

Economic Crisis's influence over the quantification of Puerto Rico's Shadow Economy: Parsimonious Econometric Proposal

Segundo Castro-González
Universidad del Este

Julio C. Medina León
Universidad del Este

This work proposes a model based on econometric technics, which through the use of Partial Least Squares-Structural Equation Modeling (PLS-SEM) achieves the quantification of Puerto Rico's shadow economy in 2014. Using structural and internal consistency quality measures for reflective as for formative variables, the econometric model is optimized. The selected model with the best overall measures was denominated as MIMIC_UNE (6-2-1-3). This study has found that for 2014, the informal economy in Puerto Rico is of the order of 36.47% of the GDP, as the fact that it has been rising since 2000 up until this study's date.

INTRODUCTION

The effect that the shadow economy has on a country's taxes is very significant, it's estimated that the money that doesn't become part of the nation's total collections dues to this phenomenon surpasses the billions of dollars in the economies of different countries (Anghel & Vázquez, 2010). Additionally, the shadow economy is highly related to crime related activities, which represent a great worldwide problem. In Puerto Rico's case, similar levels of interest exist on the concept of informal economy, as the country's economy hasn't been exempt of said activity's influence. It gains more importance at this time, as the country is looking for effective tax reforms that will help in minimizing the effects of this type of activity. Recent studies, as the one performed by "Estudios Técnicos, Inc.", (2010), have found that the shadow economy in Puerto Rico could represent 27% of the GDP. Previously, along this analysis line, various studies have been developed in attempts to estimate shadow economy levels present in Puerto Rico, the great majority of these focused on the legal and informal economy, although there has been a gradual increase in the consideration of other aspects of this phenomenon, that affects this country significantly (Estudios Técnicos, Inc., 2010). Nevertheless, the shadow economy is an element that, at the same time, is deceptively simple and extraordinarily complex, trivial in its daily manifestation and able to subvert a nation's economic and political order (Portes & Haller, 2004), this makes measuring this type of activity a very complex task (Anghel & Vázquez, 2010). For this reason, several direct and indirect methods have been developed through the years as attempts of measuring this phenomenon.

However, in the past there has been very few studies calculating the shadow economy in Puerto Rico, even more considering the fact that it has been a decade since Puerto Rico has been suffering an economic

recession. In comparison with other countries, the informal economy phenomenon hasn't been that much studied in Puerto Rico; at a worldwide level, there are very few investigations in terms of this topic and they denote some incoherence between them, greatly due to the different methods used, the diversity of considered indicators, and the broad spectrum of adopted definitions for this type of economic activity (Pol, 2004). Is for this reason that this research proposes 2 central objectives: 1) identify the elements that constitute the economic activity denoted as "shadow" in Puerto Rico and 2) quantitatively estimate the shadow economy activity in Puerto Rico between the years 2000 and 2014, period that covers the know recession.

The methodological sustenance for this study is the model proposed by Schneider & Enste (2000) known as the Model Approach or MIMIC (Multiple Indicators Multiple Causes), later validated by Dell'Anno (2007) and others; based on these guides a new model is proposed, more comprehensive and adapted to the new economic events that are being presented, in which there are more variables considered in the original model and it's validated by the Puerto Rican economical deficit. This work is justified given the fact that the informal economy is of much importance in the entire world; in addition to the constant changes in the economy, the shadow economy becomes elusive and complex in its perception, and of great materiality for the finances of any given country. Is for this reason that, despite all the difficulties that may present themselves, it's necessary to undertake efforts to measure or estimate this type of activity, as obtaining precise statistics of the distribution of a country's resources is very important when making effective economic policy decisions (Schneider & Enste, 2000). Looking to develop (or improve existing) instruments that help in the efforts of controlling informal economy levels, it's vital to start by acknowledging the academic support. It's for this reason that this work pretends to make an academic contribution by producing updated results by means of an improved model proper to this study, based on the MIMIC econometric model (Schneider & Enste, 2000). Assisting in the efforts of measuring the informal economy in Puerto Rico will be very beneficial, as quantitative estimations of this phenomenon bring clarity over the true national economic activity. Also, it allows to measure with more certainty the effectiveness of control measures, facilitating the design of better tools that will contribute to a healthier socio-economic environment.

LITERATURE REVIEW

To quantify the size of the shadow economy in any context, it's necessary to start by first determining what it is and which are its principal components. Jie, Tat, Rasli & Chye (2011) assert that defining this phenomenon is very important when trying to understand how this "invisible hand" works. However, due to its complex nature, this is a difficult task. The main problem when studying the informal economy is how we define it (Sabra, Ahmad, & Rahman, 2015). Schneider, Buehn, & Montenegro (2010) state that in spite the difficulties that have risen through the years when trying to establish with precision a concrete definition of this concept, experts in the matter have adopted various popularly accepted general definitions.

The concept of the shadow economy originated in the third world, in a study of the urban labor market in Africa carried out by the anthropologist Keith Hart, and published in an International Labor Office (ILO) report around 1970 (Portes & Haller, 2004). In this context, Hart deemed as "informal sector" the part of the urban labor force that was employed outside the formal labor market (Noboa Peña, 2014). As time passed, the ILO redefined this concept and converted it into a poverty synonym, giving it a negative connotation (Portes & Haller, 2004). In this process, Portes & Haller (2004) argue that this negative connotation was fed, among other things, by publications of the ILO's PREALC (*Programa Regional del Empleo para América Latina y el Caribe*) that regarded the informal sector as "sub employment" and determined that those who were part of it couldn't be part of the formal sector. At the same time, Portes & Haller (2004) express that this negative point of view was questioned by many of this subject's scholars, as in the case of the Peruvian economist Hernando de Soto who in 1989 defined it as a popular answer to the unjust practices of favoring elitist minority groups in the share of legal economy by predominant mercantilist structures.

