Universitat Autònoma de Barcelona

# ESSAYS ON PUBLIC SECTOR MANAGEMENT: AN INTERNATIONAL STUDY ON TAX ADMINISTRATION

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PhD in Entrepreneurship and Management (iDEM)

# Essays on Public Sector Management: An International Study on Tax Administration

Doctoral Thesis

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# ESSAYS ON PUBLIC SECTOR MANAGEMENT: AN INTERNATIONAL STUDY ON TAX ADMINISTRATION

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# DECLARATION

This Thesis is the result of my own work and includes nothing, which is the outcome of work done in collaboration except where specifically indicated in the text. It has not been previously submitted, in part or in whole, to any university of institution for any degree, diploma, or other qualification.

Signed:___________________________________________________________

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(This declaration should also make clear any parts of the work that have been submitted for any other qualification.)

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| Supervisor | Supervisor |
| (signed) | (signed) |
| Prof. Dr. Diego Prior Jiménez | Prof. Dr. Stefan Felix van Hemmen |

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# INTRODUCTION§

## Problem statement

Given the extent to which it affects our lives, we all have a concern or interest in the accomplishments of productivity and efficiency improvements in the public sector (Fox, 2013).[1] Yet, citizens are not motivated or inspired by paying taxes, most often the main source for public sector financing, nor are they particularly concerned about the efficiency of the part of the administration in charge of collecting them.

Nowadays, governments throughout the world are confronted by the vast global competition affecting new business creation and investment attraction, which is used as the major driver for tax revenue collection to finance operations, particularly under high government budget deficits. Tax administration (hereafter TA) mainly focuses on collecting tax revenues due efficiently with optimal costs for both administration and taxpayers. Tax administrations worldwide, however, are faced with significant challenges resulting from, for example, the digital age, bureaucracy, and societal trends, which all carry implications for the potential tax gap and require constant monitoring and adaptation. Accordingly, the effectiveness and efficiency of TA-related procedures will help ensure the tax compliance and enforcement. This stimulates a decline in corruption, a lower level of tax avoidance and/or evasion, small share of the informal sector and, importantly, more investment and entrepreneurship activities. In fact, efficient TA is advantageous for firms and helps reduce the administrative cost, attracting the starting and doing business. Tax administrative burden has a significant inhibiting effect on market entry: a 10% reduction in administrative burden results in a 3% increase in entry rate (Braunerhjelm and Eklund, 2014),[2] and this effect even varies over the

§ Unless indicated in the corresponding footnotes, all the citations made here are to be found in the references listed at the end of each corresponding chapter.

[1] Fox, K. J. (2003). Efficiency on the public sector, ed. by Kevin J. Fox: Dordrecht[u. a.]: Kluwer Acad. Publ., 2002. The Economic Journal.

[2] Braunerhjelm, P, & Eklund, J. E. (2014). Taxes, tax administrative burdens and new firm formation. Kyklos, 67(1), 1–11. https://doi.org/10.1111/kykl.12040.

entrepreneurial life cycle (Braunerhjelm et al., 2015).[3] Likewise, economies with simple, well-designed tax systems are able to help the growth of businesses and, ultimately, the growth of overall investment (Djankov et al., 2010).[4] Therefore, a TA needs, sufficient resources i.e. employee, budget, infrastructure, etc. to ensure good tax compliance among taxpayers. Under the constraints of limited endowed resources, the efficiency of TA in resource management is of high importance. The effectiveness of TA affects not only governments but also, in the broader scope, social welfare through administrative burdens that taxpayers incur to comply with tax obligations (Alm, 1996).[5] Thus, the understanding of determinants affecting the variation of TA and tax administration-related issues appears to be relevant to both academia and policymakers.

Under globalisation, countries all over the world have been impacted differently by their macroeconomic conditions and other random factors particular to them. Governments and policymakers require a comparison of tax systems among different countries and, consequently, the study of TA at the cross-country level is a necessary reference for Governments when designing tax policy. The panoramic view of comparable countries will provide a standard to help policy-makers to outline appropriate policies for strengthening the effectiveness and efficiency of TA and TA-related operations.

Nonetheless, in the literature, the empirical research on TA with a multiple country sample has been rather limited, generally resulting from the absence of appropriate databases. Fortunately, the recent introduction of a comparative database on TA from OECD has partially filled this gap and will now facilitate comparable analysis among countries. This was the starting point, inspiring and motivating this project as a branch of public administration and from the view of interdisciplinary research themes.

The Thesis aims to reach the following research objectives and thus answer the corresponding questions as:

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[3] Braunerhjelm, P., Eklund, J. E., & Thulin, P. (2015). Taxes , the tax administrative burden and the entrepreneurial life cycle. Swedish Entrepreneurship Forum _ WP 2015:40.

[4] Djankov, S., Ganser, T., McLiesh, C., Ramalho, R., & Shleifer, A. (2010). The effect of corporate taxes on investment and entrepreneurship. American Economic Journal: Macroeconomics, 2(3), 31-64.

[5] Alm, J. (1996). What is an" optimal" tax system?. National Tax Journal, pp.117-133.

1. To evaluate the performance of TA across countries, considering the presence of contextual variables, for two periods between 2008-2011 and 2012-2015.

    1.1. Q1. How efficient are TA entities across countries?

    1.2. Q2. Which period in which TA organisations are more efficient? And how different between these two periods?

2. To stress the value of simplifying tax system complexity, from the perspective of social costs, in order to enhance the ease of doing business, which affects new business creation and investment attraction.

    2.1. Q1. How is the performance of tax complexity simplification across countries and over time? Short-term and long-term efficiency?

    2.2. Q2. What are the rankings of these tax systems in terms of tax procedure simplification?

    2.3. Q3. How is the productivity change of these tax systems?

3. To investigate the variation of tax complexity across 88 countries and over the timespan, 2005-2016, focusing on the impact of institutional quality reflecting the governance and economic freedom.

    3.1. Q1. Does it exist the negative relationship between the institutional quality indicators and the tax complexity measure?

    3.2. Q2. Is the higher institutional quality accompanied with the better tax simplification performance?

    3.3. Q3. Does this impact vary among the alternative income groups?

## Research outline

This Thesis is organised into three chapters (Chapters 1 to 3) in accordance with three empirical papers.

*Chapter 1. Measuring tax administration efficiency using stochastic semi-nonparametric frontier approach: Evidence from a cross-country study*[6]

The chapter addresses the performance evaluation of Tax administration (TA) at a cross-country level to provide a necessary reference for governments when designing tax policy. Specifically, this research sought to shed light on TA efficiency, as related to both cost usage and enforcement. The chapter measures the efficiency of TA across 44 countries (32 OECD and 12 non-OECD countries) over the two periods between 2008-2011 and 2012-2015. This study was conducted with comparative data, extracted from the recent database on TA, the OECD TA database, versions 2013, 2015 and 2017. Under globalisation, countries all over the world have been impacted differently by both their macroeconomic conditions and other random factors particular to them. For incorporating contextual variables[7] into efficiency measures of tax general operations, this research employed the 1-DEA semi-nonparametric estimator, the StoNEZD approach (Johnson and Kuosmanen, 2011, 2012)[8] and then conducted a robustness check using the conditional order-m efficiency method (Daraio and Simar, 2005, 2007).

The estimation results generated from StoNEZD show that, in terms of general operation performance, tax agencies in these countries may increase the current level of tax revenue by about 58.7% and 34.2% on average for the two periods, respectively, while maintaining the current level of input usage. Equivalently, an extra $7,737 and $4,667 per capita (PPP) of tax revenue could be collected over the two periods, respectively. The results also indicate that the composite error term could be

[6] This chapter was published under title "Stochastic semi-nonparametric frontier approach for tax administration efficiency measure: Evidence from a cross-country study" in Economic Analysis and Policy (EAP), volume 66, June 2020, pages 137-153.

[7] Contextual variables are the additional factors that are neither inputs nor outputs, but which characterise the operating environment in which production takes place.

[8] All citations here are to be found in the list of references at the end of each corresponding chapter.

primarily caused by inefficiency (inefficiency $\sigma_u$ outweighs statistical noise $\sigma_v$). Therefore, there was the potential for these countries to improve their TA efficiency. To treat the inconsistency of data extracted from OECD Tax administration database resulting from the lack of standard treatment among countries, i.e. federal versus unitary, the estimation was also run with the alternative sample, which excludes the most decentralised countries i.e. Germany and Switzerland. Fortunately, the estimation outcomes largely hold and are consistent. The robustness check, using the conditional order-m efficiency method (similar to the StoNEZD approach), also demonstrates and consolidates the improvement of efficiency during the second period (2012 – 2015) with an increase of 12.6 % (compared to the 24.5 % increase that was generated by the StoNEZD approach).

This chapter contributes to the existing research field. Firstly, the work is, to the best of my knowledge, the first empirical paper to use the recently developed and innovative estimators to measure TA performance across multiple countries. Secondly, this study is one among only a few efforts to address the performance of TA across countries using comparative data extracted from the most recent OECD TA database. To explore any potential difference in TA efficiency in general operation during and after the financial crisis, I conducted an analysis for both periods, 2008-2011 and 2012-2015, as the year 2012 was considered to be the end of the worst part of the recession in many countries. In this sense, the study, with a sample of 44 countries (including 32 OECD countries), can be regarded to be an extension of Alm and Duncan (2014)'s research, which measured tax agency efficiency in 38 countries (including 28 OECD countries) over the 2007-2011 period. Unlike Alm and Duncan (2014)'s approach, which used three-stage estimation approach combining DEA and SFA (see also Fried et al., 2002), I employ the two aforementioned approaches to introduce exogenous variables to the TA production process. By doing so, I aimed to avoid the separability conditions as these estimators directly include the environmental factors from the obtainable set. As a further matter, this study makes the preliminary contribution towards measuring the efficiency of TA, acquired simultaneously from the views of both administrative cost and enforcement level for optimal TA, as found in Keen and Slemrod (2017).

*Chapter 2. Performance of tax simplification around the world: A panel frontier analysis*

This chapter is in line with chapter 1 for the target of measuring the performance of tax agencies at cross-country level; however, it captures another lens. While chapter 1 addresses the problem from tax system's general objective, maximising tax revenues, chapter 2 tends to minimise the operating cost.

It should be noted that the cost to be evaluated here is from the perspective of social cost instead of that of the tax system itself. It is the so-called compliance cost (or administrative burden) imposed on taxpayers when complying with tax obligations. While this cost is unavoidable, it is optimisable. Therefore, the more these resources are saved, the more the social deadweight loss is decreased.

Creating new business and attracting investment activities, which is used as the main driver for tax revenue collection to finance government operations, particularly under high budget deficits, has been increasingly intense among countries. Due to tax complexity, the ease of doing business in a specific country suffers due to the rising fixed cost and the opportunity cost of taxpayers' time. Entrepreneurs and investors, thus, feel unsatisfied and discouraged and may even forego chasing opportunity altogether when encountering highly complex tax systems. On the contrary, a simplified tax system can also eliminate unnecessary tax expenditure and relieve the economic agents of the burden of complex TA, possibly enabling the growth of businesses and, ultimately, the growth of overall investment and employment (Djankov et al., 2010). Therefore, tax simplification has drawn the concern of academia and policymakers and has gradually become the core part of tax system reform all over the world.

The chapter observes the tax competitiveness in its tax simplification dimension by covering 88 countries over the timespan 2005-2016 and employing the panel data nonparametric frontier method to provide a thorough view on tax simplification performance, measuring efficiency, ranking, and examining the productivity change of these tax systems.

I started with the meaning and measure of tax simplification in this chapter. As a multidimensional concept conveying alternative meanings depending on alternative perspectives, tax simplification (sometimes, named tax simplicity) or tax complexity as its mirror, bears many alternative definitions and measures. Among them, this work's attention is likely on the business's perspective that tax complexity refers to the time and monetary costs spent in complying with the requirements of business tax laws (Tran-Nam and Evans, 2014). Tax simplicity, thus, generally refers to administrative procedures to comply with the tax obligations and is the so-called tax compliance cost or tax administrative burden (Braunerhjelm and Eklund, 2014; Braunerhjelm et al., 2015) to the economic agents. In terms of measures, I followed Awasthi and Bayraktar (2015) and took the two sub-indicators of paying taxes (as an indicator of measuring the ease of doing business) i.e. time to comply (*taxtime*) and number of payments (*taxpay*) capturing all three taxes i.e. corporate income tax, labour tax, and consumption tax. The premise is that "the lower the time taken to comply with the tax system and the fewer the number of payments, the easier it is for business to comply with their tax paying obligations" (Awasthi and Bayraktar, 2015). These two subindicators are extracted from the Paying Taxes datasets and were also used in Lawless (2013) as a measure of tax complexity.

First, I measured the efficiency of tax system simplification using the data envelopment analysis model without explicit output (DEA-WEO). In this sense, the model includes four inputs (total *taxpay* and three *taxtime* corresponding to three taxes) and a constant virtual output of one. In addition to contemporaneous efficiency measurement, I derived the panel data DEA model (first proposed by Surroca et al., 2016, and then extended by Pérez-López et al., 2018) conditional on WEO context for the long-run analysis. The findings suggest that the tax systems' relative efficiency has been generally increased throughout the years from 2005 to 2016, with a rise in the median of 21.3%, from 31.3% to 52.6%, showing an increasing convergence of the tax simplification trend. The number of efficient units occupies around 4.5% - 10.2% of the studied sample. The time-invariant long-run performance indicates the difference among groups. The average score reached 28.7% for the full sample. Switzerland was found to be the only efficient system. Furthermore, the year-on-year evolution of time-variant performance, over the timespan 2005-2016, signifies the uptrend in tax system simplification in all the groups of countries. It also highlights the general conclusion that Norway had the most feasible practice and model (appearing 600 times in reference sets), followed by Ireland (433 times), Singapore (388 times), and Switzerland (273 times).

Second, the rankings were made using a *state-of-the-art* algorithm by Toloo and Kresta (2014). Accordingly, the top ranks belong to the expected classified countries, such as Switzerland, Singapore, New Zealand, Norway and Estonia. This reflects the mature tax systems, simplified effective administrative burden and the effective employment of electronic platform between the tax authorities and taxpayers in these advanced economies. Conversely, Brazil was found to be a typical case of tax complexity and was the bottom-ranked country for all 12 years of the period. This could be partially blamed on the country's burdensome tax compliance procedures.

Third, the measure of productivity change by Malmquist index was adapted from Karagiannis and Lovell (2016) as an attribution to the performance analysis. The averages of 27.7% and 19.6% signify the productivity progress for the 2006-2011 and 2011-2016 periods, respectively. China and the Ukraine were the most improved countries with indices of 327.4% and 318.5% for the two respective periods. These figures revealed the considerable advance in their tax systems' simplification, despite the existing poor performance, lagging behind the frontiers and being relatively inefficient during certain years.

Finally, the study contributes to the research field in certain aspects. Methodologically, the paper extends the standard panel data DEA estimator (Surroca et al., 2016 and Pérez-López et al., 2018) to apply for WEO condition. Empirically, it is the first application of panel data DEA-WEO proposal for long-run panel estimation in addition to contemporaneous analysis with cross-sectional data DEA-WEO model, to provide practical contribution results from the measuring of tax system performance. This is completed through measuring the efficiency (both contemporaneous and long-run panel data analysis), ranking, and examining the productivity change of 88 tax systems throughout the period (2005-2016), addressing the implied social costs (tax costs) incurred by the taxpayers in order to comply with taxes. This is, to the best of my knowledge, the first empirical application of tax performance measure with nonparametric frontier method conditional on the implicit output. With the synthetic assessment of combined tax burden indicators (*taxpay* and *taxtime*), the findings, including the benchmarking peers along with the assessment of efforts on tax simplification, reflect the overall level of recovery and innovation and might act as a source of reference relating to the policy implications for tax design and reform.

*Chapter 3. The impact of institutional quality on tax complexity: A global sample with panel GMM approach*

Previously, I addressed the tax system administration through the view of performance evaluation, both general operations and internal procedures. In this chapter, I further examine the variation of tax complexity across countries and over time, stressing the impact of institutional quality. As internationalisation and globalisation have intensively developed and spread all over the world, the institutional environment has become increasingly critical and has contributed to the quality of governments' operations. This study focuses on the determinants of tax complexity – the institutional variables reflecting the governance and economic freedom aspects.

As mentioned in the earlier chapter, tax complexity is known to be a multidimensional concept and is, thus, difficult to define and measure. In this chapter, tax complexity generally refers to administrative procedures followed to comply with the tax obligations and is the so-called tax compliance cost or tax administrative burden to the economic agents (Braunerhjelm and Eklund, 2014; Braunerhjelm et al. 2015). It is measured by two sub-indicators of paying taxes, time to comply (*taxtime*) and number of tax payments (*taxpay*), following Lawless (2013). This supports the premise that the lower the time taken to comply with the tax system and the fewer the number of payments, the easier it is for businesses to comply with their tax paying obligations (Awasthi and Bayraktar, 2015; Bayraktar, 2020). There are some limitations caused by the inconsistency of measures as well as the methodology and data presentation;[9] however, paying taxes indicators the only available set providing the comparative indicators of the tax complexity across countries and can be regarded as the best-suited measure of tax complexity.

It has been acknowledged that institutions shape the strategic environment in which actors fight for their interests (Hall and Taylor, 1996; Thelen and Steinmo, 1992). As argued from the public policy perspective of the institutional reform, comprehension of institutions has become the key role in understanding the policy process (Peter, 1991) and, once institutionalised, the policies can intensively

[9] See Tran-Nam and Evans (2014, p.356) and Awasthi and Bayraktar (2015, p.301) for further explanation.

shape the preferences of actors in the next iteration of the policy game (Steinmo, 2003). Therefore, tax design, at least in favour of tax complexity, needs to consider the effects of institutional quality. The variables on institutional quality were extracted from Worldwide Governance Indicators – WGI (World Bank) and Economic Freedom of the World – EFW – index (the Fraser Institute) for the governance and economic freedom indices, respectively. The former source was developed by Kaufmann, Kraay, and Mastruzzi (2011) and is "[one] of the most well-known and comprehensive studies of the institutional environment of countries" (Daniel, Cieslewicz, & Pourjalali, 2012, p. 373). Meanwhile, Gwartney and Lawson (2003) developed the latter, a quality measure of a country's institutional and policy environment. This index measures the consistency of a nation's policies and institutions with economic freedom, reflecting personal choice, voluntary exchange, freedom to compete, and protection of person and property.

Methodologically, for investigating the tax complexity determinants, the work employed the system generalised method of moments (system-GMM) for panel data regression, following Arellano and Bover (1995) and Blundell and Bond (1998). I retained the sample of 88 countries for the same timespan 2005-2016, as per Chapter 2. At one extreme, *taxtime* and *taxpay* are weakly correlated, and *taxtime* can be considered as a function of *taxpay* applications; at another extreme, the cost taxpayers incur to comply with taxes is finally the *taxtime*. It seems that the ultimate goal of tax systems is to reduce the *taxtime*. I thus opt to take *taxtime* as the main tax complexity measure to be explained.

Public governance might be defined as "the traditions and institutions by which authority in a country is exercised" (Kaufmann et al., 2011, p. 222). A country with high-quality institutional system is thought to facilitate effective public administration. Thus, once critical country characteristics are accounted for, poorer institutional quality is expected to increase tax complexity. Therefore, for the baseline model, I regressed institutional quality variables (*inst*) over *taxtime* and expected the existence of a statistically negative link between *inst* and *taxtime*. Then, in order to see if the impact varies according to the alternative levels of income, I ran the interaction terms between the institutional quality indicators and tax complexity measures. I also assumed the institutional indicators were those that were not strictly exogenous but weakly exogenous, and that they were considered as pre-determined variables. As justified, tax simplicity is the mirror of tax complexity; I believed the effort taken to simplify the tax complexity could be positively impacted by the institutional indicators. As an alternative, the slackness time to comply with taxes (*taxsk*) was also used to capture both tax complexity indicators (i.e. *taxtime* and *taxpay*). The slacks were generated from a performance evaluation measure, using Data Envelopment Analysis model without explicit output (DEA-WEO) estimations, consisting the total *taxpay* and all three components of *taxtime*.[10] It was thus expected to see the positive correlation between institutional quality (*inst)* and tax simplification efficiency, and an equivalent negative correlation between the slack of *taxtime* (*taxsk*) and institutional quality (*inst*).

The estimation results suggested, in general, that the institutional quality capturing a country's governance and economic freedom exerts a statistically negative effect on the tax complexity measure; however, this impact varies due to the specific indicators. It should be recalled that this empirical evidence appears diverse in alternative income groups. The findings are robust, justified by alternative measures of tax complexity and estimations. Accordingly, a rise in institutional quality focusing on governance and economic freedom is likely to be accompanied with a reduction in tax complexity.

The work contributes to filling the gap in the field as a cross-country empirical study, which explores the tax complexity measured by two sub-indicators of paying taxes, taking an institutional approach. The existence of a negative link between tax complexity and institutional quality was empirically supported through alternative measures of tax complexity, either the direct indicators or the indirect ones as the outcomes generated from another estimation; and alternative estimators and specifications, combining parametric and non-parametric methods.

[10] Results on *taxsk* are extracted from efficiency measure, using DEA-WEO with 4 inputs (total tax payments, time to comply with corporate income tax, time to comply with labour tax, and time to comply with consumption tax) and single constant (virtual) output (of social outcome).

# CHAPTER 1 Measuring tax administration efficiency using stochastic semi-nonparametric frontier approach: Evidence from a cross-country study♣


Abstract

Under globalisation, countries all over the world have been impacted differently by both their macroeconomic conditions and other random factors particular to them. As such, governments and policymakers require a comparison of tax systems across different countries and, consequently, a study on the performance of Tax administration (TA) at a cross-country level would be a necessary reference for governments when designing tax policy. This study seeks to measure the performance of TA across 44 countries, while considering the presence of contextual variables, using the recently developed and advanced frontier estimators, such as the semi-nonparametric StoNED (Stochastic Nonparametric Envelopment of Data) approach by Johnson and Kuosmanen (2011, 2012) and the conditional order-m (Daraio and Simar, 2005, 2007) approach, for two periods between 2008-2011 and 2012-2015. The results show that Tax agencies in these countries could have increased tax revenue, on average, by about 58.7% and 34.2% for the two periods, respectively. Equivalently, $7,737 and $4,667 PPP (purchasing power parity) per capita of tax revenue could have been increased for the two periods, respectively. It is also suggested, in general, the latter period (2012-2015) shows a higher level of efficiency than the former period (2008-2011), justified by both estimators.



*JEL classification:* C44, H21, H83, M21, M48.

*Keywords:* tax administration, efficiency analysis, contextual variable, StoNED, conditional order-m.


♣ This chapter was published under the title "Stochastic semi-nonparametric frontier approach for tax administration efficiency measure: Evidence from a cross-country study" in Economic Analysis and Policy, volume 66 (June 2020), pages 137-153.

## 1.1 Introduction

It has been widely acknowledged and asserted, in the literature, that tax administration (hereafter TA), which deals with the collecting and processing of taxes, plays an undeniably key role in any tax system, ensuring effective enforcement and compliance. This is believed to result from the universal truth that people are not motivated or inspired by paying their taxes.

TA, like other public organisations, can be viewed as a producer, "engaged in the production of different outputs by combining labour with other inputs" (Afonso et al., 2010). The problem of examining the higher efficiency unit among different TA organisations, i.e. produce more outputs with the same inputs, and the opposite – use fewer inputs to produce the same outputs when keeping other things equal – has played an important role in the field of public sector efficiency.

According to Fox (2003), the management of the public sector could affect our lives wherever we live. Thus, we all have an interest in the accomplishments of productivity and efficiency improvements in the public sector.

In reference to the public sector and services, it has been stated that, the assessment of performance and identification of the likely determinants of variation in efficiency across jurisdictions, and through time, has not only drawn much attention and concern but also motivated and inspired academics and practitioners (Fox, 2003).

Many recent papers have used non-parametric approaches for measuring comparative expenditure efficiency across countries, notably Data Envelopment Analysis (DEA). This has been completed by converting inputs into outputs for a Decision-Making Unit (DMU) that might include non-profit or public organisations, such as hospitals, universities, local authorities or countries (Afonso et al., 2010).

Since the introduction of DEA by Charnes, Cooper and Rhodes (1978) (also known as CCR, 1978), for measuring the relative efficiency of each DMU using a mathematical programming approach, studies in the efficiency field have been increasingly prevalent. The staggering amount of papers having been produced is around 236,000, 11,384 and 6,842 studies found in Google scholar, Scopus and Web of Science, respectively (searched on April 20th, 2019, for the previous 31-year period including 1978-2019).

In a narrower view of TA performance, the existing literature on efficiency in TA also covers Bahl (1971), Bird et al. (2008), and Keen (2013)[11], among others, who discussed tax efficiency through various other approaches, i.e. regression, tax effort's conventional model, C-efficiency[12] indicator, etc. Furthermore, other articles examine efficiency in TA through the application of DEA or DEA-relevant methods. These studies include Thanassoulis et al. (1987), Jha and Sahni (1997), Thirtle et al. (2000), Maekawa and Atoda (2001), Jiménez and Barrilao (2001), Esteller-Moré (2003), Barros (2005, 2007), Katharaki and Tsakas (2010), Barrilao-González and Villar-Rubio (2013), among others. More recently, the literature acknowledges the studies of Ruy and Lee (2013), Katharaki and Tsakas (2010), and Førsund et al. (2015). The above-mentioned studies have generally considered a specific country as the unit of analysis. An exception to this is the work of Alm and Duncan (2014), estimating the efficiency of tax agencies in 28 OECD countries for the years 2007-2011, and Savić et al. (2015), analysing the performance of TA and its effect on tax evasion in 13 European countries. The lack of comparative data on TA renders the conducting of research on this subject, across various countries, to be rather impracticable.

My paper aims at extending the existing literature on efficiency in TA. Specifically, I seek to shed light on TA efficiency, as related to both cost usage and enforcement.[13] I estimate the relative efficiency of TA in terms of general operation, i.e. tax revenue collection in a cross-country context using a considerable sample of OECD and other advanced and emerging countries, addressing the impacts of environmental factors, i.e. the additional factors that are neither inputs nor outputs, but which characterise the operating environment in which production takes place. Taking advantage of comparable data on TA across countries and using the most recent data extracted from OECD TA

[11] Bahl (1971) measured tax effort and compared inter-country tax effort. Bird et al. (2008) dealt with tax effort's conventional model in terms of showing the impact of demand factors i.e. corruption, voice and accountability beside the supply factors. Keen (2013) estimated the efficiency of VAT (value added tax) using "C-efficiency".

[12] "C-efficiency" is an indicator of the departure of the VAT from a perfectly enforced tax levied at a uniform rate on all consumption.

[13] See Keen and Slemrod (2017), equation (9) for more details on optimal TA.

database, I will examine the potential difference in TA performance, during and after the financial crisis, through two periods 2008-2011 and 2012-2015. Incorporating the contextual variables into measuring the tax efficiency, I have adopted the recently developed frontier estimators, namely, the 1-DEA semi-nonparametric estimator i.e. StoNEZD approach (Johnson and Kuosmanen, 2011, 2012) and the conditional order-m efficiency method (Daraio and Simar, 2005, 2007). On the one hand, StoNEZD is a promising alternative, especially in noisy scenarios, to the "oldies" – SFA and DEA (Andor and Hesse, 2014; Kuosmanen et al., 2013). On the other hand, the conditional nonparametric methods show the obvious outperformance, when compared with the traditional alternatives, such as the one-stage approach and two-stage approach (Cordero et al, 2016).

This study contributes to the existing research field. Firstly, the paper uses the recently developed and innovative estimators, i.e. the StoNEZD approach and conditional order-m for estimating the performance of tax agencies across countries. This is, to the best of my knowledge, the first empirical paper to use these methods for measuring the TA performance across countries. Secondly, this study is the one among the few efforts to address the performance of TA across countries using comparative data extracted from the most recent OECD TA database. For exploring any potential difference in TA efficiency in general operation during and after the financial crisis, I will conduct the analysis for both periods including 2008-2011 and 2012-2015, as the year 2012 was considered to be the end of the worst part of the recession in many countries. In this sense, my paper, with a sample of 44 countries (including 32 OECD countries), can be regarded to be an extension of Alm and Duncan (2014)'s research, which measures tax agency efficiency in 38 countries (including 28 OECD countries) over the 2007-2011 period. Unlike Alm and Duncan (2014)'s approach, using three-stage estimation approach combining DEA and SFA (see also Fried et al., 2002), this paper employs the StoNEZD approach as the main method and then conducts a robustness check using the conditional efficiency method to introduce exogenous variables to the TA production process. By doing so, I may avoid the separability conditions, as these estimators directly include the environmental factors from the obtainable set. As a further matter, this study makes the preliminary contribution to measuring the efficiency of TA, acquired simultaneously from the views of both administrative cost and enforcement level for optimal TA, as found in Keen and Slemrod (2017).

The paper is structured as follows. In section 1.2, I briefly review the related literature on efficiency in TA. Section 1.3 refers to the theoretical background, while section 1.4 relates the empirical estimation methodology. Section 1.5 describes the data collection and the sample used in the research. Section 1.6 will analyse the efficiency of TA with different frontier estimators. Section 1.7 of the paper will address the conclusions of the study and their implications for public policymakers.

## 1.2 Related literature

Welfare policies are designed to compensate social unbalances in economic development, especially in times of commercial (globalisation) and industrial (the fourth industrial revolution) transition. Faced with hard budget constraints and robust public deficits, productivity accomplishments and efficiency improvements in the public sector have become indispensable goals across all welfare states. Non-parametric approaches have been used for measuring comparative expenditure efficiency across countries, such as DEA through converting inputs into outputs for DMUs that might include non-profit or public organisations, such as hospitals, universities, local authorities or countries (Afonso et al., 2010).

In the context of TA, we find numerous papers using a variety of approaches to estimate tax efficiency. Bahl (1971) used a regression approach to estimate tax effort and compare inter-country tax effort. This was extended in more recent papers including Bird et al. (2008), which dealt with tax effort's conventional model in terms of showing the impact of demand factors i.e. corruption, voice and accountability beside the supply factors. Keen (2013) estimated the efficiency of VAT (value added tax) using 'C-efficiency' i.e. an indicator of the departure of the VAT from a perfectly enforced tax levied at a uniform rate on all consumption. There have been various papers that have discussed the efficiency of TA using DEA or DEA-relevant approaches. Thanassoulis et al. (1987) conducted relative efficiency assessments using DEA applied to data on the rates departments of London Boroughs and

Metropolitan District Councils. Jha and Sahni (1997), using panel data, conducted a tax efficiency and productivity analysis for Canadian Fiscal Federalism, for the years between 1971 and 1993. Jha et al. (1999) analysed the technical efficiency of the TA in India, for the period between 1980 and 1993, using the stochastic frontier. Both studies chose to use the total tax collection as outputs and the fiscal capacity as inputs.

In terms of the research context, there can be no doubt that a significant number of papers on tax agency efficiency have tended to concentrate on a single country context. These include: Jiménez and Barrilao (2001), Fuentes (2008), Barrilao-González and Villar-Rubio (2013), Cordero et al. (2018a) for Spain; Barros (2005, 2007) for Portugal; Katharaki and Tsakas (2010) for Greece; Førsund et al. (2015) for Norway (see Table A.1 in the appendix for further information). This might be explained by the lack of comparative data on TA across countries until recently. Alm and Duncan (2014) conducted a notable study, estimating the efficiency of tax agencies across 28 countries, considering data from the OECD TA database for the years 2007-2011. Continuing with the research theme, the work of Savić et al. (2015) analysed the performance of TA and its effect on tax evasion in 13 European countries.

In methodology, these papers have generally applied multiple techniques besides the standard DEA method. Remarkably, the recently developed frontier estimators such as the 1-DEA semi-nonparametric StoNEZD estimator proposed by Johnson and Kuosmanen (2011, 2012) and the non-parametric conditional efficiency method (Daraio and Simar, 2005, 2007) have not been used in any study on measuring the performance of tax agencies, particularly at a cross-country level.

Under globalisation, countries all over the world have been impacted differently by their macroeconomic conditions and other random factors particular to them. Governments and policymakers require a comparison of tax systems among countries and, consequently, the study on the performance of TA at cross-country level is a necessary reference for Governments when designing tax policy. The panoramic view of comparable countries will provide a standard for policy-makers to base and outline appropriate policies for strengthening the efficiency in TA. Fortunately, the recent introduction of a comparative database on TA from OECD has filled this gap and will now facilitate comparable analysis among countries.

## 1.3 Economic backgrounds

As stated by Leach (2004), "everyone would be better off if no one attempted to evade tax". Individual opportunistic behaviour underlies the motivation to engage in either tax avoidance or tax evasion. Tax avoidance generally refers to legal behaviour intended to reduce tax liability; while it is not illegal, it generally requires time and effort and was once called "the only intellectual pursuit that carries any reward" by John Maynard Keynes (cited in Rosen and Gayer, 2010). Tax evasion denotes the failure to pay due tax and comprises any illegal and intentional actions taken by individuals to decrease due tax obligations, and this phenomenon is widespread all over the world.[14]

TA is charged with the collecting and processing of tax revenue. It plays a key role in any tax system, ensuring the effective enforcement of tax rules. Tax transfer efficiency (or "income redistribution") refers to maximising the transfer bucket by limiting leakage on tax avoidance and evasion and, thus, serving the general distributive purpose of welfare policies. Actions taken to avoid paying taxes alter the allocation of resources in ways that reduce economic welfare (Leach, 2004). In this sense, the effectiveness and efficiency of TA can be considered as vital to socio-economic development.

The processing and collecting of taxes involve the incurring of administrative costs (see Rosen and Gayer, 2010; Salanie and Locker, 2003). Enhancing TA efficiency and effectiveness entails the improvement of tax compliance and enforcement, while also reducing administrative costs (OECD, 2012). A shortage of necessary resources, i.e. man-power and/or technological facilities, to enforce the tax regulations will hamper efforts to collect taxes. The TA apparatus can, to the extent of applying procedures to collect taxes, be viewed as a services production unit, where inputs such as employees

[14] Lump-sum tax is the only tax that cannot be evaded as it falls beyond the control of taxpayers (Leach, 2004).

and infrastructure are used to produce the output of tax revenue. As such, a successful TA should be endowed with the appropriate level of inputs to carry out its functions properly (Bird, 2004).

It is well-known that the objective of the government is to maximise potential revenue, with respect to the conventional tax rate and the inflation rate, entitled to its budget constraints. Accordingly, a reduction in the efficiency of the tax system results in an increase in the optimal inflation tax rate and a fall in the inflation tax base (De Gregorio, 1993). While the former seems ambiguous, the latter shows that the share of income tax revenues falls as the share of revenue from the inflation tax in total resources rises. As a result, even when the optimal conventional tax rate increases, it will not outweigh the effects of the fall in efficiency on the revenue collected from the income tax.

This article seeks to measure the efficiency of TA agencies across countries. The government, in order to optimise compliance, decides whether to increase the marginal revenue or decrease the marginal collection costs and man-power. This is the exercise of TA efficiency.

In this paper, due to limited data availability, I chose to optimise the efficiency of TA organisations by maximising the revenue for tax system general operations. The next section will deal with methodology facilitating these objectives of the study.

## 1.4 Estimation methodology

In this research, I consider a production function in which the production units operate with a set of p inputs $x(x \in R_+^p)$ used to produce a set of q outputs y (y $\in R_+^q$) such that:

$$f(x) = \{(x, y) \in R_+^{p+q} \mid x \; can \; produce \; y\}$$

It is the reality that additional variables, that are neither inputs nor outputs of production function, may present in the classical DEA model. These additional variables, however, characterise the operating environment in which the production takes place. Hence, they should be incorporated into the model as environmental or contextual variables (Lovell et al., 1994). Put differently, these variables may have a productivity relevant influence on the production process but are not under the control of the TA, a country-level management unit. Therefore, the actual output may deviate from the maximum owing to the non-negative inefficiency ($u_i$), the random noise ($v_i$), and the impact of environmental factors ($z_i$). As such, the multiplicative production model is written as:

$$y_i = f(x_i)\exp(\varepsilon_i) \qquad \text{with } \varepsilon_i = \delta z_i + v_i - u_i$$

where $\delta$ is a vector of coefficients of $z_i$. The element $\delta z_i$ can be interpreted in two ways: (i) it affects the location of the frontier and the obtainable output for each individual $i^{th}$, or (ii) it impacts $i^{th}$'s distance to the production frontier (Johnson and Kuosmanen, 2011).

Among several approaches addressing the impacts of exogenous variables on the production process in performance evaluation (in place of the traditional approaches, namely, one-stage approach and two-stage approach), I chose to measure the efficiency of tax agencies across countries using the recently developed frontier estimators, including the semi-nonparametric StoNEZD (Johnson and Kuosmanen, 2011, 2012) and the conditional DEA (Daraio and Simar, 2005, 2007b).[15]

When comparing between these two estimators, which share the incorporating the impact of environmental factors into efficiency measures, the StoNEZD estimator has been proven to outperform the conditional DEA in all the evaluated scenarios (Cordero et al., 2018b). Furthermore, it encounters the correlation of inputs and contextual variables, while facilitating the simultaneous estimation of the frontier and the effects of contextual variables. This paper employs the StoNEZD estimator as the main estimator besides the conditional order-m method, used as a robustness check.

*1.4.1 Stochastic Nonparametric Envelopment of Z-Variable Data (StoNEZD) Approach*

Among many other researchers who address the effects of contextual variables on performance with the two-stage DEA estimator (2-DEA), Banker and Natarajan (2008) contributed to the DEA literature by presenting a DEA-based stochastic frontier estimation framework, allowing for both one-sided inefficiency deviations and two-sided random noise. More importantly, the authors asserted DEA as a

[15] The literature on efficiency encountering environmental variables also deals with the latent class SFA proposed and developed by Greene (2005) and Orea and Kumbhakar (2004). This paper, however, due to sample limitation, failed to employ this approach as an alternative.

nonparametric stochastic frontier estimation (SFE) methodology. Furthermore, it was provided with a statistical foundation for the analysis of the impact of contextual variables on productivity. The authors also demonstrated how DEA-based methods provided consistent estimators of the impact of contextual variables affecting productivity, when deviations from the production frontier result from the contextual variables and random noise, in addition to DMU inefficiency. It was also noted that when data is generated by a monotone increasing and concave production function separable from a parametric function of the contextual variables, a two-stage approach comprising a DEA model followed by an ordinary least squares (or maximum likelihood estimation) model yields consistent estimators of the impact of the contextual variables. The extensive Monte Carlo simulations were applied, and it was indicated that two-stage DEA-based procedures with OLS, ML, or even Tobit estimation in the second stage significantly outperform the parametric methods. This approach, however, was stated to be statistically consistent under certain assumptions and regularity conditions.[16]

Derived from the standard StoNED estimator (Kuosmanen, 2006; Johnson and Kuosmanen, 2011, 2012), it further elaborated the statistical properties of the 2-DEA estimator by relaxing some restrictive assumptions imposed by Banker and Natarajan (2008).

