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Abstract

This working paper analyzes the behavior of tax revenue (the ratio of tax revenue to gross domestic product [GDP]) throughout the business cycle. In order to replicate empirical evidence, we develop a simple model combining the standard *Ak* growth model with the tax evasion phenomenon. When individuals conceal part of their true income from the tax authority, they face the risk of being audited and, hence, of paying the corresponding fine. In this setup, the effect of a positive technological shock on the government revenue to output ratio is fully characterized by the value of intertemporal elasticity of substitution (IES). In particular, under the empirically plausible assumption that the IES exhibits a sufficiently small value, we show that the elasticity of government revenue with respect to output is larger than one, which agrees with the empirical evidence.

Key words

Tax evasion, technology shocks, growth.

Resumen

Este documento de trabajo analiza el comportamiento de la presión fiscal (proporción de la recaudación impositiva sobre el producto interior bruto [PIB]) a lo largo del ciclo económico. Con el objetivo de compatibilizar la evidencia empírica con los resultados teóricos, hemos introducido el fenómeno de la evasión fiscal en el modelo estándar de crecimiento económico *Ak*. Cuando los contribuyentes evaden parte de su renta real corren el riesgo de ser inspeccionados y, por lo tanto, sancionados con una multa proporcional a la cantidad de impuestos evadidos. En este contexto, el efecto que produce una innovación tecnológica sobre la presión fiscal depende del valor que tome la elasticidad de sustitución intertemporal (ESI) siempre y cuando las innovaciones tecnológicas estén autocorrelacionadas. Concretamente, cuando la ESI toma un valor suficientemente pequeño, demostraremos que la elasticidad de la recaudación impositiva con respecto del PIB es mayor que uno, lo que replica el resultado obtenido por la literatura empírica.

Palabras clave

Evasión fiscal, innovación tecnológica, crecimiento.

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1. Introduction

In their seminal paper, Kydland and Prescott (1982) introduced some novel ideas, which constituted the starting point for a new approach to the study of business cycle behavior. One of these ideas is that it is possible to unify business cycle and growth theory by emphasizing that business cycle models must be consistent with the empirical stylized facts of long-run growth. Most authors, who have followed the approach proposed by Kydland and Prescott, have based their work on the role played by real technology shocks in driving business fluctuations.

The behavior of government revenue over the business cycle has received some attention in the empirical literature of recent years. It is well known that economic recessions tend to reduce the tax revenue making it difficult for governments to fund their existing programs. Moreover during expansion periods tax revenue increases, creating additional pressure on the government to increase public spending. Therefore empirical research on this matter focuses on performing estimates of the income elasticity of tax revenue in order to find out whether tax revenues have a more than proportional response to output fluctuations [1]. It is important to distinguish between the long-run income elasticity of tax revenue, which indicates how revenues will grow over time as income grows, and the short-run income elasticity of tax revenue, which indicates how much revenues will fluctuate over the business cycle. For instance, Holcombe and Sobel (1997) estimate both the short-run personal income elasticity of tax revenue and the short-run personal income elasticity of the tax base for U.S. states, and find that on average they are equal to 1.392 and 1.192, respectively [2]. Hence, the average elasticity estimate suggests that a one percent increase in personal income should result in a 1.4% increase in the tax revenue. Recent studies by Dye and Merriman (2004) and Bruce, Fox and Tuttle (2006) provide more

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[1] See Dye (2004) for a review of this literature.

[2] Researchers distinguish between two tax measures to use in estimating elasticities: the tax base and the tax revenue. Tax revenue data by type of tax are easily available for several developed countries, but they can include changes of the tax rate which lead to bias in the short-run elasticity estimator.

accurate estimates which support the idea that the short-run personal income elasticity of the tax base tends to be greater than one.