One of the most favored definitions reads as follows: the informal economy gathers all economic activity that contributes to the Gross Domestic Product (GDP), but that is not registered in actuality (Schneider & Enste, 2000). Some authors argue that even though this is a good conceptualization of the hidden economy, it fails in clarifying the concept as a whole. So, for them, it would be more effective to hold this concept as every type of economic activity (legal or illegal) that, if registered or reported, would be subject to taxation. In other words, all unreported income from the production of goods or services, realized by monetary or barter transactions (Schneider & Enste, 2000). Schneider et al. (2010), concurring with the popular use of this definition, decide to take a different approach to define this type of activity by sustaining that the shadow economy comprehends all legal production of goods and/or services that is intentionally not reported to the public authorities. This is due to diverse persuasive elements, which include: tax evasion, evasion of employer contribution payments, not complying with labor laws and regulations, not complying with administrative procedures, etc. Although more specific, this definition fails to clarify this concept more accurately.

When analyzing the causes of shadow economy, it is necessary to begin by exposing those found in literature, where it has been found that there exist three groups considered as primary, which are: tax burden, intensity of regulations, and public-sector services. While studying the tax burden, it becomes evident that this cause is one of the most relevant when people decide to enter in this type of economic activity. Because of the consequences that this factor can have over national accounts, this cause is observed very closely by the authorities. Schneider et al. (2010) state that the participation in the informal economy is proportionally affected by the resulting difference between the cost of working in the formal sector and the benefits or profits after taxes; this is, the greater the difference, the greater will the shadow economy activity be. Another one of the principal causes for the development of shadow economy activity is the intensity of regulations, where the level and number of restrictions imposed by regulations that govern formal economic activity that exist in a country are considered. Schneider et al. (2010) express that these regulations include: labor market regulations, trade barriers, and labor market restrictions for foreigners. They also point out that these regulations bump up labor costs, and since these costs can be passed down to employees, they incentivize informal economic activity. The other principal cause discussed in this paper is the public-sector services. This cause represents a dangerous cycle of consequences for a nation's coffer, as the rise in informal economic activity leads to reduced national income; with less income, governmental services are affected, thus prompting the rise of tax rates to compensate for the decline in income; which in turn leads to people migrating to the informal sector (Schneider et al., 2010; Sabra et al., 2015).

Nevertheless, directly and indirectly shadow economy activity has a positive impact on the formal economy. As observed in what has been previously stated, any movement in a nation's economy formal sector can have the effect of incentivizing participation in the informal economy. However, money produced in the informal sector will ultimately end up being part of the formal sector, bringing up national production. In Puerto Rico, there are no academic studies analyzing the principal causes of shadow economy, although there are some technical reports like the one submitted to the Government Development Bank of Puerto Rico by "*Estudios Técnicos, Inc.*", (2010) which considers as principal causes of Puerto Rico's shadow economy aspects of tax evasion, labor participation, and unemployment. There is also talk about the size of the government, but no proper analysis of causality about this or the other factors mentioned in the report take place. Respecting tax burden, even though there is no established causal analysis, "*Estudios Técnicos, Inc.*", (2010), state that due to the serious tax evasion fiscal problem experienced, there can be a causal relation.

Methods for Quantifying Shadow Economy

Through the years, various methods have been developed in hopes of measuring the shadow economy, reason why this research divides them into two groups: direct and indirect methods. Aguilar & Sarmiento (2009) state that direct methods are based on directly obtaining behavioral information from economic agents, reason why they use "first hand" instruments to directly quantify shadow economy activity in a specific context. One of the more known methods under this group is the Survey method,

implemented with relative success in Norway, Denmark, Canada, Great Britain, United States, among others (Schneider & Enste, 2000), and consists in surveying individuals to voluntarily gather information about their involvement in the shadow economy (Schneider & Enste, 2000; Gómez & Alañón, 2004; Asiedu & Stengos, 2014). However, this method has the disadvantage of time and monetary costs, difficulty establishing representative samples, errors due to incorrect answers, to name a few. Another of the more known methods under this group is the Tax audit method. Implemented through fiscal audit programs, it provides detailed information about the profile of strong evaders (Frey & Schneider, 2000). This method's disadvantage is that only a part of the shadow economy is perceived this way (Asiedu & Stengos, 2014), as tax evasion is just one of the diverse elements that integrate this type of activity.

Indirect methods are known as macroeconomic methods or as indicator approaches. They analyze the differences between what would be considered normal in an economy and what really is observed in respects of expenses, employment, and the use of money (Anghel & Vázquez, 2010). These methods infer the size of the shadow economy by comparing macroeconomic indicators containing information about their development through time (Schneider & Enste, 2000). The discrepancy between national expenditure and income method is considered among these indirect approaches; as its name suggests, the principal factors here are the national expense and national income, and it's based in the presumption that the informal income present in a specific economic environment will be reflected in that's environment total expense, so that the excess expense over formal income can be taken as an estimation of the size of the shadow economy in that economic environment (Anghel & Vázquez, 2010; Asiedu & Stengos, 2014). However, in spite its ability to produce relatively good results, this method has as a disadvantage the possibility of presenting incorrect estimations, as it doesn't take into consideration illegal activities like contraband and drug trafficking (Lozano, 2013). Pol (2004) used this method in his study about the shadow economy in Puerto Rico. With data from Puerto Rico's Planning Board, he calculated the amount of informal economic activity between the years 1960 and 2002. According to this calculation, the difference between the expense and national income amounted to \$317 million, which represented 1% of the country's GDP.

