Taxation, Underground Economy and Economic Performance*

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Abstract

In this paper, we develop and estimate a dynamic stochastic general equilibrium model with limited tax enforcement for the Sri Lankan economy by means of Bayesian techniques. Our objective is to estimate the size and trend of the underground economy and investigate possible reforms of the income tax policy in Sri Lanka. Our findings reveal that the underground economy in Sri Lanka accounts for an average of 42 per cent of GDP and has been on a growing trajectory since 2012. Counterfactual experiments based on the estimated model suggest that policy reforms to fight against tax evasion are more effective alternatives to stimulating fiscal revenue generation than merely imposing higher income tax rates. Finally, we propose several policy adjustments that not only hold the potential to foster tax compliance but also contribute to augment overall economic performance in Sri Lanka.

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1 Introduction

Over the last decade, there has been a renewed interest in researching the aggregate effects of fiscal policy interventions, particularly following the significant economic challenges posed by events such as the global financial crisis of 2008, the subsequent sovereign debt crises, and the COVID-19 pandemic. These events have led governments worldwide to implement diverse fiscal stimulus and consolidation packages, leading to a rich body of literature that extensively analyzed the outcomes and the effectiveness of these fiscal interventions (Leeper et al., 2017; Sims and Wolff, 2018; Ramey, 2019; Alesina et al., 2019; Favero and Mei, 2019; Rannenberg, 2021). Furthermore, recognizing that tax evasion and underground transactions are pervasive global phenomena (La Porta and Shleifer, 2014; Medina and Schneider, 2018), a branch of this research has focused on the fiscal policy implications of imperfect tax enforcement (Pappa et al., 2015; Junior et al., 2021; Herranz and Turino, 2023; Dellas et al., 2024).

While the findings of this literature are not yet conclusive, there is emerging consensus that incomplete tax enforcement exacerbates the recessionary effects of tax hikes, ultimately dampening the effectiveness of tax-based consolidation plans (Pappa et al., 2015; Basile et al., 2016; Herranz and Turino, 2023; Dellas et al., 2024). These insights are particularly relevant for developing countries because underground transactions account for a significantly large share of economic activity in these countries (La Porta and Shleifer, 2014), and many of them are facing persistent fiscal imbalances that necessitate the implementation of deficit reduction plans (Pahula et al., 2024).

A pertinent example is Sri Lanka, a developing country with a sizeable underground economy (Samaranayake and Dayarathna-Banda, 2015), and an overall fiscal deficit of more than 10 per cent of its official GDP by 2020 (CBSL, 2022). Furthermore, to correct this fiscal imbalance, the Sri Lankan government has recently implemented a tax-based consolidation plan aimed at enhancing fiscal revenues (IMF, 2023).[1] Under such circumstances, several related questions arise: (i) evaluating the effectiveness of tax-based consolidation plans in increasing fiscal revenues in countries with a large share of output produced underground; (ii) assessing the costs of such policies for developing economies with a high degree of tax avoidance; and (iii) exploring alternative policy options to improve fiscal revenue collection in economies where tax compliance is low.

Clearly, addressing all of these questions requires first an assessment of the main drivers

[1]Since May 2022, Sri Lanka has implemented a progressive tax reform plan, which, among other adjustments include, raising the marginal personal income tax rate schedule and increasing the statutory capital income tax rate. This tax-based consolidation policy aims ambitiously to raise the total fiscal revenues to GDP ratio from 8.2 per cent in 2022 to 15 per cent by 2026 (IMF, 2023).

behind underground transactions and tax evasion. This paper sheds light on these issues by developing and estimating a dynamic stochastic general equilibrium (DSGE) model of the Sri Lankan economy using Bayesian econometric techniques. Our objective is twofold: firstly, to study the driving forces behind the underground economy dynamics in Sri Lanka, and secondly, to evaluate the implications of limited tax enforcement for the successful implementation of tax policy. Inspired by Orsi et al. (2014), who pioneered the use of an estimated DSGE model to measure the underground economy, we adopt their Bayesian-DSGE approach. We choose this methodology for two reasons: firstly, underground transactions, by their very nature, are unobservable. The inferential procedure proposed by Orsi et al. (2014), enables us to treat tax evasion and underground economy variables as latent variables, to be estimated alongside the structural parameters of the model. Secondly, a DSGE model allows for the assessment of the effects of fiscal policy from both short-run and long-run perspectives within a unified framework, making it well-suited for quantitative policy analyses.

Building upon these considerations, the model developed in this paper is a standard neoclassical real DSGE model extended to include imperfect tax enforcement and underground production. Within the scope of our study, underground activities refer to legal economic transactions unreported to fiscal authorities to evade taxes and social security contributions. Following Busato and Chiarini (2004), such transactions are integrated into a two-sector model by assuming that firms can get access to two different production technologies, namely formal and underground production functions. The key distinction lies in imperfect tax enforcement, which allows firms to effectively conceal underground production from authorities, thereby evading tax payments, as the government can only detect such activities upon inspection. As the main distinguishing aspect compared to existing DSGE models, our study enriches this economic environment by incorporating specific characteristics pertinent to the Sri Lankan economy, including the social security legislation and the monitoring process undertaken by fiscal authorities to discourage tax evasion.

We estimate the model using annual data over the 1982-2019 period. Results of the Bayesian estimation show that Sri Lanka's underground economy is substantial, averaging 42 percent of GDP. The implied rate of tax evasion is also significant, recording an average of 28 percent of total taxes due. In terms of dynamics, the model predicts distinct trends in the behavior of the underground economy during the sample period. Specifically, the Kalman smoothed estimates highlight that the underground economy increased until the mid-1980s, and then continuously declined until 2012. Importantly, the results suggest that the size of Sri Lanka's underground economy is currently on an upward trajectory. The historical shock decomposition analysis reveals that negative fiscal shocks were among the main drivers behind the downward trend from 1982 to 2012, while a decline in the government's enforcement ability is a crucial factor explaining the subsequent increase in the underground economy. We argue that these results perfectly align with the recent economic history of Sri Lanka, a country that experienced a decline in fiscal pressure as a consequence of trade liberalization policies of the 1980s and early 1990s (Lakshman, 2017; Athukorala et al., 2017) and, after a period of sustained growth, is currently facing a severe economic crisis (IMF, 2023) along with a deterioration in the quality of its institutions (Daniel and Aart, 2023).

To address the research question posited above, we utilize the estimated model to simulate the implications of the fiscal consolidation plan recently undertaken by the Sri Lankan government. By characterizing Laffer curves and transitional dynamics, we show that imperfect tax enforcement significantly reduces the effectiveness of tax-based consolidation plans in fostering fiscal revenues. This occurs due to a resource-reallocation mechanism, where firms increase the share of their outputs produced underground in response to higher tax rates. This mechanism implies that although a tax hike can be successful in increasing fiscal revenues, in developing countries it comes at the cost of substantially amplified recessionary effects. According to our model, the loss of measured GDP due to the Sri Lankan fiscal consolidation plan is expected to be three times larger than that predicted by a counterfactual version of the model with perfect tax enforcement. Because of this effect, we ascertain that policies aimed at increasing tax compliance, such as imposing higher fines or conducting more intense inspections, are superior to tax hikes as an alternative fiscal consolidation strategy in economies with a high degree of tax avoidance. Hence, this underscores the significance of prioritizing measures to fight against tax evasion as a key policy priority for the governments of developing countries.

The present paper primarily contributes to the extensive body of research that relies on DSGE models for fiscal policy analysis (for example, Forni et al., 2009; Leeper et al., 2010; Mertens and Ravn, 2012; Leeper et al., 2017; Sims and Wolff, 2018). Within this literature, aside from Orsi et al., 2014, our analysis is most closely related to the works of Pappa et al. (2015), Junior et al. (2021), Herranz and Turino (2023), and Dellas et al. (2024), who also assess the implications of limited tax enforcement on the effectiveness of fiscal consolidation plans. Specifically, Pappa et al. (2015) introduced tax evasion and corruption into a New Keynesian model with search and matching frictions in the labour market, and revisited the effects of deficit-reduction policies in developed economies such as Greece, Italy, Portugal, and Spain. By simulating calibrated versions of the model, the authors found that tax evasion and corruption cause a larger increase in the tax rate needed to reduce debt, thereby amplifying the distortionary effects of tax-based consolidation plans. Similar results are reported by Herranz and Turino (2023), who estimated a DSGE model of the Spanish economy to evaluate the implications of limited tax enforcement for public debt accumulation and fiscal policy, and by Dellas et al. (2024), who incorporated the informal sector into the Bank of Greece's DSGE model to assess the impact of fiscal consolidation plans undertaken by the Greek government in response to the 2010 sovereign debt crisis. In contrast, Junior et al. (2021) focused on emerging economies by estimating an open-economy DSGE model with limited tax enforcement using Brazilian data. We contribute to this literature by providing a detailed analysis of the implications of a tax hike in a developing country characterized by a significant underground sector. Accordingly, our findings complement and extend previous research by showing that tax-based consolidation plans, while effective in increasing fiscal revenues, entail costly losses in terms of GDP and investment in economies with high levels of tax avoidance. Additionally, policies aimed at combating tax evasion may also serve as viable strategies to reduce deficits effectively.

Our paper also contributes to the empirical literature aimed at estimating the size and dynamics of the underground economy. Spanning 38 years, our results provide the most up-to-date insights into the trend and size of the Sri Lankan underground economy. Our estimates reveal a slight downward deviation of the underground economy size, compared with previous estimates that employed alternative methods such as, Schneider et al. (2010), Medina and Schneider (2018), Elgin et al. (2021), and Ohnsorge and Yu (2022). Notably, none of those studies have observed the recent upturn in the underground economy. In contrast to the statistical approaches used in these papers, our measurement method is based on an estimated micro-founded general equilibrium model. Compared to previous works, we believe this approach is advantageous for two reasons: it takes into account the multiple factors that determine size and trend of the underground economy (for example, tax burden, tax morale, the provision of public services, opportunity costs, deterrence, and so on), and recognizes that the impacts of underground transactions manifest themselves simultaneously across several markets. Due to these features, the results presented in our paper contribute to the literature by providing a more comprehensive analysis of the underground economy and tax evasion in Sri Lanka.

The rest of the paper proceeds as follows. Section 2 describes the model, while details of the estimation method and data are presented in Section 3. Findings are discussed in Section 4, whereas Section 5 provides a discussion about policy implications. Section 6 concludes.

2 The model

The model presented in this paper consists of households that supply capital and labour while purchasing goods for consumption and investment purposes, firms that produce a homogeneous good, and a government that collects taxes to finance public expenditures. There are two production sectors in the economy: the official (formal) sector and the unofficial (underground) sector. Within the unofficial sector, both firms and households engage in transactions that are not reported to the fiscal authorities. To deter tax evasion, the government employs monitoring procedures and conducts random inspections of firms. All interactions among households, firms, and the government take place in a stochastic environment characterized by supply, demand and fiscal shocks.

2.1 *Firms*

There is a continuum of perfectly competitive firms indexed by $i \in [0, 1]$, each producing the same homogeneous good. To carry out production activities, firms have access to two different Cobb-Douglas technologies: the formal production function and the underground production function. With the formal production function, a firm i produces formal output, $Y^m_{i,t}$, by combining formal labour, $H^m_{i,t}$, with formal capital, $K^m_{i,t}$, via the following technology,

$$Y^m_{i,t} = A_t (K^m_{i,t})^{\alpha} (H^m_{i,t})^{(1-\alpha)} \tag{1}$$

where $\alpha \in (0, 1)$, while A_t is a sector-specific stochastic productivity that evolves over time according to an AR(1) process of the form,

$$ln(A_t) = \rho_A ln(A_{t-1}) + \epsilon^A_t$$

where $\epsilon^A_t \sim N(0, \sigma^2_A)$ and $|\rho_A| < 1$.

