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The Evolution of Potential VAT Revenues
and C-Efficiency in Advanced Economies

by Junji Ueda

I N T E R N A T I O N A L M O N E T A R Y F U N D

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Fiscal Affairs Department

**The Evolution of Potential VAT Revenues
and C-Efficiency in Advanced Economies**

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Abstract

To understand the cyclical movements of value-added tax (VAT) revenues in advanced economies, this paper analyzes changes in the C-efficiency ratio by decomposing it into changes in the compliance and policy gaps between 2000 and 2014. The results from a panel of EU member countries and Japan suggest that the cyclical movements of C-efficiency are explained by the correlation of both gaps with the output gap. The cyclical movements of the compliance gap appear to be short lived, and larger in countries with high compliance gaps. The cyclical movements of the policy gaps largely reflect not changes in policy parameters, but rather, behavior-induced changes, notably in government consumption and, to a lesser degree, in the composition of household consumption.

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I. INTRODUCTION

In many countries, revenue from the value-added tax (VAT) is a major source of government revenue, making it important to understand the yearly performance of VAT revenues. One would expect that the base of an idealized VAT—final consumption—would be fairly stable through business cycles, but observed VAT revenues are sometimes more volatile than GDP or final consumption. This paper explores the reasons for this fluctuation by presenting and analyzing detailed decompositions of VAT revenues, thereby providing a better understanding of the responsiveness of VAT revenues with respect to output gap cycles.

Algebraically speaking, changes in VAT revenue as a share of GDP can be attributed to three factors: changes in the VAT standard rate, in the share of consumption in GDP, and in the C-efficiency ratio. The last of these is the ratio of the actual VAT revenue to the theoretical revenue derived from the product of aggregate final consumption and the VAT standard rate, which is widely used as a broad indicator of the overall efficiency and effectiveness of the VAT system.² Keen (2013) points out that changes in the C-efficiency ratio have been more influential than the changes in the standard rate and final consumption ratio to GDP for the evolution of overall VAT revenues in many countries, but does not explore the drivers of C-efficiency movements. This paper focuses on those drivers.

There is a strand of literature analyzing the structural factors affecting the evolution of the C-efficiency ratio through tax compliance. For example, Aizenman and Jinjarak (2008) use several structural variables, such as degree of urbanization, trade openness, and the share of agriculture, to explain the differences in C-efficiency ratios over time and across countries. De Mello (2009) uses the VAT standard rate, administrative costs, and other governance indicators in each country for cross-section analysis. However, short-term fluctuations of the C-efficiency ratio over the business cycle have received no attention.

Recently, Brondolo (2009) and Sancak, Velloso, and Xing (2010) emphasized the fact that C-efficiency in many countries shows clear comovement with output gaps.³ Sancak et al. note that C-efficiency has been significantly affected by both short-term behavioral changes, such as in consumption patterns, and the short-term fluctuation of taxpayer compliance, along with business cycles. They quantify these effects and estimate the elasticity of VAT revenue to movements in the output gap, concluding that, for advanced economies, a 1 percent increase in the output gap in good times is associated with a 1.12 percent increase in VAT revenue collections over one year (after controlling the changes in final consumption) or, equivalently, with a 1.02 percentage point increase in C-efficiency.

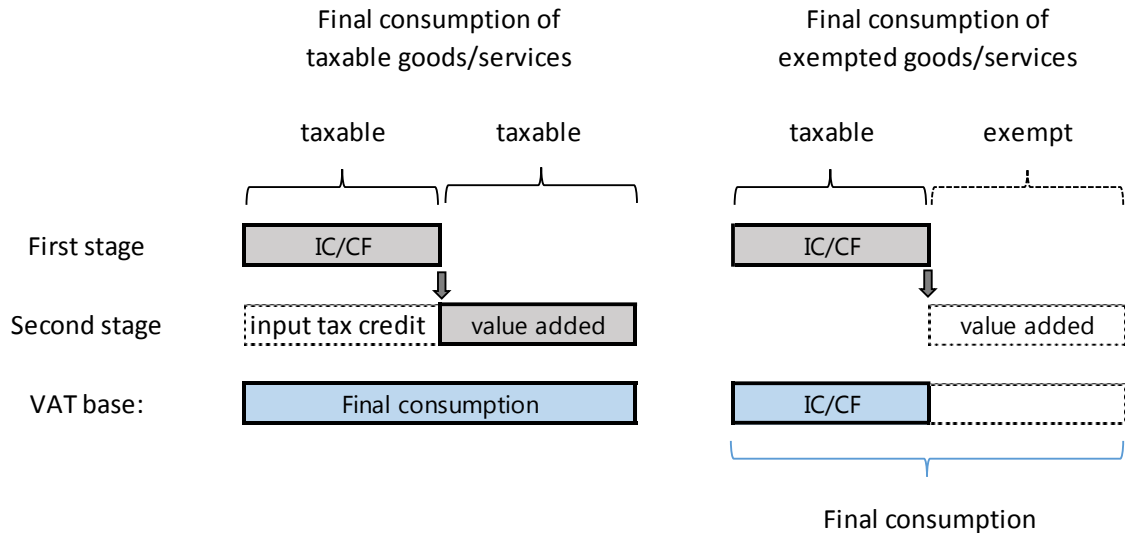
Some important ambiguities are left, however, in the results of Sancak et al. (2010). They consider changes in private consumption patterns as the only explanatory variables representing short-

² It is also sometimes called the “VAT revenue ratio,” as for instance in OECD (2016).

³ This issue was also addressed by the IMF (2015a).

term changes related to the VAT's tax base.⁴ In fact, there can be other channels that affect the VAT base, and therefore, C-efficiency, such as changes in taxable intermediate consumption (IC) and capital formation (CF) incurred by entities that produce goods and services which are not subject to VAT, as shown in Figure 1. Such entities usually include the governments and other providers of VAT-exempted goods and services,⁵ and transactions in these items make up a considerable part of the VAT base other than taxable final consumption in a country; they also fluctuate with business cycles.⁶

Figure 1. VAT Base for Taxable Consumption and Exempted Consumption



In addition, to estimate the effect of changes in taxpayer compliance, Sancak et al. used only a qualitative indicator of tax evasion as an explanatory variable.⁷ Consequently, while the estimated coefficients of variables reflecting changes in private consumption patterns and the tax evasion

⁴ Sancak et al. (2010) use the shares of food and nonalcoholic beverages in total consumption to represent the main driver of the VAT's changing tax base according to business cycles, with a presumption that food and nonalcoholic beverages are either zero rated or taxed at a lower than standard rate. This is not true, however, in countries with universal single rates, such as Japan and new entrants to the EU, including the Baltic countries (Latvia, Lithuania, Estonia, Bulgaria, Romania, and Slovakia).

⁵ For VAT-exempted goods and services, output is untaxed while input tax is not recoverable.

⁶ If VAT levied on purchases of capital goods is deductible by purchasers, it is not regarded as a part of VAT base, but if capital goods are purchased by entities who cannot claim deductions for their purchases, such as governments and producers of VAT-exempted goods and services, these purchases of capital goods should be regarded as VAT base.

⁷ The indicator, provided by the IMD, a research center in Switzerland, is based on its company executives' surveys, sent to senior business leaders, to evaluate current and expected competitiveness conditions in the countries in which they worked.

indicator are statistically significant, much of the fluctuation in C-efficiency ratios remains unexplained.⁸

The main contribution of this paper is to quantify the short-run effects of business cycles on C-efficiency using detailed data on key components of the VAT base and taxpayer compliance. A series of VAT compliance gaps, from 2000 to 2014, in 26 European countries, were estimated by Barbone et al. (2013), Barbone et al. (2015), and Poniatowski et al. (2016) in work conducted by CASE (Center for Social and Economic Research, Warsaw), and commissioned by the TAXUD (Directorate General for Taxation and Customs Union) of the European Commission.⁹ For Japan, Ueda and Tsutsui (2013) provide estimated VAT compliance gaps after 2000. These newly available data enable a decomposition of C-efficiency into “compliance,” and “policy” gaps for 26 European countries and Japan from 2000 to 2014, and fully specify the channels through which business cycles affect the movements of the ratios.^{10,11} (The compliance gap measures the proportionate difference between potential VAT revenues, with perfect compliance, under current VAT legislation, and actual VAT collections. The policy gap is the proportional difference between potential revenues under the current policy and those under a perfectly enforced “ideal” or “normative” VAT system.)

This paper first shows that changes in C-efficiency can be understood as the sum of independent movements of the compliance and policy gaps, because covariance between these gaps is close to zero; therefore separate analyses for these gaps are critical to understanding the evolution of C-efficiency (Section II). The focus then shifts to the effects of business cycles. The response of taxpayer compliance to economic boom and bust is quantified by using a dynamic panel model (Section III). The effects of VAT policy changes on policy gaps and movements in three categories of tax base—final consumption, intermediate consumption, and capital formation—are then quantified (Section IV). Finally, these results are used to estimate the elasticity of VAT with respect to the fluctuation of the output gap, and implications drawn for the diagnosis of VAT revenue performance are discussed (Section V).

⁸ Sancak et al. (2010) estimate the following model with the output gap and other explanatory variables, including the share of necessity goods and qualitative compliance indicators:

$$\text{C-efficiency}_{i,t} = \alpha_i + \beta_1 \text{gap}_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t} .$$

The estimated coefficient of the output gap was 0.562-0.629, significantly different from zero at 5 percent significance. Thus, changes in C-efficiency are still associated with output gaps after controlling the effects of the share of necessity goods and compliance indicators.

⁹ Hereafter, the analyses for European countries are referred to as CASE (2013), CASE (2015), and CASE (2016).

¹⁰ The decomposition of the C-efficiency ratio into compliance and policy gaps follows the method proposed by Keen (2013).

¹¹ Both estimations use a top-down approach, applying tax policy structure to detailed macroeconomic data to calculate potential VAT revenues. Appendix I briefly explains these estimation methods.

