Sustainability of the Fiscal Process in Emerging Countries: Evidence from Iran and Turkey

Amir Kia
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Amir Kia*
Finance and Economics Department
Utah Valley State College
800 West University Parkway, Orem, UT 84058-5999
USA

Email: kiaam@uvsc.edu

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Abstract

This paper investigates the fiscal sustainability of two emerging countries — Iran (an oil-producing country) and Turkey (an agricultural country) — for both stochastic and non-stochastic environments. Cointegration and multicointegration methodologies were used to evaluate fiscal budgeting processes in these countries. A model for testing the sustainability of a fiscal policy, based on Barro’s tax smoothing, was also developed to test the Iranian fiscal policy. It was found that the fiscal budgeting process in both countries is not sustainable. Furthermore, the Iranian fiscal policy, as far as oil and gas income is concerned, is not a fully responsible policy.

Keywords: fiscal sustainability, multicointegration and tax smoothing

JEL Codes: H60, E62, C32
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1. Introduction

The credibility of a government is extremely important for its ability to borrow both domestically and internationally. This is particularly true for the government of developing countries which also, at times, needs to rely intensively on international lenders. Governments, like individuals, are constrained in their ability to borrow. In fact, this constraint limits the government’s choices in issuing debt, imposing taxes or printing money to finance deficits. However, government budgets tend to move between balance, surplus, and deficit. It is, consequently, important to examine the budget position of a government over time, namely, the intertemporal budgeting.

Sustainability, in general, concerns current and expected future policies. If economic agents do not expect current and future policies to lead to an intertemporal budget constraint then the fiscal process would be unsustainable and government insolvency would be possible. This means an asymptotically negative expected present value of a debt is possible. Furthermore, solvency requires that the government asymptotically cannot leave a debt with a positive expected value. A government is insolvent if it cannot, both politically and economically, impose a tax set and generate seignorage plans that permit the outstanding stock of debt to be serviced.

Most of the empirical work in this area focuses on the time-series behavior of tax revenues and expenditures as well as debt series to investigate if the behavior of these series is consistent with the intertemporal budget balance. Specifically, such a balance holds if the stock of debt and the flow of revenue (spending) are cointegrated. The empirical results of the existing literature vary depending on the sample period and the methodology used. For example, Trehan and Walsh (1991), Martin (2000) and Cunado et al. (2004) failed to reject intertemporal budget balance for the United States while other studies, including Hamilton and Flavin (1986), Wilcox (1989) and Hakkio and Rush (1991) rejected it. These studies, similar to Hansen et al. (1991) and Gali (1991) have assumed the discount rate remained positive and constant.

Using the cointegration methodology on the data of other countries, for instance,
Wu (1998) finds the fiscal policy of Taiwan is sustainable as did Green et al. (2001) for Poland’s fiscal policy. Furthermore, Bravo and Silvestre (2002) find the fiscal process in Austria, France, Germany, Netherlands and the UK is sustainable, while the process is unsustainable in Belgium, Denmark, Finland, Ireland, Italy and Portugal. Hatemi-J (2002) finds that Sweden did not violate its intertemporal budget constraint and Goyal et al. (2004) find the fiscal policy of the Centre and State Governments in India is individually unsustainable, but for all states together it is sustainable.

Luporini (2002) argues that the efficiency of cointegration analysis is constrained by its assumptions on real interest rate and the stochastic process that drives deficit. Luporini applied Bohn’s (1998) approach to investigate the response of Brazil’s budget surplus to its variation of debt-income ratio and found Brazil had an unsustainable fiscal structure, in contrast to the result found earlier by Issler and Lima (1997) who adopted a cointegration approach. Telatar et al. (2004) also follow Bohn’s (1998) approach, but use Bayesian Gibbs sampling simulation to observe changes in the behavior of the Turkish government period by period. They found that the relationship between primary surpluses and government total liabilities might be unstable in Turkey as the intention of the government towards the sustainability of fiscal policy has been changing.

A more serious problem with the cointegration analysis, as mentioned by Bohn (1995, 1998) and Ball et al. (1998), is that persistent deficits and the accumulation of debt do not necessarily imply that the debt is unmanageable and, hence, fiscal processes are unsustainable. In fact, the key issue with regards to sustainability depends on the growth of the economy and its impact on the stochastic discount factor. As it was also mentioned by Leachman et al. (2005), this implies that the standard cointegration approach may not provide sufficient criteria for determining whether the fiscal process is truly sustainable under a stochastic environment.

Leachman (1996), consequently, uses a more encompassing set of criteria under more realistic assumptions for determining whether a country exhibits a sustainable budgeting process. His criteria for sustainability are based on the multicointegration approach first presented by Granger and Lee (1989, 1990). Leachman et al. (2005) use the one-step multicointegration approach which was developed by Engsted et al. (1997). Multicointegration can ensure that a country’s budgeting strategy is also sustainable in
‘bad’ states of nature, that is, when the rate of economic growth falls short of the real interest rate on sovereign debt. To the best knowledge of the author, no such study for developing countries, especially oil producing countries and particularly Middle East and North African (MENA) countries, exists.

However, the main problem with studying the sustainability of the fiscal process in developing countries is that the tax revenue systems of these countries are frequently not well developed. Furthermore, tax revenues are not the only source of income. This is especially true for resource–oriented countries, particularly oil-producing countries. Consequently, simply inspecting the spending-tax revenue relationship may be misleading. Hence, this paper modifies the revenue series to incorporate natural resource revenues, one source of which is oil, using Barro’s (1979, 1986) tax smoothing model. We will look at two countries – Iran which has an important alternative source of revenue (oil) and Turkey which does not.

The heterogeneity of these countries makes the study unique. Furthermore, the methodology used is purely for a stochastic environment which is more relevant for these countries than for developed countries. Note that in a stochastic environment uncertainty exists and the discount rate is subjective and time variant. Finally, contrary to the existing literature, this study incorporates policy regime changes that influence the short-run dynamics of the system. The rest of the paper is organized as follows: Section II is devoted to a brief review of the fiscal process in Iran and Turkey. Section III formulates the models and explains the methodology. Section IV focuses on the empirical results. The final section provides some concluding remarks. It was found in this paper that the fiscal budgeting process in Iran is unsustainable in both stochastic and non-stochastic environments. Furthermore, the Iranian fiscal policy, as far as oil and gas income is concerned, is not a fully responsible fiscal policy. In Turkey, the fiscal budgeting process is also unsustainable in a stochastic environment, but revenues and expenditures are cointegrated.

II. A Brief Review of the Fiscal Process in Iran and Turkey

In this section we review the fiscal policy of our oil-producing country, Iran and our agricultural country, Turkey, for sample periods 1970-2003 and 1967-2001,
respectively. The sample period for each country is chosen according to the availability of the data. The sources of data, unless specified, are the *International Financial Statistics* (IFS) online. To make the variables in real terms the GDP deflator was used for Iran and since for Turkey the GDP deflator was not available for the entire period, therefore, the CPI was used. The IFS provides data on outstanding debt for Iran only for the period 1975-77. The data for the period 1978-2003, available upon request, was obtained from the Monetary and Banking Research Academy of Iran. For the period 1970-74, I constructed this data.\(^1\) Furthermore, since IFS provides data on the volume of oil and gas exports only in an index form, I constructed oil and gas revenues from different sources.\(^2\) Some missing data for both countries were taken from the *World Development Indicator* (WDI). Some missing observations for Turkey were also taken from the State Institute of Statistics of Turkey (SIS) or *IMF – Economic and Financial Data for Turkey*. The outstanding debt for Turkey for the period 1967-69 was not available, and I, therefore, constructed this data similar to the missing part for Iran, see Footnote 1. The information on institutional and policy changes in Turkey was taken from *The Middle East and North Africa* (2004) and for Iran, from various Central Bank publications, including *Economic Trends*, as well as from Kia (2003).