We assume that any transaction that occurs in the formal sector is observable by the government. Therefore, each unit of corporate gross income − defined as revenues net of labour cost − generated from formal production is taxed at the corporate tax rate, $\tau^c_t < 1$. This evolves over time according to,

$$ln(\tau^c_t) = (1 - \rho_c) ln(\tau^c) + \rho_c ln(\tau^c_{t-1}) + \epsilon^c_t$$

where τ^c stands for the tax rate at the steady state, $\epsilon^c_t \sim N(0, \sigma^2_c)$ and $|\rho_c| < 1$.

The firm also pays a portion of each employee's social security contributions based on the employee's total earnings. Consistently with the Sri Lankan social security regulations, these contributions adhere to two specific rates: τ_1^s for the Employees' Provident Fund (EPF), and τ_2^s for the Employees' Trust Fund (ETF).[2] In addition, each employee is required to make contributions to the EPF at a rate of τ_3^s. These payments are withheld by firms and remitted to the government on behalf of their employees.

Firms may avoid tax and social security payment obligations by hiding part of their productions from tax authorities. To do so, a firm i combines underground labour, $H_{i,t}^u$, and underground capital, $K_{i,t}^u$, to produce underground output, $Y_{i,t}^u$, according to the following Cobb-Douglas technology,

$$Y_{i,t}^u = B_t \left(K_{i,t}^u\right)^{\alpha_u} \left(H_{i,t}^u\right)^{(1-\alpha_u)} \tag{2}$$

where $\alpha_u \in (0,1)$, and B_t is the sector-specific stochastic technological component, evolving over time according to,

$$ln(B_t) = \rho_B ln(B_{t-1}) + \epsilon_t^B$$

where $\epsilon_t^B \sim N(0, \sigma_B^2)$ and $|\rho_B| < 1$.

As in Busato and Chiarini (2004), goods produced with the underground production function are assumed to be identical to the formal ones. Accordingly, total output produced by a firm i, namely $Y_{i,t}$, can be defined as,

$$Y_{i,t} = Y_{i,t}^m + Y_{i,t}^u \tag{3}$$

The homogeneity assumption also implies that, in equilibrium, goods produced in the formal and underground sectors have to be sold at the same price, which, for the sake of simplicity, is normalized to be 1 in each period. Also, we assume that labour and capital markets are perfectly competitive, wages paid for one unit of labour services in the formal and underground sectors are W_t^m and W_t^u, and the rental rates paid by firms to rent one unit of capital from the formal or underground markets are R_t^m and R_t^u, respectively.

Further, we assume that the government attempts to deter tax evasion through random inspections of firms and compel fraudulent entities to pay taxes on undeclared income and social security contributions for underground workers, augmented by penalty surcharge factors (Allingham and Sandmo, 1972). This process is overseen by two government authorities in Sri Lanka, namely, the Labour Department (LD), which is responsible for monitoring social security contri-

[2]The Employees' Provident Fund was founded pursuant to EPF Act No. 15 of 1958, and the Employees' Trust Fund was formed in accordance with the regulations stipulated in the ETF Act No. 46 of 1980. Being the largest social security fund in Sri Lanka, the value of EPF fund was more than three billion Sri Lankan Rupees by the end of 2021 (EPF, 2021).

butions, and the Inland Revenue Department (IRD), which oversees the tax compliance of firms.[3] Employers found by the LD failing to pay social security contributions face punishment at a surcharge rate of $s^e > 1$, while those evading corporate taxes identified by the IRD are fined at the rate of $s^x > 1$. We assume that each department carries out independent, random inspections. Thus, a firm could be caught by the LD with the probability of p^e_t, and by the IRD with the probability of p^x_t. These probabilities are assumed to be exogenous and stochastic, evolving over time according to,

$$ln(p^e_t) = (1 - \rho_e)ln(p^e) + \rho_e ln(p^e_{t-1}) + \epsilon^e_t$$

$$ln(p^x_t) = (1 - \rho_x)ln(p^x) + \rho_x ln(p^x_{t-1}) + \epsilon^x_t$$

where ϵ^j_t, $\{j = e, x\}$, are normally distributed innovations with mean 0 and standard deviation σ_j; p^j stands for the probability of being discovered at the steady state; while $|\rho_j| < 1$.

As a result of random inspections, for firm i, revenues net of taxes on corporate income, namely $NR_{i,t}$, and the total cost for social security contributions, namely $CS_{i,t}$, are also random variables, respectively described by the following expressions:

$$NR_{i,t} = \begin{cases} Y_{i,t} - \tau^c_t \Big[Y^m_{i,t} - \Omega W^m_t H^m_{i,t} + s^x (Y^u_{i,t} - \Omega W^u_t H^u_{i,t}) \Big], & \text{with probability } p^x_t \\ Y_{i,t} - \tau^c_t \Big[Y^m_{i,t} - \Omega W^m_t H^m_{i,t} \Big], & \text{with probability } (1 - p^x_t) \end{cases}$$

$$CS_{i,t} = \begin{cases} (\tau^s_1 + \tau^s_2) W^m_t H^m_{i,t} + \Big[s^e(\tau^s_1 + \tau^s_2 + \tau^s_3) - \tau^s_3 \Big] W^u_t H^u_{i,t}, & \text{with probability } p^e_t \\ (\tau^s_1 + \tau^s_2) W^m_t H^m_{i,t} - \tau^s_3 W^u_t H^u_{i,t}, & \text{with probability } (1 - p^e_t) \end{cases}$$

where $\Omega = (1 + \tau^s_1 + \tau^s_2)$. In the case of non-detection by the LD, notice that the total cost for social security contribution is scaled down by the payments levied on underground workers, $\tau^s_3 W^u_t H^u_{i,t}$. The reason is that a firm deducts the share of EPF benefits from employees before paying their salaries, and this adds to their inflows unless the firm does not make social security remittances to the government.

A firm's decision problem then consists of choosing productive factors $H^u_{i,t}$, $H^m_{i,t}$, $K^u_{i,t}$ and $K^m_{i,t}$ in order to maximize the expected profits within the constraints imposed by technologies in

[3] This assumption aligns with Sri Lankan regulations. The Department of Inland Revenue, established in 1932 to administer income taxation in Sri Lanka, oversees the country's self-assessment tax payment system. The main goal of the department is to enhance voluntary compliance by taxpayers. Also, they aim to improve public trust and confidence in the tax system and implement necessary programs to identify those who do not comply with the law and, where necessary, take appropriate corrective measures. The Department of Labour was created in accordance with Indian Immigrant Labour Ordinance No. 01 of 1923. The department is committed to ensuring the well-being and protection of the interests of the labour force.

equations (1) and (2). As shown in the technical Appendix A, the resulting optimal planning should satisfy the following conditions,

$$\frac{R_t^m}{(1-\tau_t^c)} = \alpha \frac{Y_{i,t}^m}{K_{i,t}^m} \tag{4}$$

$$\Omega W_t^m = (1-\alpha)\frac{Y_{i,t}^m}{H_{i,t}^m} \tag{5}$$

$$\frac{R_t^u}{(1-\tau_t^c s^x p_t^x)} = \alpha_u \frac{Y_{i,t}^u}{K_{i,t}^u} \tag{6}$$

$$(1-\alpha_u)(1-\tau_t^c s^x p_t^x)\frac{Y_{i,t}^u}{H_{i,t}^u} \quad = \quad W_t^u\left[1+s^e p_t^e\left(\tau_1^s+\tau_2^s+\tau_3^s\right)\right] \quad - \quad W_t^u\left[\tau_t^c s^x p_t^x \Omega - \tau_3^s\right] \tag{7}$$

From equations (6) and (7), it follows that an interior solution with underground production (i.e., $Y_{i,t}^u > 0$) requires the necessary condition $(1-\tau_t^c s^x p_t^x) > 0$ to be satisfied. Intuitively, when this requirement does not hold, demanding underground factors is sub-optimal for a firm because expected net revenues from underground production are negative (i.e., $[1-\tau_t^c s^x p_t^x]Y_{i,t}^u < 0$). In this circumstance, goods are produced exclusively with the formal technology, and thus firms do not evade taxes.

2.2 *The representative household*

Like Orsi et al. (2014), we assume that preferences of the representative household at time 0 are described by the following inter-temporal utility function:

$$U_0^h = \sum_{t=0}^{\infty}\beta^t E_0\left[\frac{C_t^{1-\eta_C}-1}{1-\eta_C} - \xi_t^N B_0\frac{(H_t^m+H_t^u)^{1+\eta_L}}{1+\eta_L} - B_1\frac{(H_t^u)^{1+\eta_{LS}}}{1+\eta_{LS}}\right] \tag{8}$$

where, $\beta \in (0,1)$ is the inter-temporal subjective discount factor, $(B_0, B_1) \in R_+^2$ are disutility parameters, E_0 stands for the mathematical expectation operator conditional on the information available at time 0, $\eta_C > 0$ is the inverse of the inter-temporal elasticity of substitution, $\eta_L > 0$ and $\eta_{LS} > 0$ respectively stand for the inverse of the Frisch elasticity of total and underground labour supply, while ξ_t^N is a preference shock that evolves over time according to,

$$ln(\xi_t^N) = \rho_N ln(\xi_{t-1}^N) + \epsilon_t^N$$

with $\epsilon_t^N \sim N(0, \sigma_N^2)$ and $|\rho_N|<1$.

Although we assume that labour mobility across the formal and underground sectors is perfect, in the above preferences specification, we include a disutility component that is specific to the underground labour supply, H_t^u. This term is meant to capture additional utility costs for employment in the underground sector, such as those due to the lack of job security or those resulting from the non-provision of social security and health insurance (Busato and Chiarini, 2004).

In addition to income generated through labour supplied to formal and underground sectors, households also earn by renting out the capital to firms. The total capital stock, K_t, supplied to formal and underground sectors by households is,

$$K_t = K_t^m + K_t^u \tag{9}$$

where, K_t depreciates at the constant rate $\delta \in (0, 1)$. In addition, we assume that the efficiency with which investment, I_t, is transformed into capital is stochastic, depending upon an investment-specific shock, ξ_t^I (Justiniano et al., 2010). Hence, the representative household's total capital stock evolves over time according to the following law of motion:

$$K_{t+1} = \xi_t^I I_t + (1 - \delta)K_t \tag{10}$$

where ξ_t^I is assumed to follow an auto-regressive process of the form,

$$ln(\xi_t^I) = \rho_I ln(\xi_{t-1}^I) + \epsilon_t^I$$

with $\epsilon_t^I \sim I(0, \sigma_I^2)$ and $|\rho_I| < 1$.

The law mandates households to pay taxes. The personal income tax rate, $\tau_t^h < 1$, established by the fiscal authority, is applicable to both wages and capital gains. We assume that τ_t^h evolves according to,

$$ln(\tau_t^h) = (1 - \rho_h)ln(\tau^h) + \rho_h ln(\tau_{t-1}^h) + \epsilon_t^h$$

where, τ^h is the steady state personal income tax rate, $\epsilon_t^h \sim N(0, \sigma_h^2)$ and $|\rho_h|<1$.

