TECHNICAL

NOTES & MANUALS

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The Revenue Administration Gap Analysis Program

Patricio Barra, Eric Hutton, and Polina Prokof'yeva

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Authorized for distribution by Ruud de Mooij

Patricio Barra and Polina Prokof'yeva are members of the Revenue Administration Gap Analysis Program (RA-GAP) team in the Fiscal Affairs Department of the IMF. Eric Hutton, formerly the lead of the RA-GAP team, is currently Deputy Unit Chief in the IMF Legal Department. This note has benefitted from information, corrections, and suggestions kindly provided by Vyanne Lai, Allan Partington, Anthony Siouclis, and April Yap (Australian Taxation Office); Frederico Alencar, Leonardo Pereira Moreira, and Marcelo de Souza Silva (Receita Federal do Brasil); Sun Jae Kim, Valerie Pare, and Celine Renaud (Canada Revenue Agency); Søren Pedersen (Skatteforvaltningen); Lars Lindvall and Damian Migueles Chazarreta (Skatteverket); Alex Bacon, Linda Green, and Tom Purslow (His Majesty's Revenue and Customs); Jonathan M. Fieman, Andrew K. Johns, and Mary-Helen Risler (Internal Revenue Service). This version has received corrections and suggestions from Debra Adams, Elena D'Agosto, Ruud De Mooij, Ricardo Fenochietto, Andrea Lemgruber, Andrew Okello, Stefano Pisani, Enrique Rojas, and Shan Zhong (IMF). Subsisting errors remain the responsibility of the authors.

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Abbreviations

CIT	corporate income tax
EV	extreme values
RA	revenue administration
RA-GAP	Revenue Administration Gap Analysis Program

I. How Do Countries Measure Noncompliance in Corporate Income Tax by Using Bottom-Up Techniques?

Why Estimate the Corporate Income Tax Gap?

Corporate income tax (CIT) gap analysis offers to ministries of finance, revenue administrations (RAs), and the public an estimate of the amount of CIT revenues that are not collected because of noncompliance. Thus, it allows an estimation of the potential to mobilize additional resources by conducting more effective tax administration.[1] Estimating the tax gap is not an easy task. Noncompliance is not an observable variable for obvious reasons: taxpayers would never directly reveal how much they fail to comply with their tax obligations. Thus, indirect methods based on different approaches must be used to infer noncompliance amounts.

What Estimation Approaches Are Applied for the Corporate Income Tax Gap?

Two main approaches can be used to estimate CIT noncompliance: bottom-up and top-down approaches. Techniques based on a bottom-up approach focus on using tax administration data, such as results of random audits or operational audits targeted by some criteria, or other interventions by tax authorities to directly estimate the size of the gap. Techniques based on a top-down approach use third-party data to estimate the size of potential revenue and then derive the size of the gap by subtracting actual revenue from potential revenue. Bottom-up techniques are better at determining the root causes of any estimated noncompliance. Top-down techniques provide a more comprehensive assessment of all tax revenue foregone through noncompliance.

Some countries use macroeconomic aggregates to measure CIT noncompliance based on the top-down approach, which is also the standard for the IMF's Revenue Administration Gap Analysis Program (RA-GAP).[2] This method uses the operating surplus of corporations from national accounts data. Certain assumptions about other accounting items affecting net CIT liability, such as deductions, credits, and carryforward losses, are made to estimate CIT potential revenues. The top-down approach compares aggregated potential CIT revenues with actual CIT collections to obtain CIT gap estimates (see Ueda 2018).

Other countries apply the bottom-up approach to infer CIT noncompliance from the rich audits microdata available within their RAs.[3] The three different CIT gap bottom-up types of techniques are based on (1) results from a random audit program, (2) results from an operational audit, and (3) general administrative data. Random audit programs are ones in which a sample of taxpayers is randomly selected to be audited. Operational audits are regularly performed examinations in which a sample of taxpayers is selected based on risk. With these first two types, random audit programs and operational audits, CIT gap estimates are obtained by extrapolating the audit results to the total population under certain assumptions. Techniques

[1] The overall gap concept of the IMF's Revenue Administration Gap Analysis Program (RA-GAP) includes two components: the compliance gap and the policy gap. Because this note focuses only on the CIT compliance gap, for simplicity, the authors use "gap" and "compliance gap" indistinguishably.

[2] Since the RA-GAP on the CIT gap began in 2017, about six technical assistances have been delivered to estimate CIT gap. Although the number is smaller than the activities provided for estimating the value-added tax gap (at more than 45 assistances since 2012), there is growing demand for them, especially by emerging market economies interested in better understanding their CIT gap.

[3] See Thackray, Jennings, and Knudsen (2021) for a review of bottom-up techniques applied to personal income tax gap estimations.

based on general administrative data exploit the information collected by the RAs beyond the audit information to diagnose a CIT gap at the level of each entity.

What Opportunities Does the Bottom-Up Approach Bring to Estimating Corporate Income Tax Compliance Gaps?

CIT gap bottom-up techniques provide information about the gap by segments of economic agents. A strong advantage of bottom-up techniques, compared with top-down techniques, is that they can provide gap estimates for different segments of CIT taxpayers, not just the general size of the gap. For large businesses' CIT gap, techniques based on operational audits are the most common. For small businesses, a random audit program is the preferred technique for estimating the CIT gap. For mid-sized businesses, the CIT gap is usually jointly estimated with large or small segments.

A random audit program can provide more information about the nature of the noncompliance. Countries applying a random audit program have been able to observe that in small businesses, the CIT gap is frequently associated with the omission of incomes and the overreporting of expenses. In large businesses, noncompliance practices can be a bit more sophisticated than that, including errors in the basis for depreciation or amortization, losses to be carried forward, nondeductible expenses, and taxable loans to shareholders.[4] Similarly, bottom-up techniques can provide very useful information about the gap by economic sector and type of firm.

Bottom-up techniques can also provide insights into the level of risk of various noncompliance behaviors. Random audit program results provide the opportunity to confirm or improve current risk identification and management models and identify the types of errors that could be better addressed through different treatment strategies (for example, taxpayer education, better services, and audit and reassessment).[5]

CIT gap bottom-up techniques allow RAs to distinguish between the gross (results before audits) gap and the net (after audit results) gap. The difference between those two concepts is used by some countries as a proxy for the yield from RA actions on CIT compliance and collections and communicated in this manner to the public.

CIT gap bottom-up techniques also allow for statistical sensitivity analysis of the results. Because it is possible to apply more than one technique to the same segment of taxpayers, it is possible to work with upper and lower bounds in the estimates. Statistical sampling tools can help to handle mean values and ranges, unlike the top-down approach.

The precaution that must be taken with bottom-up techniques is in the undetected compliance gap in the audits. A fraction of noncompliance could be undetectable, even under the best efforts of auditing.

[4] The estimates use audit recommendations based on laws and regulations. In some countries, the gap estimates include tax avoidance practices as interpreted by the RA. For practical reasons, the estimates are not adjusted by subsequent legal appeal results, which might occur years after the audit is closed by the RA. In addition, the scope of the estimates is limited to CIT's domestic obligations. This implies that the international compliance gap component is not necessarily included; it would require detailed information from other jurisdictions.

[5] A random audit program jointly detects errors in different taxes for an audited business (CIT, value-added tax, Social Security contributions, withholdings); however, to estimate the CIT gap, only the items that affect the CIT obligation are considered.

Such approaches as uplift factors, auditors' best guesses, Delphi methods (engaging a highly experienced group of auditors), and upper and lower estimates bounds are used to deal with CIT nondetection.[6,7]

Corporate Income Tax Compliance Gap Bottom-Up Techniques Applied in Selected Countries

This technical note describes bottom-up CIT gap estimation techniques applied by RAs in the following countries, which are highly experienced in this approach: Australia, Brazil, Canada, Denmark, Sweden, the United Kingdom, and the United States. The selection of these RAs is exclusively based on their experience in bottom-up techniques. For simplicity, each RA experience is presented in this note by the name of the country. This does not imply that a cross-country analysis was carried out. The presentation by country is made solely to help examine the different gap estimation techniques in a simple manner. There are major differences in scale in the RAs and in the CIT designs of each country, the analysis of which is not an objective of this note. However, some characteristics of the selected countries' CITs, such as collection over GDP and top rates, are similar among them (see Annex 1).

The main source of the content is a series of technical discussion meetings of CIT gap techniques with each RA's officials.[8] The focus of the discussions was more on the practical issues associated with the execution of the methods used and less on the theoretical framework. Because the theoretical methods used by the RAs interviewed are published and largely available, this note emphasizes the practical issues and lessons the RAs learned in executing their chosen estimation methods. The main topics shared by the RAs were (1) descriptions of the techniques applied, (2) CIT gap results, (3) advantages and disadvantages of different available options, and (4) future developments and recommendations for any RA interested in starting bottom-up CIT gap estimation programs but having little or no prior experience.

The rest of this note is structured as follows. Section II discusses the definitions of the CIT gap under bottom-up and top-down approaches. Section III presents analysis of the different techniques used for each CIT segment (large, mid-sized, and small businesses) by each selected country. The CIT gap results and treatments provided by each selected country are included in Section IV. Section V presents lessons learned and conclusions.

6 In simple terms, the methods to correct CIT nondetection try to adjust the results of the audits considering that (1) the highest-performing auditors would have conducted each one of the audits, and (2) the highest-performing auditors would have had unlimited time and resources to complete their audits adjusting to the last monetary unit of noncompliance. Even so, there will always be a fraction of noncompliance that is impossible to detect, so it is likely that with audit-based techniques, a degree of underestimation of the gap will remain. See Section III for a description of these methods.

7 Nondetection may vary in each RA. Some RAs are more effective than others in their ability to detect noncompliance. If each RA controls the estimates for its own specific detection capability, then results will be somewhat more comparable than if this were not the case. Australia and the United Kingdom, for example, initially corrected their estimates by using US uplift factors, but they are currently working on their own multiplier factors.

8 Previous versions of this report were reviewed by the officials of the selected countries RAs that participated in the technical discussion meetings. However, any errors or omissions that remain are the responsibility of the authors and do not compromise the officials or RAs of the countries.

II. CIT Gap Definitions

RA-GAP Definition

The IMF's RA-GAP defines the overall tax gap as the difference between potential revenue of the underlying economic tax base and actual revenue (see Hutton 2017). This overall tax gap can then be divided into two elements: the effect of noncompliance (compliance gap) and the effect of policy choices (policy gap). The compliance gap is the difference between the revenue collected for a given year and the potential revenue that could have been collected given the economic activity that took place during that year. For CIT, the compliance gap is the difference between the potential CIT within the current tax policy framework and the CIT collected. The policy gap is the difference between the potential CIT if all corporate incomes were taxed at the current standard rate and the potential CIT given the current policy framework. The size of the policy gap is affected by two factors: changes in the policy structure and changes in the tax base composition. In other words, the policy gap may increase or decrease without any explicit changes in policy; if there is a shift in the tax base so that more net income is subject to standard-rated CIT, the policy gap will increase.