II. DECOMPOSITION OF THE C-EFFICIENCY RATIO

A. Illustration of the C-Efficiency Ratio

The C-efficiency ratio is the most commonly used indicator for evaluating the revenue performance and overall efficiency of the VAT system. It is simply the ratio of actual revenues to theoretical revenues from a perfectly enforced tax levied at a uniform rate on all consumption. It also has the advantage of requiring small data sets because the ratio (E^C) is simply calculated by

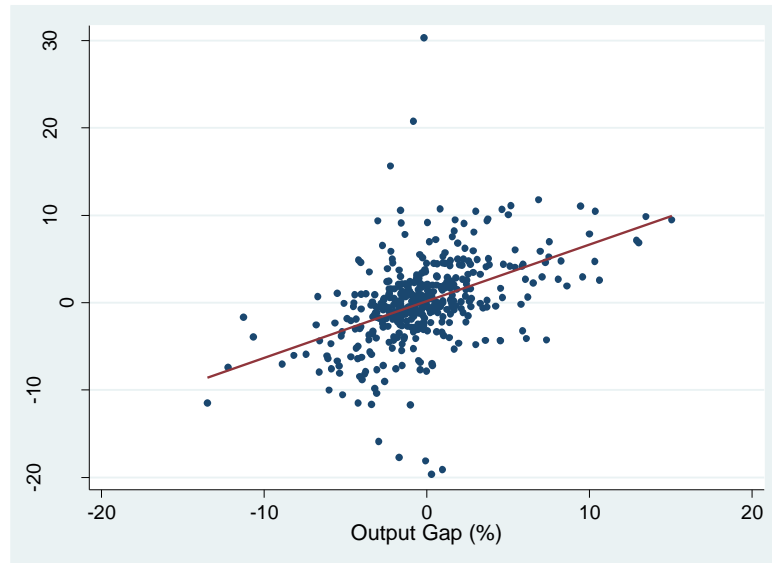
$$E^C \equiv \frac{V}{PV^T},$$

$$\text{where } PV^T = \tau^S (FC - V).$$

The numerator V is actual VAT revenue, and the denominator PV^T is theoretical VAT revenue calculated as the product of τ^S , the standard rate of VAT, and FC (final consumption), at prices exclusive of collected VAT.¹²

As pointed out by Brondolo (2009) and Sancak et al. (2010), short-term fluctuations of C-efficiency over business cycles have been widely observed. Figure 2 shows that the deviations of the C-efficiency ratio from country-mean have been positively correlated with the output gap, measured as actual output minus potential output. This means that higher C-efficiency ratios have been observed in booming periods, and conversely.

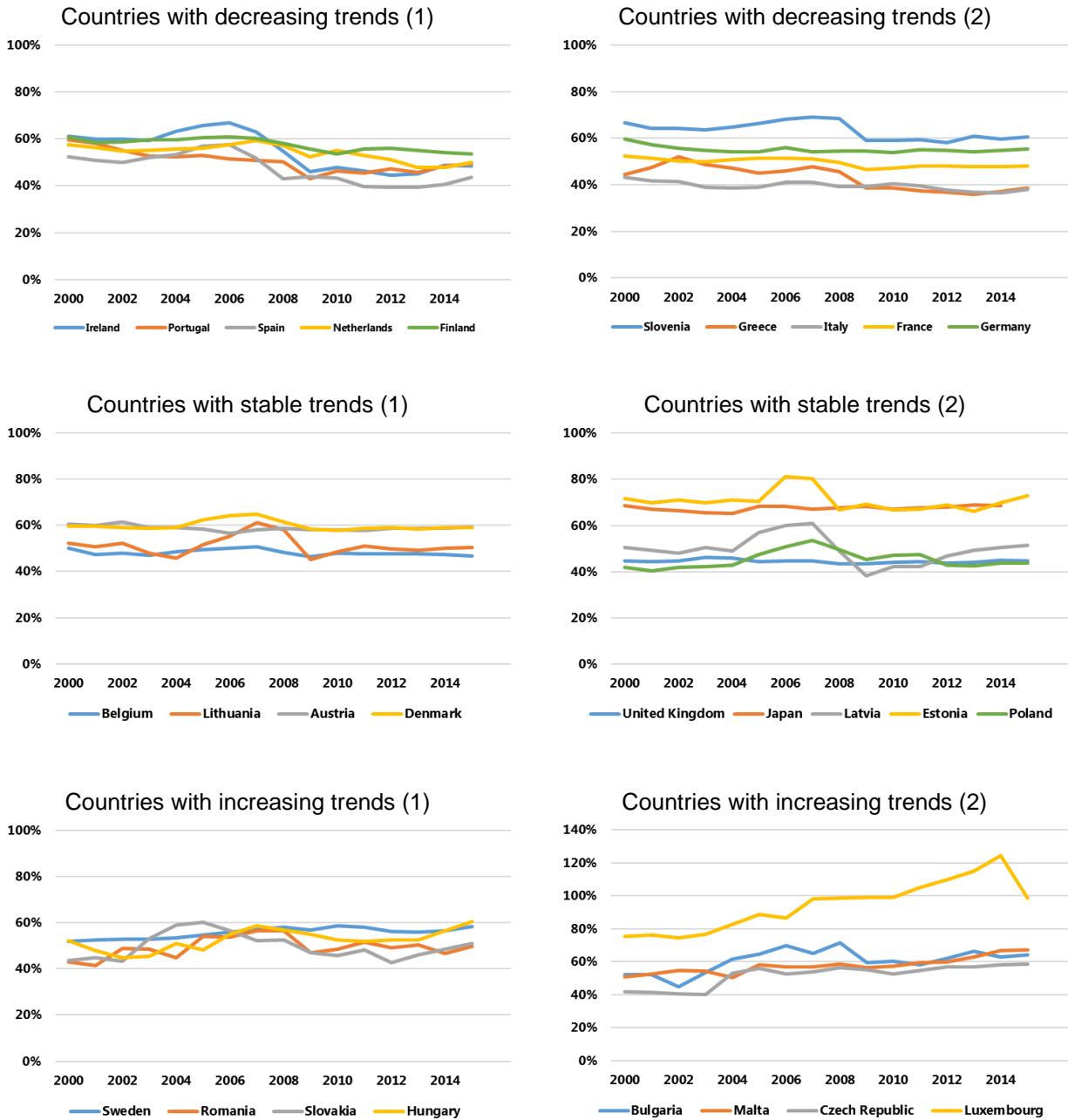
Figure 2. Deviations of C-Efficiency Ratios and Output Gaps



Sources: WEO, Eurostat, and author's calculations (see Appendix II).

¹² In this paper, the denominator of the C-efficiency ratio is final consumption, including consumption by households, the government, and nonprofit institutions serving households (NPISH), following the method proposed in Keen (2013).

Figure 3. Evolution of C-Efficiency Ratios in 27 Countries



Source: Eurostat and author’s calculations (see Appendix II).

(Note) The countries within each figure are ordered by the decreasing size of the accumulated decline in each country’s C-efficiency ratio between 2000 and 2015. So, for example, Ireland’s C-efficiency ratio declined most dramatically over the 15 years among the 27 countries, Portugal was next, and Luxembourg recorded the largest increase in C-efficiency ratio during the period. The reasons for the high level and the increasing trend of Luxembourg’s C-efficiency are explained in Appendix IV.

Over the long run, both upward and downward trends in C-efficiency have been observed in many countries. Figure 3 illustrates the evolution of C-efficiency ratios in Japan and 26 EU

countries between 2000 and 2015. The levels differ across countries (from less than 40 percent to more than 100 percent), and there are also significant differences in trends during the period. The top two charts show the countries with clearly decreasing trends in their C-efficiency ratios (a more than 4 percentage point decrease), the middle two charts show the countries with stable trends, and the bottom two show the countries with clearly increasing trends (a more than 4 percentage point increase).

B. Compliance Gap and Policy Gap

The C-efficiency ratio can be decomposed into the compliance gap and policy gap.¹³ The former is the difference between potential VAT revenues under current legislation with full compliance (PV^C), and actual VAT revenue (V), expressed relative to the former, showing the effectiveness of revenue administration and taxpayer compliance. The latter is the difference between theoretical VAT revenue under a hypothetical VAT system with a single rate applied to all final consumption (PV^T) and PV^C , relative to the former, indicating the impact of tax policy choices, such as adoption of differentiated rates and exemptions. This decomposition is expressed as

$$\begin{aligned} E^C &= \frac{V}{PV^T} \\ &= \left(\frac{V}{PV^C} \right) \left(\frac{PV^C}{PV^T} \right) \\ &= (1-\Gamma)(1-P), \end{aligned}$$

$$\text{where } \Gamma = 1 - \frac{V}{PV^C}, P = 1 - \frac{PV^C}{PV^T},$$

where Γ is the compliance gap and P is the policy gap.¹⁴ The yearly proportional changes in C-efficiency (E^C) can thus be decomposed into the sum of yearly proportional changes in compliance gaps ($1-\Gamma$) and the policy gap ($1-P$) as

¹³ The explanation below follows Keen (2013).

¹⁴ Since VAT revenue as a percent of GDP (Y) can be written as

$$\frac{V}{Y} = \tau^s \times E^C \times \frac{C}{Y},$$

the proportional changes in the ratio of VAT revenue to GDP can be expressed as the sum of proportional changes in the standard VAT rate, C-efficiency, and final consumption relative to GDP, as follows:

$$\left(\frac{V}{Y} \right) = \tau^s + E^C + \left(\frac{C}{Y} \right).$$

$$E^C = 1 - \Gamma + 1 - P.$$

Historical data on annual compliance gaps and policy gaps are limited, but CASE (2013) and CASE (2016) provide yearly estimates for the potential VAT revenues and compliance gaps from 2000 to 2014 for 26 European countries. In addition, for Japan, Ueda and Tsutsui (2013) estimated potential VAT revenues under current VAT legislation from 2000 to 2011, and this has been extended to 2014 for the present paper. This means that we have 405 observations (27 countries, 15 years) on a combination of compliance gaps and policy gaps.¹⁵

Using these data, we will analyze yearly changes in the C-efficiency ratio relative to the country-mean, i.e., variations within a group. The log of the C-efficiency deviation against country-mean ($DevE^C$) for each nation can be expressed as sum of log deviations of one minus compliance gaps against country-mean ($Dev(1-\Gamma)$), and log deviations of one minus policy gaps against country-mean ($Dev(1-P)$). The variations of these variables should satisfy

$$Var(DevE^C) = Var(Dev(1-\Gamma)) + Var(Dev(1-P)) + 2Cov(Dev(1-\Gamma), Dev(1-P)).$$

Table 1 shows the values for the entire data set. Interestingly, the variances of both gaps are equally large compared to the overall fluctuation of the C-efficiency ratios against country-means, while the covariance between the gaps is quite small. This means that yearly changes in the C-efficiency ratio have been significantly affected by both compliance gaps and policy gaps, and, moreover, these gaps have moved independently. So, it is reasonable to think of changes in (log) C-efficiency as simply the sum of the changes in (the logs of unity minus the) compliance and policy gaps, and to analyze the evolution of each gap separately to understand the overall movements of the C-efficiency ratio.