The main objective of this working paper is to provide a theoretical setup that can be consistent with the empirical findings. The standard *Ak* growth model with flat tax rates predicts that the government revenue to output ratio will remain constant when a technology shock takes place. Under flat tax rates, a technology shock equally affects both output and government revenue since government revenue is a constant proportion of the output. Therefore the standard *Ak* growth model with flat tax rates does not offer a plausible explanation for the empirical evidence, as the short-run income elasticity of tax revenue that the model predicts is equal to one. One natural way to explain this empirical phenomenon is to disregard the assumption of constant marginal tax rates and to consider, instead, a progressive tax schedule. Obviously, as the average tax rates increase with income, government revenue (and, thus, government spending under balanced budget) will increase more than aggregate income.

Our approach will rest on the flat tax rate assumption and provide an alternative mechanism generating the same pattern of cyclicality of government revenues [3]. Undoubtedly under a progressive tax system, my mechanism, based on tax evasion, will reinforce our results and, thus, under a value greater than one of the inverse of intertemporal elasticity of substitution, the government revenue will overshoot even more as a response to a productivity shock.

In order to endow the standard *Ak* growth model with tax evasion, we assume that individuals have to choose, in each period, the amount of income they want to consume and the amount of income they want to evade. When individuals conceal part of their true income from the tax authority, they face the risk of being audited and, hence, of paying the corresponding fine. Both taxes and fines determine individual savings and the rate of capital accumulation. Two types of shocks coexist in this model: the aggregate shock, which is given by changes in the total factor productivity of the economy, and the idiosyncratic shock, which is introduced by means of the tax evasion inspection policy. The main result shows that when technology shocks are correlated, the value of intertemporal elasticity of substitution (IES) fully determines the behavior of the government revenue to output ratio. In particular, when the inverse of IES is greater than one, the govern-

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[3] During the last decade, some countries made severe reforms in their income taxation system. They replaced their previous progressive tax structure by a pure flat tax rate. For instance, Russia, Serbia, Iraq, Slovakia and Ukraine set a flat tax rate of 13, 14, 15, 19 and 13%, respectively.

ment revenue increases more than the output does in the presence of a positive technology shock. In this case, the elasticity of tax revenue with respect to output is greater than one, which is consistent with the empirical regularity. Moreover, when the IES is equal to one or technology shocks are not correlated, the result of the standard *Ak* model is recovered.

In the next section, we develop the basic model with penalties proportional to the amount of evaded taxes. In section 3, we will discuss the implications of a technology shock on the government revenue to output ratio. Some final remarks conclude the working paper.

2. The Model

LET us consider a competitive economy in discrete time with a continuum of identical individuals who are uniformly distributed on the interval [0,1]. Each individual i has access to a common technology represented by the production function $y_{i,t} = \tilde{A}_t k_{i,t}$ where $\tilde{A}_t > 0$ is the random total factor productivity, $y_{i,t}$ is the output per capita of individual i, and $k_{i,t}$ is the capital per capita of individual i in period t[4]. Therefore, production is exposed to technology shocks which make $\tilde{A}_t$ random.

We assume that the stochastic process of technology shocks $\{\tilde{A}_t\}$ follows a logarithmic autoregressive process,

$$1n\,\tilde{A}_{t+1} = \rho\,\ln\tilde{A}_t + \tilde{u}_{t+1}, \tag{2.1}$$

where $\rho \in [0, 1]$ and $\tilde{u}_{t+1}$ is normally distributed with mean zero and variance σ^2. Under this specification, the behavior of the process $\{\tilde{A}_t\}$ is determined by the serial correlation parameter ρ and the standard deviation σ of the noise $\tilde{u}_{t+1}$.

Output can be devoted to either consumption or investment. After production has taken place, each individual i decides both his consumption $c_{i,t}$ and the amount $x_{i,t}$ of declared income, and then pays the corresponding income tax at the rate $\tau \in (0, 1)$. If he is inspected by the tax enforcement agency, the total amount of unreported income is discovered and the taxpayer has to pay a penalty at the flat rate $\pi > 1$, which is imposed on the amount of evaded taxes (as in Yitzhaki, 1974)[5]. Inspection of a particular individual is an event that occurs with probability $\rho \in (0, 1)$. We also assume that $\rho\pi < 1$ in order to ensure positive tax evasion.