Definition Adopted by Revenue Administrations When Applying a Bottom-Up Approach

The definition for the CIT gap used by the seven RAs is limited to the compliance gap, thus excluding the concept of a policy gap. The efforts for estimating the CIT policy gap are conducted by other areas, such as through tax expenditure estimates executed by a ministry of finance, and were not included in this analysis. The compliance gap definitions applied by the RAs for bottom-up techniques are remarkably similar to those used by the RA-GAP (see Annex 2). All of them consider the CIT gap as the difference between the theoretical and actual CIT revenues, and the theoretical CIT revenues represent the potential amount to be collected if all taxpayers declared and paid the amount due as within the current tax policy framework.

Some of the RAs introduce a nuance to the definition of the compliance gap by adopting the concepts of gross and net CIT gap. The gross CIT gap is the initially observed gap before including any corrective actions from the RA or the taxpayer. The net CIT gap is the observed gap after all these corrective actions can be computed in the actual revenues. The RA-GAP definition is equivalent to the net CIT gap. In some cases, the difference between gross and net gap is used to illustrate the revenue yield of the RA. For example, Canada presents both components to the public, and it attributes the difference to their deployed compliance and collection actions.

Another nuance is that nonfilers and nonregistered gaps are not included in the CIT gap definition under the bottom-up approach. Under the RA-GAP definition, all forms of noncompliance are captured through the estimation of potential collection. In the bottom-up approach, nonfiling and nonregistration are not intrinsically included in the potential revenue, and they are usually assessed by other gap estimation techniques.

III. CIT Gap Bottom-Up Techniques

Types of CIT Gap Bottom-Up Techniques

Based on a Random Audit Program

In a random audit program, each taxpayer has an equal probability of being chosen so that the sample of taxpayers will be an unbiased representation of the total population.[9] All taxpayers in the sample are subjected to the same type of audit, usually a comprehensive audit. The audit findings (that is, the differences detected between what the taxpayers declared and what they should have declared according to legislation) can be used as an estimate for the compliance gap of the sample.

A compliance gap detected for a random sample would be an unbiased estimator of the compliance gap to be detected for the population if it were feasible to audit all of them. In practice, the key requisite for extrapolating the sample results to the total population is how pure of a random selection has been executed, that is, ensuring that no selection criteria have been applied to choose the cases to be audited. Operational audit programs usually do not apply random selection because they need to select the taxpayers showing the highest compliance risk to increase the yield of each audit effort. For that reason, a random audit program for estimating CIT gap must be developed as a parallel compliance action.

To quantify more accurately the compliance gap under a random audit program technique, it is necessary to adjust for nondetected portions of noncompliance. Noncompliance detection capacity is limited in any audit. Although random audits are typically designed to be exhaustive, there is no guarantee that they will fully detect all noncompliance by the targeted taxpayers. There are several adjustment methods for including the nondetected amounts based on uplift factors, auditors' abilities impact, and standardized multipliers.[10]

Based on Operational Audits

Operational audits are regularly performed examinations of a risk-based selection of taxpayers. Because of the selection criteria, not all taxpayers have the same probability of being chosen. Hence, the operational audit results will not be an unbiased representation of the total population. The compliance gap can be quantified by using operational audits through techniques that try to infer characteristics of the general population based on the observations from a biased sample.

Several techniques are used to infer what the results from biased operational audits imply for the general population. These include extreme values (EV) methods, econometric methods, clustering techniques, and expert judgment.

- The EV methods assume that noncompliance is concentrated among higher-risk taxpayers and that the operational audits precisely select those taxpayers. If detected noncompliance values fit a Pareto statistical distribution, then it is possible to extrapolate them to the total population (Bloomquist, Hamilton, and Pope 2014).
- The most common econometric technique is the Heckman two-stage procedure (Heckman 1979). For this technique, the first stage estimates the probability that a case should be included in the sample (that is, selected for an audit), and the second stage models the outcome of an audit (that is, the determinants of yield) using both explanatory variables and a regressor that controls for the selection bias.

[9] This only applies if the random audit program is a simple random sample. Typically, RAs work with stratified samples for reasons of efficiency, introducing varying probabilities of being chosen based on the strata.

[10] The phenomenon of incomplete detection is common to all audit activities: financial, environmental, and labor (Feinstein 1990).

- Clustering techniques consider that audited and non-audited taxpayers can be divided into different clusters using variables relevant in the selection of cases for audit. The tax gap for each group is estimated by scaling audit results from the audited taxpayers to the population in each cluster.
- Expert judgment approaches are varied, but they involve having experienced auditors provide their own subjective risk evaluations for the taxpayers in a segment and then extrapolating the operational audit to the general population using those risk assessments.

Based on General Administrative Data

One of the selected countries, Brazil, has developed a tool that exploits all the information collected on each business for estimating the frontier of its CIT obligations. This technique considers a wide range of information from the businesses, including transaction data, to model the theoretical tax gross liability of each business in the form of a frontier production function explained by such factors as capital, purchases, and workers. The gap is obtained by aggregating the differences between actual and theoretical tax for all the businesses.

Mixing the Use of Different Techniques for an Overall Estimation

RAs may use random audit programs, operational audits, or other techniques to estimate CIT gaps , taking into consideration the one most suitable for each taxpayer segment: small, mid-sized, and large businesses (Table 1). The RAs consider the segment characteristics along with their own internal approaches, capabilities, and knowledge of those populations to choose a particular CIT gap technique.

There are differences among RAs in the definitions of the segments for CIT gap purposes. The definitions for which business is a large, mid-sized, or small taxpayer can vary in each case, so they are not strictly comparable. Most RAs use an annual turnover level that they sometimes combine with level of assets, number of employees, and legal structure.

Large Businesses' Corporate Income Tax Gap

Techniques based on operational audits are the ones used the most for estimating large businesses' CIT gap (Table 1). Most RAs agree that a random audit program is the most statistically robust means of producing gap estimates from audit data. However, in the segment of large businesses, it appears more cost-effective to use existing data from operational audits than to create a random sample program.

Large businesses are usually complex and heterogeneous entities, which makes it difficult in their case to apply a random audit program. The population of large businesses is much smaller than those of the small and mid-sized business segments. With a smaller overall population, the random sample size necessary to guarantee a minimum level of confidence for large businesses would be a much greater proportion of that population. In addition, there can be significant differences in the operational profiles across large businesses, which, combined with a small population size, makes it difficult to extend observations from a sample to the population. For example, large businesses can operate simultaneously in different sectors and exhibit a higher level of variance in their risk than small and mid-sized businesses. These factors make the cost of each individual audit of large businesses much higher in terms of time and resources than audits of small and mid-sized businesses, while also making it less certain that the results will provide the proper general observations.

In some RAs, the high audit coverage rate for large corporations makes it reasonable to base the estimation solely on existing operational audit results. In the United States, for example, the audit rate for large corporations has historically been close to 33 percent of the population, and it increases progressively, even

Table 1. Corporate Income Tax Gap Bottom-Up Techniques Applied by Revenue Administrations

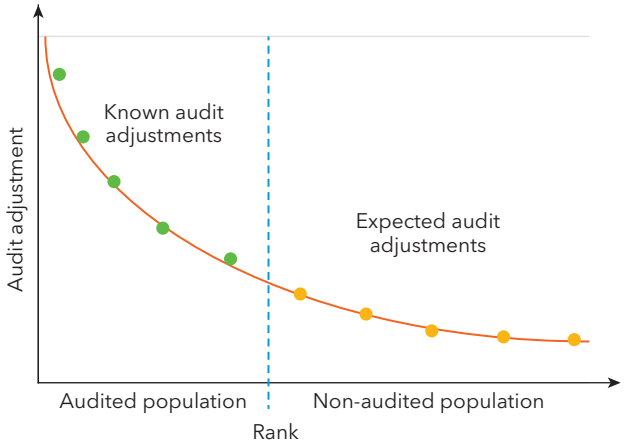
Revenue Administration	Random Audits Programs	Operational Audits/ Extreme Values	Operational Audits/ Econometric, Statistical	Other Administrative Data, Expert Judgment, etc.
Large Businesses				
Australia				√
Brazil[1]		√		√
Canada		√	√	
Denmark	√			
Sweden				√
United Kingdom		√		
United States		√		
Mid-Sized Businesses				
Australia			√	
Brazil[1]				
Canada	√			
Denmark	√			
Sweden	√			
United Kingdom		√		
United States		√		
Small Businesses				
Australia	√			
Brazil[1]				√
Canada	√			
Denmark	√			
Sweden	√			
United Kingdom	√			
United States			√	

Source: IMF staff calculations based on information from the revenue administrations of the select countries.

Note: Each revenue administration has its own definition of the small business, mid-sized business, and large business segments.

[1] An extreme values method has been applied to all segments but only for trial purposes.

Figure 1. Illustrative Example of an Extreme Values Technique in Canada



Source: Canadian revenue administration.

reaching 80 percent of the largest of the large corporations).[11,12] In this context, a random sample would certainly overlap cases with risk-based audits, making the random audit program estimation inefficient.

Random Audits

Only one of the RAs, Denmark's, has obtained CIT gap estimates for large companies through random audits. Denmark used random audit program surveys, which included a sample of the 80 largest corporations considering the CIT liability but excluding the top 25 stock exchange corporations.

Operational Audits: Extreme Values Technique

In four of the RAs, the EV technique uses operational audits for estimating the CIT gap of large businesses (see Table 1 and Annex Box 3.1). The EV method uses the audit results assuming that they fit a Pareto statistical distribution. This assumption can be expressed mathematically considering that the logarithm of the known noncompliance amount is inversely related to the logarithm of the rank of the noncompliance amount. The rank is built for each return starting with the highest audit adjustment ranked as 1. The second-highest audit adjustment is ranked as 2, and so on. Thus, the adjustments for the audited businesses are extrapolated to the non-audited population considering that estimated inverse relationship (Figure 1).

The first assumption of the EV technique is that the underreported CIT amounts for large businesses are well-described by a Pareto statistical distribution. This assumption is based on statistical research findings that business income is well-described by a Pareto statistical distribution for the higher-income entities.[13] Thus, if large businesses underreport a fraction of their income and that fraction varies around some average value for the segment, then the average underreported amount will also tend to follow a Pareto distribution.

The second assumption of the EV technique is that the audits identify the highest value adjustments for large businesses. If the audits have fully identified all noncompliance by the audited taxpayers, then the audit adjustments will represent the highest EVs of the Pareto distribution. This is a bit of a strong assumption, as audit identification of noncompliance is never 100 percent effective. For this reason, the possibility of underestimation will be greater the more ineffective the risk selection is, making audit recovery more ineffective as well.

11 At present in the United States, large business operational audits are based on a risk analysis over the CIT filed returns. This means that the audit cases are not intended to control one specific item for the whole population but categories of high-risk characteristics obtained by algorithms that combine different items from each return (Internal Revenue Service 2022).