Another important indirect method is the currency demand approach; also known as the cash demand method. The implementation of this model was initiated by Phillip Cagan in 1958, establishing a correlation between the currency demand and tax pressure as cause of informal economy (Gómez & Alañón, 2004). It's based in the simple idea that the formal and informal economic agents realize transactions using cash payments (Aguilar & Sarmiento, 2009). Under this assumption, the main reason behind the use of cash is to hide income from the government (Sabra et al., 2015); transactions carried out this way are more difficult to detect than those carried out by other means, as the details of such are registered in diverse financial institutions (Ahumada, Canavese, Canavese, & González, 2003). These authors point out that part of the money circulating by means of those transactions is used to finance occult activities, so if the participating amount of this type of monetary transactions circulating in an economic system is known, an estimation of the size of the shadow economy could take place.

According to Schneider & Enste (2000) and Anghel & Vázquez (2010), various base assumptions are taken into account in the use of this method, such as: high tax pressure and regulations are causes for the existence of informal economy and that all informal economy transactions are carried out in cash, among others. Despite its worldwide employment, this method is not exempt of weaknesses; for example, the assumption that all shadow economy transactions are carried out in cash may not be at all true (Anghel & Vázquez, 2010). They mention as an example that in Norway, according to surveys, 80% of informal transactions are realized in cash. Based on this, an estimation of the hidden economy using this method would not yield a representative approximation. In Puerto Rico's case, no evidence was found of the use of this method to quantitatively measure the size of the informal economy.

The third indirect method discussed in this research is the *physical input* (or electricity consumption) method; its implementation is relatively simple, as it is limited to the use of two variables: electric energy consumption (measured in kilowatts-hour) and GDP at constant prices (Aguilar & Sarmiento, 2009). Under this system, it is assumed that electricity consumption is the best indicator of formal and informal economic activity, so it is understood that any rise in electricity consumption is indicative of a rise in

national production (Asiedu & Stengos, 2014). If a difference between the national product growth and electricity consumption exist, it could be taken as an indicator of the size of the shadow economy. Schneider & Enste (2000) and Anghel & Vázquez (2010) assert that empiric evidence shows that total economic activity and electricity consumption move together, with an elasticity of electricity consumption in relation to gross domestic product close to one. This method was implemented in Puerto Rico by Pol (2004), in a study done with the purpose of estimating the size of the island's shadow economy. Pol calculated that for 2002 the informal economy reached \$6,283 million, representing 9% of the GDP; however, due to a series of circumstances this method isn't very reliable.

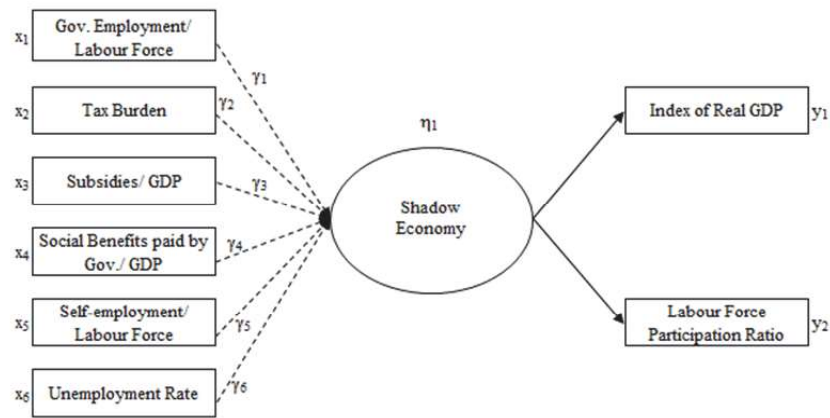
Because of the truly complex nature of the shadow economy, the multiple variables that converge in this phenomenon and that require be considered in its estimation, in addition to considering that the shadow economy is composed of (and affects) various economic elements or indicators simultaneously, the Multiple Indicators Multiple Causes (MIMIC) method comes into play as a viable response to the worldwide shadow economy quantification effort dilemma. According to Schneider & Enste (2000), Weck in 1983 and Frey & Weck also 1983, are consider pioneers of this model. Frey & Weck-Hannemann later applied it to data of 24 OECD countries in a 1984 study. In 1988, Aiger, Schneider & Gosh developed and adjusted the Dynamic MIMIC model (DYMIMIC) to apply it in the United States (Trebicka, 2014).

MIMIC Method and Structural Equation Models

To describe the MIMIC method, it's important to start by talking about the Structural Equation Models (SEM). According to Aguilar & Sarmiento (2009), these models give count to a formalization of the relationships between observed variables and sets of unobserved variables that can be grouped in latent variable constructs or factors. They state that the concept of Structural Equations started with Arthur Goldberger in 1970, in a conference organized to analyze causality models. This antecedent, in addition to a social research methodological proposal established by Jöreskog & Sörborn (1975), gave way to the development of effective tools for the analysis and quantification of informality.