The amount of output remaining after consumption has taken place and taxes and (potential) penalties which were paid constitutes the capital

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[4] See Rebelo (1991) for a model where the *Ak* production function rises endogenously when physical and human capitals are perfect substitutes. In this case the capital stock k embodies both kinds of capital.

[5] If the penalty rate π were smaller than one, evading taxpayers would never be punished.

stock $k_{i,\,t+1}$ that is used for the next production period. Therefore, the budget constraint of an audited individual is,

$$\tilde{A}_t\, k_{i,\,t} - \tau x_{i,\,t} - \pi\tau\; (\tilde{A}_t\, k_{i,\,t} - x_{i,\,t}) = c_{i,\,t} + k_{i,\,t+1},$$

whereas the budget constraint of a non-audited individual is,

$$\tilde{A}_t\, k_{i,\,t} \; - \tau x_{i,\,t} = c_{i,\,t} + k_{i,\,t+1}.$$

We assume that the amount of taxes collected by the tax agency is devoted to financing government spending that enters into the instantaneous utility of individuals in an additive way. Therefore, the marginal rate of substitution of private consumption between two arbitrary periods is not affected by the level of government spending. Since consumers take as given the path of government spending, the utility accruing from this spending can be suppressed from the consumers' objective function. Individuals are assumed to maximize the following discounted sum of instantaneous utilities:

$$\sum_{t=0}^{\infty} \beta^t U\,(c_{i,\,t}), \tag{2.2}$$

where $\beta \in (0,\, 1)$ is the discount factor. We assume that the utility function is isoelastic,

$$U\,(c_{i,\,t}) = \frac{c_{i,\,t}^{1-\gamma}}{1-\gamma},$$

where γ plays a double role: 1) it is the value of the (constant) relative risk aversion index, and 2) it is the inverse of the intertemporal elasticity of substitution (IES).

The amount of unreported income in period t for each individual i, is $\varepsilon_{i,\,t} = \tilde{A}_t\, k_{i,\,t} - x_{i,\,t}$. Hence, we can use the previous budget constraints to write the law of motion of capital per capita as,

$$k_{i,\,t+1} = \begin{cases} (1-\tau)\; \tilde{A}_t\, k_{i,\,t} - c_{i,\,t} - \tau \;\; (\pi - 1)\; \varepsilon_{i,\,t}, & \text{with probability } p, \\ (1-\tau)\; \tilde{A}_t\, k_{i,\,t} - c_{i,\,t} + \tau\varepsilon_{i,\,t}, & \text{with probability } (1-p), \end{cases}$$

or, equivalently,

$$k_{i,\,t+1} = (1-\tau)\; \tilde{A}_t\, k_{i,\,t} - c_{i,\,t} + \tau\varepsilon_{i,\,t}\,\tilde{h}_i, \tag{2.3}$$

where $\tilde{h}$ is a random variable with the following probability function:

$$f(h) = \begin{cases} p & \text{for } h = 1 - \pi, \\ 1 - p & \text{for } h = 1. \end{cases} \tag{2.4}$$

Note that $E(\tilde{h}) = 1 - p\pi > 0$ because of the assumption $p\pi < 1$, which guarantees that some evasion takes place. We define the net true income per capita as,

$$n_{i,\,t} = (1 - \tau)\ \tilde{A}_t\, k_{i,\,t}. \tag{2.5}$$

Then, using (2.3) we can compute $n_{i,\,t+1}$ as,

$$n_{i,\,t+1} = (1 - \tau)\ \tilde{A}_{t+1}\ (n_{i,\,t} - c_{i,\,t} + \tau\varepsilon_{i,\,t}\tilde{h}_i). \tag{2.6}$$