12 Budget constraints have reduced coverage in recent years relative to historical levels.

13 A variety of phenomena in nature are characterized by concentrating in a small number of cases the largest portion of the total amount of a variable. These phenomena are typically well described by a Pareto distribution (also called a "power law"). In Bloomquist, Hamilton, and Pope (2014), evidence is mentioned that suggests that in the segment of 1 to 3 percent of higher-income individuals, the distribution of income follows a Pareto distribution. In the same sense, it is exemplified in 11 percent of the largest businesses accounting for 93 percent of the total recommended CIT by the Internal Revenue Service's audits in 2006.

For applying the EV technique, RAs need to have audit databases that cover results for several years. CIT audits for large businesses usually take many years to close. RAs must maintain multiyear information for the audits initiated each year. The United States looks at information spanning seven years of audit results; Canada uses eight years. This aspect of the procedure creates a lag in the production of the gap estimate; if the estimate of the gap for a given year depends on the audits being completed for that given year, and the audits take many years to complete, then the gap estimate cannot be completed until those years have passed. The United Kingdom uses an imputation method based on the historical data of closed cases to obtain a projection for open cases. The imputation is based on a random association of average closed cases to open cases. Through the imputation method, it is possible to extend the Pareto statistical distribution to all current taxpayers.

RAs use different criteria to define the number of large entities to be considered for the EV technique. The United States contemplates about 8,000 entities in the segment of large businesses, of which up to 2,700 are annually audited, and only about 100 of the audited entities are included as the EV for the estimation process. Other RAs apply statistical iteration or practical judgment to identify the number of EV to be considered. A still-pending issue that may affect the number of businesses in some RAs is the treatment of positive audit adjustments. In the standard method, a simple truncation process is used (see Annex Box 3.1), but there are variations in the approach used by the RAs.

None of the RAs uses the final assessment of the adjustments for applying the EV technique. In large businesses, noncompliance is usually related to legal interpretations and sometimes it can involve several years of litigation. For practical reasons then, the RAs tend to work with the initial auditors' assessments of the level of noncompliance for applying the EV technique and not to wait for what the results end up being after the taxpayers have exhausted all avenues of disputation.

Operational Audits: Econometric and Statistical

Canada has alternatively applied a clustering technique to estimate the CIT gap for large businesses. It does this in addition to employing the EV technique to produce two separate estimates for the gap. This technique consists of grouping similar taxpayers (audited and non-audited) in an optimal number of clusters by using a set of the most relevant reporting characteristics (for example, corporation types, reported amounts, industry types, and revenues and expenses ratios from the declarations).

Canada has developed different ratios and metrics by trial and error to feed the clustering technique. This is done through consultations with audit program experts and the incorporation of their experience and knowledge into the process. Canada also contacts academic experts for advice.

Canada's clustering technique assumes that tax filers within each cluster have similar chances to be audited as they have similar characteristics. Audited and non-audited tax filers in the same cluster should exhibit similar behaviors and have the same potential level of adjustments (relative to their size). However, if a fraction of unaudited taxpayers would have a higher level of compliance than those audited within the cluster, then the result would tend to generate an upper bound estimate. Canada uses primarily two-step clustering analysis for this estimation, but it has also used propensity score matching techniques to check the clustering procedure and has obtained comparable results.

Other Techniques

Sweden has developed an ad hoc technique that combines samples of audit results and specific estimates for tax avoidance. For this method, the CIT gap is divided into two components to be assessed separately. The first component is the portion of the gap caused by inadequate internal business practices. These gaps are estimated based on the follow-up of audits and controls, including random audits over businesses on the borderline between mid-sized and large and audits and controls over other subpopulations of large

businesses. The second component of the CIT gap is referred to as tax avoidance schemes; it is based on a few operational audits (not based on risk), but the specific method for estimating this portion of the gap is kept confidential due partly to the fact that disclosure might identify audited enterprises.

Australia uses audit coverage levels and expert judgment to estimate unreported CIT for large businesses.[14] A business is considered to be in compliance when RA actions result in no amendments being required. Projected results are calculated based on the average value of revenue collected for the number of years since the income year. For estimating unreported amounts, Australia uses adjustment factors. An adjustment factor is separately derived for income, expenses, and offsets for each year by taking amendments, including projected amendments, dividing the amounts by the sum of the relevant base, and multiplying this by the selection bias discount factor. A discount for selection bias, based on expert judgment, is required as RA compliance actions have historically been targeted to outperform random selection. The adjustment factors are then discounted by the level of coverage applicable for an entity and period. For entities with high assurance, the adjustment factor is discounted by 95.45 percent to reflect that the taxpayer and their income tax return have been examined to a high standard, and any material errors would have been discovered. For medium assured cases, the amendment factor is discounted by 68.27 percent. For entities with no assurance, but one or more compliance cases for a given period, the highest materiality applicable for the intensity of the compliance case is used to discount the amendment factor. For entities with no assurance, or any compliance cases actioned, no discount is applied.

Brazil applies a method for large businesses based on a benchmark approach. It calculates the average effective rate of taxpayers classified as low risk in each economic sector, removing any outliers. This rate is considered an acceptable standard. With this standard rate, it then calculates the dispersion of each taxpayer concerning the standard rate. Finally, the gap is estimated from the sum of the dispersions of the previous item.

Accounting for Undetected Noncompliance

RAs recognize that a fraction of CIT noncompliance can be undetectable despite their best efforts of auditing. As mentioned earlier, it is assumed that even the best audit program will still miss some noncompliance by taxpayers. This is generally because (1) the best cases selection method may be incomplete in detecting all the risk entities; (2) RAs do not have enough resources to audit all the cases rated to be risky;[15] and (3) even if a risky case is audited, there are limits to the capacity, time, and resources needed to detect even the last monetary unit of noncompliance from that case. RAs use a variety of techniques to compensate for this:

- The United States has developed a methodology to estimate what the "uplift factor" on detected audit adjustments might be to compute undetected individual income tax underreporting.[16] The United States has applied this methodology for the individual income tax and self-employment tax gaps but not for businesses' CIT gap. Other countries use uplift factors for their estimates of the CIT gap. Australia uses an uplift factor that it varies for its categories of assurance: (1) not assured, (2) medium assurance examined, and (3) high assurance examined businesses. The uplift factors are 3 percent, 2 percent, and 1 percent over the CIT base, respectively, for each category.

[14] In Australia, the CIT gap is also estimated for companies connected with high-wealth groups by using a logistic/linear regression technique. This segment includes individuals connected with high-wealth groups and companies controlled by high-wealth groups that are not covered in the large firm groups' CIT gap.

[15] This is probably more likely to be observed in the cases of mid-sized companies, according to the experience of some RAs.

[16] The United States applies a detection controlled estimation methodology (Feinstein 1990) by sampling about 14,000 annual individual income tax returns under the National Research Program (Internal Revenue Service 2019).

- Canada is analyzing the use of an uplift factor appropriate to its particular context. However, the Canadian practice of estimating an upper and lower value of the gap may be an interesting option to measure the orders of magnitude that an estimate corrected for nondetection might reach. The upper bound comes from the clustering technique and the lower bound from the EV technique.
- The United Kingdom used to apply uplift factors adapted from other countries, but now it is applying an approach based on lower and upper bound estimates. The upper bound comes from an EV technique under the assumption that compliance cases are representative of the population (treating the risk-based audits as if they were a random sample of audits). The lower bound comes from the EV technique under the standard Pareto assumption.

Mid-Sized Businesses' Corporate Income Tax Gap

Estimated Jointly with Large Businesses or Small Businesses

In most of the RAs, the mid-sized businesses' CIT gap is jointly estimated with other segments. Only Australia estimates CIT gaps for mid-sized businesses independently of other segments.

The United Kingdom and the United States include mid-sized businesses in the EV technique for large businesses.[17] After the United States uses the EV technique for large corporations, it applies their proportion of underreported CIT to the aggregation of large and mid-sized corporations, obtaining the CIT gap for these two segments jointly. The United Kingdom directly uses the EV technique for a unified segment of large and mid-sized corporations. However, while the United States presents the results jointly for large and medium-sized companies, the United Kingdom presents them separately.

Canada and Sweden include mid-sized businesses in the random audit program for small businesses. For these RAs, the sampling process considers a targeted population that includes mid-sized businesses, so there is no treatment specific to them. In Sweden, the resulting proportion is applied to add a gap associated with limited companies' share of trading partnerships and limited partnerships profits. These RAs present the results jointly for small and mid-sized companies. Denmark, as mentioned earlier, applies a random audit program for large, mid-sized, and small business segments jointly.

Operational Audits: Econometric and Statistical

Australia produces its CIT gap estimates for mid-sized businesses based on a logistic/linear regressions technique (see Annex Box 3.2). It uses the mid-sized businesses that have adjustments to their assessments, correcting for selection bias and extrapolating the results to the population of this segment by two regressions.[18] First, a logistic regression is applied to label each business as noncompliant or compliant. Second, a linear regression is applied to estimate the size of the gap for those businesses labeled as noncompliant in the first regression.

Small Businesses' Corporate Income Tax Gap

A random audit program is the preferred technique for estimating small businesses' CIT gap (Table 1). RAs agree that in their cases, a random audit program is the most statistically robust means of producing gap estimates from audit data. Of the countries surveyed, only the United States applies a different technique for this segment.[19]

[17] Although Brazil does not do an EV systematic estimate, it has included all segments in its trials.

[18] Australia conducts compliance activities at the level of groups for mid-sized businesses (not at the level of a single company or individual). The sampled groups are subject to compliance and assurance activities. The sampled groups typically represent 10 percent of the whole population for this segment; this rate was reduced to 4 or 5 percent during the COVID-19 period.

[19] The Internal Revenue Service National Research Program Office has developed studies by using random samples of returns from corporations, but they are not used for CIT gap estimation purposes (Bloomquist, Hamilton, and Pope 2014).

Random Audits

A random audit program can be considered the simplest technique for estimating a CIT gap (see Annex Box 3.3). This technique's main methodological requirement is to correctly extract a random sample of entities to be audited and extrapolate the audit results to the population.

The sample size for a random audit program is defined by the level of statistical confidence required, but it is naturally subject to resource limitations. The small businesses segment is the largest of the taxpayer segments under all the selected countries' definitions. Thus, the random sample size necessary to guarantee a minimum level of confidence would be much lower in proportion to the population compared to other segments. The cost of each individual random audit involving small businesses would also be much lower than those for mid-sized and large businesses as the nature of their operations tends to be simpler.

Canada has one of the higher sample sizes, at about 4,500 cases in each estimation process,[20] including mid-sized businesses, and the United Kingdom has one of the smaller sample sizes, at about 330 cases per process (Table 2). The rest of RAs show sample sizes of fewer than 1,000 cases. Canada, Denmark, and Sweden include mid-sized businesses in the random audit program sample, so this will tend to require the sample size to be a bit larger. Some RAs discard some enterprises before sampling. Sweden, for example, is focused on limited companies and sole traders and excludes dormant entities, entities with no employees, those with low levels of income, and certain small businesses, such as partnerships, limited partnerships, publicly owned companies, financial corporations, and nondomestic companies.[21] Australia excludes small businesses under a legal vehicle different from an incorporated company. On the contrary, the United Kingdom intends to consider the population of small businesses without exclusions, thus including inactive and dormant companies).