The authors demonstrated that the consistency of 2-DEA estimator does not require the contextual variables to be uncorrelated with inputs. Accordingly, they developed a new one-stage semi-nonparametric estimator (1-DEA) method, combining the axiomatic, DEA-style production frontier with the parametric regression of the contextual variables. This method was thereafter referred as the stochastic semi-nonparametric envelopment of z-variables data, also known as StoNEZD.[17] This approach is justified to be consistent even when the noise term is unbounded and there is the correlation between inputs and contextual variables. It is also asymptotically efficient, asymptotically normally distributed, and converges at the standard parametric rate of order $n^{-1/2}$ (Johnson and Kuosmanen, 2011).

[16] See Simar and Wilson (2011) for seven assumptions that were found restrictive.

[17] Note that SFA approach has evolved from the two-stage approach to the one-stage approach where the frontier and the effects of contextual variables are simultaneously estimated.

The 2-DEA addresses the estimator where DEA efficiency estimates are regressed on contextual variables representing operational conditions; in the meantime, the 1-DEA refers to an estimator in which contextual variables are directly incorporated into the standard DEA problem. The evidence from Monte Carlo simulations suggest that the 1-DEA estimator performs systematically better than the conventional 2-DEA estimator, in both deterministic and noisy scenarios (Johnson and Kuosmanen, 2012).

Moreover, compared to another recently developed estimator for incorporating contextual variables into efficiency measures, i.e. non-parametric conditional DEA method (Daraio and Simar, 2005, 2007), the StoNEZD approach is proven to outperform conditional DEA in all the evaluated scenarios (Cordero et al., 2018b; Nieswand and Seifert, 2018).

In a word, StoNEZD is a one-stage stochastic (semi-) nonparametric envelopment of z-variables data estimator, which encounters the correlation of inputs and contextual variables and facilitates the simultaneous estimation of the frontier and the effects of contextual variables. It is thought to have several advantages for estimating the impacts of contextual variables. This approach is found to be appropriate for modelling with multiple inputs and a single output, for use with cross-sectional estimation and has been proven to be applicable for Finnish electricity distribution networks (Kuosmanen, 2012). When measuring the efficiency of tax general operations, I adopted the StoNEZD approach to examine the mean distance to the empirical frontier of the sample of studied countries, and to investigate the potential space for performance improvement.[18]

*Production frontier model*

$$\min_{\alpha,\beta_i,\widehat{\phi}_i,\delta} \sum_{i=1}^{n} \epsilon_i^2 \quad s.t. \tag{1.1}$$

$$\ln y_i = \ln \widehat{\phi}_i + z_i\delta + \epsilon_i \tag{1.2}$$

$$\widehat{\phi}_i = \alpha_i + x_i\beta_i, \quad i = 1, \dots, n \tag{1.3}$$

$$\widehat{\phi}_i = \alpha_h + x_i\beta_h, \quad h = 1, \dots, n \tag{1.4}$$

$$\beta_i \geq 0 \tag{1.5}$$

$$\epsilon_i \leq V^M \tag{1.6}$$

[18] All computations for the paper are programmed in GAMS language and are available upon request.

in which $\epsilon_i$ is composite error term including both inefficiency (u) and stochastic noise (v); $\epsilon_i = -u_i + v_i$; *x*, *y*, and *z* are input(s), output, and contextual variables, respectively. The first constraint, equation (1.2), is a regression equation with $\widehat{\phi_i}$ non-parametric estimator of unknown frontier point $\phi(X_i)$. The second constraint, equation (1.3), defines non-parametric estimators, as linear tangent hyperplanes are unit-specific. The third, equation (1.4), enforces concavity axiom. The last two, equations (1.5) and (1.6), impose free disposability and the truncation of noise term ($V^M$: truncated point), respectively. In case of level data, constraint (1.2) turns into level formula and the rest remains as above. Regarding returns-to-scale, if one imposes $\alpha_i = 0\ \forall i$, then the system (1.1) implies constant returns-to-scale (CRS); hence, the variable returns-to-scale (VRS) case is corresponding to unrestricted $\alpha_i\ \forall i$ (Kuosmanen et al., 2015, p. 203).

To compute the mean distance to the empirical frontier, *E*(*u*), I employ the formulas mentioned in the foregoing literature as follows:

$$E\ (u) = \sigma_u * \sqrt{\frac{2}{\pi}} \tag{1.7}$$

with

$$M_2 = \left[\frac{\pi-2}{\pi}\right]\sigma_u^2 + \sigma_v^2 \ \ ,\ \ M_3 = \left(\sqrt{\frac{2}{\pi}}\right)\left[1-\frac{4}{\pi}\right]\sigma_u^3 \tag{1.8}$$

where $\sigma_u$ and $\sigma_v$, respectively, denote standard deviations of $u_i$ and $v_i$, which are approximated by the second and third central moments, $M_2$ and $M_3$ respectively, of the CNLS residuals $\epsilon_i$ as

$$\widehat{M}_2 = \frac{\sum_{i=1}^{n}(\hat{\epsilon}_i - \bar{\epsilon})^2}{n} \ \ ,\ \ \widehat{M}_3 = \frac{\sum_{i=1}^{n}(\hat{\epsilon}_i - \bar{\epsilon})^3}{n} \tag{1.9}$$

so that,

$$\hat{\sigma}_u = \sqrt[3]{\frac{\widehat{M}_3}{\left(\sqrt{\frac{2}{\pi}}\right)\left[\frac{4}{\pi}-1\right]}} \ \ ,\ \ \hat{\sigma}_v = \sqrt{\widehat{M}_2 - \sigma_u^2\left[\frac{\pi-2}{\pi}\right]} \tag{1.10}$$

For the case of output orientation, the mean distance to the empirical frontier equals to exp $(E(u))$, which takes the value of one if itself is the frontier, so that the mean distance is expected above unity.

*1.4.2 Conditional (order-m) efficiency*

The non-parametric conditional efficiency model used in the paper was initially proposed by Cazals et al. (2002) and further developed by Daraio and Simar (2005, 2007). The conditional approach (based originally on the development of the so-called conditional order-m efficiency) extends the probabilistic formulation of the production process, where the attainable set is interpreted as the support of some probability measure based on input-output space. This approach orients to comparing only units operating under similar operational environments. That is to say, the choice of the reference set for an observation is conditional on contextual variables z. Conditional models do not rely on the separability condition between the space of output and that of z-variables (Simar and Wilson, 2007). Correspondingly, z-variables can affect the shape of the production set and, thus, the frontier. Conditional models estimate the efficiency scores based on an attainable production set conditioned on a set of z-variables. The (non-parametric) output-oriented order-m model is thus read

$$\hat{\lambda}_m(x, y \mid z) = \int_0^{\infty} \left[1 - \left(1 - \hat{S}_Y(\theta y \mid x, z)\right)^m\right] d\theta \qquad (1.11)$$

where $\theta$ is the efficiency score, and m is the chosen order based on principles discussed in Cazals et al. (2002). The empirical function $\hat{S}_Y$ is defined as

$$\hat{S}_Y(y \mid x, z) = \frac{\sum_1^n \mathbf{1}(X_i \leq x, Y_i \geq y) K((z - z_i)/h_n)}{\sum_1^n \mathbf{1}(X_i \leq x) K((z - z_i)/h_n)} \qquad (1.12)$$

where **1**(.) is the indicator function, whereas $K((z - z_i)/h_n)$ is the kernel density which is obtained from the empirical distribution estimated from Z. The latter implies the estimation of the conditional order-m frontier depends upon the bandwidth vector, $h_n$, the selection of this parameter hence plays a pivotal role. The most common approach, if z-variables are continuous, is the data-driven selection method, as suggested by Badin et al. (2010) based on the least squares cross-validation (LSCV) algorithm (Li and Racine, 2004, 2007). For each unit, the bandwidths determine the range of z in which other units are similar.

The kernel function K provides the unit-specific kernel probabilities that are used to define the unit-specific reference sets. The units closely located to unit ith, in terms of z, thereby receive higher kernel probabilities, while small (or even zero) kernel probabilities are assigned to units coping with very different operating environments than that unit.

Regarding to the value of m, this parameter is chosen in order to obtain a consistent estimator of the true frontier, such that the number of the super-efficient observations to be left out is stable.

To summarise, the conditional efficiency method can avoid the separability conditions as it directly includes the environmental factors in the obtainable set. Moreover, it defines and estimates nonparametrically, which is considered a major advantage over the semi-parametric approaches in reference to flexibility. It also does not require the specifications in terms of the direction of the impact of the contextual variables (Cordero et al, 2016). In addition, as stated in Cazals et al. (2002) and Jeong et al. (2010), the consistency and asymptotic properties have been proven. As such, the estimators will converge to the true but unknown value that they are supposed to estimate when the sample size rises. The conditional nonparametric methods show the obvious outperformance when compared with all the traditional alternatives, namely the two (or several)-stage approaches. As a result, the conditional methods have been increasingly popular in efficiency literature.[19] Unfortunately, this approach is found to be limited by the availability of software to conduct the estimation. It also requires time-consuming bandwidth optimisation, resulting in a major drawback when dealing with the large data sets (Cordero et al., 2016). Furthermore, when compared to the StoNEZD estimation method (presented in section 4.1), the conditional nonparametric approach was justified to be inferior (see Cordero et al., 2018b; Nieswand and Seifert, 2018). Consequently, this method is used in the study as a robustness check to support the validity of the inferences generated from the StoNEZD estimator and as an alternative to a major estimation inference tool.

[19] Conditional approaches have been found in multiple frameworks, see Cherchye et al (2010); Haelermans and De Witte (2012); Cordero et al. (2015, 2016), among others.

## 1.5 Data

### *1.5.1 Sample and data collection*

My data set is built on the OECD (2017, 2015, 2013) extracted from TA in OECD and Selected Non-OECD Countries: Comparative Information Series 2017, 2015, and 2013 which report data for years 2015, 2013, and 2011 respectively. This initially employs a chosen set of 56 advanced and emerging economies, including all 34 OECD and 22 non-OECD countries i.e. EU and G20 members. After outliers and missing value obstructions being excluded, my data set is finally composed of 44 (32 OECD and 12 non-OECD) countries. Figure 1 shows the relationships between tax revenues per active citizen (horizontal axis) and TA expenditures per active citizen (blue dots), and full-time equivalent TA staffs per thousand citizens (red rectangle). Note that revenues and expenditures are in terms of purchasing power parity dollar ($PPP). The OECD TA series, commencing in 2004, provides internationally comparative cross-country information on tax systems and their TA. The primary purpose was to share information that will facilitate dialogue among tax officials on important TA issues, as well as exploring the opportunities to improve the systems' design and administration.[20] It covers all jurisdictions that were members of the OECD's Forum on Tax Administration (FTA). The data in the database was obtained from a survey of national revenue bodies, revenue bodies' annual reports, third-party information sources, i.e. the International Bureau of Fiscal Documentation, and selected other OECD tax publications, such as Revenue Statistics, Tax Cooperation.

Some limitations are to be acknowledged with this data. These are caused by the inconsistency of variables across countries in the sample and the lack of standard treatment of countries, i.e. federal versus unitary. Indeed, tax revenue collection, resulting from the level of government decentralisation, needs to be addressed. Accordingly, I have run alternative models with a sub-sample excluding the most decentralised countries such as Germany and Switzerland. Besides, I failed to have the data to control for variety in tax base magnitude (deductions, exemptions, etc…) and tax rate among the different

[20] See the OECD tax administration series for details.

countries in the sample. I chose to address this issue by including the measures capturing the tax capacity of the tax agencies, as discussed later.

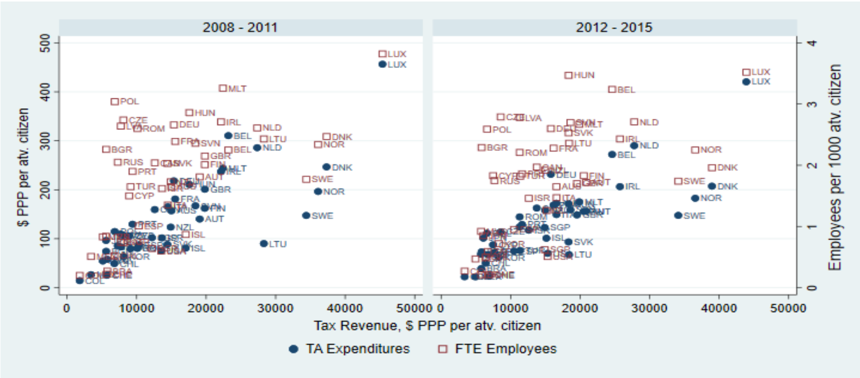


Figure 1: Relationships between tax revenues per active citizen and TA expenditures per active citizen and full-time equivalent TA staffs per thousand citizens. Source: OECD Tax administration database.

Despite the limitations, this data represents the best currently available information on comparable administrative performance. It is starting to be used in research for examining tax agencies and is expected to be a remarkably useful source for TA data.[21] I acknowledge this as a limitation of the study, and expect that this shortcoming will be improved in the future as OECD has increasingly extended the data set and improved its quality.

Besides the variables corresponding to TA resources and operational performance extracted from OECD Tax Administration database and OECD Statistics, the relevant contextual factors are retrieved from published sources, such as the World Bank (2018a, b) and IMF (2018). Tables 1 and 2 summarise all variable definitions and their descriptive statistics.

In spite of having data for the years between 2008-2015, I failed to capture the time dimension in this estimation due to data insufficiency. Instead, I adopted the strategy found in Alm and Duncan (2014), using average measures of inputs and outputs to allow compensation for some inconsistencies across years and countries. I chose to conduct a cross-sectional analysis of 44 countries, including 32 OECD and 12 non-OECD countries, over two different periods 2008-2011 and 2012-2015 to examine any differences in tax agency efficiency between the two afore-mentioned periods. These periods were

[21] See Robinson and Slemrod (2012) for an analysis of the multi-dimensions of tax systems and Alm and Duncan (2014) for the estimation of tax agency efficiency using OECD Tax administration database among remarkable examples.

chosen as 2012 is often considered to represent the end of the worst part of the recession in many countries.

Table 1. Data description of variables

| Variable | Role in model | Definition | Source |
|---|---|---|---|
| Revenues | output | Total tax revenue per active citizen, $PPP | Authors' calculation, adapted from OECD tax administration data |
| Salary_cost | input | Salary cost for Tax FTE employee per active citizen, $PPP | Authors' calculation, adapted from OECD tax administration data |
| IT_cost | input | IT cost for Tax FTE employee per active citizen, $PPP | Authors' calculation, adapted from OECD tax administration data |
| Employees | input | Number of Tax FTE employee per 1,000 active citizens | Authors' calculation, adapted from OECD tax administration data |
| Trade | contextual variable | Trade openness, %GDP | World Bank |
| Agriculture | contextual variable | Value added of agriculture, %GDP | World Bank |
| Service | contextual variable | Value added of service, %GDP | World Bank |
| Public_debt | contextual variable | Public debt, %GDP | IMF |
| Tax_rate | contextual variable | Total tax rate, % of commercial profit | World Bank |

Note: $PPP is the international constant dollar 2011 obtained from the World Bank.

Table 2. Descriptive statistics of variables

| Period | | 2008 - 2011 | | | | 2012 - 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Statistics | N | Mean | SD | Min | Max | Mean | SD | Min | Max |
| Revenues | 44 | 15289.30 | 9896.33 | 1803.24 | 45358 | 15309.76 | 9571.20 | 3384.00 | 43905.51 |
| Salary_cost | 44 | 97.03 | 67.30 | 10.86 | 373.9 | 94.23 | 60.78 | 14.04 | 342.31 |
| IT_cost | 44 | 14.81 | 13.46 | 0.49 | 52.73 | 14.72 | 13.35 | 0.26 | 45.19 |
| Employees | 44 | 1.79 | 0.91 | 0.20 | 3.82 | 1.78 | 0.90 | 0.21 | 3.52 |
| Trade | 44 | 103.78 | 75.63 | 24.18 | 389.07 | 110.28 | 77.19 | 25.73 | 367.81 |
| Agriculture | 44 | 3.02 | 2.41 | 0.04 | 10.14 | 2.94 | 2.17 | 0.04 | 9.06 |
| Service | 44 | 68.31 | 7.55 | 49.07 | 85.76 | 69.71 | 7.81 | 51.18 | 87.34 |
| Public_debt | 44 | 53.68 | 34.47 | 6.88 | 206.5 | 66.35 | 40.71 | 14.29 | 244.90 |
| Tax_rate | 44 | 42.44 | 13.54 | 19.96 | 80.26 | 41.14 | 13.42 | 18.48 | 74.78 |

Note: Value of variables are averaged over periods 2008-2011 & 2012-2015, respectively.

For variable selection, the measuring of inputs and (more importantly) the outputs of any government department is not a straightforward task (Fox, 2001). In this paper, the choice of input and output indicators has critically been determined upon the data availability and in compliance with the objectives. Relying on public data sources, instead of using the share of total tax revenue in GDP as the outcome of the model as used by some other researchers (namely, Jha and Sahni, 1997; Jha et al., 1999; Maekawa and Atoda, 2001; Barros, 2005; and Alm and Duncan, 2014), I select the total tax revenue per active citizen. For inputs, I decide to actualise the objective of observing the TA performance from both resource management and enforcement flexibility. This results in the consideration of the salary cost and IT cost for TA employee per active citizen, and number of TA staff per 1,000 active citizens, although I could witness an apparently high correlation between salary cost and employee. The salary and IT cost symbolise the administrative cost, and the employee proxies for the enforcement effort mentioned in Keen and Slemrod (2017, equation 9) to guarantee the sufficient compliance (audit, tax avoidance / evasion detection). In this case, an employee is not only the ingredient of cost usage but also the service of tax agency (the capacity for serving the citizens). This is different from Alm and Duncan (2014) as the authors' inputs were selected only for cost instance (salary and IT cost). Please note, since all the inputs and outputs are measured in terms of purchasing power parity dollar ($PPP), the income gap between countries has considerably minimised.

For the contextual variables to be included in this estimation, they cover measures, that is tax base and tax rate capturing the tax capacity, which is beyond the control of the tax body. As such, I use the share of trade in GDP, the share of agriculture in GDP, the share of service in GDP to control for tax capacity[22] and tax rate, as per Alm and Duncan (2014). Furthermore, I control for public debt to examine the impact of the fiscal burden on tax revenue (during and after the crisis).

The proposed model, thus, includes three inputs (salary cost, IT cost, and tax FTE employee) and one output (tax revenue), and contextual variables in the forms of two factors obtained from the factor analysis. The estimation consisting of multiple inputs and a single output may raise some certain concern. In fact, the StoNEZD estimator originally facilitated multiple input and single output as in the standard convex non-parametric regression, cross-sectional production model (Johnson and Kuosmanen, 2011, 2012). The extended model with multiple outputs, which used to be difficult to use has been recently developed (Kuosmanen and Johnson, 2017). Nevertheless, with the limitation of data availability, I intentionally limited the scope of this paper to the canonical StoNEZD setting, as I aimed to examine the performance of TA at the overall level (the total tax revenue corresponding to the overall level of consumed inputs) instead of the performance corresponding to the individual tax component. My model might include the extra outputs (for instance, the tax revenue corresponding to individual taxes as in Alm and Duncan, 2014), but using data that is not widely available from the OECD TA database but from other sources (for example, OECDStatExtracts) may cause the data inconsistency

[22] See Bahl (1971); Bird, Martinez-Vazquez, and Togler (2008); and Alm and Duncan (2014) for details.

across countries. In doing so, the sample will be reduced (due to the missing values), resulting in a dimensionality problem. This is also why I opted to use the inputs.

*1.5.2 Factorisation of the contextual variables*

To eliminate the multicollinearity and high correlation among contextual variables, I opt to factorise five variables. It is employed the principal components analysis, in which the components are calculated as linear combinations of the original variables. Bearing the goal of explaining as much of the total variance in the variables as possible, I intentionally prefer using the principal components analysis to reduce the data into a smaller number of variables than understanding what constructs underlie the data. In doing this, I could determine the number of factors to extract in a factor analytic study. Moreover, among the 4 types of estimation (principal-factor method, principal-component factor method, iterated principal-factor method, and maximum-likelihood factor method) performed in Stata, the principal-component factor method is used to analyse the correlation matrix. The communalities, assumed to be all 1, i.e. there are no unique factors, are estimated using the squared multiple correlation coefficients." Based on the eigenvalues, which are expected to be larger than one, and the observation of a jump between the eigenvalue of the last extracted factor and the first not extracted, I obtained two factors that explain about 70% of the variability of contextual variables. The scree plots in Figure 2 (below) illustrate the two factors with their eigenvalues much above 1. The scatter plots, Figure 3, explore the statistical relationships between those factors and other variables shown in Table 1 and Table 2.

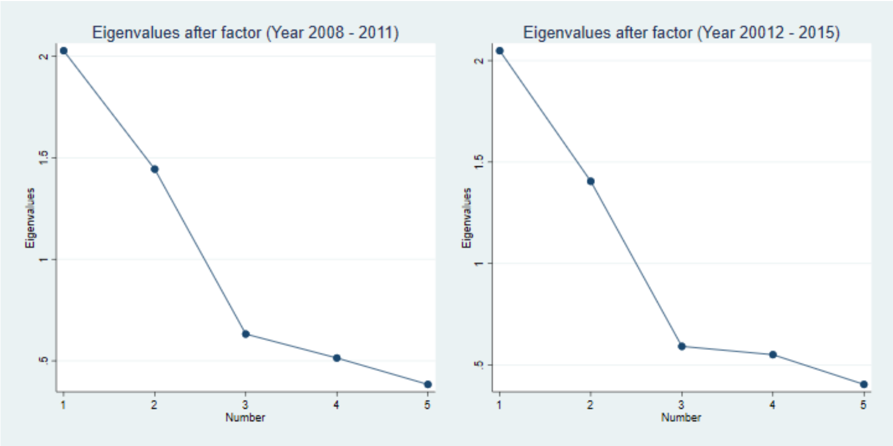


Figure 2: Scree plots of eigenvalues

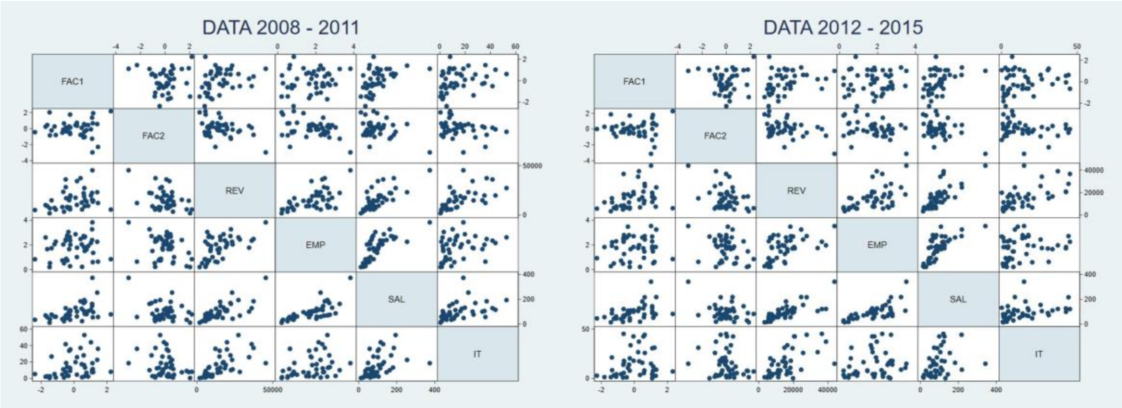


Figure 3: Scatter plot matrix of factors and other variables in Tables 1 & 2

## 1.6 Results and Analysis

For measuring performance of tax agencies to the extent of general operation, I account for 44 countries over two periods (2008-2011 and 2012-2015). Encountering the effects of exogenous variables, I employed the StoNEZD approach (Johnson and Kuosmanen, 2011, 2012), and then robustness check with conditional order-m efficiency method (Daraio and Simar, 2005, 2007).

### *1.6.1 Efficiency in revenue production: StoNEZD approach*

I measure the efficiency of tax agencies through a production function model (formula 1.1) following the StoNEZD approach. The outcomes are presented in Table 3.

Table 3. TA efficiency results: Comparison between StoNEZD estimator and 3-stage DEA approach

| Period | $\theta_{BCC}^{VRS}$ | 3-stage DEA | StoNEZD | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Ratio data | | | | Level data (PPP$) | | |
| | | | $\sigma_u$ | $\sigma_v$ | E(u) | Mean Efficiency | $\sigma_u$ | $\sigma_v$ | E(u) |
| 2008 - 2011 | 1.588 | 1.657 | 0.578 | 0.093 | 0.462 | 1.587 | 9,675 | 3,313 | 7,737 |
| 2012 - 2015 | 1.564 | 1.566 | 0.370 | 0.220 | 0.295 | 1.342 | 5,850 | 4,065 | 4,667 |

$\theta_{BCC}^{VRS}$ is the BCC-VRS efficiency score, and also the 1st-stage's result; $E(u) = \mu_u$: mean distance to the empirical production frontier; StoNEZD mean efficiency = Exp($\mu_u$).

As observed, the StoNEZD efficiency scores for the two periods 2008 – 2011 and 2012 – 2015 are around 1.587 and 1.342, respectively; equivalently, 158.7% and 134.2%, respectively. In other words, there is an improvement of about 24.5% in the second period. This means that, given the current level of input usage (salary cost, IT cost, and Tax FTE employee), these countries, on average, may reach an efficient collection of revenue through an increase of 58.7% and 34.2% of the current level of revenue for the two periods, respectively.

The results indicate that the composite error term can be principally caused by inefficiency (instead of statistical noise that is completely exogenous and stochastic). Accordingly, there is space for these countries to improve in TA efficiency.

In addition, in terms of level data, the results with inefficiency figures show possibility of increasing tax revenue by 7,737 and 4,667 dollars per capita in terms of purchasing power parity for the two periods 2008 – 2011 and 2012 – 2015, respectively. The improvement is translated into approximately $ 3,000 PPP per capita. This is to say, the distance to the production frontier is significantly shortened by around $ 3,000 PPP per capita for the second period (2012 – 2015).

Another aspect that should be considered is the performance of TA in specific countries. I identify 9 countries to form the efficiency list and rank the top positions for the first period (2008 – 2011). These countries include Brazil, Colombia, Lithuania, Luxembourg, Portugal, Romania, Sweden, Switzerland, and the USA. Portugal and Romania are not part of this list in the second period (2012 – 2015), leaving space for Denmark, Italy, Mexico, Malta, Norway, and Turkey to form the list of 13 efficient countries. On the other hand, the list of bottom ranked countries includes Russia, Latvia, and the Czech Republic among others.

The potential revenue for the inefficient countries needs to be increased to enable them to achieve greater efficiency. For example, for the first period (2008 – 2011), Chile could have collected an extra average of $3,037.6 ($6795.49 * 44.7%) PPP per capita, while Spain and Korea could have collected $2,360.9 PPP and $4,661.6 PPP, respectively. Similarly calculated, the numbers for the second period (2012 – 2015) are $2,214.8 PPP, $5,653.6 PPP, and $5,424.8 PPP for France, Russia, and Singapore, respectively.[23]

[23] The potential revenue was computed based on the individual efficiency scores (which were generated directly from formula (1.2) and presented in Table A.2 in the Appendix) and the total tax revenue per capita.

The second and third columns in Table 3 report the estimation results generated from the VRS and 3-stage DEA models. It is evident that there are no sharp differences between the first-stage and the third-stage outcomes due to the sub-optimal measurement of managerial inefficiency in the 3-stage DEA procedure, which is also stated in Alm and Duncan (2014)'s results. The efficiency scores of all countries in the sample are listed in Table A.2 in the appendix. Although I do not discuss the 3-stage results any further here, it is interesting to note that the mean distances to the empirical frontiers across the two periods, 2008 – 2011 and 2012 – 2015, appear to be overestimated in the 3-stage DEA estimations as 1.657 and 1.566, respectively. The gap, however, seems to be small at 9.1%. On the contrary, an empirical distance gap of about 25% was observed with the StoNEZD estimator, signifying the power of joint estimation of the effect of the contextual variable (Johnson and Kuosmanen, 2012).

I also chose to run the estimation with the alternative sample, which excludes Germany and Switzerland. Fortunately, the estimation outcomes largely hold and are consistent. Accordingly, the average relative efficiency of TA is rather robust between the two samples, presenting similar efficiency scores (1.626 compared to 1.587, and 1.349 compared to 1.342 for 2008 – 2011 and 2012 – 2015, respectively). The efficient countries forming the top rankings mostly remain the same.

Table 4. StoNEZD estimation results: Comparison between the alternative samples

| Period | 44 countries | | 42 countries | |
|---|---|---|---|---|
| | Mean efficiency | Efficient countries | Mean efficiency | Efficiency countries |
| 2008-2011 | 1.587 | BRA, CHE, COL, LTU, LUX, PRT, ROM, SWE, USA | 1.626 | BRA, COL, ISL, LTU, LUX, PRT, ROM, SWE, USA |
| 2012-2015 | 1.342 | BRA, CHE, COL, DNK, ITA, LTU, LUX, MEX, MLT, NOR, SWE, TUR, USA | 1.349 | BRA, COL, DNK, ITA, LTU, LUX, MEX, MLT, NOR, SWE, TUR, USA |

One of my aims was to measure the empirical frontier and frontier shift between the two periods (inter-period performance) instead of the individual performance within the periods (intra-period performance). Using the StoNEZD estimator, the mean distance controlled for some contextual factors is directly generated from the estimation instead of the arithmetic mean. One important finding is the frontier shift, which implies the TA collection improvement in the 2012 – 2015 period. The robustness check, using the conditional order-m efficiency method, was thus used to validate the present estimations.

*1.6.2 Robustness check: Conditional order-m efficiency method*

In order to observe any potential difference in the estimation outcomes, I estimate the output-oriented order-m efficiency for both unconditional model – excluding environmental variables – and conditional model.

The mean values of efficiency are, for the period 2008 – 2011, 1.271 and 1.261 for conditional and unconditional models, respectively. Similarly, these values are 1.145 and 1.142 for 2012 – 2015, for conditional and unconditional models, respectively. The models were selected at order-m of 50. Obviously, as expected, there is an increase in TA efficiency by 12.6% in the second period when controlling the environmental factors.

The results show the efficiency score generated from the conditional order-m model is larger than that of the unconditional model, reflecting unfavourable factors (Z) as discussed in Daraio and Simar (2005, p.105-106). In this sense, the environmental variable works as a “compulsory” or unavoidable output to be produced to face the negative environmental condition. Z, in a certain sense, penalises the production of the outputs of interest. This is, however, treated as a useful descriptive diagnostic support in lieu of inference (Daraio and Simar, 2005, p.106).

Table 5. Conditional order-m efficiency estimation results

| Period | Order-m conditional efficiency | | | Order-m efficiency | | | Efficiency ratio | | |
|---|---|---|---|---|---|---|---|---|---|
| | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max |
| 2008-2011 | 1.000 | 1.271 | 3.650 | 0.923 | 1.261 | 3.633 | 0.999 | 1.008 | 1.083 |
| 2012-2015 | 1.000 | 1.145 | 2.434 | 0.931 | 1.142 | 2.425 | 0.950 | 1.004 | 1.074 |

N.B: Efficiency ratio = order-m conditional efficiency / order-m efficiency

In summary, the estimation results generated from both frontier estimators (StoNEZD and conditional order-m efficiency) show that the tax entities in the sample are, on average, more efficient in the second period (2012 – 2015). In other words, after the financial crisis, these countries achieved better performance in terms of resource management and enforcement.

## 1.7 Conclusions and Further Implications

The paper estimated the efficiency of TA across countries. I used the recently developed frontier estimators applied with comparative data, basically extracted from the most recent database on TA - OECD TA database, versions 2013, 2015, and 2017. This study analysed the performance measure of TA entities in 44 countries (32 OECD and 12 non-OECD countries) over the two periods between 2008 – 2011 and 2012 – 2015.

Methodologically, for incorporating contextual variables into efficiency measures of tax general operations, I employed the 1-DEA semi-nonparametric estimator, the StoNEZD approach (Johnson and Kuosmanen, 2011, 2012) and then conducted a robustness check using the conditional order-m efficiency method (Daraio and Simar, 2005, 2007). In addition, to eliminate multicollinearity among the contextual variables, I used a multivariate descriptive technique, factor analysis, to finally attain two factors representing around 70% of variability of these variables.

The findings show that, in terms of general operation performance, tax agencies in these countries may increase the current level of tax revenue, on average, by about 58.7% and 34.2% for the two periods, respectively, while maintaining the current level of input usage. Equivalently, an extra $7,737 and $4,667 per capita (PPP) of tax revenue could be collected over the two periods, respectively. The results also indicated that the composite error term could be primarily caused by inefficiency (inefficiency $\sigma_u$ outweighs statistical noise $\sigma_v$). Therefore, there was the potential for these countries to improve their TA efficiency.

The robustness check, using the conditional order-m efficiency method (similar to the StoNEZD approach), also demonstrates and consolidates the improvement of efficiency in the second period (2012 – 2015) with an increase of 12.6 % (compared to the 24.5 % increase that was generated by the StoNEZD approach).

The findings reveal that these tax entities enhance the enforcement, reduce the concealed income, and increase the revenue given a certain tax level. In the meantime, they should maintain a sufficient number of employees to ensure the enforcement level and the management of resource usage.

It seems undeniable that efficiency is sensitive to the choice of inputs, outputs and model specifications. Nevertheless, the findings were achieved through different models and different estimators for two different periods. As a result, there is good reason to believe that the methodologies and their results could provide a reference for measuring the performance of TA in other contexts or for the performance of other relevant public sectors. The study, to some extent, contributes to the research field as one of the few papers on comparative efficiency in TA across multiple countries and continues and extends on the work of Alm and Duncan (2014), using the recently developed frontier estimators. Moreover, it is arguably the preliminary comparison of efficiency in TA between the two periods 2008-2011 and 2012-2015 in order to examine any difference in TA performance during and after the crisis. Additionally, this study makes the preliminary attempt to measure the efficiency of TA, acquired simultaneously from the views of both administrative cost and enforcement level for optimal TA, as stated in Keen and Slemrod (2017).

The results show that many countries in the sample are efficient and are not likely to collect more tax revenue given the current level of TA resources while others need an improvement in TA efficiency. Nonetheless, from the policy making perspective, these conclusions require cautious interpretation. As asserted, the inefficiency might result from many other causes besides the managerial capacity. In addition to regular tax assessments, an increase in tax revenue could result from taxpayers' voluntary compliance to tax regulations, irrespective of the origin of the taxpayer (Villar-Rubio, Barrilao-González, and Delgado-Alaminos, 2017). Moreover, the TA efficiency could have increased if the tax structure was of lower complexity. A less complicated tax system may facilitate higher tax revenue collection and lower rate of tax corruption (Zelekha, 2017; Tanzi, 2017; Liu and Feng, 2015; Awasthi and Bayraktar, 2015). Recommending an appropriate policy and benchmark performance (in the segment) for governments in inefficient countries would require a thorough examination with an extended data set corresponding to the specific cause.

Finally, this paper deals with a certain research sample of countries that belong mainly to high and upper-middle income groups. This might have caused a failure to capture the generality of the findings. Furthermore, the insufficient data obstructs the longitudinal study to better capture causality, especially as it is likely to bring to light the potential for further examining the efficiency of TA in another extreme. As a supplement to finding the mean distance to the empirical frontier as a benchmark in this paper, the TA efficiency of every single country and the determinants affecting the variance in this efficiency will need to be investigated in details. I save the arrears for continued development for the next step in future research.