Table 1. Variance of C-Efficiency, Compliance Gap, and Policy Gap

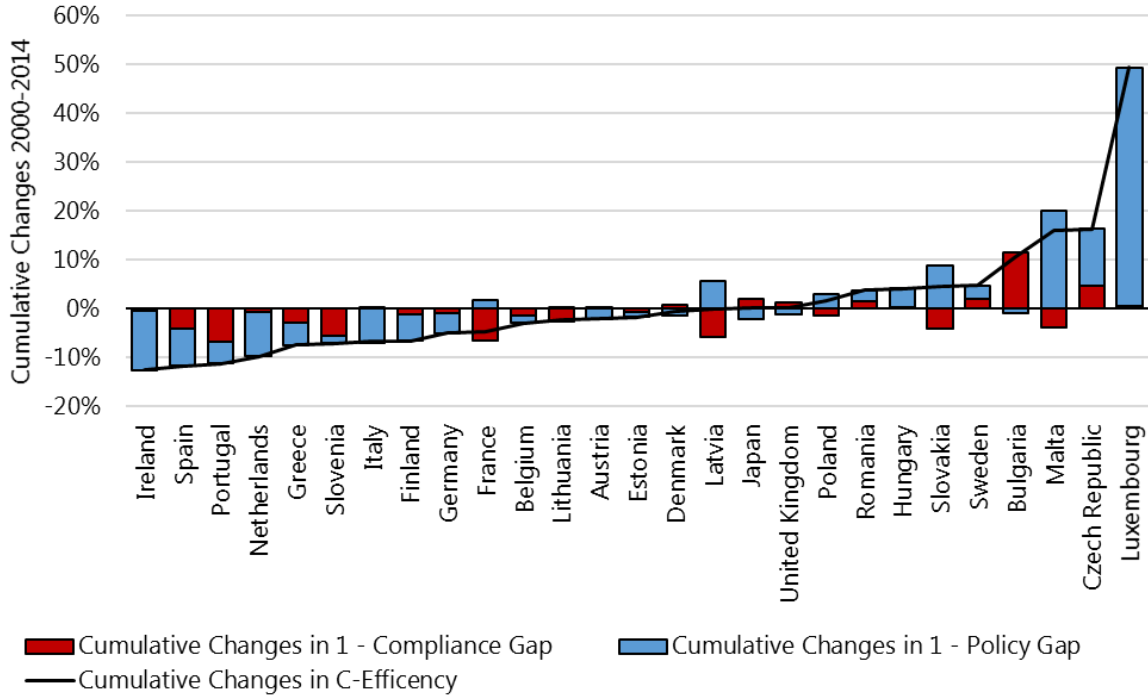
	Var. ($DevE^C$) [C-Efficiency]	Var. ($Dev(1-\Gamma)$) [Compliance Gap]	Var. ($Dev(1-P)$) [Policy Gap]	2×Cov. ($Dev(1-\Gamma)$, $Dev(1-P)$)
Variance and Covariance	0.007400	0.003334	0.004565	-0.000500
Ratio to Var. ($DevE^C$)	100%	45%	62%	-7%

Source: Author's calculations.

Figure 4 breaks down cumulative changes in C-efficiency over the sample period into effects through compliance and policy gaps. It shows that some large cumulative changes in C-efficiency ratios, both positive and negative, have been driven by changes in policy gaps. It suggests that, at least in advanced economies, trends in C-efficiency ratios are explained less by changes in tax compliance than by changes in the effects of tax policy.

¹⁵ The values of compliance gaps and policy gaps used in this paper are different from the original results of CASE (2013, 2016) and Ueda and Tsutsui (2013) because those values are adjusted to maintain consistency across the whole period and common data treatments for actual VAT revenues. See details in Appendix II.

Figure 4. Cumulative Changes in C-Efficiency Ratio 2000-2014

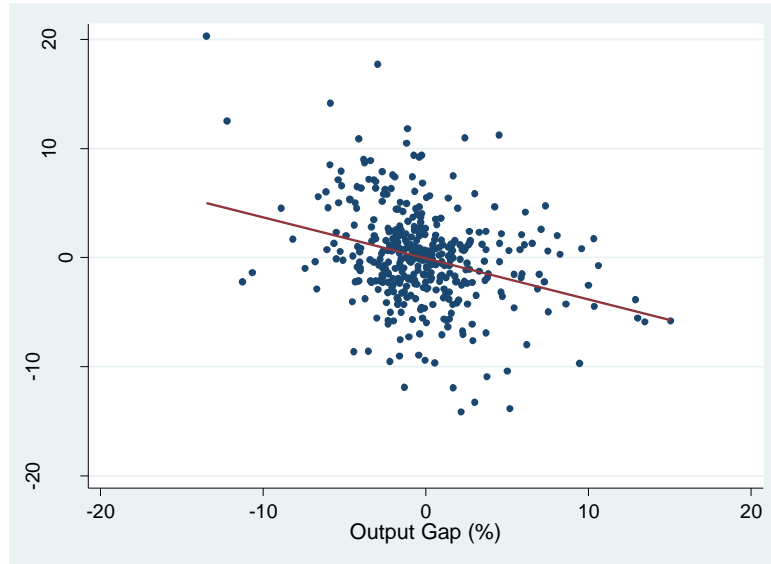


Source: Author's calculations.

III. CHANGES IN COMPLIANCE GAPS

A. Evolution of Compliance Gaps and Business Cycles

Figure 5 plots the relationship between compliance gaps, shown as deviations from country-means, and output gaps between 2000 and 2014. It shows a clear negative relationship: the correlation coefficient is -0.30 for the full sample, indicating that taxpayer compliance has worsened under weak economic situations, and conversely.

Figure 5. Deviations of Compliance Gaps and Output Gaps

Sources: WEO, CASE, and author's calculations (see Appendix II).

Brondolo (2009) points out several channels through which the risk of taxpayer noncompliance increases during an economic downturn: 1) credit-constrained taxpayers may be tempted to use tax evasion as an alternative source of finance, 2) taxpayers facing the risk of bankruptcy may downplay the risks of tax evasion and penalties compared with the potential upside gains of avoiding bankruptcy, and 3) there is a shift in economic activity from the formal to the informal sector. In addition, the deterioration of the fiscal position in an economic downturn may lead to reduced resource allocation to the revenue administration and a consequent loss of effectiveness in tax collection.¹⁶

To quantify such effects, we estimate a dynamic panel model by using the series of compliance gaps and output gaps. CASE (2013) estimates a model addressing the same issue, but finds no statistically significant relationship between these variables. Presumably, this is because that analysis includes GDP per capita as another explanatory variable, which may cause multicollinearity between explanatory variables.¹⁷

The approach here is to estimate

$$\Delta\Gamma_{i,t} = \alpha_i + \beta_1\Gamma_{i,t-1} + \beta_2\Delta og_{i,t} + \beta_3\Delta\tau_{i,t} + \beta_4\Delta P_{-dp_{i,t}} + \varepsilon_{i,t},$$

¹⁶ When compliance gaps are measured by comparing net cash collections (payments minus refunds) with potential revenues, the values may fluctuate along with business cycles through the differing timing of payments and refunds, which is not relevant to any changes in taxpayer compliance. This is discussed further in Section V.

¹⁷ CASE (2013) uses a fixed effects model with country and year dummies and other control variables, including real GDP per capita, years following accession to the EU, and a corruption perceptions index. Real GDP per capita is included to capture the changes in the economic circumstances of new member states over the sample period.

where Γ_{it} is the compliance gap in country i in year t , og_{it} is the output gap (a positive value indicating booming period), τ_{it} is the standard VAT rate, and P_dp_{it} is an indicator showing the direct effects of VAT policy changes on the VAT policy gap (a larger value represents a greater revenue loss). The last indicator is derived by mapping the different VAT policies onto the same VAT base before the policy changes and then taking the difference. It thus does not reflect any indirect effects on the VAT base from behavioral changes induced by VAT policy, or the effects of other government policies, such as changes in government consumption, on policy gaps.¹⁸

This specification does not include GDP per capita or time effects, but it does include the lagged dependent variable, in order to account for the sluggish movements of compliance gaps (recognizing that any shocks to compliance gaps may propagate to gaps in subsequent years).

This, of course, does not explain *why* the level of the compliance gaps differ across countries. The focus is on the marginal effects of changes in the output gap and policy variables in sample countries. The results of the OLS estimation with countries' fixed effects are shown in column [1] of Table 2.