Stratifying the population is a widespread practice (Table 2). Most of the RAs stratify the population by using turnover and other variables. Australia distinguishes four strata by considering two categories of turnover size and two types of industry—companies investing in financial assets versus the rest of population. Canada stratifies the population around the sector of activity, classifying business into one of 21 different economic sectors. In both cases, the samples are randomly selected to each stratum. Sweden stratifies the target population of limited companies into six different strata based on annual salary total and the target population of sole traders into three different strata based on annual turnover.[22] Many firms within each stratum are randomly selected. This number is not fixed and varies depending on available resources and the need to improve estimates in different strata. Given that each stratum shares comparable properties, the average tax gap for the sample is extrapolated to all other firms of the same stratum. Some RAs are analyzing new stratification variables while considering how these would affect the necessary overall sample size.

Some RAs use sample pooling to improve the efficiency of the random audit program (Table 2). Denmark changed its schedule of sampling every three years to sampling every year but with a smaller number of cases, then pooling the data for two or three years. This is useful for reducing the resources required to execute the random audit program. Australia selects cases from each stratum each year and bundles audit samples from different years, working under the assumption that noncompliance is constant over the short term.

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20 Canada's random audits are not an annual exercise. Instead, Canada conducts period random audits to better understand compliance trends and enhance risk-assessment systems.

21 Sweden only samples entities under those conditions (87 percent of the sample of limited companies and 19 percent of the sole traders), but the sample results are extended to some nontargeted groups by using the proportion of the corrections to the final tax.

22 The definition of small and mid-sized businesses in Sweden considers annual salary total less than 75 million Swedish krona (local currency) for limited companies and annual turnover less than 75 million Swedish krona for sole traders (values for 2018).

Table 2. Random Audits Technique for Small Businesses' Corporate Income Tax Gap

Revenue Administration	Number of Entities[1]	Mid-Sized Businesses Included	Sample per Estimation Process[1]	Profiling and/or Preprocessing	Sample Pooling	Stratification
Australia	1,060,000	No	987	Yes	Yes (3 years)	Yes (strata based on turnover and industry)
Canada	n.a.	Yes	4,500	n.a.	No	Yes (strata based on 21 industries)
Denmark	217,000	Yes	350	No	Yes (2 or 3 years)	No
Sweden	533,000	Yes	600	No	No	Yes (once type of business is determined, strata based either on turnover or annual salary total)
United Kingdom	5,900,000	No	330	n.a.	No	Yes (strata based on turnover)

Source: IMF staff based on information from the revenue administrations of the select countries.

Note: n.a. = not available.

[1] Approximate numbers for the most recent CIT gap estimation period. The number of entities represents the segment population, but not necessarily the targeted population for sampling. Some RAs, for example, exclude certain types of businesses before sampling. The estimation process may involve one or more fiscal years.

The use of standardized audit checklists, profiling, and preprocessing can also be helpful in optimizing the use of resources in a random audit program (Table 2). In Sweden, each one of the 600 firms selected through the random audit program is audited with a standardized audit tool (a set of controls and checks) developed by the Swedish RA that reviews about 100 aspects of the firm and its tax returns.[23] If the auditor finds mistakes or any indication of noncompliance when using the audit tool, that motivates further inquiries and a deeper audit. For about 50 percent of the audited companies, there is no indication of noncompliance. On average, an auditor takes about 10 to 12 days to audit a firm, with a large standard deviation, because of complexity and firm size; for the largest companies within the sample it takes on average of 17 days. Between 60 to 70 auditors work on the random audit program. The checklist for inclusion or deemed compliance, and the parameters of the audit do not change year over year, so the data for different years are comparable. Australia, for each taxpayer sampled, gathers information provided by the taxpayer and from third parties. It identifies all the tax risks and issues associated with each taxpayer. If no material risks are found, the company will be considered as compliant. If the auditors identify potential tax risks, then they initiate an audit. Consequently, the audit cases are not strictly randomly selected because of the preprocessing, but the efficiency of the overall process is improved.

The random audit is usually a comprehensive audit. The audits of a random audit program are not based on risks. In some RAs, the random audit program includes not only CIT, but other taxes, such as value-added tax, Social Security contributions, and self-employment contributions. For that reason, random audits are

[23] Partnerships, limited partnerships, publicly owned companies, financial corporations, and nondomestic companies have not been subject to random audits.

considered broad, but shallow compared to risk-based audits. However, a random audit program is not expected to exhaustively cover all types of noncompliance practices. Denmark, for example, recognizes that its random audit program includes a value-added tax gap, but it does not cover items such as transfer prices issues, unregistered businesses, economic crime, tax havens, and undeclared work. Those gaps are estimated in Denmark separately by other techniques.

Operational Audits: Econometric and Statistical

Only the United States uses operational audits for estimating small businesses' CIT gap. The US technique uses the Heckman approach based on an econometric model of five simultaneous equations: (1) the probability of a CIT return being audited, (2) the probability of detecting underreported CIT conditional on an audit, (3) the amount of underreported CIT conditional on detected underreporting, (4) the probability of detecting overreported CIT conditional on an audit and no detected underreporting, and (5) the amount of overreported CIT conditional on an audit and no detected underreporting (Heckman 1979). These equations are estimated combining data from randomly selected audited and unaudited returns. To apply this approach, the small companies are categorized into five activity code levels on the basis of reported assets. The independent variables of the model are items from the CIT returns, but how they are specifically input in the equations is confidential. The United States also adds as an independent variable a risk score for each return received during the regular CIT declaration process.

Other Techniques

Brazil estimates the CIT gap in micro and small businesses by adapting the stochastic frontier method, a technique that comes from other fields of econometric analysis (see Annex Box 3.4).[24] For this purpose, the stochastic frontier method makes use of administrative information to model a Cobb–Douglas production function. The production of a business is assimilated to the gross tax liability and explained by factors such as (1) purchases, (2) salaries and reported employees, (3) bank transactions, and (4) fixed capital. Controls are also applied to economic sector, region, and years of each business. The gap for each business is obtained through the "vertical distance" between its actual revenue level and the frontier (the potential revenue) that is estimated, based on information of the most compliant business operating with the same combined use of factors.[25]

The stochastic frontier method that Brazil uses requires high information technology capacities to apply the model over the population. The model runs over about 2.7 million active taxpayers per year in Brazil. For each taxpayer, an important volume of data is compiled from declarations and from third parties, necessitating the use of agile data management tools. Because the stochastic frontier method applies at a detailed level of data, it could also offer opportunities to assist with the risk analysis of a particular taxpayer, through sectoral benchmarks.

Accounting for Undetected Noncompliance

The problem of nondetection in a random audit program is addressed in a similar way to operational audit-based techniques. Given the broad shallow nature of the audits generally performed under a random

[24] Micro and small businesses can join a special tax regime in Brazil known as SIMPLES Nacional, which simplifies the overall tax burden. Under this regime, firms can include up to six federal taxes (one being CIT), one state tax, and one municipal tax, totalizing eight different taxes, using a single document, by calculation and payment of a single rate applied to the company's gross revenue.

[25] A major assumption of this method is that in each segment of comparable businesses, the companies that are on the frontier of declared taxes exhibit perfect compliance. It is possible that in certain segments in which noncompliance practices are widespread, this assumption is not fully verified.

audit program, it is recognized that the audit is not likely to result in a full assessment of the level of noncompliance by some taxpayers. For this reason, some RAs apply an uplift factor over random audit programs' detected amounts in a similar fashion for the estimation using operational audit data. Recently, Sweden and the United Kingdom started applying a method to formalize the estimation of a CIT uplift factor based on the survey results from an experienced group of auditors, that is, using the Delphi method (see Annex Box 3.5). Canada, Denmark, and the United States do not currently apply an uplift factor for any segment of CIT.

IV. CIT Gap Estimates

CIT gap estimates have different uncertainty levels, and some RAs aim to be more explicit about these differences when publishing results. The United Kingdom declares an uncertainty rating for each CIT gap estimate. For the most recent years, the small and mid-sized businesses CIT gap estimates were assessed a "moderate level" of uncertainty whereas the large businesses estimates were considered to have "high level" of uncertainty. The United Kingdom also includes a section in the gap report for discussing previous revisions to the tax estimates, adopting a standard statistical transparency practice. Australia uses a similar rating for each population segment CIT gap estimate.

The public estimated net CIT gap levels are not comparable and range from 3 to 15 percent of potential in the RAs (Figure 2).[26] The net CIT gap as a percentage of potential could facilitate the use of a common concept among different countries,[27] but it must be interpreted with caution. The RAs have different gap estimation methods for each segment of population based on their characteristics and on their own internal approaches, capabilities, and knowledge of those populations. Thus, the total net CIT gap of each RA is the result of a very particular combination of different target population and estimation techniques (Table 1).

The difference between gross and net CIT gap estimates can be used to communicate the relevance of compliance actions. This difference corresponds to enforced CIT compliance and late payments after the RAs execute compliance and collection actions. The estimated compliance gap for Canada, for example, was reduced by more than 11 percent points of potential after accounting for compliance actions. The United States had comparable results, with a reduction of more than 3 percentage points (Figure 3).

The portion of the CIT gap attributable to large companies was more than half of the entire CIT gap (Figure 4). This result was upheld even when the RAs combined different estimation methodologies and different definitions of large corporations. The United Kingdom was the only outlier in the group for many reasons, including the estimate techniques and segment definitions it applied, the relative weight of each segment in the CIT revenues, and a relatively greater compliance risk in small and mid-sized businesses than in large ones (Figure 5).