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# Appendix

## *A1. Related literature on efficiency in Tax administration*

The table summarises the major related literature on TA efficiency using DEA or/and DEA-relevant approach, concentrating on the context of research.

| No. | Context | Author | Methodology | Objective |
|---|---|---|---|---|
| 1 | Spain | Jiménez and Barrilao (2001) | Empirical studies. | Efficiency in the management of the Spanish State TA Agency (AEAT). |
| | | González and Miles (2000) | Input-oriented variable returns to scale (VRS) DEA and bootstrap technique. | Technical efficiency in the inspection of the 15 State Agency of TA (AEAT) in 1995. |
| | | Fuentes (2008) | Output-oriented variable returns to scale (VRS) and constant returns to scale (CRS) DEA, Malmquist Productivity and modified quasi-Malmquist indices. | Behaviour of the efficiency and productivity of 32 SUMA tax offices in Alicante between 2004 and 2006. |
| | | Barrilao-González and Villar-Rubio (2013) | DEA | Management efficiency in 14 of the 17 Special Tax Offices in Spain, including the regional offices of the Autonomous Communities. |
| | | Villar-Rubio, Barrilao-González and Delgado-Alaminos (2017) | Output-oriented two-stage DEA technique. | Analysis of 47 Spanish regional TA and evaluated the relative efficiency of each office. |
| | | Avellon Naranjo and Prieto Jano (2017) | DEA. | Relative technical efficiency of Regional Tax Administration of Common Regime in Spain, in the period 2004 to 2012. |
| | | Avellon Naranjo and Prieto Jano (2018) | DEA measure besides a cluster analysis for arranging these organisations in homogeneous groups. | Efficiency of the regional tax management of the Spanish subnational levels of government and Autonomous Communities for 2004-2012 period. |
| | | Cordero et al. (2018a) | Conditional directional distance function approach. | Analysis of the technical efficiency of Spanish regional tax offices for the period 2005-2014. |
| 2 | India | Thirtle et al. (2000), | DEA. | Tax efficiency in 15 Indian states from 1980/81 to 1992/93. |
| 3 | Japan | Maekawa and Atoda (2001) | Stochastic frontier (pooled data), total tax revenue was taken as output, and administrative expenses (capital and labour) and fiscal capacity (GDP) as inputs. | Technical efficiency and institutional reforms of the TA in Japan (1995-1997). |
| 4 | Belgium | Moesen and Persoon (2002) | Non-parametric best practice frontier approach using Free Disposal Hull (FDH) and DEA method. | Measurement and explanation of the productive efficiency of 289 regional tax offices being responsible for personal income tax in Belgium. |
| 5 | Indonesia | Lewis (2006) | Stochastic frontier analysis with a set of transversal data. | Efficiency analysis of the administrative costs of the municipal tax agencies of Indonesia for 2003. |
| | | Laksono and Widyawati (2018) | Stochastic frontier analysis approach and aggregated data at provincial level. | Measurement of the technical efficiency of tax offices from 2010 to 2016. |
| 6 | Portugal | Barros (2005) | Stochastic frontier model to allow benchmarking the tax offices accurately. | Performance measurement in 41 tax offices in Lisbon from 1999 to 2002. |

| No. | Context | Author | Methodology | Objective |
|---|---|---|---|---|
| | | Barros (2007), | Using data from offices in central and greater Lisbon and input-oriented CRS and VRS DEA / Tobit approach. | Measuring the achievements of the Portuguese Government's policy, analysed the technical and Allocative Efficiency (AE) of Lisbon's tax offices. |
| 7 | Greece | Katharaki and Tsakas (2010) | DEA method was used to estimate efficiency scores and rank the Greek tax offices before window analysis to detect efficiency trends and stability over time. As well, Tobit analysis was applied to examine the role of non-discretionary factors in these tax offices' performance. | Technical and scale efficiency of a set of 27 tax offices (Inland Revenue) in Greece during the period 2001-2006. |
| | | Tsakasa and Katharaki (2014) | DEA with bootstrap methods. | Examining the performance of a sample of 35 tax offices in the period from 2001 to 2006. |
| 8 | Norway | Forsund, Kittelsen, Lindseth and Fjeld Edvaedsen (2006) | Output-oriented VRS DEA and Malmquist index were used to measure efficiency scores and productivity respectively of 98 local tax offices from 2002 to 2004. They were followed by the bias-corrected estimates by using a bootstrap approach. | Efficiency and productivity of Norwegian tax offices. |
| | | Førsund, Edvardsen and Kittelsen (2015) | Bottom-up approach, DEA to calculate the Malmquist productivity indices. Also, the bootstrap approach was carried out to establish confidence intervals for the individual indices. | Performance of local tax offices over periods 2002-2003 and 2003-2004. |
| 9 | Korea | Ruy and Lee (2013) | Windows-DEA oriented to input. | Exploratorily evaluating the efficiency of 14 tax jurisdictions from 1998 to 2011. |
| 10 | Iran | Mohammadi, Sadeghi, Shojaei and Rezaei (2017) | A combination of the qualitative and quantitative model from 2011 to 2014. Accordingly, the provinces are prioritised by DEA/AHP (Analytical Hierarchy Process) integrated model application before prioritizing provinces by AHP based on pairwise comparison matrices. | Evaluating the performance of Iran's provincial tax offices. |
| 11 | Taiwan | Huang et al. (2017) | Network data envelopment analysis (NDEA) and a Russell directional distance function. | Examination of the performance of 20 Taiwan's local offices for 2013 in terms of both tax collection and tax management. |
| 12 | Cross-country (28 countries) | Alm and Duncan (2014) | OECD TA database for the years 2007-2011, novel three-stage estimation approach was employed, taking DEA and stochastic frontier analysis (SFA). | Estimating the efficiency of tax agencies in input usage in 28 countries. |
| | Cross-country (13 European countries) | Savic et al. (2015) | DEA input-oriented model before the regression analysis. | Performance of the TA and its effect on tax evasion in 13 European countries. |
| Total | | 24 papers | | |

*A2. Efficiency scores, generated from alternative methods*

| | | 2008 - 2011 | | | | | 2012 - 2015 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | **Country** | **VRS** | **3-stage DEA** | **StoNEZD** | **StoNEZD-42** | **Conditional order-m DEA** | **VRS** | **3-stage DEA** | **StoNEZD** | **StoNEZD-42** | **Conditional order-m DEA** |
| 1 | AUS | 2.151 | 2.237 | 2.222 | 2.219 | 1.137 | 2.045 | 2.090 | 1.887 | 1.894 | 1.000 |
| 2 | AUT | 1.496 | 1.524 | 1.390 | 1.402 | 1.000 | 1.680 | 1.703 | 1.634 | 1.635 | 1.000 |
| 3 | BEL | 1.552 | 1.578 | 1.340 | 1.385 | 1.000 | 1.281 | 1.289 | 1.144 | 1.165 | 1.000 |
| 4 | BGR | 1.000 | 1.000 | 1.067 | 1.009 | 1.000 | 2.178 | 2.337 | 2.345 | 2.324 | 1.950 |
| 5 | BRA | 1.167 | 1.204 | 1.000 | 1.000 | 1.000 | 1.198 | 1.226 | 1.000 | 1.000 | 1.198 |
| 6 | CAN | 2.467 | 2.600 | 2.407 | 2.399 | 1.503 | 2.133 | 2.193 | 2.096 | 2.093 | 1.186 |
| 7 | CHE | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | 1.000 | - | 1.000 |
| 8 | CHL | 1.311 | 1.367 | 1.447 | 1.074 | 1.000 | 1.321 | 1.360 | 1.119 | 1.080 | 1.000 |
| 9 | COL | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 10 | CYP | 1.226 | 1.255 | 1.298 | 1.229 | 1.000 | 2.093 | 2.205 | 2.229 | 2.196 | 1.519 |
| 11 | CZE | 3.664 | 4.057 | 3.613 | 3.640 | 3.471 | 2.545 | 2.681 | 2.465 | 2.472 | 2.147 |
| 12 | DEU | 2.170 | 2.255 | 1.844 | - | 1.818 | 2.105 | 2.156 | 1.898 | - | 1.165 |
| 13 | DNK | 1.015 | 1.015 | 1.018 | 1.015 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 14 | ESP | 1.385 | 1.428 | 1.229 | 1.135 | 1.000 | 1.244 | 1.262 | 1.154 | 1.142 | 1.000 |
| 15 | FIN | 1.751 | 1.793 | 1.805 | 1.798 | 1.716 | 1.574 | 1.594 | 1.558 | 1.558 | 1.000 |
| 16 | FRA | 1.727 | 1.779 | 1.377 | 1.454 | 1.000 | 1.346 | 1.361 | 1.137 | 1.159 | 1.000 |
| 17 | GBR | 1.781 | 1.824 | 1.743 | 1.721 | 1.701 | 1.490 | 1.508 | 1.618 | 1.605 | 1.000 |
| 18 | HUN | 1.952 | 2.012 | 1.814 | 1.869 | 1.571 | 1.371 | 1.386 | 1.260 | 1.271 | 1.000 |
| 19 | IRL | 1.687 | 1.721 | 1.755 | 1.717 | 1.513 | 1.429 | 1.441 | 1.478 | 1.471 | 1.000 |
| 20 | ISL | 1.000 | 1.000 | 1.009 | 1.000 | 1.000 | 1.517 | 1.542 | 1.445 | 1.430 | 1.011 |
| 21 | ISR | 1.531 | 1.575 | 1.450 | 1.392 | 1.000 | 1.432 | 1.457 | 1.444 | 1.425 | 1.000 |
| 22 | ITA | 1.322 | 1.347 | 1.017 | 1.045 | 1.000 | 1.099 | 1.104 | 1.000 | 1.000 | 1.000 |
| 23 | JPN | 2.699 | 3.088 | 1.980 | 1.965 | 1.452 | 2.464 | 2.652 | 2.259 | 2.232 | 1.365 |
| 24 | KOR | 1.492 | 1.564 | 1.573 | 1.337 | 1.000 | 1.288 | 1.314 | 1.149 | 1.125 | 1.000 |
| 25 | LTU | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 26 | LUX | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 27 | LVA | 3.753 | 4.183 | 3.841 | 3.793 | 3.622 | 2.240 | 2.321 | 2.244 | 2.241 | 1.628 |

| | | 2008 - 2011 | | | | | 2012 - 2015 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | MEX | 1.254 | 1.354 | 1.212 | 1.205 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 29 | MLT | 1.416 | 1.436 | 1.380 | 1.358 | 1.249 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 30 | MYS | 2.295 | 2.496 | 2.606 | 2.533 | 1.111 | 1.820 | 1.933 | 1.405 | 1.401 | 1.000 |
| 31 | NLD | 1.403 | 1.419 | 1.325 | 1.346 | 1.350 | 1.479 | 1.491 | 1.486 | 1.473 | 1.331 |
| 32 | NOR | 1.000 | 1.000 | 1.006 | 1.014 | 1.000 | 1.056 | 1.057 | 1.000 | 1.000 | 1.000 |
| 33 | NZL | 1.870 | 1.935 | 2.031 | 2.017 | 1.145 | 1.895 | 1.939 | 1.714 | 1.722 | 1.024 |
| 34 | POL | 1.911 | 2.074 | 1.815 | 1.815 | 1.473 | 2.121 | 2.253 | 2.111 | 2.113 | 1.000 |
| 35 | PRT | 1.067 | 1.075 | 1.000 | 1.000 | 1.000 | 1.579 | 1.615 | 1.472 | 1.474 | 1.000 |
| 36 | ROM | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 2.050 | 2.118 | 1.671 | 1.693 | 1.382 |
| 37 | RUS | 2.705 | 2.990 | 2.652 | 2.701 | 1.254 | 1.874 | 1.961 | 1.737 | 1.746 | 1.000 |
| 38 | SGP | 1.167 | 1.183 | 1.519 | 1.358 | 1.108 | 1.148 | 1.155 | 1.364 | 1.333 | 1.027 |
| 39 | SVK | 1.151 | 1.082 | 1.156 | 1.156 | 1.000 | 1.200 | 1.208 | 1.162 | 1.165 | 1.000 |
| 40 | SVN | 1.651 | 1.690 | 1.712 | 1.687 | 1.000 | 1.588 | 1.611 | 1.578 | 1.577 | 1.000 |
| 41 | SWE | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 42 | TUR | 1.159 | 1.180 | 1.145 | 1.162 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 43 | USA | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 44 | ZAF | 1.494 | 1.570 | 1.515 | 1.270 | 1.000 | 2.225 | 2.367 | 2.138 | 2.038 | 1.032 |

Note: StoNEZD-42 is the estimation results generated from StoNEZD estimator for 42-country sample.

# CHAPTER 2 Performance of tax simplification around the world: A panel frontier analysis♥


Abstract

Governments throughout the world are confronted by the vast global competition affecting new business creation and investment attraction, which is used as the main driver for tax revenue collection to finance operations, particularly under high government budget deficits. A complex tax system may affect the ease of doing business in a specific country through rising fixed cost and the opportunity cost of taxpayers' time, thus constituting a barrier to foreign direct investment and entrepreneurship. Therefore, tax simplification has increasingly drawn the concern of academia and policymakers and has gradually become the core part of tax system reform all over the world. This study observes the tax competitiveness in its tax complexity dimension, by covering 88 countries over timespan (2005-2016) and using the panel data nonparametric frontier method, i.e. the data envelopment analysis model without explicit output (hereafter, panel data DEA-WEO). A thorough view on tax simplification was conducted by measuring the efficiency (both contemporaneous and long-run analysis), which allows producing a ranking, and examining the productivity change of these tax systems. Findings show the uptrend of tax systems' relative efficiency through years, from 31.2% (2005) to 52.6% (2016), along with an increasing convergence of the tax simplification trend. Switzerland was found to be the most efficient country, considering long-run performance; however, Norway appeared to have the most feasible practice and model in the segment. It was also found that the average productivity progress of tax simplification for both periods, 2006-2011 and 2011-2016, was 27.7% and 19.6%, respectively.



*JEL classification:* C44, H21, H83, M21, M48.

*Keywords:* Tax complexity, Tax simplification, Panel frontier analysis, Panel data DEA, DEA-WEO.


♥ The chapter was submitted to Socio-Economic Planning Sciences (SEPS) journal and is now under review.

## 2.1 Background

Governments throughout the world are confronted by the vast global competition affecting new business creation and investment attraction, which is used as the main driver for tax revenue collection to finance operations, particularly under high government budget deficits. Entrepreneurs and investors feel unsatisfied and discouraged and may even forego chasing opportunity altogether when encountering highly complex tax systems. Therefore, tax complexity has increasingly drawn the concern of academia and policymakers and has gradually become the core part of tax system reform all over the world. A complex tax system increases the costs of administration and requires compliance with many tax obligations (Tanzi, 2017). Tax complexity may affect the ease of doing business in a particular country, through rising fixed cost and the opportunity cost of taxpayers' time. As such, this constitutes a barrier to foreign direct investment and entrepreneurship (see, for example, Weber, 2015; Braunerhjelm et al. 2015; Braunerhjelm and Eklund, 2014; Lawless, 2013 among others).

In terms of tax administration (TA), a complex tax system may cause a tax gap as a result of the taxpayers' unintentional avoidance of taxes and tax corruption problems. Tax complexity causes compliance to suffer, and it was found the most important determinant of tax evasion (Richardson, 2006) or non-compliance (Saad, 2012, 2014). It can be argued that a less complex tax system might increase the efficiency of tax revenue collection (Bayraktar, 2020). More importantly, a simplified tax system can also eliminate unnecessary tax expenditure and relieve the economic agents of the burden of complex TA. This can help the growth of businesses and, ultimately, the growth of overall investment and employment (Djankov et al., 2010), which will contribute to economic development nationally and internationally. For these reasons, tax simplification has become a worthwhile topic and a common goal amongst policymakers.

Measuring and monitoring the level of tax complexity was an important step towards tax simplification (Tran-Nam and Evans, 2014); it was, however, perceived as an obstacle (Morris and Qiao, 2011). In literature, there have been diverse measures of tax complexity – a multidimensional concept meaning different things to different people –, and no universally accepted overall measures have been proposed. In this study, I follow Awasthi and Bayraktar (2015) and Bayraktar (2020) to measure of tax simplification using the two sub-indicators of paying taxes (as an indicator of measuring the ease of doing business) i.e. time to comply (*taxtime*) and number of payments (*taxpay*).[24] The premise is that "the lower the time taken to comply with the tax system and the fewer the number of payments, the easier it is for businesses to comply with their tax paying obligations" (Awasthi and Bayraktar, 2015). These two variables were also used in Lawless (2013), Braunerhjelm and Eklund (2014) and Braunerhjelm et al. (2015) to reflect tax complexity.

Focusing on business taxes, *taxtime* and *taxpay* capture all three taxes (corporate income tax, labour tax, and consumption tax. Plots 1(a) and 1(b) of Figure 1 show the steady downtrend of tax complexity across countries over the observed period, 2005-2016. The average number of payments decreased from 37.4 per year in 2005 to 18.5 per year in 2016. Time-to-comply with these payments in 2016 is about 64% of the hours in 2005, which is equivalent to a total reduction of 150 hours per year. This remarkable improvement in tax simplification can also be observed in panels 1(c) and 1(d), where data on two years, namely 2005 and 2016, is directly contrasted. Grey circles, representing pairs of total hours and payments, appear to be more compact in plot 1(d) than those in plot 1(c), indicating a convergence tendency towards the benchmarking countries (empirical frontier) over the timespan 2005 – 2016. This trend has been seen for a number of years, reflecting a continued focus by many governments in developing efficient systems for tax collection (Paying Taxes Report 2018, p.6).

[24] Paying taxes covers 4 indicators i.e. taxpay, taxtime, total tax rate (TTR), and recently new indicator post-filing. In this study, I exclude TTR as it has been criticised to be not indicative of the ease of doing business (Independent Panel Review of the Doing Business Report, June 2013, http://www.dbrpanel.org/sites/dbrpanel/files/doing-business-review-panel-report.pdf). Post-filing index has been nly developed since the last 4 years, suffering from shortage of values.

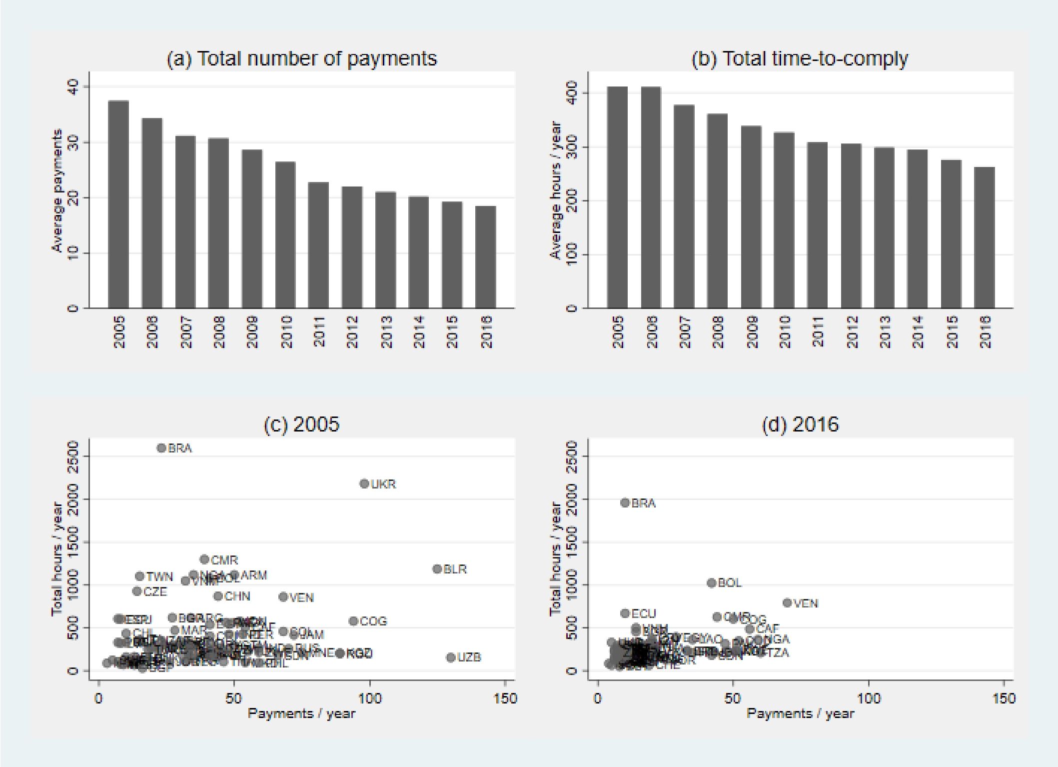



Figure 1. Illustration of tax compliance burden. Source: Paying Taxes Reports (PwC & World Bank).

In the existing literature, a number of studies were found to cover the impacts of tax complexity on tax cost, notably Saad (2014, 2012), Mulder et al. (2009), Picciotto (2007), Dean (2005), Oliver and Bartley (2005), Evans (2003), Cuccia and Carnes (2001), and Alm (1999), among many others. Other authors discussed the relationship between complex tax systems and lower taxes, including Slemrod (2007), Kirchler et al. (2006), Richardson (2006), Mills (1996), etc. Also, some articles controversially studied the link between tax complexity and higher taxes, for example, White et al. (1990) and Scotchmer (1989). Nonetheless, empirical research on the performance evaluation of tax simplicity across countries, which is an essential component of the tax complexity framework, appears not to have received thorough attention.

Literature on performance evaluation has exhibited, in addition to other parametric methods, the popular usage of nonparametric approach for measuring the comparative efficiency. Data Envelopment Analysis (DEA) has been a common choice since its introduction by Charnes, Cooper and Rhodes (CCR, 1978) and Banker, Charnes and Cooper (BCC, 1984), where it was used to convert inputs into outputs for a Decision–Making Unit (DMU). The traditional DEA models have been developed for the general case of multiple inputs and multiple outputs; however, in some real applications inputs or outputs are implicit and not directly considered. Recently, the greater application of a single constant input DEA model (known as model without explicit input, DEA-WEI) or single constant output DEA model (known as model without explicit output, DEA-WEO) has been utilised in the various areas of static performance evaluation, where all variables have a natural role of input or output (for examples, see Lovell and Pastor, 1999; Zanella et al., 2013; Charles and Kumar, 2014; Karagiannis and Lovell, 2016). The DEA-WEI has been primarily used for measuring the outcomes of units using index indicators in performance evaluation of business, human development, health service, etc. On the other hand, the DEA-WEO has drawn the concern and has been used for resource usage measuring. This approach is similar to what has been known in part of literature as "Benefit-of-the-Doubt (BoD) model", which has defined the assessment seeking to only aggregate outputs for constructing the composite indicators (Melyn and Moesen, 1991; Lovell et al., 1995; Despotis, 2005; Cherchye et al., 2007; Färe and Karagiannis, 2014; and Van Puyenbroeck, 2017; among others).

Although, this literature on DEA-WEO has been rather scarce, the economic significance of this model application seems apparent and has begun to catch the interest of academia and policymakers (see Toloo and Kresta, 2014, 2017, for an assessment of the performance of 139 different alternatives for long-term asset financing at Czechia financial institutions). In the case of tax systems, procedures largely determine the resources that taxpayers (economic agents) use to maintain tax compliance. This is the tax cost imposed on taxpayers when starting or doing business, which is certain and unavoidable, but optimisable (or minimisable, in this case). Therefore, it is undeniable that the more these resources are saved, the more the social deadweight loss is decreased.

In this study, I examine the tax system procedures of 88 countries from various income groups, over 12 years (2005-2016), using the nonparametric frontier approach. In order to observe the tax competitiveness of the countries, in the tax simplification dimension, I have utilised the data envelopment analysis (DEA) model without explicit output (DEA-WEO) to analyse the tax administrative burden (*taxpay* and *taxtime*) for minimising the compliance costs. Besides the contemporaneous efficiency measurement, I derived the panel data DEA model (first proposed by

Surroca et al., 2016, and then extended by Pérez-López et al., 2018), conditional on WEO context for the long-run performance analysis. Moreover, the rankings were applied using a *state-of-the-art* algorithm by Toloo and Kresta (2014), and the measure of productivity change with Malmquist index was adapted from Karagiannis and Lovell (2016) and used to complement the performance evaluation. As a result, I have identified the top-ranked peers to set the benchmarks, the potentials for tax systems to improve, and the implications for policymakers to base my analysis on.

The findings suggest that the tax systems' relative efficiency has been generally increased throughout the years, from 31.3% (2005) to 52.6% (2016), with an increasing integration of the tax simplification trend. The number of efficient units occupies around 4.5%-10.2% of the studied sample. The time-invariant long-run performance indicates the difference among groups. The average score reached 28.7% for the full sample. Switzerland was found to be the only efficient system. Furthermore, the year-on-year evolution of time-variant performance, over the timespan 2005-2016, signifies the uptrend in tax system simplification in each group of countries. It also highlights the general conclusion that Norway had the most feasible practice and model (appearing 600 times in reference sets), followed by Ireland (433 times), Singapore (388 times), and Switzerland (273 times). Moreover, the results of the rankings demonstrate that, on the one hand, the top ranks belong to the expected, classified countries, such as Switzerland, Singapore, New Zealand, Norway and Estonia. This reflects the mature tax systems, simplified effective administrative burden and the effective employment of electronic platform between the tax authorities and taxpayers in these advanced economies. Contrarily, Brazil is acknowledged as a typical case of tax complexity. It achieved the bottom rank over the 12 years, which was caused by burdensome compliance procedures. Another aspect that should be of concern is the productivity change measure. The averages of 27.7% and 19.6% signify the productivity progress for the 2006-2011 and 2011-2016 periods, respectively. Despite the existing inefficient performances during these years, China and the Ukraine had recorded achievements in tax procedure simplification, leading to the highest productivity progress of 327.4% and 318.5% respectively.

This study contributes to the research field in certain aspects. Methodologically, the work extends the standard panel data DEA estimator (Surroca et al., 2016 and Pérez-López et al., 2018) to apply to the model without explicit output condition. Empirically, it is the first application of panel data DEA-WEO proposal for long-run panel estimation in addition to contemporaneous analysis with cross-sectional data DEA-WEO model, to provide practical contribution results from the measuring of tax system performance. Indeed, this is a performance evaluation of tax simplification in 88 countries, over 12 years (2005-2016), addressing the implied social costs (the tax compliance costs) paid by taxpayers in order to comply with taxes. The study provides a thorough view of the tax system competitiveness of different countries, by way of measuring efficiency and ranking and examining the productivity changes of these tax systems. This is, to the best of my knowledge, the first empirical application of tax performance measure with nonparametric frontier method conditional on the implicit output. This accounts for the synthetic assessment and analysis obtained from the combination of the different tax administrative indicators (tax payments and time to comply with taxes). Subsequently, I sought to identify the most feasible reference peers, which the other tax systems may imitate or emulate to become more efficient. Additionally, the assessment of tax simplification efforts, reflecting the level of recovery and innovation, might assist policymakers with creating effective tax design.

The remainder of the chapter is organised as follows. Section 2.2 deals with the theoretical framework and Section 2.3 discusses the methodology and estimators used for measure and computation. Section 2.4 is about sample, data collection, and variable selection. The results relating to performance measure for both contemporaneous and long-run analysis are presented in Section 2.5. Section 2.6 provides the country rankings, which is followed by productivity change measure in Section 2.7. The study finally concludes with a summary of the main findings, policy implications, and suggestions for further research.

## 2.2 Theoretical framework

The model of optimal TA, which was proposed by Keen and Slemrod (KS model, 2017), which was further explained by Creedy (2016), can be simplified in the plot Figure 2 as below

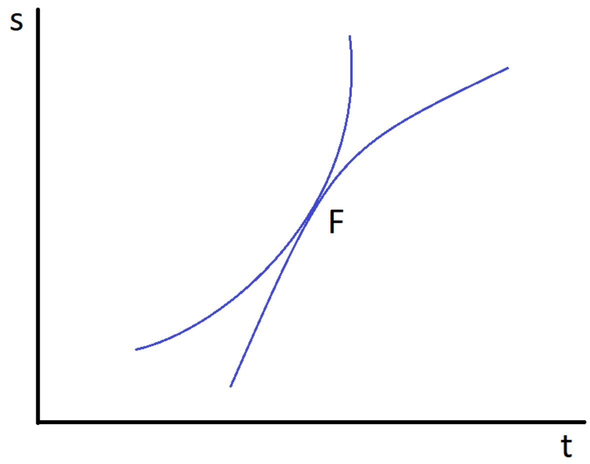



Figure 2: Government optimal choice

where $s$ denotes public non-enforcement spending, and $t$ is the tax rate which is chosen by the government for a given value of enforcement level $\alpha$. The tangent point F illustrates the government optimal combination of $(t,\alpha)$ so that the social welfare is maximised.

KS model considers two cases: (i) choose the optimal $t$ given a fixed $\alpha$; or (ii) set $t$ fixed then choose the optimal $\alpha$. The first case implies, for a predetermined enforcement level $\alpha$, the government raises tax rate until the proportional tax revenue increases. Meanwhile, in the second case, KS derived the government choice of optimal enforcement level $\alpha$ as follows:

$$\emptyset = \alpha\left(\frac{\frac{c_\alpha}{v'}+a_\alpha}{tz}\right) \tag{2.1}$$

It is the adjusted marginal cost-revenue ratio, in the sense that the numerator is a linear approximation to the sum of compliance and administration costs, in which $\emptyset = E(z,\alpha) = \frac{\alpha}{z}\frac{\delta z}{\delta\alpha}$ is referred to as the enforcement elasticity of tax revenue, α is tax enforcement parameter, the term $\frac{c_\alpha}{v'}$ represents the marginal cost of evasion (also referred to the "marginal compliance cost" in Keen and Slemrod), $c_\alpha$ is the marginal private cost, and the term $a_\alpha$ is the marginal administration cost.

The first-order "enforcement" condition in equation (2.1) has a straightforward interpretation in recognisable terms (Creedy, 2016, p.12). By rearranging equation (2.1) into a simple equi-marginal condition, the more intuitive model read:

$$v'\left(\frac{t\delta z}{\delta\alpha}\right) = c_{\alpha} + v'a_{\alpha} \tag{2.2}$$

in which the left-hand side measures the marginal revenue valued in terms of the benefit from the resulting expenditure, and the right-hand side measures the marginal cost of raising that revenue. Therefore, it can be said that for a given tax rate, the marginal benefits and costs of raising α must be equal at the optimum. The revenue component, $\left(\frac{t\delta z}{\delta\alpha}\right)$, and the marginal valuation, v', are likely to fall as α increases, while the marginal costs are likely to increase. Therefore, α increases until the two sides of equation (2.2) are equal, and it acquires the increase in enforcement if marginal revenue is greater than marginal costs.

A direct implication from the abovementioned discussion is, on the one side, that the enforcement cost seems far from the optimum so that the government seeks to reduce the gap between actual costs, namely, official salary and operational expenditures, and the empirical benchmark. This is an exercise of efficiency measurement (see, for example, Alm and Duncan, 2014; Nguyen, Prior, and Van Hemmen, 2020).

On the other side, individual economic agents in the KS model incur some costs to comply with the tax enforcement (Alm, 1996). In this sense, we can consider reducing the tax complexity giving rise to a gain in social welfare, through decreasing social deadweight loss (Allingham and Sandmo, 1972; Paul, 1997; Krause, 2000). From this observation, tax agency would minimise input usage conditional on a unit social welfare or maximise social gains given its current level of complexity. It is worth emphasizing that social welfare is a conceptual (virtual) measurement, which can be normalised by an arbitrary constant; whereas, tax complexity is proxied by several dimensions such as time to comply (*taxtime*) and number of tax payments (*taxpay*) (Lawless, 2013; Awasthi and Bayraktar, 2015). Therefore, benchmarking TA performance across countries and over time can be achieved from utilising the conventional frontier techniques.

## 2.3 Methodology

In this section, I first present the nonparametric frontier methods to measure the performance of tax systems in the presence of a constant input or output. Next, I expand the model to account for panel data. Finally, the ranking and productively change measure methods are discussed.

Every specific decision-making unit (DMU)—tax agency—chooses a production plan, say, a combination of inputs and outputs to convert inputs into outputs. The background of the DEA literature is production theory, and DMUs have a common underlying technology (T), which is:

$$T = \{(x, y) \in R_+^m \times R_+^n \mid x \; can \; produce \; y\}$$

where DMU $k$ uses $m$ inputs to produce $n$ outputs, $x^k = (x_1^k, \ldots, x_m^k) \in R_+^m$ and $y^k = (y_1^k, \ldots, y_n^k) \in R_+^n$.

DEA combines an estimation of the technology with the measurement of performance related to this technology. This is a mathematical programming approach that was introduced by Charnes, Cooper and Rhodes (1978) (CCR), to estimate the best practice production frontiers and evaluate the relative efficiency of different units.

The relative efficiency is defined as the ratio of total weighted output to total weighted input. By comparing $n$ units with single output[25] denoted by $y_j$ and $m$ inputs denoted by $x_{ij}$ ($i \in [1 \ldots m]$), the CCR or constant returns-to-scale (CRS) efficiency measure for DMU $j$ can be expressed in the primal program as

$$\begin{aligned} & min \; \theta_o^* = \textstyle\sum_{i=1}^{m} v_i x_{io} && (2.3) \\ & \text{s.t.} \\ & u y_o = 1 \\ & u y_j - \sum_{i=1}^{m} v_i x_{ij} \le 0 && j = 1, \ldots n \\ & u \ge 0 \\ & v_i \ge 0 && i = 1 \ldots m. \end{aligned}$$

[25] In fact, the CCR model generally accommodates single (multiple) outputs and/or single (multiple) inputs, but, for the sake of simplicity, I intentionally proposed a single output – multiple inputs model.

where $v_i$ and $u$ are weights for $i^{th}$ input and single output, respectively. I solve the program (2.3) $n$ times to obtain a set of $\theta_o^*$—efficiency score of the observed decision-making unit. The unit is called CCR efficient if $\theta_o = \theta_o^{*-1} = 1$[26], otherwise $0 < \theta_o < 1$.

In practice, the case of evaluating performance using (2.3) without a single explicit output or input is found in many applications (for example, see Thompson et al., 1986; Halkos and Salamouris, 2004; Liu et al., 2011; Zanella et al., 2013; Yang et al., 2014; Charles and Kumar, 2014, etc.). If the DMU does not have an explicit output, then Lovell and Pastor (1999) show that no model is found without input or output, but with constant input or output. Thus, any implicit output or input can be replaced with a constant, so that their CRS efficiency scores are also Banker, Charnes and Cooper (1984) (or BCC) variable returns-to-scale (VRS) efficiency measures. Returns-to-scale is, thus, irrelevant in any model with single constant output or input. Model (2.3) is rewritten for $y_j = 1\ \forall j$, which is in the DEA-WEO form where there are only inputs and a single constant output, as

$$\begin{aligned} & min\ \theta_o^* = \textstyle\sum_{i=1}^m v_i x_{io} \\ & s.t. \\ & \textstyle\sum_{i=1}^m v_i x_{ij} \geq 1 \qquad j = 1, \dots n \\ & v_i \geq 0 \qquad\qquad\quad i = 1 \dots m \end{aligned} \tag{2.3'}$$

Besides the cross-sectional computations for short-run performance, I considered the long-run performance of TA agencies by using longitudinal data to capture performance over the period of 2005-2016. I adapted the new proposal of panel data DEA, first suggested by Surroca et al. (2016) and extended by Pérez-López et al. (2018), to apply the single constant output time-invariant panel data DEA model as below.

$$\begin{aligned} & \min_{u^{ti}, v_i^{ti}} \theta_o^{*ti,crs} = \textstyle\sum_{i=1}^m v_i^{ti}\, \bar{x}_i^o \\ & s.t. \\ & u^{ti}\bar{y}_o = 1 \\ & u^{ti} y_j - \sum_{i=1}^m v_i^{ti} x_{ij}^\tau \leq 0 \qquad j = 1 \dots n;\ \tau = 1 \dots t \\ & u^{ti} \geq 0;\ v_i^{ti} \geq 0; \qquad\quad i = 1, \dots, m. \end{aligned} \tag{2.4}$$

[26] The inversion is only valid for CRS case.

where the superscript $ti$ merely refers to time-invariant panel measure. Practically, one sets the constant output $y_j = 1$ for all DMUs so that $u^{ti} = 1$. Subscripts $i$ and $j$ have a usual meaning as in (2.3), while $\tau$ is the time variable that runs from period 1 to t. Overbar $\bar{x}_i{}^o$ represents the average value of input $x_i$ of the observed DMU over the time, and $v_i^{ti}$ ($i \in [1 \dots n]$) are common weights. The input-oriented efficiency score is merely $\theta_o^{ti,crs} = \left(\theta^{*ti,crs}\right)^{-1}$. Please note that, as shown in Pérez-López et al. (2018), if a DMU is long-run efficient, it is also efficient in each and every year over the assessment period, but not vice versa.

Analogously to the definition of time-variant panel DEA efficiency in Pérez-López et al. (2018), I decompose the time-invariant panel score of model (2.4) as follows.

$$\theta_j^{*ti,crs} = w_1\theta_{j,\tau=1}^{*tv,crs} + w_2\theta_{j,\tau=2}^{*tv,crs} + \cdots + w_T\theta_{j,\tau=t}^{*tv,crs} \qquad (2.5)$$

where the superscript *tv* denotes the time-variant panel score, and $w_{\tau\in[1..t]}$ is the weight set that takes the constant value of *1/t* since in the DEA-WEO model, output is a single constant. $\theta_j^{*tv,crs}$, time-variant panel score of DMU *j*, is computed as in Pérez-López et al. (2018) using the estimated common set of input weights ($v_i^{ti}$) for the complete time span in formula (2.5).

To complement the efficiency assessment, this work employed two alternative estimation techniques to provide insight on the estimated efficiency scores of tax systems in the sample. First, I ranked the tax system performance to discriminate between the efficient units based on their efficiency scores using the two-step mixed integer linear program described in Toloo and Kresta (2014).[27]

Second, I measured the productivity change of TA agencies in these countries, i.e. I adapted Karagiannis and Lovell's (2016) formulas to compute the individual and aggregate Malmquist indices.[28] This is the technology-based productivity index, which is expressed in terms of distance functions defined on the benchmark technology. Applying the input-orientation in the DEA-WEO context, the

[27] See Formula 2.6 in Appendix 1 for details.
[28] See Tone (2004) for more details.

Malmquist index can be decomposed into a product of technical efficiency change effect (ΔTE) and technical change effect (ΔT) as below.

$$Malmquist\ index\ (MI) = (Catch-up) \times (Frontier-shift)$$

$$= \Delta TE \times \Delta T = \frac{D_i^{t+1}(x^{t+1},1)}{D_i^t(x^t,1)}\left[\frac{D_i^t(x^t,1)}{D_i^{t+1}(x^t,1)} \times \frac{D_i^t(x^{t+1},1)}{D_i^{t+1}(x^{t+1},1)}\right]^{\frac{1}{2}} \quad (2.7)$$

The aggregate productivity index is calculated by aggregating the individual productivity indices, adapting Karagiannis and Lovell's (2016) formulas and Zelenyuk's (2006) definition of the aggregate output-oriented Malmquist productivity index to the single constant input model to form the aggregate input-oriented Malmquist productivity index ($M_I^A$) with single constant output as a geometric average of the individual contemporaneous and mixed-period input distance functions.

$$M_I^A = \left[\frac{\sum_k D_{I,k}^t(x_k^{t+1},1)}{\sum_k D_{I,k}^t(x_k^t,1)} \frac{\sum_k D_{I,k}^{t+1}(x_k^{t+1},1)}{\sum_k D_{I,k}^{t+1}(x_k^t,1)}\right]^{1/2} \quad (2.8)$$

## 2.4 Sample and data collection

Tax simplification, following Awasthi and Bayraktar (2015), was measured by the two sub-indicators of paying taxes (as an indicator of measuring the ease of doing business) i.e. time to comply (*taxtime*) and number of payments (*taxpay*). The *taxtime* indicator refers to the time needed to comply with taxes i.e. the time to prepare, file and pay taxes. The *taxpay* indicator measures the total number of tax payments by businesses, including electronic filing. I extracted data on tax complexity from Paying Taxes – PricewaterhouseCoopers (PwC)'s reports[29] (part of the World Bank's Doing Business project) for obtaining the components of tax costs, i.e. time-to-comply with the three individual taxes, which are used as inputs for the performance evaluation in the study. This is the annual data for every year from 2007 to 2018, which corresponds to data for the calendar years 2005-2016. In spite of some criticism on the choice of paying taxes indicator for measuring the tax complexity[30] regarding the robustness of measure, methodology and data presentation, it is considered the only available set of data

[29] See http://www.doingbusiness.org/Methodology/Paying-Taxes for full details of the case study and methodology and http://www.doingbusiness.org/Methodology/Methodology-Note for details on how the data is collected.

[30] See Tran-Nam and Evans (2014) for details.

points providing the objective, worldwide comparison of indicators on the tax simplicity of tax regimes, as mentioned in Awasthi and Bayraktar (2015).

Based on the dataset of Paying Taxes (PwC's reports), the countries are selected conditional to the availability of data and data quality throughout the period of 12 years (2005-2016) to guarantee a balanced panel data. Otherwise, countries are excluded. Finally, I obtain the data set of 88 countries, including 35 OECD countries and 53 other countries, covering all continents and regions and representing the whole world.

