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The Optimal Tax Rate and Efficiency of Government in Selected Lower-Middle and Upper-Middle-Income Countries and Members of the OIC: Stochastic Metafrontier Approach

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Abstract

In the last two decades, some economists have provided a model for obtaining the optimal tax rate to maximize economic growth. Aiming to contribute to these studies, this work presents a new approach for the determination of the optimal tax rate based on a stochastic metafrontier analysis. To this end, the meta technical efficiency (MTE), group's technical efficiency (TE), technology gap ratio (TGR), and optimal tax rate (OTR) were determined for the period 1996-2018 in a selection of member countries of the Organization of Islamic Cooperation (Group A), lower-middle-income (Group B) and upper-middle-income (Group C). It was found that Group A has the maximum average values of MTE, TE, and TGR, while most countries in Group B have the minimum average MTE. The results demonstrated that Russia enjoys the highest average values of MTE, TE, and TGR, and can be considered as the reference for the countries in Group C. Finally, it was concluded that with 90% statistical confidence, the average real tax rates in Iran and Kuwait are less than the balanced budget OTR during the studied period. The emphasis on increasing tax rates to maximize economic growth and the improvement in the efficiency of these governments seems necessary.

Highlights

- A new approach to determine the optimal tax rate based on a stochastic metafrontier analysis was presented.
- OIC countries have the maximum average values of MTE, TE, and TGR.
- Lower-middle-income countries have the minimum average MTE.
- The average real tax rates in Iran are less than the balanced budget OTR.

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1. Introduction

In the last two decades, the economists' and policymakers' viewpoints have been focused on taxation and its spending with the aim of economic growth and the welfare of societies. In this regard, some researchers (Barro, 1989, 1990, 1991; Lucas, 1988; Romer, 1986, 1990) introduced a new theory of endogenous growth with an emphasis on the role of government which is focused on the endogeneity of growth rate in both transaction and stability conditions.

Barro (1991) pointed to the role of governments in growth theory following this viewpoint that although governments may reduce economic growth due to financing government expenditure by collecting more taxes, at the same time they can increase it through the positive influence of R&D, economic infrastructures, education and health expenditures on the marginal productivity of production inputs. This viewpoint emphasizes the fact that the endogenous growth theory could not ignore the negative and positive effects of the government's economic activities on the growth process. Regarding Barro's view, the tradeoff between government expenditure and economic growth is non-monotonic. Because when the public sector is highly large, the reducing effect of a rise in taxation on growth is more than the increasing effect of expensing it and conversely.

Chao and Grubel (1998) stated that some parts of government expenditures will decelerate economic growth by reducing the effective labor supply and investment. These parts of government expenditures may have discouraging effects on the individuals' and agents' economical life and vary their economical behaviors by decreasing their risk components. Also, Scully (1996, 2000, 2003, 2006) found out that excessive increases in public expenditure negatively affect economic growth. King and Rebelo (1990), Rebelo (1991), Chusseau and Hellier (2008), Forte and Magazzino (2011), and Akhtar et al. (2018) determined the optimal government size and tax rate to maximize economic growth using the BARS Curve (the curve relates the size of government to the rate of economic growth). It was found that high Gross Domestic Product (GDP) countries have overcome the government size level compatible with GDP growth rate maximization.

On the other hand, using a panel threshold regression model, Akram and Rath (2020) pointed that government size positively and significantly affect economic growth for both aggregate and sub-panels based on income and region. Similar results were reported for the Middle East and North African countries (Asghari et al., 2014). Divino et al. (2020) employed a theoretical approach to explore optimal relations between government size, public spending, and economic growth for the Brazilian states. It was concluded that the average tax burden is below the estimated optimal level, indicating more space to increase the tax rate without sacrificing economic growth. The study of Kavese and Phiri (2020) differs from the previous researches in two respects. Firstly, they distinguished between revenue-maximizing and growth-maximizing OTRs. Secondly, they considered optimal tax estimates for six sub-categories of tax rates employed by South African authorities. The results indicated that while fiscal authorities have implemented revenue-maximizing tax policies during economic recession, they shift towards growth-maximizing tax rate policy during the expansion period.

According to the above literature, many researchers have discussed the government role in economic growth. The main question is that what is the government role through the composition of government expenditure or government consumption and taxes on long-term economic growth.