Figures 1 to 4 about here

**A. Iran**

The average of real government spending, revenues and energy (oil and gas) income during the sample period in Iran is 1265.49, 1110.48 and 742.64 billion rials, respectively. As we can see in Figure 1, spending and revenues, including energy revenue, except on two occasions have moved together during the sample period. However, government spending is almost always higher than revenue. This means

\[\text{Debt}_t = \text{Debt}_{t-1}[1 + (\text{interest rate on debt})_{t-1}] + (\text{government spending on goods and services and transfer payments})_t - (\text{government revenues})_t - (\text{change in monetary base})_t.\]

\[\text{The outstanding debt is calculated backward, based on the following formula, so that the 1975 value corresponds with the IFS-provided value:}\]

\[\text{Data on the volume of Iranian oil and gas exports, in an index form, the world oil price in SUS and the official rial-SUS exchange rate are taken from IFS. The data on oil and gas exports, in SUS, since 1991, is taken from *Economic Trends*, published by the Central Bank of Iran. The latter data was converted from the Iranian to the Gregorian calendar and was divided by the oil price to get the actual volume of exports for the 1991-2003 period. The resulting data as well as the index on the volume of exports were used to construct the volume of exports for the entire period. The data on oil price in rials, using the official}\]
deficits and the accumulation of debt are the norm in the Iranian fiscal process. Then the question is whether the outstanding debt has been monetized since 1970. According to Figure 2, as the outstanding debt per GDP increased, the monetary base per GDP was also raised during the sample period, implying that most of the debt was monetized in Iran. However, during the recent (1995-2003) period, the outstanding government debt, on average, is 3.62% of GDP (fell sharply from 41.36% of GDP in the 1976-1994 period) while the monetary base is 15.28% of GDP. The latter evidence indicates a 100% monetization of the debt as well as the imposition of an inflation tax. Such an observation for an oil producing country may be interpreted as an irresponsible fiscal policy. In an oil producing country one would expect the oil and gas revenue, at least, to be used to reduce debt. As we can see in Figure 3, there is a negative relationship between the energy income per GDP and the debt per GDP up to 1994, but the reverse is true since that time. This result confirms the above conclusion that the debt in Iran has been monetized completely since 1994. Furthermore, as Figure 4 shows, a negative government surplus (deficit) has been always associated with a high per GDP issue of monetary base, which further supports an irresponsible fiscal policy in Iran during the 1970-2003 period. However, a formal statistical analysis is required to confirm the above results.

Figures 5 to 8 about here

B. Turkey

The average of real government spending and revenue in Turkey during the sample period is 194.21 and 148.90 million liras, respectively. As Figure 5 depicts, although government expenditure has always been higher than government revenue, these two fiscal variables have been moving together in Turkey since 1967. However, it seems deficits and debt accumulation have been the norm in Turkey. Figure 6 depicts a seemingly negative relationship between per GDP debt and surplus. In fact, the correlation coefficient between the debt per GDP at the beginning of the period and the surplus per GDP at the end of the period is -0.67. Everything else being constant, this means that during the sample period whenever the debt per GDP increased, the average tax rate in the following year was not increased in order that enough revenue would be

 exchange rate and the world oil price in SUS, was calculated. Then, using the actual volume of exports and the price, the data on oil and gas revenues was calculated.
collected to cover the debt services as well as to reduce the debt. Consequently, the fiscal process in Turkey is not sustainable. Then, we may ask if the outstanding debt has been monetized during the sample period. The sample correlation coefficient between the monetary base per GDP and debt per GDP in Turkey is -0.55, which rejects the monetization of debt in Turkey. Figure 7 also shows such a negative relationship. Furthermore, Figure 8 shows a negative relationship between the deficits (negative surplus) and the monetary base, both scaled by GDP. However, again a formal statistical analysis is required to confirm the above results. Sections III and IV of the paper are devoted to such an analysis for both Iran and Turkey.

III. The Model and the Methodology

A. The Standard Model

The intertemporal budget balance holds when revenues and the outstanding debt are cointegrated. This implies that deficit processes are sustainable. The bulk of the existing literature assumes the discount rate remains positive and constant. This assumption is valid in a non-stochastic environment. Bohn (1995) shows that in a stochastic environment, in the absence of lump-sum taxes, even seemingly prudent fiscal policies such as running a balanced budget may be unsustainable. Specifically, if the growth rate of real income is a unit root process that can take on negative values, then fiscal policies, which run a balanced budget, may be unsustainable. In this case, there is a positive probability of large income declines that can make the debt-to-income ratio large enough to threaten sustainability. Consequently, studies under the condition of certainty (non-stochastic economy) are too simple to be realistic.

Under stochastic conditions, uncertainty exists. In this situation, higher risk averse agents attach a higher value to sure claims to future consumption. This implies a higher demand for government bonds, which itself tends to increase the bond price and so to lower the risk-free (safe) rate of interest. This means that, unless agents are risk neutral, the discount rate in a stochastic situation should be subjective and time variant. In other words, the rate should be a function of the probability distribution of future debt.

Therefore, we need to use criteria that correctly assess whether the behavior of these emerging countries, over the sample period, is consistent with sustainable
budgeting policies, regardless of economic performance while ruling out default or inflation. Consequently, following Ahmed and Rogers (1995), among others, I assume the discount rate \( \beta_t, 0<\beta_t<1 \), is subjective and variable (i.e., a stochastic environment), utility is time separable and marginal utility of consumption follows a random walk. Furthermore, assume the covariance between the marginal substitution between current and future consumption and fiscal variables (i.e., real government expenditure on goods and services as well as transfer payments, \( G \), and real government revenues, \( R \)) is constant. In other words, all risk premia are time-invariant. The current government budget constraint, when there is no inflationary finance, is given by:

\[
G_t - R_t + r_{t-1} D_{t-1} = D_t - D_{t-1},
\]

where \( r \) and \( D \) are the real interest rate and the outstanding debt at time \( t \), respectively. Substituting forward for \( D_t \) in Equation (1) and denoting \( E \) as expectations operator, conditional on all available information at time \( t \), and rearranging we will have:

\[
(1 + r_{t-1}) D_{t-1} = G_t - R_t + E_t[(1 + r_t)^{-1} (G_{t+1} - R_{t+1}) + (1 + r_t)^{-1} (1 + r_{t+1})^{-1} (G_{t+2} - R_{t+2}) + \ldots + (1 + r_t)^{-1} (1 + r_{t+n})^{-1} (G_{t+n} - R_{t+n}) \ldots |I_t] \\
+ \lim_{n \to \infty} E_t[(1 + r_{t+n})^{-1} D_{t+n} |I_t].
\]

In Equation (2), \( I_t \) is the information available at time \( t \), including the state of the economy. This equation is the standard intertemporal government budget constraint in expected value terms. In other words, it implies that, given all available information, the current value of government debt is equal to the expected present value of all future primary surpluses, plus a limiting term representing the asymptotic expected present value of the government debt. Solvency requires that the government, asymptotically, would not leave a debt with a positive expected value. Furthermore, the government should not allow anyone to run Ponzi schemes against it, an asymptotically negative expected present value of a debt is not allowed either. This means

\[
\lim_{n \to \infty} E_t[(1 + r_{t+n})^{-1} D_{t+n} |I_t] = 0.
\]

Such a condition immediately implies that the government should satisfy its intertemporal budget constraint. Namely, the sum of the current primary budget surplus and the expected present discounted value of the future primary surplus, given \( I_t \), should be equal to the amount needed to repay the principal and interest on the initial debt, Ahmed and Rogers (1995).
The above condition generates a sustainable fiscal process. Under some necessary and sufficient conditions, Ahmed and Rogers prove the existence of a long-run cointegrating relationship between $G'_t (= G_t + r_{t-1}D_{t-1})$ and $R_t$ with the cointegrating vector of $(1, -1)$ ensures \[ \lim_{n \to \infty} \mathbb{E}_t[(1 + r_{t+n})^{-1}D_{t+n}|I_t] = 0, \] i.e., a sustainable fiscal process. They assume expectations are rational, the real rate of return is constant and

\[ \Delta G'_{t+n} = a_{G'} + v_{G't+n}, \quad (3) \]
\[ \Delta R_{t+n} = a_R + v_{Rt+n}, \quad (4) \]

where $\Delta$ is the first difference operator, $a_{G'}$ and $a_R$ are constant parameters, $v_{G'}$ and $v_R$ are zero-mean stationary processes. They stressed that cointegration between expenditures and revenues is both necessary and sufficient conditions for the government’s present value condition to hold even under a stochastic environment. However, this does not mean that the national debt must eventually be paid off.