Households may also avoid the payment of income taxes by redistributing their labour and capital services from the formal to the underground sector. Accordingly, the inflows from the underground sector, $(W_t^u H_t^u + R_t^u K_t^u)$, are not disclosed, and the tax rate, τ_t^h, is not applicable to this share of the earnings. Further, each employer deducts the worker's share of the social security payment before disbursing wages, at a rate of $\tau_3^s < 1$. Households use the resulting net income to finance consumption, C_t, and investment expenditure, I_t, and therefore the household budget constraint can be written as,

$$C_t + I_t = \left(1 - \tau_t^h\right)\left(W_t^m H_t^m + R_t^m K_t^m\right) + W_t^u H_t^u + R_t^u K_t^u - \tau_3^s\left(W_t^m H_t^m + W_t^u H_t^u\right) \tag{11}$$

Under the above assumptions, the representative household chooses consumption, formal and informal hours of work, and capital in the two sectors to maximize the expected inter-temporal utility function (8), subject to the constraints given by equations (9)-(11). The associated optimal planning conditions are as follows,

$$\beta E_t\left\{C_{t+1}^{-\eta_C}\left[\frac{1-\delta}{\xi_{t+1}^I} + (1-\tau_{t+1}^h)R_{t+1}^m\right]\right\} = \frac{C_t^{-\eta_C}}{\xi_t^I} \tag{12}$$

$$W_t^m = \frac{\xi_t^N B_0(H_t^m + H_t^u)^{\eta_L}}{(1-\tau_t^h - \tau_3^s)C_t^{-\eta_C}} \tag{13}$$

$$W_t^u = \frac{\xi_t^N B_0\left(H_t^m + H_t^u\right)^{\eta_L} + B_1(H_t^u)^{\eta_{LS}}}{C_t^{-\eta_C}(1-\tau_3^s)} \tag{14}$$

$$R_t^u = (1-\tau_t^h)R_t^m \tag{15}$$

Equation (12) is a standard Euler equation that controls for the supply of savings. Equation (13) is an intra-temporal condition that determines the total amount of labour supplied by the representative household (i.e., $H_t = H_t^m + H_t^u$), whereas Equation (14) describes the optimal time allocation for underground working activities, H_t^u. Finally, Equation (15) determines how the supply of total capital is allocated in the formal and underground sectors, establishing that, in equilibrium, the rental rate of underground capital equals the formal rate, net of personal income taxes.

2.3 *Government*

The role of the government is to levy taxes on firms and households to finance non-productive government expenditures, G_t. The total fiscal revenue gathered by the government originates from three distinct sources, namely, corporate income taxation g_t^c, personal income taxation g_t^h, and social security contributions g_t^s. We assume that the government cannot issue bonds, and therefore public expenditures need to be financed on a balanced budget basis, i.e.,

$$G_t = g_t^c + g_t^h + g_t^s$$

where

$$g_t^c = \tau_t^c \int_0^1 \left[Y_{i,t}^m - \Omega W_t^m H_{i,t}^m + p_t^x s^x (Y_{i,t}^u - \Omega W_t^u H_{i,t}^u)\right] di$$

$$g_t^h = \tau_t^h \Big(W_t^m H_t^m + R_t^m K_t^m\Big)$$

$$g_t^s = \int_0^1 (\tau_1^s + \tau_2^s + \tau_3^s) \left[W_t^m H_{i,t}^m + p_t^e s^e W_t^u H_{i,t}^u\right] di$$

As a result of imperfect tax enforcement, the government's fiscal revenues fall short of the expected tax collection when agents engage in underground transactions. In each period t, the total revenue loss resulting from tax evasion by both firms and households can be expressed as follows,

$$\begin{aligned} evs_t = \quad & (1 - p_t^x)\tau_t^c \int_0^1 (Y_{i,t}^u - \Omega W_t^u H_{i,t}^u) di + (1 - p_t^e)(\tau_1^s + \tau_2^s + \tau_3^s) W_t^u \int_0^1 H_{i,t}^u di + \\ & \tau_t^h (W_t^u H_t^u + R_t^u K_t^u) \end{aligned}$$

2.4 *Symmetric equilibrium*

We focus on symmetric equilibria where firms in both the formal and underground markets produce equal amounts of goods and use identical inputs. The following market-clearing conditions need to be satisfied to achieve the symmetric equilibrium

$$C_t + I_t + G_t = \int_0^1 Y_{i,t}\, di$$

$$H_t^m = \int_0^1 H_{i,t}^m\, di \qquad H_t^u = \int_0^1 H_{i,t}^u\, di$$

$$K_t^m = \int_0^1 K_{i,t}^m\, di \qquad K_t^u = \int_0^1 K_{i,t}^u\, di$$

Since underground transactions are officially unrecorded by the government, the officially recorded GDP of the economy may not align with the total production. Therefore, we introduce the following definition of official – or measured – GDP in the model. The present paper adopts the assumption that official GDP is represented by the total formal production, namely,

$$GDP_t = \int_0^1 Y_{i,t}^m\, di$$

3 Estimation

We linearize market clearing and optimality conditions of the model around its non-stochastic steady state, and then solve the resulting system of equations for the rational expectations equilibrium. The solution takes the form of a linear process that, along with a measurement equation, forms a Gaussian state-space system, which is estimated by means of Bayesian methods using yearly data from 1982 to 2019. Our objective is to estimate the model's structural parameters as well as the time series measures for the unobservable underground economy and tax evasion in Sri Lanka. The inferential procedure used in the analysis is based on the Kalman filtering technique. As it is well known, the Kalman filter enables recursive estimates of unobserved endogenous variables by exploiting the information contained in the observed variables in combination with the restrictions imposed by the model on the covariance structure (Hamilton, 1994). We do this by running a Monte Carlo Markov-Chain (MCMC) algorithm based on five parallel chains of 500,000 replications.[4]

3.1 *Data*

We use seven observable variables including consumption (C_t), investment (I_t), official GDP (Y_t^m), hours worked in the formal sector (H_t^m), corporate income tax collection (G_t^c), fiscal revenues from personal income taxation (G_t^h), and social security contributions (G_t^s). In particular, as an empirical counterpart for consumption in the model, we use the final consumption expenditure of households. Gross fixed capital formation serves as an approximation of the total amount of investment made in the economy. GDP data published by the Sri Lankan department of statistics is not adjusted for underground transactions. We thus use these figures as formal GDP. To measure the amount of time households allocate to the formal sector, we first compute the total formal employment by summing up public employment with the count of active EPF accounts administered by the EPF department of the central bank of Sri Lanka annually, serving as an approximation for formal private employment. To convert this to working hours, it is assumed that public sector employees engage in five working days, while other formal sector workers observe a five and a half-day workweek. On average, an employee dedicates eight hours to a full working day.

[4]Specifically, parameter estimates and predictions for the unobservable tax evasion and underground economy are obtained with a three-steps procedure. In the first step, we elicit prior distributions for the estimated parameters and assign values to the fixed parameters. In the second step, we compute numerically the posterior mode. Finally, setting the starting point at the posterior mode, we sample from the posterior distributions by utilizing a Metropolis-Hastings algorithm. According to the results, the algorithm converges within 200,000 iterations.

In selecting the observable variables, we focus on macroeconomic aggregates that are most informative for measuring the extent of underground economic transactions and tax evasion, according to our model. Specifically, fiscal revenue coupled with GDP provides information about the degree of fiscal pressure in the Sri Lankan economy and therefore captures the incentive of agents to engage in underground activities in order to under-report their own incomes to fiscal authorities. Consumption and investment represent the level of aggregate demand, and the formal hours worked provide information about how labour adjusts in response to shocks over the sample period. The latter coupled with the covariance restrictions imposed by the model is useful to infer the behaviour of underground labour.

Furthermore, the observable variables are deflated by using the GDP implicit deflator (base year = 2010), expressed in per-capita terms using the population aged 18 to 64, and then linearly de-trended. Aggregate data on consumption, investment, and GDP are taken from the World Bank database. Tax data are retrieved from the Central Bank of Sri Lanka. The measurement equation connecting observables with variables in the model is as follows:

$$\begin{bmatrix} dlCONS_t \\ dlINVEST_t \\ dlGDP_t \\ dlG_t^c \\ dlG_t^h \\ dlG_t^s \\ dlHOURS_t^m \end{bmatrix} = \begin{bmatrix} \hat{C}_t - \hat{C}_{t-1} \\ \hat{I}_t - \hat{I}_{t-1} \\ \hat{Y}_t^m - \hat{Y}_{t-1}^m \\ \hat{g}_t^c - \hat{g}_{t-1}^c \\ \hat{g}_t^h - \hat{g}_{t-1}^h \\ \hat{g}_t^s - \hat{g}_{t-1}^s \\ \hat{H}_t^m - \hat{H}_{t-1}^m \end{bmatrix}$$

where dl stands for log difference, and the deviation of each variable from the steady state is represented by a hat on each variable.

3.2 *Calibrated parameters*

We calibrate parameters when they are better identified by using information not provided by the observables or when they are ex-ante regulated by Sri Lankan law. Accordingly, the following parameters were calibrated: the tax rates (τ^h, τ^c, τ_1^s, τ_2^s and τ_3^s), the penalty surcharge factors (s^e and s^x), the long-run detection probabilities (p^e and p^x), the subjective discount factor (β), and the disutility parameters (B_0 and B_1). Table 1 summarizes calibrated parameters, and the calibration strategies are explained below.

For the fiscal parameters, τ^h and τ^c; first, we set $\tau^h = 0.0123$, implying in the model a steady

Table 1: Fixed Parameters.

Parameter name	Parameter	Value
Disutility factor of labour supply	B_0	9.3418
Disutility factor of labour supply in the underground sector	B_1	33.742
Discount factor	β	0.8807
Steady state personal income tax rate	τ^h	0.0123
Probability of detection by labour right authorities	p^e	0.0270
Probability of detection by tax authorities	p^x	0.0068
Steady state corporate income tax rate	τ^c	0.2800
Rate-Employer's contribution to EPF	τ_1^s	0.1200
Rate-Employer's contribution to ETF	τ_2^s	0.0300
Rate-Household's contribution to EPF	τ_3^s	0.0800
Surcharge factor for not paying social security payments	s^e	1.5000
Surcharge factor for not paying tax	s^x	1.2000

state ratio of personal income tax over the official GDP of 0.01.[5] Personal income tax and GDP data are drawn from the fiscal revenue data of the Central Bank of Sri Lanka and the World Bank database (WDI, 2021). We use the average ratio over the 1979-2020 period. Second, we notice that in 2018, the corporate tax rate in Sri Lanka was fixed at 28 per cent for all corporations, except for the special rates applicable to selected categories.[6]. Hence, we set $\tau^c = 0.28$. Additionally, based on the *Inland Revenue Act*, the tax authorities impose a 20 per cent penalty surcharge of the total tax due for the fraudulent firms. Therefore, we fix s^x at 1.2. As for social security contributions, the EPF and ETF Acts establish that employers are obligated to pay a minimum of 12 per cent and 3 per cent of gross earnings of an employee to the EPF and ETF, respectively. Each employee should also contribute a minimum of 8 per cent of gross earnings to the EPF. Moreover, if an employer is revealed to be evading the EPF and ETF payments, they will be subjected to a penalty surcharge of 1.5 times the total contribution due if the delay exceeds 12 months. Hence, we set $\tau_1^s = 0.12$, $\tau_2^s = 0.03$, $\tau_3^s = 0.08$ and $s^e = 1.5$. Following Busato and Chiarini (2004), we use the unconditional mean for the fraction of inspected firms in a given year as an estimate for the probability of being caught. In the case of social security payment collection, that fraction is computed relative to the total number of active members in the fund, while in the case of tax collection, the fraction is computed relative to the total number of registered taxpayers. The aggregate average probability of detection is then estimated as $p^i = \frac{1}{T}\sum_{t=1}^{T} \overline{p}_t^i$, where i=x, e, and $\overline{p}_t^i$ is the fraction in a given year t. Data on inspections are taken from the

[5]The implied value for τ^h is consistent with the Sri Lankan effective tax rate on labour income. According to the data provided by Bachas et al. (2022) over the 1982-2018 period, this average effective tax rate amounts to 0.0206.

[6]Starting in 2013, the tax rate for companies with a taxable income exceeding Rs. 5 million was set at 28 per cent, while for income up to Rs. 5 million, the rate was 12 per cent. In 2018, a uniform tax rate of 28 per cent was introduced to all corporations, with special tax rates for small and medium enterprises, agriculture businesses, and businesses in betting and gaming, liquor, tobacco etc.