While the above standard econometric methods for determining the optimal tax rate used are based on the technical efficient behavior assumption (i.e. moving on the frontier of production), the inefficiency in the behavior of economic agents can violate this assumption. The effect of government economic behavior on the production process may be analyzed by using the stochastic frontier production in which government economic variables can be substituted by private sector input to evaluate the government efficiency and determine the optimal tax rate (OTR) i.e., growth-maximizing. Therefore, the stochastic frontier analysis can be significantly better than standard estimation methods to determine the OTR, especially among countries willing to integrate (such as Islamic countries).

The aim of the present work is to determine the meta technical efficiency (MTE), group's technical efficiency (TE), technology gap ratio (TGR), optimal tax rate (OTR), and relationships between them in selected lower-middle and upper-middle-income countries and members of the Organization of Islamic Cooperation (OIC) for the period 1996-2018. Although these relationships have been studied by many researchers, in this study a new approach is proposed to determine the OTR based on a stochastic metafrontier analysis. Additionally, although most of these countries are rich in natural resources, however, adequate means have not been channeled in them toward institutional reforms. To this end, the analytical framework is introduced in Section 2 in two subsections. Section 2.1 is allocated to generalize the Scully production function and section 2.2 refers to the estimation method based on stochastic metafrontier analysis. Data description and model estimation and statistical analysis are explained in Sections 3 and 4. Finally, Section 5 concludes the paper.

2. Framework

2.1 The Growth Maximizing Tax Rate

Consider the aggregate production function of an economy as a Cobb-Douglas form (Eq. 1):

$$Y_t = A_t L_t^a K_t^b \tag{1}$$

where Y_t, L_t and K_t denote GDP, labor force, and private capital stocks in period t, respectively and A is exogenous technical progress in the form $A_t = Ae^{\omega t}$.

Based on the studies of Barro (1990) and Scully (1995), if the ratio of disposal income (YD) to private capital stocks (K_t) is assumed as a monotonic function of the ratio of government expenditure (G) to private capital stocks (Eq. 2):

$$\frac{YD_t}{K_t} = \zeta \left(\frac{G_t}{K_t}\right)^{\theta} \qquad with \quad \zeta, \theta > 0 \tag{2}$$

Therefore, private capital stocks are:

$$K_t = \lambda Y D_t^{\phi} G_t^{1-\phi} \qquad with \quad \lambda = \zeta^{-\frac{1}{1-\phi}} \quad and \quad \phi = \frac{1}{1-\theta} \tag{3}$$

Considering $YD_t = (1-\tau_t)Y_t$ and replacing Eq. 3 in Eq. 1, the logarithm of the production function is:

$$\ln Y_t = \Omega + a \ln L_t + \beta \ln(1-\tau_t) + \delta \ln G_t + \omega t \tag{4}$$

where $\Omega = \left(\frac{1}{1-\phi b}\right) \ln\left(A\lambda^{\beta}\right), a = \frac{1}{1-\phi b}, \beta = \frac{\phi b}{1-\phi b}, \delta = \frac{(1-\phi)b}{1-\phi b}$ and τ is the average tax rate[1].

Considering government expenditure is equal to the sum of government tax revenue $(\tau_t Y_t)$ and other government revenue[2] (OR_t), the maximizing condition of GDP with respect to tax rate is as Eq. 5:

$$\frac{d \ln Y_t}{d\tau_t} = \left(\frac{d \ln Y_t}{d \ln(1-\tau_t)}\right)\left(\frac{d \ln(1-\tau_t)}{d\tau_t}\right) + \left(\frac{d \ln Y_t}{d \ln G_t}\right)\left(\frac{d \ln(\tau_t Y_t - OR_t)}{d\tau_t}\right)$$
$$= -\frac{\beta}{1-\tau_t} + \frac{\delta Y_t}{G_t} \tag{5}$$

And finally, the optimal tax rate is calculated as Eq. 6[3]:

$$\tau_t^* = \frac{\delta - \beta\left(\frac{OR_t}{Y_t}\right)}{\beta + \delta} \tag{6}$$

2.2 Econometric Model

Firms[4] in different situations are faced with various production opportunities. In these conditions, entrepreneurs choose different technology sets to change the available combinations of input-output sets. Changes in these technology sets will be affected by changes in the labor force, human capital, economic infractions, existing natural resources, and social-economic conditions that are usually altered by taxation and government spending. Therefore, measuring the technical efficiencies of firms in various groups must be estimated in separate frontier technology sets. However, the comparison of measured efficiency levels subjected to different frontiers is generally impossible because one frontier cannot be compared to another one.