Specifically, even if government spending, including interest payments, and revenues are cointegrated, the Ponzi scheme (i.e., the possibility of issuing new debt to pay interest on the outstanding debt) is still possible. In general, the agents who purchase safe-government issued bonds rather than invest in risky assets are logically risk averse. In stochastic economies when uncertainty exists, the agents’ subjective discount rate will increase when the initial debt relative to the income is high. When the outstanding debt at its maturity is rolled over, it will be priced lower and while the safe rate of return increases, there is a need for more debt (i.e., new issues) to be marketed to replace the initial debt. Consequently, debt can grow as government roll over the old debt with new issues, which has a lower market value or a higher rate of return. Furthermore, as Bohn (1995) also mentions, in a stochastic setting the government might issue a portfolio of securities that promises a total payoff conditional on the state of the economy at the time of maturity. The new level of government debt, therefore, will change according to the state of the economy. This means that besides the cointegration condition between government expenditures, including interest payments, and revenues, we need to impose an additional condition for the sustainability of fiscal processes. This extra condition

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3 For proof, see Ahmed and Rogers (1995), Appendix A2.
would be that the government debt should also be cointegrated with its revenues/expenditures.

Specifically, a fiscal process is sustainable if expenditures and revenues do not drift apart over the long run, and in the meantime the outstanding debt and revenues/expenditures do not drift apart either, i.e., revenues and spending to be multico-integrated in the sense of Granger and Lee (1989, 1990). In other words, government revenues and expenditures or government revenues and outstanding debt can deviate from each other over the short run, but market forces and/or fiscal policy bring them back together over the long run. This multico-integration condition guarantees the sustainability of fiscal processes in a stochastic environment.

Note that if $G'_t$ and $R_t$ are both I(1) and are cointegrated, then the government deficit series, i.e., $z_t = G'_t - R_t$, will be I(0). In this case, the outstanding government debt, $D_t = \sum_{i=0}^{t} z_{t-i}$ will be I(1). We know $D_t$ is a function of $G'_t$, $R_t$ and their lags. If the government fiscal process does not allow $D_t$ and $G'_t$, or $D_t$ and $R_t$ to drift apart over the long run and so be cointegrated, then $G'_t$ and $R_t$ will be said to be multico-integrated. In this case, the government considers both the change and the rate of change in economic conditions in formulating its fiscal policy. In a one-step test for the sustainability of fiscal processes in a stochastic environment we need to run OLS on the following equation:

$$Y_t = C_0 + C_1 X_t + C_2 \Delta X_t \text{ (or } C'_2 \Delta Y_t) + C_3 \text{ trend} + C_4 \text{ trend}^2 + e_t$$

(5)

where $C$’s are constant coefficients, $Y_t = \sum_{i=0}^{t} G'_{t-i} \sim I(2)$, and $X_t = \sum_{i=0}^{t} R_{t-i} \sim I(2)$.

Noting that $\Delta X_t = R_t$ we will have: $Y_t = X_t + C \Delta X_t + e_t$, where $e_t \sim I(0)$. We can also replace $\Delta X_t$ by $\Delta Y_t = G'_t$.

We need to test if, in the integral regression (5), $e_t$ follows an I(0) process (the case of multico-integration), an I(1) process (the case of first level cointegration, but no multico-integration) and finally the case of an I(2) process where there is no cointegration among variables. Note that, in the case of multico-integration, the least squares estimated coefficient of our I(1) variable (i.e., $G'_t = \Delta Y_t$ or $R_t = \Delta X_t$) is super consistent, and that of

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4 Appendix A fully describes the derivation of Equation (5).
I(2) variable (i.e., $X_t = \sum_{i=0}^{t} R_{t-i}$) is super-super consistent, see Haldrup (1994), Theorem 1 and Engsted et al. (1997).

The interpretation of Equation (5) is as follows: if $C_1>1$ spending, on average, outpaces revenues. Sustainability requires $C_2>1$ (or $C'_2<1$) so that revenues rise (or expenditure falls) to accommodate the rising level of debt. If $C_1<1$, revenues, on average, outpace spending. Sustainability requires $C_2<1$ (or $C'_2>1$) so that revenues fall (or expenditure rises) to accommodate the rising level of savings. These conditions ensure neither government nor private agents are involved in a Ponzi scheme or gamble. For example, if $C_1>1$ and $C_2<1$, then the government may be engaged in a Ponzi gamble requiring tax increases (or spending cut) in bad states of nature, see also Leachman et al. (2005). If $C_1=1$ the budget, on average, is balanced. Then the magnitude of $C_2$ (or $C'_2$) is no longer important for sustainability.

**B. A Model for Oil-Producing Countries**

Since Iran is an oil-producing country, we need an extra assumption in order to use Equation (5) to test the sustainability of the Iranian fiscal process. Specifically, we need to assume the Iranian reserve of oil lasts forever. This assumption is somehow artificial as Iranian oil resources, based on BP’s latest *Statistical Review of World Energy* and on the country’s current production would last only 89 years, see IRNA Report, London, June 2005. Unless we further assume that government will be able to effectively diversify revenue and/or enormously cut expenditure when oil resources are exhausted, the use of the above criteria for a sustainable fiscal process is unrealistic. Let us impose these assumptions and investigate if the fiscal policy in Iran, using Equation (5) is sustainable. If the fiscal process under these assumptions is not sustainable, then, clearly, it cannot be sustainable under more restrictive assumptions. If, on the other hand, we find the fiscal policy in Iran is sustainable, then we need also a forward-looking criteria to evaluate our result. In this case, I will extend Barro’s (1979, 1986) tax smoothing model for an energy producing country.

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5 The critical values for the cointegration ADF-test with intercept are given in Haldrup (1998) and with intercept and trends, in Engsted et al. (1997).
In Barro’s approach, the government faces the exogenous deterministic stream of real expenditures, other than interest payments, as given by $G_t$. The base of real taxable income is the deterministic amount $y_t$, which is a fixed fraction of real GDP and generally depends on the path of tax rates. In contrast to Barro’s model, I assume GDP to be also a function of energy (oil and gas) income of the country, i.e., $y_t = f[e^{\text{EN}_t}, M_t]$, where $f$ is a fixed function, $M_t$ is a set of other factors of production and $\text{EN}_t$ is the real energy income at time $t$. Following Barro (1986), let $\tau_t$ be the average tax rate at time $t$ so that the real tax revenue is $\tau_t y_t$. However, in this model, variable $R_t$ in Equation (1) is now equal to the sum of $\tau_t y_t$ and $\text{EN}_t$. The government budget constraint, Equation (2), in a continuous form and with constant real interest rate, $r$, and when the country has the energy income, will be

$$\int_0^\infty \tau_t e^{-rt} \, dt + \int_0^m \text{EN} e^{-rt} \, dt \mid I_t] = \int_0^\infty G t e^{-rt} \, dt \mid I_t] + D_0.$$  

(6)

Note that the time when the country energy resources will be exhausted is assumed to be known at $t=m$ and $D_0$ is the outstanding debt at $t=0$. The model, contrary to Barro’s model is also stochastic, but similar to his model, is based on a Ramsey’s (1969)-type optimal-taxation perspective. Specifically, it is assumed the allocative effects from taxation depend on the average marginal tax rate ($\tau^m_t$) for each period. In other words, it is assumed people’s incentive to work, produce and consume at time $t$ depends on the average tax rate. In such an environment, the tax rate depends on the state of the economy at each period. Following Barro (1986), I assume that the government plans for equal average marginal tax rates in each period. Furthermore, the average marginal tax rate for any period has a time invariant and stable relationship with that period’s average tax rate, $\tau_t$, so that the stabilization of average marginal tax rates entails the stabilization of average tax rates. Similar to Barro (1986), let $\tau$ denote the constant value of the average tax rate. Substitute $\tau$ for $\tau_t$ in (6) to get

$$\tau = \left[ \frac{\int_0^\infty G t e^{-rt} \, dt - \int_0^m \text{EN} e^{-rt} \, dt \mid I_t] + D_0}{\int_0^\infty y t e^{-rt} \, dt \mid I_t]} \right].$$  

(7)

Note that, only for the sake of simplicity, it is assumed that the real interest rate is constant as none of the following analyses would change if we replace constant $r$ by $r_t$. 