As previously stated, almost all methods developed to quantify the shadow economy consider one indicator of shadow economy. However, Schneider & Enste (2000) and Schneider et al., (2010) consider that the use of just one variable is not recommendable, when it is evident that this effects have simultaneous influence on production, labor, and the money market of a nation. Anghel & Vázquez (2010) concur with this statement, confirming that all other indirect methods only consider one or two economic indicators. Is for this reason that Schneider & Enste (2000) promote the use of this method, as it considers the multiple causes and multiple effects of the shadow economy. These authors state that this model is based on the latent (unobserved) statics theory, considering multiple indicators and multiple causes of a phenomenon. Schneider et al. (2010) coincide with this statement; in the same sense, Dell'Anno (2007) adduces that the MIMIC model is a special structural equation model case (statistical relationships between latent and manifested variables). The MIMIC model allows the consideration of the informal economy as a latent variable with connections to multiple observed cause variables and multiple observed indicators (which reflect changes in the size of the informal economy). Figure 1 shows a diagram representing the description of the MIMIC model, in this case developed by Dell'Anno (2007).

FIGURE 1
SHADOW ECONOMY ESTIMATION MODEL USING MIMIC



Source: Dell' Anno (2007)

Schneider & Enste (2000) argue that in the application of this model, a factor analytical approach is used to measure the shadow economy as a latent variable through time, and that the unknown coefficients are estimated in a set of structural equations in which the latent variable can't be measured directly. Trebicka (2014) explains that the MIMIC model consists of two parts: the structural equation (which examines the relationship between the latent variable and its causes), and measurement equation system (which relates indicators to the latent variable). So that, Castro-González, Espina & Tinoco, (2017) affirm that under the structural equation the shadow economy is the latent variable (η), and its linearly determined subject to a disturbance (ζ) by observable causes (xq); the linear equation is represented by equation (1):

$$\eta = y_1x_1 + y_2x_2 + \dots + y_qx_q + \zeta \tag{1}$$

Under the measurement system the latent variable (η) linearly determines the observed indicators (yp), subject to error (ϵp); this is represented by equation (2):

$$yp = \lambda p\eta + \epsilon p \tag{2}$$

In Puerto Rico, this model has been employed in two occasions to estimate the size of the shadow economy. The first time was in an international study carried out by F. Schneider (2004, 2006), who measured and compared the sizes of the informal economy in 145 countries between the years 1999 to 2003, and found that for 2003 this phenomenon represented 31% of the country's GDP. The second implementation was by "Estudios Técnicos, Inc.", (2010) in its report to the Government Development Bank, and found that for 2009 the size of the island's shadow economy represented 26.6% of the GDP.

METHODOLOGY

This research proposes and develops an improved model over those analyzed in the previous section. Based mainly in the strength of the different MIMIC models found in literature, and grounded in the evidence of previous publications in Puerto Rico and other parts of the world, the causes (inputs) and indicators (outputs) of the proposed model were selected. Given the fact that the MIMIC method looks to quantitatively estimate the size of the shadow economy considering its *relationship* as a latent (unobserved) variable not to one, but to *multiple observed causes and indicators*, it's important as a first

step to correctly define and select the variables to be used. For this purposes, after an exhaustive literature analysis, eight causes (formative variables) and four effects (reflective variables) of the shadow economy were considered at the beginning. Dell'Anno (2007) citing Duncan (1975) states that the meaning of the latent variable will totally depend on the *quality* of the relationship between it and its causes and indicators; in addition to stating that a consensus or established guide to determine which exactly are the causes and indicators of the shadow economy doesn't exist, although a lot of literature focused on this particular does (Schneider, 2006).

Elaboration of the Proposed Model: MIMIC_UNE

For the exposed reasons, in the construction of this theoretical proposal, the following eight causes were selected after a bibliographical review: 1) corporation's net taxable income; 2) individual's net taxable income; 3) violent crimes (intentional homicides); 4) unemployment rate; 5) self-employment; 6) government employment in proportion to the total labor force; 7) tax burden; and 8) government expenditure in proportion to GDP. The following were considered as shadow economy reflective variables: 1) Gross domestic product (GDP); 2) Real personal consumption; 3) Electricity consumption; and 4) Labor force participation ratio. Data was extracted from the following validated sources: Puerto Rico's Planning Board, the World Bank, Puerto Rico's Treasury Department, among others. In regard to the optimization of the model, a unit adjustment process has been used, without modifying the real value, to work in a range of values in a more parsimonious manner.

The justification for the use of the formative determinants of the shadow economy is presented next. In regards to the use of *violent crimes* as a formative variable; given the fact that the more relevant components of illegal activity are characterized by the generation of illegal goods and/or services like drug traffic, prostitution, contraband, robbery, fraud, gambling, etc. (Schneider, 2004), in other words activities related to *criminality*, which is one of the most related aspects of shadow economy (Dell'Anno & Scheneider, 2003), it was considered primordial to include it as a cause in the model. Tax Burden was used as it comprehends the total income from state taxes expressed as a percentage of the GDP (Dell'Anno, 2007). It is believed that growth of this concept encourages work in the informal sector of the economy. The relationship between the *unemployment rate* and the shadow economy is complicated. Divided opinions can be found in literature on this matter. Dell'Anno (2007) states that the decrease of the informal economy could be positively related to the GDP growth rate, and in turn negatively related to the unemployment rate. On the other hand, he mentions that other economic theories state that the unemployment rate does has a positive relationship with the informal economy. To help clarify this controversy, the *unemployment rate* was considered in this model. Along unemployment rate, Dell'Anno (2007) also used the *self-employment*, considered in this model as well. According to Bordignon y Zanardi (1997), high levels of shadow economy can be very prone in labor markets with high presence of small businesses, independent professionals, and self-employed.