Table 2. Estimation Results Relating Compliance Gaps to Output Gaps

	[1]	[2]	[3]
	Δ Compliance Gap	Δ Compliance Gap	Δ Compliance Gap
		[High Average]	[Low Average]
Compliance Gap (-1)	-0.4087*** [0.0391]	-0.4195*** [0.0610]	-0.3631*** [0.0511]
Δ Output Gap	-0.3593*** [0.0622]	-0.4903*** [0.1171]	-0.1912*** [0.0649]
Δ VAT Standard Rate	0.0071** [0.0032]	0.0079 [0.0058]	0.0027 [0.0037]
Δ Direct Policy Effects on Policy Gap	-0.2634 [0.1676]	-0.2431 [0.2382]	-0.4698 [0.4098]
Constant	0.0634*** [0.0064]	0.1135*** [0.0172]	0.0285*** [0.0042]
Observations	378	154	224
R-squared	0.2992	0.3543	0.213

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

The coefficient on the change in the output gap is estimated to be -0.36, meaning that a one percentage point decrease in output relative to potential is associated with a 0.36 percentage point increase in the compliance gap in a short run, on average. Any shocks to the compliance gaps tend to become smaller over time; in the next year, it falls back by about 0.21 percentage point (0.36 multiplied by $1 + (-0.41)$, coefficient of the lagged compliance gap), leaving the compliance gap around 0.15 percentage point higher than the initial level. This suggests that the impacts on the compliance gaps by the shocks to output gaps may be short-lived, and the

¹⁸ The construction of the indicator showing the direct effects of VAT policy change on the policy gaps is described in Appendix III, and the impacts of direct and other effects on policy gaps are discussed in Section IV.

compliance gaps are mean-reverting. The coefficient of the VAT standard rate is estimated to be positive, which coincides with the results of preceding analyses.¹⁹

Another explanatory variable in the estimation model pertains to a question regarding whether the direct effects of policy changes that reduce the policy gap also lower the compliance gap.²⁰ For example, changes in differentiated rates or exempted treatments for specific goods and services will cause a direct shift in the policy gap. In addition, making changes in the standard rate while maintaining reduced rates will also directly change the policy gap. Theoretically, the effects on the compliance gap of VAT policy changes that directly affect policy gaps are ambiguous. If for example VAT policy is changed in such a way as to increase the policy gap by introducing additional exemptions for goods and services, which consequently results in excluding hard-to-tax segments from the VAT system, compliance gaps may decline because potentially noncompliant taxpayers come to be outside the calculation of compliance gaps.²¹ On the other hand, an increase in the complexity of the VAT system due to differential treatments of specific goods and services may raise compliance costs for taxpayers and monitoring costs for tax administrations, thereby increasing compliance gaps and policy gaps simultaneously.

While the negative coefficient on direct policy effects in the current year suggests that the former effect (excluding/including hard-to-tax entities, which may increase/decrease the compliance gap) may override the latter effect in the short term, the result is not statistically significant. This result implies that episodes during which policy changes have lowered policy gaps have not always directly been associated with the lowering of compliance gaps, at least in the short term.

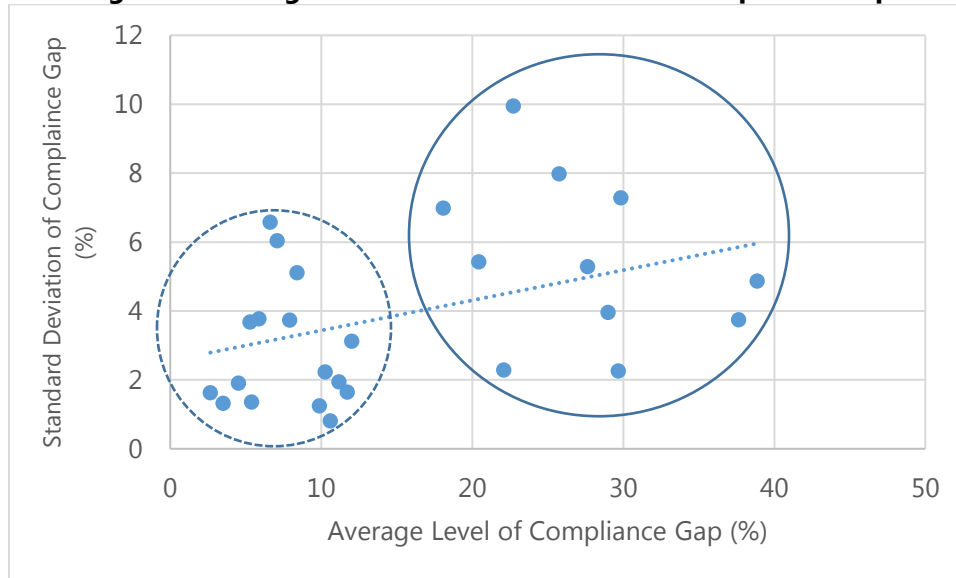
B. Differences Across Countries

The reactions of compliance gaps to the business cycle may be affected by the strength and stability of the revenue administration. Figure 6 shows scatter plots of 27 countries with average levels of compliance gaps through time on the horizontal axis and standard deviations of compliance gaps through time on the vertical axis. It indicates that the average level and standard deviation of compliance gaps vary across countries, and the volatility of the compliance gap tends to be higher in countries with higher compliance gaps. To explore this heterogeneity among countries, two subgroups are considered: one includes countries with high compliance gaps (more than 15 percent)—meaning weak revenue administrations—within the solid circle in the figure, and the other includes those with low compliance gaps (less than 15 percent) within the dotted circle in the figure.

¹⁹ Previous empirical studies, including Agha and Haughton (1996), Christie and Holzner (2006), and CASE (2013), have found that higher standard rates result in larger compliance gaps.

²⁰ Simultaneous changes in standard and reduced rates with the same proportions will not affect the size of the policy gap because such changes may affect both the nominator and denominator of a policy gap in the same proportion, if there are no changes in the consumption share for goods and services with differentiated rates.

²¹ Typical examples are policy changes introducing exemptions for small retailers and agricultural producers, or an increase in the VAT registration threshold. In addition, wider use of reduced rates for such segments may lower the tax burden for small taxpayers, and induce them to be more compliant.

Figure 6. Average and Standard Deviation of Compliance Gap

Source: Author's calculations.

Column [2] of Table 2 reports results for the high average group. The coefficient of the output gap is estimated to be much larger (-0.49) than it is for the full sample, and that of the low average group in column [3] of Table 2 is much smaller (-0.19). This suggests that the impact of the output gap on compliance is greater where high compliance gaps are observed due to the weakness and instability of revenue administration.

IV. CHANGES IN POLICY GAPS

A. Direct Effects of Policy Changes and Behavior-Induced Changes

In this section, changes in the policy gap will be analyzed further. As discussed in the previous section, any changes in VAT policies that alter the rate structure and coverage of tax base will result in changes in the magnitude of the policy gap (direct policy effects).

In addition, it needs to be emphasized that the policy gap can also be affected by changes in the tax base due to changes in economic activities, even without VAT policy change. For example, changes in the composition of consumption taxed at different rates will affect the policy gap by changing the share of taxable consumption in total consumption. We refer to such behavioral shifts as 'behavior-induced' changes in the policy gap.

By quantifying the effects of actual policy changes on potential revenues, we can decompose total changes in policy gaps into the direct policy effects and the behavior-induced changes for every year. Then, to illustrate the evolution of these effects over time, indices presenting levels

for the direct policy effects (P_{dp}) and the behavior-induced changes (P_{bc}) can be constructed by accumulating yearly changes for each country.²²

Table 3 shows the variance of the policy gap against the country-mean (variation within groups) and its decomposition into the variance of the direct policy effects and the behavior-induced changes, as well as the covariance between them. It clearly shows that a large part of policy gap change has been driven by behavior-induced changes. In fact, the variation of the direct policy effects has not been less frequent, and mainly driven by a limited number of VAT reforms or policy changes.²³

Table 3. Variance of Policy Gap, Direct Policy Effects, and Behavior-Induced Changes

	Var. (P) [Policy Gap]	Var. (P_dp) [Direct Policy Effect]	Var. (P_bc) [Other Base Change]	2×Cov. (P_dp, P_bc)
Variance and Covariance	0.002677	0.000579	0.002363	-0.000266
Ratio to Var. (P)	100%	22%	88%	-10%

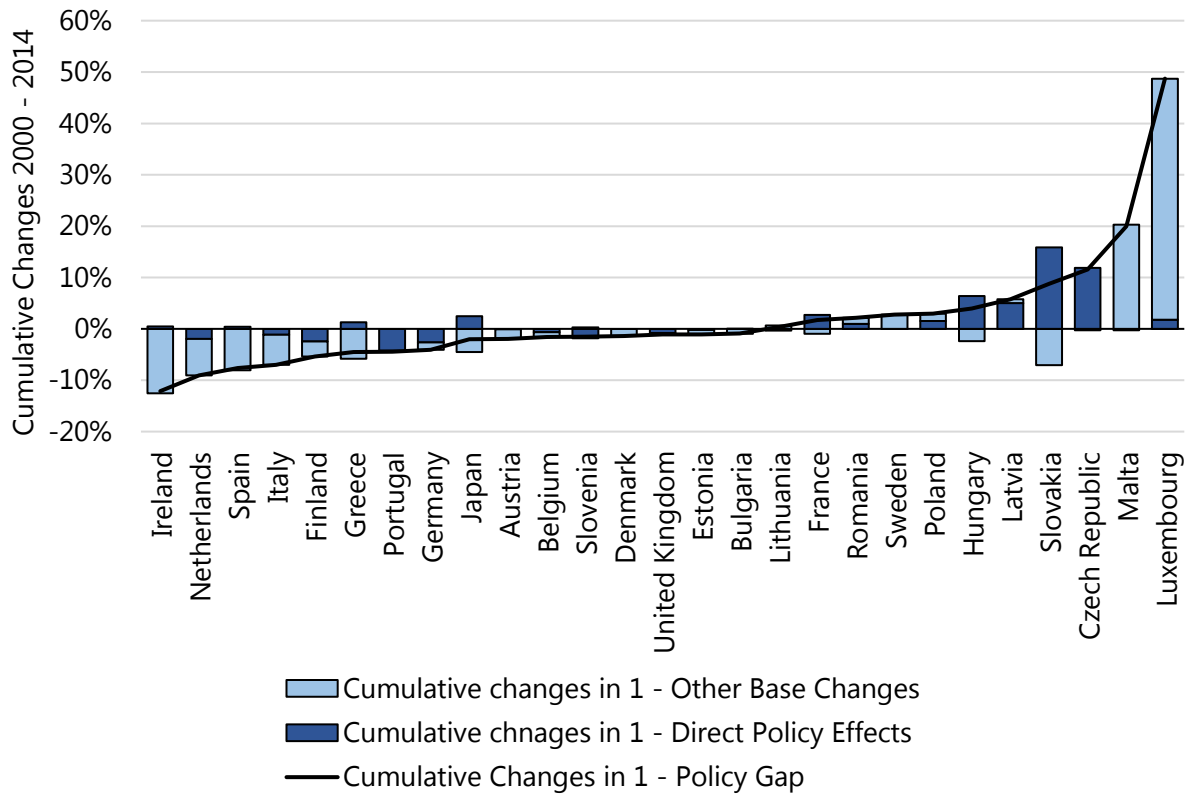
Source: Author's calculations.