Metafrontier production function was first introduced by Hayami (1969), and Hayami and Ruttan (1970) and then developed by Battese and Rao (2002), Battese et al. (2004), and O'Donnell et al. (2008). Metafrontier production is based on the idea that producers in various production groups have potential

[1] This production presents either direct effects of government taxation on GDP or indirect effects of government expenditure (from labor force) on GDP.

[2] Including budget deficit items, foreign aids etc.

[3] The optimal tax rate in the balanced budget condition $OR_t = 0$ is constant (i.e. $\tau_t^* = \frac{\delta}{\beta+\delta}$).

[4] In this study, total of an economy is considered as one firm.

access to a set of technologies, but each may choose a particular technology, depending on specific circumstances mentioned above. This method provides the possibility of comparing the technical efficiencies among firms in a single industry in which there are different technology sets. The technology gap (meta technology) ratio is considered as a measure for making this comparison. The frontier of an unrestricted technology set is defined as a common frontier, hence restricted technologies sets are considered as groups frontiers.

Since the metafrontier curve envelopes all groups' frontiers, measured efficiency with respect to this metafrontier can be divided into two terms. The first term is due to general technical efficiency and calculates the distance of input-output to its group frontier. The second one measures the distance between the group frontier and that metafrontier which is corresponding to restricted characteristics of production technologies.

Based on the studies of Battese and Rao (2002), Battese et al. (2004), and Karthick et al. (2015) it is assumed that the stochastic frontier of a frontier production model in K groups is as Eq. 7:

$$Y_{it}^{m} = f(X_{it}, \beta^{m}) \exp(v_{it}^{m} - u_{it}^{m}) = e^{X_{it}\beta^{m} + v_{it}^{m} - u_{it}^{m}} \tag{7}$$

Where Y_{it}^{m} is the product of i_{th} firm existing in m_{th} group, X_{it} is inputs vector used by i_{th} firm existing in m_{th} group, β^{m} is unknown parameter vector due to m_{th} group, v_{it}^{m} is traditional disturbance term of i_{th} firm existing in m_{th} group with a normal distribution (i.e., $v_{it}^{m} = IN\left(0, \sigma_{v^m}^{2}\right)$), u_{it}^{m} is the inefficiency term of i_{th} firm existing in m_{th} group with normal distribution truncated in zero which has average μ_{i}^{m} and variance $\sigma_{u^m}^{2}$ and t is time subscript.

As proposed by Battese and Coelli (1995), u_{it}^{m} is defined in the appropriate inefficiency model[1] and technical efficiency of i_{th} firm subjected to the frontier of m_{th} group in period t will be:

$$TE_{it}^{m} = \frac{Y_{it}^{m}}{e^{X_{it}\beta^{m} + v_{it}^{m}}} = e^{-u_{it}^{m}} \tag{8}$$

Also, as proposed by O'Donnell et al. (2008), the stochastic metafrontier production function for all firms can be presented as Eq. 9:

$$Y_{it}^{*} = f(X_{it}, \beta^{*}) = e^{X_{it}\beta^{*}} \tag{9}$$

where Y_{it}^{*} is metafrontier production in period t and β^{*} is the vector of metafrontier parameters that must satisfy the following restriction (Eq. 10):

$$X_{it}\beta^{*} \geq X_{it}, \beta^{m} \qquad for\ all \qquad m = 1, 2, \ldots, M \tag{10}$$

This restriction satisfies that the metafrontier function cannot stay below any group's function. Therefore, an estimated metafrontier function (as the Envelop curve of estimated groups functions curves) can be obtained by solving the above restricted optimizing problem.