Sri Lankan Department of Labour and the Department of Inland Revenue and are available from 2009 at an irregular annual frequency. Accordingly, we fix $p^e = 0.027$ and $p^x = 0.0068$. We set $\beta = 0.88$, so that, conditional on all of the other parameter values, the steady state equilibrium is characterized by a capital to GDP ratio of 2.4. According to the IMF *Investment and Capital Stock* dataset (ICSD, 2021), this target corresponds to the average capital-GDP ratio over the 1978-2019 period. Finally, parameters B_0 and B_1 are set in order to ensure that, in steady state equilibrium, an individual devotes a quarter of the time to working activities, as is standard in the DSGE literature. Further, the share of total labour hours absorbed by the underground sector is equal to 22.21 per cent, calculated corresponding to the average share of underground labour from 2010 to 2021. For this purpose, we use data from the Sri Lankan *Labour Force Survey* (LFS, 2022).[7]

3.3 *Prior distributions*

Table 2 summarizes prior distributions. In eliciting prior densities for parameters commonly used in the DSGE literature, we refer to previous studies, including Ihrig and Moe (2004), Smets and Wouters (2007), Iacoviello and Neri (2010), Justiniano et al. (2010), Orsi et al. (2014), and Christiano et al. (2018), among others. Specifically, the elasticity of capital in formal output, α, is assumed to be beta distributed with a mean of 0.40 and a standard deviation of 0.02. The parameter controlling for the inter-temporal elasticity of substitution, η_C, and the parameter controlling for the Frisch elasticity of total labour supply, η_L, are both gamma distributed with a mean of 1 and a standard deviation of 0.10. The depreciation rate of capital, δ_k, is assumed to follow a beta distribution with a standard deviation of 0.02 and a prior mean of 0.07. According to the *Penn World Table* database (version 10) (Feenstra et al., 2015), the prior mean for δ_k corresponds to the average yearly depreciation of capital in Sri Lanka over the 1970-2019 period.

In determining prior distributions for the underground related parameters, η_{LS} and α_u we follow the strategy pursued by Orsi et al. (2014). We assume that the inverse elasticity of underground labour supply, η_{LS}, follows a gamma distribution with a mean of 1 and a standard deviation of 0.10, while the elasticity of capital in the underground production function, α_u, is beta distributed with a mean of 0.4599 and a standard deviation of 0.02. The prior mean of α_u is elicited such that, conditional on all of the other prior means and calibrated parameters values, the size of the underground economy in the steady state equilibrium equal to a 45.58 per cent

[7]The labour Force Survey, 2022, Sri Lanka, classifies those working in the informal economy into four groups: "regular informal employees, informal employers, own account workers/self-employed, and contributing family workers." The earliest accessible information is from 2010. Consistently, in computing the average share of total labour absorbed by the underground sector, we restricted our focus to the first two classes.

Table 2: Priors and Posterior Distributions.

Parameter		Prior			Posterior		
		Density	Mean	SD	Mean	Mode	90% Interval
Elasticity of capital - formal sector	α	Beta	0.4000	0.0200	0.3989	0.3969	[0.3633,0.4347]
Elasticity of capital - underground sector	α_u	Beta	0.4599	0.0200	0.4488	0.4511	[0.4104,0.4858]
Depreciation of capital	δ_k	Beta	0.0700	0.0200	0.1459	0.1419	[0.1173,0.1751]
Inverse intertemporal elasticity of Substitution	η_C	Gamma	1.0000	0.1000	1.0338	1.0219	[0.8789,1.1876]
Inverse Frisch elasticity of labour supply	η_L	Gamma	1.0000	0.1000	1.0943	1.0825	[0.9225,1.2646]
Inverse Frisch elasticity of underground labour supply	η_{LS}	Gamma	1.0000	0.1000	1.1749	1.1643	[1.0008,1.3462]
PP - formal sector productivity shock	ρ_A	Beta	0.8000	0.1000	0.8477	0.8580	[0.7622,0.9378]
PP - underground sector productivity shock	ρ_B	Beta	0.8000	0.1000	0.7774	0.7800	[0.6452,0.9163]
PP - corporate tax shock	ρ_c	Beta	0.8000	0.1000	0.7584	0.7692	[0.6265,0.8937]
PP - income tax shock	ρ_h	Beta	0.8000	0.1000	0.7705	0.7804	[0.6360,0.9097]
PP - labour supply shock	ρ_N	Beta	0.8000	0.1000	0.9055	0.9329	[0.8302,0.9836]
PP - investment technology shock	ρ_I	Beta	0.8000	0.1000	0.7868	0.7984	[0.6645,0.9140]
PP - detection shock (labour)	ρ_e	Beta	0.8000	0.1000	0.8993	0.9114	[0.8332,0.9698]
PP - detection shock (tax)	ρ_x	Beta	0.8000	0.1000	0.8004	0.8462	[0.6522,0.9598]
SE - formal sector productivity shock	σ_A	invg	0.0500	0.1000	0.0314	0.0301	[0.0254,0.0372]
SE - underground sector productivity shock	σ_B	invg	0.0500	0.1000	0.0352	0.0352	[0.0299,0.0436]
SE - corporate tax shock	σ_c	invg	0.0500	0.1000	0.1794	0.1724	[0.1458,0.2119]
SE - income tax shock	σ_h	invg	0.0050	0.1000	0.1743	0.1682	[0.1423,0.2064]
SE - labour supply shock	σ_N	invg	0.0500	0.1000	0.0689	0.0660	[0.0551,0.0826]
SE - investment technology shock	σ_I	invg	0.0500	0.1000	0.0398	0.0375	[0.0296,0.0495]
SE - detection shock (labour)	σ_e	invg	0.0500	0.1000	2.9704	2.8425	[2.3853,3.5360]
SE - detection shock (tax)	σ_x	invg	0.0500	0.1000	0.0443	0.0248	[0.0128,0.0790]

Note: PP - Persistence parameter, SE - Standard error of innovations, invg - Inverse Gamma

of the official GDP. This last number represents the average size of the underground economy in Sri Lanka over the 1991-2015 period, according to Medina and Schneider (2018). Regarding the stochastic processes, we refer to Smets and Wouters (2007) and utilize beta distributions with a mean of 0.80 and a standard deviation of 0.10 for the auto-regressive parameters. The standard errors of innovations are instead assumed to follow a quite dispersed inverted gamma distribution centered at 0.05.

3.4 *Posterior estimates*

The mean, mode, and 90 per cent credible interval for each posterior distribution are displayed in Table 2. The parameters that control for the overall labour supply, the underground labour supply (η_L and η_{LS}, respectively) and the inter-temporal elasticity of substitution, η_C, appear to be well identified. The depreciation rate of capital, δ_k, is also well identified, with a posterior mean that is substantially higher than what we have assumed at priori. By contrast, the posterior means of parameters α and α_u exhibit a modest decline with respect to their prior counterparts. As for the exogenous shocks, the results we obtain provide evidence in support of highly persistent stochastic processes, with the auto-regressive parameter for labour supply shock (i.e., ρ_N) that appears to be the highest. Among the stochastic processes, the data suggests that the labour supply shock is also more volatile. Finally, the posterior distributions of ρ_x and σ_x suggest that the data do not convey much information on the shock affecting the probability of being inspected by the IRD. We have carried out several sensitivity checks on these parameters and found that our main findings are not particularly sensitive to changes in parameters ρ_x and σ_x.[8]

4 Results of the estimated model

In this section, we make use of the estimated model to provide predictions of the size and dynamics of the underground economy and tax evasion in Sri Lanka. In order to evaluate the reliability of our approach, we will first perform a sensitivity analysis of a subset of calibrated parameters and then compare the results with previous estimates based on different measurement methods. We will also study the sources of fluctuations in the underground economy by assessing how the shocks have contributed to the predicted dynamics over the sample period. This section is concluded by characterizing the properties of the estimated long-run Laffer curve.

4.1 *Underground economy in Sri Lanka*

Figure 1 displays the smoothed estimates of underground production as a percentage of official GDP, along with 95 per cent credible bands. The graph depicts the model's predictions over the 1982-2019 period, indicating that a substantial share of total output has been produced underground in Sri Lanka. On average, this accounts for 42 per cent of official GDP. These findings corroborate earlier ones in the literature, such as Medina and Schneider (2018) and Elgin et al. (2021), which also highlight the significant size of Sri Lanka's underground sector.

In terms of dynamics, after an initial increase up to the middle of the 80s, our results reveal a prolonged and downward sloping trend in the size of the underground economy, decreasing from a peak of 59 per cent in 1985 to a trough of 30 per cent in 2012. However, since 2012, the size

[8] Results are available from the authors upon request.

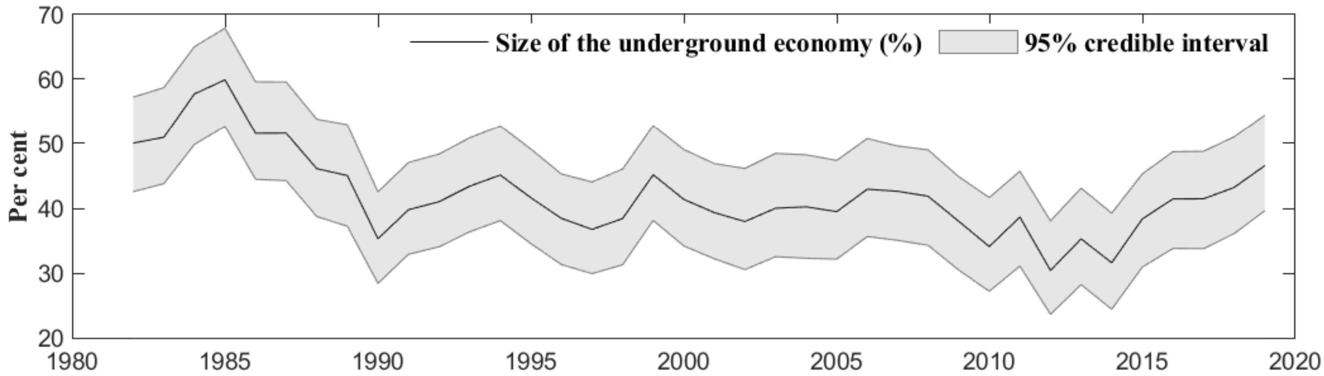

Figure 1: The underground economy in Sri Lanka over the 1982-2019 period.

Notes: The black line depicts the smoothed estimates for the size of the underground economy of Sri Lanka as a percentage of official GDP, while the shaded area is the 95 per cent credible interval.

of the underground economy has exhibited again an upward trend, reaching over 46 per cent by the end of the sample period. In addition, it is interesting to note that, while the declining trend is predicted by the model to be relatively smooth, the subsequent expansion in the size of the underground economy has occurred rather sharply. This expansion, in fact, recorded a 53 per cent increase in the relatively short period of time that spans from 2012 to 2019.

To test for the robustness of the above findings, we re-estimated five alternative versions of the model, by fixing a subset of calibrated parameters to different values. We aim to understand the impact of specific parameter calibrations on the model's predictions regarding the size and trend of the underground economy. This assessment allows us to evaluate the extent to which these predictions, and consequently our measurement approach, are sensitive to the chosen values for the fixed parameters. For this purpose, we concentrated on parameters that wield the most significant influence on the share of underground output in the steady state equilibrium. These include the probabilities of detection (p^e, p^x), the long-run tax rates (τ^c, τ^h), and the parameter controlling for the disutility of the underground labour supply (B_1). Results are reported in Table B.1 of Appendix B, which summarizes the posterior means in different estimations. Figure 2, displays the time series for the ratio of underground output to official GDP predicted by alternative model versions. As the picture illustrates, we find no major differences in the smoothed estimates for the underground economy in terms of both trend and size. The reported series are in fact very close to each other, displaying virtually the same dynamics over the sample period. This clearly reassures that the predictions of the estimated model are robust across alternative calibrations.