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6 Note that, only for the sake of simplicity, it is assumed that the real interest rate is constant as none of the following analyses would change if we replace constant $r$ by $r_t$. 

Similar to Barro, but in a non-deterministic economy, assume the real government expenditure, $G_t$, and the real tax base $y_t$ are expected to fluctuate around trend values that grow at the common rate $n$ so that the time paths $G^*_t = G^*_0 e^{-nt}$ and $y^*_t = y^*_0 e^{-nt}$. This implies that $G^*_t$ and $y^*_t$ have the same expected present values as the actual time paths $G_t$ and $y_t$. These assumptions, as mentioned by Barro (1986), rule out any drift in the ratio of the government expenditure and real GDP. Then the current normal values, $G^*_0$ and $y^*_0$, satisfy the conditions:

$$G^*_0 = (r-n) \mathbb{E}[\int_0^\infty G_t e^{-rt} dt | I]$$

(8)

$$y^*_0 = (r-n) \mathbb{E}[\int_0^\infty y_t e^{-rt} dt | I]$$

(9)

I also assume the expected present value of the energy income is the current value of the energy income, i.e.,

$$\mathbb{E}N_t = \mathbb{E}[\int_0^m EN_t e^{-rt} dt | I_t].$$

(10)

This means that the government and private agents expect the energy revenue to stay at the current level for the remaining life of the resources. Substituting (8), (9) and (10) in (7) yields:

$$\tau = [G^*_t + (r-n) D_{t-1} - (r-n) \mathbb{E}N_t] / y^*.$$

(11)

Equation (11) is similar to the stabilized average tax rate of Barro (1986), except that here we have an extra term which accounts for the (expected present value of) energy income. As this income goes up, the average tax rate will fall. For countries like Saudi Arabia or Kuwait where EN relative to $y^*$ is large, $\tau$ is equal to zero or negative (i.e., $\tau$ is the average subsidy rate). Let $S$ be the primary real surplus. Then, we can write

$$S_t = \tau y_t + \mathbb{E}N_t - G_t - r D_{t-1} = [G^*_t + (r-n) D_{t-1} - (r-n) \mathbb{E}N_t] y_t / y^* + \mathbb{E}N_t - G_t - r D_{t-1}.$$  

After rearranging terms this expression becomes:

$$S_t = -n D_{t-1} - [G^*_t + (r-n) D_{t-1}] (1 - y_t / y^*) - (G_t - G^*_t) + \mathbb{E}N_t [1 - (r-n) y_t / y^*].$$

(12)

7 Over the long run, this drift would be subject to the bound $0 < G/y < 1$.

8 $S_t = -(G_t - G^*_t) - G^*_t (1 - y_t / y^*) - r D_{t-1} (1 - y_t / y^*) + n D_{t-1} (1 - y_t / y^*) - n D_{t-1} + \mathbb{E}N_t [1 - (r-n) y_t / y^*]$

$$= -(G_t - G^*_t) - [G^*_t + (r-n) D_{t-1}] (1 - y_t / y^*) - n D_{t-1} + \mathbb{E}N_t [1 - (r-n) y_t / y^*].$$
For empirical purposes, let us divide both sides of (12) by GDP and then we can write
\[ s_t = \alpha_0 + \alpha_1 d_t + \alpha_2 \text{YVAR}_t + \alpha_3 \text{GVAR}_t + \alpha_4 \text{ENERGY}_t + \varepsilon_t, \]  
(13)
where \( s \) is the primary surplus, excluding interest payments, per GDP at the end of the period, \( d \) is the outstanding government debt per GDP (or \( y \)) at the beginning of the period, \( \text{YVAR}_t = (1-y_t/y^*) (G^*/y_t) \), \( \text{GVAR}_t = (G_t-G^*)/y_t \), \( \text{ENERGY}_t = \text{EN}_t/y_t \) and \( \varepsilon \) is an error term. Following Barro (1986), I assume \((r-n)D_{t-1}\) relative to the size of the government expenditure is empirically too small, which can be ignored. I also assume this is true for \((r-n) y_t/y^* \). The temporary government spending is measured by \((G_t-G^*)\) and the temporary shortfall of output is measured by \((1-y_t/y^*)\). Note that variables can be measured in either real or nominal terms since price cancels out in ratios.

Everything else being constant, considering equations (11) and (12), the outstanding real debt increases at the rate of \( n \), which is the trend growth rate of the economy. If debt did not grow (\( S \) did not fall) with the economy, interest payments would fall over time relative to GNP. This result would be inconsistent with stabilizing the average tax rate. Hence, as debt grows, from Equation (11), the optimum-welfare average tax rate \( \tau \) should increase which leads to a rise in revenues (surplus). Consequently, the sustainability of fiscal processes requires a positive relationship between primary surplus and the outstanding debt, i.e., \( \alpha_1 \) should be positive. To evaluate the sustainability of U.S. fiscal processes, Bohn (1998) also uses this relationship when \( \text{EN}_t \) is zero.

Everything else being equal, the coefficients of \( \text{YVAR}, \text{GVAR} \) and \( \text{ENERGY} \) reflect the behavior of the government in different situations. As for the coefficient of \( \text{YVAR}_t \), when \( y_t/y^*<1 \), the output is below normal and tax revenues fall in proportion to the fall in output. Debt will rise (surplus will fall) implying \( \alpha_2<0 \). However, when tax rates are stabilized over time, the coefficient of the countercyclical variable \( \text{YVAR}_t \) will be unity. Alternatively, if the government were to set relatively low tax rates during recessions, then it would have to increase tax rates during the expansion to respond to deficit, then \( \alpha_2 \) would be more than 1 in the absolute value term.

The coefficient of temporary abnormal government expenditure mostly depends on unusual cases, like wars or when the government has to increase expenditure above normal. The surplus will fall (or debt will increase) when \( G>G^* \) as Equation (12)
indicates. In these cases, the government avoids increasing taxes to deal with the rise of
debt. This means a negative unitary coefficient on GVAR\textsubscript{t} variable in Equation (13)
indicates that the government desires to equalize tax rates during war/unusual-time and
peace/normal-time periods. If, alternatively, tax rates positively change with variable
GVAR\textsubscript{t}, the coefficient on this variable would be less than one in the absolute value term,
i.e., |\alpha_3|<1.

Again, other things being equal, as oil and gas revenue increases, surplus/debt
will increase/fall if the government acts responsively by using the income to reduce the
debt and/or invest it for future generations. Consequently, \alpha_4 \geq 1 indicates a fully
responsible fiscal policy. Note also that since we assumed \( y_t = f[e^{EN_t}, M_t] \) the tax revenue
will also increase through a rise in GDP if energy revenue is used responsibly to create
capital. Specifically, if the government considers energy revenues as a temporary income,
invests them for future generations and only spends the return on that investment, then
\alpha_4 > 1 since the revenue will also go up through the GDP-effect of energy income. The
coefficient of \alpha_4 \leq 0 reflects that all energy revenue is allocated to government spending,
implying an irresponsible policy. Furthermore, if \alpha_4 < 0, spending rises more than the
energy revenue in anticipation of future energy or tax revenues (a Ponzi game), implying
an even more irresponsible policy.

