
Barlett's test of sphericity	Chi^2	197.492
	p-value	.000

Source: Prepared by the author.

TABLE 8 Total explained variation

	Initial eigenvalues			Sums of the squared saturations of the extraction		
Component	Total	Percentage variance	Cumulative percentage	Total	Percentage variance	Cumulative percentage
1	3.393	84.834	84.834	3.393	84.834	84.834
2	0.369	9.236	94.070			
3	0.220	5.505	99.575			
4	0.017	0.425	100.000			

Source: Prepared by the author.

TABLE 9 Component matrix

Component	OWN	MAR	FDI	AUT
1	0.872	0.974	0.915	0.921

Note: OWN represents the expansion of non-State forms of ownership; MAR the expansion of free markets; FDI the extent of openness to foreign direct investment and AUT level of managerial autonomy.

Source: Prepared by the author.

APPENDIX B.

Alternative estimations of the system of equations

TABLE 10 3SLS estimation of the system of Equations 1, 2, and 3

End.Var	Parameters	Obs	RMSE	R^2	p-value
Ln Y	4	39	0.088	0.835	.000
Ln K_eq.5	2	39	0.057	0.972	.000
Ln X	3	39	0.132	0.939	.000
	Equation 1	Equation 2		Equation 3	
Ln K_eq.5[a]	0.558 (0.000)[b]	–		–	
Ln L[c]	−0.243 (0.222)	–		–	
DI	0.112 (0.000)	–		–	
Ln Emb	−0.279 (0.000)	–		–	
Cons	8.427 (0.000)	0.464 (0.076)		−15.469 (0.000)	
Ln K_eq.5(−1)	–	0.833 (0.000)		–	
Ln X (−1)	–	0.142 (0.000)		–	
Ln Y	–	–		1.518 (0.000)	
GPTP	–	–		0.011 (0.000)	
TOT	–	–		−0.153 (0.121)	

[a]Based on Equation 5.

[b]p-value shown in parenthesis.

[c]Without considering education.

Source: Prepared by the author.

TABLE 11 3SLS estimation of the system formed by Equations 1, 2, and 3

End.Var	Parameters	Obs	RMSE	R^2	*p*-value
Ln Y	4	39	0.157	0.470	.000
Ln K_eq.4	2	39	0.013	0.998	.000
Ln X	3	39	0.135	0.937	.000
	Equation 1	Equation 2		Equation 3	
Ln K _eq.4[b]	0.849 (0.000) [c]	–		–	
Ln H[d]	−1.660 (0.000)	–		–	
DI	0.249 (0.000)	–		–	
Ln Emb	−0.025 (0.840)	–		–	
Cons	17.709 (0.000)	0.891 (0.000)		−8.688 (0.000)	
Ln K_eq.4(−1)	–	0.864 (0.000)		–	
Ln X (−1)	–	0.062 (0.000)		–	
Cons					
Ln Y	–	–		1.609 (0.000)	
GPTP	–	–		0.011 (0.000)	
Ln TOT	–	–		−0.160 (0.117)	
Cons					

[a]Based on Equation 4.

[b]*p*-value shown in parenthesis.

[c]Without considering education.

Source: Prepared by the author.

TABLE 12 3SLS estimation of the system formed by Equations 1, 2, and 3

End.Var	Parameters	Obs	RMSE	R^2	*p*-value
Ln Y	4	39	0.173	0.355	.000
Ln K_eq.4	2	39	0.013	0.998	.000
Ln X	3	39	0.137	0.936	.000
	Equation 1	Equation 2		Equation 3	
Ln K _eq.4[a]	0.829 (0.000)[b]	–		–	
Ln L[d]	−1.505 (0.011)	–		–	
DI	0.036 (0.310)	–		–	
Ln Emb	−0.131 (0.316)	–		–	
Cons	14.227 (0.000)	0.889 (0.000)		−8.988 (0.000)	
Ln K_eq.4(−1)	–	0.865 (0.000)		–	
Ln X (−1)	–	0.061 (0.000)		–	
Ln Y	–	–		1.640 (0.000)	
GPTP	–	–		0.011 (0.000)	
TOT	–	–		−0.155 (0.128)	

[a]Based on Equation 4.

[b]*p*-value shown in parenthesis.

[c]Considering education.

Source: Prepared by the author.