To further validate the reliability of our measurement approach, we compare our estimates with those reported in the empirical literature. This comparison is depicted in Figure 3 where the estimates from our DSGE model are represented by the blue continuous line. We juxtapose

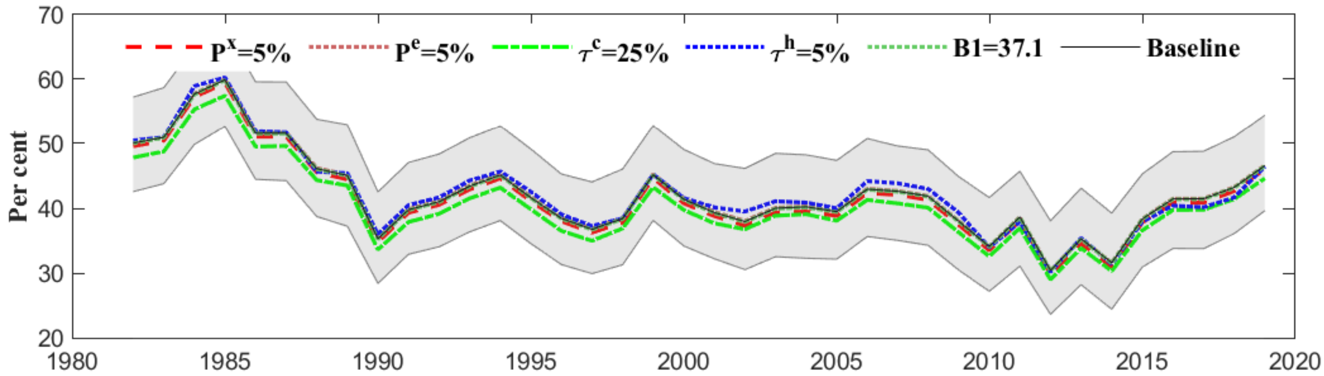

Figure 2: Robustness analysis.

these against estimates from Schneider et al. (2010) and Medina and Schneider (2018), derived using the MIMIC approach, as well as estimates from Elgin and Oztunali (2012) and Elgin et al. (2021), obtained through calibrated non-stochastic general equilibrium models (DGE approach). As the picture illustrates, the size and trend of the underground economy predicted by our DSGE model closely align with the alternative estimates available in the literature. Notably, regardless of the methods used, all of the alternative estimates reported confirm the prediction of our model of a downward sloping trend in the size of the underground economy over the 1985-2012 period. This robust alignment provides strong empirical support for our findings.

4.2 *Drivers of underground economy dynamics*

In order to get a glimpse of the main driving forces behind the predicted dynamics of the underground economy, we examine the historical contribution of four types of shocks, namely, technology, fiscal, demand, and enforcement, to fluctuations in the underground output (relative to official GDP) over the sample period. Figure 4 represents these results. Fiscal shock, among others, emerges as a key determinant of the dynamics of the underground economy, particularly during the 1982-2012 period. Tax rate shocks, in conjunction with unpredictable changes in the probability of detection (the enforcement component) and, to a lesser extent, positive technology shocks turn out to be the primary drivers behind the predicted downward sloping trend in the size of the underground economy. In the subsequent period, however, fiscal shocks assume a secondary role and the enforcement component emerges as the crucial explanatory factor behind the sharp increase in the underground sector.

It is interesting to note that the outcomes of the historical decomposition analysis seamlessly align with Sri Lanka's recent economic history. In this respect, three main observations are worth emphasizing. Firstly, the pivotal role of fiscal policy shocks in explaining the estimated downward sloping trend in the size of the underground economy can be related to the trade

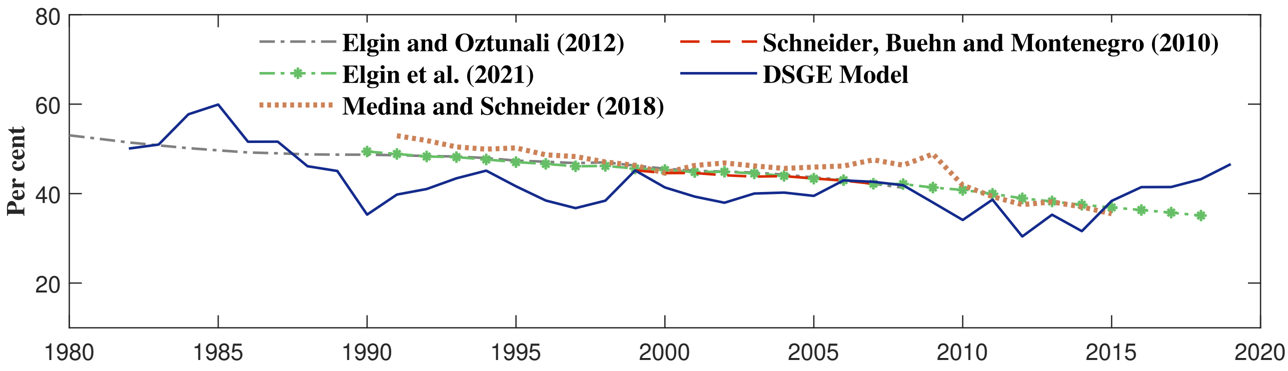

Figure 3: Comparing the DSGE estimates with alternative measurement methods.

Sources: Elgin and Oztunali (2012), Medina and Schneider (2018), Elgin et al. (2021), Schneider et al. (2010) and own computations based on the estimated model.

liberalization policies during the 1980s and the early 90s (Athukorala et al., 2017). As highlighted by Herring (1987), this period witnessed strong encouragement of the private sector to contribute to domestic production mostly due to reductions in personal and corporate income taxes resulting from changes in tax policies associated with trade liberalization. Lakshman (2017) presented a comprehensive documentation of Sri Lanka's political economy and taxation history, and noted a substantial reduction in fiscal pressure as a consequence of these tax policy changes. For instance, he shows that the revenue from corporate and non-corporate tax declined from 15 per cent of total government revenue in 1980 to 11 per cent by 1990. This feature is also apparent in our data set, which shows that revenues collected from taxes on personal and corporate income and social security contributions decreased from a maximum of 4.9 per cent of official GDP in 1985 to 3.3 per cent in 2004.

The estimated model conforms with the above discussion by attributing the declining pattern in fiscal pressure we observe in the data to a decrease in both corporate and personal income tax rates. This feature is well apparent in Figure 5, which reports the smoothed estimates of corporate and personal income tax rates, and shows that both tax rates substantially decline over the 1985-2012 period. The mechanism associating these expansionary tax policies with the downward-sloping trend in the size of the underground economy is based on a resource reallocation effect. In our model, a tax cut reduces the expected gains from tax evasion, thereby dampening the agents' incentives to engage in underground transactions. As a result, the size of the underground economy contracts in response to a tax cut because, with this fiscal policy intervention, firms increase official output and, simultaneously, decrease irregular production (see Figure ??).

The economic reforms of the 80s and 90s also led to a notable revival of economic growth for Sri Lanka, despite escalated ethnic tensions somewhat impeding its sustained momentum (Athukorala

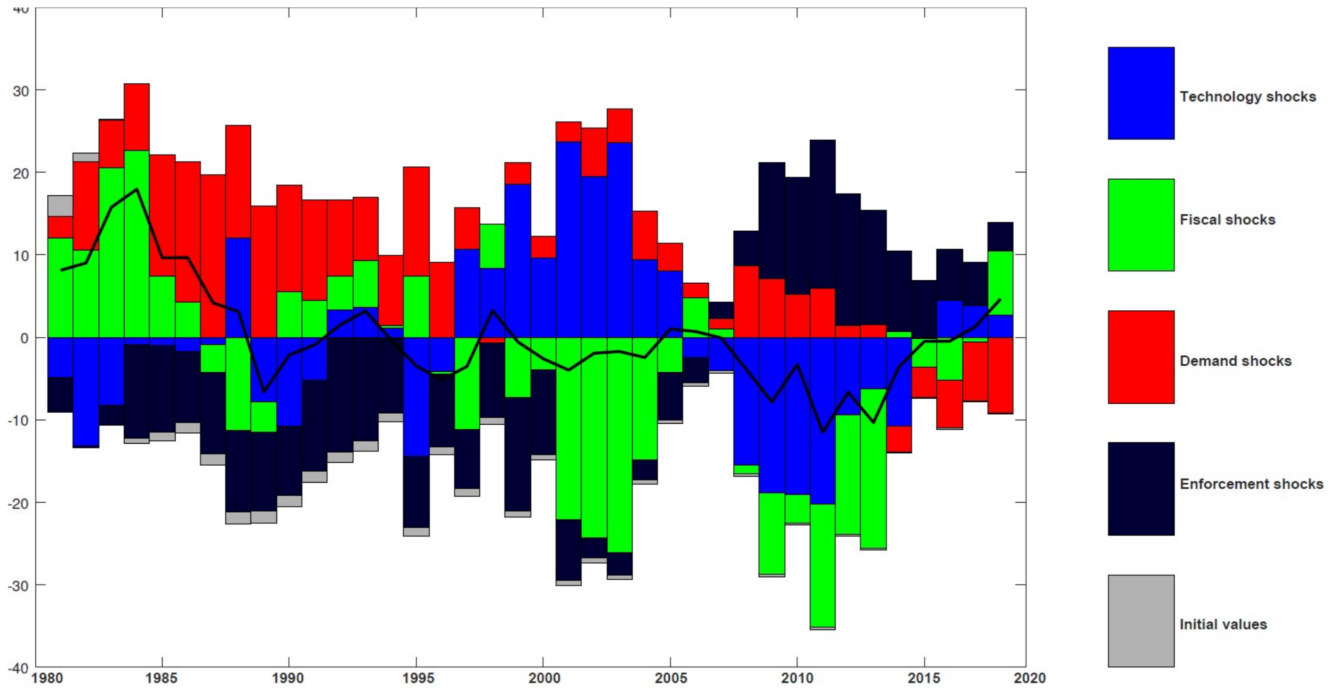

Figure 4: Historical shock decomposition.

Notes: The continuous black line represents the underground output to official GDP ratio in deviation from the steady state. The contribution of each shock is represented by a stacked coloured bar. Technology shock is the sum of two productivity shocks in formal and underground sectors (ϵ_t^A and ϵ_t^B). Fiscal shock is the sum of the corporate tax shock (ϵ_t^c) and personal income tax shock (ϵ_t^h). Labour supply shock, (ϵ_t^N), and shock to investment, (ϵ_t^I), are added together to get the demand shock, whereas shocks to detection probability (ϵ_t^x and $\overset{e}{\epsilon}_t$) make up the enforcement shock.

et al., 2017). Per capita real official output grew at a yearly rate of 3.4 per cent between 1982 and 1999, and for the period 2000–2015, it achieved an even more impressive annual growth rate of 4.8 per cent (WDI, 2021). According to Kumari and Tang (2024), total factor productivity emerged as the most significant driver of growth in official GDP over this period. This finding is clearly consistent with the important role of technological factors, jointly with fiscal shocks, in explaining the declining trend in the predicted underground economy. This is our second observation.[9]

Finally, with the conclusion of the prolonged civil war in 2009, a period of sustained economic growth in the country was expected.[10] However, the Sri Lankan economy faced uncertainties and imbalances in the subsequent years, diminishing optimism regarding the growth prospects of the post-conflict era. The total factor productivity growth of the economy went down substantially during the period 2013–2016, amidst the balance of payment pressures and accumulating debt levels (IMF, 2017). Further, Sri Lanka's vulnerabilities were aggravated by significant shocks

[9]Similar to fiscal policy shocks, the mechanism here works again through a resource-allocation effect. In our model, a boost in productivity in the official sector makes formal production more convenient for firms. As shown in Figure ??, this effect triggers an increase in formal output accompanied by a simultaneous decline in underground production. Consequently, the size of the underground economy declines in response to a positive technology shock in the official sector.