According to Schneider (2004), *government employment* expressed as a percentage of the total labor force is another of the principal causes of informal economy. He states that rises in informal economy can lead to decreases in state income and in the quality of goods and services provided by the public sector, which in turn can lead to increases of the country's tax rates and the participation of people in the informal economy. Lastly, *government expenditure* as a portion of GDP, representing in another way the public-sector services. Also considered as a principal cause of shadow economy by Schneider (2004); in Puerto Rico, this formative indicator can be high due to the size of the government. Table 1 presents all the variables used in the proposed model, the types of variables in the structural equation and measurement model, the acronyms used in the PLS-SEM runs, and the units used in the analysis.

Four measurable consequences of the shadow economy were identified in this model, and were labeled as reflective variables of the latent variable. Given the fact that the shadow economy can't be measured directly, certain economic indicators are used to measure its effect in the efforts of quantifying it. These indicators are shown in Table 1. The first one is the *real personal consumption*, employed in "Estudios Técnicos, Inc.", 2010 study. The behavior of this variable was very interesting, as in spite the recession period present in the last years, the growth of this indicator was not stopped, contrasting to the

tendencies to decrease shown by many other variables considered in this study. Following Dell'Anno (2007) and Dell'Anno, Gómez-Antonio, & Pardo (2007), the *GDP* is used as a reference variable. More important than its value will be the sign assigned to it, as it will help establish the relative magnitude of the other variables (Dell'Anno et al., 2007). The third indicator used is *electricity consumption*, because it has been used in previous shadow economy studies through the Physical Input method in various countries, including Puerto Rico (Pol, 2004; “*Estudios Técnicos, Inc.*”, 2010). Lastly, the *labor participation ratio* is also used as a shadow economy indicator. It is composed of the portion of the total population active in the labor market. Dell'Anno (2007) points out that a decrease of this indicator could mean movement of the labor force from the formal labor market to the informal labor market.

TABLE 1
VARIABLES, TYPES OF VARIABLES, NOMENCLATURE AND UNITS USED IN THE PROPOSED MODEL

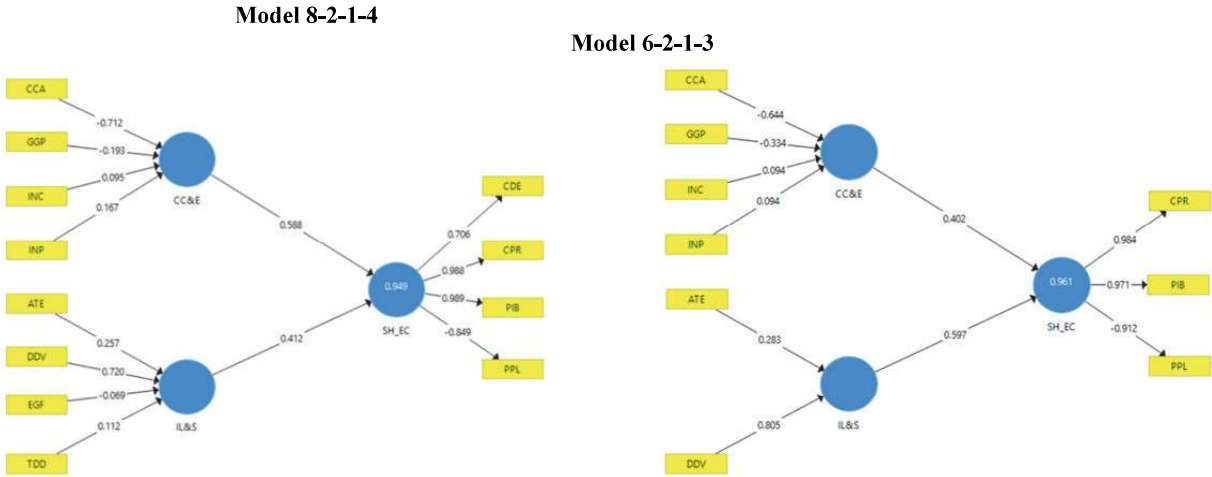
Variables used	Type of Variable	Acronym	Units
Corporation's net taxable income	Formative	INC	Thousands of dollars
Individual's net taxable income	Formative	INP	Thousands of dollars p/100,000
Violent crimes	Formative	DDV	persons
Unemployment rate	Formative	TDD	Percent
Self-employment	Formative	ATE	Percent
Government employment/Labor force	Formative	EGF	Percent
Tax burden	Formative	CCA	Percent
Government expenditure/GDP	Formative	GGP	Percent
Real personal consumption	Reflective	CPR	Billions of dollars
Gross domestic product	Reflective	PIB	Billions of dollars
Electricity consumption	Reflective	CDE	Thousand KWh
Labor force participation ratio	Reflective	PPL	Percent

Technic Used and Optimization of the Model

Initially, the proposed model was subject to an optimization process to determine which indicators or variables were more significant. For this reason, it was necessary to precisely define the structural equation and the measurement model used to estimate the phenomenon subject to this study. Firstly, the approach to work with structural equations was selected; given the fact that there are two approaches to estimate the relationships or parameters in structural equation models: Covariance-Based Structural Equation Modeling (CB-SEM) and Partial Least Squared-Structural Equation Modeling (PLS-SEM) (Hair, Hult, Ringle, & Sarstedt, 2014). Considering the different measurement scales, the nature and limited availability of the statistical data related to the considered variables, the PLS-SEM was opted. This because, unlike CB-SEM, the PLS-SEM technique can work with small samples and of different measurement scales (Roberts & Thatcher, 2009; Hair et al., 2014). Through the use of this technique, the coefficients of the relationship between the latent variable and its causes or indicators will be calculated, with the purpose of minimizing the error terms (maximize explained variance) of the endogenous constructs (Hair et al., 2014).