The Bellman equation for the stochastic dynamic problem faced by an individual is,

$$V(k_{i,\,t}) = \underset{c_{i,\,t},\,\varepsilon_{i,\,t}}{Max} \left\{ \frac{1}{1-\gamma} (c_{i,\,t})^{1-\gamma} + \beta E_t \left[V(n_{i,\,t+1}) \right] \right\}, \tag{2.7}$$

where $n_{i,\,t+1}$ satisfies (2.6). It is well known that the value function for this problem is an affine transformation of the isoelastic function, $V(n_{i,\,t}) = \frac{D}{1-\gamma}\,(n_{i,\,t})^{1-\gamma}$ with $D > 0$ (see Hakansson, 1970). Therefore, using (2.6) and computing the conditional expectation $E_t\,[V(n_{i,\,t+1})]$, the optimization problem faced by a taxpayer with initial net true income $n_{i,\,t}$ becomes,

$$\underset{c_{i,\,t},\,\varepsilon_{i,\,t}}{Max} \left\{ \frac{1}{1-\gamma} (c_{i,\,t})^{1-\gamma} + \beta E_t \left[\frac{D}{1-\gamma} \left((1 - \tau)\ \tilde{A}_{t+1}\ (n_{i,\,t} - c_{i,\,t} + \tau\varepsilon_{i,\,t}\tilde{h}_i) \right)^{1-\gamma} \right] \right\}. \tag{2.8}$$

Differentiating with respect to $c_{i,\,t}$ and $\varepsilon_{i,\,t}$, we obtain the following first order conditions for the previous problem:

$$(c_{i,\,t})^{-\gamma} = \beta D E_t \left[\left((1 - \tau)\ \tilde{A}_{t+1} \right)^{1-\gamma} (n_{i,\,t} - c_{i,\,t} + \tau\varepsilon_{i,\,t}\tilde{h}_i)^{-\gamma} \right], \tag{2.9}$$

and

$$(1 - p)\ (n_{i,\,t} - c_{i,\,t} + \tau\varepsilon_{i,\,t})^{-\gamma} \;=\; p\,(\pi - 1)\ \left(n_{i,\,t} - c_{i,\,t} + \tau\,(1 - \pi)\varepsilon_{i,\,t} \right)^{-\gamma}. \tag{2.10}$$

Since we assume that $\tilde{A}_{t+1}$ and $\tilde{h}_i$ are independent, equation (2.9) can be rewritten as,

$$(c_{i,\,t})^{-\gamma} = \beta D\,(1 - \tau)^{1-\gamma}\,\alpha E_t \left[(n_{i,\,t} - c_{i,\,t} + \tau\varepsilon_{i,\,t}\tilde{h}_i)^{-\gamma} \right], \tag{2.11}$$

where,

$$\alpha = E_t\left[(\tilde{A}_{t+1})^{1-\gamma}\right].$$

Solving for $c_{i,t}$ and $\varepsilon_{i,t}$ the system composed by equations (2.11) and (2.10), we obtain,

$$c_{i,t} = \theta n_{i,t}, \tag{2.12}$$

and

$$\varepsilon_{i,t} = \lambda\,(n_{i,i} - c_{i,t}), \tag{2.13}$$

where,

$$\theta = \frac{1}{1 + \left(\beta D\,(1-\tau)^{1-\gamma}\,\alpha\,\left[(1-p)\;(1+\tau\lambda)^{-\gamma} + p\,(1-(\pi-1)\;\tau\lambda)^{-\gamma}\right]\right)^{\frac{1}{\gamma}}}, \tag{2.14}$$

and

$$\lambda = \frac{\left[\left(\frac{1-p}{p\,(\pi-1)}\right)^{\frac{1}{\gamma}} - 1\right]}{\tau\left[1 + (\pi-1)\;\left(\frac{1-p}{p\,(\pi-1}\right)^{\frac{1}{\gamma}}\right]}. \tag{2.15}$$