Regarding variable selection, in order to measure the performance of tax systems' procedures, I apply the DEA-WEO model with four inputs, namely, total number of tax payments and time to comply for three types of tax (corporate income, labour, and consumption) and a constant virtual output of one. The input variables reflect not only the taxpayers' resources devoted to tax compliance but also the tax system's effort towards procedure simplification to obtain effective tax enforcement.

Tables 1 and 2 show the data description and statistics summary of the variables used in the model.

Table 1. Data description of variables.

| Variable | Definition | Source |
|---|---|---|
| Tax_pay | Number of Tax payments by businesses: the total number of taxes per year paid by businesses, including electronic filing. In other words, it is the frequency with which the company has to file and pay different types of taxes and contributions, adjusted for the manner in which those filings and payments are made per year. | Paying Taxes, PwC & World Bank |
| Tax_time_corp | Time (hour) to comply with corporate income tax i.e. the total time (hours) per year required to prepare, file and pay corporate income tax. | |
| Tax_time_lab | Time (hour) to comply with labour tax i.e. the total time (hours) per year required to prepare, file and pay labour tax. | |
| Tax_time_cons | Time (hour) to comply with consumption tax i.e. the total time (hours) per year required to prepare, file and pay consumption tax. | |

Table 2. Summary statistics of variables used in the model.

| | Tax_pay | | | | | | Tax_time_corp | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | p50 | SD | Min | Max | | Mean | p50 | SD | Min | Max |
| 2005 | 37.4 | 33.5 | 25.9 | 3 | 130 | | 102.0 | 49.0 | 151.5 | 5 | 960 |
| 2006 | 34.3 | 29.5 | 26.0 | 2 | 124 | | 106.8 | 48.5 | 150.0 | 5 | 960 |
| 2007 | 31.2 | 23 | 25.5 | 2 | 113 | | 98.6 | 49.5 | 142.0 | 5 | 960 |
| 2008 | 30.7 | 22 | 27.7 | 2 | 147 | | 95.5 | 48.5 | 126.3 | 5 | 736 |
| 2009 | 28.6 | 20 | 24.6 | 2 | 135 | | 86.3 | 48.5 | 104.3 | 5 | 736 |
| 2010 | 26.4 | 17 | 23.4 | 4 | 135 | | 83.5 | 49.5 | 99.6 | 5 | 736 |
| 2011 | 22.7 | 15 | 17.3 | 4 | 71 | | 79.8 | 53.5 | 93.0 | 10 | 736 |
| 2012 | 22.0 | 12.5 | 17.2 | 4 | 71 | | 79.6 | 53.5 | 92.9 | 10 | 736 |
| 2013 | 21.0 | 11 | 17.0 | 4 | 71 | | 77.8 | 51.5 | 91.8 | 10 | 736 |
| 2014 | 20.1 | 11 | 16.4 | 4 | 70 | | 76.8 | 51.5 | 91.1 | 10 | 736 |
| 2015 | 19.2 | 11 | 16.1 | 4 | 70 | | 70.6 | 51.5 | 70.7 | 10 | 486 |
| 2016 | 18.5 | 11 | 16.0 | 4 | 70 | | 64.6 | 46.0 | 60.8 | 5 | 462 |
| | Tax_time_lab | | | | | | Tax_time_cons | | | | |
| | Mean | p50 | SD | Min | Max | | Mean | p50 | SD | Min | Max |
| 2005 | 159.3 | 96.0 | 149.8 | 10 | 800 | | 150.2 | 96.0 | 197.3 | 8 | 1374 |
| 2006 | 156.4 | 98.5 | 146.6 | 10 | 732 | | 147.3 | 94.0 | 192.7 | 8 | 1374 |
| 2007 | 143.6 | 96.0 | 129.4 | 10 | 700 | | 134.9 | 90.0 | 170.4 | 8 | 1374 |
| 2008 | 136.1 | 96.0 | 124.7 | 10 | 700 | | 129.0 | 86.0 | 167.7 | 8 | 1374 |
| 2009 | 125.6 | 96.0 | 103.3 | 10 | 490 | | 126.4 | 84.5 | 164.3 | 8 | 1374 |
| 2010 | 121.1 | 86.5 | 102.9 | 10 | 490 | | 121.9 | 79.5 | 163.2 | 8 | 1374 |
| 2011 | 113.6 | 86.0 | 95.7 | 10 | 507 | | 115.1 | 76.0 | 160.8 | 8 | 1374 |
| 2012 | 112.4 | 86.0 | 95.3 | 10 | 507 | | 113.9 | 73.0 | 161.0 | 8 | 1374 |
| 2013 | 108.8 | 80.0 | 94.9 | 10 | 507 | | 112.1 | 69.5 | 161.7 | 8 | 1374 |
| 2014 | 106.5 | 80.0 | 92.8 | 12 | 507 | | 111.6 | 69.0 | 161.5 | 8 | 1374 |
| 2015 | 100.0 | 80.0 | 83.9 | 13 | 507 | | 105.4 | 69.5 | 138.1 | 8 | 1189 |
| 2016 | 95.0 | 77.0 | 77.6 | 10 | 507 | | 102.5 | 67.5 | 135.7 | 8 | 1161 |

## 2.5 Performance measure

In this section, I measure the performance of tax procedure simplification using a DEA-WEO model, based on the contemporaneous analysis with annual data and the long-run analysis with longitudinal data.

### *2.5.1 Contemporaneous analysis*

I utilise the DEA-WEO model with data from the 12 years between 2005 and 2016. As mentioned earlier in the Data section, the model uses four inputs, i.e. number of payments and time to comply with three types of tax (corporate income, labour, and consumption), and a constant virtual output of one. Table 3 reports the summary statistics of the efficiency scores of these tax agencies during these years.[31]

Table 3. Summary statistics of contemporaneous efficiency scores for 12 years.

| Statistics | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 0.400 | 0.413 | 0.457 | 0.476 | 0.488 | 0.512 | 0.535 | 0.543 | 0.566 | 0.580 | 0.563 | 0.522 |
| Std. dev | 0.260 | 0.253 | 0.249 | 0.257 | 0.252 | 0.248 | 0.244 | 0.243 | 0.244 | 0.244 | 0.238 | 0.216 |
| Min | 0.046 | 0.050 | 0.091 | 0.098 | 0.109 | 0.104 | 0.115 | 0.115 | 0.115 | 0.121 | 0.120 | 0.095 |
| Median | 0.313 | 0.344 | 0.409 | 0.411 | 0.423 | 0.482 | 0.500 | 0.510 | 0.519 | 0.543 | 0.542 | 0.526 |
| IQR | 0.322 | 0.328 | 0.300 | 0.326 | 0.336 | 0.364 | 0.355 | 0.332 | 0.341 | 0.356 | 0.362 | 0.326 |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Note: IQR is interquartile range | | | | | | | | | | | | |

As observed in Table 3, the average performance of tax systems has improved throughout the years, demonstrating an increase from a median of 31.3% in 2005 to above 52% in the last three years 2014-2016, with a fluctuation within the range of 52%-56%. This was also accompanied by a gradual reduction in standard deviation throughout the years, signalling an increasingly narrowed dispersion of the efficiency in tax simplification process among countries in the sample. It could be argued that the estimated distance from the frontiers throughout the years (for example, 68.7% for 2005 or 48% for 2016) has revealed many opportunities for these countries to improve the simplification of tax procedures. The countries that make the list of relative efficiency will be introduced later, in Table 5.

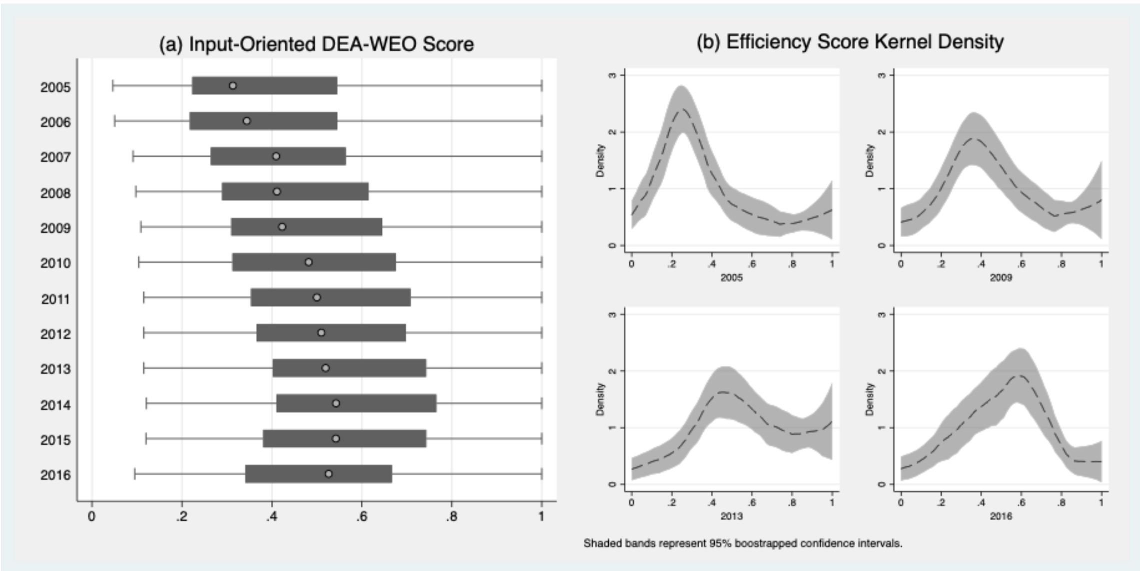



Figure 3. Contemporaneous efficiency scores of tax systems through 12 years.

[31] All computations are programmed in R, and available upon request. The full performance estimation can be found in Table A.4 in the Online Appendix

Figure 3(a) graphically depicts the trend of efficiency scores of tax systems throughout the 12 years. Figure 3(b) shows the distribution of efficiency scores for some typical years (i.e. 2005, 2009, 2013, and 2016). It seems reasonable to confirm that movement of efficiency shifts from the left to the right side throughout the years, representing the growing efficiency and convergence tendency of the benchmarking countries.

### *2.5.2 Long-run panel data DEA analysis*

In order to observe the long-run performance of the tax systems for the entire period (2005-2016), I apply the panel data DEA model for WEO conditions (or panel data DEA-WEO).

Table 4 shows the summary statistics of the time-invariant long-run performance, classified by the different groups: (i) full sample, (ii) OECD and non-OECD, and (iii) high income, upper middle income, low income and lower middle income.[32]

Table 4. Time-invariant long-run DEA efficiency scores.

| Statistics | Mean | Std. dev | Median | Min | Max |
|---|---|---|---|---|---|
| Full Sample | 0.353 | 0.207 | 0.287 | 0.088 | 1 |
| OECD | 0.500 | 0.200 | 0.464 | 0.210 | 1 |
| Non-OECD | 0.256 | 0.145 | 0.228 | 0.088 | 0.960 |
| High income | 0.496 | 0.218 | 0.460 | 0.176 | 1 |
| Upper Middle Income | 0.288 | 0.122 | 0.270 | 0.092 | 0.674 |
| Lower Middle & Low Income | 0.197 | 0.072 | 0.201 | 0.088 | 0.325 |

As observed in Table 4, the tax systems in the sample show, on the average, an inefficiency in tax administrative burden performance, with a median of 28.7% efficiency. The minimum relative efficiency is quite low (8.8%) and this belongs to the Ukraine.[33] Remarkably, the only relatively long-run efficient country is Switzerland, asserting a stable performance over the 12 years. I did also consider two other countries, Norway (96.2%) and Singapore (96%), to be efficient over the period. These countries are followed by Ireland (80.9%). These tax systems appear the most frequently in the reference

[32] Income classification adapted from World Bank, which divides income level into 3 groups, (i) high-income economies (HIC) are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $12,376 or more; (ii) upper middle-income economies (UMC) are those between $3,996 and $12,375; and (iii) lower middle-income & low-income economies (LMC) are those $3,995 or less.

[33] Refer to Section 2.7 (Productivity change measure) for more discussion about the Ukraine.

sets and should be regarded as the most feasible benchmarking units to be learnt from by other peers in the segments.[34] Besides, there is sharp difference between OECD and non-OECD groups, illustrated by the respective medians of 46.4% and 22.8%. In terms of income groups, the high-income group's superiority (46%) was very clear when compared with upper-middle income group (27%) and lower-middle and low income group (20.1%). Obviously, the non-OECD and middle and low-income groups will require many improvements in tax simplification to reach the levels of the OECD and high-income groups, which are still far from the potential frontiers.

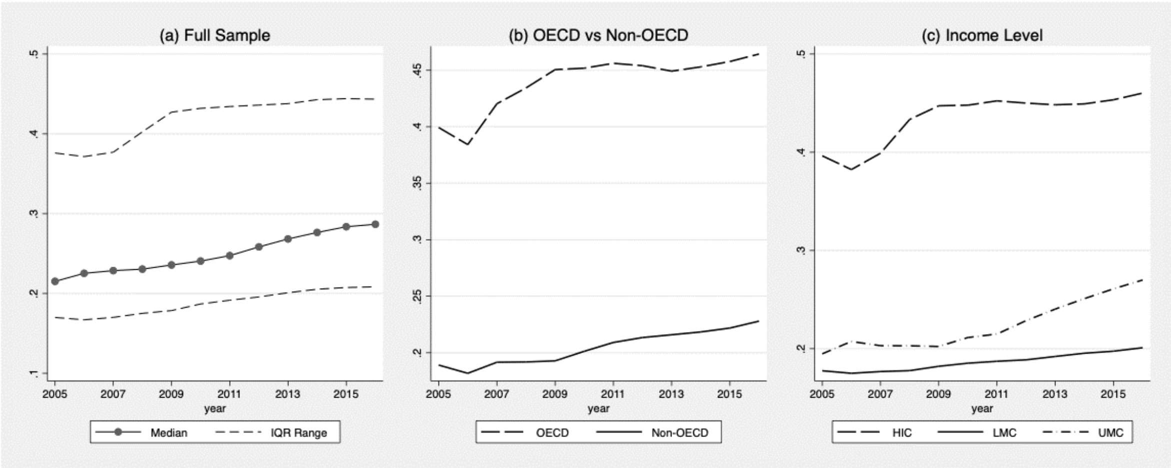



Figure 4. Evolution of time-variant panel data efficiency over years.

In terms of time-variant long-run efficiency estimation, the study revealed the year-on-year evolution of the time-invariant performance during the period. Figure 3 depicts the evolution of median values of time-variant panel data efficiency throughout the 12-year period.[35] While Figure 4(a) characterises the full sample, Figure 4(b) demonstrates the difference between OECD and non-OECD groups and Figure 4(c) illustrates performance according to income level. The figures suggest an uptrend for the average performance of tax systems throughout the years, with a rise from the median of 21.5% in 2005 to a median of 28.7% in 2016. In addition, the standard deviation decreasing from 22.9% (2005) to 20.7% (2016) demonstrates the convergence tendency of tax simplification efficiency. The uptrend of tax simplification efficiency appears in all groups, regardless of the existing gaps in their

[34] Refer to Table A.4 in the Online Appendix for the panel efficiency scores.

[35] Estimation results of time-variant long-run efficiency, classified by different groups, can be found in Table A.3 in the Appendix.

performances. OECD countries experience the 7% increase in reduction of tax costs (from 39.9% in 2005 to 46.4% in 2016) compared to the non-OECD group's rise of 4% (from 18.9% in 2005 to 22.8% in 2016). Meanwhile, the improvements are obtained at 6.4%, 7.5%, and 2.3% for high-income, upper-middle, and lower-middle and low income groups, respectively. These findings confirm the need for greater efforts in tax procedure simplification in non-OECD and middle and low-income countries in order to achieve better performance.

I conducted nonparametric tests to consolidate the significant difference in efficiency and its distribution across the years. The results from the tests suggest a significant inequality in kernel density and difference in rank between 2005 or the panel and the other individual years in terms of density (see Table A2 in the Appendix: Nonparametric tests).

### *2.5.3 Benchmarking performance*

Table 5. The efficient DMUs with times appearing in reference sets through years.

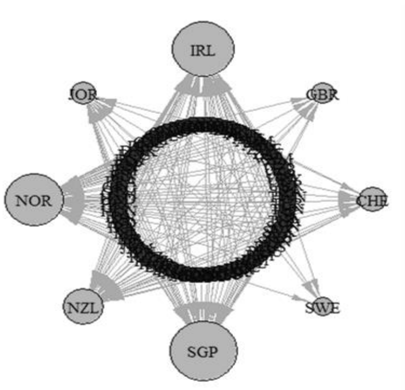
| Country | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Panel | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Estonia | | | | | 29 | | | 29 | 35 | 14 | | 61 | | 168 |
| Finland | | | | 16 | 6 | 27 | 28 | 9 | 9 | 32 | 23 | | | 150 |
| France | | | | | 9 | 14 | 20 | 5 | | | | | | 48 |
| Ireland | 48 | 64 | 40 | 39 | 39 | 38 | 36 | 29 | 31 | 32 | 37 | | | 433 |
| Jordan | 15 | 6 | 4 | 4 | 5 | 5 | 2 | 2 | 1 | 1 | 1 | | | 46 |
| New Zealand | 30 | | 45 | 41 | | | | | | | | | | 116 |
| Norway | 46 | 51 | 51 | 54 | 47 | 45 | 49 | 49 | 60 | 63 | 40 | 45 | | 600 |
| Singapore | 45 | 49 | 23 | 22 | 27 | 30 | 29 | 23 | 19 | 15 | 54 | 52 | | 388 |
| Sweden | 4 | 14 | 20 | 20 | 15 | 18 | 20 | 24 | | | | | | 135 |
| Switzerland | 11 | 21 | 23 | 24 | 33 | 32 | 30 | 28 | 25 | 25 | 20 | 1 | x | 273 |
| United Kingdom | 7 | | | | | | | | | | | | | 7 |
| Total | 206 | 205 | 206 | 220 | 210 | 209 | 214 | 198 | 180 | 182 | 175 | 159 | | 2364 |

Table 5 summarises the efficient tax systems, taking short-run and long-run perspectives and discussing number of appearances in the reference sets, corresponding to the individual year and efficient country. As discussed earlier, of the 88 studied tax systems, Switzerland is the only efficient unit, when considering the time-invariant panel data estimation. Two other countries, Norway and Singapore, were found to be inefficient, despite being found to be efficient in all 12 years from 2005 to 2016.

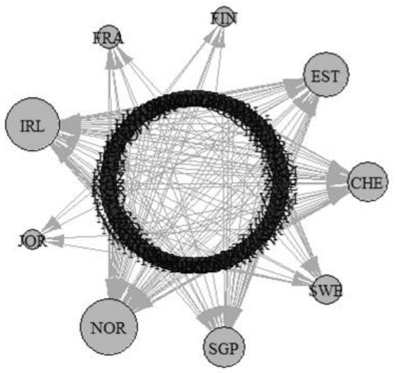
In the extreme of benchmark performance, I identified 11 countries to form the efficiency list, including Estonia, Finland, France, Ireland, Jordan, New Zealand, Norway, Singapore, Sweden, Switzerland, and the United Kingdom. The number of efficient units for the 12 years vary from four to nine, occupying approximately 4.5% to 10.2% of the studied sample.

Another finding that should be of concern are the good practices and models. Ireland ranks first in the years 2005 and 2006, appearing 48 times and 63 times, respectively, in the reference sets. The list of top ranking for consecutive years includes Norway for 8 continuous years from 2007 to 2014 (with 51 times, 54 times, 47 times, 45 times, 49 times, 49 times, 60 times, and 63 times, respectively); and accounts for Singapore (54 times), and Estonia (61 times) for the last 2 years 2015 and 2016, respectively. Accordingly, during the whole period (2005-2016), Norway appears the most with a total of 600 times. As a result, Norway is likely to be the best practice and model for other tax systems in the segment to imitate and emulate. Norway is followed by Ireland and Singapore, with a total of 433 times and 388 times, respectively. Switzerland only appears 273 times as a reference peer, even though it was found to be efficient every year of the whole period and is the only efficient tax system when considering the long-run performance estimation.

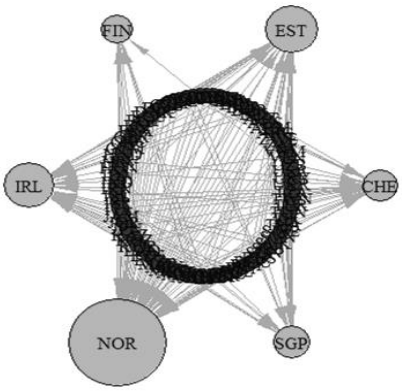
Figure 5 illustrates the reference sets in certain years. The outer circles represent the peer units. The bigger the circle, the more frequently this unit appears in the reference sets for the other units in the segments to imitate and emulate. The arrow connects an inefficient unit—lying on the central ring—to its peers in the reference set, so that the connection density between the outer circle and the ring represents the number of times that an efficient tax agency appears as a good practice and model. In this respect, Figure 5 visualises the information summarised in Table 5.



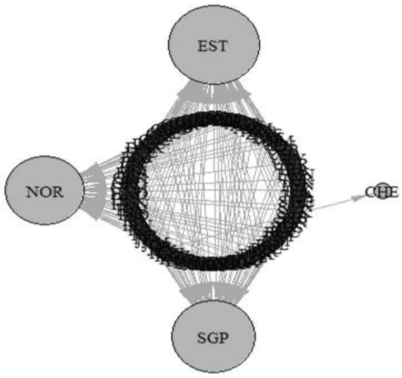

2005




2009




2013




2016

Figure 5. Reference set visualisation.

## 2.6 Rankings

The preceding analysis provides a list of efficient tax systems (efficiency scores are of 1) in Table 5, but the DEA-WEO estimator cannot distinguish efficient agencies from one another as they all have the same scores of one. Practically, it is tempting to rank these tax systems based on their efficiency level (performance in terms of tax system simplification) to provide guidance for policy implementation (or implication).

Using the ordering method specifically designed for DEA-WEO model (Toloo and Kresta, 2014),[36] I compute the ranks of the studied countries for every year from 2005 to 2016, and present the best and worst 10 countries classified by the different groups: (i) full sample, (ii) OECD, and (iii) non-OECD corresponding to each year in Table 6a (interested readers should refer to Table A5 in the Online Appendix for the full list of rankings).

Table 6a. The 10 top and bottom ranked tax systems through years (2005-2016), full sample.

| | Rank | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **THE BEST** | | | | | | | | | | | | | |
| **Full** | 1 | SGP | SGP | NZL | NZL | CHE | CHE | CHE | CHE | CHE | CHE | SGP | EST |
| | 2 | NZL | NZL | IRL | IRL | IRL | IRL | SGP | SGP | SGP | NOR | CHE | SGP |
| | 3 | CHE | IRL | CHE | CHE | EST | SGP | IRL | IRL | NOR | EST | NOR | CHE |
| | 4 | IRL | CHE | SGP | SGP | SGP | NOR | NOR | NOR | EST | SGP | IRL | NOR |
| | 5 | NOR | NOR | NOR | NOR | NOR | EST | EST | EST | IRL | IRL | EST | IRL |
| | 6 | GBR | EST | EST | EST | GBR | FIN | FIN | FIN | FIN | FIN | FIN | FIN |
| | 7 | EST | GBR | GBR | MKD | AUS | GBR | GBR | GBR | AUS | AUS | AUS | AUS |
| | 8 | AUS | AUS | MKD | GBR | SWE | AUS | AUS | AUS | GBR | GBR | GBR | GBR |
| | 9 | JOR | SWE | AUS | AUS | JOR | SWE | SWE | SWE | MKD | MKD | MKD | LTU |
| | 10 | SWE | JOR | SWE | SWE | CAN | NLD | NLD | NLD | SWE | SWE | SWE | MKD |
| | | | | | | | | | | | | | |
| **OECD** | 1 | NZL | NZL | NZL | NZL | CHE | CHE | CHE | CHE | CHE | CHE | CHE | EST |
| | 2 | CHE | IRL | IRL | IRL | IRL | IRL | IRL | NOR | NOR | NOR | NOR | CHE |
| | 3 | IRL | CHE | CHE | CHE | EST | NOR | NOR | EST | EST | EST | IRL | NOR |
| | 4 | NOR | NOR | NOR | NOR | NOR | EST | EST | IRL | IRL | IRL | EST | IRL |
| | 5 | GBR | EST | EST | EST | GBR | FIN | FIN | FIN | FIN | FIN | FIN | FIN |
| | | | | | | | | | | | | | |
| **Non-OECD** | 1 | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP |
| | 2 | JOR | JOR | MKD | MKD | JOR | JOR | MYS | MYS | MKD | MKD | MKD | MKD |
| | 3 | MKD | MKD | JOR | JOR | TUN | MYS | MKD | MKD | MYS | MYS | TUN | MNG |
| | 4 | THA | MYS | MYS | MYS | MYS | MKD | TUN | TUN | TUN | TUN | CRI | JOR |
| | 5 | PHL | TZA | ZAF | ZAF | MKD | TUN | JOR | JOR | ROU | CRI | MNG | TUN |
| | | | | | | | | | | | | | |
| **THE WORST** | | | | | | | | | | | | | |
| **Full** | 79 | CZE | VEN | VEN | COG | ECU | ECU | CAF | CAF | CAF | CAF | BGR | EGY |
| | 80 | VNM | CZE | CZE | UKR | COG | COG | PAK | PAK | PAK | PAK | CAF | BGR |
| | 81 | TWN | VNM | UKR | VEN | CMR | BLR | ECU | COG | COG | COG | VNM | VNM |
| | 82 | BOL | BOL | NGA | NGA | UKR | CMR | COG | ECU | ECU | ECU | COG | CAF |
| | 83 | NGA | NGA | ARM | BLR | BLR | UKR | CMR | CMR | CMR | CMR | ECU | COG |
| | 84 | ARM | ARM | VNM | ARM | VEN | VEN | VEN | VEN | VEN | VNM | CMR | CMR |
| | 85 | BLR | BLR | BOL | VNM | NGA | VNM | VNM | VNM | VNM | VEN | VEN | ECU |
| | 86 | CMR | CMR | BLR | BOL | VNM | NGA | NGA | NGA | NGA | NGA | NGA | VEN |
| | 87 | UKR | UKR | CMR | CMR | BOL | BOL | BOL | BOL | BOL | BOL | BOL | BOL |
| | 88 | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA |
| | | | | | | | | | | | | | |
| **OECD** | 31 | ITA | SVK | SVK | ITA | CHL | CHL | CHL | CHL | CHL | HUN | ISR | CZE |
| | 32 | CHL | JPN | JPN | JPN | POL | POL | POL | POL | POL | MEX | POL | POL |
| | 33 | MEX | POL | POL | POL | JPN | JPN | MEX | MEX | MEX | CHL | HUN | ISR |
| | 34 | ESP | MEX | MEX | MEX | MEX | MEX | JPN | JPN | JPN | JPN | MEX | HUN |
| | 35 | CZE | CZE | CZE | CZE | CZE | CZE | CZE | CZE | CZE | CZE | CHL | CHL |
| | | | | | | | | | | | | | |
| **Non-OECD** | 49 | ARM | ARM | VNM | ARM | VEN | VEN | VEN | VEN | VEN | VNM | CMR | CMR |
| | 50 | BLR | BLR | BOL | VNM | NGA | NGA | VNM | VNM | VNM | VEN | VEN | ECU |
| | 51 | CMR | CMR | BLR | BOL | VNM | VNM | NGA | NGA | NGA | NGA | NGA | VEN |
| | 52 | UKR | UKR | CMR | CMR | BOL | BOL | BOL | BOL | BOL | BOL | BOL | BOL |
| | 53 | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA |

[36] The computations are programmed in GAMS and are available upon request.

As can be seen in general, Singapore is the top ranked tax system in 2005, 2006, and 2015. New Zealand is ranked first in 2007 and 2008. Estonia is the best country in 2016. Switzerland tops the board for the six consecutive years from 2009 to 2014. In reverse, the bottom ranked country is Brazil for all years of the period (2005-2016). The list of the worst countries also includes Bolivia, Ukraine, Cameroon, and Czechia among others.

Looking into groups, New Zealand appears the best in 4 consecutive years 2005-2008, Switzerland leads the table in 7 continuous years 2009-2015, and the top belongs to Estonia in 2016 for the OECD group. On the contrary, Czechia occupies the bottom the most frequently in 10 years, from 2005 to 2014 besides Chile in 2015-2016. As regards the non-OECD group, Singapore undeniably outperforms during the whole timespan 2005-2016, oppositely to Brazil at the bottom list as anticipated.

Switzerland's efficiency derives from tax simplification. While the tax procedures (i.e. tax payments) during the period are not far from the average number of the sample,[37] the compliance time quite clearly demonstrates the great effort expended towards tax system improvement and reform. In general, Switzerland uses 15 hours for corporate income tax, 40 hours for labour tax, and 8 hours for consumption tax. These numbers show a superiority over the average sample from 102 to 64 hours, from 159 to 95 hours, and from 150 to 102 hours, corresponding to the three afore-mentioned taxes (see Table 2 for summary statistics of the variables). This signifies the effective and efficient process and lower compliance cost resulting from the automation and modernisation of the tax system in this country. In the more recent years (from 2015 onwards), however, Switzerland is not regarded as the leading unit any longer. This may mean that this country had already reached its optimal capacity, and/or that its technology seems infeasible, hindering peers from imitating and elaborating on the technology (refer to Table 5 and Figure 5 for more details).

[37] Switzerland applied 13 tax payments in 2005, which was then increased to 24 payments in the next 3 years (from 2006 to 2008), before finally reducing and remaining at 19 payments for the eight consecutive years (2009-2016). The sample's average number of payments shows a downtrend from 37.4 in 2005 to 18.5 in 2016.

Singapore's outcomes were clearly due to the tax system's simplicity. Singapore only carried out a small number of tax payments during the period, while also having a smaller amount of time for tax compliance.[38]

Likewise, New Zealand, during the 12 years (2005-2016), is found to be efficient in 3 years (2005, 2007, and 2008). 2007 and 2008 helped to establish the first order, with the same 8 tax payments and 70 hours. The resources that taxpayers in this country spent on tax compliance are much lower than the average level (around 31 and 30 payments, and 377 and 360 hours) of the studied countries in the sample. Nonetheless, the later years (2009-2016) reveal a considerable rise in tax time, despite reducing the tax payments, kicking New Zealand out of the efficiency list.

It is worth noting the case of Estonia, which gains the most efficient classification in 2016 with a total of 8 payments and only 50 hours of tax procedures. It also appears in the reference sets in 2009, 2012, 2013 and 2014. In accordance with the digital economy and e-Government model, Estonia implemented new electronic services in TA. Consequently, Estonia is among the most competitive tax systems in the developed world, having a simplified tax system, neutral property taxes, and a simple, broad-based value-added tax. This country has been used as an example when discussing the business tax reform, due to the full expensing and single layer of taxation on corporations, the exemption of foreign earned income, and the well-structured property taxes.

On the other hand, Brazil is a typical case of tax complexity, highlighting the need to simplify tax procedures for the sake of tax compliance. Although the number of tax payments is below the average number of the studied sample, the taxpayers in this country generally spend a large amount of time on tax compliance, which is far from the average level of the sample.[39] It is clear that Brazil has been following the trend of tax simplification and has made some improvement with respect to tax payments

[38] Singapore had 16 payments, 5 payments, and 5 payments in 2005, 2006, and 2015, respectively; along with 10 hours for each of three taxes in 2005; 30 hours, 10 hours, and 9 hours for these taxes in 2006; and 24 hours, 10 hours, and 30 hours for these taxes in 2015.

[39] Brazil reduced the tax payments from 23 in 2005 to 10 in 2016, compared to the general average (from 37 in 2005 to 18 in 2016). In terms of time-to-comply, it was a consumption of 2600 hours and 1958 hours, for 2005 and 2016, respectively, which were far beyond the average (411 hours in 2005 reduced to 262 hours in 2016).

and tax compliance time. Brazil is still far from achieving efficiency and competitiveness in reducing the tax expenditures and relieving the burden of starting and/or doing business cost. By achieving this, Brazil may attract more investment and new entry, which may contribute to the country's economic growth.

I also ran the rankings corresponding to two separate sub-groups and the results are introduced in Table 6b. Accordingly, the results largely hold as expected.

Table 6b. The top and bottom ranked tax systems through years (2005-2016), sub-samples.

| | Rank | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OECD** | **THE BEST** | | | | | | | | | | | | |
| | 1 | NZL | NZL | NZL | NZL | CHE | CHE | CHE | CHE | CHE | CHE | CHE | EST |
| | 2 | CHE | IRL | IRL | IRL | IRL | IRL | IRL | NOR | NOR | NOR | NOR | CHE |
| | 3 | IRL | CHE | CHE | CHE | EST | NOR | NOR | EST | EST | EST | IRL | NOR |
| | 4 | NOR | NOR | NOR | NOR | NOR | EST | EST | IRL | IRL | IRL | EST | IRL |
| | 5 | GBR | EST | EST | EST | GBR | FIN | FIN | FIN | FIN | FIN | FIN | FIN |
| | **THE WORST** | | | | | | | | | | | | |
| | 31 | ITA | SVK | SVK | ITA | CHL | CHL | CHL | CHL | CHL | HUN | ISR | CZE |
| | 32 | CHL | ITA | JPN | JPN | POL | POL | POL | POL | POL | MEX | POL | POL |
| | 33 | MEX | POL | POL | POL | JPN | JPN | MEX | MEX | MEX | CHL | HUN | ISR |
| | 34 | ESP | MEX | MEX | MEX | MEX | MEX | JPN | JPN | JPN | JPN | MEX | HUN |
| | 35 | CZE | CZE | CZE | CZE | CZE | CZE | CZE | CZE | CZE | CZE | CHL | CHL |
| **Non-OECD** | **THE BEST** | | | | | | | | | | | | |
| | 1 | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP | SGP |
| | 2 | JOR | JOR | MKD | MKD | JOR | JOR | MYS | MYS | MKD | MKD | MKD | MKD |
| | 3 | MKD | MKD | JOR | JOR | TUN | MYS | MKD | MKD | MYS | MYS | TUN | MNG |
| | 4 | THA | MYS | MYS | MYS | MYS | MKD | TUN | TUN | TUN | TUN | CRI | TUN |
| | 5 | PHL | TZA | ZAF | ZAF | MKD | TUN | JOR | JOR | ROU | CRI | MNG | JOR |
| | **THE WORST** | | | | | | | | | | | | |
| | 49 | ARM | ARM | VNM | ARM | VEN | VEN | VEN | VEN | VEN | VNM | CMR | CMR |
| | 50 | BLR | BLR | BOL | VNM | NGA | NGA | VNM | VNM | VNM | VEN | VEN | ECU |
| | 51 | CMR | CMR | BLR | BOL | VNM | VNM | NGA | NGA | NGA | NGA | NGA | VEN |
| | 52 | UKR | UKR | CMR | CMR | BOL | BOL | BOL | BOL | BOL | BOL | BOL | BOL |
| | 53 | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA | BRA |

## 2.7 Productivity change measure

The productivity change is measured by distance function through Malmquist index (MI)[40] (Karagiannis and Lovell, 2016) for the 2006-2011 and 2011-2015 periods, respectively. This index represents effort on tax system reform (concerning number of payments and time-to-comply for taxes) of TA agencies across the countries included in the sample. A great MI signifies a good improvement

[40] The computations are done in GAMS, and available upon request.

in tax system procedures, i.e. less administrative burden. MI > 1 represents a progress in total factor productivity, which is opposed by a regress in the total factor productivity represented by MI < 1. MI = 1 indicates status quo in the total factor productivity. To see the potential change of productivity during the period, I chose three years (2006, 2011, and 2016) as the interval points to mark equal intervals of five years. These years were also chosen due to the similar distribution of efficiency score for two years 2005 and 2006 (see Figure 3 for the efficiency scores of tax systems throughout 12 years).

The results show that, on the average, these countries obtain productivity progress in both periods, showing the mean indices of 1.277 and 1.196, respectively. It was found that the progress was slightly higher in the former period (see Table 7). This might be explained by the fact that the countries in the sample had, in the latter period, already reached or approached their own frontiers relating to the extent of tax system simplification, causing the slowdown in productivity change.[41]

Table 7. Summary of Malmquist index

| Statistics | Min | Median | Mean | Max | Aggregation |
|---|---|---|---|---|---|
| Malmquist index (MI) 2006-2011 | 0.575 | 1.047 | 1.277 | 4.274 | 1.076 |
| Catch-up (ΔTE) | 0.586 | 1.269 | 1.540 | 4.786 | |
| Frontier-shift (ΔT) | 0.449 | 0.903 | 0.858 | 1.055 | |
| | | | | | |
| Malmquist index (MI) 2011-2016 | 0.705 | 1.025 | 1.196 | 4.185 | 1.125 |
| Catch-up (ΔTE) | 0.500 | 0.922 | 1.043 | 3.978 | |
| Frontier-shift (ΔT) | 0.992 | 1.152 | 1.166 | 2.001 | |

The former period, 2006 to 2011, shows progress in the relative efficiency (ΔTE = 1.540) accompanied by a regress in the frontier technology (ΔT = 0.858). This is the opposite of the latter period, 2011 to 2016, which shows progress both in the relative efficiency (ΔTE = 1.043) and in the frontier technology (ΔT = 1.166). To be clear, in the former period, the slow shift of frontier opened space for the tax systems in the studied countries to keep pace with the frontier, and vice versa, in the latter period. The quick shift of frontier slowed down in some of the tax systems in the segment, making them lag behind the frontier. This resulted in the lower average index in the latter period when compared to the former period.

[41] The full details can be found in Tables A6-A7 in the Online Appendix.

In terms of aggregate productivity index, similar to MI with composition, the progress in both periods was represented by the respective indices of 1.076 and 1.125. Unlike the mean Malmquist index with decomposition, however, the progress is slightly higher in the latter period. If compared between the two Malmquist indices within every period, a decrease in aggregation index (1.076 vs. 1.277 and 1.125 vs. 1.196 for 2 periods, respectively) became apparent. As mentioned in the formula for computation (Methodology section), in the single constant output case, the aggregate input-oriented MI is given by the geometric average between any two periods of the simple (un-weighted) arithmetic average of the individual contemporaneous and mixed period input distance functions. The results help consolidate the improvement in total factor productivity for the countries in both periods. Moreover, the aggregation Malmquist index (or harmonic mean) could be of higher validity and reliability, compared to simple mean MI values, and eliminated the leveraging effects of some super-efficiency units in the samples.