Now, Eq. 8 can be presented in a different form by using Eq. 10:

[1] In this study, the inefficiency is considered as time varying model in the form of $u_{it}^{m} = -\eta^{m}(T - t)u_{i}^{m}$, where η^{m} is unknown parameter of m_{th} group, T is period of end, t is consideration period and u_{i}^{m} is average inefficiency of i_{th} firm existing in m_{th} group.

$$Y_{it}^{m} = e^{-u_{it}^{m}} \times \frac{e^{X_{it}^{m}\beta^{m}}}{e^{X_{it}^{m}\beta^{*}}} \times e^{X_{it}\beta^{*}+v_{it}^{m}} \tag{11}$$

Where $e^{-u_{it}^{m}}$ is the technical efficiency subject to the frontier of m_{th} group (group's technical efficiency) for i_{th} firm in a period of t and the second term shows the technology gap ratio (TGR):

$$TGR_{it}^{m} = \frac{e^{X_{it}^{m}\beta^{m}}}{e^{X_{it}^{m}\beta^{*}}} \qquad where \quad 0 \leq TGR \leq 1 \tag{12}$$

TGR_{it}^{m} is defined as the ratio of i_{th} firm product in the frontier production function of m_{th} group to the potential product measured by the metafrontier function in a period of t. The gap between group frontier and metafrontier is reduced when its value tends to one.

Finally, meta technical efficiency (*MTE*) of i_{th} firm in t_{th} period is given by Eq. 13:

$$MTE_{it} = \frac{Y_{it}}{e^{X_{it}\beta^{*}+v_{it}^{m}}} \tag{13}$$

Or by considering Eq. 12, the estimated metafrontier technical efficiency is:

$$\widehat{MTE}_{it} == \widehat{TE}_{it}^{m} \times \widehat{TGR}_{it}^{m} \tag{14}$$

3. Data Description

This study uses the World Bank database to provide GDP[1] and government expenditure[2] data (both in billion dollars, PPP exchange rate, and constant price of 2011), the number of employment[3] (in million persons), and the average rate of tax for 32 selected countries during 1996-2018. Although most of these countries are rich in natural resources, however, adequate means have not been channeled in them toward institutional reforms. Due to the heterogeneity in these countries, they have been used in the following three country groups:

i) **Member Countries of the Organization of Islamic Cooperation** as Group A, including Albania, Azerbaijan, Egypt, Morocco, Malaysia, Turkey, Bangladesh, Indonesia, Kuwait, Jordan, Lebanon, and Iran.

ii) **Lower-middle-income Countries** as Group B, including Ukraine, El Salvador, Ghana, Honduras, India, Moldavia, and the Philippines.

iii) **Upper-middle-income Countries** as Group C, including Argentina, Belarus, Peru, Bulgaria, Costa Rica, Mauritius, Russia, Romania, South Africa, Jamaica, Brazil, Thailand, and Guatemala.

4. Results

A summary of aggregate statistical criteria of the variables studied in the considered three groups of countries is given in Table 1. The differences in these statistics indicate differences in the characteristics of these three groups.

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[1] This variable is obtained by dividing GDP (in current price) by the consumer price index.

[2] This variable is calculated by multiplying the ratio of government expenditure in GDP by GDP.

[3] This variable is derived by multiplying the employment rate by the number of workers.

Table 1. Summary statistics of variables for all groups (World Bank, 1996-2018)

Group	**Statistic**	**GDP**	**Real Tax Rate**	**Government Expenditure**	**Employment**	**Number of Countries**	**Number of Observations**
A	Mean	523.1631	0.132191	129.3998	29471.60	12	276
	Standard Deviation	595.1491	0.056960	196.7452	40552.76		
B	Mean	789.5445	0.143116	131.6987	104065.6	7	161
	Standard Deviation	1733.207	0.030564	267.0691	215435.1		
C	Mean	634.9425	0.161178	157.4376	25561.96	13	299
	Standard Deviation	930.1554	0.045520	252.6328	32984.01		

***Source**: Research findings*

Log-likelihood ratio test based on the logarithm of maximum likelihood results of the estimation models under the null and alternative hypothesis was used to determine the structure of inefficiencies distribution and select the appropriate estimation method between the pooled model of three groups of countries and the metafrontier model. The results of testing these assumptions are presented in Table 2.