Figure 7 shows the breakdown of the cumulative changes in the policy gaps in Figure 4 into direct policy effects and behavior-induced changes. While direct policy effects due to substantial VAT reforms have been significant in a few countries (such as Slovakia, the Czech Republic, and Hungary), it seems that behavior-induced changes have been dominant in causing the cumulative changes in the overall policy gaps in most of the countries.

²² See Appendix III, where it is shown that total changes in policy gaps ($\Delta P_{i,t}$) can be expressed as the sum of direct policy effects ($\Delta P_{dp_{i,t}}$) and behavior-induced changes ($\Delta P_{bc_{i,t}}$). With the initial level in year 2000 being zero, a yearly index showing the direct policy effects ($P_{dp_{i,t}}$) and a yearly index showing the effects of behavior-induced changes ($P_{bc_{i,t}}$) can be constructed.

²³ Episodes of tax reform with positive policy gap changes of more than 2 percentage points occurred in the Czech Republic (2008 and 2012); Greece (2011); Hungary (2004, 2006, and 2007); Japan (2004); Latvia (2003); Luxembourg (2005); Romania (2001); and Slovakia (2003, 2004). On the other hand, episodes of tax reform with negative policy gap changes of more than 2 percentage points occurred in Germany (2007), Finland (2009), Greece (2010), Hungary (2011), and Malta (2004).

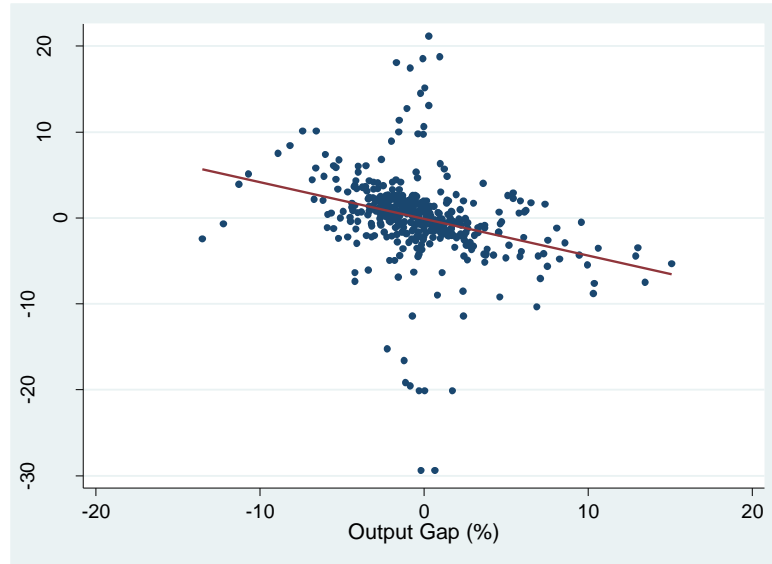
**Figure 7. Cumulative Changes in Policy Gap:
Direct Policy Effects and Behavior-Induced Changes**



Source: Author's calculations.

B. Behavior-Induced Changes on Policy Gap and Business Cycle

Figure 8 shows a scatter plot of the index of behavior-induced changes against the country-mean and output gap. A negative relationship between these variables is indicated, which means that, during a boom period, C-efficiency ratio tends to be increased by a behavior-induced reduction in policy gaps, in addition to the reduction of compliance gaps discussed in the previous section. This implies that the VAT base tends to grow faster than total final consumption when an economy is booming.

Figure 8. Deviations of Behavior-Induced Changes and Output Gaps

Sources: WEO, Eurostat, and author's calculations (see Appendix II).

To analyze this relationship, we must consider how the actual VAT base differs from total consumption, and how the output gap is correlated with fluctuation of the actual VAT base. As described in Figure 1, the existence of non-taxable activities and exempted goods and services transforms the characteristics of VAT from a tax levied on only final consumption (FC) to a tax levied on a combination of portions of final consumption, intermediate consumption (IC), and capital formation (CF). This is because VAT is levied on the purchases (IC and CF) of these activities, and they cannot claim input tax credit for VAT in IC and CF.²⁴

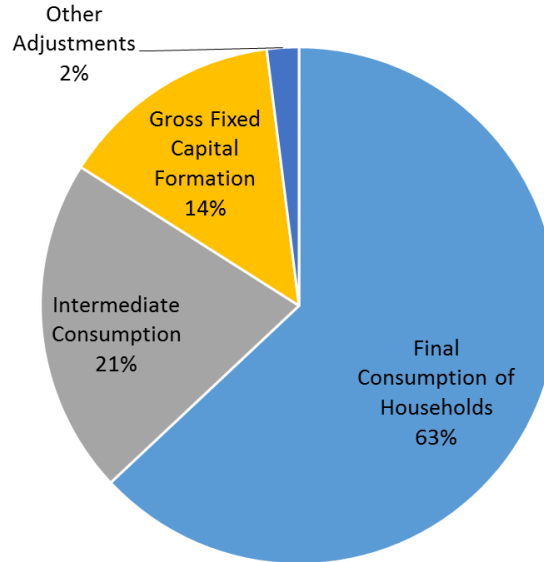
It is standard to exclude several items in final consumption from VAT base, namely, nonmarket services provided by governments, housing rent, and financial services. In addition, in many countries, educational and health services are exempted for reasons of social policy, and some other goods and services are treated as exempted due to discretionary policy decisions. Thus, the degree of deviation of real VAT systems from a tax on final consumption can be substantial.

This is illustrated in CASE (2013), showing potential VAT revenue under current VAT policies classified into different components (FC, IC, CF) on which VAT is charged in 26 European countries (Figure 9). More than a third of total VAT is attributable to intermediate consumption and capital formation by non-taxable and exempted activities, such as government, households

²⁴ In addition, there are various provisions in VAT legislation that cause the actual VAT base to diverge from final consumption, including non-registration of small business entities (allowing exemptions for their sales while not allowing input tax credits for their purchases), and limitation of input tax credits on certain business expenditures, such as purchases of car and fuel, and entertainment expenses. In CASE (2013, 2015, 2016) and Ueda and Tsutsui (2013), the effects of these provisions are reflected in the potential VAT revenues by 'other adjustments'.

(housing construction), and other business entities producing non-taxable and exempted goods and services.²⁵

Figure 9. Potential VAT Revenues by Attributable Demand Components in European Countries (2000–2011)



Source: CASE (2013).

CASE (2013, 2015, 2016) and Ueda et al. (2013) provide time series of each component of total potential VAT revenues: [1] VAT on household final consumption ($PV^{C,fc}$), [2] unrecoverable (nondeductible) VAT on intermediate consumption by non-taxable and exempted activities ($PV^{C,ic}$), [3] unrecoverable (nondeductible) VAT on capital formation by non-taxable and exempted activities ($PV^{C,cf}$), and [4] other adjustments made for specific reasons ($PV^{C,adj}$).²⁶ The total potential revenue is expressed by the sum of each component as:

$$PV^C = \sum_k PV^{C,k} \quad (k = fc, ic, cf, adj).$$

By definition, the behavior-induced changes in the policy gap (ΔP_{bc}) can be understood as changes in the ratio of PV^C to PV^T (the latter being theoretical VAT revenue when levying all final consumption at a standard rate) from the previous year under the assumption of no policy

²⁵ In Figure 9, potential VAT for government purchases of goods and services are included in "Intermediate Consumption," and government purchases of capital goods are included in "Gross Fixed Capital Formation."

²⁶ "Other adjustment" includes the effects of exemptions for small businesses, the restriction on the right to deduct in respect to business purchases, and specific taxable exports of goods and services (such as fuel, information services, and banking services) in Luxembourg.

changes.²⁷ Because the ratio of PV^C to PV^T is the sum of four components, the ratios of $PV^{C,fc}$, $PV^{C,ic}$, $PV^{C,cf}$, and $PV^{C,adj}$ to PV^T , the behavior-induced changes in the policy gap can be decomposed into four parts as follows:

$$\begin{aligned}
\Delta P_{bc}_t &= \left[\left(1 - \frac{PV_t^C}{PV_t^T} \right) - \left(1 - \frac{PV_{t-1}^{C^*}}{PV_{t-1}^{T^*}} \right) \right] \\
&= - \left(\frac{\sum_k PV_t^{C,k}}{PV_t^T} - \frac{\sum_k PV_{t-1}^{C^*,k}}{PV_{t-1}^{T^*}} \right) \\
&= \left[- \left(\frac{PV_t^{C,fc}}{PV_t^T} - \frac{PV_{t-1}^{C^*,fc}}{PV_{t-1}^{T^*}} \right) \right] + \left[- \left(\frac{PV_t^{C,ic}}{PV_t^T} - \frac{PV_{t-1}^{C^*,ic}}{PV_{t-1}^{T^*}} \right) \right] \\
&\quad + \left[- \left(\frac{PV_t^{C,cf}}{PV_t^T} - \frac{PV_{t-1}^{C^*,cf}}{PV_{t-1}^{T^*}} \right) \right] + \left[- \left(\frac{PV_t^{C,adj}}{PV_t^T} - \frac{PV_{t-1}^{C^*,adj}}{PV_{t-1}^{T^*}} \right) \right] \\
&\equiv \Delta P_{bc_{fc}}_t + \Delta P_{bc_{ic}}_t + \Delta P_{bc_{cf}}_t + \Delta P_{bc_{adj}}_t,
\end{aligned}$$

where $PV_{t-1}^{C^*}$ and $PV_{t-1}^{T^*}$ denote potential VAT revenues under "year t policy (after policy change)" with the "year t-1 base."²⁸

The behavior-induced changes through final consumption ($\Delta P_{bc_{fc}}$) arise from a shift in the ratio of taxable final consumption to total final consumption. If non-taxable or exempted consumption is more or less volatile than total final consumption, the effective tax rate may fluctuate over the business cycle. For example, the share of necessity goods in total private consumption tends to increase when consumers face an economic downturn because it is easier for them to reduce their consumption of luxurious goods. If necessity goods are taxed at reduced rates, the ratio of taxable consumption to total consumption is also reduced during an economic downturn.