IV. Sustainability Test Results

The model is tested on the data of our two emerging countries: Iran (1970-2003)
and Turkey (1967-2001). Table 1 reports augmented Dickey-Fuller (ADF) and Phillips-
Perron non-parametric (PP) test results as well as multicointegration test results for each
country for both a linear and a quadratic time trend. The ADF statistics for the presence
of a unit root allows a drift and trend in each series. According to these results, both G’
and R are homogenous of degree one. I also used Zivot and Andrews’ (1992) unit-root
test which allows for unknown breaks in intercept and slopes. The test results were
consistent with those of ADF’s and PP’s, but for the sake of brevity these results are not
reported, but are available upon request. As for the multicointegration test, according to
the ADF test result, reported in the last column of the table, government spending and
revenues are not multicointegrated for any of these countries. Consequently, the
conventional cointegration test between spending and revenues implied by Equation (14), provided $\beta_1=1$, should be used for checking the sustainability of fiscal processes in these countries.

$$G'_t = \beta_0 + \beta_1 R_t + z_t,$$  \hspace{1cm} (14)

where $\beta$’s are coefficients and $z_t$ is, as before, the error term.

According to Hakkio and Rush (1991) cointegration between two non-stationary variables $G'$ and $R$ is a necessary condition for the government to obey its present value budget constraint, provided $\beta_1=1$. However, Quintos (1995) shows that, in the context of Equation (14), the fiscal process is strongly sustainable if two non-stationary variables, $G'$ and $R$, are cointegrated and $\beta_1=1$, and it is weakly sustainable if, beside the cointegration condition, we also have $\beta_1>1$. However, Quintos (1995) argues that government cannot continue over the long run to spend more than its revenues as eventually it will not be able to market its debt. Therefore, the weak sustainability condition is problematic for the government. Hakkio and Rush (1991, p. 433) also show the condition $\beta_1>1$, although it is “consistent with a strict interpretation of the government’s intertemporal budget constraint, it is inconsistent with the requirement that debt to GNP (debt per capita) must be finite and hence may be inconsistent with the government’s ability to market its debt.” Following Hakkio and Rush (1991) we consider a cointegration relationship between $G'$ and $R$ and $\beta_1=1$ as two necessary conditions for the sustainability of the fiscal process.

Table 2 reports the results of these tests. However, it should be noted that, as it was shown by Gregory and Hansen (1996), the power of ADF test in rejecting the null of no cointegration will fall sharply in the presence of a regime shift. It is possible that the government changes its fiscal policy according to some circumstances, e.g., wars, recessions, etc. Consequently, I also reported in Table 2 Gregory and Hansen’s (1996) augmented Dickey-Fuller test (ADF*) when there is a possibility of an unknown break point. ADF* is the Dickey-Fuller statistics at its lowest value where there is a possibility of break. If this statistics rejects the null of no cointegration even with a regime shift, then we will conclude that a long-run relationship between government spending and revenues exists and, therefore, the fiscal process of the country may be sustainable in a non-stochastic environment. Then to verify if sustainability also exists in a stochastic
environment we need to conduct Granger and Lee’s (1990) two-stage multicointegration test to ensure debt and revenues/spending are also cointegrated. This is due to the fact that the ADF statistics for our multicointegration test may also have a low power in rejecting the null of no cointegration. In this case, we need to test if the error term in Equation (15) or (16) is I(0), where $S_z_t = \sum_{i=0}^{t} z_{t-i}$, $z$ being the error term from Equation (14), $\alpha$’s and $\delta$’s are parameters and $u_t$ and $\varepsilon_t$ are the error terms.

$$S_z_t = \alpha_0 + \alpha_1 R_t + u_t, \quad (15)$$

$$S_z_t = \delta_0 + \delta_1 G’_t + \varepsilon_t, \quad (16)$$

Tables 1 and 2 about here

A. Iran

Since spending and revenues are not multicointegrated (see Table 1), the fiscal process in Iran is unsustainable in a stochastic environment. According to the conventional ADF as well as ADF* test results for Iran reported in Table 2, government spending and revenues are not cointegrated over the whole sample as well as sub-sample periods. This result implies that the fiscal process in Iran, an energy producing country, is not sustainable in the sense that the government spending and revenues do not move together over the long run even in a non-stochastic environment. These fiscal variables can deviate from each other without any market force or government action to bring them back together.

Iran has witnessed several changes in policy regimes and undergone numerous exogenous shocks during the past two and a half decades. These changes include the oil price shock in 1975, the revolution of April 1979, the first formal U.S. sanctions against Iran ordered by President Carter in April 1980, following the break in diplomatic relations between the two countries, the Iraq-Iran war over the period 1980-88, the unification of official and market foreign exchange rates in 1993, the increase in the limit for the travelers during 1995 and 2000, the inflation targeting in the period 1996-98, and the introduction of the first privately own financial institution after the revolution in September 1997.

These changes could easily affect both government revenues and spending in Iran. The results given in Table 2 clearly entail these shocks. The first break is in 1975 when
the oil price brought a positive shock to revenues. The second break is associated with the revolution, U.S sanctions, more oil price shocks and the war of 1980-88 which happened all during the same period. To ensure the lack of cointegration is not due to these breaks, I used the modified Trace test developed in Johansen and Juselius (1992), which allows for structural breaks, discussed in Johansen et al. (2000), to test the cointegration relationship between G’ and R. Specifically, allowing for the structural breaks in 1975 and 1980 and also letting the short-run dynamics of the system to be affected by all policy regime changes which could only affect the short-run dynamics of the system (see previous paragraph on these changes), again I did not find any cointegration relationship between G’ and R implying that the Iranian fiscal policy is not sustainable in a non-stochastic environment.⁹

The above result is not, of course, surprising for an energy producing country like Iran and since, to the best of my knowledge, there is no study of this sort on the fiscal sustainability of any energy producing country, the finding itself is a contribution to this literature. Specifically, finding no cointegration relationship between government spending and revenues is due to the fact the country can simply sell its oil and pay its debt without resorting to printing money or imposing taxes.

Furthermore, it is possible that spending and revenues move together, without causing each other, as the country sells oil to finance its expenditure in excess of its tax revenues. These two facts explain the lack of no cointegration relationship between revenues and spending. The oil price and world demand for oil determine most of the revenues of the country while spending is determined by the size of the government. In fact, these two fiscal variables in Iran are independent. Specifically, in estimating changes of real spending on its lagged value and a lagged value of changes in real revenue, a Wald test of 0.14 with p-value of 0.70 cannot reject that the changes in government spending cause the changes in spending. At the same time, a Wald test of 2.37 with p-value 0.13 also cannot reject the null hypothesis that changes in real revenues do not Granger cause changes in spending. Furthermore, a Wald test of 0.01 with p-value of 0.93 cannot reject the null hypothesis that changes in real government spending do not

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⁹ The result was obtained using CATS in RATS, Version 2 [Dennis (2006)]. However, for the sake of brevity, it is not reported, but available upon request.
Granger cause changes in real revenues and a Wald test of 0.60 with \( p \)-value of 0.54 also cannot reject the null hypothesis that changes in revenues are not affected by their lagged values. This evidence clearly indicates that government revenues and spending are independent from each other. In sum, from the above evidence, we can clearly conclude that the fiscal process in Iran is unsustainable.

The above results were based on the assumption that Iran’s energy resources are expected to last forever or the Iranian government will be able to effectively diversify revenue and/or enormously cut expenditure when oil resources are exhausted. Under these somehow artificial assumptions, we found the fiscal process in Iran is not sustainable. To avoid the artificial assumptions made above, I will use the tax smoothing model (13), which is relevant for an energy producing country to further investigate the sustainability of the fiscal process in Iran. Moreover, with this model, I can investigate how responsible the government is in spending energy income.