Table 2. Composite hypothesis test related to the parameters of γ, μ, η

H_0	H_1	$\sum_{i=1}^{3} \log L(H_0)$	$\sum_{i=1}^{3} \log L(H_1)$	LR statistics	Result test
$\gamma = \mu = \eta = 0$	$\gamma \neq 0, \mu = \eta = 0$	235.803	565.353	659.1	H_0 reject
$\gamma \neq 0, \mu = \eta = 0$	$\gamma, \mu, \eta \neq 0$	565.353	619.656	108.606	H_0 reject
$\gamma \neq 0, \mu = \eta = 0$	$\gamma, \eta \neq 0, \mu = 0$	565.353	620.206	109.706	H_0 reject
$\gamma, \mu \neq 0, \eta = 0$	$\gamma, \mu, \eta \neq 0$	557.385	619.656	124.36	H_0 reject

***Source**: Research findings*

From the results of the first test, the LR statistical calculated value of the likelihood ratio test (=659.1) is larger than the critical value of x^2 statistical with 3 degrees of freedom. Therefore, it is evident that the traditional average production in the three groups of countries is not an adequate representation of the data (i.e. the null hypothesis lack of stochastic frontier production function is rejected). Furthermore, the results of other hypothesis tests point to the half-normal distribution and its variation over time for inefficiencies components in accordance with the model of Battese and Coelli (1992) is as[1]:

$$u_{it} = \{\exp[-\eta(t - T)]\} u_i \tag{15}$$

[1] Note: Because, for three groups countries in 5 % level of error, the null hypothesis $\eta = 0$ is rejected in every condition and the null hypothesis $\mu = 0$ (restricted to $\gamma, \eta \neq 0$) is not rejected.

Since the LR (=416.296) statistical calculated value of the likelihood ratio test reported in Table 3 is larger than the critical value of x^2 statistical with 14 degrees of freedom in one percent level of error, the hypothesis of identical technology between the group's stochastic frontier models is rejected. Therefore, due to the impossibility of applying the pooled model, one needs to employ the metafrontier model to determine the efficiency of the governments in the three groups of countries.

Table 3. The likelihood ratio test for selection of the model estimation technique

Null Hypothesis	$\log L(pooled)$	$\sum_{i=1}^{3} \log L(H_1)$	LR statistics	Result test
Polled Model is true	411.508	619.656	416.296	H_0 reject

***Source**: Research findings*

Based on the selected structure of inefficiency distribution and the method of estimation resulting from hypothesis testing in Tables 2 and 3, the maximum likelihood estimation results of a stochastic frontier production function for an individual and pooled model of the three groups studied countries, together with their metafrontier function by using linear programming method are shown in Table 4.

Table 4. Estimations of group frontiers, pooled frontier, and metafrontier production

variable	**coefficient**	**Group A**	**Group B**	**Group C**	**Pooled**	**Metafrontier**
constant	Ω	1.2101 (0.91)	-5.9557 (-4.04)	-1.1553 (-0.67)	-7.1946 (-7.35)	0.3012 (0.1)
Ln(emp)	α	0.5345 (24.24)	0.2424 (2.59)	0.1994 (2.34)	0.5389 (1.87)	0.4727 (5.28)
Ln(G)	δ	0.2432 (9.7)	0.3364 (8.55)	0.5466 (9.61)	0.4439 (1.77)	0.1793 (3.7)
Ln(1-t)	β	-0.2172 (-0.7)	1.8934 (6.81)	0.7391 (3.84)	1.4242 (3.47)	0.224 (0.32)
t	ω	0.0042 (1.46)	0.0334 (10.24)	0.0013 (0.28)	-0.0069 (-0.48)	0.0268 (3.82)
	σ^2	0.4909 (2.48)	3.1448 (1.46)	0.5839 (1.01)	0.106 (0.4)	
	γ	0.9718 (82.49)	0.9979 (669.120)	0.9904 (98.84)	0.8426 (1.03)	
	η	0.0243 (8.65)	-0.0053 (-3.77)	0.0095 (1.61)	0.041 (0.76)	
Log Likelihood		163.609	148.832	307.765	399.384	

***Source**: Research findings*

These results emphasize that most of the production function coefficients in each of the three countries group's frontiers are statistically significant in a one percent level of errors[1]. In both groups of lower-middle and upper-middle-income countries (Groups B and C), 99 % of the variance of the estimated error component belongs to the inefficiency and this amount in OIC countries (Group A) equals 97 %. Statistical significance of the estimated values at the significant level of 5 % together with their signs indicate an increase in the average group's technical efficiency of a government in Groups A and C and a decrease in the average efficiency in Group B during the studied period. On the other hand, the estimated results show that both the coefficients of the employment and the government expenditure variables in the metafrontier production function have positive signs and are statistically significant in less than the level of one percent errors[2].