Table 8a shows, in overall, the most and the least improved ten countries, due to the technology progress level in tax procedure simplification. In the former period (2006-2011), the ten countries that mainly belong to non-OECD group form the top list are China, Ukraine, Russia, Mexico, Armenia, Korea, Belarus, Argentina, Tunisia, and Slovak Republic, whose productivity progress was recorded between 327.4% (MI = 4.274) and 83% (MI = 1.83). Accordingly, China gained the leading position with the decomposition of progress in technical efficiency (ΔTE = 4.786) and a technical regress (ΔT = 0.893). It seems clear that China greatly improved their technical efficiency and, thus, achieved a great improvement in tax procedure simplification.[42] The innovation aspect, however, revealed an incompatible shift of the frontier. Put differently, China's frontier shifted quite slowly, facilitating the improvement of its technical efficiency. This could be seen through their relatively inefficient performance of 11.9% in 2006, increasing up to 57.1% in 2011, leaving the substantial distance to the potential frontier of the segment.

[42] In 2011, China applied 7 payments and taxpayers needed 74 hours to comply with corporate tax, 152 hours for labour tax, and 112 hours for consumption tax; compared to 35 payments, 200 hours for corporate tax, 288 hours for labour tax, and 384 hours for consumption tax in 2006.

Table 8a: Top & Bottom 10 countries ranked by Malmquist index, full sample.

| Period | | 2006-2011 | | | | 2011-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Country | MI | ΔTE | ΔT | Country | MI | ΔTE | ΔT |
| TOP | Full | CHN | 4.274 | 4.786 | 0.893 | UKR | 4.185 | 3.978 | 1.052 |
| | | UKR | 3.968 | 3.990 | 0.994 | GTM | 2.549 | 2.374 | 1.074 |
| | | RUS | 3.379 | 4.197 | 0.805 | VNM | 2.153 | 2.113 | 1.019 |
| | | MEX | 3.076 | 4.263 | 0.722 | TJK | 2.119 | 1.911 | 1.109 |
| | | ARM | 2.785 | 3.044 | 0.915 | MAR | 2.046 | 1.903 | 1.075 |
| | | KOR | 2.123 | 3.349 | 0.634 | IND | 1.763 | 1.475 | 1.195 |
| | | BLR | 1.962 | 2.543 | 0.772 | POL | 1.761 | 1.651 | 1.067 |
| | | ARG | 1.906 | 2.233 | 0.853 | ROU | 1.742 | 1.422 | 1.225 |
| | | TUN | 1.890 | 2.567 | 0.736 | UZB | 1.725 | 1.523 | 1.133 |
| | | SVK | 1.830 | 1.918 | 0.954 | EST | 1.646 | 1.028 | 1.602 |
| | OECD | MEX | 3.076 | 4.263 | 0.722 | POL | 1.761 | 1.651 | 1.067 |
| | | KOR | 2.123 | 3.349 | 0.634 | EST | 1.646 | 1.028 | 1.602 |
| | | SVK | 1.830 | 1.918 | 0.954 | SVK | 1.395 | 1.215 | 1.149 |
| | | FIN | 1.767 | 1.834 | 0.963 | LTU | 1.390 | 1.147 | 1.212 |
| | | POL | 1.588 | 1.704 | 0.932 | AUT | 1.366 | 1.113 | 1.227 |
| | Non-OECD | CHN | 4.274 | 4.786 | 0.893 | UKR | 4.185 | 3.978 | 1.052 |
| | | UKR | 3.968 | 3.990 | 0.994 | GTM | 2.549 | 2.374 | 1.074 |
| | | RUS | 3.379 | 4.197 | 0.805 | VNM | 2.153 | 2.113 | 1.019 |
| | | ARM | 2.785 | 3.044 | 0.915 | TJK | 2.119 | 1.911 | 1.109 |
| | | BLR | 1.962 | 2.543 | 0.772 | MAR | 2.046 | 1.903 | 1.075 |
| BOTTOM | Full | USA | 0.858 | 1.622 | 0.529 | IRL | 0.918 | 0.785 | 1.169 |
| | | PRT | 0.854 | 0.886 | 0.964 | BRA | 0.900 | 0.900 | 1.000 |
| | | PRY | 0.738 | 0.862 | 0.857 | CHL | 0.857 | 0.857 | 1.000 |
| | | ITA | 0.670 | 0.788 | 0.850 | SWE | 0.841 | 0.833 | 1.009 |
| | | UZB | 0.669 | 0.727 | 0.920 | COL | 0.830 | 0.762 | 1.089 |
| | | SWE | 0.634 | 1.000 | 0.634 | FRA | 0.813 | 0.717 | 1.134 |
| | | SGP | 0.623 | 1.000 | 0.623 | ECU | 0.800 | 0.800 | 1.000 |
| | | JOR | 0.604 | 1.000 | 0.604 | TZA | 0.791 | 0.678 | 1.167 |
| | | IRN | 0.587 | 0.586 | 1.003 | COD | 0.788 | 0.603 | 1.305 |
| | | NZL | 0.575 | 0.706 | 0.814 | HRV | 0.705 | 0.558 | 1.263 |
| | OECD | USA | 0.858 | 1.622 | 0.529 | DEU | 0.967 | 0.850 | 1.139 |
| | | PRT | 0.854 | 0.886 | 0.964 | IRL | 0.918 | 0.785 | 1.169 |
| | | ITA | 0.670 | 0.788 | 0.850 | CHL | 0.857 | 0.857 | 1.000 |
| | | SWE | 0.634 | 1.000 | 0.634 | SWE | 0.841 | 0.833 | 1.009 |
| | | NZL | 0.575 | 0.706 | 0.814 | FRA | 0.813 | 0.717 | 1.134 |
| | Non-OECD | PRY | 0.738 | 0.862 | 0.857 | COL | 0.830 | 0.762 | 1.089 |
| | | UZB | 0.669 | 0.727 | 0.920 | ECU | 0.800 | 0.800 | 1.000 |
| | | SGP | 0.623 | 1.000 | 0.623 | TZA | 0.791 | 0.678 | 1.167 |
| | | JOR | 0.604 | 1.000 | 0.604 | COD | 0.788 | 0.603 | 1.305 |
| | | IRN | 0.587 | 0.586 | 1.003 | HRV | 0.705 | 0.558 | 1.263 |

Note: MI, ΔTE and ΔT are Malmquist index, technical efficiency change (catch-up / recovery) effect and technical change (frontier shift / innovation) effect, respectively.

On the contrary, New Zealand occupied the bottom rank in the studied sample with a productivity decline of 42.5% (MI = 0.575), covering a regress in both technical efficiency (ΔTE = 0.706) and innovation (ΔT = 0.814).[43] The list of the ten lowest countries included a part of OECD group i.e. the USA (ΔTE = 0.858), Portugal (ΔTE = 0.854), Italy (ΔTE = 0.670), Sweden (ΔTE = 0.634), and New

[43] New Zealand applied the same number of payments (8) for two years 2006 and 2011, but there was a remarkable increase in time to comply with taxes, i.e. 34 hours for corporate tax, 59 hours for labour tax, and 59 hours for consumption tax in 2011. In 2006, the time for tax compliance was 25 hours for corporate tax, 30 hours for labour tax, and 15 hours for consumption tax.

Zealand (ΔTE = 0.575) together with Paraguay (ΔTE = 0.738), Uzbekistan (ΔTE = 0.669), Singapore (ΔTE = 0.623), Jordan (ΔTE = 0.604), and Iran (ΔTE = 0.587).

Regarding the latter period from 2011 to 2016, the leading country is the Ukraine with a great progress in total factor productivity of 318.5% (MI = 4.185), decomposed into the progress in both technical efficiency (ΔTE = 3.978) and innovation (ΔT = 1.052). This was illustrated by tax system simplification, with 5 payments and 328 total hours for complying with taxes in 2016, compared to 28 payments and a total of 491 hours for tax compliance in 2011. Clearly, the Ukraine made a significant advance in tax procedure simplification despite their existing poor performance (long-run efficiency of 8.8%). This country has never been relatively efficient considering the short-run efficiency (the highest efficiency at 80% in 2016, compared to 20.1% in 2011). Therefore, Ukraine still needs a lot of augmentation to catch up with the reference tax systems in the segment to achieve good practice. The list of top countries includes Guatemala, Vietnam, Tajikistan, Morocco, India, Poland, Romania, Uzbekistan, and Estonia whose total factor productivity recorded an improvement between 154.9% (MI = 2.549) and 64.6% (MI = 1.646).

On the other hand, the ten countries that made the worst list include Ireland, Brazil, Chile, Sweden, Colombia, France, Ecuador, Tanzania, Democratic Republic of Congo, and Croatia. They all presented a regress in total factor productivity. Croatia had the deepest regress of 29.5% (MI = 0.705) with a significant decline of 44.2% (ΔTE = 0.558) in technical efficiency, despite an innovation increase of 26.3% (ΔT = 1.263).[44]

In addition, the productivity change was also measured for the two separate sub-groups (OECD and non-OECD) and the results are shown in Table 8b. The outcomes remain as expected. In OECD sub-sample, Mexico leads the board, followed by Korea, Finland, Slovakia, Poland for the former period (2006-2011). In the meantime, Poland gains the first position, considering the latter period (2011-2016) before Estonia, Lithuania, Slovakia, and Austria. They all demonstrate a productivity progress.

[44] Croatia had 35 payments and needed a total of 206 hours for tax compliance in 2016, compared to 18 payments and 196 hours in 2011.

Contrastively, New Zealand, Sweden, Italy, the USA, and Portugal; and France, Chile, Sweden, Ireland, and Germany are considered the bottom of the list for the two periods, respectively.

The non-OECD sub-sample witnesses, on the one hand, the strong productivity progress in tax procedure simplification in the top countries, which include China, Ukraine, Russia, Armenia, and Argentina for the former period (2006-2011), and Ukraine, Tajikistan, Vietnam, Morocco, and Guatemala for the latter period (2011-2016). On the other hand, the bottom positions host Paraguay, Singapore, Uzbekistan, Jordan, and Iran along with Croatia, Ecuador, China, Colombia, and Jamaica for the two respective periods.

Table 8b: Top & Bottom countries ranked by Malmquist index, sub-samples.

| Period | | 2006-2011 | | | | | 2011-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Country | MI | ΔTE | ΔT | | Country | MI | ΔTE | ΔT |
| OECD | TOP | MEX | 2.573 | 3.319 | 0.775 | | POL | 1.731 | 1.651 | 1.049 |
| | | KOR | 2.179 | 2.579 | 0.845 | | EST | 1.590 | 1.000 | 1.590 |
| | | FIN | 1.840 | 1.828 | 1.006 | | LTU | 1.419 | 1.212 | 1.170 |
| | | SVK | 1.768 | 1.852 | 0.955 | | SVK | 1.348 | 1.217 | 1.108 |
| | | POL | 1.598 | 1.653 | 0.967 | | AUT | 1.328 | 1.099 | 1.208 |
| | | | | | | | | | | |
| | BOTTOM | PRT | 0.858 | 0.886 | 0.969 | | DEU | 0.975 | 0.914 | 1.067 |
| | | USA | 0.846 | 1.073 | 0.789 | | IRL | 0.921 | 0.785 | 1.172 |
| | | ITA | 0.673 | 0.763 | 0.883 | | SWE | 0.879 | 0.914 | 0.962 |
| | | SWE | 0.671 | 1.000 | 0.671 | | CHL | 0.857 | 0.857 | 1.000 |
| | | NZL | 0.566 | 0.670 | 0.846 | | FRA | 0.811 | 0.751 | 1.079 |
| | | | | | | | | | | |
| Non-OECD | TOP | CHN | 4.670 | 4.800 | 0.973 | | UKR | 4.276 | 3.729 | 1.147 |
| | | UKR | 3.788 | 4.021 | 0.942 | | TJK | 2.351 | 2.073 | 1.134 |
| | | RUS | 3.585 | 4.090 | 0.877 | | VNM | 2.286 | 2.286 | 1.000 |
| | | ARM | 2.345 | 2.493 | 0.941 | | MAR | 2.227 | 1.971 | 1.130 |
| | | ARG | 2.111 | 2.111 | 1.000 | | GTM | 2.148 | 1.593 | 1.348 |
| | | | | | | | | | | |
| | BOTTOM | IRN | 0.683 | 0.815 | 0.838 | | JAM | 0.866 | 0.745 | 1.162 |
| | | JOR | 0.672 | 1.000 | 0.672 | | COL | 0.864 | 0.726 | 1.190 |
| | | UZB | 0.650 | 0.883 | 0.736 | | CHN | 0.818 | 0.778 | 1.052 |
| | | SGP | 0.521 | 1.000 | 0.521 | | ECU | 0.800 | 0.800 | 1.000 |
| | | PRY | 0.485 | 0.581 | 0.835 | | HRV | 0.795 | 0.763 | 1.042 |

Note: MI, ΔTE and ΔT are Malmquist index, technical efficiency change (catch-up / recovery) effect and technical change (frontier shift / innovation) effect, respectively.

## 2.8 Concluding remarks

The study seeks to evaluate the performance of the tax systems of 88 countries through tax procedure simplification using the lens of latent social cost. In other words, this study investigates the competitiveness of the various tax systems through tax simplicity to minimise the compliance burden paid by taxpayers when complying with taxes, in addition to the general purpose of tax revenue collection.

Given the data availability on tax simplification stressing paying taxes indicator, i.e. tax payment and time-to-comply, I used the DEA model with pure inputs (DEA-WEO) approach (Lovell and Pastor, 1994). Methodologically, I used the panel data DEA-WEO approach to measure the relative long-run performance of tax systems over a 12 year period, adapted from Surroca et al. (2016) and Pérez-López et al. (2018), alongside their annual performance. The rankings, using Toloo and Kresta (2014), addressing the DEA-WEO condition and the measure of productivity change by Malmquist index, adapted from Karagiannis and Lovell (2016), attributed to the performance analysis.

The results showed that the performance of tax systems has generally improved throughout the years between 2005 and 2016, with a rise in the median of 21.3%, from 31.3% to 52.6%. The studied tax systems have also shown an increasing integration of tax simplification. It should be noted that measuring the long-run performance gives a median score of 28.7% for the whole period, and that Switzerland was found to be the only relatively efficient system. The evolution of time-variant long-run efficiency, on a year-on-year basis, reveals an uptrend in tax simplicity efficiency in all groups of countries over the period.

It could also be suggested from the findings of benchmark units that the relative efficiency list consists of 11 countries (Estonia, Finland, France, Ireland, Jordan, New Zealand, Norway, Singapore, Sweden, Switzerland, and United Kingdom) with 4 to 9 efficient units annually, occupying approximately 4.5% to 10.2% of the studied sample. Norway appears the most frequently in the reference sets with a total of 600 times, followed by Ireland (433 times), Singapore (388 times), and Switzerland (273 times).

Regarding rankings throughout the period of 12 years, it was unsurprising that Switzerland came first in the six consecutive years from 2009 to 2014. This might be explained by the effective and efficient tax process and lower compliance cost, which results from the automation and modernisation of the tax system in this country. The top-ranked countries also saw Singapore top the list in 2005, 2006, and 2015; New Zealand in 2007 and 2008; and Estonia in 2016. This helped to confirm the beneficial effects of mature tax systems, the support of electronic mechanism and the lighter administrative burden in these high-income economies. Conversely, Brazil was found to be a typical case of tax complexity and was the bottom-ranked country for all 12 years of the period. This could be partially blamed on the country's burdensome tax compliance procedures. Brazil could benefit from radical tax simplification to increase tax compliance and collection, which would help to improve their currently anaemic economic growth.

Furthermore, with reference to productivity change measure, the results indicated that there was an average progress of 27.7% and 19.6% for both periods (2006-2011 and 2011-2016) respectively. Accordingly, China and the Ukraine were the most improved countries with indices of 327.4% and 318.5% for the two respective periods. These figures revealed the considerable advance in tax simplification, despite their existing poor performance, lagging behind the frontiers and being relatively inefficient during certain years.

This article contributes to the research field both methodologically and empirically. First, the work extends the standard panel data DEA estimator (first proposed by Surroca et al., 2016 and then extended by Pérez-López et al., 2018) to apply for WEO condition. Second, it is the first application of panel data DEA-WEO proposal for long-run panel estimation in addition to contemporaneous analysis with cross-sectional data DEA-WEO model, to provide practical contribution results from the measuring of tax system performance. This is completed through measuring the efficiency (both contemporaneous and long-run panel data analysis), ranking, and examining the productivity change of 88 tax systems throughout the period (2005-2016), addressing the implied social costs (tax costs) paid by the taxpayers in order to comply with taxes. With the synthetic assessment of combined tax burden indicators (tax payments and time to comply), the findings, including the benchmarking peers along with the assessment of efforts on tax simplification, reflect the overall level of recovery and innovation and might act as a source of reference relating to the policy implications for tax design and reform.

The results suggest a general conclusion that, even though Switzerland appears to be the most efficient tax system, Norway is the most feasible tax system, and one that the policymakers, in other countries in the segment, should seek to emulate to enhance the efficiency of tax simplification. It is worthy, however, to carefully consider the recommendations when applied to a context. Other countries that could be considered feasible references are Singapore, Ireland, and Estonia.

Finally, regarding future research, the study leaves room to further explore the determinants affecting tax simplicity performance. Indeed, the inefficiency may result from the impact of various country-specific factors, i.e. the institutional quality, the socio-economic environment, the infrastructure and the taxpayers' perception, etc. Even within the tax complexity framework, effects could be derived from either pure complexity of procedure, bureaucracy, tax system structure or tax levels. Another proposal that requires further study is the interaction of tax complexity measure with other ease-of-doing-business indicators. Similarly, an in-depth study on whether tax simplification convergence is a general trend or it is observed only in certain legal traditions and depends on particular institutional conditions should be of interest. In a broader scope, it is also worthy to frame tax simplification under the procedure streamlining perspective as the increasingly good practice in public administration for tackling the business bureaucracy. These require further thorough examination.

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# Appendix

*A1. Toloo and Kresta (2014)'s formula for rankings (2.6)*

I solve program (2.6a) to obtain the parameter $\varepsilon = \varepsilon^*$, then solve (2.6b) for finding the single most efficient unit alongside with the full ordering basing on optimised $d_{max}$ values.

| | |
|---|---|
| $\min \varepsilon$ (2.6a) | $\min d_{max}$ (2.6b) |
| s.t | s.t |
| $\sum_{i=1}^{m} v_i x_{ij} - d_j = 1 \quad j = 1,2,\dots,n$ | $\sum_{i}^{m} v_i x_{ij} - d_j = 1 \quad j = 1,2,\dots,n$ |
| $\sum_{j=1}^{n} \theta_j = n-1$ | $\sum_{j=1}^{n} \theta_j = n-1$ |
| $\theta_j \leq Md_j \quad j = 1,2,\dots,n$ | $d_{max} - d_j \geq 0 \quad j = 1,2,\dots,n$ |
| $d_j \leq N\theta_j \quad j = 1,2,\dots,n$ | $\theta_j \leq Md_j \quad j = 1,2,\dots,n$ |
| $d_j \geq 0 \quad j = 1,2,\dots,n$ | $d_j \leq N\theta_j \quad j = 1,2,\dots,n$ |
| $v_i \geq \varepsilon \quad i = 1,2,\dots,m$ | $\theta_j \in \{0,1\} \quad j = 1,2,\dots,n$ |
| $\theta_j \in \{0,1\} \quad j = 1,2,\dots,n$ | $v_i \geq \varepsilon^* \quad i = 1,2,\dots,m$ |

where $d_j$ is deviation from common set of weights-efficiency for DMU j, $d_{max} = \min\{dj : j = 1,\dots,n\}$; M and N are some large enough numbers. The most efficient unit will have $d^*_{max} = 0$ and $\theta^*_{max} = 0$ (otherwise $\theta_j = 1$). I solve program (2.6a) to obtain$\varepsilon^*$, and then solve (2.6b). All computations are implemented in GAMS with the suitable mixed integer solver.

*A2. Non-parametric tests.*

| Time | Li test (p-value) | | Kruskal-Wallis test (p-value) | |
|---|---|---|---|---|
| | 2005 vs. | Panel average vs. | 2005 vs. | Panel average vs. |
| 2005 | | >0.10 | | >0.10 |
| 2006 | >0.10 | <0.10 | >0.10 | >0.10 |
| 2007 | <0.10 | <0.05 | <0.05 | <0.01 |
| 2008 | <0.10 | <0.01 | <0.05 | <0.001 |
| 2009 | <0.05 | <0.01 | <0.001 | <0.001 |
| 2010 | <0.01 | <0.01 | <0.001 | <0.001 |
| 2011 | <0.01 | <0.001 | <0.001 | <0.001 |
| 2012 | <0.01 | <0.001 | <0.001 | <0.001 |
| 2013 | <0.01 | <0.001 | <0.001 | <0.001 |
| 2014 | <0.001 | <0.001 | <0.001 | <0.001 |
| 2015 | <0.001 | <0.001 | <0.001 | <0.001 |
| 2016 | <0.001 | <0.001 | <0.001 | <0.001 |

Note: Kernel Consistent Density Equality Test With Mixed Data Types (Li, Maasoumi, and Racine, 2009), H0: density equality.

*A3. Time-variant long-run DEA efficiency scores.*

| Year | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Full sample | | | | | | | | | | | | |
| Mean | 0.305 | 0.310 | 0.318 | 0.325 | 0.329 | 0.334 | 0.337 | 0.341 | 0.344 | 0.347 | 0.350 | 0.353 |
| Std. dev | 0.229 | 0.229 | 0.228 | 0.227 | 0.226 | 0.224 | 0.219 | 0.216 | 0.213 | 0.210 | 0.207 | 0.207 |
| Median | 0.215 | 0.225 | 0.229 | 0.230 | 0.236 | 0.241 | 0.247 | 0.258 | 0.268 | 0.276 | 0.284 | 0.287 |
| Min | 0.043 | 0.043 | 0.049 | 0.050 | 0.052 | 0.053 | 0.059 | 0.064 | 0.071 | 0.077 | 0.082 | 0.088 |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| OECD | | | | | | | | | | | | |
| Mean | 0.443 | 0.451 | 0.460 | 0.468 | 0.473 | 0.478 | 0.483 | 0.487 | 0.491 | 0.494 | 0.497 | 0.500 |
| Std. dev | 0.237 | 0.235 | 0.232 | 0.228 | 0.225 | 0.220 | 0.216 | 0.212 | 0.209 | 0.205 | 0.202 | 0.200 |
| Median | 0.399 | 0.384 | 0.420 | 0.434 | 0.451 | 0.452 | 0.456 | 0.454 | 0.449 | 0.453 | 0.458 | 0.464 |
| Min | 0.095 | 0.115 | 0.117 | 0.136 | 0.154 | 0.171 | 0.186 | 0.200 | 0.207 | 0.210 | 0.210 | 0.210 |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Non-OECD | | | | | | | | | | | | |
| Mean | 0.215 | 0.218 | 0.225 | 0.231 | 0.234 | 0.239 | 0.241 | 0.244 | 0.247 | 0.250 | 0.253 | 0.256 |
| Std. dev | 0.173 | 0.171 | 0.171 | 0.171 | 0.171 | 0.171 | 0.161 | 0.156 | 0.153 | 0.149 | 0.145 | 0.145 |
| Median | 0.189 | 0.182 | 0.192 | 0.192 | 0.193 | 0.201 | 0.209 | 0.213 | 0.216 | 0.218 | 0.222 | 0.228 |
| Min | 0.043 | 0.043 | 0.049 | 0.050 | 0.052 | 0.053 | 0.059 | 0.064 | 0.071 | 0.077 | 0.082 | 0.088 |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0.980 | 0.957 | 0.96 |
| HIC | | | | | | | | | | | | |
| Mean | 0.439 | 0.447 | 0.457 | 0.465 | 0.471 | 0.475 | 0.481 | 0.485 | 0.488 | 0.491 | 0.493 | 0.496 |
| Std. dev | 0.257 | 0.254 | 0.249 | 0.245 | 0.242 | 0.238 | 0.234 | 0.231 | 0.227 | 0.223 | 0.219 | 0.218 |
| Median | 0.396 | 0.382 | 0.399 | 0.433 | 0.447 | 0.448 | 0.452 | 0.450 | 0.448 | 0.449 | 0.453 | 0.460 |
| Min | 0.100 | 0.124 | 0.154 | 0.158 | 0.156 | 0.155 | 0.158 | 0.161 | 0.163 | 0.166 | 0.170 | 0.176 |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| UMC | | | | | | | | | | | | |
| Mean | 0.224 | 0.235 | 0.245 | 0.254 | 0.258 | 0.264 | 0.266 | 0.270 | 0.275 | 0.280 | 0.284 | 0.288 |
| Std. dev | 0.176 | 0.174 | 0.174 | 0.173 | 0.174 | 0.174 | 0.152 | 0.140 | 0.133 | 0.128 | 0.124 | 0.123 |
| Median | 0.195 | 0.207 | 0.203 | 0.203 | 0.202 | 0.211 | 0.215 | 0.229 | 0.240 | 0.251 | 0.261 | 0.270 |
| Min | 0.087 | 0.091 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 | 0.092 |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | 0.875 | 0.8 | 0.75 | 0.714 | 0.688 | 0.674 |
| LMC | | | | | | | | | | | | |
| Mean | 0.181 | 0.176 | 0.177 | 0.179 | 0.182 | 0.184 | 0.187 | 0.189 | 0.191 | 0.193 | 0.195 | 0.197 |
| Std. dev | 0.076 | 0.068 | 0.066 | 0.066 | 0.066 | 0.066 | 0.067 | 0.068 | 0.069 | 0.069 | 0.071 | 0.072 |
| Median | 0.178 | 0.175 | 0.177 | 0.178 | 0.182 | 0.185 | 0.187 | 0.189 | 0.192 | 0.195 | 0.197 | 0.201 |
| Min | 0.043 | 0.043 | 0.049 | 0.050 | 0.052 | 0.053 | 0.059 | 0.064 | 0.071 | 0.077 | 0.082 | 0.088 |
| Max | 0.371 | 0.333 | 0.322 | 0.317 | 0.314 | 0.312 | 0.309 | 0.311 | 0.313 | 0.314 | 0.318 | 0.325 |

----------------------------------------

# Online Appendix

*A4. Efficiency measure: contemporaneous analysis and time-invariant long–run analysis*

| No. | Country | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Panel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ARG | 0.156 | 0.199 | 0.342 | 0.342 | 0.342 | 0.444 | 0.444 | 0.444 | 0.444 | 0.444 | 0.444 | 0.444 | 0.245 |
| 2 | ARM | 0.108 | 0.117 | 0.121 | 0.121 | 0.139 | 0.192 | 0.357 | 0.400 | 0.434 | 0.435 | 0.341 | 0.341 | 0.150 |
| 3 | AUS | 0.727 | 0.742 | 0.790 | 0.790 | 0.772 | 0.772 | 0.758 | 0.769 | 0.769 | 0.787 | 0.722 | 0.620 | 0.591 |
| 4 | AUT | 0.313 | 0.407 | 0.450 | 0.453 | 0.452 | 0.490 | 0.514 | 0.495 | 0.496 | 0.514 | 0.691 | 0.572 | 0.353 |
| 5 | BEL | 0.650 | 0.729 | 0.729 | 0.729 | 0.729 | 0.729 | 0.764 | 0.764 | 0.764 | 0.776 | 0.768 | 0.597 | 0.596 |
| 6 | BGR | 0.280 | 0.402 | 0.402 | 0.402 | 0.402 | 0.398 | 0.444 | 0.507 | 0.507 | 0.512 | 0.512 | 0.437 | 0.363 |
| 7 | BLR | 0.178 | 0.173 | 0.207 | 0.238 | 0.163 | 0.245 | 0.439 | 0.461 | 0.826 | 0.865 | 0.755 | 0.690 | 0.124 |
| 8 | BOL | 0.138 | 0.150 | 0.150 | 0.148 | 0.148 | 0.142 | 0.148 | 0.155 | 0.155 | 0.159 | 0.159 | 0.139 | 0.129 |
| 9 | BRA | 0.130 | 0.182 | 0.182 | 0.200 | 0.200 | 0.444 | 0.444 | 0.444 | 0.444 | 0.400 | 0.400 | 0.400 | 0.183 |
| 10 | CAF | 0.313 | 0.317 | 0.317 | 0.317 | 0.317 | 0.310 | 0.417 | 0.417 | 0.417 | 0.423 | 0.423 | 0.208 | 0.208 |
| 11 | CAN | 0.709 | 0.569 | 0.698 | 0.690 | 0.676 | 0.707 | 0.703 | 0.688 | 0.699 | 0.720 | 0.617 | 0.617 | 0.543 |
| 12 | CHE | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 13 | CHL | 0.426 | 0.503 | 0.503 | 0.503 | 0.524 | 0.517 | 0.667 | 0.571 | 0.571 | 0.571 | 0.571 | 0.571 | 0.479 |
| 14 | CHN | 0.106 | 0.119 | 0.357 | 0.406 | 0.461 | 0.571 | 0.571 | 0.571 | 0.571 | 0.467 | 0.467 | 0.526 | 0.257 |
| 15 | CMR | 0.153 | 0.095 | 0.125 | 0.125 | 0.128 | 0.129 | 0.129 | 0.129 | 0.129 | 0.130 | 0.123 | 0.117 | 0.097 |
| 16 | COD | 0.243 | 0.198 | 0.243 | 0.240 | 0.265 | 0.277 | 0.277 | 0.250 | 0.231 | 0.217 | 0.208 | 0.167 | 0.163 |
| 17 | COG | 0.122 | 0.096 | 0.143 | 0.132 | 0.156 | 0.157 | 0.157 | 0.165 | 0.165 | 0.169 | 0.145 | 0.129 | 0.089 |
| 18 | COL | 0.144 | 0.315 | 0.315 | 0.415 | 0.410 | 0.592 | 0.572 | 0.533 | 0.520 | 0.529 | 0.444 | 0.436 | 0.256 |
| 19 | CRI | 0.416 | 0.413 | 0.413 | 0.417 | 0.417 | 0.456 | 0.556 | 0.556 | 0.635 | 0.849 | 0.800 | 0.657 | 0.283 |
| 20 | CZE | 0.214 | 0.248 | 0.248 | 0.261 | 0.264 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.278 |
| 21 | DEU | 0.415 | 0.533 | 0.546 | 0.565 | 0.568 | 0.631 | 0.733 | 0.686 | 0.709 | 0.727 | 0.656 | 0.623 | 0.456 |
| 22 | DNK | 0.547 | 0.744 | 0.779 | 0.789 | 0.763 | 0.732 | 0.734 | 0.723 | 0.723 | 0.750 | 0.726 | 0.620 | 0.584 |
| 23 | ECU | 0.393 | 0.463 | 0.463 | 0.463 | 0.359 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.400 | 0.333 |
| 24 | EGY | 0.190 | 0.165 | 0.182 | 0.224 | 0.234 | 0.223 | 0.227 | 0.234 | 0.234 | 0.242 | 0.242 | 0.208 | 0.185 |
| 25 | ESP | 0.711 | 0.603 | 0.635 | 0.635 | 0.635 | 0.649 | 0.756 | 0.737 | 0.746 | 0.800 | 0.784 | 0.683 | 0.559 |
| 26 | EST | 0.709 | 0.830 | 0.914 | 0.912 | 1.000 | 0.966 | 0.973 | 1.000 | 1.000 | 1.000 | 0.897 | 1.000 | 0.739 |
| 27 | FIN | 0.588 | 0.545 | 0.547 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.850 | 0.612 |
| 28 | FRA | 0.460 | 0.628 | 0.767 | 0.991 | 1.000 | 1.000 | 1.000 | 1.000 | 0.873 | 0.901 | 0.851 | 0.717 | 0.578 |
| 29 | GBR | 1.000 | 0.802 | 0.836 | 0.831 | 0.890 | 0.911 | 0.997 | 0.979 | 0.980 | 0.985 | 0.976 | 0.837 | 0.662 |
| 30 | GRC | 0.655 | 0.271 | 0.424 | 0.424 | 0.426 | 0.447 | 0.523 | 0.548 | 0.583 | 0.587 | 0.553 | 0.553 | 0.344 |
| 31 | GTM | 0.224 | 0.243 | 0.243 | 0.317 | 0.317 | 0.297 | 0.297 | 0.571 | 0.659 | 0.669 | 0.669 | 0.705 | 0.290 |
| 32 | HND | 0.229 | 0.235 | 0.352 | 0.351 | 0.351 | 0.351 | 0.372 | 0.372 | 0.372 | 0.392 | 0.390 | 0.277 | 0.208 |
| 33 | HRV | 0.309 | 0.359 | 0.440 | 0.460 | 0.563 | 0.551 | 0.539 | 0.527 | 0.453 | 0.457 | 0.372 | 0.301 | 0.283 |
| 34 | HUN | 0.539 | 0.334 | 0.474 | 0.474 | 0.474 | 0.472 | 0.494 | 0.513 | 0.535 | 0.547 | 0.547 | 0.493 | 0.403 |
| 35 | IDN | 0.134 | 0.232 | 0.273 | 0.272 | 0.275 | 0.275 | 0.284 | 0.281 | 0.289 | 0.326 | 0.302 | 0.312 | 0.173 |
| 36 | IND | 0.240 | 0.306 | 0.306 | 0.306 | 0.309 | 0.312 | 0.336 | 0.334 | 0.334 | 0.348 | 0.349 | 0.496 | 0.229 |
| 37 | IRL | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.785 | 0.809 |
| 38 | IRN | 0.565 | 0.680 | 0.395 | 0.396 | 0.414 | 0.398 | 0.398 | 0.413 | 0.413 | 0.426 | 0.423 | 0.339 | 0.324 |
| 39 | ISL | 0.498 | 0.455 | 0.507 | 0.506 | 0.505 | 0.505 | 0.501 | 0.508 | 0.508 | 0.552 | 0.515 | 0.439 | 0.334 |
| 40 | ISR | 0.322 | 0.241 | 0.389 | 0.354 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.402 | 0.356 | 0.340 | 0.210 |
| 41 | ITA | 0.782 | 0.840 | 0.568 | 0.601 | 0.645 | 0.662 | 0.662 | 0.662 | 0.662 | 0.681 | 0.681 | 0.541 | 0.446 |
| 42 | JAM | 0.304 | 0.379 | 0.379 | 0.379 | 0.379 | 0.410 | 0.411 | 0.411 | 0.411 | 0.418 | 0.520 | 0.493 | 0.240 |
| 43 | JOR | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.556 | 0.674 |
| 44 | JPN | 0.546 | 0.355 | 0.534 | 0.534 | 0.646 | 0.644 | 0.644 | 0.644 | 0.644 | 0.644 | 0.862 | 0.641 | 0.344 |
| 45 | KAZ | 0.368 | 0.362 | 0.387 | 0.387 | 0.391 | 0.744 | 0.744 | 0.744 | 0.866 | 0.821 | 0.662 | 0.662 | 0.400 |
| 46 | KGZ | 0.170 | 0.327 | 0.368 | 0.368 | 0.368 | 0.360 | 0.358 | 0.354 | 0.354 | 0.344 | 0.329 | 0.268 | 0.200 |
| 47 | KOR | 0.324 | 0.207 | 0.434 | 0.434 | 0.525 | 0.592 | 0.693 | 0.901 | 0.901 | 0.839 | 0.839 | 0.637 | 0.299 |
| 48 | LAO | 0.335 | 0.184 | 0.201 | 0.243 | 0.243 | 0.243 | 0.238 | 0.238 | 0.238 | 0.286 | 0.310 | 0.238 | 0.168 |
| 49 | LTU | 0.545 | 0.425 | 0.516 | 0.582 | 0.592 | 0.591 | 0.591 | 0.586 | 0.586 | 0.620 | 0.619 | 0.678 | 0.464 |
| 50 | LVA | 0.596 | 0.696 | 0.696 | 0.696 | 0.696 | 0.685 | 0.685 | 0.696 | 0.740 | 0.750 | 0.844 | 0.764 | 0.630 |
| 51 | MAR | 0.275 | 0.333 | 0.333 | 0.333 | 0.333 | 0.352 | 0.350 | 0.667 | 0.667 | 0.667 | 0.667 | 0.667 | 0.310 |
| 52 | MEX | 0.163 | 0.156 | 0.181 | 0.333 | 0.419 | 0.667 | 0.667 | 0.667 | 0.667 | 0.667 | 0.667 | 0.667 | 0.243 |
| 53 | MKD | 0.333 | 0.655 | 0.962 | 0.958 | 0.627 | 0.627 | 0.658 | 0.657 | 0.912 | 0.939 | 0.939 | 0.823 | 0.406 |

| No. | Country | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Panel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 54 | MNE | 0.430 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.331 | 0.331 | 0.331 | 0.401 | 0.390 | 0.335 | 0.203 |
| 55 | MNG | 0.268 | 0.325 | 0.365 | 0.400 | 0.394 | 0.394 | 0.391 | 0.387 | 0.500 | 0.507 | 0.456 | 0.491 | 0.261 |
| 56 | MYS | 0.374 | 0.498 | 0.695 | 0.728 | 0.764 | 0.739 | 0.739 | 0.741 | 0.741 | 0.743 | 0.706 | 0.672 | 0.430 |
| 57 | NGA | 0.180 | 0.114 | 0.151 | 0.151 | 0.173 | 0.177 | 0.166 | 0.157 | 0.164 | 0.150 | 0.151 | 0.154 | 0.099 |
| 58 | NLD | 0.393 | 0.575 | 0.605 | 0.615 | 0.727 | 0.788 | 0.789 | 0.791 | 0.791 | 0.824 | 0.842 | 0.704 | 0.561 |
| 59 | NOR | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.962 |
| 60 | NZL | 1.000 | 0.948 | 1.000 | 1.000 | 0.743 | 0.717 | 0.670 | 0.647 | 0.647 | 0.657 | 0.672 | 0.694 | 0.627 |
| 61 | PAK | 0.296 | 0.510 | 0.510 | 0.510 | 0.510 | 0.510 | 0.519 | 0.519 | 0.519 | 0.527 | 0.515 | 0.434 | 0.292 |
| 62 | PER | 0.223 | 0.540 | 0.540 | 0.615 | 0.516 | 0.539 | 0.539 | 0.548 | 0.548 | 0.555 | 0.555 | 0.526 | 0.406 |
| 63 | PHL | 0.714 | 0.546 | 0.546 | 0.546 | 0.546 | 0.546 | 0.512 | 0.512 | 0.512 | 0.518 | 0.537 | 0.468 | 0.325 |
| 64 | POL | 0.343 | 0.203 | 0.211 | 0.236 | 0.248 | 0.271 | 0.346 | 0.335 | 0.335 | 0.571 | 0.571 | 0.571 | 0.237 |
| 65 | PRT | 0.544 | 0.564 | 0.564 | 0.564 | 0.564 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.441 |
| 66 | PRY | 0.249 | 0.255 | 0.255 | 0.255 | 0.280 | 0.280 | 0.220 | 0.229 | 0.259 | 0.262 | 0.236 | 0.236 | 0.186 |
| 67 | ROU | 0.223 | 0.361 | 0.361 | 0.361 | 0.312 | 0.312 | 0.331 | 0.359 | 0.567 | 0.584 | 0.578 | 0.470 | 0.215 |
| 68 | RUS | 0.183 | 0.183 | 0.202 | 0.420 | 0.470 | 0.525 | 0.767 | 0.767 | 0.848 | 0.865 | 0.755 | 0.742 | 0.284 |
| 69 | SDN | 0.239 | 0.320 | 0.412 | 0.387 | 0.442 | 0.442 | 0.442 | 0.442 | 0.442 | 0.448 | 0.418 | 0.403 | 0.248 |
| 70 | SGP | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.960 |
| 71 | SRB | 0.297 | 0.287 | 0.287 | 0.269 | 0.269 | 0.269 | 0.281 | 0.280 | 0.280 | 0.322 | 0.355 | 0.252 | 0.189 |
| 72 | SVK | 0.225 | 0.220 | 0.244 | 0.310 | 0.310 | 0.343 | 0.422 | 0.422 | 0.422 | 0.509 | 0.516 | 0.513 | 0.269 |
| 73 | SVN | 0.252 | 0.267 | 0.305 | 0.317 | 0.352 | 0.370 | 0.454 | 0.449 | 0.489 | 0.538 | 0.479 | 0.479 | 0.281 |
| 74 | SWE | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.952 | 0.970 | 0.833 | 0.833 | 0.784 |
| 75 | THA | 0.330 | 0.208 | 0.453 | 0.417 | 0.473 | 0.473 | 0.481 | 0.479 | 0.479 | 0.492 | 0.418 | 0.398 | 0.213 |
| 76 | TJK | 0.234 | 0.313 | 0.357 | 0.357 | 0.357 | 0.357 | 0.349 | 0.348 | 0.372 | 0.322 | 0.333 | 0.667 | 0.219 |
| 77 | TUN | 0.303 | 0.278 | 0.372 | 0.363 | 0.696 | 0.713 | 0.713 | 0.701 | 0.706 | 0.734 | 0.617 | 0.578 | 0.318 |
| 78 | TUR | 0.323 | 0.404 | 0.407 | 0.408 | 0.406 | 0.397 | 0.397 | 0.441 | 0.441 | 0.446 | 0.464 | 0.442 | 0.359 |
| 79 | TWN | 0.200 | 0.212 | 0.465 | 0.727 | 0.820 | 0.820 | 0.842 | 0.838 | 0.858 | 0.883 | 0.752 | 0.702 | 0.271 |
| 80 | TZA | 0.229 | 0.355 | 0.425 | 0.436 | 0.439 | 0.439 | 0.439 | 0.431 | 0.413 | 0.431 | 0.337 | 0.298 | 0.228 |
| 81 | UKR | 0.046 | 0.050 | 0.091 | 0.098 | 0.109 | 0.110 | 0.201 | 0.216 | 0.800 | 0.800 | 0.800 | 0.800 | 0.088 |
| 82 | URY | 0.220 | 0.215 | 0.219 | 0.218 | 0.220 | 0.221 | 0.264 | 0.253 | 0.252 | 0.286 | 0.294 | 0.328 | 0.176 |
| 83 | USA | 0.800 | 0.470 | 0.632 | 0.632 | 0.753 | 0.762 | 0.762 | 0.742 | 0.742 | 0.755 | 0.734 | 0.618 | 0.423 |
| 84 | UZB | 0.299 | 0.490 | 0.490 | 0.228 | 0.362 | 0.362 | 0.357 | 0.356 | 0.387 | 0.398 | 0.349 | 0.543 | 0.202 |
| 85 | VEN | 0.104 | 0.111 | 0.111 | 0.110 | 0.111 | 0.104 | 0.115 | 0.115 | 0.115 | 0.121 | 0.120 | 0.095 | 0.092 |
| 86 | VNM | 0.134 | 0.106 | 0.114 | 0.115 | 0.125 | 0.130 | 0.135 | 0.130 | 0.133 | 0.145 | 0.167 | 0.286 | 0.116 |
| 87 | ZAF | 0.364 | 0.362 | 0.564 | 0.553 | 0.619 | 0.652 | 0.652 | 0.682 | 0.744 | 0.753 | 0.654 | 0.625 | 0.394 |
| 88 | ZWE | 0.225 | 0.235 | 0.282 | 0.270 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.302 | 0.278 | 0.267 | 0.184 |