The proposed MIMIC model in this research has been denominated MIMIC_UNE, due to the fact that it considers eight causes (formative indicators) and four indicators (reflective indicators) of the island's shadow economy (latent variable), in an 8-2-1-4 configuration (8 causes grouped in 2 formative constructs of the latent variable reflected in 4 indicators). The two latent formative variables respectively gather four of the eight causes considered in this study. This helps to study the implications of this groups of causes over the studied phenomenon more deeply, and facilitates the determination of their significance. The first formative latent variable was denominated *Tax and Economic Burden (CC&E)* and it groups the causes associated to tax or economic aspects of the shadow economy: (1) Corporation's net taxable income [INC], (2) Individual's net taxable income [INP], (3) Tax Burden [CCA], and (4) Government expenditure as portion of GDP [GGP]. The second formative latent variable was denominated *Labor and Social Indicators (IL&S)* and groups the causes related to labor and social aspects of the shadow economy: (1) Violent Crimes [DDV], (2) Unemployment Rate [TDD], (3) Self-Employment [ATE], and (4) Government Employment as a percentage of Total Labor Force [EGF]. The principal construct was denominated *Shadow Economy (SH_EC)* and represents the latent variable shadow economy. Through quality tests, an optimization process was carried out which comprehends the use of the PLS-SEM technique to estimate the factor weights, factor loadings, and other statistical criteria, in order to evaluate the quality of the model and eliminate those formative and reflective indicators that aren't significant in the model's context. SmartPLS®, program developed by Ringle, Wende, & Becker (2015), will be used to carry out these estimations. The use of this technique involves two stages: (1) the evaluation of the measurement model and (2) the evaluation of the structural model (Roberts & Thatcher, 2009; Hair et al., 2014; Castro-González, Peña-Vinces & Guillén, 2016 and Castro-González, et al., 2017). Figure 2 presents the outputs of SmartPLS®, of the initial proposed model for this analysis.

FIGURE 2
OUTPUT OF THE PROPOSAL MODELS FOR SHADOW ECONOMIC IN PUERTO RICO



Output from SmartPLS®

Evaluation of the Reflective and Formative Indicators

First, the measurement model was evaluated. This at the same time incorporated two phases: (1) the evaluation of the reflective measurement model (indicators) and (2) evaluation of the formative measurement model (causes) (Hair et al., 2014). The results of the reflective (measurement) model are presented in table 2. The first evaluated criterion was *Internal consistency reliability*. A good measurement of this criterion is *Composite reliability*, which should be greater than 0.708 according to Hair et al. (2014). Results equal to .803 or greater were obtained in all runs of the model. This proves

unfailingly that the proposed model is consistent in terms of its internal composition. After this, the *Indicator reliability* of each indicator was assessed through their factor loads and relative *communality*, which is the square of the factor loads. The factor loads describe how much the indicator contributes to the latent variable (Castro-González, et al., 2016; Castro-González, et al., 2017). The *communality* indicates how much of the latent variable's variability is explained by the indicator (Hair et al., 2014), so the theory recommends that the estimated values of the loads be greater than 0.708 (Hair et al., 2014). As observed in table 2, in the model 8-2-4-1; Electricity consumption's factor load was 0.706, so it was eliminated from the model.

Another of the evaluated quality criterions of the proposed model, recommended for reflective variables, was the Average Variance Extracted (AVE). This value explains the variability of the latent variable in respect to its respective indicators; according to the consulted literature, the AVE should be greater than 0.50 (Hair, et al., 2014; Castro-González, et al., 2016 and Castro-González, et al., 2017). In the model's first run, this value was equivalent to 0.793. When the non-significant was eliminated, it rose to 0.941 showing a significant improvement in the 6-2-1-3 model.

TABLE 2
PROPOSED MODEL'S REFLECTIVE INDICATORS RESULTS

Modelos	Carga / [Comunalidad]				Composite Reliability	Average Variance Extracted
	CPR	PIB	CDE	PPL	CR	AVE
8-2-1-4	0.988	0.989	0.706	-0.849	0.803	0.793
	[0.976]	[0.978]	[0.498]	[0.721]		
6-2-1-3	0.984	0.971	-	-0.912	0.809	0.914
	[0.968]	[0.943]	-	[0.832]		

After evaluating the reflective variables, the formative variables of the proposed model were evaluated; that is to say, the shadow economy causes in this study. To evaluate the formative (measurement) model, it is necessary to consider different quality criterions to those in the reflective model according to Roberts & Thatcher, 2009; Hair et al., 2014. First, it's necessary to corroborate that no multi-collinearity problems exist between formative indicators, as relevance and significance of formative models should only be analyzed when no critical collinearity levels exist (Roberts & Thatcher, 2009 y Hair et al., 2014). To evaluate collinearity levels, the *Variance Inflation Factor (VIF)* was evaluated. When values under 5.0 are obtained, no critical levels of collinearity exist (Roberts & Thatcher, 2009; Hair et al., 2014; Castro-González, et al., 2016). When the different SmartPLS® outputs were obtained in the run sequences, it is observed that the Unemployment rate obtained a VIF of 5.238, so it was eliminated from the model. After confirming that no collinearity problems exist, the respective formative indicator weights were evaluated to corroborate which were significant and relevant in the model (Hair et al., 2014). According to Roberts & Thatcher (2009), Hair et al., (2014) and Castro-González, et al., (2016), when evaluating the factor weight and respective communality of formative variables, if this values are minimal they should be eliminated as they don't contribute significant relevance to the model. For this reason, when evaluating the factor weight and respective communality (.069) of Government employment as percentage of total labor force, it was eliminated from the MIMIC_UNE model as it doesn't denote significant weight. Table 3 presents the previously discussed results.