[10]In fact, an average growth of 8 per cent in per capita real official GDP was achieved during 2010–2012 (WDI, 2021).

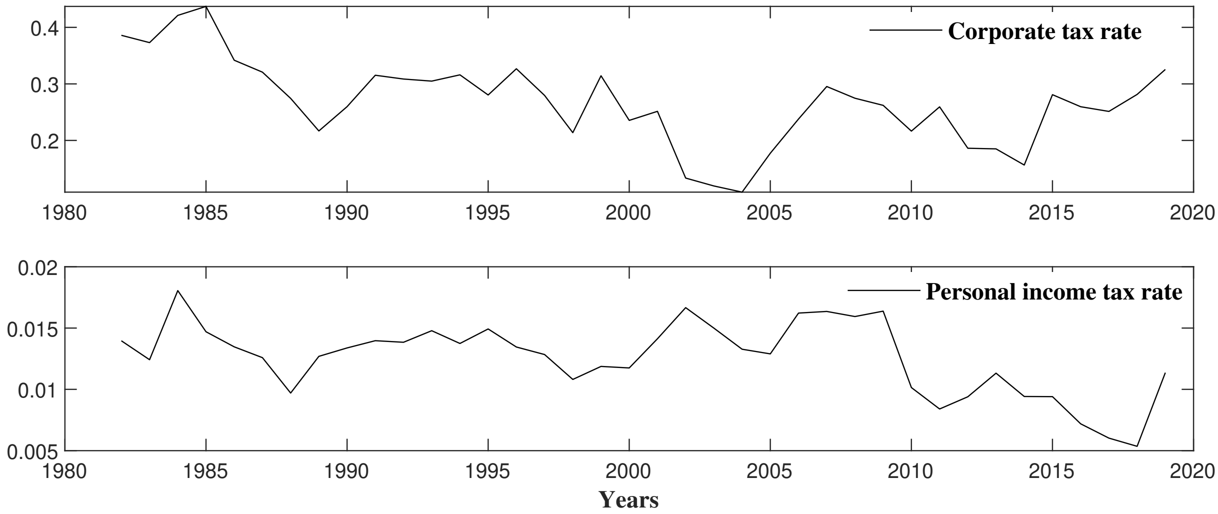

Figure 5: Predicted tax rates.

Notes: Smoothed estimates of the tax rates.

during the period 2017–2019, encompassing events such as the 2018 political crisis, and the 2019 *Easter Sunday attack* (IMF, 2023).[11] The latter significantly escalated the instability in the economy while exacerbating the economic deceleration across various sectors in the aftermath of the incident (CBSL, 2019). The growing uncertainty is also mirrored in Sri Lanka's institutional quality, encompassing the maintenance of the rule of law, control of corruption, and regulatory standards (WGI, Daniel and Aart, 2023). Figure 7 shows that relative to 2003, these governance indicators substantially declined in recent years. The prominent role of enforcement shocks in explaining the sharp increase in the underground economy's size predicted by the model over the 2012-2019 period clearly aligns with this evidence.[12]

4.3 *Tax evasion*

We now quantify the costs of imperfect tax enforcement in terms of uncollected fiscal revenues for the Sri Lankan economy. We begin by focusing on the steady-state equilibrium to evaluate how long-run revenue collection adjusts in response to permanent changes in tax rates. Results are depicted in Figure 8, which displays total fiscal revenues as a function of the corporate (panel A) and the personal income tax rate (panel B). To evaluate the implications of tax evasion, the

[11]On Easter Sunday, 2019, a series of coordinated terrorist suicide bombings occurred in Sri Lanka, killing more than 250 people and injuring more than 500 others.

[12]Figure ?? shows that unexpected changes in the probabilities of detection induce, once again, a resource-reallocation effect. The transmission mechanism is the same as that triggered by changes in the corporate tax rate. An unanticipated change in the perceived probability of detection, in fact, affects the expected gains from tax evasion, thereby modifying firms' incentive to conceal part of their productions to fiscal authorities. This effect results into movements in the demand for productive factors that, through price adjustments, transmit the shock to the rest of the economy.

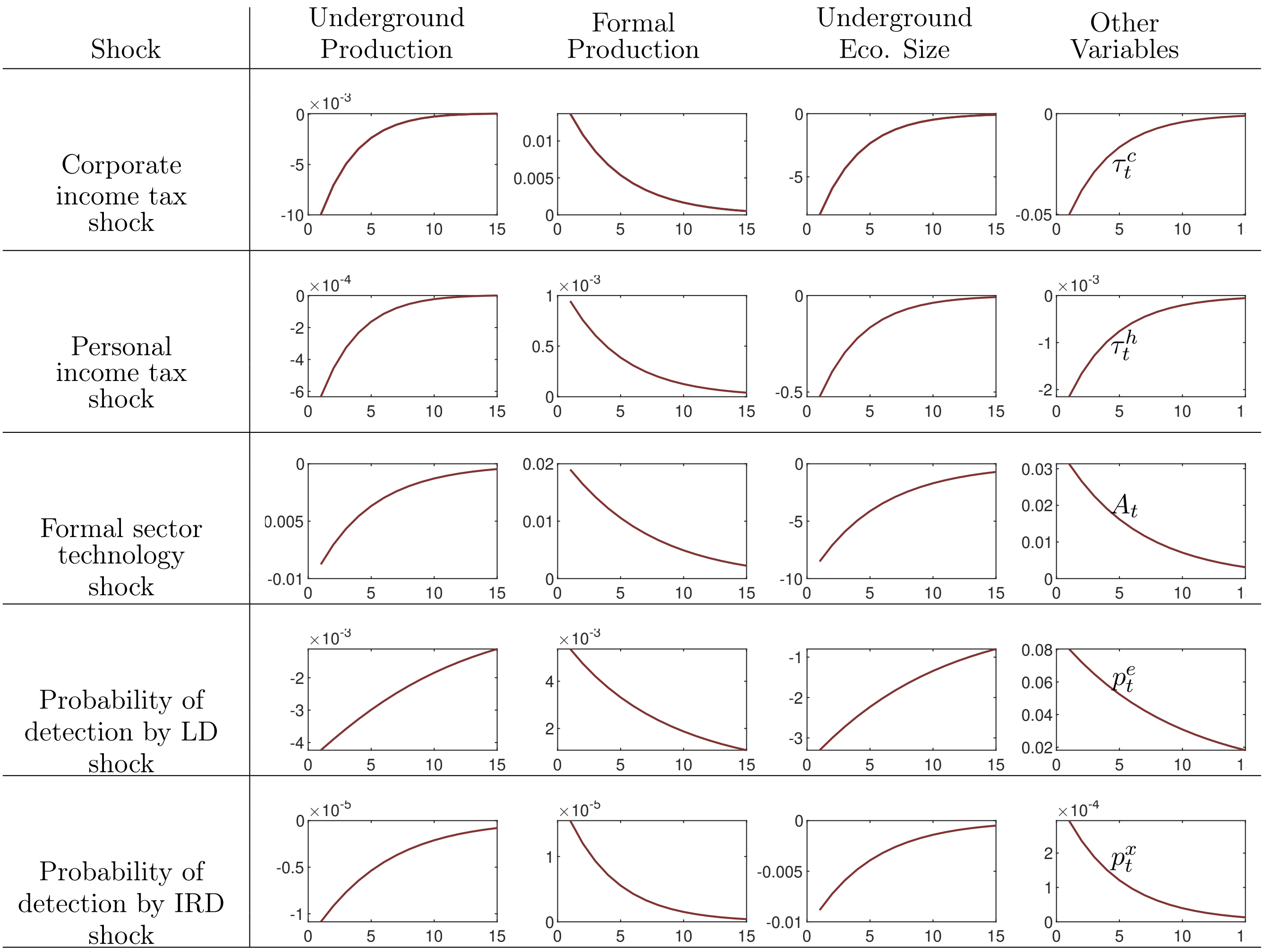

Figure 6: Impulse response functions.

Notes: Parameters have been set to their posterior mean values. τ_t^c is the corporate income tax rate, τ_t^h is the personal income tax rate, A_t is formal sector productivity, p_t^e is the probability of detection by LD, and p_t^x is the probability of detection by IRD.

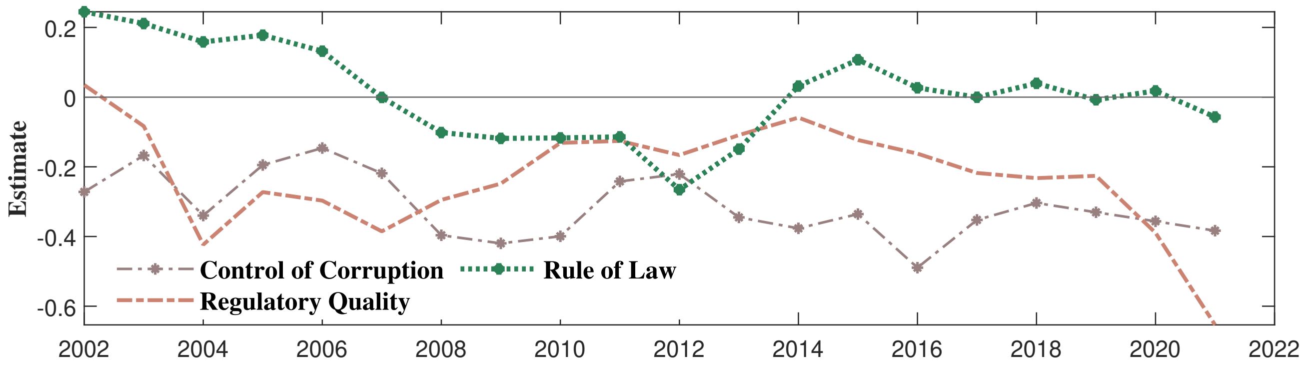

Figure 7: Governance indicators.

Sources: Daniel and Aart (2023), Worldwide Governance Indicators, 2023 Update.

Laffer curves are also computed by means of a counterfactual version of the estimated model in

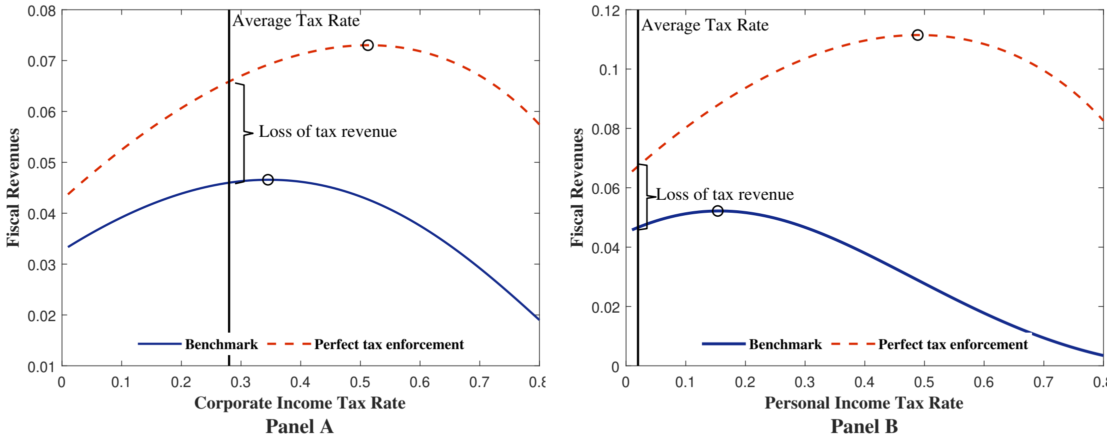

Figure 8: Long-run Laffer curve.