*A5. Rankings: The tax systems with their deviation from efficiency*

| No. | Country | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ARG | 13.109 | 10.741 | 4.923 | 4.923 | 4.634 | 4.171 | 4.049 | 4.049 | 4.049 | 4.049 | 4.111 | 4.535 |
| 2 | ARM | 24.435 | 20.667 | 11.923 | 11.923 | 6.695 | 5.512 | 3.793 | 3.756 | 3.037 | 2.939 | 3.542 | 4.638 |
| 3 | AUS | 1.565 | 1.204 | 0.526 | 0.526 | 0.464 | 0.464 | 0.464 | 0.415 | 0.415 | 0.415 | 0.611 | 1.000 |
| 4 | AUT | 5.348 | 2.574 | 1.475 | 1.462 | 1.342 | 1.244 | 1.220 | 1.171 | 1.171 | 1.171 | 0.986 | 1.466 |
| 5 | BEL | 2.696 | 2.093 | 1.141 | 1.141 | 1.037 | 1.037 | 1.037 | 1.086 | 1.086 | 1.098 | 1.389 | 1.535 |
| 6 | BGR | 12.978 | 10.722 | 7.116 | 7.116 | 6.720 | 5.305 | 4.720 | 4.695 | 4.695 | 4.329 | 5.486 | 7.052 |
| 7 | BLR | 27.544 | 23.296 | 15.667 | 11.910 | 9.732 | 7.195 | 3.244 | 3.012 | 1.317 | 1.232 | 1.542 | 2.293 |
| 8 | BOL | 23.370 | 19.759 | 13.372 | 13.385 | 12.683 | 12.683 | 12.012 | 12.012 | 12.012 | 12.012 | 13.820 | 17.397 |
| 9 | BRA | 56.044 | 47.371 | 32.487 | 32.462 | 30.829 | 30.817 | 30.817 | 30.817 | 30.817 | 30.829 | 27.445 | 32.931 |
| 10 | CAF | 11.131 | 9.333 | 6.154 | 6.154 | 5.805 | 5.805 | 5.817 | 5.573 | 5.573 | 5.573 | 6.486 | 8.293 |
| 11 | CAN | 1.804 | 1.371 | 0.641 | 0.641 | 0.695 | 0.695 | 0.695 | 0.695 | 0.695 | 0.695 | 0.931 | 1.397 |
| 12 | CHE | 0.761 | 0.611 | 0.116 | 0.116 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.139 | 0.414 |
| 13 | CHL | 8.609 | 5.037 | 3.180 | 3.180 | 2.964 | 2.964 | 2.622 | 2.634 | 2.646 | 2.634 | 3.139 | 4.138 |
| 14 | CHN | 18.913 | 15.796 | 5.577 | 5.551 | 3.939 | 3.939 | 3.207 | 2.964 | 2.268 | 2.293 | 2.722 | 2.724 |
| 15 | CMR | 28.109 | 25.685 | 17.475 | 17.475 | 7.512 | 7.512 | 7.512 | 7.220 | 7.220 | 7.220 | 8.361 | 10.517 |
| 16 | COD | 6.522 | 5.296 | 3.359 | 3.359 | 3.488 | 3.488 | 3.488 | 3.634 | 3.464 | 3.854 | 4.528 | 5.862 |
| 17 | COG | 13.565 | 11.871 | 7.551 | 7.551 | 7.134 | 7.134 | 7.134 | 6.939 | 6.939 | 6.951 | 8.056 | 10.242 |

| No. | Country | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | COL | 10.391 | 5.241 | 2.680 | 1.923 | 1.781 | 1.464 | 1.586 | 1.598 | 2.049 | 2.049 | 2.486 | 3.328 |
| 19 | CRI | 8.631 | 7.241 | 3.167 | 3.154 | 2.829 | 2.378 | 2.037 | 2.025 | 1.268 | 0.951 | 1.236 | 1.776 |
| 20 | CZE | 19.522 | 16.445 | 11.077 | 7.013 | 5.939 | 5.890 | 4.134 | 4.134 | 4.134 | 4.037 | 2.361 | 3.414 |
| 21 | DEU | 1.978 | 2.926 | 1.718 | 1.718 | 1.817 | 1.842 | 1.634 | 1.768 | 1.768 | 1.768 | 2.153 | 2.914 |
| 22 | DNK | 2.326 | 1.667 | 0.846 | 0.846 | 0.756 | 0.768 | 0.707 | 0.707 | 0.707 | 0.707 | 0.945 | 1.414 |
| 23 | ECU | 12.218 | 10.259 | 6.795 | 6.795 | 7.073 | 7.073 | 7.073 | 7.073 | 7.073 | 7.073 | 8.333 | 10.655 |
| 24 | EGY | 11.544 | 12.833 | 8.487 | 5.526 | 4.634 | 4.634 | 4.134 | 4.134 | 4.134 | 4.134 | 4.847 | 6.259 |
| 25 | ESP | 12.239 | 4.685 | 2.103 | 1.833 | 1.500 | 1.378 | 1.134 | 1.134 | 1.134 | 1.037 | 1.222 | 1.776 |
| 26 | EST | 1.500 | 0.685 | 0.167 | 0.167 | 0.073 | 0.134 | 0.134 | 0.073 | 0.073 | 0.086 | 0.278 | 0.000 |
| 27 | FIN | 5.152 | 4.352 | 2.705 | 2.218 | 2.061 | 0.232 | 0.232 | 0.232 | 0.232 | 0.232 | 0.403 | 0.742 |
| 28 | FRA | 2.500 | 1.871 | 0.833 | 0.782 | 0.695 | 0.695 | 0.695 | 0.695 | 0.768 | 0.768 | 1.042 | 1.552 |
| 29 | GBR | 1.435 | 1.093 | 0.449 | 0.513 | 0.439 | 0.439 | 0.439 | 0.439 | 0.439 | 0.439 | 0.639 | 1.035 |
| 30 | GRC | 4.152 | 4.278 | 2.000 | 2.000 | 1.854 | 1.854 | 1.561 | 1.451 | 1.451 | 1.451 | 1.792 | 2.466 |
| 31 | GTM | 6.478 | 6.093 | 3.910 | 3.718 | 3.488 | 3.488 | 3.342 | 3.061 | 2.220 | 2.220 | 2.667 | 3.414 |
| 32 | HND | 9.261 | 7.722 | 2.475 | 2.475 | 2.305 | 2.305 | 2.305 | 2.305 | 2.317 | 2.317 | 2.778 | 3.690 |
| 33 | HRV | 4.109 | 3.148 | 1.731 | 1.731 | 1.598 | 1.598 | 1.610 | 1.622 | 1.768 | 1.744 | 2.292 | 3.155 |
| 34 | HUN | 6.131 | 5.741 | 3.410 | 3.410 | 2.549 | 2.537 | 2.525 | 2.525 | 2.512 | 2.512 | 3.000 | 3.966 |
| 35 | IDN | 12.652 | 4.871 | 3.064 | 3.064 | 2.866 | 2.866 | 2.781 | 2.793 | 2.890 | 2.512 | 2.667 | 3.328 |
| 36 | IND | 6.022 | 5.130 | 3.244 | 3.231 | 2.829 | 2.500 | 2.366 | 2.366 | 2.366 | 2.366 | 2.695 | 2.914 |
| 37 | IRL | 0.826 | 0.574 | 0.090 | 0.090 | 0.037 | 0.025 | 0.073 | 0.086 | 0.086 | 0.110 | 0.264 | 0.569 |
| 38 | IRN | 5.957 | 4.815 | 3.692 | 3.692 | 3.439 | 3.439 | 3.439 | 3.439 | 3.439 | 3.439 | 4.056 | 5.276 |
| 39 | ISL | 2.435 | 2.167 | 1.192 | 1.192 | 1.086 | 1.061 | 1.061 | 1.025 | 1.025 | 0.964 | 1.236 | 1.776 |
| 40 | ISR | 4.609 | 3.871 | 2.372 | 2.372 | 2.268 | 2.268 | 2.268 | 2.268 | 2.268 | 2.268 | 2.722 | 3.621 |
| 41 | ITA | 7.152 | 5.945 | 3.475 | 3.475 | 2.659 | 2.659 | 2.464 | 2.464 | 2.464 | 2.451 | 2.528 | 3.345 |
| 42 | JAM | 9.565 | 8.000 | 5.231 | 5.231 | 4.927 | 4.927 | 3.927 | 3.927 | 3.927 | 3.817 | 2.875 | 3.810 |
| 43 | JOR | 1.761 | 1.352 | 0.628 | 0.628 | 0.549 | 0.720 | 1.146 | 1.146 | 1.146 | 1.146 | 1.361 | 1.655 |
| 44 | JPN | 6.935 | 5.722 | 3.718 | 3.718 | 3.500 | 3.195 | 3.195 | 3.195 | 3.195 | 3.195 | 1.625 | 1.845 |
| 45 | KAZ | 3.131 | 4.185 | 2.590 | 2.590 | 2.415 | 1.378 | 1.378 | 1.378 | 1.366 | 1.378 | 1.570 | 2.190 |
| 46 | KGZ | 5.370 | 4.130 | 2.551 | 2.551 | 2.049 | 2.195 | 2.183 | 2.183 | 2.195 | 2.366 | 2.833 | 3.759 |
| 47 | KOR | 5.891 | 5.259 | 2.385 | 2.385 | 2.220 | 1.890 | 1.646 | 1.403 | 1.403 | 1.439 | 1.778 | 2.448 |
| 48 | LAO | 3.587 | 12.074 | 6.616 | 4.077 | 3.829 | 3.829 | 3.829 | 3.829 | 3.842 | 3.842 | 4.514 | 5.845 |
| 49 | LTU | 2.804 | 2.519 | 1.321 | 1.282 | 1.268 | 1.268 | 1.268 | 1.268 | 1.268 | 1.220 | 1.528 | 1.069 |
| 50 | LVA | 6.131 | 3.185 | 2.667 | 2.667 | 2.659 | 2.622 | 2.305 | 2.305 | 1.439 | 1.439 | 1.445 | 2.035 |
| 51 | MAR | 9.783 | 6.148 | 3.949 | 3.949 | 3.707 | 2.110 | 2.110 | 1.903 | 1.903 | 1.646 | 2.014 | 1.776 |
| 52 | MEX | 12.065 | 9.722 | 6.385 | 5.705 | 4.000 | 3.305 | 3.183 | 3.146 | 3.146 | 2.561 | 3.056 | 3.259 |
| 53 | MKD | 2.261 | 1.741 | 0.475 | 0.475 | 0.939 | 0.793 | 0.805 | 0.805 | 0.537 | 0.537 | 0.750 | 1.173 |
| 54 | MNE | 5.152 | 7.519 | 4.910 | 4.910 | 4.476 | 4.049 | 3.256 | 3.256 | 3.256 | 3.037 | 3.417 | 4.483 |
| 55 | MNG | 4.348 | 3.556 | 2.154 | 2.013 | 1.866 | 1.842 | 1.842 | 1.842 | 1.305 | 1.305 | 1.320 | 1.638 |
| 56 | MYS | 3.891 | 2.722 | 1.013 | 1.013 | 0.915 | 0.781 | 0.781 | 0.781 | 0.781 | 0.598 | 1.403 | 2.379 |
| 57 | NGA | 24.109 | 20.389 | 11.475 | 11.475 | 10.866 | 10.866 | 11.159 | 11.232 | 10.659 | 10.793 | 12.431 | 6.224 |
| 58 | NLD | 4.913 | 2.500 | 1.423 | 1.218 | 0.744 | 0.659 | 0.659 | 0.610 | 0.610 | 0.610 | 0.778 | 1.207 |
| 59 | NOR | 0.957 | 0.685 | 0.167 | 0.167 | 0.110 | 0.110 | 0.110 | 0.061 | 0.061 | 0.061 | 0.208 | 0.500 |
| 60 | NZL | 0.718 | 0.445 | 0.000 | 0.000 | 1.439 | 1.195 | 0.951 | 0.951 | 0.951 | 0.951 | 1.208 | 1.535 |
| 61 | PAK | 12.196 | 10.241 | 6.782 | 6.782 | 6.403 | 6.403 | 6.403 | 6.610 | 6.817 | 6.817 | 3.986 | 5.190 |
| 62 | PER | 9.370 | 7.019 | 4.551 | 3.987 | 3.744 | 2.878 | 2.683 | 2.683 | 2.683 | 2.281 | 2.736 | 3.638 |
| 63 | PHL | 2.326 | 3.482 | 2.103 | 2.103 | 1.951 | 1.951 | 1.927 | 1.793 | 1.793 | 1.793 | 1.972 | 2.483 |
| 64 | POL | 3.739 | 7.500 | 4.872 | 4.577 | 3.317 | 2.964 | 2.707 | 2.707 | 2.707 | 2.390 | 2.861 | 3.604 |
| 65 | PRT | 6.283 | 5.222 | 3.308 | 3.308 | 2.732 | 2.451 | 2.451 | 2.451 | 2.451 | 2.451 | 2.486 | 3.328 |
| 66 | PRY | 6.848 | 5.722 | 3.654 | 3.654 | 3.220 | 4.146 | 4.146 | 4.025 | 3.854 | 3.854 | 4.528 | 5.862 |
| 67 | ROU | 5.239 | 4.519 | 3.039 | 3.039 | 3.086 | 3.086 | 2.134 | 1.915 | 1.110 | 1.110 | 1.431 | 2.052 |
| 68 | RUS | 6.087 | 7.704 | 5.026 | 3.244 | 3.037 | 2.646 | 1.244 | 1.244 | 1.134 | 1.134 | 1.431 | 2.017 |
| 69 | SDN | 4.348 | 3.111 | 1.846 | 1.846 | 1.707 | 1.707 | 1.707 | 1.707 | 1.707 | 1.707 | 2.083 | 2.828 |
| 70 | SGP | 0.000 | 0.000 | 0.141 | 0.141 | 0.086 | 0.086 | 0.061 | 0.061 | 0.061 | 0.098 | 0.000 | 0.190 |
| 71 | SRB | 3.544 | 5.389 | 3.423 | 3.423 | 3.207 | 3.207 | 3.207 | 3.207 | 3.220 | 2.488 | 2.597 | 3.466 |
| 72 | SVK | 7.131 | 5.945 | 3.564 | 2.692 | 2.512 | 2.195 | 1.768 | 1.768 | 1.768 | 1.415 | 1.778 | 2.448 |
| 73 | SVN | 5.652 | 4.222 | 2.616 | 2.616 | 2.439 | 2.439 | 2.305 | 2.305 | 2.305 | 2.110 | 2.542 | 3.397 |
| 74 | SWE | 1.761 | 1.296 | 0.590 | 0.590 | 0.512 | 0.537 | 0.537 | 0.537 | 0.561 | 0.561 | 0.778 | 1.207 |
| 75 | THA | 2.261 | 4.537 | 2.680 | 2.680 | 2.500 | 2.500 | 2.488 | 2.488 | 2.488 | 2.488 | 2.986 | 3.879 |
| 76 | TJK | 5.065 | 4.148 | 2.564 | 2.564 | 2.390 | 2.573 | 2.573 | 2.573 | 1.927 | 2.707 | 2.750 | 2.966 |

| No. | Country | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77 | TUN | 5.804 | 4.815 | 2.205 | 2.205 | 0.854 | 0.854 | 0.854 | 0.854 | 0.854 | 0.854 | 1.111 | 1.655 |
| 78 | TUR | 4.913 | 3.408 | 2.051 | 2.051 | 1.903 | 1.903 | 1.903 | 1.890 | 1.890 | 1.890 | 2.167 | 2.914 |
| 79 | TWN | 23.326 | 5.722 | 3.654 | 2.833 | 2.488 | 2.171 | 1.842 | 1.842 | 1.829 | 1.829 | 2.222 | 3.000 |
| 80 | TZA | 5.435 | 3.074 | 1.821 | 1.821 | 1.683 | 1.683 | 1.683 | 1.732 | 1.805 | 1.781 | 2.445 | 3.604 |
| 81 | UKR | 48.631 | 39.445 | 11.141 | 10.321 | 8.659 | 8.659 | 5.329 | 4.098 | 3.329 | 3.329 | 4.014 | 4.742 |
| 82 | URY | 6.413 | 5.611 | 3.987 | 3.987 | 3.744 | 3.744 | 3.183 | 3.183 | 3.207 | 2.756 | 3.042 | 2.621 |
| 83 | USA | 6.283 | 5.204 | 1.526 | 1.526 | 1.415 | 1.415 | 1.268 | 1.268 | 1.268 | 1.268 | 1.583 | 2.207 |
| 84 | UZB | 5.131 | 4.815 | 2.872 | 4.923 | 2.037 | 2.000 | 2.000 | 2.000 | 1.756 | 1.756 | 2.320 | 2.293 |
| 85 | VEN | 19.261 | 16.296 | 10.975 | 10.987 | 10.390 | 10.390 | 9.525 | 9.525 | 9.525 | 9.512 | 10.972 | 13.862 |
| 86 | VNM | 22.522 | 19.037 | 12.872 | 12.872 | 10.866 | 10.866 | 10.025 | 10.025 | 10.025 | 8.756 | 6.931 | 7.828 |
| 87 | ZAF | 7.109 | 5.685 | 1.680 | 1.680 | 1.549 | 1.549 | 1.549 | 1.525 | 1.525 | 1.525 | 1.917 | 2.742 |
| 88 | ZWE | 4.978 | 4.704 | 2.949 | 3.116 | 2.549 | 2.549 | 2.549 | 2.549 | 2.549 | 2.549 | 3.070 | 4.052 |

*A6. Malmquist index and its decomposition (2006-2011)*

| DMU | Eff.X0\|Tek0 | Eff.X0\|Tek1 | Eff.X1\|Tek1 | Eff.X1\|Tek0 | MalmIDX | ∆TE | ∆T |
|---|---|---|---|---|---|---|---|
| ARG | 0.199 | 0.211 | 0.444 | 0.342 | 1.906 | 2.233 | 0.853 |
| ARM | 0.117 | 0.113 | 0.357 | 0.289 | 2.785 | 3.044 | 0.915 |
| AUS | 0.742 | 0.779 | 0.758 | 0.717 | 0.970 | 1.022 | 0.949 |
| AUT | 0.407 | 0.448 | 0.514 | 0.461 | 1.141 | 1.263 | 0.903 |
| BEL | 0.729 | 0.764 | 0.764 | 0.729 | 1.000 | 1.049 | 0.953 |
| BGR | 0.402 | 0.382 | 0.444 | 0.469 | 1.166 | 1.106 | 1.054 |
| BLR | 0.173 | 0.211 | 0.439 | 0.320 | 1.962 | 2.543 | 0.772 |
| BOL | 0.150 | 0.144 | 0.148 | 0.155 | 1.029 | 0.987 | 1.043 |
| BRA | 0.182 | 0.364 | 0.444 | 0.222 | 1.222 | 2.444 | 0.500 |
| CAF | 0.317 | 0.417 | 0.417 | 0.315 | 0.996 | 1.314 | 0.758 |
| CAN | 0.569 | 0.834 | 0.703 | 0.583 | 0.930 | 1.237 | 0.752 |
| CHE | 1.000 | 1.000 | 1.000 | 1.112 | 1.055 | 1.000 | 1.055 |
| CHL | 0.503 | 0.494 | 0.667 | 0.633 | 1.304 | 1.326 | 0.984 |
| CHN | 0.119 | 0.121 | 0.571 | 0.461 | 4.274 | 4.786 | 0.893 |
| CMR | 0.095 | 0.147 | 0.129 | 0.122 | 1.062 | 1.358 | 0.782 |
| COD | 0.198 | 0.289 | 0.277 | 0.197 | 0.975 | 1.399 | 0.697 |
| COG | 0.096 | 0.149 | 0.157 | 0.096 | 1.028 | 1.640 | 0.627 |
| COL | 0.315 | 0.334 | 0.572 | 0.509 | 1.665 | 1.818 | 0.916 |
| CRI | 0.413 | 0.556 | 0.556 | 0.511 | 1.112 | 1.346 | 0.826 |
| CZE | 0.248 | 0.333 | 0.500 | 0.390 | 1.535 | 2.013 | 0.763 |
| DEU | 0.533 | 0.566 | 0.733 | 0.686 | 1.290 | 1.374 | 0.939 |
| DNK | 0.744 | 0.772 | 0.734 | 0.705 | 0.949 | 0.987 | 0.962 |
| ECU | 0.463 | 0.500 | 0.500 | 0.359 | 0.880 | 1.079 | 0.815 |
| EGY | 0.165 | 0.160 | 0.227 | 0.235 | 1.423 | 1.373 | 1.036 |
| ESP | 0.603 | 0.594 | 0.756 | 0.690 | 1.207 | 1.254 | 0.963 |
| EST | 0.830 | 0.977 | 0.973 | 0.886 | 1.031 | 1.172 | 0.880 |
| FIN | 0.545 | 0.527 | 1.000 | 0.897 | 1.767 | 1.834 | 0.963 |
| FRA | 0.628 | 0.615 | 1.000 | 0.869 | 1.501 | 1.592 | 0.942 |
| GBR | 0.802 | 0.868 | 0.997 | 0.669 | 0.979 | 1.244 | 0.787 |
| GRC | 0.271 | 0.345 | 0.523 | 0.448 | 1.585 | 1.934 | 0.820 |
| GTM | 0.243 | 0.260 | 0.297 | 0.317 | 1.220 | 1.222 | 0.998 |
| HND | 0.235 | 0.250 | 0.372 | 0.351 | 1.490 | 1.583 | 0.941 |
| HRV | 0.359 | 0.448 | 0.539 | 0.387 | 1.139 | 1.500 | 0.759 |
| HUN | 0.334 | 0.317 | 0.494 | 0.513 | 1.547 | 1.480 | 1.046 |
| IDN | 0.232 | 0.275 | 0.284 | 0.255 | 1.064 | 1.221 | 0.872 |
| IND | 0.306 | 0.322 | 0.336 | 0.319 | 1.043 | 1.097 | 0.951 |
| IRL | 1.000 | 1.074 | 1.000 | 1.086 | 1.006 | 1.000 | 1.006 |
| IRN | 0.680 | 0.696 | 0.398 | 0.410 | 0.587 | 0.586 | 1.003 |
| ISL | 0.455 | 0.501 | 0.501 | 0.455 | 1.000 | 1.101 | 0.908 |
| ISR | 0.241 | 0.409 | 0.393 | 0.240 | 0.980 | 1.633 | 0.600 |
| ITA | 0.840 | 0.942 | 0.662 | 0.537 | 0.670 | 0.788 | 0.850 |
| JAM | 0.379 | 0.411 | 0.411 | 0.421 | 1.055 | 1.085 | 0.972 |
| JOR | 1.000 | 2.000 | 1.000 | 0.729 | 0.604 | 1.000 | 0.604 |
| JPN | 0.355 | 0.661 | 0.644 | 0.335 | 0.959 | 1.812 | 0.529 |

| DMU | Eff.X0\|Tek0 | Eff.X0\|Tek1 | Eff.X1\|Tek1 | Eff.X1\|Tek0 | MalmIDX | ΔTE | ΔT |
|---|---|---|---|---|---|---|---|
| KAZ | 0.362 | 0.444 | 0.744 | 0.518 | 1.548 | 2.058 | 0.752 |
| KGZ | 0.327 | 0.365 | 0.358 | 0.326 | 0.988 | 1.094 | 0.903 |
| KOR | 0.207 | 0.311 | 0.693 | 0.419 | 2.123 | 3.349 | 0.634 |
| LAO | 0.184 | 0.177 | 0.238 | 0.238 | 1.320 | 1.293 | 1.021 |
| LTU | 0.425 | 0.457 | 0.591 | 0.583 | 1.331 | 1.390 | 0.958 |
| LVA | 0.696 | 0.685 | 0.685 | 0.696 | 1.000 | 0.984 | 1.016 |
| MAR | 0.333 | 0.334 | 0.350 | 0.337 | 1.030 | 1.051 | 0.980 |
| MEX | 0.156 | 0.195 | 0.667 | 0.432 | 3.076 | 4.263 | 0.722 |
| MKD | 0.655 | 0.745 | 0.658 | 0.616 | 0.911 | 1.005 | 0.907 |
| MNE | 0.254 | 0.272 | 0.331 | 0.314 | 1.225 | 1.301 | 0.942 |
| MNG | 0.325 | 0.362 | 0.391 | 0.354 | 1.085 | 1.203 | 0.902 |
| MYS | 0.498 | 0.459 | 0.739 | 0.681 | 1.483 | 1.483 | 1.000 |
| NGA | 0.114 | 0.178 | 0.166 | 0.102 | 0.913 | 1.463 | 0.625 |
| NLD | 0.575 | 0.616 | 0.789 | 0.749 | 1.291 | 1.371 | 0.942 |
| NOR | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| NZL | 0.948 | 1.384 | 0.670 | 0.648 | 0.575 | 0.706 | 0.814 |
| PAK | 0.510 | 0.519 | 0.519 | 0.510 | 1.000 | 1.018 | 0.982 |
| PER | 0.540 | 0.532 | 0.539 | 0.548 | 1.015 | 0.998 | 1.017 |
| PHL | 0.546 | 0.556 | 0.512 | 0.505 | 0.923 | 0.939 | 0.984 |
| POL | 0.203 | 0.224 | 0.346 | 0.331 | 1.588 | 1.704 | 0.932 |
| PRT | 0.564 | 0.559 | 0.500 | 0.460 | 0.854 | 0.886 | 0.964 |
| PRY | 0.255 | 0.269 | 0.220 | 0.170 | 0.738 | 0.862 | 0.857 |
| ROU | 0.361 | 0.369 | 0.331 | 0.344 | 0.924 | 0.915 | 1.010 |
| RUS | 0.183 | 0.210 | 0.767 | 0.572 | 3.379 | 4.197 | 0.805 |
| SDN | 0.320 | 0.442 | 0.442 | 0.320 | 1.000 | 1.379 | 0.725 |
| SGP | 1.000 | 2.576 | 1.000 | 1.000 | 0.623 | 1.000 | 0.623 |
| SRB | 0.287 | 0.302 | 0.281 | 0.260 | 0.919 | 0.980 | 0.938 |
| SVK | 0.220 | 0.234 | 0.422 | 0.408 | 1.830 | 1.918 | 0.954 |
| SVN | 0.267 | 0.370 | 0.454 | 0.364 | 1.293 | 1.698 | 0.762 |
| SWE | 1.000 | 2.000 | 1.000 | 0.805 | 0.634 | 1.000 | 0.634 |
| THA | 0.208 | 0.473 | 0.481 | 0.222 | 1.042 | 2.308 | 0.451 |
| TJK | 0.313 | 0.349 | 0.349 | 0.313 | 1.000 | 1.113 | 0.898 |
| TUN | 0.278 | 0.377 | 0.713 | 0.525 | 1.890 | 2.567 | 0.736 |
| TUR | 0.404 | 0.397 | 0.397 | 0.404 | 1.000 | 0.982 | 1.018 |
| TWN | 0.212 | 0.505 | 0.842 | 0.404 | 1.782 | 3.970 | 0.449 |
| TZA | 0.355 | 0.437 | 0.439 | 0.373 | 1.028 | 1.236 | 0.832 |
| UKR | 0.050 | 0.050 | 0.201 | 0.195 | 3.968 | 3.990 | 0.994 |
| URY | 0.215 | 0.243 | 0.264 | 0.214 | 1.040 | 1.227 | 0.848 |
| USA | 0.470 | 0.901 | 0.762 | 0.409 | 0.858 | 1.622 | 0.529 |
| UZB | 0.490 | 0.511 | 0.357 | 0.315 | 0.669 | 0.727 | 0.920 |
| VEN | 0.111 | 0.104 | 0.115 | 0.110 | 1.047 | 1.034 | 1.013 |
| VNM | 0.106 | 0.127 | 0.135 | 0.125 | 1.122 | 1.274 | 0.880 |
| ZAF | 0.362 | 0.569 | 0.652 | 0.416 | 1.147 | 1.798 | 0.638 |
| ZWE | 0.235 | 0.294 | 0.297 | 0.255 | 1.048 | 1.264 | 0.829 |

Note: Eff.X# | Tek@ represents the projection of DMU in time t=# to the frontier in time t=@. MalmIDX is Malmquist Index.

*A7. Malmquist index and its decomposition (2011-2016)*

| DMU | Eff.X0\|Tek0 | Eff.X0\|Tek1 | Eff.X1\|Tek1 | Eff.X1\|Tek0 | MalmIDX | ΔTE | ΔT |
|---|---|---|---|---|---|---|---|
| ARG | 0.444 | 0.444 | 0.444 | 0.444 | 1.000 | 1.000 | 1.000 |
| ARM | 0.357 | 0.358 | 0.341 | 0.355 | 0.973 | 0.956 | 1.018 |
| AUS | 0.758 | 0.620 | 0.620 | 0.774 | 1.010 | 0.818 | 1.235 |
| AUT | 0.514 | 0.440 | 0.572 | 0.737 | 1.366 | 1.113 | 1.227 |
| BEL | 0.764 | 0.606 | 0.597 | 0.747 | 0.981 | 0.781 | 1.256 |
| BGR | 0.444 | 0.413 | 0.437 | 0.469 | 1.057 | 0.982 | 1.076 |
| BLR | 0.439 | 0.457 | 0.690 | 0.705 | 1.556 | 1.570 | 0.992 |
| BOL | 0.148 | 0.139 | 0.139 | 0.148 | 1.000 | 0.939 | 1.065 |
| BRA | 0.444 | 0.444 | 0.400 | 0.400 | 0.900 | 0.900 | 1.000 |
| CAF | 0.417 | 0.208 | 0.208 | 0.417 | 1.000 | 0.500 | 2.001 |
| CAN | 0.703 | 0.617 | 0.617 | 0.703 | 1.000 | 0.878 | 1.140 |
| CHE | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| CHL | 0.667 | 0.667 | 0.571 | 0.571 | 0.857 | 0.857 | 1.000 |

| DMU | Eff.X0\|Tek0 | Eff.X0\|Tek1 | Eff.X1\|Tek1 | Eff.X1\|Tek0 | MalmIDX | ∆TE | ∆T |
|---|---|---|---|---|---|---|---|
| CHN | 0.571 | 0.571 | 0.526 | 0.577 | 0.964 | 0.921 | 1.047 |
| CMR | 0.129 | 0.114 | 0.117 | 0.133 | 1.024 | 0.904 | 1.133 |
| COD | 0.277 | 0.213 | 0.167 | 0.219 | 0.788 | 0.603 | 1.305 |
| COG | 0.157 | 0.127 | 0.129 | 0.167 | 1.037 | 0.819 | 1.265 |
| COL | 0.572 | 0.521 | 0.436 | 0.471 | 0.830 | 0.762 | 1.089 |
| CRI | 0.556 | 0.338 | 0.657 | 0.717 | 1.583 | 1.182 | 1.340 |
| CZE | 0.500 | 0.500 | 0.500 | 0.500 | 1.000 | 1.000 | 1.000 |
| DEU | 0.733 | 0.632 | 0.623 | 0.697 | 0.967 | 0.850 | 1.139 |
| DNK | 0.734 | 0.620 | 0.620 | 0.734 | 1.000 | 0.845 | 1.183 |
| ECU | 0.500 | 0.500 | 0.400 | 0.400 | 0.800 | 0.800 | 1.000 |
| EGY | 0.227 | 0.208 | 0.208 | 0.227 | 1.000 | 0.916 | 1.092 |
| ESP | 0.756 | 0.660 | 0.683 | 0.775 | 1.030 | 0.903 | 1.140 |
| EST | 0.973 | 0.780 | 1.000 | 2.056 | 1.646 | 1.028 | 1.602 |
| FIN | 1.000 | 0.850 | 0.850 | 1.000 | 1.000 | 0.850 | 1.177 |
| FRA | 1.000 | 0.895 | 0.717 | 0.825 | 0.813 | 0.717 | 1.134 |
| GBR | 0.997 | 0.837 | 0.837 | 0.982 | 0.992 | 0.840 | 1.182 |
| GRC | 0.523 | 0.526 | 0.553 | 0.549 | 1.050 | 1.056 | 0.994 |
| GTM | 0.297 | 0.272 | 0.705 | 0.745 | 2.549 | 2.374 | 1.074 |
| HND | 0.372 | 0.277 | 0.277 | 0.372 | 1.000 | 0.746 | 1.341 |
| HRV | 0.539 | 0.417 | 0.301 | 0.371 | 0.705 | 0.558 | 1.263 |
| HUN | 0.494 | 0.467 | 0.493 | 0.517 | 1.051 | 0.999 | 1.053 |
| IDN | 0.284 | 0.233 | 0.312 | 0.368 | 1.318 | 1.099 | 1.199 |
| IND | 0.336 | 0.256 | 0.496 | 0.539 | 1.763 | 1.475 | 1.195 |
| IRL | 1.000 | 0.896 | 0.785 | 0.962 | 0.918 | 0.785 | 1.169 |
| IRN | 0.398 | 0.339 | 0.339 | 0.398 | 1.000 | 0.850 | 1.176 |
| ISL | 0.501 | 0.439 | 0.439 | 0.555 | 1.052 | 0.876 | 1.202 |
| ISR | 0.393 | 0.340 | 0.340 | 0.393 | 1.000 | 0.865 | 1.156 |
| ITA | 0.662 | 0.506 | 0.541 | 0.708 | 1.069 | 0.818 | 1.308 |
| JAM | 0.411 | 0.272 | 0.493 | 0.566 | 1.581 | 1.199 | 1.319 |
| JOR | 1.000 | 0.500 | 0.556 | 1.111 | 1.111 | 0.556 | 2.000 |
| JPN | 0.644 | 0.517 | 0.641 | 0.862 | 1.289 | 0.996 | 1.294 |
| KAZ | 0.744 | 0.709 | 0.662 | 0.683 | 0.926 | 0.890 | 1.041 |
| KGZ | 0.358 | 0.283 | 0.268 | 0.347 | 0.959 | 0.750 | 1.279 |
| KOR | 0.693 | 0.614 | 0.637 | 0.839 | 1.121 | 0.919 | 1.220 |
| LAO | 0.238 | 0.238 | 0.238 | 0.238 | 1.000 | 1.000 | 1.000 |
| LTU | 0.591 | 0.519 | 0.678 | 0.875 | 1.390 | 1.147 | 1.212 |
| LVA | 0.685 | 0.669 | 0.764 | 0.800 | 1.155 | 1.116 | 1.035 |
| MAR | 0.350 | 0.303 | 0.667 | 0.667 | 2.046 | 1.903 | 1.075 |
| MEX | 0.667 | 0.667 | 0.667 | 0.667 | 1.000 | 1.000 | 1.000 |
| MKD | 0.658 | 0.474 | 0.823 | 0.874 | 1.518 | 1.250 | 1.214 |
| MNE | 0.331 | 0.251 | 0.335 | 0.359 | 1.202 | 1.011 | 1.189 |
| MNG | 0.391 | 0.314 | 0.491 | 0.599 | 1.550 | 1.257 | 1.233 |
| MYS | 0.739 | 0.571 | 0.672 | 0.704 | 1.059 | 0.909 | 1.165 |
| NGA | 0.166 | 0.149 | 0.154 | 0.209 | 1.138 | 0.923 | 1.233 |
| NLD | 0.789 | 0.670 | 0.704 | 0.836 | 1.055 | 0.892 | 1.182 |
| NOR | 1.000 | 1.000 | 1.000 | 1.052 | 1.026 | 1.000 | 1.026 |
| NZL | 0.670 | 0.611 | 0.694 | 0.780 | 1.150 | 1.036 | 1.111 |
| PAK | 0.519 | 0.434 | 0.434 | 0.519 | 1.000 | 0.836 | 1.197 |
| PER | 0.539 | 0.526 | 0.526 | 0.539 | 1.000 | 0.976 | 1.025 |
| PHL | 0.512 | 0.433 | 0.468 | 0.557 | 1.085 | 0.915 | 1.186 |
| POL | 0.346 | 0.304 | 0.571 | 0.571 | 1.761 | 1.651 | 1.067 |
| PRT | 0.500 | 0.500 | 0.500 | 0.500 | 1.000 | 1.000 | 1.000 |
| PRY | 0.220 | 0.171 | 0.236 | 0.255 | 1.266 | 1.073 | 1.180 |
| ROU | 0.331 | 0.254 | 0.470 | 0.543 | 1.742 | 1.422 | 1.225 |
| RUS | 0.767 | 0.723 | 0.742 | 0.791 | 1.029 | 0.968 | 1.063 |
| SDN | 0.442 | 0.403 | 0.403 | 0.442 | 1.000 | 0.912 | 1.096 |
| SGP | 1.000 | 1.000 | 1.000 | 1.261 | 1.123 | 1.000 | 1.123 |
| SRB | 0.281 | 0.204 | 0.252 | 0.347 | 1.236 | 0.897 | 1.377 |
| SVK | 0.422 | 0.337 | 0.513 | 0.540 | 1.395 | 1.215 | 1.149 |
| SVN | 0.454 | 0.439 | 0.479 | 0.489 | 1.084 | 1.054 | 1.028 |
| SWE | 1.000 | 1.087 | 0.833 | 0.922 | 0.841 | 0.833 | 1.009 |
| THA | 0.481 | 0.406 | 0.398 | 0.479 | 0.988 | 0.827 | 1.194 |
| TJK | 0.349 | 0.284 | 0.667 | 0.667 | 2.119 | 1.911 | 1.109 |
| TUN | 0.713 | 0.617 | 0.578 | 0.695 | 0.956 | 0.811 | 1.179 |
| TUR | 0.397 | 0.367 | 0.442 | 0.466 | 1.189 | 1.114 | 1.067 |

| DMU | Eff.X0\|Tek0 | Eff.X0\|Tek1 | Eff.X1\|Tek1 | Eff.X1\|Tek0 | MalmIDX | ∆TE | ∆T |
|---|---|---|---|---|---|---|---|
| TWN | 0.842 | 0.702 | 0.702 | 0.866 | 1.014 | 0.834 | 1.217 |
| TZA | 0.439 | 0.378 | 0.298 | 0.349 | 0.791 | 0.678 | 1.167 |
| UKR | 0.201 | 0.182 | 0.800 | 0.800 | 4.185 | 3.978 | 1.052 |
| URY | 0.264 | 0.200 | 0.328 | 0.432 | 1.642 | 1.245 | 1.319 |
| USA | 0.762 | 0.618 | 0.618 | 0.762 | 1.000 | 0.812 | 1.232 |
| UZB | 0.357 | 0.307 | 0.543 | 0.600 | 1.725 | 1.523 | 1.133 |
| VEN | 0.115 | 0.094 | 0.095 | 0.115 | 1.005 | 0.825 | 1.219 |
| VNM | 0.135 | 0.130 | 0.286 | 0.286 | 2.153 | 2.113 | 1.019 |
| ZAF | 0.652 | 0.578 | 0.625 | 0.596 | 0.995 | 0.959 | 1.037 |
| ZWE | 0.297 | 0.267 | 0.267 | 0.297 | 1.000 | 0.896 | 1.116 |

Note: Eff.X# | Tek@ represents the projection of DMU in time t=# to the frontier in time t=@. MalmIDX is Malmquist Index.