TABLE 3
PROPOSED MODEL'S FORMATIVE INDICATORS RESULTS

Modelo	Peso Factorial / [VIF]							
	INC	INP	CCA	GGP	ATE	DDV	TDD	EGP
8-2-1-4	0.095	0.167	-0.712	-0.193	0.257	0.72	0.112	-0.069
	[2.5]	[3.299]	[2.991]	[2.285]	[2.414]	[4.844]	[5.238]	[2.212]
6-2-1-3	0.094	0.094	-0.644	-0.334	0.283	0.805	-	-
	[2.5]	[3.3]	[2.99]	[2.29]	[1.55]	[1.55]	-	-

Once the measurement model was evaluated, the structural model was evaluated to assess the relationship between the constructs (CC&E and IL&S with SH_EC) and the model's prediction capability. The results for the structural model can be observed in table 4: the path coefficients describing the relationship between the latent variable (SH_EC) and each construct, and the coefficient of determination (R²) of each model. The principal quality criterion of the structural model is the R², and serves to measure the predicting capability of the model (Hair et al., 2014). A value greater than 0.75 is indicative of a good model. In MIMIC_UNE's case, in the first run a R² of 0.949 was obtained. When the non-significant indicators were eliminated from the model, a R² of 0.961 was obtained, showing significant improvement in the model's predicting capability.

TABLE 4
SUMMARY OF PATH COEFFICIENTS AND RESULTS OF THE PROPOSED MIMIC_UNE MODEL

Modelos	CC&E	IL&S	R2
8-2-1-4	0.588	0.412	0.949
6-2-1-3	0.402	0.597	0.961

RESULTS AND ANALYSIS OF RESULTS

After the optimization measurements have been defined for the proposed model, the next step is to estimate the size of the shadow economy by means of the results obtained from the structured equation used. Following the recommendations made by Dell'Anno (2007) and Schneider et al. (2010), the estimated coefficients in the structured equations model are used to calculate the MIMIC_UNE index. They represent the behavior of the country's shadow economy. This calculation is made by applying the following equation (3):

$$\eta_{it} = \{0.402[(0.094*INC_t) + (0.094*INP_t) + (-0.644*CCA_t) + (-0.334*GGP_t)]\} + \{0.597[(0.283*ATE_t) + (0.805*DDV_t)]\} \quad (3)$$

In which η_{it} is the MIMIC index calculated for a reference year t and it will be the sum of the products from the multiplication of each time series of significant causes by its respective coefficients and the appropriate coefficient of its construct (CC&E or IL&S). Afterwards, it is necessary to convert the MIMIC index into absolute values of the shadow economy, based on an exogenous estimate of a reference year (Schneider et al., 2010). The estimate that will be used as reference for the MIMIC_UNE model is 28.4% (of 2000's GDP) calculated by Schneider (2006). Schneider conducted an estimation of Puerto Rico's shadow economy from 1999 to 2003. To perform this conversion, the equation (4) described below is applied:

$$\eta_t = \frac{\eta_{it}}{\eta_{i_{2000}}} * \frac{\eta_r}{\text{PIB}_{2000}} \quad (4)$$

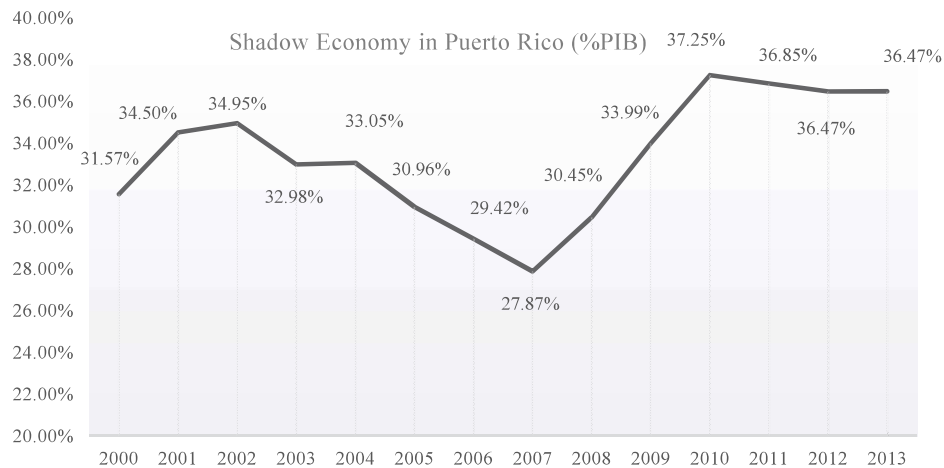
Where η_t represents the shadow economy as a percentage of the GDP of a reference year t , η_{it} represents the MIMIC index for that year t , $\eta_{i_{2000}}$ is the MIMIC index for the base year of the study (in this case 2000), and η_r stands for 28.4% of the reference year's GDP (Schneider et al., 2010; Schneider, 2006). Based on these econometric formulas that were validated in previous studies, the shadow economy's behavior was calculated from 2000 to 2014, years with valid published data. Table 5 is a summary of these calculations:

TABLE 5
ESTIMATION OF THE UNDERGROUND ECONOMY ACCORDING TO THE PROPOSED MIMIC_UNE MODEL

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Shadow Economy (%PBI)	28.40%	31.57%	34.50%	34.95%	32.98%	33.05%	30.96%	29.42%	27.87%	30.45%	33.99%	37.25%	36.85%	36.47%	36.47%

It can be appreciated that between the years 2000 and 2014 the shadow economy increased in Puerto Rico, but it had periods in which it's amount reduced (such as 2008, the lowest observed amount). In general, it can be observed that the size of the shadow economy in Puerto Rico has increased significantly, since the beginning of the island's recession period. Figure 3 helps to visually analyze the behavior of this phenomenon.