The calculated average values of TGR, group's TE, and MTE are reported in Tables 5 and 6. Based on these results, the highest average value of these three indicators are allocated to countries in Group A with 0.8219, 0.6041, and 0.3773, respectively, and the lowest is devoted to group C (with 0.5418) and B (with 0.3045 and 0.2096). Also, Moldavia has the highest average technology gap, and Russia has the maximum average values of each of the three calculated indicators. Guatemala and Moldavia respectively have the minimum average of technology gap ratio and group's technical efficiency and the minimum average of meta technical efficiency belongs to countries in Group B including Honduras, Ghana, and Moldavia.

As is observed in Table 5, the countries with a technology gap of 1, are fully placed on the metafrontier production function and other countries must be compared with them. For example, Russia and Turkey in 1999 and 1998, respectively have a technology gap of 1.

The average values of actual tax rates ($real\,\tau$) together with the estimated metafrontier optimal tax rates values ($meta\,\tau$) and the lower bounder of 90% confidence level of $meta\,\tau$ ($L\,meta\,\tau$)[3] for all countries are calculated by replacing the estimated coefficients of the metafrontier production function and considering both average of government revenue ratio (OR/y) and also balance budget condition in Eq. 6 and are reported in Table 6.

Table 5. Annual average of estimated TGR, TE, and MTE

year	Group A			Group B			Group C		
	TGR	TE	MTE	TGR	TE	MTE	TGR	TE	MTE
1996	0.8219	0.4591	0.3773	0.6264	0.3347	0.2096	0.7093	0.4943	0.3506
1997	0.8046	0.4656	0.3747	0.6181	0.3332	0.2060	0.7084	0.4971	0.3521
1998	0.7924	0.4722	0.3742	0.6087	0.3318	0.2020	0.7014	0.4999	0.3507
1999	0.7730	0.4789	0.3702	0.6135	0.3304	0.2027	0.6978	0.5027	0.3508
2000	0.7599	0.4855	0.3689	0.6239	0.3290	0.2053	0.6862	0.5055	0.3469

[1] All of them, except for the coefficient of tax rate variable in OIC countries.
[2] The bootstrapping method was used to calculate the standard deviation of the coefficients of this function. This technique was built by creating a random sample with 1000 members (of 1000 cycles), with mean and covariance matrix of the group's stochastic frontier production function estimated coefficients for each of the three groups of countries.
[3] By using the lower bound and the upper bound 90% confidence range, the coefficients δ and β are calculated, respectively.

Table 5 (Continued). Annual average of estimated TGR, TE, and MTE

2001	0.7430	0.4921	0.3656	0.6305	0.3276	0.2066	0.6670	0.5084	0.3391
2002	0.7277	0.4988	0.3630	0.6459	0.3262	0.2107	0.6641	0.5112	0.3395
2003	0.7148	0.5055	0.3613	0.6501	0.3248	0.2112	0.6622	0.5140	0.3403
2004	0.7022	0.5121	0.3596	0.6483	0.3234	0.2097	0.6523	0.5168	0.3371
2005	0.6925	0.5188	0.3593	0.6560	0.3221	0.2113	0.6374	0.5196	0.3312
2006	0.6846	0.5255	0.3598	0.6515	0.3207	0.2089	0.6288	0.5224	0.3284
2007	0.6766	0.5321	0.3601	0.6595	0.3193	0.2106	0.6235	0.5252	0.3274
2008	0.6650	0.5388	0.3583	0.6614	0.3179	0.2103	0.6273	0.5279	0.3312
2009	0.6563	0.5454	0.3580	0.6737	0.3166	0.2133	0.6190	0.5307	0.3285
2010	0.6402	0.5520	0.3534	0.7061	0.3152	0.2226	0.6271	0.5335	0.3346
2011	0.6227	0.5587	0.3479	0.7118	0.3138	0.2234	0.6146	0.5363	0.3296
2012	0.6125	0.5652	0.3462	0.7084	0.3125	0.2214	0.5991	0.5390	0.3229
2013	0.6000	0.5718	0.3431	0.7157	0.3111	0.2227	0.5878	0.5418	0.3185
2014	0.5878	0.5783	0.3399	0.7202	0.3098	0.2231	0.5809	0.5446	0.3164
2015	0.5773	0.5848	0.3376	0.7252	0.3085	0.2237	0.5750	0.5473	0.3147
2016	0.5650	0.5913	0.3341	0.7092	0.3071	0.2178	0.5621	0.5501	0.3092
2017	0.5541	0.5977	0.3312	0.7144	0.3058	0.2184	0.5565	0.5528	0.3076
2018	0.5428	0.6041	0.3279	0.7187	0.3045	0.2188	0.5418	0.5556	0.3010
average	0.6746	0.5319	0.3553	0.6694	0.3194	0.2135	0.6317	0.5251	0.3308
Standard Deviation	0.0838	0.0449	0.0144	0.0401	0.0093	0.0071	0.0503	0.0189	0.0147
min	0.4208	0.1441	0.3279	0.4086	0.0809	0.202	0.2944	0.2108	0.3010
max	1.0000	0.9706	0.3773	1.0000	0.969	0.2237	1.0000	0.98	0.3521
Growth rate	-0.018	0.012	-0.006	0.006	-0.004	0.001	-0.012	0.005	-0.006