# CHAPTER 3 The impact of institutional quality on tax complexity: A global sample with panel GMM approach[♦]


Abstract

Tax complexity has been well discussed in literature. It is a multidimensional concept with a diversity of definitions and measures, depending on perspective. Institutions have been acknowledged to shape the strategic environment in which actors fight for their interests (Hall and Taylor, 1996; Thelen and Steinmo, 1992) and comprehension of the institutions has become central to understanding of the policy process (Peter, 1991). Tax design, at least in favour of tax complexity, needs to consider the effects of institutional quality. This study, taking an institutional approach, addresses the determinants of tax complexity stressing the impact of institutional environment quality, employing the system generalised method of moments (system-GMM) for a panel of 88 countries from 2005 through to 2016. The empirical results generally suggest the existence of a statistically negative effect of institutional quality on tax complexity and are robust with alternative measures of tax complexity from direct to indirect indicators, via alternative estimators and specifications. This effect varies across different income groups. The results offer some recommendations for tax policy making.



*JEL classification*: H21, H83, M21, M48.

Keywords: tax complexity; tax simplification; GMM; institutions; institutional quality.


[♦] The chapter was submitted to the international conference on Taxation, Trade and Regional Development (TTRD), expected on December 3 - 4, 2020 and is now under review.

## 3.1 Introduction

Tax complexity is known to be a multidimensional concept and is, thus, difficult to define and measure. It conveys different meanings to different people, depending on their perceptions. In the literature, there have been alternative definitions of tax complexity (or tax simplicity/simplification, as its mirror)[45], from a variety of sources and indicators. Unfortunately, there has been a lack of a conventional single measure of tax complexity.

Tax complexity varies significantly among different countries and even over time. It creates opportunities for corruption in tax administration (TA), obstructing compliance and/or enforcement. As found in Richardson (2006), complexity was the most important determinant of tax evasion and the cause of non-compliance among taxpayers (Milliron, 1985; Saad, 2012, 2014). Thus, there is a need to consider tax complexity as an essential part of tax policy design. Furthermore, it has also been acknowledged that institutions shape the strategic environment in which actors fight for their interests (Hall and Taylor, 1996; Thelen and Steinmo, 1992) and an understanding of institutions becomes central to the understanding of the policy process (Peter, 1991). Once established, institutions profoundly shape the preferences of actors in the next iteration of the policy game (Steinmo, 2003). Therefore, the investigation of institutions, or factors relating to institutions that affect and decide tax complexity, seems increasingly important.

Among the diverse definitions, this study is more likely to be in line with the business's perspective in that tax complexity refers to the time and monetary costs spent in complying with the requirements of business tax laws (Tran-Nam and Evans, 2014). Tax complexity, thus, generally refers to administrative procedures followed to comply with the tax obligations and is the so-called tax

[45] In Milliron (1985), tax complexity was defined in terms of four distinct dimensions, representing four aspects of complexity: the nature of the topic (personal versus financial), the quantitativeness of the presentation, the vulnerability of the law to misuse, and the readability of the passage. Slemrod (1989, p. 157) identified four aspects of tax system complexity: predictability, enforceability, difficulty, and manipulability, using the approach of describing tax complexity by a set of collectively exhaustive, fundamental properties. McCaffery (1990, p. 1269–73) discussed the normative feature of simplification and identified three types of tax complexity: technical, structural and compliance complexity. Cooper (1993, p. 424) argued that tax complexity contains, within it, intimations of predictability, proportionality, consistency, compliance, administration, coordination, and expression (cited in Tran-Nam and Evans, 2014). An alternative approach is to classify tax complexity by where it occurs during different stages of the operation of the tax system i.e. policy complexity, statutory complexity, administrative complexity, and compliance complexity (Evans and Tran-Nam, 2010, p.249), among others.

compliance cost or tax administrative burden to the economic agents (Braunerhjelm and Eklund, 2014; Braunerhjelm et al. 2015). In terms of measures, multiple indicators were justified in the literature such as policy complexity, statutory complexity, compliance complexity, administrative and compliance complexity, and legal and effective complexity.[46] Following Lawless (2013), I refer to tax complexity by using two sub-indicators of the paying taxes indicator, say, time to comply with taxes, and the number of tax payments.[47] This supports the premise that the lower the time taken to comply with the tax system and the fewer the number of payments, the easier it is for businesses to comply with their tax paying obligations and, thus, this can also be used to measure tax simplicity or tax simplification (Awasthi and Bayraktar, 2015; Bayraktar, 2020). Despite some limitations caused by the inconsistency of measures as well as the methodology and data presentation,[48] the paying taxes sub-indicators are the only available set providing the comparative indicators of the tax complexity across countries and can be regarded as the best-suited measure of tax complexity.

Some studies in the existent literature on tax complexity have discussed the impacts of tax complexity on tax cost, notably Alm et al. (1992), Heyndels and Smolders (1995), Cuccia and Carnes (2001), Forest and Sheffrin (2002), Evans (2003), Oliver and Bartley (2005), Picciotto (2007), and Saad (2010, 2012, 2014) among many others. Other authors examined the relationship between the complex tax system and lower taxes, including Milliron (1985), Mills (1996), Richardson (2006), etc. We can also find some controversial articles on the link between tax complexity and higher taxes, for example, White et al. (1990) and Scotchmer (1989). Recently, there have been studies on the impact of tax complexity on corruption, including Awasthi and Bayraktar (2015), Liu and Feng (2015), Zelekha (2017), Tanzi (2017) among others. The exploration of variation in tax complexity measured by two sub-indicators of paying taxes among countries and over multiple years and, in particular, the effect of institutional quality, however, has not undergone detailed investigation. This study then addresses tax complexity in view of administrative burden and through the institutional lens. In doing so, I investigate the empirical evidence on the correlation between tax complexity and institutional quality.

[46] See Tran-Nam and Evans (2014, p.350).
[47] Refer to Doing Business project (WB) and Paying Taxes Reports (PwC) for definitions and methodologies.
[48] See Tran-Nam and Evans (2014, p.356) and Awasthi and Bayraktar (2015, p.301) for further explanation.

Methodologically, I have employed the system generalised method of moments (system-GMM) following Arellano and Bover (1995) and Blundell and Bond (1998) for panel data regression. The tax complexity has been proxied with alternative measures, namely time to comply with taxes (*taxtime*), number of tax payments (*taxpay*), efficiency score of tax simplification performance (taxeff), and slack of tax simplification evaluation (*taxsk*). The results suggest, in general, that institutional quality exerts a statistically negative effect on tax complexity measure; however, this impact varies due to specific indicators. It should be stressed that this empirical evidence appears to vary across different income groups, as is less prominent in high-income economies. The results are robust due to alternative measures and estimators. The study contributes to filling the gap in the field as a cross-country empirical study, which explores the tax complexity measured by two sub-indicators of paying taxes, taking an institutional approach. The link between tax complexity and institutional quality was empirically explored through alternative measures of tax complexity, either the direct indicators or the indirect ones, as the outcomes generated from another estimation and alternative estimators and models, combining parametric and non-parametric methods.

The structure of the chapter is organised as follows. Section 3.2 reviews the related literature. Section 3.3 discusses the methodology for empirical analysis. Sections 3.4 and 3.5 discuss the estimation results, corresponding to alternative measures of tax complexity. The work concludes in Section 3.6.

## 3.2 Related literature

Being a multidimensional concept, tax complexity (or its mirror, tax simplicity) has been addressed in literature from diverse perspectives. This section gives a brief review of some relevant works on tax complexity, capturing a variety of research interests.

First, Krause (2000) addressed tax complexity in the United States, focusing on the federal income tax. Tax complexity is argued to represent either a problem or an opportunity. On the one hand, uncertainty, ignorance and burdensome documentation requirements deterred some taxpayers from taking advantage of legitimate deductions and credits. On the other hand, others found opportunities for creative tax avoidance in ambiguous provisions. Edmiston et al. (2003) found that complexity and uncertainty, in the sense of multiple tax rates, indeterminate language in the tax law and inconsistent changes in the tax laws, had a significant negative effect on inward FDI. Slemrod (2005) analysed the variation in complexity in the U.S. state income tax system, based on the number of lines in the tax forms and the number of pages in the instruction booklets. The author found that the states with more professional legislatures, as measured by the salaries paid, and those with a less active voting population, tended to have more complex tax systems. Morris and Qiao (2011) discussed tax complexity from a different perspective. Understanding the difficulty in defining or measuring tax complexity directly as an obstacle to tax simplification, the paper suggested a general approach for slowing the pace of tax complexity. This was conducted based on the courts' apparently increasing role as final arbiter of meaning in tax disputes. Tran-Nam and Evans (2014) sought to fill the need for a commonly agreed upon definition in the field by proposing the construction of an index of tax system complexity, which was conceived as a summary indicator of the overall complexity of a tax system at a particular point in time. Budak et al. (2016) investigated the international experiences of tax simplification from relevant experts in 11 countries including Australia, Canada, China, Malaysia, New Zealand, Russia, South Africa, Thailand, Turkey, the U.K., and the U.S. The analysis demonstrated that a considerable degree of complexity was inevitable given the different aims of taxation and the complex socioeconomic environments in which tax systems had to operate. The article also focused on the relevant factors and issues involved in classifying unavoidable and unnecessary complexity with respect to not only legislation but also tax policy and administrative systems.

Besides, there have been several articles discussing the relationship between tax complexity and tax cost. Alm et al. (1992) examined the effects of institutional uncertainty on taxpayer compliance using laboratory experiments. The results provided mixed support for the hypothesis that greater uncertainty increased compliance. Accordingly, the impact of greater fiscal uncertainty depended upon the institutional setting in which the individual made the compliance decision. Thus, it was a risky tool for generating increased compliance if based on a policy of increasing the fiscal uncertainty level.

Heyndels and Smolders (1995) discussed the relationship between tax complexity and fiscal illusion,[49] using the Hirschman-Herfindahl index (HHC). Cuccia and Carnes (2001) conducted an experiment to look at the correlation between tax complexity and tax equity perceptions. Accordingly, the authors found that the provision's complexity negatively affected equity assessments only when subjects were prompted with an alternative provision with relatively favourable economic consequences, and then only when no explicit justification for its complexity and relative economic consequences was offered. Forest and Sheffrin (2002) conducted an empirical investigation of complexity and compliance. This was an analysis of whether a simple tax system created comfort and encouraged compliance. Evans (2003) provided an overview of the studies on the operating costs of taxation, i.e. compliance costs for taxpayers and administrative costs for revenue authorities. Oliver and Bartley (2005) examined the factors affecting the level of tax complexity and compliance costs. Picciotto (2007) proposed a rethinking of approaches to tax compliance, extending perspectives viewing regulation as an interactive or reflexive process mediated by sociolinguistic practices. As a result, the paper considered some of the current proposals for improving tax compliance, stressing the importance of reducing complexity. Saad (2010) investigated the impact of tax complexity on fairness perception of salaried taxpayers in Malaysia, employing the Theory of Planned Behaviour. Saad (2012, 2014) studied the taxpayers' views on their level of perceived complexity of the income tax system and the underlying reasons for non-compliance behaviour among income taxpayers in New Zealand. According to the results, the tax system was perceived as being complex and tax complexity was also regarded as a determinant of non-compliance among the taxpayers.

In addition, some papers have studied the influence of tax complexity on taxes. On one hand, it was claimed that tax complexity reduced taxes. Milliron (1985) conducted a behavioural research of the meaning and investigated the effect of tax complexity on taxpayers' reporting positions. As such, complexity was found to significantly influence the tax reporting positions. The finding appeared inconsistent, however, supporting either an effect on opportunity to evade taxes or a necessity for

[49] Fiscal illusion refers to the tendency of government to be involved more than appropriate in economic activity and is given by the fact that those who decide about what programs will be publicly provided do not weight full social costs of those programs (Buchanan and Wagner, 1977).

equitable tax laws and positive relationship with compliance. Mills (1996) studied the relationship between compliance costs and taxes paid. The existing descriptive research emphasised the social cost burden of such compliance costs. And the preliminary results indicated that firms that spent more on tax research and planning would report lower tax expense. Richardson (2006) conducted a cross-country investigation of tax evasion's determinants. It was found that complexity was the most important factor, contributing the greatest part to the variation of tax evasion level, besides other non-economic determinants. On the other hand, some articles controversially claimed a link between tax complexity and higher taxes, for example, White et al. (1990) with a behavioural study investigating the effect of knowledge of income tax laws and tax policy on individual perceptions of federal income tax fairness, or Scotchmer (1989) on identifying the beneficiary from taxpayer confusion.

Recently, a number of studies have been carried out to explore the relationship between tax complexity and corruption. Awasthi and Bayraktar (2015) found empirical evidence of the negative relationship between tax simplification and corruption in TA using a sample of 104 countries over the 2002-2012 period. A less complex tax system was shown to result in lower corruption in TA. This effect was found to differ among the income groups and regions. In the same vein, Liu and Feng (2015)'s cross-country study analysed tax structure and corruption. It was suggested that countries with more complex tax systems tend to be more corrupt than those with less complex tax systems. The study confirmed the positive link between tax complexity and corruption through alternative estimations and measures. Furthermore, the empirical study conducted by Zelekha (2017) stated that high degrees of tax complexity might serve as a breeding ground for corruption by providing more opportunities for rent-seeking tax officials and politicians to grant favours and thus attracting the activity of fixers. Also, tax complexity effects were driven by the pure complexity of the bureaucratic procedures represented by the time needed to comply. Similarly, Tanzi (2017) affirmed that corruption was facilitated by a complex tax system. Nevertheless, tax complexity was argued to be evitable as it has become far more complex than necessary.

In brief, the existent literature on tax complexity has dealt with various research topics and interests, covering compliance, tax cost, taxes, and social instances like corruption perception. Nonetheless, there is an apparent absence of empirical studies on the link between tax complexity and institutional quality indicators. As a result, there is a necessity for papers using multiple countries as an analysis unit to examine the impact of the institutional quality factors, taking an institutional approach, to fill the gap in the field.

## 3.3 Empirical methodology

### *3.3.1 Empirical background*

According to North (1990), "Institutions are a set of rules, compliance procedures and moral and ethical behavioural norms designed to constrain the behaviour of individuals in the interests of maximising the wealth or utility of the principals." (p.201–202). Institutions have been acknowledged to shape the strategic environment in which actors fight for their interests (Hall and Taylor, 1996; Thelen and Steinmo, 1992). From the public policy perspective of the institutional reform, comprehension of institutions has been argued to become the key role in understanding the policy process (Peter, 1991) and, once institutionalised, the policies can intensively shape the preferences of actors in the next iteration of the policy game (Steinmo, 2003). Therefore, tax design, at least in favour of tax complexity, needs to consider the effects of institutional quality. As internationalisation and globalisation have intensively developed and spread all over the world, the institutional context has been of increasingly important contribution (see, for example, Yamen et al., 2018 for impact of institutional environment quality on tax evasion; Gwartney et al., 2004 for the examination of the issue of cross-country differences in income levels and growth rates, using institutional approach; Gwartney et al., 2006 for the impact of institutions on investment, and the resulting impact of investment on growth; among others). This study focuses on the determinants of tax complexity – the institutional variables reflecting the governance and economic freedom aspects.

*3.3.2 Econometric models*

As mentioned earlier, this study aims to examine the effect of the institutional quality indicators on tax complexity across countries and over multiple years. A regression model with the tax complexity measures as dependent variables over the set of institutional variables is written as

$$taxcomp_{it} = f(inst_{it}, controls_{it}) + \eta_i + \gamma_t + \varepsilon_{it} \tag{3.1}$$

where taxcomp denotes the tax complexity proxied by measures of tax administrative burden; *inst* refers to the vector of institutional quality indicators; control is the vector of condition variables. Subscript it represents country i and year t. Two components $\eta_i$ and $\gamma_t$ are time-invariant and unit-invariant modelled effects, respectively, which help get rid of biasness due to omitted variables.

Public governance might be defined as "the traditions and institutions by which authority in a country is exercised" (Kaufmann et al., 2011, p. 222). A country with high-quality institutional system is thought to facilitate effective public administration. Thus, once critical country characteristics are accounted for, poorer institutional quality is expected to increase tax complexity. Put another way, I expect that the institutional quality factors negatively affect tax complexity.

At one extreme, *taxtime* and *taxpay* are weakly correlated, and *taxtime* can be considered as a function of *taxpay* applications; at another extreme, the cost taxpayers incur to comply with taxes is finally the *taxtime*. It seems that the ultimate goal of tax systems is to reduce the *taxtime*. In the study, I thus opt to take *taxtime* as the main tax complexity measure to be explained.

The model to test the relationship turns out

$$taxtime_{it} = f(inst_{it}, controls_{it}) + \eta_i + \gamma_t + \varepsilon_{it} \tag{3.1a}$$

Since tax simplicity is the mirror of tax complexity, the effort taken to simplify the tax complexity could be positively impacted by the institutional indicators. Thus, it is expected to exist a positive correlation between institutional quality and tax simplification performance. As an alternative to tax complexity measure, the slackness time to comply with taxes (*taxsk*) was also used to capture both tax complexity indicators.[50] The slacks are generated from a tax simplification performance evaluation measure, using Data Envelopment Analysis methods (Lovell and Pastor, 1999; Nguyen et al., 2020, Ch.2; and the reference therein). Note that the DEA evaluations consist of the total *taxpay* and all three components of *taxtime*. And slacks of *taxtime* is, hence, expected to decline as institutional quality increases.

The implied econometric model reads

$$taxsk_{it} = f(inst_{it}, controls_{it}) + \eta_i + \gamma_t + \varepsilon_{it} \tag{3.1b}$$

where *taxtime* and *taxsk* denote total time to comply with taxes and slacks of total time to comply with taxes (generated from the performance evaluation of tax simplification), respectively.

### *3.3.3 Estimation methods*

Due to the nature of dependent variables (*taxtime* and *taxsk*), which is slowly changed or unchanged in some certain situations, their first-lags should be included in the right hand side of model (3.1a, b) to fully capture the two sources of persistence over time (Baltagi, 2005, p.135). This implies the panel data is dynamic so that the OLS estimator is biased and inconsistent. Since the dataset covers a few periods (T = 12) and many individual units (N = 88), the panel GMM estimator (Arellano and Bover, 1995; Blundell and Bond, 1998) with a small sample variance correction (Windmeijer, 2005) is utilised for testing the relationship between the institutional quality and tax complexity.

### *3.3.4 Data*

As found in Lawless (2013), tax complexity was measured by the two sub-indicators of paying taxes (as an indicator of measuring the ease of doing business) i.e. time to comply (*taxtime*) and number of payments (*taxpay*). These two variables are also used in Awasthi and Bayraktar (2015) as a measure of tax simplicity for the premise that “the lower the time taken to comply with the tax system and the

[50] The slackness time to comply is the distance to the empirical frontier constructed by the DEA-WEO.

fewer the number of payments, the easier it is for businesses to comply with their tax paying obligations" (Awasthi and Bayraktar, 2015).

The *taxtime* indicator refers to the time needed to comply with taxes i.e. the time to prepare, file and pay taxes. In this study, besides the total time required for all three taxes (corporate income tax, labour tax, and consumption tax), I also consider the time to comply with individual tax. The *taxpay* indicator measures the total number of tax payments by businesses, including electronic filing. Data on taxpay and *taxtime* can be extracted either from Doing Business project (World Bank) or Paying Taxes Reports (issued by PwC and World Bank) since they provide the similar and even identical, in some cases, total of these two subindicators.[51] However, the data from the latter source also helps us obtain the subcomponents of *taxtime*, and thus used in this study to facilitate further estimations.[52] Although the choice of paying taxes indicator for measuring the tax complexity has encountered some criticism[53] on the robustness of measure, methodology and data presentation, it is considered the only available set of data points providing the objective, worldwide comparison of indicators on the tax complexity (or simplicity) of tax regimes as mentioned in Awasthi and Bayraktar (2015).

In addition, for examining the determinants of tax complexity variation, I took into consideration the institutional quality indicators, which exogenously determine the operation of the tax systems. I focus on the institutional quality measures reflecting governance (see Daniel, Cieslewicz, and Pourjalali, 2012; Yamen et al., 2018, among others) and economic freedom (see Gwartney et al., 2004, 2006, among others). Based on Worldwide Governance Indicators – WGI (World Bank), which was developed by Kaufmann, Kraay, and Mastruzzi (2011) and is "[one] of the most well-known and comprehensive studies of the institutional environment of countries" (Daniel et al., 2012, p. 373), I extracted the variables for the six dimensions of governance including rule of law (rullaw), government effectiveness (goveff), corruption control (concor), regulatory quality (regqua), political stability

[51] Data on each tax complexity indicator (taxtime/taxpay) extracted from both sources shows high consistency (correlation is over 96%).

[52] See http://www.doingbusiness.org/Methodology/Paying-Taxes for full details of the case study and methodology and http://www.doingbusiness.org/Methodology/Methodology-Note for details on how the data is collected.

[53] See Awasthi and Bayraktar (2015) and Tran-Nam and Evans (2014) for further discussion on these tax complexity's indicators.

(polsta) and voice and accountability (voiacc), ranging from approximately -2.5 to +2.5. The variables for economic freedom index (efw) and its component indicators i.e. legal system (legal), regulation (regu), sound money (sndmoney), and government size (govsize), measured on a scale from 0 to 10, were extracted from the Economic Freedom of the World – EFW – datasets (the Fraser Institute). EFW index, a quality measure of a country's institutional and policy environment, was developed by Gwartney and Lawson (2003) and it measures the consistency of a nation's policies and institutions with economic freedom, reflecting personal choice, voluntary exchange, freedom to compete, and protection of person and property. As for the control variables, I took internet usage as a percentage of the population (internet), level of income and economic integration such as trade openness (trade) and GDP (rGDPpc) and dummies of income classifications, extracted from World Bank. All data is established on the yearly basis. 88 countries (including 35 OECD countries and 53 other countries) were selected conditional to the availability of data and data quality throughout the timespan (2005-2016) to guarantee a balanced panel data. Table 1 shows the descriptive statistics of variables used in regressions, while the description of data can be found in Table A.1 in the Appendix.

Table 1. Descriptive statistics of variables.

| | concor | goveff | polsta | rullaw | regqua | voiacc | efw | govsize | legal | sndmoney | regu | internet | trade | taxtime | taxpay | taxsk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Obs** | 1056 | 1056 | 1055 | 1056 | 1056 | 1056 | 1008 | 1008 | 1008 | 1008 | 1008 | 1038 | 1053 | 1056 | 1056 | 1056 |
| **Mean** | 0.187 | 0.325 | -0.040 | 0.191 | 0.305 | 0.184 | 7.00 | 6.54 | 5.77 | 8.41 | 7.01 | 45.87 | 0.87 | 330.8 | 26.0 | 206.1 |
| **Std.Dev** | 1.110 | 1.012 | 0.967 | 1.092 | 1.016 | 1.019 | 0.92 | 1.07 | 1.64 | 1.48 | 1.02 | 28.30 | 0.50 | 332.6 | 22.3 | 277.4 |
| **Min** | -1.544 | -1.848 | -2.810 | -2.241 | -2.236 | -2.124 | 2.65 | 3.86 | 1.75 | 0.00 | 2.49 | 0.24 | 0.14 | 30.0 | 2.0 | 0.0 |
| **Max** | 2.470 | 2.437 | 1.596 | 2.100 | 2.261 | 1.740 | 8.79 | 9.47 | 9.14 | 9.92 | 9.17 | 98.24 | 4.02 | 2600.0 | 147.0 | 2261.7 |

## 3.4 Tax complexity determinants

### *3.4.1 Baseline models*

In this section, I start my estimations with baseline models for the individual institutional quality indicator. The regression specifications are conducted with (log) total of time to comply with taxes (ltaxtime) as a dependent variable.

The estimation outcomes are summarised in Table 2. The results show the signs associated with the coefficients of the institutional quality indicators are consistent with the expected outcome across all 11 models. Except for model (8), which captured political stability that was found to be insignificant, all other models show the statistically significant and negative effect of the institutional quality on tax complexity. Noticeably, the institutional quality variables such as economic freedom, government size, legal system, regulation, and regulatory quality respectively show the highest impact on *taxtime*, at 1% of significance level. They are followed by rule of law, whose impact is observed at 5% of significance level. At 10% of significance, we witness the impact of other institutional variables, namely, sound money, corruption control, government effectiveness, and voice accountability.

Evidently, in an average country whose institutions and policies are highly consistent with the government's protective function, and in which the freedom of individuals to make their own decisions are high, there was a lower level of complexity in the tax system. A higher level of government spending as a share of the total, a bigger government enterprise sector, and higher marginal tax rates accompanied a more complex tax system. Similarly, a country with highly effective governmental protective functions; the less regulatory restraints limiting the freedom of exchange in credit, labour, and product markets; and higher ability of the government to formulate and implement sound policies and regulations permitting and promoting market competition and private sector development can help reduce the tax system's complexity. A stronger law and order system may also be associated with a less complicated tax system. Although the effect is not very strong, the high consistency of monetary policy and ease of alternative currencies, high perception of corruption control, high quality of public and civil service, and high perceptions of expression, association and media freedom in a country may facilitate a reduction in time to comply with taxes. Contrarily, the process by which governments are selected, monitored, and replaced i.e. perceptions of political instability or politically motivated violence does not affect the tax complexity. The magnitudes of the estimated coefficients suggest a unit institutional quality increase would result in a decrease in the total time to comply by approximately 2% to 8.6% per year, controlling for the rate of internet users, trade openness, and income level. Thus, I illustrate the partial effects of some typical institutional variables on tax complexity in Figure 1. It firmly characterises the negative relationship between institutional indicators (*inst*) and *taxtime* as expected.

Regarding *taxpay* coefficients, it was clearly shown that the number of tax payments has a significantly positive effect on the *taxtime*, but the magnitudes are considerably lower than the institutional ones. Meanwhile, the *taxtime* improvement appears to be a sluggish process as its AR(1) coefficients are relatively high, above 0.8.

The regression estimations are also included different specification tests such as the first- and second-order Arellano-Bond (1991) serial correlations, AR(1) and AR(2), and the Hansen (1982)'s overidentification (J-test) tests, respectively. The validity of system-GMM estimation requires the null of the AR(1) test should be rejected, whilst the alternatives of the other two tests should be in favour. The last three rows of Table 2 indicate the baseline models are valid and consistent.

For robustness check, I ran regressions using data on *taxtime* extracted from Doing Business project. The results are introduced in Table A.2 in the Appendix. Although I do not further discuss here, it may be said that the estimation outcomes demonstrate and support the existence of the negative link between institutional quality and *taxtime*. This justifies the data consistency as mentioned in the earlier discussions.

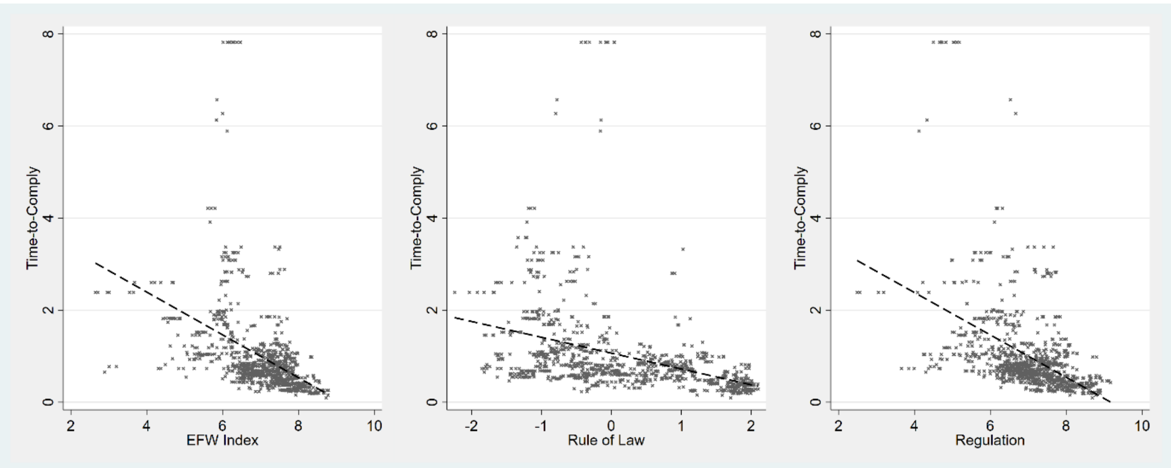


Figure 1. The partial effects of some typical institutional indicators on total time to comply with taxes.

Table 2. Estimations results: baseline models

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime |
| | | | | | | | | | | | |
| ltaxtime(-1) | 0.811*** | 0.841*** | 0.807*** | 0.824*** | 0.825*** | 0.812*** | 0.832*** | 0.850*** | 0.856*** | 0.845*** | 0.847*** |
| | (0.066) | (0.052) | (0.055) | (0.071) | (0.063) | (0.089) | (0.083) | (0.053) | (0.055) | (0.067) | (0.059) |
| taxpay | 0.001* | 0.001*** | 0.001** | 0.001** | 0.001** | 0.001** | 0.001** | 0.001*** | 0.001*** | 0.001** | 0.001*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) |
| internet | -0.001* | -0.002** | 0.000 | -0.002** | -0.001 | -0.001 | -0.000 | -0.001 | -0.001 | -0.000 | -0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| trade | -0.023 | -0.035 | -0.028 | -0.030 | -0.017 | -0.034 | -0.018 | -0.026 | -0.013 | -0.024 | -0.035 |
| | (0.024) | (0.024) | (0.024) | (0.024) | (0.022) | (0.030) | (0.025) | (0.025) | (0.021) | (0.025) | (0.023) |
| rGDPpc | 0.004 | 0.000 | 0.007 | 0.001 | 0.004 | 0.004 | 0.010 | 0.000 | 0.005 | 0.006 | 0.002 |
| | (0.007) | (0.006) | (0.008) | (0.007) | (0.007) | (0.009) | (0.011) | (0.007) | (0.006) | (0.008) | (0.006) |
| efw | -0.059*** | | | | | | | | | | |
| | (0.019) | | | | | | | | | | |
| govsize | | -0.029*** | | | | | | | | | |
| | | (0.010) | | | | | | | | | |
| legal | | | -0.051*** | | | | | | | | |
| | | | (0.015) | | | | | | | | |
| sndmoney | | | | -0.020* | | | | | | | |
| | | | | (0.011) | | | | | | | |
| regu | | | | | -0.042*** | | | | | | |
| | | | | | (0.015) | | | | | | |
| concor | | | | | | -0.069* | | | | | |
| | | | | | | (0.036) | | | | | |
| goveff | | | | | | | -0.086* | | | | |
| | | | | | | | (0.044) | | | | |
| polsta | | | | | | | | -0.026 | | | |
| | | | | | | | | (0.016) | | | |
| regqua | | | | | | | | | -0.061*** | | |
| | | | | | | | | | (0.022) | | |
| rullaw | | | | | | | | | | -0.071** | |
| | | | | | | | | | | (0.031) | |
| voiacc | | | | | | | | | | | -0.038* |
| | | | | | | | | | | | (0.020) |
| Constant | 1.435*** | 1.174*** | 1.243*** | 1.229*** | 1.215*** | 1.027** | 0.779** | 0.917*** | 0.757** | 0.787** | 0.910** |
| | (0.448) | (0.332) | (0.344) | (0.449) | (0.412) | (0.438) | (0.368) | (0.311) | (0.302) | (0.322) | (0.360) |
| Observations | 913 | 913 | 913 | 913 | 913 | 952 | 952 | 952 | 952 | 952 | 952 |
| Number of cid | 86 | 86 | 86 | 86 | 86 | 87 | 87 | 87 | 87 | 87 | 87 |
| Year dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Income dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| AR(1)-test | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| AR(2)-test | 0.454 | 0.524 | 0.407 | 0.473 | 0.642 | 0.451 | 0.415 | 0.433 | 0.452 | 0.434 | 0.478 |
| J-test | 0.361 | 0.205 | 0.223 | 0.126 | 0.232 | 0.175 | 0.140 | 0.113 | 0.165 | 0.161 | 0.138 |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

### *3.4.2 Interaction effects*

To gain further insights into the effects of institutional quality across different income groups, I expand the baseline models with interaction terms (institutional quality and income groups). The outcomes are reported in Table 3.