Notes: Benchmark refers to the estimated model with imperfect tax enforcement. Vertical lines refer to average tax rates (i.e. 28 per cent in Panel A and 1.23 per cent in Panel B). Fixed parameters have been set to their posterior mean values.

which tax enforcement is perfect.[13]

Regardless of the tax rate we consider, we see that the steady state Laffer curve exhibits the typical textbook inverted U-shape. This pattern is due to the distortionary effect of taxation, which implies that the tax base falls in response to a high tax rate. For a sufficiently high value of the latter, this effect is strong enough to imply that fiscal revenues decline if the government further increases the tax burden as shown in Figure 8. Most importantly, the picture highlights that tax evasion amplifies such a distortionary effect. In comparison with the counterfactual counterparts with perfect tax enforcement, we see that fiscal revenues in the estimated model are uniformly lower. This finding has two related implications. Firstly, the cost of tax evasion in terms of uncollected revenues turns out to be quantitatively important in Sri Lanka. At average tax rates, total fiscal revenues in the estimated model are around 43 per cent lower than revenues with perfect tax enforcement. Secondly, although the model suggests that the Sri Lankan government may successfully raise long-run fiscal revenues by increasing the actual average tax rates,[14] the gains from such a fiscal policy are substantially dampened if firms evade taxation. This is true not only because total fiscal revenues are consistently lower when tax enforcement is incomplete, but also because the economy quickly shifts to the *suboptimal* side of the Laffer curve as the tax rate increases. This last finding suggests that taking tax evasion into account is substantially important for fiscal policy design in Sri Lanka.

[13] Counterfactual results are computed by setting the enforcement parameters p^x and s^x to values guaranteeing that the condition $(1 - \tau^c s^x p^x) < 0$ holds in the steady state equilibrium. All of the remaining parameters have been kept fixed to their posterior mean values.

[14] This can be seen in Figure 8 by noticing that for both tax rates, the vertical line is at the left of the peak in the Laffer curve.

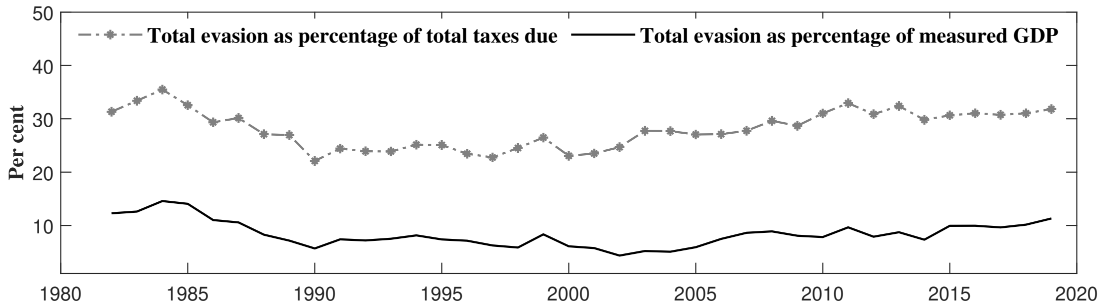

Figure 9: Predicted tax evasion.

A related question is how tax evasion has historically impacted fiscal revenue collection in Sri Lanka. To provide an answer, we compute the Kalman-smoothed estimates of tax evasion over the sample period. Figure 9 presents the results, showing tax evasion relative to total taxes due (continuous line) and as a percentage of official GDP (dashed line).[15] Accordingly, the figure shows that the losses in fiscal revenues have been substantial over the 1982-2019 period, averaging 28 percent of total taxes due. On average, this represents an amount of resources equivalent to approximately 9 percent of the official GDP. In terms of dynamics, the overall rate of tax evasion as a percentage of the total taxes due shows a volatile pattern, and notably, it appears to be on an upward trend over recent years. Accordingly, in the year 2019, the government lost around 32 per cent of the total taxes due. This pattern is confirmed when tax evasion is expressed as a percentage of official GDP, a ratio that has been increasing steadily over time since 1990.

5 Policy implications

Recent tax reforms in Sri Lanka have been aimed mainly to restore the country's fiscal sustainability. A key question concerning the country's tax policy in the coming debates is whether or not raising tax rates would bring desired objectives. The results provided in the previous section suggest that the answer is positive in the long-run, although the gains in terms of higher fiscal revenues are predicted by the model to be substantially dampened by tax evasion. Given the distortionary effects of taxation, this finding raises further doubts on the effectiveness of tax hikes as a fiscal consolidation plan in developing economies characterized by a quantitatively important underground sector.

To explore this issue in detail, we use the estimated model to perform counterfactual policy experiments. We aim to assess the benefits and costs of a tax-based consolidation plan and explore possible policy alternatives. Especially, we evaluate the aggregate implications of two different

[15]Total taxes due are computed by summing up fiscal revenues and tax evasion.

policies: (i) a general tax hike implemented by permanently raising the personal income tax rate to 3.7 per cent and, simultaneously, increasing the corporate income tax rate to 30 per cent; and (ii) a permanent and stronger monitoring effort by the IRD (i.e. a higher probability of detection p^x) that yields the same increase in steady state fiscal revenue as that resulting from the general tax hike. In the first experiment, the rationale behind selecting these tax rates is to align with the conditions outlined in the IMF-mediated fiscal consolidation arrangements implemented in Sri Lanka (IMF, 2023). Accordingly, the personal income tax rate is set to achieve a target total tax revenue-to-GDP ratio of 15 per cent within the model.[16] In these experiments, we will assume that the economy is initially at steady state equilibrium, and the policy is unanticipated by the agents.

Numerical simulations are carried out by setting all of the parameters at their posterior mean values. Results of the counterfactual experiments are reported in Table 3, which summarizes the steady state effects. Figure 10, illustrates the transitional dynamics for selected endogenous variables, depicting the changes from the pre-policy to the post-policy steady state. For a comparison, Table 3 also reports the impact of a tax hike with perfect tax enforcement. Several remarks can be made. Firstly, a general tax hike causes an increase in fiscal revenues not only in the long-run but also along the whole transition to the new steady state equilibrium. In particular, Figure 10 shows that fiscal revenues overshoot in the short-run, staying above the new steady state level for several years after the policy. Hence, a tax hike turns out to be effective in increasing fiscal revenues overall. However, in comparison with the perfect tax enforcement case, the increase in fiscal revenues induced by the tax hike appears to be quantitatively modest in the estimated model (+1.5 per cent vs +8.0 per cent).

Second, the above mentioned result clearly indicates that the gains of a tax-based consolidation plan are substantially dampened when tax enforcement is imperfect. The observed amplification of the decline in official GDP induced by the policy, (-9.1 per cent vs -3.1 per cent), indicates that the mechanism operates through the resource-reallocation effect. As tax rates increase, agents become more inclined to engage in underground transactions because the expected gains from tax evasion are higher. The resulting reallocation of resources from the official to the unobserved sector boosts underground production (+15.1 per cent) and tax evasion (+27.0 per cent). These two effects jointly amplify the decline in the tax base induced by the policy, and thereby dampen the increase in fiscal revenues triggered by higher tax rates.

[16] Under the Extended Fund Facility-supported program for Sri Lanka, the IMF recommended an ambitious revenue-based fiscal consolidation plan as part of a comprehensive policy package. This plan entails increasing the statutory corporate income tax rate to 30 per cent, and the total revenue-to-GDP ratio to 15 per cent by 2026.

Table 3: steady state effects.

	Estimated model		Perfect tax enforcement
Variables	**(A) Tax hike**	**(B) Higher** P^x	**(C) Tax hike**
ΔFiscal revenue	1.5	1.5	8.0
Δofficial GDP	-9.1	0.8	-3.1
ΔUnderground output	11.6	-2.4	-
ΔSize of the underground economy	15.1	-2.1	-
ΔTax evasion	27.0	-4.0	-
ΔCapital	-3.8	-1.0	-8.2
ΔWelfare	-2.0	-0.2	-3.3
ΔConsumption	-4.0	-0.3	-6.3

Notes: Δ refers to percentage changes with respect to the pre-policy steady state.

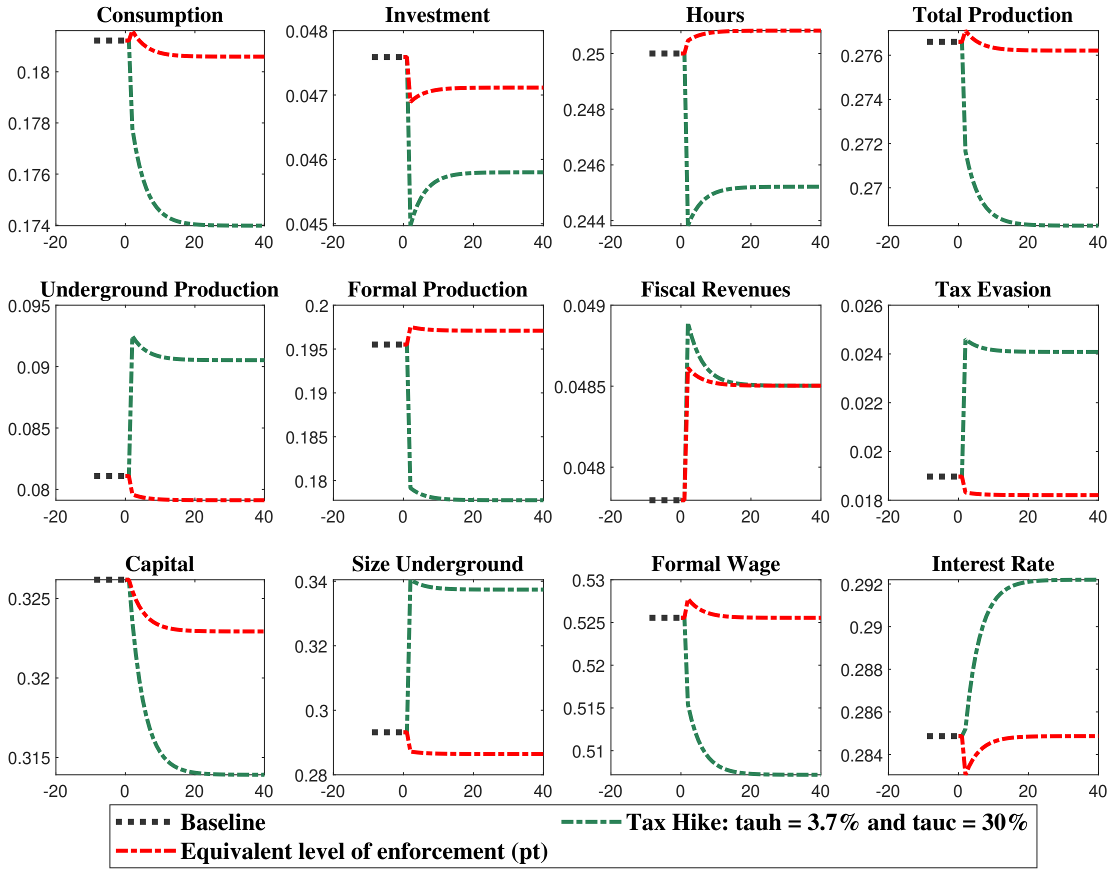

Figure 10: Transitional dynamics.

Finally, although the two policies are welfare-detrimental, the agents are better off in the equilibrium with a stronger monitoring process than in the equilibrium with a general tax hike. This result is apparent in Table 3 by noticing that welfare losses are substantially dampened when the government adopts a stronger monitoring process to improve fiscal sustainability (-0.2 per cent vs -2.0 per cent).[17] Interestingly, by fostering the formalization of firms, the policy is not only effective in fighting against tax evasion but also avoids the recessionary implications of a tax hike.

[17]Welfare is measured with the inter-temporal utility function evaluated at the steady state.