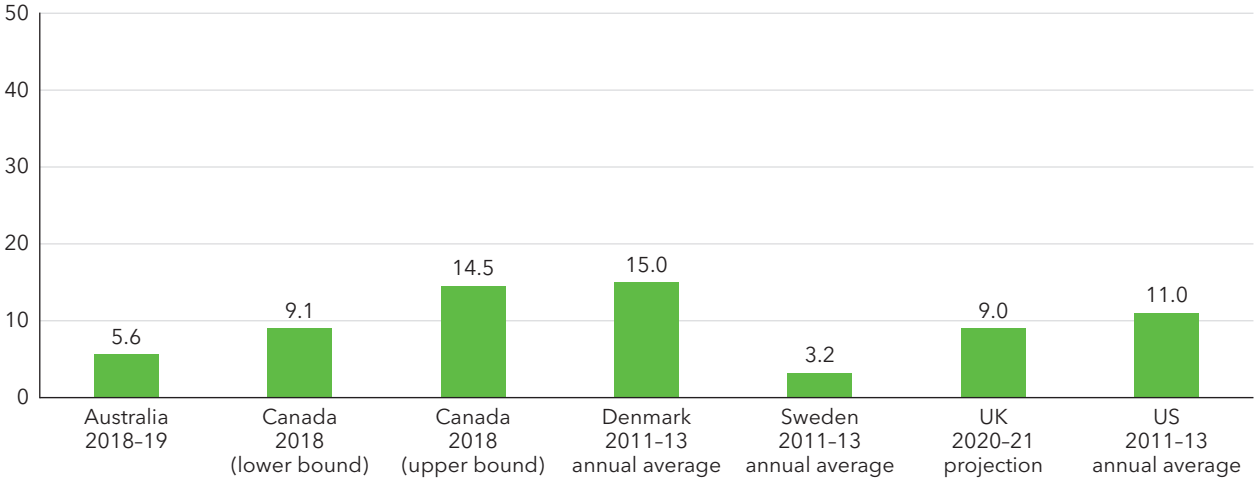
RAs seek to maintain consistency in their estimate technique over time to make the results comparable. The United Kingdom reports the most extensive series of CIT gaps, including 16 fiscal years for each of the segments (Figure 5). The United Kingdom has introduced some changes in its technique over time, replacing the use of other countries' uplift factors for its own expert judgment factors, for example. In such instances, when there is a change in the method, the CIT gap report will include a comparison to previous estimates and note how the change affects that comparison. Furthermore, the United Kingdom applies a three-year moving average to the results with a double weighting for the current year. That practice is used to reduce the estimation noise in any particular year and to produce a smoother overall annual series.

CIT gap estimates based on audits provide an opportunity to estimate the distinct CIT noncompliance practices (Figure 6). Denmark, for example, publishes the CIT gap broken down by economic sector and by type of error obtained by its random audit program. These results allow an evaluating of the activities in which the risk of compliance is concentrated and the practices preferred by economic agents to try to bypass their CIT obligations. Denmark also classifies types of errors to distinguish those that are unintentional versus those that reflect deliberate CIT noncompliance to compare them to different risk levels assigned to taxpayers (see Annex Figure 4.2).

[26] The values included in Figure 2 correspond to the most recent period available. In countries that base their estimates on audits, these are closed after several years of audit work, which explains a lag in the period of the estimated and published gap. The United Kingdom uses a projection method to provide a more up-to-date provisional value.

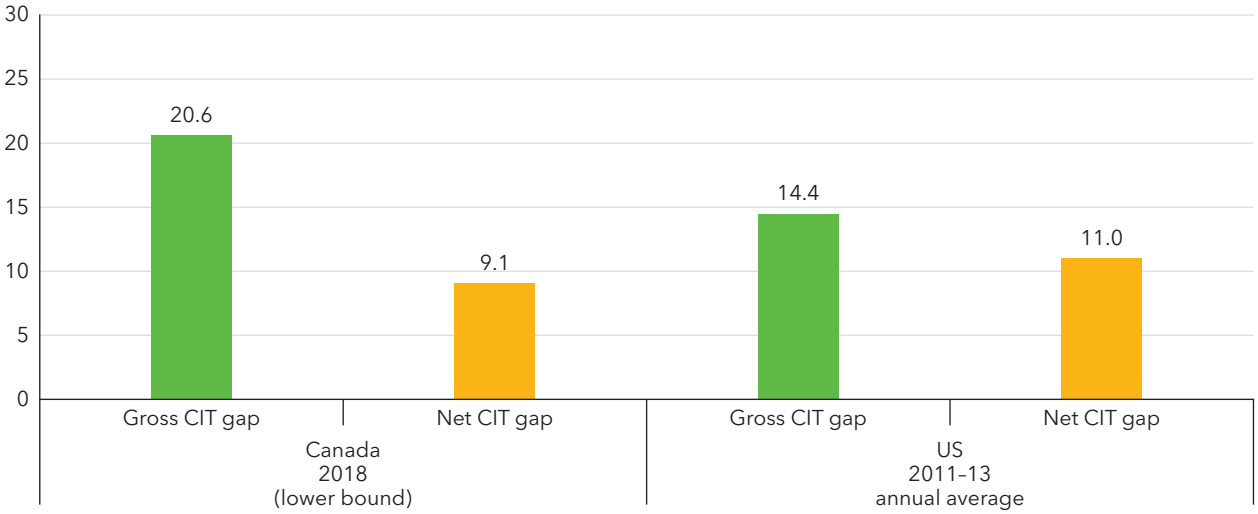
[27] In some countries, among them Canada, the net CIT gap is communicated as a percentage of the actual CIT revenue. In this note, the net CIT gap is expressed as a percentage of the potential CIT revenue. The potential CIT revenue corresponds to the sum of the actual CIT revenue and the net CIT gap amount.

Figure 2. Net Corporate Income Tax Gap
(Percent of potential)



Source: IMF staff calculations based on information from the revenue administrations of the select countries.

Figure 3. Gross versus Net Corporate Income Tax Gap
(Percent of potential)

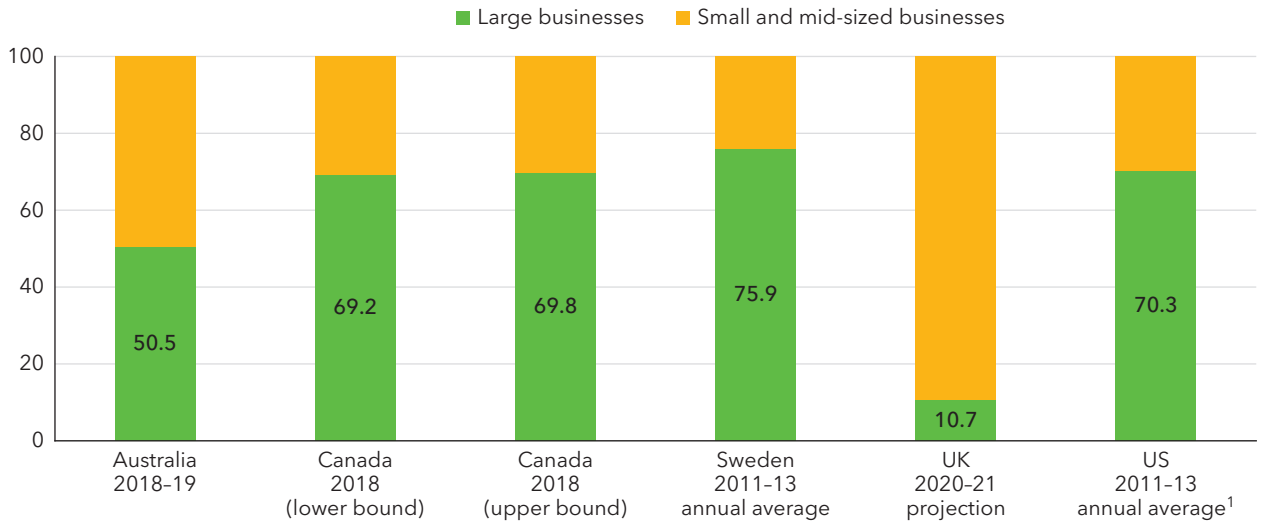


Source: Canada revenue administration; US revenue administration.
Note: CIT = corporate income tax.

Almost all the RAs in this survey make their CIT gap estimates available to the public.[28] In recent years, some of the RAs have received an explicit mandate from government to estimate and make public the tax gap. Several already had long been preparing and publishing their gap estimates. Internal communication of the results is also crucial for broader and better understanding of compliance causes and assessment of current and future compliance actions to reduce it.

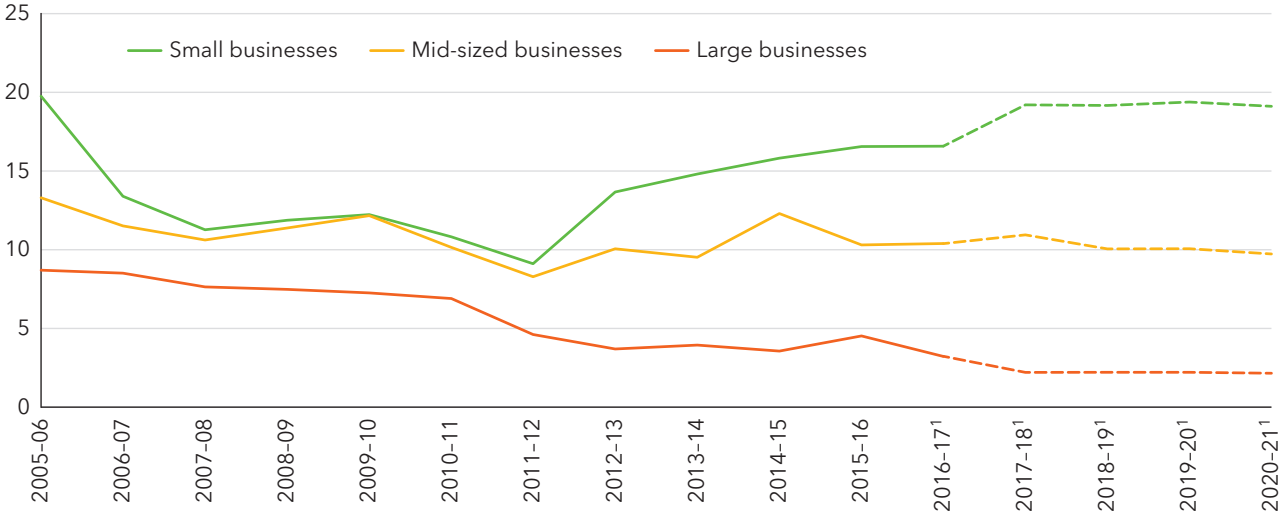
[28] Denmark publishes error rates and the share of private individuals and businesses that deliberately do not comply, but it does not publish the CIT gap amount estimates. Brazil plans to move forward with publishing CIT gap estimates toward the end of 2023.

Figure 4. Large Businesses' Shares of the Net Corporate Income Tax Gap
(Percent)



Source: IMF staff calculations based on information from the revenue administrations of the select countries.
[1]Calculated for gross corporate income tax gap including that of jointly large and mid-sized businesses.