The behavior-induced changes through intermediate consumption ($\Delta P_{bc_{ic}}$) and capital formation ($\Delta P_{bc_{cf}}$) show the changes in the ratio of the actual tax base in IC and CF relative to the theoretical tax base (PV^T) determined by total final consumption. These may fluctuate, for example, when purchases (IC or CF) by government, households, or business entities providing non-taxable or exempted goods and services significantly increase or decrease compared to changes in total final consumption. The behavior-induced changes through other adjustments

²⁷ See Appendix III for a detailed explanation of behavior-induced changes in the policy gap.

²⁸ To show the evolution of each component's effect over time, indices presenting levels of behavior-induced changes for all components ($P_{bc_{fc}}$, $P_{bc_{ic}}$, $P_{bc_{cf}}$, $P_{bc_{adj}}$) can be constructed by accumulating yearly changes. The cumulative effect of each component from 2000 to 2013 on behavior-induced changes is shown in Appendix IV.

reflect the changes in tax base due to specific reasons, such as taxable exports of goods and services, relative to final consumption.

To quantify the impact of the output gap on each of these behavioral changes, we estimate

$$\Delta P_{bc_k}_{i,t} = \delta_i + \gamma_1^k P_{bc_k}_{i,t-1} + \gamma_2^k \Delta og_{i,t} + u_{i,t}^k \quad (k = fc, ic, cf).$$

Table 4. Estimated Effects of Output Gaps on Behavior-Induced Changes in Policy Gaps

	[4]	[5]	[6]
	Base Changes through Final Consumption	Base Changes through Intermediate Consumption	Base Changes through Capital Formation
Lagged Dependent Variable (Index of Base Changes)	-0.2880*** [0.0316]	-0.0346 [0.0226]	-0.1485*** [0.0288]
Δ Output Gap	-0.1569*** [0.0194]	0.0192 [0.0229]	-0.0779*** [0.0193]
Δ Output Gap (-1)			-0.0925*** [0.0193]
Constant	0.0056*** [0.0007]	-0.0022*** [0.0007]	0.0002 [0.0006]
Observations	378	378	351
R-squared	0.2778	0.0085	0.1881

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

The results of OLS with country fixed effects are shown in Table 4.²⁹ For behavior-induced changes through final consumption, the estimated coefficient on the change in the output gap is significantly negative (-0.16), while that of the lagged dependent variable (-0.29) reveals its mean-reverting feature. The negative correlation means that, all else equal, there is a smaller policy gap during a booming period, as well as higher C-efficiency, due to a larger share of total final consumption being taxable.

The estimated coefficient on the change in output gap in the case of behavior-induced changes through intermediate consumption is not statistically significant. This suggests that the relative magnitude of intermediate consumption by non-taxable and exempted activities to total final consumption may not be associated with the business cycles, and therefore may not cause fluctuation of C-efficiency ratio along with business cycles.

For the behavior-induced changes through capital formation, the pattern of the dynamics along with output fluctuation seem to be similar to the effects on final consumption, but show longer impacts. The coefficients of the changes in the output gaps are estimated to be negative for both

²⁹ The VAT standard rate and the direct policy effect did not prove to be statistically significant.

the current and previous years (-0.08 and -0.09).³⁰ Also, the estimated coefficient of the lagged dependent variable is negative, but smaller in absolute value than that for final consumption (-0.16). This means that the effects of output fluctuation on policy gaps through capital formation are more persistent than those operating through final consumption.

This result sheds light on the importance of the fluctuation of capital formation along with business cycles for the movement of C-efficiency ratio. The major part of nondeductible capital formation consists of housing construction and government investment, and it would be important to note that the cyclical movement of such activities may cause cyclical movement of C-efficiency and VAT revenues.

C. Differences Across Countries

The estimated results in Table 4 show the average effects across the countries, but such effects may, of course, vary with different VAT policies. For example, the effects of behavior-induced changes in final consumption can differ across countries; if reduced rates or exemptions are applied to a wider coverage of goods and services, which are inelastic to income fluctuations, the changes in the share of taxable consumption to total final consumption in business cycles may be larger. On the other hand, the countries in which the standard rate is applied to most goods and services may show smaller correlations between the output gaps and the shares of taxable consumption to total final consumption.

To explore the possibility of such differences between countries for the effects of final consumption, two different channels need to be considered. The differences between taxable final consumption and total final consumption come from: (1) household consumption for goods and services with reduced rates or exemptions, and (2) government consumption that is commonly non-taxable. It is expected that the effect of the former may differ across countries because of differences in VAT policies, while the latter effect may not be so markedly different.

To understand the differences across countries in respect of consideration (1), Table 5 reports the results of regressing the share of taxable household consumption relative to total household consumption on output gaps in different country groups. One group consists of countries that apply reduced rates to food, and the other, those that apply the standard rate.³¹ The estimated coefficient of the output gap in countries without reduced rates on food is not different from zero. This means that, in these countries—as one would expect—policy gaps have not been noticeably affected by changes in the share of taxable consumption through business cycles,

³⁰ For the other channels, the coefficient of the lagged output gap was estimated to be not significantly different from zero, and therefore excluded from the estimation model.

³¹ The estimated model is

$$\Delta \frac{PV_{i,t}^{C,fc}}{\tau_{i,t} \times FCH_{i,t}} = \delta_i + \eta_1 \frac{PV_{i,t-1}^{C,fc}}{\tau_{i,t-1} \times FCH_{i,t-1}} + \eta_2 \Delta \log_{i,t} + u_{i,t},$$

where $FCH_{i,t}$ is household final consumption. The countries applying their standard rates to food are Bulgaria, Denmark, Estonia, Japan, Latvia, Lithuania, Romania, and Slovakia.

while this channel may increase the reaction of policy gaps to business cycles in countries with reduced rates for food.

Table 5. Regressing the Share of Taxable Consumption on the Output Gaps

	[7]	[8]	[9]
	PV^{fc}/PV^{fcT}	PV^{fc}/PV^{fcT}	PV^{fc}/PV^{fcT}
	[Full Sample]	[With Reduced Rates]	[No Reduced Rate]
Lagged Dependent Variable	-0.2349*** [0.0316]	-0.2579*** [0.0417]	-0.1962*** [0.0503]
Δ Output Gap	0.0780*** [0.0279]	0.1069*** [0.0401]	0.0454 [0.0407]
Constant	0.1251*** [0.0169]	0.1268*** [0.0206]	0.1274*** [0.0328]
Observations	378	280	98
R-squared	0.1506	0.1585	0.1478

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

On the other hand, for both groups, the share of household consumption to total consumption, including government final consumption, is positively correlated with the output gap.³² A theoretical reason for this is the sluggish movement of government consumption, which is measured by government spending for providing its services. If it is more sluggish than household consumption, the share of government consumption to total consumption will decrease when the output gap becomes positive, and conversely.

Thus, a factor common to all countries that underlies the negative correlation between the output gap and behavior-induced change in the policy gap through final consumption—which results in the cyclicity of C-efficiency—is the change in the share of government consumption to total consumption. Furthermore, in countries where reduced rates are applied to basic foodstuffs, the effects of the output gap will be larger.

V. IMPLICATIONS FOR VAT REVENUE ANALYSIS

A. Implications for Revenue Elasticity of VAT to Output Gap

The results in the previous sections highlight several reasons for the fluctuation of VAT revenues with business cycles by looking at detailed decompositions of VAT revenues, which can provide a better understanding of the responsiveness of the VAT revenue and C-efficiency ratios to output gap cycles.

By using the numerical results of the analyses, we can illustrate the magnitude of the responsiveness of C-efficiency by adding up the estimated coefficients of output gaps for compliance gaps and policy gaps to see how they differ from those in the previous literature.

³² Results are shown in Appendix V.

When the levels of the compliance and policy gaps are at the average of 27 countries (compliance gap = 16 percent, policy gap = 33 percent, and consequently C-efficiency of 55 percent), a 1 percentage point decrease in the output gap (negative economic shock) may result in a 0.44 percentage point decrease in the C-efficiency ratio by using the full sample results. This is the sum of the compliance gap (0.24) and policy gap effects (0.13 + 0.07).³³

In the meantime, the responsiveness of compliance gaps and policy gaps can differ across countries for several reasons; compliance gaps are more volatile in countries with lower compliance gaps, as discussed in Section III, and policy gaps are more volatile in countries with reduced rates on food, as discussed in Section IV. To illustrate how these will affect the responsiveness of C-efficiency to output gap cycles, the numerical results of the estimations for some subgroups are used to show possible variations for these effects in the second column of Table 6.

When C-efficiency is 55 percent (average of sample), the elasticity of C-efficiency to the output gap is calculated to be 0.79, and the range of illustrative possible variations of elasticity are calculated to be 0.54-1.00.³⁴ The results also make clear that the responsiveness of C-efficiency to the output gap is likely to differ across countries.³⁵

Table 6. Illustration of C-Efficiency Ratio Change with Output Gap Change by 1% Point

	Change	Illustrative Variation
C-Efficiency Ratio (% point change)	0.44	(0.30 ~ 0.55)
Compliance Gap Effect	0.24	0.13 ~ 0.33 ³⁶
Policy Gap Effect (Final Consumption)	0.13	0.10 ~ 0.16 ³⁷
Policy Gap Effect (Capital Formation)	0.07	

Source: Author's calculations.