***Source**: Research findings*

These results indicate that the maximum amount of $meta\ \tau$ and $real\ \tau$ tax rates belong to Bangladesh and Jamaica and the minimum of them belong to Kuwait. Although in all countries, the average annual values of actual tax rate were lower than the mean values of their optimal tax rates, with 90% confidence, it can be stated that the actual tax rate in Bangladesh, Indonesia, India, Philippines, and Guatemala is less than the optimal rate of it. However, the actual tax rate ($real\ \tau$) in comparison with the optimal tax rate of the Balanced Budget (equal to 6.83 percent) suggests that with 90% confidence, the actual tax rate in Iran and Kuwait was lower than this optimal tax rate.

Table 6. Average of estimated TGR, TE, and MTE together with real and meta optimal tax rate with 90% confidence

Group	Country	TGR	TE	MTE	$L\ meta\ \tau$ (%)	$meta\ \tau$ (%)	$real\ \tau$ (%)
A	Albania	0.5307	0.2295	0.1218	9.39	27.26	16.44
	Azerbaijan	0.5867	0.2992	0.1755	10.62	28.24	13.84
	Egypt	0.7717	0.5318	0.4104	4.1	23.01	14.35
	Morocco	0.6942	0.3247	0.2254	12.79	29.99	21.15
	Malaysia	0.7177	0.7025	0.5042	13.52	30.57	15.51
	Turkey	0.8191	0.8275	0.6778	6.98	25.32	17.02
	Bangladesh	0.6354	0.2627	0.1669	15.05	31.8	7.48
	Indonesia	0.8155	0.5823	0.4749	13.72	30.73	12.5
	Kuwait	0.6153	0.9588	0.5899	0.44	5.71	1.1
	Jordan	0.5951	0.3295	0.1961	7.14	25.45	18.38
	Lebanon	0.5756	0.3736	0.2150	4.9	23.69	14.25

Table 6 (Continued). Average of estimated TGR, TE, and MTE together with real and meta optimal tax rate with 90% confidence

	Iran	0.7386	0.9612	0.7099	4.46	15.33	6.54
B	Ukraine	0.7224	0.3320	0.2398	13.4	20.8	15.74
	El Salvador	0.7745	0.1492	0.1156	11.15	28.67	14.02
	Ghana	0.5625	0.1512	0.0851	12.08	29.42	16.14
	Honduras	0.6866	0.1127	0.0774	10.1	27.82	14.89
	India	0.4698	0.9671	0.4543	11.4	28.87	9.9
	Moldavia	0.9011	0.0936	0.0843	4.11	23.02	15.96
	Philippines	0.5693	0.4301	0.2449	14.54	31.39	13.5
C	Argentina	0.7227	0.7221	0.5219	9.011	26.95	11.32
	Belarus	0.6216	0.3589	0.2231	6.47	24.91	17.3
	Peru	0.4783	0.4900	0.2344	12.93	30.1	14.55
	Bulgaria	0.7032	0.3446	0.2423	4.14	23.04	18.51
	Costa Rica	0.5560	0.3140	0.1746	7.09	25.41	13.47
	Mauritius	0.5010	0.2826	0.1416	13.03	30.18	16.5
	Russia	0.8813	0.9778	0.8617	7.29	25.57	12.94
	Romania	0.7751	0.4707	0.3648	13.82	22.79	17.21
	South Africa	0.7695	0.5955	0.4582	11.49	28.94	22.42
	Jamaica	0.4737	0.2463	0.1167	12.62	29.85	23.35
	Brazil	0.8078	0.8101	0.6544	8.9	23.67	13.6
	Thailand	0.5557	0.7491	0.4163	14.68	31.5	15.09
	Guatemala	0.3665	0.4642	0.1701	15.02	31.78	10.52
Balance Budget τ		----	----	----	6.83	16.004	----