Applying the envelope theorem, that is $U'(c_{i,t}) = V'(n_{i,t})$, it must hold that

$$c_{i,t}^{-\gamma} = D n_{i,t}^{-\gamma}. \tag{2.16}$$

Substituting (2.12) in (2.16) and using (2.14), we obtain,

$$D = \frac{1}{1 + \left(\beta D\,(1-\tau)^{1-\gamma}\,\alpha\,\left[(1-p)\;(1+\tau\lambda)^{-\gamma} + p\,(1-(\pi-1)\;\tau\lambda)^{-\gamma}\right]\right)^{\frac{1}{\gamma}}}.$$

Therefore, D is equal to,

$$D = \left[\frac{1}{1-\beta^{\frac{1}{\gamma}}(1-\tau)^{\frac{1-\gamma}{\gamma}}\,\alpha^{\frac{1}{\gamma}} H^{\frac{1}{\gamma}}}\right]^{\gamma}, \tag{2.17}$$

where,

$$H = (1-p)\ (1+\tau\lambda)^{-\gamma} + p\left(1-(\pi-1)\ \tau\lambda\right)^{-\gamma}.$$

Substituting (2.17) into (2.14), (2.12), and (2.13), we get the following consumption and evasion policies:

$$c_{i,t} = \left(1-(\beta\ (1-\tau)^{1-\gamma}\ \alpha H)^{\frac{1}{\gamma}}\right) n_{i,t}, \tag{2.18}$$

and

$$\varepsilon_{i,t} = \lambda\left(\beta\ (1-\tau)^{1-\gamma}\ \alpha H\right)^{\frac{1}{\gamma}} n_{i,t}. \tag{2.19}$$

In order to obtain the value of the aggregate net true income in equilibrium, n_{t+1}, which is given by (2.6), we compute,

$$\begin{aligned} n_{t+1} = \textstyle\int_{[0,1]} n_{i,t+1}\, d_i = (1-\tau)\ \tilde{A}_{t+1}\ \left[\int_{[0,1]} n_{i,t}\, d_i - \int_{[0,1]} c_{i,t}\, d_i + \tau \int_{[0,1]} \varepsilon_{i,t}\, \tilde{h}_i\, d_i\right] = \\ = (1-\tau)\ \tilde{A}_{t+1}\ \left[\textstyle\int_{[0,1]} n_{i,t}\, d_i - \int_{[0,1]} c_{i,t}\, d_i + \tau\ \left(\int_{[0,1]} \varepsilon_{i,t}\, d_i\right)\ \left(\int_{[0,1]} \tilde{h}_i\, d_i\right)\right] = \\ = (1-\tau)\ \tilde{A}_{t+1}\ \left[n_t - c_t + \tau\ (1-p\pi)\ \varepsilon_t\right], \end{aligned}$$

where the second equality follows from the independence between the variables $\tilde{h}_i$ and $\varepsilon_{i,t}$ at the beginning of period t, whereas the last equality comes from the law of large numbers for a continuum of i.i.d. random variables according to which $\int_{[0,1]} \tilde{h}_i\, di = E\,(\tilde{h}_i) = 1 - p\pi$, and from the definitions of aggregate consumption, $c_t = \int_{[0,1]} c_{i,t}\, di$ and aggregate evasion, $\varepsilon_t = \int_{[0,1]} \varepsilon_{i,t}\, di$.

In consequence, the aggregate values of evaded income and consumption are,

$$c_t = \left(1-(\beta\ (1-\tau)^{1-\gamma}\ \alpha H)^{\frac{1}{\gamma}}\right) n_t, \tag{2.20}$$

and

$$\varepsilon_t = \lambda\left(\beta\ (1-\tau)^{1-\gamma}\ \alpha H\right)^{\frac{1}{\gamma}} n_t. \tag{2.21}$$

In order to analyze the effect of a technology shock on evaded income and on consumption, we must compute the value of α. Expression (2.1) can be rewritten as,

$$\tilde{A}_{t+1} = \tilde{A}_t^{\rho}\ e^{\tilde{u}_{t+1}}.$$

Therefore,

$$(\tilde{A}_{t+1})^{1-\gamma} = \tilde{A}_t^{\rho\,(1-\gamma)}\, e^{\tilde{u}_{t+1}(1-\gamma)}.$$