This illustrated aggregate responsiveness is much smaller than that found in Sancak et al. (2010), who estimated a 1.02 percent increase in C-efficiency in response to a 1 percentage point output gap reduction for advanced countries. There seem to be two reasons for this difference: the use

³³ The compliance gap effect (0.24) is calculated by $1 [\text{output gap impact}] \times -0.36 [\text{Table 2, column [1]}] \times (1 - 0.33) [1 - \text{sample mean policy gap}]$, the policy gap effect through final consumption (0.13) is $1 [\text{output gap impact}] \times -0.15 [\text{Table 4, column [4]}] \times (1 - 0.16) [1 - \text{sample mean compliance gap}]$, and the policy gap effect through capital formation (0.07) is $1 [\text{output gap impact}] \times -0.08 [\text{Table 4, column [6]}] \times (1 - 0.16) [1 - \text{sample mean compliance gap}]$.

³⁴ The estimated elasticity of C-efficiency corresponds to a part of a short-term tax buoyancy indicator, discussed in the literature such as Belinga et al. (2014), measuring overall changes in revenue mobilization in response to economic growth consolidating the effects of changes in rate, base and efficiency.

³⁵ Empirical observations for the sample countries also show such variations; estimated coefficients of simple regressions for the C-efficiency ratio on changes in output gaps for each country vary between 0.05 and 1.05.

³⁶ Using the estimated coefficients in columns [2] and [3] in Table 2.

³⁷ Using the estimated coefficients in columns [8] and [9] in Table 5, and columns [A2] and [A3] in Table 7.

of different output gap numbers, and different model specifications. First, Sancak et al. (2010) use a different series of output gaps using data from 1995 to 2008.³⁸ Second, they regress the current year's C-efficiency ratio on the current year's output gap, without the short-term dynamics and mean-reverting feature of the C-efficiency ratio present here.

B. Implications for Diagnosing VAT Revenue Performance

As discussed above, the responsiveness of the C-efficiency ratio and VAT revenues to the state of the business cycles can reflect several factors, and the magnitude of the effect can vary across countries. Therefore, to diagnose the VAT revenue performance appropriately for a specific country, it is critical to look closely at its particular past experience, and that of countries with similar characteristics.

If observed changes are consistent with the results after considering country-specific characteristics, the revenue performance is deemed to be in line with the normal cyclical movements. If, however, observed changes in the C-efficiency ratio are more volatile, it is worth evaluating the reasons for this in detail. For that purpose, it is helpful to consider the decomposition into the compliance and policy gaps by using detailed macroeconomic data.³⁹

If the calculated compliance gap responds more strongly to changes in output gap than the coefficient estimated in Table 2, it is advisable to consider the possibility that taxpayer compliance is deteriorating beyond what would be expected from normal cyclical fluctuations, and some structural measures would be necessary to cope with it. However, it should be noted that if VAT revenues are measured by net cash collections (payment minus refund), the calculated compliance gap can fluctuate for reasons not associated with any changes in taxpayer compliance. If there are lags between tax periods and actual transactions of payments and refunds, or different lags between payments and refunds, net VAT collections can be affected by the deferral of payments and refunds, which are not relevant to taxpayer compliance.⁴⁰

If the calculated policy gap responds more strongly to changes in output gap than the sum of the coefficients of column [4] and [6] in Table 4, it is helpful to check the reasons behind the direct policy effect and the behavior-induced changes, and the latter can be further decomposed into detailed tax bases. This makes it possible to have a better understanding of past revenue performance due to changes in policy gaps, and provides more plausible assumptions for future revenue projections.

³⁸ Output gaps are defined as the deviation of the actual real GDP from the HP-filter-derived potential real GDP data; the filtered values are sensitive to the period of data used, and revised reflecting the recent data.

³⁹ The RA-GAP (Revenue Administration— Gap Analysis Program) of the IMF provides such analyses by taking into consideration all aspects related to VAT revenue performance. The methodology adopted in the program is explained in IMF (2015b), Appendix I.

⁴⁰ See Section III.B in Hutton (2017). For example, the RA-GAP report for South Africa (IMF (2015b)) showed that a large portion of the decline in the C-efficiency ratio (increase in compliance gap) in 2009 was due to large refunds corresponding to excess credit claims in the previous years.

Finally, and above all, it is critical to recognize that, as discussed above, C-efficiency ratios can be time-variant, and strongly cyclical with business cycles.⁴¹ Therefore, a simplified projection for VAT revenues by assuming an unchanging C-efficiency ratio for a final consumption forecast can be inaccurate for the short term. It is advisable to look carefully at historical changes in the C-efficiency ratio in each country, incorporate country-specific characteristics when VAT revenues are projected, and use the average over the cycle for the long-term projection.

VI. CONCLUSION

The main contribution of this paper is to analyze the cyclical movements of C-efficiency in advanced economies by using its decomposition into compliance and policy gaps, and to further explore the drivers of movements in policy gaps. The results show that both gaps have independent impacts on the movements of C-efficiency ratios through business cycles.

The responses of taxpayer compliance to economic boom and bust are relatively short lived, and differ among countries. Also, the effects of direct policy change in the policy gap on the compliance gap appear to be insignificant, so we cannot assume that measures closing the policy gap will close the compliance gap immediately.

Perhaps surprisingly, changes in measured policy gaps have been driven by behavior-induced shifts rather than by the direct effects of changes in policy parameters. In fact, policy changes with significant direct effects have been fairly infrequent in most sample countries. In addition, it is important to note that behavior-induced changes in policy gaps are associated with business cycles, with smaller policy gaps and larger C-efficiency when an economy is booming. Common reasons for this relationship are sluggish government spending relative to total consumption and volatile non-deductible capital formation by governments and households, and countries with reduced rates for necessity goods and services have larger changes in policy gaps and C-efficiency along with business cycles.

The illustrated responsiveness of C-efficiency with respect to a 1 percentage point change in the output gap was calculated to be 0.44 percent, which consists of 0.24 percent points through the compliance gap, and 0.20 percentage points through the policy gap, from the full sample estimation. When C-efficiency is 55 percent (sample average), the elasticity of C-efficiency to the output gap is calculated to be 0.79, and depending on the strength of the channels, the elasticity could vary from 0.54 to 1.00. These values are much lower than those in the previous literature.

The estimated coefficients in this paper can be regarded as broad benchmarks (for advanced economies) for the average effects on C-efficiency through respective channels, and compared with observed changes in countries to analyze the revenue performance of VAT. If observed changes in C-efficiency significantly exceed the benchmark values, diagnosing the changes in

⁴¹ To analyze the revenue performance of VAT appropriately, it is also important to calculate C-efficiency ratios by using net revenues after subtracting refunds or excess credit claims, even though refunds are recorded separately as government expenditures. If the C-efficiency ratio is calculated based on gross VAT revenues before subtracting refunds or excess credit claims, the ratio can be more volatile, reflecting fluctuations in exports/imports and deductible capital formations, which may result in changes in the amounts of refunds or excess credit claims concurrent with business cycles.

compliance and policy gaps, and further decomposing policy gaps into their drivers, can usefully inform appropriate responses. The analysis also strongly warns that a simplified revenue projection for VAT by using an unchanging C-efficiency ratio for the final consumption forecast can be highly inaccurate for the short-term because C-efficiency ratios vary systematically with the business cycle.

APPENDIX I. METHODOLOGY FOR CALCULATION OF POTENTIAL VAT REVENUES

CASE (2013, 2015, 2016) for EU Countries

For European countries, potential revenues for VAT were calculated by CASE (2013) for the period between 2000 and 2011, and updated by CASE (2015) for the period between 2009 and 2013, and by CASE (2016) for the period between 2010 and 2014. These calculations follow the same demand approach based on this common framework:

$$\begin{aligned}
 PV^C &= \sum_{c=1}^n \frac{\tau_c}{1 + \tau_c} \times FC_c \\
 &+ \sum_{s=1}^n propex_s \times \left(\sum_{i=1}^n \frac{\tau_c}{1 + \tau_c} \times IC_{s,c} \right) \\
 &+ \lambda \times CF \\
 &+ \text{other adjustments.}
 \end{aligned}$$

where FC_c is final consumption of a specific good or service (c), $IC_{s,c}$ is intermediate consumption of a specific good or service (c) by a specific sector (s), CF is total capital formation, τ_c is the VAT rate of a specific good or service (c), $propex_s$ is the ratio of the irrecoverable amount of VAT paid on intermediate consumption for a specific sector (s), and λ is the share of the irrecoverable amount of VAT paid on capital formation.

CASE (2013) used use tables provided by the WIOD (World Input-Output Database) with 59 goods and services and 36 sectors from 2000 to 2009, and the others used use tables provided by Eurostat with 65 goods and services and 65 sectors. These use tables were extended to the overall period, and $propex_s$ were assumed to be the same as the share of nontaxable consumption of sector s . The share of the irrecoverable amount of VAT paid on capital formation (λ) and other adjustments were collected by direct communications with country authorities.

Ueda and Tsutsui (2013) for Japan

Ueda and Tsutsui (2013) estimated potential VAT revenues for Japan by using input and output tables for CY2000 and CY2005, and calculated the effective tax rates for 10 categories of gross domestic demands for these years. Yearly potential revenues are calculated by applying the effective rate in CY2000 to domestic demand in each year between FY2000 and 2007, and the rate in CY2005 to domestic demand after FY2008. The effects of policy changes were subtracted as net adjustment components.

APPENDIX II. DESCRIPTION OF DATA USED IN FIGURES AND MODELS

C-efficiency ratio

Final consumption (including household, government, and NPISH):

For European countries, final consumption data are retrieved from the Eurostat database based on ESA 2010 (GDP and main components: nama_10_gdp). For Japan, final consumption data are retrieved from the national accounts database provided by the Cabinet Administration Office.

VAT revenue

For European countries, VAT revenue data are retrieved from the Eurostat database based on ESA 2010 (Main national accounts tax aggregates: gov_10a_main), VAT receivables. For Italy (2009–14), Spain (2000–14), and the U.K. (2000–14), the data in CASE (2013, 2015, 2016) are used to maintain consistency with their analyses. For Italy and Spain, alternative revenue data in CASE (2016) are used to reflect the changes in VAT credit stocks. For Japan, VAT revenue data are retrieved from the national accounts database provided by the Cabinet Administration Office.