For normal or trend GDP, i.e, \( y^* \) [see Equation (13) and the definition of \( \text{YVAR} \)] and government expenditures, i.e. \( G^* \) [see Equation (13) and the definition of \( \text{GVAR} \)], I used a 10-year moving average, as both of these series are available from 1960. I used ADF, PP, Zivot and Andrews’ (1992) and Perron’s (1997) unit tests to investigate the stationarity properties of the variables in Equation (13). While Zivot and Andrews’ (1992) test allows for an unknown break in the intercept, Perron’s (1997) test allows for the unknown break in both the slope and the intercept. According to ADF and PP, the variables \( s \) (surplus per GDP), \( d \) (outstanding debt per GDP) and \( \text{GVAR} \) are homogeneous of degree one. However, according to Zivot and Andrews’ (1992) test result, these variables are homogeneous of degree 2 and according to Perron’s (1997) unit test result they are stationary. Resorting to visual (graphical) inspection, these variables seem to have a unit root. I, consequently, assume these variables are homogeneous of degree one.

The variable \( \text{YVAR} \) has a unit root according to ADF and PP test results. However, it is stationary according to both Zivot and Andrews’ (1992) and Perron’s (1997) test results. I, therefore, assume it is a stationary series. The variable \( \text{ENERGY} \) is homogeneous of degree one according to ADF and PP test results, and has two unit roots according to Zivot and Andrews’ (1992) test results. However, according
to Perron’s (1997) test result, ENERGY has a unit root. Using visual inspection, I assume it is homogeneous of degree one.\textsuperscript{10}

Assuming variables $YVAR_t$, $GVAR_t$ and $ENERGY_t$ are weakly exogenous in Equation (13), I, as before in the paper, used the modified Trace test which allows for structural breaks, discussed in Johansen \textit{et al.} (2000), to check if variables $s_t$ and $d_t$, conditional on the weakly exogenous variables $YVAR_t$, $GVAR_t$ and $ENERGY_t$, are cointegrated. The structural breaks as before are in 1987 and 1989 while the short-run dynamics of the system is allowed to be affected by policy regime changes (explained before in this paper) which could influence the short-run coefficients. However, only the dummy variable Zero (=1 since 1984 and=0, otherwise), which accounts for the introduction of zero interest rate in 1984, was found to be statistically significant. I used the Lagrange Multiplier (LM) testing procedure to ensure that the lag profiles used in the tests are sufficiently long to yield residuals which are not autocorrelated.

The critical values, using the procedure in CATS in RATS Version 2, with 2500 replications, are simulated. According to both LM(1) test (Chi-squared=3.28, $p$-value=0.51) and LM (4) test (Chi-squared=1.43, $p$-value=0.84), a lag length of one year was sufficient to guarantee the lack of autocorrelation. The normality test (Chi-squared=9.07, $p$-value=0.06) also indicates that the error term is distributed normally. I also adjusted the resulting Trace test statistics to correct for potential finite-sample biases, Cheung and Lai (1993). The correction factor $[(N-kp)/N]$ was 0.9375, where $N$ is the number of observations, $k$ is the number of lag lengths and $p$ is the number of endogenous variables. The Trace test result (87.43>48.22) rejects $r$ (cointegration rank)=$0$ at 5% level and the Trace test result (13.90<24.59) cannot reject $r \leq 1$, implying that $r=1$. Consequently, we can conclude the primary surplus and debt, both per GDP, and conditional on the temporary shortfall of output ($YVAR$) and the temporary government spending ($GVAR$) as well as the energy income per GDP ($ENERGY$), are cointegrated. The long-run relationship, normalized on the primary surplus per GDP, is given in Equation (17), where $t$-statistics is given below each coefficient.\textsuperscript{11}

\textsuperscript{10} For the sake of brevity the test results are not reported, but they are available upon request.

\textsuperscript{11} Note that $d_t$ is the debt at the beginning of the year divided by the current GDP while $s_t$ is the current surplus per current GDP. Therefore, $s_t$ should adjust to $d_t$ and not vice versa. This means that, although
\[
s_t = -0.13 - 0.07 d_t - 0.52 YVAR_t + 0.14 GVAR_t + 0.03 \text{ENERGY}_t
\]

\begin{align*}
(t\text{-stat.}) & \quad (-6.16) \quad (-5.28) \quad (-2.51) \quad (0.82) \quad (0.63) \\
& \quad -0.04 \text{Break87} + 0.03 \text{Break89} \quad (17) \\
(t\text{-stat.}) & \quad (-3.79) \quad (2.99)
\end{align*}

The estimated coefficient of debt variable is negative and highly significant, implying that over the long run the optimum-welfare average tax rate will not increase as the debt per GDP rises. This result is an indication of an unsustainable fiscal process in Iran. An estimated negative and highly significant coefficient for the cyclical variable YVAR indicates a strong counter-cyclical behavior of deficits in Iran. Specifically, the evidence suggests that, on average, the government increases its expenditure during recessions as well as tax rates or reduces government expenditure during the expansion to respond to deficit, i.e., a Keynesian prescription. This result contradicts the finding of Talvi and Vegh (2005) who find that the fiscal policy in developing countries is highly procyclical although they did not include Iran in their study.

The estimated coefficient of temporary government abnormal expenditure GVAR is positive, but statistically insignificant. The estimated coefficient of variable ENERGY (oil and gas income per GDP) is positive, but is statistically insignificant. A positive, but both statistically and economically \((0.03<1)\) insignificant coefficient for ENERGY indicates that the energy income is not used for investment and debt reduction, implying an irresponsible fiscal policy in Iran. In sum, this section provides evidence that the fiscal policy in Iran is unsustainable and irresponsible in terms of energy income.

**B. Turkey**

According to the result given in Table 1, the fiscal process in Turkey is unsustainable in a stochastic environment. However, the conventional ADF test results for Turkey reported in Table 2 indicate that government spending and revenues are cointegrated over the whole sample period. Furthermore, as the result of ADF* statistics indicate, there are breaks in 1973 and 1986. Note that again, as it was found by Gregory
and Hansen (1996), the power of ADF test in rejecting the null of no cointegration will fall sharply in the presence of a regime shift. Despite this fact, the conventional ADF test result rejects the null of no cointegration for Turkey. We can, therefore, conclude that government spending and revenues are cointegrated over the whole sample period. However, the estimated long-run coefficient $\beta$ is more than one implying that although spending and revenues share a long-run equilibrium relationship, that relationship is characterized by persistently higher spending relative to revenues. In other words, deficits and debt accumulation have been the norm in Turkey.

Note that the existence of a cointegration relationship between the levels of government spending and revenues indicates that valid error correction models (ECM) exist. To ensure the ECM is not misspecified and the result in Table 1 (the lack of multicointegration) is not due to structural breaks, I also conducted Granger and Lee’s (1990) two-stage test. The result is reported in the last four rows of the second panel of Table 2 for Turkey. As we can see, both conventional ADF and ADF* reject the null of multicointegration. Finding that the lack of multicointegration is not due to structural breaks, we should note that during the sample period there is a policy regime change which clearly could influence the fiscal process in Turkey over the short run. In 1984, the government introduced a value-added tax to replace the previous unwieldy system of production taxes. To incorporate the impact of this policy regime change, I constructed dummy variable $v_{tax}=1$ since 1984 and $=0$, otherwise.