Source: *Research findings*

5. Concluding Remarks

According to the results, meta technical efficiency (MTE) demonstrates a slightly increasing trend just in Group B while an inverse trend was observed in other groups. Improvements in the average technology gap ratio (TGR) between countries in Group B at a higher rate than the decline in the average technical efficiencies (TE) of its group have caused a rise in the average MTE. On the other side, reducing the average TGR between countries in Groups A and C at a rate more than the increase in the average TE of their groups has caused a decrease in the average MTE of the two groups of countries.

According to the average values for the whole period, the maximum amount of the TGR, group's TE, and MTE belong to the OIC countries. This is because some Muslim countries are advancing and taking development and modernization issues more seriously as can be observed through the application of modern technologies and the development of infrastructure (Noon et al., 2018). Some of them have even attained a higher level of GDP, Gross National Income (GNI), literacy rates, and urban lifestyles like Iran (MTE=0.71), Turkey (MTE=0.68), Kuwait (MTE=0.59), and Malaysia (MTE=0.50) due to their implementation and engagement with modernization in transforming their societies from traditional to a modern one.

Since 1970, members of the OIC have pursued the aim of improving economic and commercial cooperation to enhance the economic linkages and coordination among the OIC countries and to act against the global challenges. Considerable attention has been paid to trade and significant effort has been made at OIC forums to develop ways of joint cooperative actions to raise trade among the OIC countries (Alpay et al., 2011; Elmi & Ranjbar, 2012; Zaroki & Yadollahi Otaghsara, 2021). For example, Turkey and Indonesia have achieved a TGR of 0.81.

The emphasis on increasing tax rates to maximize economic growth and the improvement in the efficiency of the governments in Iran and Kuwait seems necessary. As mentioned previously, the actual tax rate in Iran and Kuwait is lower than the optimal tax rate. Since these oil countries enjoy underground resources, it is urgent to improve their structure of earning and devote their oil income to future generations and investments. On the other hand, despite economic sanctions, the Iran government with TGR=0.73, TE=0.96, and MTE=0.7 has demonstrated acceptable performance, indicating the significance of the resistive economy.

On the other hand, the minimum values of MTE belong to lower-middle-income countries (Group B). This is attributed to poverty (high unemployment, hunger, malnutrition, lack of well-defined child welfare practice systems, and lack of access to education for sustainability).

Additionally, Russia has the maximum of three estimated indicators i.e., TGR, TE, and MTE during the studied period. The budget efficiency, structural reforms, encouragement of entrepreneurship, public administration efficiency, and welfare state modernization are among the key elements responsible for Russia’s international development at both the regional and global levels (Medvedev, 2016). Considering the above, the governments in the surveyed countries (especially upper-middle-income countries) can choose this country to improve their technological behaviors and group’s technical efficiencies as the reference country. Moreover, these countries can increase their metafrontier technical efficiency by reducing their budget deficits and moving toward a balanced budget tax rate.

Additionally, emerging countries such as Malaysia, Brazil, and Turkey have successfully shifted the focus away from poverty reduction toward stronger stress on development. For example, although Turkey has no oil reserves, however, due to foreign investment, the tourism industry, as well as its geographical location, has achieved a promising technology gap and group technical efficiency of 0.8 and can be considered as the reference for D8 and OIC countries as well as Iran as its neighbor. Moreover, emerging countries such as Malaysia, Brazil, Turkey, Thailand, South Africa, Indonesia, Morocco, Philippines, and Peru can converge to an optimal tax rate of 29.13%.

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Conceptualization, all authors; methodology, Golnaz Hadian and Sara Ghobadi; validation, Golnaz Hadian; formal analysis, all authors; writing—original draft preparation, Golnaz Hadian; writing—review and editing, all authors; supervision, Sara Ghobadi. All authors have read and agreed to the published version of the manuscript.

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