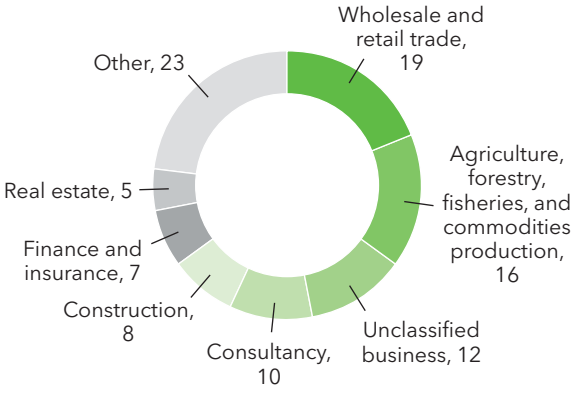
Figure 5. Net Corporate Income Tax Gap in the United Kingdom, by Segment, 2005–21
(Percent of potential)



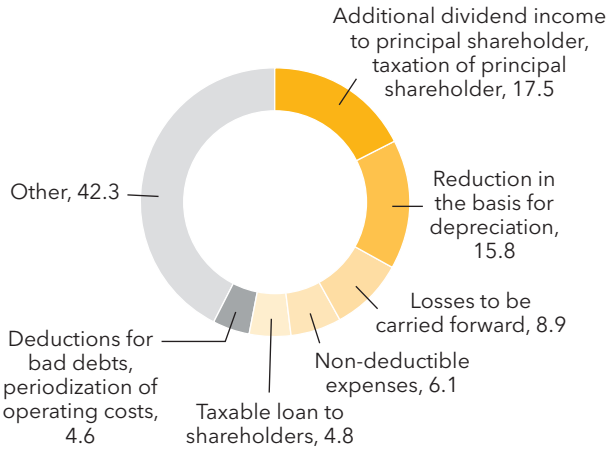
Source: United Kingdom, HM Revenue and Customs.
[1] HM Revenue and Customs labeled these estimates "projections" given the lag in the final audit results.

Figure 6. Net Corporate Income Tax Gap Share in Denmark, by Economic Sector and Type of Error, 2014
(Percent)

1. By Economic Sector



2. By Type of Error



Source: IMF staff calculations based on Danish Customs and Tax Administration (2017).

V. Lessons Learned and Conclusions

The Bottom-Up Techniques

CIT gap bottom-up techniques provide information about the composition of the gap. A strong advantage of bottom-up techniques, compared with top-down techniques, is that the former can provide insight into what types of practices are behind the compliance gap, not just the general size of the gap. A random audit program can also provide insight into the level of risk of various noncompliance behaviors in the general population, to either confirm or improve current risk identification and management models and to identify the types of errors and other unintentional noncompliance factors that could be more easily addressable by the RA through taxpayer outreach and education, rather than audit and reassessment.

Bottom-up techniques can be limited in their ability to estimate the overall size of the compliance gap. Top-down methods by design can capture the overall size of noncompliance, whereas bottom-up methods are constrained by being able to work only with the noncompliance issue the administration is potentially addressing. The various RAs included in this note have produced a few options to deal with this difficulty, such as uplift factors in regard to detected gap amounts based on econometric estimates or auditors beliefs, a Delphi method (using a highly experienced group of auditors), and estimating upper and lower bounds.

In general, a random audit program is the bottom-up technique with the greatest relative statistical advantages, but it is also the most expensive to execute (see Annex 5). All RAs applying a random audit program must dedicate time and resources in parallel to their operational audits. These resources come with a high opportunity cost, because if a random audit program is well designed, it will consume audit resources in unproductive cases. In large businesses, a random audit program could be costly and unfeasible because the expected high variability and the reduced population could require an extremely high sample size to obtain reliable results. For reducing costs of a random audit program, some RAs adopt certain strategies, such as stratification, preprocessing and profiling, and pooling of samples.

An EV technique is a low-cost approach, but it requires a comprehensive database of audit results spanning many years (see Annex 5). To use the EV method, a RA's audit management system must be able to record not only the results of audits, but also the fiscal periods covered, and ideally how the audit results relate to each fiscal period, the causes of the audit changes, and other details of the CIT adjustments made by the auditors. These data should ideally cover as many years as possible; certainly more than a decade's worth of results would be required to be able to construct a reasonable picture of the level and trends in audit results. In addition, estimates based on the EV technique will need to be reestimated given the long delays that can occur in completing audits, which will result in the levels and trends in audit results changing over time.

A well-designed bottom-up gap estimation program does not have to choose between one method or another but can use a combination of techniques to better target the gap estimates for different taxpayer segments. In general, RAs have found that a random audit program is most suitable for small businesses, whereas techniques based on operational audit data work better for large businesses. Both techniques can be extended to encompass mid-sized businesses. Other techniques based on econometric or statistical approaches are used less frequently, but they are also targeted to a particular segment of businesses.

Revenue Administration Strategies to Apply Bottom-Up Techniques

The RAs' experience suggests that the development of bottom-up CIT gap estimates is the result of several years of research. This in turn suggests that an RA without previous experience in bottom-up techniques should first develop a medium- and long-term gap estimation program. For example, if an RA without previous experience in random audit programs wants to start a random audit program, it should consider

planning for at least three years from the start of the audits until the first results are obtained. This may sound a bit disappointing for RAs interested in starting a bottom-up CIT gap program and getting quick results, but it is possible to identify some elements that can help speed up the process based on the experience of the countries highlighted in this note (see Annex 4).

All RAs develop bottom-up CIT gap estimation programs with extensive internal and external support. Although to varying extents, all RAs allocate some fraction of institutional resources to estimation processes. In all cases, there is support from government authorities, and in most cases, also from other institutional entities such as statistical offices and academic units.

Most of the RAs assign the bottom-up application to specialized staff. These staff members accumulate knowledge and experience, and they can devote time to sharing what they know after the analysis has been completed with the auditors. In a random audit program, for example, the specialized staff can prepare guidance manuals, control the completed audits to ensure high quality, and provide feedback to the case workers. In addition, the specialized staff can detect the needs of statistical or IT support to be able to apply the techniques and look for them in academic instances.

Whatever the bottom-up technique applied, a strong institutional orientation to the management of audit data is required. All the RAs observed gathered detailed information on each audit, including the audited periods, the adjustments made, the execution dates, the dedicated auditors, and the type of errors detected. Furthermore, to develop an estimate based on the EV technique, an RA should accumulate and maintain detailed and reliable information from multiple years of audit results and not just retain results for a limited time.

A public mandate to estimate the CIT gap can be just the incentive to develop or improve the bottom-up techniques and data required to do so. Having a public mandate to produce a gap estimate, along with maintaining a regular publication schedule, helps foster internal and external support for the task's allocation of resources. In addition, being transparent with the results can assist in providing credibility to the estimates and is also useful in ensuring that the results are not misinterpreted.

Annex 1. Corporate Income Tax in Selected Countries: A Brief Overview

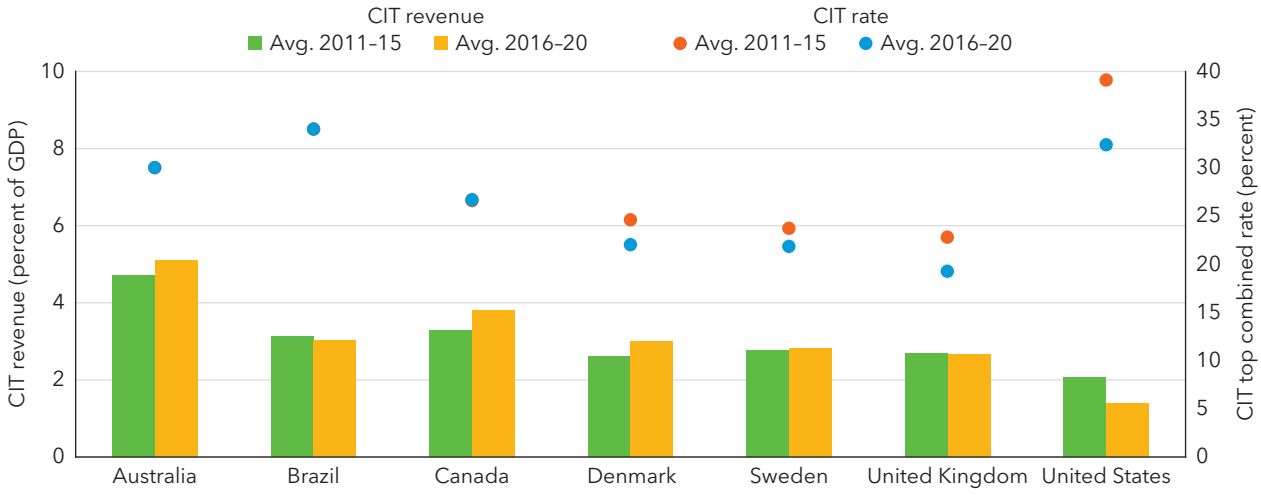
Actual Corporate Income Tax Revenue

Average corporate income tax (CIT) revenue for 2016–20 varies between 1.4 and 5.1 percent of GDP in the selected countries (Annex Figure 1.1). For Australia, Canada, Denmark, and Sweden, the CIT revenue levels increased compared with the averages for 2011–15. For Brazil, the United Kingdom, and the United States, the CIT revenue levels in a similar comparison show slight decreases (Annex Figure 1.1).

Corporate Income Tax Rate

The average CIT top combined rate for 2016–20 ranges between 19.3 and 34.0 percent in the selected countries (Annex Figure 1.1). For Australia, Brazil, and Canada, the CIT top combined rates for those years do not show changes compared to the averages for the 2011–15 period. For Denmark, Sweden, the United Kingdom, and the United States, decreases in the CIT top combined rates for 2012–20 are observed when compared to the averages for 2011–15 (Annex Figure 1.1).

Annex Figure 1.1. Actual Corporate Income Tax Revenue and Top Combined Rate



Source: IMF staff calculations.
Note: The combined CIT rate shows the basic combined central and subcentral (statutory) CIT rate given by the central government rate (less deductions for subnational taxes) plus the subcentral rate. CIT = corporate income tax.

Annex 2. Corporate Income Tax Gap Definitions

Annex Table 2.1. Corporate Income Tax Gap Definitions in a Bottom-Up Approach

Revenue Administration	Gross CIT Gap	Net CIT Gap
Australia	Difference between the amount voluntarily reported to the Australian Taxation Office (ATO), and the amount that would have been collected if every taxpayer were fully compliant with tax law (i.e., the theoretical tax liability).	Difference between the amount voluntarily reported to the ATO plus amendments as a result of compliance activities and voluntary disclosures, and the amount that would have been collected if every taxpayer were fully compliant with tax law.
Brazil	Difference between the potential tax liability under the current tax system and the actual liability as declared by taxpayers.	Gross CIT gap after subtracting enforced and late payments.
Canada	Difference between the CIT that would be paid if all obligations were fully met in all instances and CIT that is actually paid and collected before accounting for compliance and collection actions.	Gross CIT gap after subtracting compliance and collection activities results.
Denmark	Not available[1]	Tax value of the difference between the amount of taxable earnings for a given tax year, which is declared by all companies and self-employed individuals with up to 250 employees liable to Danish tax, and the amount that should have been declared if all these businesses had provided precisely the information that they were obliged to in accordance with the rules.
Sweden	Not available[1]	Difference between the tax that would have been final if all taxpayers had accounted for their activities and transactions correctly and the final tax after audits.[2]
United Kingdom	Difference between the theoretical tax liability (TTL) and the "voluntary" receipts.	Difference between the TTL and the "total" receipts (voluntary plus compliance yield receipts).
United States	Difference between total true CIT liability (TTCL) and CIT paid voluntarily and timely.[3]	Difference between TTCL and total CIT payments (voluntary and timely plus enforced and late payments).