In the first round of the estimation of ECMs, I found the error-correction term was not statistically significant in any equation. This could be due to the structural breaks in the long-run relationship over the entire period. Note that we found a strong cointegrating relationship between our fiscal variables for Turkey as the conventional ADF (with its low power due to structural breaks) test result rejects the null of no cointegration. But, we may need to consider three error-correction terms for our three sub-sample periods which were determined by ADF* test results. Table 3 reports the ECM for both changes in spending and revenues for Turkey. The specification test results reported in the table suggest that the estimated equations are statistically adequate. According to Hansen’s (1992) stability $L_1$ and $L_2$ tests results, all of the coefficients, individually and jointly with the variance of the estimation, are stable.
The variables EC67-73, EC74-86 and EC87-01 are error correction terms associated with the long-run relationship for periods 1967-73, 1974-86 and 1987-2001, respectively. The coefficient of all of these error terms is negative for the change in spending, but is statistically significant only for the 1974-86 period indicating that spending tends to adjust to divergences from the equilibrium relationship. This result is consistent with Barro’s (1979) tax-smoothing argument and is confirmed by Telatar et al. (2004) who find the intention of the Turkish government for the sustainability of the fiscal process changed in the 1980-2004 period. As for the error correcting term for the change in revenues, none of the coefficient is statistically significant. Finally, the estimated coefficient of vtax is positive for both the change in government expenditure and revenues but is only statistically significant for the change in government expenditure. This implies that while revenues did not systematically respond to this policy regime change, government spending has been increased. The overall result of this policy regime change was a higher deficit and perhaps an accumulation of debt in the country. In sum, it was found, in this section, that the fiscal process in Turkey may not be sustainable even in a non-stochastic environment, and deficit and debt accumulation have been the norm.

V. Implications and Conclusions

In this paper, a richer set of criteria under the more realistic assumption that the discount factor is variable through time for assessing the sustainability of fiscal budgeting practices is used. The multicointegration of government spending and revenues is used to test for the sustainability of the fiscal process in a stochastic environment. It has been shown in this literature [i.e., Leachman et al. (2005)] that the multicointegration condition is more appropriate for the sustainability test of the fiscal policy as it implies that both the levels and rates of change of the series are tied together over the long run. I also developed and used a model which provides criteria for the sustainability of the fiscal policy in an energy producing country and for a responsible fiscal policy when exhaustible resources are involved. I then applied the sustainability criteria to the fiscal system of Iran.
As it is common in this literature, our results confirm that intertemporal budgeting strategies vary from one country to another. Neither country exhibits the multicointegration of its system of fiscal variables. In Iran, the fiscal budgeting process is unsustainable in both a stochastic and a non-stochastic environment. Furthermore, deficits and debt accumulation are the norm in the country’s fiscal processes and the policy response is inappropriate given the budget situation. The evidence in this paper suggests that the government spending and revenues in Iran are independent. Furthermore, if these two fiscal variables move together, they do not cause each other.

In general, it was shown that the government of Iran sets on average relatively low tax rates during recessions and increases tax rates during the expansion to respond to deficit. Furthermore, the government does not desire to equalize tax rates during war/unusual-time and peace/normal-time periods. It was found that the Iranian fiscal policy, as far as oil and gas income is concerned, is not a fully responsible fiscal policy.

In Turkey, the fiscal budgeting process is unsustainable in a stochastic environment, but government spending and revenues are cointegrated. However, deficits and debt accumulation have been the norm in Turkey. The introduction of the value-added tax in 1984 resulted in a rise in revenues, but not significantly. However, the government spending in response to this policy regime change has been increased, implying the policy regime change generated a higher deficit and perhaps the accumulation of debt in Turkey.
Appendix: Multicointegration

To demonstrate formally the multicointegration formula [Equation (5)], let us follow Leachman et al. (2005) and assume $G'_t$ and $R_t$ are cointegrated with the long-run parameter set $(1, -1)$. Then the government’s response policy will be determined by the standard common factor representations of $G'_t = AW_t + x_{1t}$ and $R_t = W_t + y_{1t}$, where $A$ is equal to one by assumption, $W_t$ is $I(1)$ and both $x_{1t}$ and $y_{1t}$ are $I(0)$ processes. $W_t$ may be thought of as a state variable, which summarizes economic conditions at time $t$. Since $G'_t$ and $R_t$ are cointegrated they have $W_t$ as a component. Furthermore, in order for $\Delta W_t$ to be cointegrated with $G'_t (or R_t)$, it is necessary for this variable to have $\Delta W_t$ as a component, see Granger and Lee (1990). In other words, sustainability exists if, at time $t$, government spending and revenues as well as outstanding government debt depend on the same information variable. This will occur if full decompositions are $G'_t=W_t+\alpha_1 \Delta W_t+x_{2t}$ and $R_t=W_t+\alpha_2 \Delta W_t+y_{2t}$, where $x_{2t}$ and $y_{2t}$ are both $I(-1)$ and since $A=1$, it was dropped. Furthermore, these two decompositions should give $D_t= CW_t+\Delta^{-1} x_{2t} - \Delta^{-1} y_{2t}$, where $C=\alpha_1-\alpha_2 \neq 0$, $\Delta^{-1} x_{2t} - \Delta^{-1} y_{2t}$ is $I(0)$ and $\Delta^{-1}$ is the accumulation of $I(-1)$ variables. It follows that:

$$R_t - C^{-1} D_t = Z_t \sim I(0),$$  \hspace{1cm} (A1)

Note that the same relationship holds for $G'_t$ and $D_t$. In general, for $G'_t$ and $R_t$ to be multicointegrated we need first:

$$G'_t - R_t = z_t \sim I(0),$$  \hspace{1cm} (A2)

and then (A1) will be satisfied. Since $G'_t$, $R_t$ and $D_t$ are generated based on the same information, it is possible to show the error correction models (ECMs) associated with each system of (A1) or (A2) include both $Z_t$ and $z_t$, see Granger and Lee (1990). Otherwise, the error correction equations will be misspecified. Thus, if $G'$ and $R$ are multicointegrated, they may be considered to be generated by an ECM of the form:

$$\Delta G'_t = \rho_1 z_{t-1} + \rho_2 Z_{t-1} + \text{lagged}(\Delta G'_t, \Delta R_t) + \text{white noise residual},$$  \hspace{1cm} (A3)

$$\Delta R_t = \eta_1 z_{t-1} + \eta_2 Z_{t-1} + \text{lagged}(\Delta G'_t, \Delta R_t) + \text{white noise residual},$$  \hspace{1cm} (A4)

which is estimated by OLS and the significance of $\rho$’s and $\eta$’s can be tested using standard $t$-tests.
As an alternative test for multicointegration, one can follow the one-step process of Engsted et al. (1997), Haldrup (1998) as well as Engsted and Haldrup (1999). To obtain the one-step test of multicointegration, substitute for $D_t$ in (A1) to get:

$$R_t - C^{-1} \left[ \sum_{i=0}^{t} G'_{t-i} - \sum_{i=0}^{t} R_{t-i} \right] = R_t - C^{-1} Y_t + C^{-1} X_t \sim I(0), \quad (A5)$$

where $Y_t = \sum_{i=0}^{t} G'_{t-i} \sim I(2)$, and $X_t = \sum_{i=0}^{t} R_{t-i} \sim I(2)$. Noting that $\Delta X_t = R_t$ we will have:

$$Y_t = X_t + C \Delta X_t + e_t, \text{ where } e_t \sim I(0).$$

We can also replace $\Delta X_t$ by $\Delta Y_t$. If $e_t$ is not $I(0)$, then multicointegration does not exist. In such a case, one can test for the cointegration relationship between expenditures and revenues. If a cointegration relationship exists, then the corresponding error-correction model for $\Delta G_t$ or $\Delta R_t$ will not be misspecified.