FIGURE 3
BEHAVIOR OF SHADOW ECONOMY IN PUERTO RICO CALCULATED WITH MIMIC_UNE



In this graph, it can be observed that during the first three years of the studied period, this phenomenon's levels manifest an ascending tendency. After 2002, a descent can be observed in which shadow economy reaches its lowest point in 2007. This period, according to economists, is where the recession has had its biggest impact in Puerto Rico. A drastic increase takes place up until 2010 is reached. From 2010 and forth, shadow economy stabilizes around one of its highest level (36.47%). The observed behavior agrees with what is expected of this phenomenon in the socioeconomic context of

Puerto Rico, given the fact that throughout these last years the island has undergone an unfavorable economic panorama. Since 2006, the island has been subject to a recession period, stimulating the exodus of a significant group of individuals (specially professionals) in search of better economic conditions. This type of environment favors the growth of shadow economy, and it's evident in the results of this investigation: the increase of informal activity around 2007, concurring with the beginnings of the recessionary period.

CONCLUSIONS AND LIMITATIONS

This investigation had as its finality an estimate of Puerto Rico's shadow economy between the years 2000 and 2014. For this purpose, the first posed research question was determining the elements that constitute Puerto Rico's shadow economy. Extensive literature research served to identify what elements are associated in theory with the increase and decrease of the shadow economy, especially in the economic context of Puerto Rico and Latin America. The initial configuration was an 8-2-1-4 model (8 causes grouped in 2 formative constructs of 1 latent variable, reflected in 4 indicators). After designing several configurations of the MIMIC_UNE model, and thru the effective use of structural model quality measures for internal structure and measurement of variables, it was determined that the best model responding to the Puerto Rican context was the 6-2-1-3 model.

Another of the important findings in this investigation was that MIMIC models can't be equally applied efficiently to all countries. The country's economic conditions and peculiarities should be considered just as the behavior of the variables; this study found a theoretical method to productively use the MIMIC models in each country's economy context. Thru this model, it was determined that if efficient results of combating Puerto Rico's shadow economy are desired, it must be started by acting on the indicators that display a larger factorial load on the shadow economy in an order of importance: 1) violent crimes (0.805); 2) tax burden (0.644); and 3) excessive government spending (0.334). This investigation also found that the more relevant consequences were (in order of importance): 1) personal consumption growth (0.984), gross domestic product decrease (0.971), and minimal work force participation in Puerto Rico (-0.912). If inadequate changes of pressures are made upon the causes of the shadow economy there will be an undesirable impact in its consequences, in the work force participation, a decrease in GDP and the excessive consumption of the Puerto Rican people (inquiring debts).

This investigation establishes that the shadow economy of Puerto Rico has suffered a significant and clear increase during the time period of this study. In 2000, the shadow economy was at a 31.57% of the GDP of the country. During 2007, there was a decrease to a 27.87% of the GDP. From this period on, the shadow economy demonstrated a constant increase until its peak at the end of 2010, where it maintained a 36.47% around 2014.

Also, this study discovered a great amount of literature about the estimation of the shadow economy in different countries, but a lack of implementation in Puerto Rico. Only 2 studies had previously used the MIMIC method. When the results of these studies were compared with the results of the MIMIC_UNE model for the same period, it was confirmed that the tendencies found by Schneider (2006) agreed with the tendencies of the MIMIC_UNE model. Both investigations reflect an increase in the shadow economy in Puerto Rico between the years 2000 and 2013 (period the studies have in common). When comparing the study done by "*Estudios Técnicos, Inc.*", (2010) with this investigation, the results exhibit similarity during the 2005-2007 period. During this period, the study showed the lowest levels of the shadow economy. Due to the consistency throughout the three studies, the MIMIC-UNE model is validated. Even though the results exhibit differences in the estimated informal economy values, similar estimations weren't expected due to the differences in employed factors and methodologies. Regardless of said difference, the consistency of the tendencies within all the studies support the validation of the proposed MIMIC_UNE model.

Finally, according to the results of this investigation, the aspects of the shadow economy that should receive the most public policy attention are those related to social and labor dimensions of the informal sector. The developed model demonstrated that the construct related to social and labor causes had a

larger weight (0.597) over the studied phenomenon than the construct related to tax and economic causes (0.402). Creating strategies that contemplate the workforce problems and violent crimes related to the informal economy must be a priority in the efforts to control this type of economic activity.

As limitations of this investigation many questions are formulated regarding the reliability of the estimates developed by the MIMIC models (Schneider et al., 2010). Being that the measurement equation depends on an exogenous estimate (out of reach for this work's researchers), raises questions concerning the exactitude of the calculated estimates (Dell'Anno, 2007). Despite this and other factors, the MIMIC model remains a relevant method for estimating the size of the shadow economy of a country when compared to other available methods. The MIMIC model method's input is significant and consistent. This study converts into a useful tool that, given its nature, allows for the opportunity to deeply explore all the aspects related to this socio-economic phenomenon, in order to delimit its reach in the economic context of a country.

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