Source: IMF staff compilations based on presentations and reports from the revenue administrations of the select countries.

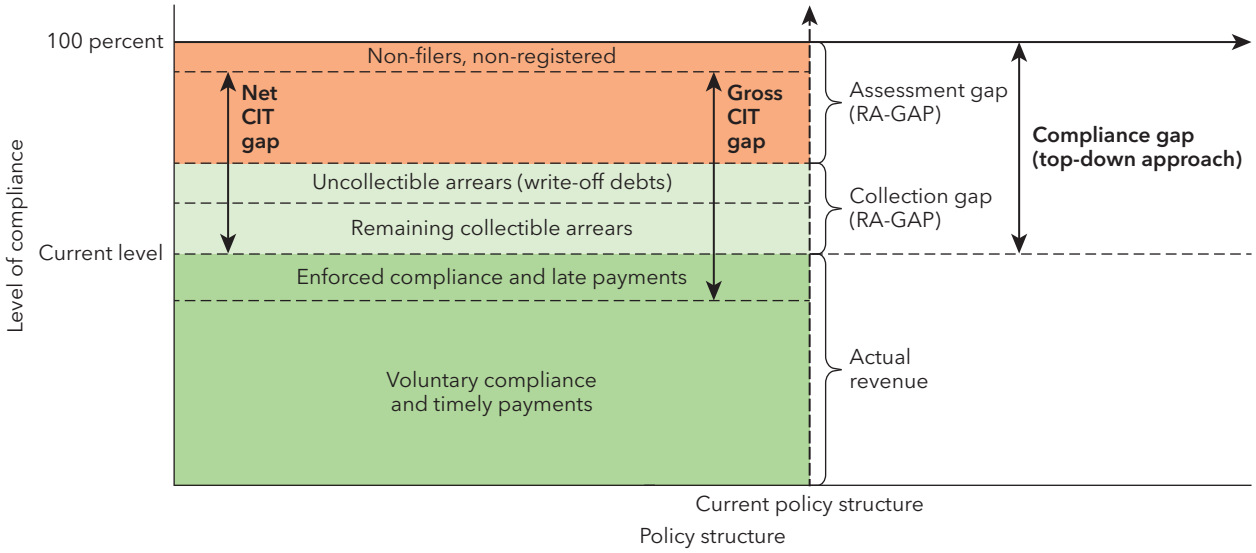
Note: CIT = corporate income tax.

[1]The distinction between gross and net CIT gap is not used explicitly, but the information is available to estimate both.

[2]Although not considered synonymous with "tax fraud" or "tax evasion," the term "tax gap" covers both as well as involuntary mistakes and omissions. The CIT gap does not include a collection gap, typically small in Sweden, which is reported separately by the tax administration.

[3]In the United States, TTCL includes underreported (net of overreported) CIT liabilities. The CIT gap definition does not include tax avoidance. "CIT avoidance" refers to legal means that can be used to reduce tax liabilities.

Annex Figure 2.1. Corporate Income Tax Compliance Gap Definitions: Bottom-Up Approach versus Top-Down RA-GAP



Source: IMF staff calculations based on presentations and reports from the revenue administrations of Australia, Brazil, Canada, Denmark, Sweden, the United Kingdom, and the United States.
Note: RA-GAP = Revenue Administration Gap Analysis Program.

Annex 3. Corporate Income Tax Gap Estimation Techniques

Annex Box 3.1. An Extreme Values Technique for Large US Corporations

- Step 1: Collect operational audits databases for large corporations.
- Step 2: Extract the amount of the NARs on each audited return.
- Step 3: Truncate the data for the top N number of NARs from the large corporations.[1]
  - Sum the net recommended tax change for all operational audit cases (S) in a selected tax year with a refund amount (that is, with a negative net tax change).[2] Record this amount as R.
  - Delete all audit cases having a refund amount or no tax change.
  - Sort the remaining cases (that is, those with a positive net recommended tax change) in ascending order by tax change amount.
  - Compute a cumulative sum for tax change.
  - Identify the audit case number (m) where the cumulative sum of tax changes is just equal to or less than the total refund amount (R).
  - Delete all cases up to and including case m. Let N represent the number of remaining audit cases. The sum of net recommended tax changes for these N firms is approximately equal to the total recommended tax change for all S operational audit cases.
  - Let $p = N/S$ = the proportion of cases remaining after steps 1 to 3.
- Step 4: Order the extreme NARs selected in a ranking (r = 1, for the highest NAR; r = 2, for the second highest NAR; and so on).
- Step 5: Estimate a linear relationship considering Log_{10}(NAR) as the dependent variable and Log_{10}(rank) as the independent one. Let a and c represent the slope and y-intercept estimates, respectively.
- Step 6: Extrapolate the number of cases remaining from the step 3 to the whole population of large corporations (F), assuming all of them were audited. Let M represent the total number of remaining cases. M would be equal to p times F.
- Step 7: Estimate the total underreported CIT (U) for all the corporations (audited and unaudited) as $U = 10^{c} \sum_{r=1}^{M} r^{a}$

Source: Bloomquist, Hamilton, and Pope 2014.
Note: CIT = corporate income tax; NAR = net audit recommendation.
[1]Largest corporations are defined as those with assets of more than $250 million.
[2]Negative values of adjustments stem from various reasons. Sometimes it happens when companies receive current positive net adjustments, but at the same time, they can carryforward or carryback operational losses.

Annex Box 3.2. A Logistic/Linear Regression Technique for Mid-Sized Businesses

Step 1: Run a logistic regression to determine the probability of noncompliance among company entities. Each company is modelled to be compliant or noncompliant by comparing it to another randomly selected. The dependent variable takes values of 1 for noncompliant or 0 for compliant. Each company is assigned to a probability of having tax gap according to its characteristics (in a continuous spectrum between 1 and 0). Some of the characteristics (independent variables) are if the company has received gross distributions from trusts, total turnover, expenses, age of the company, effective tax rate, and so forth. Australia prefers not setting a threshold in the continuous probability for labeling each company as compliant or noncompliant. Instead of that, Australia uses a Monte Carlo simulation process with more than 20,000 iterations. In each iteration, a company probability is compared to the probability of other randomly chosen company, and then it is labeled as compliant or noncompliant.

Step 2: Run a linear regression to estimate the share of unreported tax over last tax for noncompliant entities. Australia analyzes the CIT returns of companies known for being noncompliant to identify characteristics that could predict the size of the tax gap. The correction for selection bias is based on weights on the data (by using a propensity score matching process). The linear regression is applied to each company to estimate the potential size of the tax gap.

Step 3: Combine the results for the two regressions. Step 1 estimate the likelihood of being a noncompliant entity and Step 2 estimate the potential size of tax gap of a company. The potential size of tax gap for companies in Step 2 is applied to the companies predicted as noncompliant in Step 1. The results are obtained as an average (including amendments) of 20,000 iterations.

Step 4: Apply a nondetection uplift factor. For mid-sized companies with lower turnover, the small businesses uplift factor is applied. For mid-sized companies with greater turnover the large businesses uplift factor is applied.

Step 5: Consolidate the tax gap estimates.

Source: IMF staff based in Australia's revenue administration.

Annex Box 3.3. A Random Audit Program for Small Companies

Step 1: Estimate unreported amounts. Identify the average amendment and the rate of amendments in the sampled taxpayers. The sampled amendment is directly extrapolated to the whole population to obtain the unreported tax liability base.

Step 2: Estimate nondetection. This generally involves using an uplift factor, whether determined independently or based on external estimates.

Step 3: Estimate net and gross gap. The sum of steps 1 and 2 is the gross gap. When the compliance outcomes and voluntary disclosures are deducted from the gross gap, the net gap is obtained.

Step 4: Estimate the theoretical tax liability. It is the sum of the net gap and the net tax paid.

Source: IMF staff based on presentations and reports from revenue administrations.

Annex Box 3.4. A Stochastic Frontier Method

Under the stochastic frontier method, businesses on the frontier of production possibilities (such as B and C below) are considered by virtue of this characteristic to have no tax gap, whereas businesses below the frontier (such as A) are considered to exhibit a tax gap of a certain level. Thus, for business A, the difference between declared tax liabilities with respect to business B (using the same level of inputs) will be an estimate of its tax gap.

The stochastic frontier method applied by Brazil includes the next practical steps: (1) obtain population information from the revenue administration databases; (2) extract a sample with good data quality for the frontier calculation (declarations well populated, third-party data available); (3) treat outliers and missing data in the remaining population to include them indirectly in the model; (4) calculate declared tax gross operating surplus and tax liability; (5) estimate the corporate income tax gap for each business; and (6) treat and present of aggregated results.

Annex Box Figure 3.4.1.

Source: Brazil's revenue administration.

Source: Brazil's revenue administration.

Annex Box 3.5. A Delphi Method for Nondetection Multipliers

Sweden applies a Delphi methodology to estimate amounts not captured due to limitations on the time and scope of its audits. Implemented recently, the methodology is based on questionnaires distributed to the more experienced auditors and senior coworkers (for example, analysts and controllers) in a recursive process to converge on an assessed amount that would be possible to corroborate if the auditors had all the instruments and time available for an operational audit (verifiable tax gap). This iterative, qualitative process has indicated that Sweden should receive about 27 percent more in taxes from incorporated companies' tax gap and 17 percent from sole proprietorships' gap. In the aggregate estimation, an additional amount was projected over the found tax gap in both segments. On top of this, there remained a nonverifiable tax gap: a tax gap that cannot, in practice, be detected through the methodology of audits. This gap mainly arises from activities and transactions that leave no, or only very unclear, traces detectable by audits.

Source: IMF staff based on Sweden's revenue administration.

Annex 4. Bottom-Up Corporate Income Tax Gap Estimation Techniques in Revenue Administrations with Little Experience and Limited Resources

Why would the revenue administration of a country with little experience and limited resources be interested in bottom-up techniques for estimating the corproate income tax gap instead of using much less expensive approaches, such as the top-down approach?

Top-down corporate income tax (CIT) gap estimates are typically based on the gross operating surplus macro variable from national accounts (Ueda 2018). One reason for a revenue administration (RA) to explore bottom-up techniques is that it needs to test results obtained through that approach. The gap level figures of the top-down approach could raise some reasonable doubts or the macro variable is not updated or can reliably be broken down into the components required by the standard methodology. Another reason is that the RA needs to generate a deeper understanding of the composition of the CIT gap, looking for what noncompliance practices are most frequent, what types of companies are more prone to errors or noncompliance, and what controls, audits, or even tax policy adjustments could help to reduce the CIT gap. All these insights are more unlikely to be obtained from a top-down approach. Although bottom-up techniques provide opportunities to deal with these issues in countries highly experienced in them, as discussed in this note, several concerns could arise in countries interested in applying them but with little experience in them or limited resources. Three of these concerns are briefly illustrated based on experiences reported by RAs on extreme values (EV) techniques and random audit program (RAPs).