The basic one-step test procedure for sustainability is to consider $Y_t = X_t + C \Delta Y_t + e_t$, and check if $e_t \sim I(0)$, but since each series may potentially have a drift, it is necessary to include deterministic components like a linear and/or quadratic trend in the auxiliary regression. Furthermore, as mentioned by Engsted et al. (1997), when a drift is absent in the series, it is sufficient to include a time trend to account for the initial conditions. In sum, our one-step test for the sustainability of fiscal processes in a stochastic environment is to run OLS on the following equation:

$$Y_t = C_0 + C_1 X_t + C_2 \Delta X_t \quad \text{or} \quad C_2' \Delta Y_t + C_3 \text{ trend} + C_4 \text{ trend}^2 + e_t \quad (A6)$$
References


Fiscal Process in Iran

Figure 1: Spending, Revenues and Energy Income - All in Real

Figure 2: Per GDP Outstanding Debt and Monetary Base

Figure 3: Per GDP Outstanding Debt and Energy Income

Figure 4: Per GDP Monetary Base and Surplus
Fiscal Process in Turkey

Figure 5: Real Government Revenues and Expenditures

Figure 6: Per GDP Outstanding Debt and Surplus

Figure 7: Per GDP Outstanding Debt and Monetary Base

Figure 8: Per GDP Monetary Base and Surplus
Table 1: Unit Root Tests and Multicointegration

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF τ-Stat(k)</th>
<th>PP Z-Stat(k)</th>
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<td>-2.36 (0)</td>
<td>3.47⁺(4)</td>
<td>86018</td>
</tr>
<tr>
<td>R</td>
<td>0.36 (0)</td>
<td>0.82 (4)</td>
<td>85300</td>
</tr>
<tr>
<td>ΔG'</td>
<td>-5.38⁺(0)</td>
<td>-5.71⁺(4)</td>
<td></td>
</tr>
<tr>
<td>ΔR</td>
<td>-4.84⁺(1)</td>
<td>-7.41⁺(4)</td>
<td></td>
</tr>
</tbody>
</table>

1. G' and R are real government spending, including interest payments, and real revenues, respectively. Δ before a variable means its first differences.
2. All tests include constant and trend, and k is the optimal lag length, which was determined by the minimum of AIC and SC. The critical values for augmented Dickey-Fuller (ADF) τ test [for N=112, is -2.88 at 5% and -3.46 at 1%], [for N=34 is -2.93 at 5% and -3.58 at 1%], and for Phillips-Perron non-parametric (PP) Z test (window size = 4) [for N=112, is -2.88 at 5% and -3.45 at 1%, [for N=34, is -2.95 at 5% and -3.63 at 1%].
3. Yₜ = C₀ + C₁ Xₜ + C₂ ΔXₜ + C₃ trend + C₄ (trend)² + eₜ, where Yₜ = ∑₀ i Gᵢt-i ~ I(2), and Xₜ = ∑₀ i R_i t_i ~ I(2). The t-values are not shown as the e’s are far from the white noise.
4. The null hypothesis: Residuals are I(1), i.e., all I(2) variables in the model cointegrate into an I(1) relation. The alternative hypothesis: Residuals are I(0) indicating multicointegration. The critical values are from Engsted et al. (1997), Table 1, where for N=100 these values are: -4.26 for 5% and -4.85 for 1%, for N=25 they are –4.71 for 5% and –5.60 for 1%.
a=Significant at 1%. b=Significant at 5%.

Table 2: Residual-Based Cointegration Tests with Regime Shift on Intercept and Slope

<table>
<thead>
<tr>
<th>Country</th>
<th>Sample Period</th>
<th>β₀</th>
<th>β₁</th>
<th>DW</th>
<th>ADF² (k)</th>
<th>ADF*² (k)-Break</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
<td>1970-2003</td>
<td>0.91</td>
<td>0.82</td>
<td>0.82</td>
<td>-2.69 (0)</td>
<td>-4.45 (0) - 75</td>
</tr>
<tr>
<td></td>
<td>1976-2003</td>
<td>0.98</td>
<td>0.83</td>
<td>0.83</td>
<td>-2.63 (0)</td>
<td>-4.53 (0) - 80</td>
</tr>
<tr>
<td></td>
<td>1981-2003</td>
<td>0.87</td>
<td>0.72</td>
<td>0.72</td>
<td>-2.57 (0)</td>
<td>-3.60 (0) - 87</td>
</tr>
<tr>
<td>Turkey</td>
<td>1967-2001</td>
<td>1.47</td>
<td>1.41</td>
<td>1.41</td>
<td>-3.87 (0)</td>
<td>-4.84 (0) - 73</td>
</tr>
<tr>
<td></td>
<td>1972-2001</td>
<td>1.55</td>
<td>1.80</td>
<td>1.80</td>
<td>-4.51 (0)</td>
<td>-5.38 (0) - 86</td>
</tr>
<tr>
<td></td>
<td>1967-2001</td>
<td>-0.45</td>
<td>0.36</td>
<td>0.36</td>
<td>-0.90 (0)</td>
<td>-3.56 (1) - 78</td>
</tr>
<tr>
<td></td>
<td>1972-2001</td>
<td>-0.28</td>
<td>0.47</td>
<td>0.47</td>
<td>-1.10 (0)</td>
<td>-3.17 (1) - 79</td>
</tr>
</tbody>
</table>

1. G' = β₀ + β₁ R₁ + z₀, where G' is real government spending, including interest payments, R is real revenues and z is the error term. Sz = α₀ + α₁ R₁ + u₁ and Szt = δ₀ + δ₁ G'₁ + e₁, where Szt = ∑₀ i zᵢt-i, zᵢ and eᵢ are error terms.
2. ADF is the conventional augmented Dickey-Fuller test statistics and k is the optimal lag length, which was determined by the minimum of AIC, as well as SC. The critical value for ADF τ test is -2.88 at 5% and -3.46 at 1%.
3. ADF* is Gregory and Hansen’s (1996) smallest value of t-statistics of ADF. The critical value, when break is on the intercept and slope is -4.95 at 5% and -5.60 at 1%.
a=Significant at 1%. b=Significant at 5%.
Table 3: Error Correction Model for Turkey

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$\Delta G'$</th>
<th>$\Delta R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Coef. (SE)</td>
<td>Lₜ (p)</td>
</tr>
<tr>
<td>constant</td>
<td>47.31 (7.355)</td>
<td>1.00</td>
</tr>
<tr>
<td>$\Delta R_{t-1}$</td>
<td>-0.51 (0.37)</td>
<td>1.00</td>
</tr>
<tr>
<td>$\Delta G'_{t-1}$</td>
<td>0.21 (0.32)</td>
<td>1.00</td>
</tr>
<tr>
<td>EC67-73</td>
<td>-1.12 (13.02)</td>
<td>1.00</td>
</tr>
<tr>
<td>EC74-86</td>
<td>-1.22 (0.51)</td>
<td>1.00</td>
</tr>
<tr>
<td>EC87-01</td>
<td>-0.73 (0.46)</td>
<td>1.00</td>
</tr>
<tr>
<td>vtax</td>
<td>23358 (10754)</td>
<td>0.14</td>
</tr>
<tr>
<td>variance</td>
<td>-</td>
<td>0.18</td>
</tr>
<tr>
<td>joint-test $L_c$</td>
<td>-</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specification</th>
<th>$p$-value</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R bar squared</td>
<td>0.13</td>
<td>0.05</td>
</tr>
<tr>
<td>DW</td>
<td>2.07</td>
<td>2.23</td>
</tr>
<tr>
<td>Godfrey(5)</td>
<td>0.93</td>
<td>0.24</td>
</tr>
<tr>
<td>White</td>
<td>19.58</td>
<td>21.52</td>
</tr>
<tr>
<td>ARCH(5)</td>
<td>4.38</td>
<td>3.68</td>
</tr>
<tr>
<td>RESET</td>
<td>0.13</td>
<td>0.55</td>
</tr>
<tr>
<td>Normality</td>
<td>0.76</td>
<td>2.97</td>
</tr>
</tbody>
</table>

1. The sample period is 1967-2001. $\Delta$ means the first difference, $G'$ is real government spending, including interest payments, $R$ is real government revenues. EC67-73, EC74-86 and EC87-01 are the error-correction terms generated from the long-run relationship for periods 1967-73, 1974-86 and 1987-2001, respectively. Dummy variable vtax is equal to 1 since 1984 and to zero, otherwise. White is White’s (1980) general test for heteroskedasticity, ARCH is the five-order Engle’s (1982) test, Godfrey is the five-order Godfrey’s (1978) test, REST is Ramsey’s (1969) misspecification test, Normality is Jarque and Bera’s (1987) normality statistics, $L_c$ is Hansen’s (1992) stability test for the null hypothesis that the estimated coefficient or variance of the error term is constant and $L_c$ is Hansen’s (1992) stability test for the null hypothesis that the estimated coefficients as well as the error variance are jointly constant.

2. The estimation method is OLS.