Then α becomes,

$$\alpha = E_t\left[(\tilde{A}_{t+1})^{1-\gamma}\right] = \tilde{A}_t^{\rho\;1-\gamma)}\, E_t\left[e^{\tilde{u}_{t+1}(1-\gamma)}\right].$$

Given that $\tilde{u}_{t+1}$ is normal, the random variable $e^{\tilde{u}_{t+1}}$ is log-normal distributed. Since $E_t\left[(1n\; e^{(1-\gamma)\tilde{u}_{t+1}}\right] = 0$ and $Var\left[(1n\; e^{(1-\gamma)\tilde{u}_{t+1}}\right] = (1-\gamma)^2\,\sigma^2$, we get,

$$E_t = \left[e^{(1-\gamma)\tilde{u}_{t+1}}\right] = e^{\frac{(1-\gamma)^2\sigma^2}{2}}.$$

Hence, α is equal to,

$$\alpha = A_t^{\rho\,(1-\gamma)}\, e^{\frac{(1-\gamma)^2\sigma^2}{2}}. \tag{2.22}$$

The next section discusses the effect of a technology shock on both the amount of evaded income and the government revenue to output ratio.

3. Effects of Technology Shocks

In order to analyze the effect of a technology shock on government revenue to output ratio, we must first compute the effect of an increase of A_t on the ratio $\frac{\varepsilon_t}{y_t}$. Since aggregate output satisfies $y_t = \tilde{A}_t\, k_t$, and substituting (2.5) and (2.22) into (2.21), we obtain,

$$\frac{\varepsilon_t}{y_t} = \lambda \left[\beta H \left(1 - \tau\right) A_t^{\rho\,(1-\gamma)}\, e^{\frac{(1-\gamma)^2 \sigma^2}{2}} \right]^{\frac{1}{\gamma}}. \tag{3.1}$$

The next proposition summarizes the impact of A_t on the government revenue to output ratio $\frac{\varepsilon_t}{y_t}$.

Proposition 3.1. 1) *Assume that* $\rho > 0$. *Then,* $\frac{\partial \left(\frac{\varepsilon_t}{y_t}\right)}{\partial A_t} \underset{<}{\geq} 0$ *if* $\gamma \underset{>}{\leq} 1$;

and 2) *Assume that* $\rho = 0$. *Then,* $\frac{\partial \left(\frac{\varepsilon_t}{y_t}\right)}{\partial A_t} = 0.$

Proof. 1) It follows directly from (3.1) since $e^{\frac{(1-\gamma)^2 \sigma^2}{2}} > 0,\ \lambda > 0$ and $H > 0$.

2) When $\rho = 0$, $\tilde{A}_{t+1}$ does not depend on $\tilde{A}_t$ and, hence, $\alpha = e^{\frac{(1-\gamma)^2 \sigma^2}{2}}$. Therefore, $\frac{\varepsilon_t}{y_t}$ is not affected by technology shocks.

The intuition of this result comes directly from the assumption made about the utility function. The parameter γ measures both the inverse of the intertemporal elasticity of substitution (IES) and the relative risk aversion of individuals. Assume, for instance, that $\gamma > 1$. A high value of γ means that consumers want to keep a smooth path of consumption as a consequence of the implied low the IES. Note that because of the assumption of positive autocorrelation of productivity shocks, $\rho > 0$, a high value of the total factor productivity in period *t,* $\tilde{A}_t$ implies a large value of the shock in the period $t+1$, A_{t+1}. This results in a rise in both present and expected future income. In this case, consumers decide to decrease the fraction of evaded income $\frac{\varepsilon_t}{y_t}$ in order to minimize the risk borne due to evasion. If consumers conceal a smaller fraction of their income, the penalty is not as high if they were caught by an audit. This means that the discrepancy between the amount of consumption in period t and period $t+1$ will not be too large.