Table 3. Estimations with interactions.

| | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) | (21) | (22) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Inst_* Var. | efw_ | govsize_ | legal_ | sndmoney_ | regu_ | concor_ | goveff_ | polsta_ | regqua_ | rullaw_ | voiacc_ |
| VARIABLES | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime |
| | | | | | | | | | | | |
| ltaxtime(-1) | 0.811*** | 0.844*** | 0.814*** | 0.825*** | 0.825*** | 0.810*** | 0.837*** | 0.855*** | 0.854*** | 0.854*** | 0.841*** |
| | (0.066) | (0.052) | (0.054) | (0.072) | (0.063) | (0.086) | (0.083) | (0.053) | (0.054) | (0.063) | (0.066) |
| taxpay | 0.001* | 0.001*** | 0.001** | 0.001** | 0.001** | 0.001** | 0.001** | 0.001** | 0.001** | 0.001** | 0.001** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) |
| inst_HIC | -0.058*** | -0.026** | -0.047*** | -0.016 | -0.041** | -0.050 | -0.071 | -0.019 | -0.050 | -0.042 | -0.049 |
| | (0.020) | (0.012) | (0.016) | (0.011) | (0.016) | (0.035) | (0.049) | (0.025) | (0.033) | (0.033) | (0.047) |
| inst_LMC | -0.032*** | -0.017*** | -0.027*** | -0.011* | -0.023*** | -0.030 | -0.030* | -0.005 | -0.024 | -0.028* | -0.012 |
| | (0.010) | (0.005) | (0.008) | (0.007) | (0.008) | (0.018) | (0.016) | (0.011) | (0.015) | (0.017) | (0.013) |
| inst_UMC | -0.018*** | -0.008*** | -0.016*** | -0.005 | -0.013** | -0.038** | -0.029 | -0.011 | -0.020* | -0.026** | 0.001 |
| | (0.006) | (0.003) | (0.005) | (0.003) | (0.005) | (0.018) | (0.018) | (0.010) | (0.010) | (0.012) | (0.012) |
| internet | -0.001* | -0.002** | 0.000 | -0.002* | -0.001 | 0.000 | 0.001 | -0.001 | 0.000 | 0.000 | -0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Constant | 1.405*** | 1.138*** | 1.179*** | 1.188** | 1.194*** | 0.967** | 0.708* | 0.868*** | 0.730** | 0.687** | 0.855** |
| | (0.452) | (0.335) | (0.331) | (0.465) | (0.413) | (0.416) | (0.379) | (0.307) | (0.306) | (0.304) | (0.371) |
| | | | | | | | | | | | |
| Observations | 913 | 913 | 913 | 913 | 913 | 952 | 952 | 952 | 952 | 952 | 952 |
| Number of cid | 86 | 86 | 86 | 86 | 86 | 87 | 87 | 87 | 87 | 87 | 87 |
| Other Controls | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Year dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Group dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| AR(1)-test | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| AR(2)-test | 0.455 | 0.525 | 0.419 | 0.478 | 0.644 | 0.439 | 0.418 | 0.446 | 0.445 | 0.432 | 0.462 |
| J-test | 0.408 | 0.236 | 0.283 | 0.143 | 0.276 | 0.241 | 0.114 | 0.133 | 0.150 | 0.148 | 0.0507 |

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Other Controls are trade openness and income variables.

"inst_" denotes the corresponding institutional variable in each specification

HIC, LMC, and UMC denotes high income, lower middle and low income, and upper-middle income economies, respectively

As can be observed, the effects mostly remain the same in all interaction models, from (12) to (22), consolidating the negative effect of the institutional quality indicators on tax complexity. The results, however, demonstrate the slight differences in each specific income group. For high-income countries (HIC), variables of economic freedom index and legal system show the strongest impact with the significance of 1%, ($\alpha = 0.01$), followed by government size and regulation (5% of $\alpha$). The rest including sound money, corruption control, government effectiveness, regulatory quality, political stability, voice and accountability, and rule of law fails to exert the same effect on tax complexity in this income group. The group of upper-middle income countries (UMC) records the strongest influence of economic freedom index, government size, and legal system (1% of $\alpha$), followed by regulation, corruption control, and rule of law (5% of $\alpha$), then regulatory quality (10% of $\alpha$), and finally sound money, political stability, voce and accountability, and government effectiveness, which were found to be statistically insignificant. Besides, economic freedom index, government size, legal system, and regulation have the greatest effects on tax complexity in the group of lower-middle and low income economies (LMC). Meanwhile, sound money, government effectiveness, and rule of law, signify, for the first time, the impact on tax complexity despite the low influence ($\alpha$=10%). Contrarily, corruption control, political stability, voice and accountability and regulatory quality have no impact on this income group. To summarise, the institutional indicators including economic freedom index, government size, legal system, and regulation show a strong and sustainable effect on tax complexity regardless of the groups of income, with the significance of 1% and 5% of $\alpha$. The others (sound money, corruption control, government effectiveness, regulatory quality, and rule of law) showed a lower effect, in either two or even one of the groups. Political stability and voice and accountability stating the process by which governments are selected, monitored, and replaced failed to show an effect in all models. It was clear that there was a less influential impact of institutional quality in high-income countries.

### *3.4.3 Institutional quality indicators as predetermined variables*

In this sub-section, I elaborate on the assumption that institutional indicators are not strictly exogenous anymore; instead, they are weakly exogenous or predetermined variables. I hence re-ran the corresponding regressions. Accordingly, Table 4 generally confirms the negative effects of these variables on the total time to comply. The indicators including economic freedom index, government size, legal system, regulation, and regulatory quality exert the strongest impacts at 1% of significance level. Following them are sound money, corruption control, and rule of law at a significance of 5%. Government effectiveness demonstrates the lowest impact at 10% of significance level. Simply put, most of the institutional quality indicators show a sustainably and statistically negative effect on tax complexity as expected, except for political stability and voice freedom.

Table 4. Estimations results, considering institutional indicators as pre-determined.

| | (23) | (24) | (25) | (26) | (27) | (28) | (29) | (30) | (31) | (32) | (33) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime |
| | | | | | | | | | | | |
| ltaxtime(-1) | 0.801*** | 0.827*** | 0.828*** | 0.832*** | 0.818*** | 0.748*** | 0.771*** | 0.808*** | 0.820*** | 0.788*** | 0.762*** |
| | (0.068) | (0.058) | (0.050) | (0.057) | (0.063) | (0.098) | (0.116) | (0.063) | (0.065) | (0.082) | (0.104) |
| taxpay | 0.001** | 0.001** | 0.001* | 0.001*** | 0.001** | 0.002** | 0.001** | 0.002** | 0.001*** | 0.001** | 0.002** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.001) | (0.001) | (0.000) | (0.000) | (0.001) |
| internet | -0.002** | -0.002** | -0.000 | -0.002** | -0.001 | -0.001 | -0.001 | -0.002 | -0.001 | -0.001 | -0.002 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| efw | -0.064*** | | | | | | | | | | |
| | (0.019) | | | | | | | | | | |
| govsize | | -0.026*** | | | | | | | | | |
| | | (0.010) | | | | | | | | | |
| legal | | | -0.042*** | | | | | | | | |
| | | | (0.014) | | | | | | | | |
| sndmoney | | | | -0.019** | | | | | | | |
| | | | | (0.008) | | | | | | | |
| regu | | | | | -0.044*** | | | | | | |
| | | | | | (0.016) | | | | | | |
| concor | | | | | | -0.089** | | | | | |
| | | | | | | (0.037) | | | | | |
| goveff | | | | | | | -0.104* | | | | |
| | | | | | | | (0.060) | | | | |
| polsta | | | | | | | | -0.026 | | | |
| | | | | | | | | (0.021) | | | |
| regqua | | | | | | | | | -0.075*** | | |
| | | | | | | | | | (0.028) | | |
| rullaw | | | | | | | | | | -0.090** | |
| | | | | | | | | | | (0.036) | |
| voiacc | | | | | | | | | | | -0.046 |
| | | | | | | | | | | | (0.036) |
| Constant | 1.520*** | 1.227*** | 1.119*** | 1.182*** | 1.312*** | 1.408** | 1.310* | 1.312*** | 0.989** | 1.075** | 1.585** |
| | (0.460) | (0.368) | (0.332) | (0.370) | (0.416) | (0.563) | (0.678) | (0.490) | (0.396) | (0.430) | (0.691) |
| Observations | 913 | 913 | 913 | 913 | 913 | 952 | 952 | 952 | 952 | 952 | 952 |
| Number of cid | 86 | 86 | 86 | 86 | 86 | 87 | 87 | 87 | 87 | 87 | 87 |
| Other Controls | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Year dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Income dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| AR(1)-test | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| AR(2)-test | 0.466 | 0.525 | 0.412 | 0.466 | 0.641 | 0.426 | 0.393 | 0.423 | 0.440 | 0.399 | 0.439 |
| J-test | 0.423 | 0.284 | 0.116 | 0.368 | 0.261 | 0.131 | 0.139 | 0.108 | 0.116 | 0.129 | 0.109 |

Standard errors in parentheses. Other Controls are trade openness and income variables.
*** p<0.01, ** p<0.05, * p<0.1

## 3.5 Determinants of tax complexity slackness

Tax simplicity is the mirror of tax complexity, implying that the performance of tax simplification, proxied by by the slacks of *taxtime* (*taxsk*), has a positive link with the institutional quality. Precisely, *taxsk* is obtained from the performance evaluation of tax simplification using the panel DEA-WEO model of Nguyen et al. (2020, Ch.2), which uses the total *taxpay* and all three sub-components of *taxtime* for optimisation. For that reason, the variable *taxpay* should not appear on the right-hand side of equation (3.1b) because it endogenously determines the efficiency score and slackness.

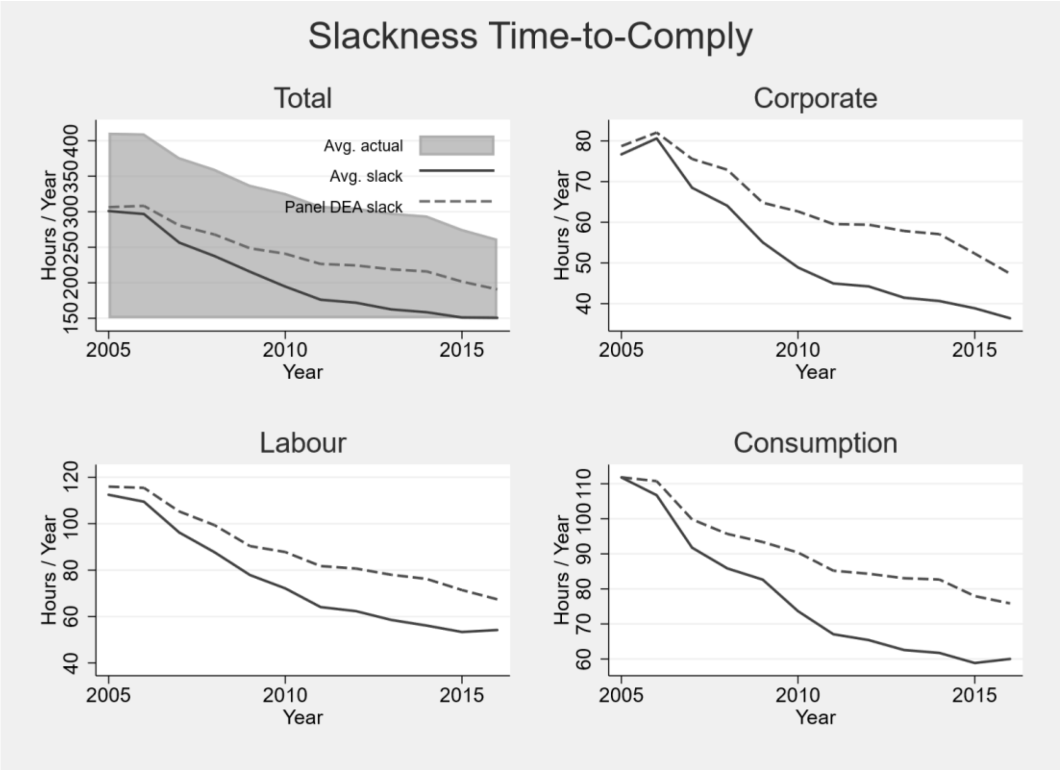


Figure 2. Slacks of time to comply (*taxsk*). Source: authors' calculations.

Figure 2 depicts the slack of *taxtime* corresponding to short-run (or contemporaneous slackness) and long-run (panel DEA slackness) levels (Surroca et al., 2016; Pérez-López et al., 2018). The dynamics of year-on-year slackness is computed by projecting each of the *taxtime* components on its respective year-on-year frontier, while the panel counterparts are simply the projections of all-year data on the same long-run frontier. For the sake of simplicity, I only plotted the actual values on the first quadrant panel of Figure 2. It was shown that the gap between the short-run and long-run curves had widened since the crisis. The lines go down from 2005 to 2016, and the world maps (Figure 3 and Figure 4) demonstrate that countries whose slacks were high in 2005 have been increasingly acknowledged to have a lower level closer towards 2016.

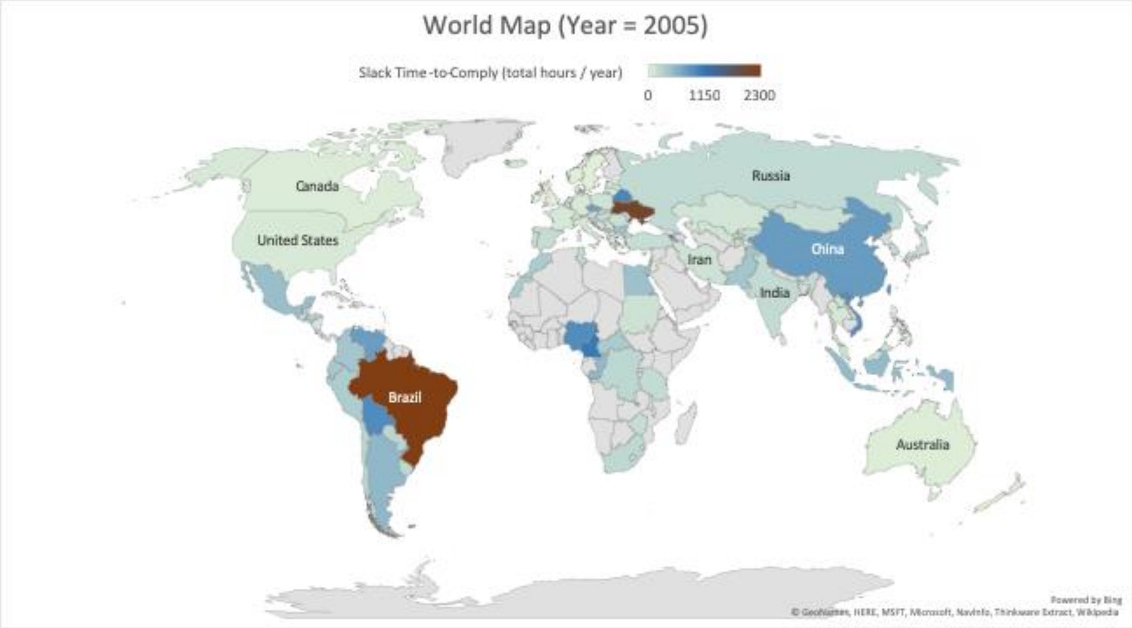


Figure 3. World map of time to comply slackness (*taxsk*), the year 2005. Source: authors' calculations.


Figure 4. World map of time to comply slackness (*taxsk*), the year 2016. Source: authors' calculations.

The GMM estimation results reported in Table 5 validate my expectations as the institutional quality indicators almost kept the significantly negative effects on the slack variation across tax systems in multiple and different models, except for the political stability and voice freedom indicators. Accordingly, a fall in the slack of the previous period induced a decrease in slacks for the current period as well. Put differently, if the tax system in a country lagged behind the efficiency frontier (to the extent of improving the compliance time) when compared to the reference set last year, it still faces this situation for the current year. Conversely, a decrease in institutional quality causes an increase in the slack of *taxtime*. As such, on average, a country with stronger law and order, higher quality public and civil service, a higher perception of corruption control, and a higher quality of regulation may facilitate tax system simplification by reducing the time for tax compliance. Similarly, countries which tend to rely on personal choice and markets rather than government budgets and political decision-making, accompanied by less regulatory restraints authorising the freedom of exchange in credit, labour, and product markets might contribute to promoting tax system simplification. Moreover, the time for tax compliance is likely to be reduced if the government's protective functions are performed effectively and, thus, the individuals have a high freedom to make their own economic decisions. Nonetheless, the consistency of monetary policy and institutions with long-term price stability and ease for alternative currencies fails to show a statistically significant impact on lowering the time for tax compliance.

As for the controlling effects, the rate of internet users can contribute to decreasing the slacks i.e. total tax time. Otherwise, both the openness of trade and GDP do not show a statistically significant relationship with the level of slacks. In an average country with an advanced economy, high income, and high level of dynamic integration, there is no empirical evidence supporting a decrease in slack of tax time. This country is likely to have more motivation to make a considerable investment in technology, as well as infrastructure, for enhancing the tax system's performance.

It is worthwhile to note that, all GMM regression models are run with two-step estimator as it is asymptotically efficient and robust to a wide range of patterns of heteroscedasticity and cross-correlation (Windmeijer, 2005). It is obvious that the institutional quality indicators exert statistically negative impacts on tax complexity irrespective of the models and specifications. As a result, in an average country, a reduction in tax system complexity may be recorded if the institutional quality is increased.

Table 5. Determinants of slackness time to comply.

| | (34) | (35) | (36) | (37) | (38) | (39) | (40) | (41) | (42) | (43) | (44) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | ltaxsk | ltaxsk | ltaxsk | ltaxsk | ltaxsk | ltaxsk | ltaxsk | ltaxsk | ltaxsk | ltaxsk | ltaxsk |
| | | | | | | | | | | | |
| ltaxsk(-1) | 0.822*** | 0.746*** | 0.730*** | 0.834*** | 0.683*** | 0.811*** | 0.852*** | 0.760*** | 0.864*** | 0.649*** | 0.653*** |
| | (0.054) | (0.072) | (0.085) | (0.051) | (0.110) | (0.090) | (0.039) | (0.089) | (0.041) | (0.088) | (0.087) |
| internet | -0.003* | -0.005* | -0.005** | -0.003* | -0.006* | -0.005* | -0.003* | -0.005* | -0.004** | -0.009** | -0.008* |
| | (0.002) | (0.003) | (0.002) | (0.001) | (0.003) | (0.003) | (0.002) | (0.003) | (0.002) | (0.004) | (0.004) |
| rullaw | -0.081* | | | | | | | | | | |
| | (0.045) | | | | | | | | | | |
| goveff | | -0.116* | | | | | | | | | |
| | | (0.064) | | | | | | | | | |
| concor | | | -0.086* | | | | | | | | |
| | | | (0.047) | | | | | | | | |
| regqua | | | | -0.094** | | | | | | | |
| | | | | (0.041) | | | | | | | |
| efw | | | | | -0.116** | | | | | | |
| | | | | | (0.045) | | | | | | |
| govsize | | | | | | -0.036** | | | | | |
| | | | | | | (0.017) | | | | | |
| legal | | | | | | | -0.039** | | | | |
| | | | | | | | (0.018) | | | | |
| regu | | | | | | | | -0.083** | | | |
| | | | | | | | | (0.039) | | | |
| sndmoney | | | | | | | | | -0.020* | | |
| | | | | | | | | | (0.012) | | |
| polsta | | | | | | | | | | 0.035 | |
| | | | | | | | | | | (0.060) | |
| voiacc | | | | | | | | | | | -0.057 |
| | | | | | | | | | | | (0.070) |
| Constant | 1.415*** | 1.804*** | 2.285*** | 1.358*** | 3.097*** | 1.848** | 1.302*** | 2.226*** | 1.280*** | 3.347*** | 3.019*** |
| | (0.476) | (0.636) | (0.751) | (0.429) | (1.079) | (0.702) | (0.344) | (0.765) | (0.381) | (0.950) | (0.960) |
| | | | | | | | | | | | |
| Observations | 824 | 824 | 824 | 824 | 824 | 824 | 824 | 824 | 824 | 824 | 824 |
| Number of cid | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 81 |
| Other Controls | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Year dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Income dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| AR(1)-test | 0.019 | 0.024 | 0.023 | 0.019 | 0.024 | 0.021 | 0.021 | 0.024 | 0.021 | 0.022 | 0.019 |
| AR(2)-test | 0.740 | 0.724 | 0.679 | 0.757 | 0.709 | 0.706 | 0.746 | 0.752 | 0.770 | 0.600 | 0.620 |
| J-test | 0.474 | 0.172 | 0.809 | 0.406 | 0.255 | 0.423 | 0.250 | 0.206 | 0.824 | 0.206 | 0.158 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## 3.6 Concluding remarks

Tax complexity, or its mirror tax simplicity, is a multidimensional concept with a diversity of definitions and measures. This work deals with complexity to the extent of administrative cost, proxied by time to comply with taxes (*taxtime*) and number of tax payments (*taxpay*). Taking an institutional approach, the study stresses the institutional quality indicators expressing governance and economic freedom as the determinants affecting the variation of tax complexity across 88 countries and over 12 years (2005-2016). Methodologically, the study uses system generalised method of moments (system-GMM) estimator for dynamic panel data estimation (Arellano and Bover, 1995; Blundel and Bond (BB), 1998) with alternative models, specifications, and measures.

The results show and consolidate the significantly negative effect of the institutional quality indicators on tax system complexity measures. Accordingly, in an average country with high quality of institutions, the complexity of the tax system tends to be decreased. In other words, the effective performance of tax system, in terms of tax administrative burden, can facilitate the simplification of tax system procedures. In details, using the direct indicators for tax complexity measure, it was suggested that in an average country with high quality of economic freedom, low level of government spending, effective government protective function and less regulatory restraints, high ability for the government to promote market competition could strongly help reduce the tax system's complexity. This effect was also found with strong law and order, which may be associated with a less complicated tax system. Although the impact is not that strong, the high consistency of monetary policy and ease of alternative currencies, high perception of corruption control, and high quality of public and civil service in a country may facilitate the reduction in time to comply with taxes. It is noteworthy that this effect was found to vary between the income groups and to be less influential in high-income economies. The institutional indicators including economic freedom index, government size, legal system, and regulation show the strongest and most sustainable effect on tax complexity regardless of the groups of income. The others (sound money, corruption control, government effectiveness, regulatory quality, and rule of law) show a lower effect, either in two or even one of the groups. Unfortunately, the perceptions entailing political instability and voice freedom are likely to be ineffective in reducing tax complexity. When proxied by slack of *taxtime*, tax complexity mostly retains the negative relation with all the institutional quality indicators as aforementioned. To conclude, an increase in institutional quality focusing on governance and economic freedom can, on average, result in a decrease in tax system complexity.

Due to its multidimensional nature, tax complexity has been defined and measured under many diverse concepts. Tax policy should consider the administrative burden aspect as an important part of tax complexity, in addition to many other tax and non-tax aspects such as tax rate, tax base, tax code, etc. Since an understanding of institutions is at the heart of understanding the policy process (Peter, 1991), tax design, at least in favour of tax complexity, needs to consider the effects of institutional quality. In general, it is highly likely that a country with a higher quality of institutions in terms of governance and economic freedom will be associated with a lower level of tax complexity. Hence, governments should foster the quality of institutions, particularly the formal ones, especially in low income and lower-middle income economies. Once the institutional quality is high enough, the tax system may possibly reduce the level of tax system complexity, as simplicity is the targeted outcome. Moreover, the tax policy design should also consider the appropriate institutional quality indicator to prioritise in accordance with the individual income group. In addition, among many other measures of tax complexity, this study opts to work with administrative burden indicators. This might result in the absence of generalisation of the findings. Future research could consider tax complexity using other concepts and by deploying other measures. Even when retaining the same measures and indicators, this research might still be extended using other ideas such as other institutional determinants. Another direction to be further investigated is the study of this effect, working with the sub-sample to focus on the individual income group instead of studying the average effect for the whole sample. By doing so, the policy implications would be of higher appropriateness, from the perspective of policymaking. Nonetheless, this would require a bigger sample.

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# Appendix

*A1. Data description of variables*

| Variable | Definition | Source |
|---|---|---|
| taxpay | The number of tax payments by businesses: the total number of taxes per year paid by businesses, including electronic filing. In other words, it is the frequency with which the company has to file and pay different types of taxes and contributions, adjusted for the manner in which those filings and payments are made per year. | Paying Taxes, PricewaterhouseCoopers (PwC) & World Bank (WB) |
| taxtime | Total time (hour) to comply with taxes i.e. the total time (hours) per year required to prepare, file and pay taxes. | Paying Taxes, PricewaterhouseCoopers (PwC) & World Bank (WB) |
| taxtime_corp | Time (hour) to comply with corporate income tax i.e. the total time (hours) per year required to prepare, file and pay corporate income tax. | Paying Taxes, PricewaterhouseCoopers (PwC) & World Bank (WB) |
| taxtime_lab | Time (hour) to comply with labour tax i.e. the total time (hours) per year required to prepare, file and pay labour tax. | Paying Taxes, PricewaterhouseCoopers (PwC) & World Bank (WB) |
| taxtime_consum | Time (hour) to comply with consumption tax i.e. the total time (hours) per year required to prepare, file and pay consumption tax. | Paying Taxes, PricewaterhouseCoopers (PwC) & World Bank (WB) |
| taxsk | Total slackness of time to comply with three taxes i.e. the inefficient units' potential reduction in total time used for complying with three taxes (corporate income tax, labour tax, and consumption tax) when compared to efficiency frontier. | Results extracted from efficiency measure, using DEA-WEO with 4 inputs (total tax payments, time to comply with corporate income tax, time to comply with labour tax, and time to comply with consumption tax) and single constant output (of social outcome). |
| rullaw | Rule of law, an indicator that measures the extent to which individuals/agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, the police, and the courts, as well as the likelihood of crime and violence.<br>Ranges from -2.5 to +2.5<br>Higher values mean stronger law and order. | Worldwide Governance Indicators – World Bank |
| goveff | Government effectiveness, the indicator measures the quality of public services, the quality of the civil service and the degree of its independence from political | Worldwide Governance Indicators – World Bank |

| Variable | Definition | Source |
|---|---|---|
| | pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Ranges from -2.5 to +2.5<br>Higher values mean higher quality public and civil service. | |
| concor | Corruption control, perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.<br>Ranges from -2.5 to +2.5<br>Higher values mean higher perception of corruption control. | Worldwide Governance Indicators – World Bank |
| regqua | Regulatory quality, an indicator that measures the ability of the government to formulate and implement sound policies and regulations that permit and promote market competition and private sector development.<br>Ranges from -2.5 to +2.5<br>Higher values mean higher quality regulation. | Worldwide Governance Indicators – World Bank |
| polsta | Political stability: Political stability and Absence of violence / Terriorism. measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. | Worldwide Governance Indicators – World Bank |
| voiacc | Voice and Accountability reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and free media. | Worldwide Governance Indicators – World Bank |
| efw | Economic freedom index is designed to measure the extent to which the institutions and policies of a nation are consistent with the government's protective function (to protect individuals and their property from aggression by others) and the freedom of individuals to make their own economic decisions.<br>The index measures the degree of economic freedom present in five major areas: [1] Size of Government; [2] Legal System and Security of Property Rights; [3] Sound Money; [4] Freedom to Trade Internationally; [5] Regulation | Fraser Institute[54] |
| legal | Legal system & property rights. This is a central element of economic freedom and a civil society, which focuses on the protection of persons and their rightfully | Fraser Institute |

[54] Retrieved from **www.fraserinstitute.org/studies/economic-freedom-of-the-world-2018-annual-report.**

| Variable | Definition | Source |
|---|---|---|
| | acquired property. It includes nine components, which are indicators of how effectively the protective functions of government are performed. | |
| govsize | Government size covers the four components (government consumption; transfers and subsidies; government enterprises and investment; and top marginal tax rate) that indicate the extent to which countries rely on the political process to allocate resources and goods and services.<br>It measures the degree to which a country relies on personal choice and markets rather than government budgets and political decision-making. Therefore, countries with low levels of government spending as a share of the total, a smaller government enterprise sector, and lower marginal tax rates earn the highest ratings in this area. | Fraser Institute |
| regu | Regulation, this area of economic freedom index focuses on regulatory restraints that limit the freedom of exchange in credit, labour, and product markets. The first component (credit market regulations) reflects conditions in the domestic credit market. The second component (labour-market regulations) is designed to measure the extent to which these restraints upon economic freedom are present. The third component (business regulations) identifies the extent to which regulations and bureaucratic procedures restrain entry and reduce competition. | Fraser Institute |
| sndmoney | Sound money: The four components (money growth, standard deviation of inflation, inflation: the most recent year, and freedom to own foreign currency bank accounts) are designed to measure the consistency of monetary policy (or institutions) with long-term price stability, and the ease with which other currencies can be used via domestic and foreign bank accounts.<br>A country with high rating in this area must follow policies and adopt institutions that lead to low (and stable) rates of inflation and avoid regulations that limit the ability to use alternative currencies. | Fraser Institute |
| internet | Internet refers the individuals use internet (% of population). Internet users are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, | World Bank |

| Variable | Definition | Source |
| --- | --- | --- |
| | personal digital assistant, games machine, digital TV, etc. | |
| | Trade openness**:** Trade (% of GDP). It is the sum of exports and imports of goods and services measured as a share of gross domestic product. | World Bank |
| rGDP | GDP, constant 2010 $US<br>GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2010 U.S. dollars. | World Bank |
| rGDPpc | GDP per capita, PPP (constant 2011 international $). GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. | World Development Indicators - World Bank |
| Income level | The category variable adapted from World Bank, dividing income level into 3 groups, (i) high-income economies (HIC) are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $12,376 or more; (ii) upper middle-income economies (UMC) are those between $3,996 and $12,375; and (iii) lower middle-income & low-income economies (LMC) as those of $3,995 or less. | World Bank |

*A2. Baseline models: Estimation results using data from Doing Business project (World Bank)*

| DB (WB) | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime | ltaxtime |
| | | | | | | | | | | | |
| ltaxtime (-1) | 0.877*** | 0.887*** | 0.846*** | 0.878*** | 0.893*** | 0.867*** | 0.822*** | 0.878*** | 0.839*** | 0.844*** | 0.844*** |
| | (0.023) | (0.021) | (0.039) | (0.025) | (0.023) | (0.043) | (0.053) | (0.052) | (0.046) | (0.067) | (0.043) |
| taxpay | 0.001* | 0.001** | 0.001** | 0.001* | 0.001 | 0.001** | 0.001* | 0.001 | 0.001** | 0.001* | 0.001* |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.001) | (0.000) | (0.000) | (0.001) |
| internet | -0.001** | -0.002*** | -0.000 | -0.002*** | -0.001* | -0.001 | -0.001 | -0.001 | -0.001 | -0.000 | -0.002** |
| | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| trade | -0.018 | -0.028** | -0.026* | -0.027** | -0.017 | -0.024 | -0.019 | -0.010 | -0.018 | -0.018 | -0.034* |
| | (0.012) | (0.013) | (0.015) | (0.012) | (0.013) | (0.015) | (0.018) | (0.019) | (0.017) | (0.019) | (0.018) |
| ly | -0.005 | -0.005 | -0.004 | -0.004 | -0.005 | 0.000 | 0.004 | -0.007 | -0.001 | 0.005 | -0.003 |
| | (0.004) | (0.004) | (0.005) | (0.004) | (0.004) | (0.005) | (0.008) | (0.006) | (0.006) | (0.007) | (0.006) |
| efw | -0.036*** | | | | | | | | | | |
| | (0.009) | | | | | | | | | | |
| govsize | | -0.022*** | | | | | | | | | |
| | | (0.006) | | | | | | | | | |
| legal | | | -0.041*** | | | | | | | | |
| | | | (0.014) | | | | | | | | |
| sndmoney | | | | -0.008 | | | | | | | |
| | | | | (0.007) | | | | | | | |
| regu | | | | | -0.020*** | | | | | | |
| | | | | | (0.007) | | | | | | |
| concor | | | | | | -0.039** | | | | | |
| | | | | | | (0.019) | | | | | |
| goveff | | | | | | | -0.076** | | | | |
| | | | | | | | (0.032) | | | | |
| polsta | | | | | | | | -0.072* | | | |
| | | | | | | | | (0.036) | | | |
| regqua | | | | | | | | | -0.056** | | |
| | | | | | | | | | (0.022) | | |
| rullaw | | | | | | | | | | -0.072** | |
| | | | | | | | | | | (0.034) | |
| voiacc | | | | | | | | | | | -0.008 |
| | | | | | | | | | | | (0.019) |
| Constant | 1.115*** | 0.955*** | 1.223*** | 0.919*** | 0.902*** | 0.777** | 0.947*** | 0.912** | 0.985*** | 0.792** | 1.028*** |
| | (0.236) | (0.207) | (0.327) | (0.236) | (0.223) | (0.298) | (0.305) | (0.388) | (0.295) | (0.381) | (0.313) |
| | | | | | | | | | | | |
| Observations | 843 | 843 | 843 | 843 | 843 | 882 | 882 | 882 | 882 | 882 | 882 |
| Number of cid | 86 | 86 | 86 | 86 | 86 | 87 | 87 | 87 | 87 | 87 | 87 |
| Year Dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| Income dummies | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| AR(1)-test | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(2)-test | 0.515 | 0.563 | 0.531 | 0.573 | 0.540 | 0.305 | 0.304 | 0.271 | 0.296 | 0.283 | 0.320 |
| J-test | 0.169 | 0.249 | 0.211 | 0.173 | 0.185 | 0.196 | 0.0600 | 0.435 | 0.151 | 0.295 | 0.241 |
| Standard errors in parentheses | | | | | | | | | | | |
| *** p<0.01, ** p<0.05, * p<0.1 | | | | | | | | | | | |

# CONCLUSIONS[♯]

This Thesis has been approached and framed to account for public administration performance perspective and presents the results of my investigations into tax administration (TA)-related issues from different dimensions, across multiple countries and many years. It covers three empirical chapters firstly addressing tax system performance from the general purpose i.e. maximising tax revenues, then tax performance from the administrative burden in view of social cost imposed for complying with tax obligations and, finally, an examination of tax complexity's determinants.

In chapter 1, my focus was to evaluate the performance of TA cross 44 countries (including 32 OECD countries), while considering the presence of contextual variables, for two periods between 2008-2011 and 2012-2015. In doing so, I used the recently developed and advanced frontier estimators, such as the semi-nonparametric StoNED (Stochastic Nonparametric Envelopment of Data) approach by Johnson and Kuosmanen (2011, 2012) and the conditional order-m (Daraio and Simar, 2005, 2007) approach. This is the first contribution to the existing research field. It is one among only a few efforts to address the performance of TA across countries using comparative data extracted from the most recent OECD TA database. The potential difference in TA efficiency in general operation during and after the financial crisis was explored conducting the analysis for both aforementioned periods, as the year 2012 was considered to be the end of the worst part of the recession in many countries. In this sense, the study can be regarded to be an extension of Alm and Duncan (2014)'s research, which measured tax agency efficiency in 38 countries (including 28 OECD countries) over the 2007-2011 period.

The second chapter stresses the value of simplifying tax system complexity in order to enhance the ease of doing business, which affects new business creation and investment attraction. Using a sample of 88 countries over the timespan 2005-2016 with the panel data nonparametric frontier method i.e. the

[♯] Unless indicated in the corresponding footnotes, all the citations made here are to be found in the references listed at the end of each corresponding chapter.

data envelopment analysis model without explicit output (hereafter, panel data DEA-WEO), I looked into the tax simplification performance from measuring efficiency to ranking and examining the productivity change of these tax systems. Besides the contemporaneous efficiency measurement, I derived the panel data DEA model (Surroca et al., 2016; Pérez-López et al., 2018), conditional on WEO context for the long-run performance analysis. Moreover, to complement the performance evaluation, the rankings were applied using a *state-of-the-art* algorithm by Toloo and Kresta (2014) and the measure of productivity change with Malmquist index was adapted from Karagiannis and Lovell (2016). This chapter then contributes to the field by extending the standard panel data DEA estimator (Surroca et al., 2016; Pérez-López et al., 2018) to be applied to the model without explicit output condition. It is also the first application of panel data DEA-WEO proposal for long-run panel estimation to provide practical contribution results from the measuring of tax system performance.

Chapter 3 continues the Thesis by further investigating the variation of tax complexity across 88 countries and over the timespan, 2005-2016, focusing on the impact of institutional quality reflecting the governance and economic freedom. The analysis was carried out, using system-GMM for panel data regression (Arellano and Bover, 1995; Blundell and Bond, 1998) with alternative measures of tax complexity from direct to indirect indicators, alternative estimators and specifications, which suggested the significantly negative effect of institutional quality on tax complexity. Interestingly, the effect varies according to specific income group.

Talking about methodology, overall, I created a combination of alternative (including parametric and nonparametric) methods, innovative techniques and multiple specifications with the recent data on TA-related operations. This research required enormous effort, including, besides STATA, learning to program and work simultaneously with new programming languages i.e. GAMS and R, especially due to the time constraints. I tried my best to overcome the challenges during the lengthy process to ensure that I reached the end.

I believe the Thesis generally contributes to public administration literature as the first quantitative empirical study and one among only a few projects that address TA at a cross-country level from multiple disciplines, i.e. public sector management, taxation, and efficiency analysis. I also hope that it will be useful reference for many more studies on TA and open the broader doors to other sectors in public administration. The project is, to the best of my knowledge, the first attempt in the field to highlight (i) the performance evaluation of TA, acquired simultaneously from the views of both administrative cost and enforcement level for optimal TA, as found in Keen and Slemrod (2017), (ii) the application of tax performance measure with nonparametric frontier method in the context of implicit output, and (iii) the investigation of institutional quality determinations of tax complexity, emphasising the governance and economic freedom with a combination of parametric and nonparametric methods.

This interdisciplinary research project falls in the thematic academic field of public sector analysis in Business Economics, mainly dealing with business taxes. Specifically, it captures the performance of the public sector and its institutions through the lens of efficiency in Tax administration. Given the contributions, this project is unavoidably affected by limitations. There were some drawbacks resulting from data availability and the quality of data and sample, among others. Data extracted from OECD TA series and Paying Taxes indicators, however, represents the best currently available information on comparable administrative performance and is considered the only available set of data points providing the objective, worldwide comparison of indicators on the tax complexity or simplicity of tax regimes, respectively. It is, therefore, worth considering the findings of this project as a source for reference to be applied to different research samples in different contexts and even different public sectors. The next step might be to conduct more detailed research project on investigating the impacts of TA on some socio-economic phenomena, for instance, tax evasion, shadow economy, income inequality, entrepreneurship, and FDI. Indeed, an overly complicated tax system is highly likely to be associated with high tax evasion. High tax compliance costs are correlated with larger informal sectors, more corruption and less investment. Conversely, economies with simple, well-designed tax systems may enable the growth of businesses, investment and entrepreneurship (Djankov et al., 2010).[55] Effective

[55] Djankov, S., Ganser, T., McLiesh, C., Ramalho, R., & Shleifer, A. (2010). The effect of corporate taxes on investment and entrepreneurship. American Economic Journal: Macroeconomics, 2(3), 31-64.

and efficient TA can help encourage businesses to become formally registered thereby increasing tax revenues through expanding the tax base. Inefficient TA will possibly bring the discredit to the tax system and the deterioration of the legitimacy to government (Haidar and Hoshi, 2015).[56] Another proposal that should be carried out is an examination of TA in the framework of procedure streamlining as the growingly good practice in public administration. By doing so, it could be made a greater contribution to the research field.

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[56] Haidar, J. I., & Hoshi, T. (2015). Implementing structural reforms in Abenomics: How to reduce the cost of doing business in Japan (No. w21507). National Bureau of Economic Research.