Costs and difficulties for a revenue administration starting bottom-up corporate income tax gap techniques

All the RAs included in this note have specialized staff in place. The background of the staff is broad, including knowledge of CIT legislation, management of micro databases, and statistical and economic knowledge. The same specialized staff also participate in gap estimation for other taxes and types of analytical studies. Training personnel with these characteristics can represent a significant effort for the RA. Another challenge is in the availability of reliable, updated, and comprehensive databases of CIT forms, audit reports, and third-party databases. In the case of the EV technique, data for several years are required. Likewise, computer tools to process these databases for analytical purposes are critically necessary. For example, the United States manages at least 10 years of very detailed information for each completed CIT audit (adjustments made, execution dates, dedicated auditors, type of errors detected, and so forth), which is essential for applying the EV technique (Annex Table 4.1).

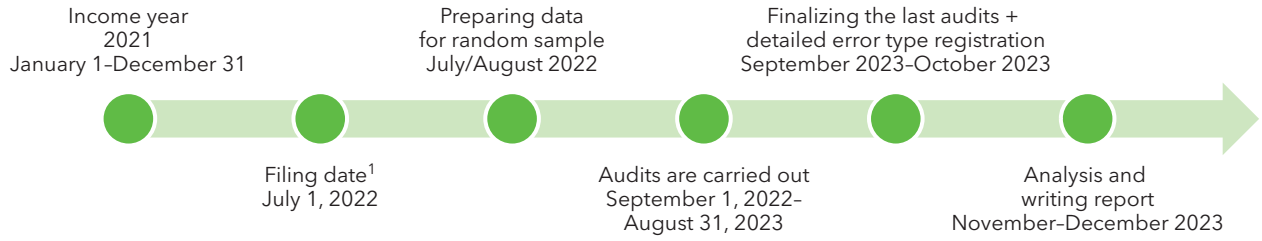
Personnel costs rise in the case of a random audit program compared to an EV technique, since it is necessary to dedicate a number of auditor hours to the execution of the randomly selected cases. In a random audit program, the results demand time, since they require a design stage, an execution stage, and a result compilation stage. This means that results cannot be obtained until two or three years after the start of the program (Annex Figure 4.1). In the experience of the countries analyzed, budgetary limitations and efficiency objectives for such an audit make it necessary to adjust it to reduce audit costs. The number of random audits executed over small businesses does not drop below 300 cases per process, but the option of completing the execution, for instance, in three years (by sample pooling) would partialize the effort to about 100 cases per year. It should also be taken into account that these random audits are usually comprehensive; thus the unit cost in the small business segment may be less onerous than in the mid-sized and large business segments.

Annex Table 4.1. Number of Closed Corporate Income Tax Audit Cases in the United States, by Tax Year and Fiscal Year of Closure

Fiscal Year	Audited Tax Year						
Audit Completed	2000	2001	2002	2003	2004	2005	2006
2001	48						
2002	2,381	61					
2003	5,589	1,555	20				
2004	3,637	3,066	1,448	255			
2005	2,014	4,625	10,563	4,823	20		
2006	1,106	2,206	5,569	8,432	4,610	139	
2007	603	1,074	2,392	5,675	6,165	6,989	391
2008	341	616	1,088	2,526	4,235	1,1620	4,602
2009	216	305	544	1,228	1,352	6,503	9,713
2010	132	211	335	710	583	2,848	6,584
2011	101	136	221	416	410	1,566	3,170
2012	54	76	119	274	380	1,010	1,716
2013	12	17	21	44	100	216	292
Total	16,234	13,948	22,320	24,383	17,855	30,891	26,468

Source: Bloomquist, Hamilton, and Pope 2014.

Annex Figure 4.1. Timeline for a Random Audit Program of Corporations and Self-Employed Individuals in Denmark

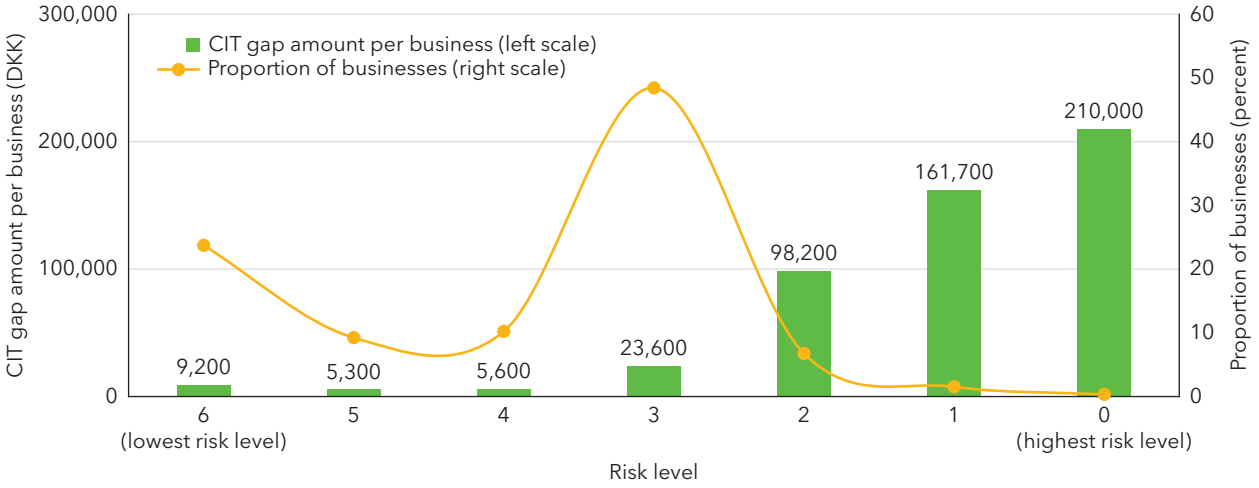


Source: Denmark's revenue administration.
[1]Because of the pandemic the filing date was postponed from July 1 to September 1 for income years 2019 and 2020.

Nonfilers and nonregistered businesses under bottom-up techniques

In the primary bottom-up techniques, EV and random audit programs, nonfiling and nonregistration are not intrinsically included in the potential revenue. In some of the countries analyzed, this type of noncompliance is assessed by other gap estimation techniques (for example, methods for estimating the underground economy). This note did not compile estimates for that type of noncompliance, but a couple of countries shared that its contribution to the CIT gap was not too significant. Two factors were mentioned to explain this. First, the development of off-registration economic activity is strongly limited by various government agencies' control. Second, the type of nonfilers and nonregistered could be limited to a form of business

Annex Figure 4.2. Compliance Risk Level versus Corporate Income Tax Gap Estimates in Denmark, 2014



Source: IMF staff based on Danish Customs and Tax Administration (2017).
Note: CIT = corporate income tax; DKK = Danish krone (local currency).

with reduced potential to generate net CIT liabilities (probably with more revenue potential in other taxes, such as tax on wages, social security, municipal fees, and so forth). However, in other countries analyzed, the phenomenon of nonfilers and nonregistered businesses has a nonnegligible effect on the CIT potential base. For this reason, it should be kept in mind by countries starting a random audit program sampling from highly incomplete returns or registration databases. In these cases, the result of the random audit program could significantly underestimate the CIT gap. Even in such a case, the random audit program results can be utilized to provide evidence about the phenomenon, especially if an audited business is detected having transactions with nonfilers or nonregistered suppliers or users. In this regard, Australia has used the random audit program for small businesses to detect entities outside the tax system, for example, cash-only businesses operating without an Australian Business Number. On the other hand, the EV technique, as it is usually applied to large businesses, is less affected by the phenomenon of nondeclaration or nonregistration.

Using Bottom-Up Corporate Income Tax Gap Results to Provide Additional Information on Risk Selection

One of the first opportunities that a country implementing a random audit program can take advantage of is the ability to compare the audit yield of the program with the yield of the risk-based programs that it has been applying regularly. For obvious reasons, the comparable yield of the random audit program would be expected to be lower because taxpayers with minimal risk of compliance are included in the sample, and their productivity will be close to zero. In most of the countries analyzed, the random audit program offers the possibility of evaluating the effectiveness of the risk-based model and recalibrating it. In this case, the RA can benefit from the analysis of the results of a random audit program and use it as an input to evaluate adjustments in the risk profiles of CIT taxpayers. In Denmark, for instance, the CIT gap estimated by a random audit program can be broken down into the seven compliance risk levels. An expected natural result is that the CIT compliance gap would increase in terms of the level of risk assigned to taxpayers, which can be observed in the case of Denmark (Annex Figure 4.2). If this increase did not happen, it would be a first alert to recalibrate the risk model by using the results of the random audit program.

Annex 5. Random Audit Programs versus Extreme Values Techniques

Annex Table 5.1. Advantages and Disadvantages for Each Technique

Random Audit Programs	Extreme Values Techniques
Advantages	
• Suitable for small and mid-sized businesses	• Suitable for large businesses and results could be extended to mid-sized businesses
• Like in any other random sample, the extrapolation to the population is straightforward	• Simpler and less expensive in resources and time than other statistical techniques.
• Better as a statistical tool for obtaining unbiased estimates of noncompliance in the current year, subject to a determined confidence interval	• Allows for obtaining orporate income tax gap results for several years
• Allows a breakdown of the results, identifying different causes of tax compliance (types of mistakes, intentional versus unintentional mistakes, demographic breakdowns, and so forth)	• The main assumption—underreported corporate income tax for largest businesses fitting a Pareto distribution—should be applicable to any tax system
• Assesses and feeds current risk analysis, allowing the opportunity to evaluate the effectiveness of the risk-based processes and recalibrate them	• Exploits existing audit results, thus not requiring additional resources to program extra audits or controls
• Can be used by audit managers to train new auditors in the audit work because the program is usually fixed every year	• Permits audits involving deeper control, thus lowering the probability of nondetection, because of their basis in risks
Disadvantages	
• Would not be efficient if applied to large businesses	• Is not applicable to small businesses
• Consumes time and resources, requiring at least three years to produce results for a single income year and with resources related to the size of the sample	• Requires more assumptions than other techniques; requires setting the tail for the Pareto distribution
• Could face internal resistances when starting because yield is normally lower than that of risk-based audits	• Takes longer, sometimes up to 10 year, to close each audit when applied to large businesses
• Allows comparison of results from one income year to the other, being less sensitive to a few cases, except if the audit methods systematically change	• Results could be sensitive to two or three important cases in a year; "production" of adjustments could also vary and affect results
• Involves broader and shallower audits, increasing the probability of nondetection.	• Fails to capture some noncompliance practices when auditors focus only on a specific audit hypothesis
• Requires assessing several practical issues, such as the replacement of cases already audited, the pool of years to achieve the minimum sample size, the variability of auditors' abilities to detect noncompliance, and so forth	• Results in estimates for current years being based on projections since many audits would not yet be closed

Source: IMF staff based on presentations and reports from the revenue administrations of Australia, Brazil, Canada, Denmark, Sweden, the United Kingdom, and the United States.

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