When $\gamma < 1$, individuals exhibit a high intertemporal elasticity of substitution, so that they care mainly about the (discounted) sum of consumption in periods t and $t+1$. In this case, if the economy suffers a positive shock, then individuals evade proportionally more in order to get an expected larger income in the next period even if the variation of future consumption is larger due to the audit risk.

The previous intuitions are not valid when the technology shocks are not correlated. Due to the lack of autocorrelation of technology shocks, individuals behave as in a sequence of static economy concerning their activity compliance. In this case, when a technology shock takes place, both the true net income n_t and the output y_t increase. Because of the assumption of isoelastic preferences, the aggregate evasion and the output rise in the same proportion, and the ratio $\frac{\varepsilon_t}{y_t}$ remains constant.

Finally, when $\gamma = 1$ (that is, the case with the logarithmic utility function), the consumption policy (2.20) is equal to,

$$c_t\,(1-\beta)\,n_t,$$

for all $\rho \in [0, 1]$. Note that what we have just obtained is exactly the same as the policy obtained when the tax evasion phenomenon is disregarded. The latter case is easily derived by making $p\pi = 1$ so that $\varepsilon_t = 0$ (see [2.21] and [2.15]). In fact, the parameters p and π, characterizing the tax enforcement policy, do not have any effect on the amount of consumption in period t for given values of both the tax rate τ and the capital stock k_t (see [2.20]). Therefore, the impact of a variation in the tax enforcement policy is totally absorbed by the amount of unreported income.

The total government revenue G_t is given by the taxes that consumers voluntary pay plus the amount of evaded taxes and the corresponding penalty paid by inspected individuals:

$$G_t = \tau x_t + p\pi\tau\,(y_t - x_t).$$

The government revenue G_t can be rewritten as,

$$G_t = \tau y_t - \tau\ (1 - p\pi)\ \varepsilon_t.$$

Therefore, the ratio $\frac{G_t}{y_t}$ equals to,

$$\frac{G_t}{y_t} = \tau \left[1 - (1 - p\pi)\frac{\varepsilon_t}{y_t} \right]. \tag{3.2}$$

The effect of a technology shock on the government revenue to output ratio is given in the following proposition:

Proposition 3.2. 1) *Assume that* $\rho > 0$. *Then,* $\frac{\partial \left(\frac{G_t}{y_t} \right)}{\partial\, A_t} \gtreqless 0$ *if* $> \gamma \gtreqless 1$;

and 2) *Assume that* $\rho = 0$. *Then,* $\frac{\partial \left(\frac{G_t}{y_t} \right)}{\partial\, A_t} = 0$.

Proof. It is immediate from proposition 3.1 and equation (3.2).

We have just shown that a technology shock not only affects the output per capita but also the government revenue to output ratio. The intuition of this result lies in the behavior of the ratio $\frac{\varepsilon_t}{y_t}$ when A_t changes. As proposition 3.1 shows, the effect of a positive technology shock on the ratio $\frac{\varepsilon_t}{y_t}$ depends on the value that the parameter γ takes. When $\gamma > 1$, the ratio $\frac{\varepsilon_t}{y_t}$ decreases, and therefore, the government revenue to output ratio increases.

In this framework, the capital k_t is given at the beginning of each period *t*. Then, the output at time *t* is only affected by changes in the technology shock A_t. Therefore, knowing the sign of the effect of a technology shock on the government revenue to output ratio is the equivalent of knowing whether the elasticity of tax revenue with respect to output is greater, equal or lower than one. Empirical evidence shows that the estimates of this elasticity are generally greater than one. This model can reproduce this fact when $\gamma > 1$, and technology shocks are correlated ($\rho > 0$). Note that in the case where consumers are honest (that is, when $p\pi = 1$) a technology shock will only affect the output per capital but not the ratio $\frac{G_t}{y_t}$, since from (3.2) we find that this ratio is equal to τ.