As Table 3 and Figure 10 illustrate, the policy of targeting an enhanced monitoring process leads to an increase in official GDP both in the long run (+0.8 per cent) and throughout the entire transition to the new steady state. In this respect, it is also worth noticing that consumption overshoots in the short-run, staying above the *ex-ante* steady state for several years after the implementation of the policy. In the long-run, however, a permanently stronger monitoring process triggers a decline in both consumption (-0.3 per cent) and capital (-1.0 per cent) but these effects are quantitatively modest, particularly in comparison with those from a tax hike. These findings further support that the fight against tax evasion as a deficit-reduction policy, overall attenuates the costs associated with a general tax hike.

6 Conclusion

This paper employs a two-sector DSGE model with imperfect tax enforcement to quantitatively assess the macroeconomic implications of tax policies. We estimate the model using Bayesian methods to suit the unique characteristics of the Sri Lankan economy. Subsequently, the estimated model is utilised to examine the macroeconomic ramifications of a tax-based consolidation plan. The results demonstrate that Sri Lanka's underground economy is substantially large, recording an average of 42 per cent of official GDP over the 1982-2019 period, with an associated tax evasion that accounts, on average, for 28 per cent of total taxes due. By characterizing the steady state Laffer curve, we show that the Sri Lankan government may successfully increase revenue collection by raising the actual tax rates on personal and corporate income. However, counterfactual policy experiments based on the estimated model suggest that, in Sri Lanka, fighting against tax evasion is superior to a general tax hike as a fiscal consolidation plan. Our results show that this policy not only is equivalently effective in raising fiscal revenues but also alleviates the costs associated with the distortionary effects of tax-based consolidation plans. Overall, our results suggest that promoting the formalization of firms and fighting against tax evasion should be the priorities for the Sri Lankan government.

Appendix A

In our theoretical framework, firms generate total output through the utilisation of productive factors. Despite the provision for the adoption of formal technology, firms opt for underground production practices to capitalise on advantages related to tax and social security evasion. Hence, the identification of optimal production factors to produce the optimal total output of firm i at time t is determined by aiming to maximize the expected net revenue of the firm. To estimate the expected total net revenue of a firm, it is necessary to consider four possible scenarios of detection by tax and labour authorities, which include,

1. no detection by both authorities [probability: $(1-p_t^x)(1-p_t^e)$]
2. detection by tax authorities and no detection by labour authorities [probability: $p_t^x(1-p_t^e)$]
3. no detection by tax authorities and detection by labour authorities [probability: $(1-p_t^x)p_t^e$]
4. detection by both authorities [probability: $p_t^x p_t^e$]

Revenues net of taxes on corporate income,

$$NR_{i,t} = \begin{cases} \underbrace{Y_{i,t} - \tau_t^c[Y_{i,t}^m - \Omega W_t^m H_{i,t}^m]}_{A} - \underbrace{\tau_t^c s^x[(Y_{i,t}^u - \Omega W_t^u H_{i,t}^u)]}_{B}, & \text{with probability } p_t^x \\ \underbrace{Y_{i,t} - \tau_t^c[Y_{i,t}^m - \Omega W_t^m H_{i,t}^m]}_{A}, & \text{with probability } (1-p_t^x) \end{cases}$$

The total cost for social security contributions,

$$CS_{i,t} = \begin{cases} \underbrace{(\tau_1^s + \tau_2^s)W_t^m H_{i,t}^m - \tau_3^s W_t^u H_{i,t}^u}_{C} + \underbrace{s^e(\tau_1^s + \tau_2^s) + \tau_3^s)W_t^u H_{i,t}^u}_{D}, & \text{with probability } p_t^e \\ \underbrace{(\tau_1^s + \tau_2^s)W_t^m H_{i,t}^m - \tau_3^s W_t^u H_{i,t}^u}_{C}, & \text{with probability } (1-p_t^e) \end{cases}$$

where $\Omega = (1 + \tau_1^s + \tau_2^s)$.

Accordingly, the total expected net revenue, $E_t(NR)$, is:

$$
\begin{aligned}
E_t(NR) &= (A - C)(1 - p_t^x)(1 - p_t^e) + (A - B - C)p_t^x(1 - p_t^e) + (A - C - D)(1 - p_t^x)p_t^e \\
&+ (A - B - C - D)p_t^x p_t^e - (W_t^m H_{i,t}^m + W_t^u H_{i,t}^u) - (R_t^m K_{i,t}^m + R_t^u K_{i,t}^u) \\
&= A - C - Bp_t^x - Dp_t^e - (W_t^m H_{i,t}^m + W_t^u H_{i,t}^u) - (R_t^m K_{i,t}^m + R_t^u K_{i,t}^u) \\
&= Y_{i,t} - \tau_t^c[Y_{i,t}^m - \Omega W_t^m H_{i,t}^m] - [(\tau_1^s + \tau_2^s)W_t^m H_{i,t}^m - \tau_3^s W_t^u H_{i,t}^u] \\
&- \tau_t^c s^x (Y_{i,t}^u - \Omega W_t^u H_{i,t}^u)p_t^x - [s^e(\tau_1^s + \tau_2^s) + \tau_3^s)W_t^u H_{i,t}^u]p_t^e \\
&- (W_t^m H_{i,t}^m + W_t^u H_{i,t}^u) - (R_t^m K_{i,t}^m + R_t^u K_{i,t}^u)
\end{aligned}
$$

Appendix B

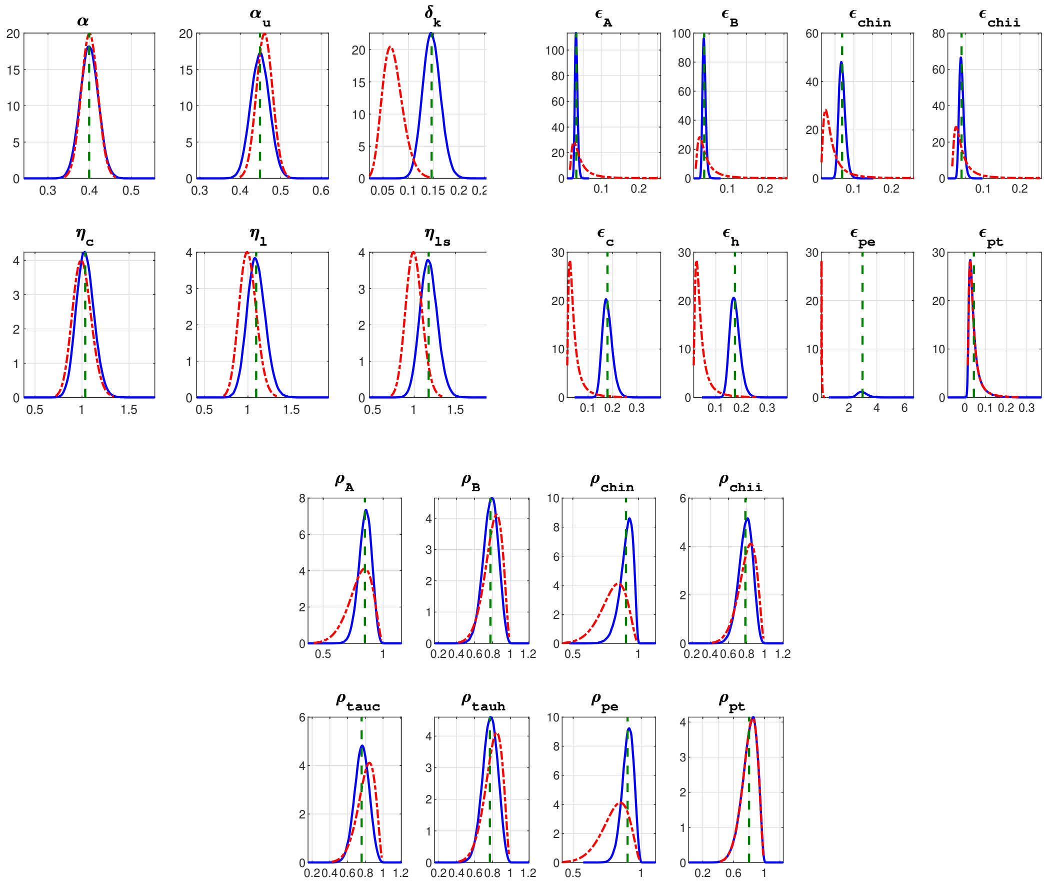

Figure B.1: Priors and posteriors

Table B.1: Robustness

Parameter			Posterior					
			Baseline *	RM1 τ^c = 25%	RM2 τ^h = 5%	RM3 p^x = 5%	RM4 p^e = 5%	RM5 B1=37.1
Elasticity of capital - formal sector	α	Beta	0.3989	0.4035	0.3986	0.4004	0.3988	0.3989
Elasticity of capital - underground sector	α_u	Beta	0.4488	0.4477	0.4459	0.4482	0.4492	0.4486
Depreciation of capital	δ_k	Beta	0.1459	0.1450	0.1469	0.1450	0.1452	0.1458
Inverse intertemporal elasticity of Substitution	η_C	Gamma	1.0338	1.0324	1.038	1.0334	1.0333	1.0329
Inverse Frisch elasticity of labour supply	η_L	Gamma	1.0943	1.0906	1.1022	1.0927	1.0947	1.0954
Inverse Frisch elasticity of underground labour supply	η_{LS}	Gamma	1.1749	1.1798	1.1670	1.1745	1.1747	1.1738
PP - formal sector productivity shock	ρ_A	Beta	0.8477	0.8595	0.8454	0.8496	0.847	0.8483
PP - underground sector productivity shock	ρ_B	Beta	0.7774	0.7861	0.7853	0.7800	0.7733	0.7763
PP - corporate tax shock	ρ_c	Beta	0.7584	0.7580	0.7580	0.7482	0.7613	0.7593
PP - income tax shock	ρ_h	Beta	0.7705	0.7714	0.7696	0.7703	0.7706	0.7714
PP - labour supply shock	ρ_N	Beta	0.9055	0.9063	0.8975	0.9060	0.9077	0.9065
PP - investment technology shock	ρ_I	Beta	0.7868	0.7894	0.7871	0.7867	0.7869	0.7874
PP - detection shock (labour)	ρ_e	Beta	0.8993	0.8989	0.9003	0.8995	0.8993	0.8997
PP - detection shock (tax)	ρ_x	Beta	0.8004	0.8004	0.8010	0.8001	0.8005	0.7989
SE - formal sector productivity shock	σ^A	invg	0.0314	0.0297	0.0315	0.0310	0.0313	0.0314
SE - underground sector productivity shock	σ^B	invg	0.0368	0.0367	0.0371	0.0370	0.0365	0.0368
SE - corporate tax shock	$\sigma^{\tau c}$	invg	0.1794	0.1792	0.1789	0.1779	0.1789	0.1794
SE - income tax shock	$\sigma^{\tau h}$	invg	0.1743	0.1738	0.1743	0.1743	0.1745	0.1743
SE - labour supply shock	$\sigma^{\xi N}$	invg	0.0689	0.0691	0.0718	0.0690	0.0690	0.0688
SE - investment technology shock	$\sigma^{\xi I}$	invg	0.0398	0.0391	0.0400	0.0400	0.0397	0.0398
SE - detection shock (labour)	σ^{pe}	invg	2.9704	3.0687	2.9012	2.9896	1.6382	2.9671
SE - detection shock (tax)	σ^{px}	invg	0.0433	0.0523	0.0450	0.0649	0.0488	0.0463

Notes: RM - Robustness Model, PP - Persistence parameter, SE - Standard error of innovations. *invg* - Inverse Gamma. *Specifications of the baseline model: $\tau^c = 28\%$, $\tau^h = 1.2\%$, $p^x = 0.68\%$, $p^e = 2.7\%$, B1=34.3

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