In order to extend the scope of our results, owe will discus some potential scenarios concerning the behavior of government spending that give rise, in turn, to some insights about the procyclical or countercyclical nature of government deficits. Let us first consider the case where public spending is exogenously determined by the government. There is a large number of empirical works that use data from developing countries to suggest that government spending tends to be procyclical [6]. The articles by Gavin and Perotti (1997), Stein, Talvi and Grisanti (1999), Braun (2001), Kaminsky, Reinhart and Végh (2004), and Akitoby et al. (2004) constitute good examples of studies that find a positive relationship between public spending and output, so that the elasticity of public spending with respect to output is positive. Now let us assume that the government wants to keep the government spending to output ratio constant, which is equivalent to fixing a unitary elasticity of public spending with respect to output. In this case, the behavior of the tax revenue to output ratio fully characterizes the path of fiscal deficits or fiscal surpluses. For instance, assume that the government budget is initially balanced. If $\gamma > 1$, a positive technology shock has a larger effect on the tax revenue to output ratio than on the public spending to output ratio. Consequently, a budget surplus appears. However when $\gamma < 1$, a positive technology shock results in a budget deficit. Note that when $\gamma = 1$ or $\rho = 0$, the government budget remains balanced. Nevertheless, when the elasticity of government spending with respect to output is greater than one, fiscal deficits can arise whatever value γ may take [7]. For $\gamma < 1$, and $\gamma = 1$ a positive technology shock gives rise to a fiscal deficit while in the case of $\gamma > 1$, deficits or surpluses appear depending on the specific value of both the elasticity of public spending and the elasticity of tax revenue.

Consider now the case where government is committed to devoting all tax revenue to financing public spending. Therefore, government spending becomes an endogenous variable and, in consequence, displays a procyclical behavior. This setup can be interpreted as the extreme case of the model developed by Talvi and Végh (2005), where government, under political pressure, increases public spending when tax revenue increases due to positive shocks on output. In the setup of this working paper, the value of parameter γ will determine the magnitude of the elasticity of public spending with respect to output. In particular, when $\gamma > 1$, the elasticity of government revenue with respect to the output is greater than 1, which agrees with some empirical evidence that estimates the elasticity of public spending with respect to output (see Akitoby et al., 2004).

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[6] A procyclical fiscal policy is defined as the reduction in public spending (or an increase in taxes) during recession periods, and increases in public spending (or reductions in taxes) during expansions periods.

[7] Akitoby et al. (2004) estimated the long and short term elasticity of government spending and output and found that this elasticity is on average greater than 1.

Traditionally, governments conduct their fiscal policies by modifying either the nominal tax rate or public spending. The introduction of the tax evasion phenomenon offers new instruments to government: the probability of inspection and the penalty rate. From expression (3.2), one clearly sees that the implementation of a tax enforcement policy, that makes $\rho\pi$ closer to 1, results in an increase in the tax revenue to output ratio. Assuming that the government runs a balanced budget, an increase in tax revenue is, thus, automatically translated to public spending. So, the government can modify the initial effect of a technology shock on public spending to output ratio by means of a tax compliance policy.

4. Final Remarks

IN this working paper, we demostrate that by introducing tax evasion to the standard *Ak* model growth with flat tax rates, it is possible to obtain an elasticity of tax revenue with respect to output greater than one, which agrees with the empirical evidence.

We consider a very simple model of capital accumulation where the static portfolio choice model of tax evasion presented by Allingham and Sandmo (1972) is extended to a dynamic setup [8]. In this framework, consumers' decisions about how much income they want to report not only affect their present consumption but also their future one. Therefore, the response of consumers to positive technology shocks affects both the tax evasion decision and government revenue. In this setup we show how the effect of a positive technology shock on the government revenue to output ratio is fully characterized by the value of the intertemporal elasticity of sustitution (IES) parameter when technology shocks are correlated. In particular, when the IES exhibits a sufficiently small value, a positive technology shock forces individuals to more than proportionally lower their amount of evaded income in order to maintain a smooth path of consumption over time. The government revenue, then, increases more than the output and, in consequence, the income elasticity of tax revenue becomes greater than one.

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8. See Lin and Yang (2001) for a similar context.

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