VAT standard rate

For European countries, the rates are obtained from “*VAT Rates Applied in the Member States of the European Union*,” by the European Commission (EU Taxud.c.1[2017] – EN).

Potential VAT revenues and compliance gaps

For European countries, potential VAT revenues and compliance gaps used in tables and models are different from the original results of CASE (2013, 2015, 2016) due to several adjustments made to potential and actual VAT revenues.

Potential revenues under the current policy are retrieved from the results in CASE (2016), for the period between 2010 and 2014, and from the results in CASE (2015) for year 2009. Before 2008, the results in CASE (2013) are used, unless there were significant revisions between CASE (2013) and CASE (2015, 2016). For countries with significant revisions between CASE (2013) and CASE (2015, 2016) relating to the components of potential revenues (more than 5 percent of the results compared with CASE (2013)), adjustment ratios are calculated by taking the average of the ratios between 2009 and 2011, and applying them to the results in CASE (2013).

The compliance gap is calculated as the ratio of actual VAT revenue to potential VAT revenue under current legislation.

Policy gap

The policy gap is calculated as the difference between the C-efficiency ratio and compliance gap, using the relationship below:

$$E^C = (1 - \Gamma)(1 - P).$$

In this decomposition, the policy gap is expressed as the ratio of actual to potential revenue under full compliance with the standard rate on all final consumption.

Direct policy effects and behavior-induced changes of policy gap

Policy gaps are decomposed into direct policy effects and behavior-induced changes according to the method described in Appendix III, and two indices—the direct policy effect index and behavior-induced portion index—are constructed. The direct policy effect index is constructed to reflect changes in VAT policy, except for the change in standard rate, and the behavior-induced portion is residual. To derive the direct policy effect for European countries, the “Index of Policy-Induced VAT Changes” in CASE (2013) is used.⁴² This index shows the changes in VAT revenues owing to the effects of rate changes based on the structure of the VAT tax base in each country in the year 2000. To exclude the effects of changes in standard rates, the indices are adjusted when standard rates have been changed. For Japan, we use data on yearly incremental revenue projections due to policy changes published by the government.

Output gap

Output gap data were retrieved from the World Economic Outlook (WEO) database in April 2016. For countries with no output gap data in the WEO database, we used data from the estimations for cyclical adjustments of budget balances, Autumn 2015, by the European Commission (Latvia, 2000–2001).⁴³

⁴² CASE (2013) provides indices of policy-induced VAT changes between 2000 and 2011 in its Table C.1. For the period after 2012, direct policy effects are calculated using final consumption data for 65 goods and services and changes in rates applied to each good and service are those presented in “*VAT Rates Applied in the Member States of the European Union*,” European Commission (2017).

⁴³ Table 14 in ‘Cyclical Adjustment of Budget Balances’ shows the gap between actual and trend gross domestic products at 2010 reference levels, and percentages of trend gross domestic products at constant prices (http://ec.europa.eu/economy_finance/db_indicators/gen_gov_data/documents/2015/ccab_autumn_en.pdf).

APPENDIX III. DECOMPOSITION OF CHANGES IN POLICY GAP

In this appendix, we show that the total changes in policy gaps (ΔP) can be expressed as the sum of direct policy effects (ΔP_{dp}) and behavior-induced changes (ΔP_{bc}). The definition of policy gap is

$$P = 1 - \frac{PV^C}{PV^T},$$

where PV^T represents the theoretical VAT revenue under a hypothetical VAT system with a single rate applied to all final consumption, and PV^C represents the VAT revenues under current legislation with full compliance.

Yearly changes in policy gap (ΔP) are expressed as

$$\Delta P_t = \left[\left(1 - \frac{PV_t^C}{PV_t^T} \right) - \left(1 - \frac{PV_{t-1}^C}{PV_{t-1}^T} \right) \right],$$

where PV^T and PV^C are calculated according to the VAT policies in years t and $t-1$.

The yearly changes can be decomposed into two parts: an effect of change in policy in year t from year $t-1$ (direct policy effect), and other effects (behavior-induced changes). If PV_{t-1}^{C*} denotes potential VAT revenues under the year t policy (after policy change) with the year $t-1$ base, direct policy effects (ΔP_{dp}) can be defined by

$$\Delta P_{dp}_t = \left[\left(1 - \frac{PV_{t-1}^{C*}}{PV_{t-1}^{T*}} \right) - \left(1 - \frac{PV_{t-1}^C}{PV_{t-1}^T} \right) \right],$$

which shows the effects of policy changes (in year t) on the size of policy gaps by using the value of the tax base of year $t-1$ (due to policy changes). The behavior-induced changes in the policy gap (ΔP_{bc}) can be defined by

$$\Delta P_{bc}_t = \left[\left(1 - \frac{PV_t^C}{PV_t^T} \right) - \left(1 - \frac{PV_{t-1}^{C*}}{PV_{t-1}^{T*}} \right) \right],$$

which represents the effects of changes in tax bases from years $t-1$ to t under the same policy of year t . Clearly, the sum of ΔP_{dp} and ΔP_{bc} is equivalent to total changes in the policy gap (ΔP).

To illustrate the historical levels of the direct policy effects and the behavior-induced changes over time, two indices—the direct policy effect index and behavior-induced portion index—can be constructed for each country i and year t as follows:

$$P_{dp_{i,t}} = P_{i,2000} + \sum_{k=2001}^t \Delta P_{dp_{i,t}}$$

$$P_{bc_{i,t}} = \sum_{k=2001}^t \Delta P_{bc_{i,t}}.$$

In this paper, we use the index of policy-induced VAT changes in order to calculate PV_{t-1}^C in each year for EU member countries, (see Appendix II). This index is calculated by applying the tax rate for each year to the tax base of VAT in 2000 for each country (see Box 1.1 in CASE (2013)).

APPENDIX IV. DECOMPOSITION OF BEHAVIOR-INDUCED CHANGES IN POLICY GAP

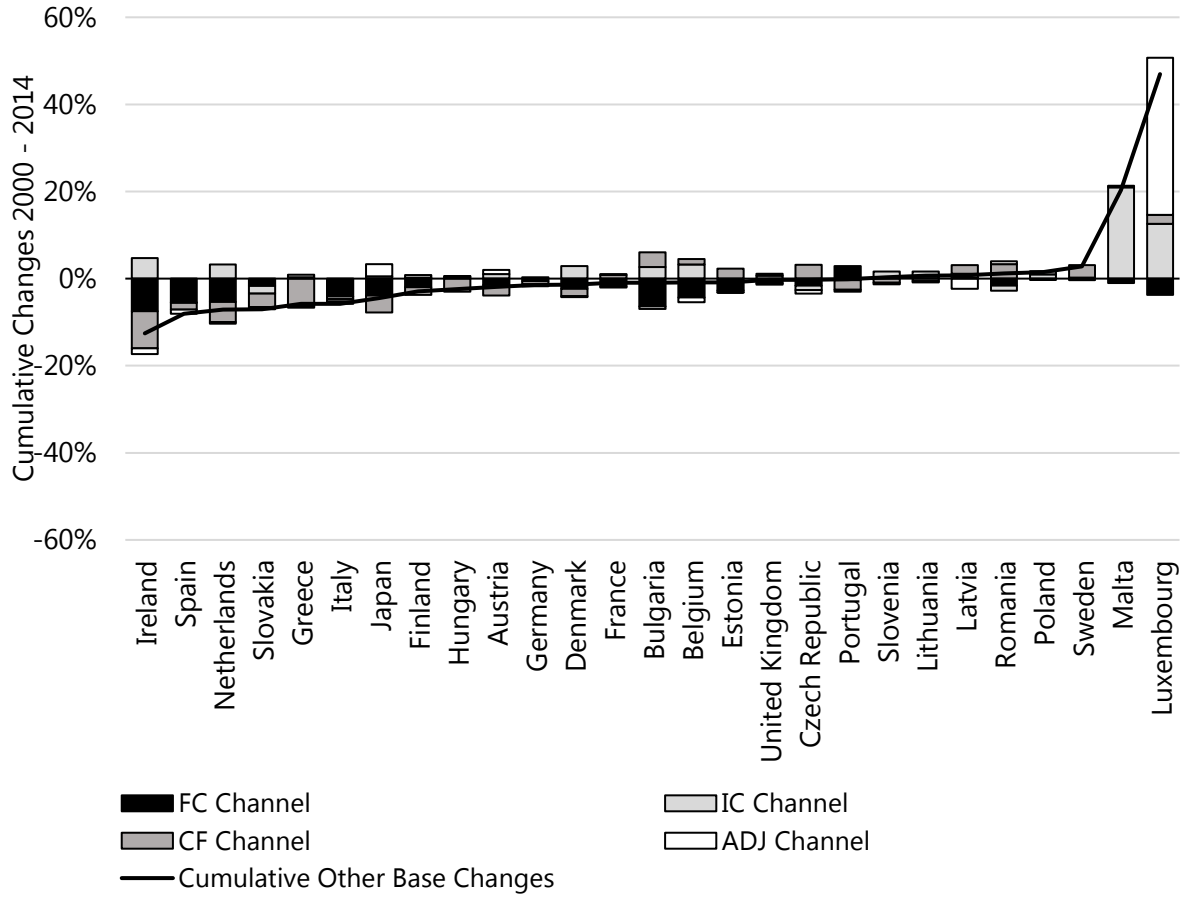
Figure 10 shows the decomposition of the cumulative behavior-induced changes in the policy gap into four channels. Notable features include:

- The effect of capital formation has contributed to the cumulative changes in the policy gap in countries, such as Ireland, Greece and Spain, that have been highly affected by financial crises caused by dwindling capital formation.
- Capital formation has also contributed to the reduction of policy gaps in Romania, the Czech Republic, Estonia, Latvia, and Bulgaria, where capital formation by government and households has shown an increasing trend after economic transition.
- In Luxembourg, a significant reduction of the policy gap has been observed due to the “adjustment” component, which reflects VAT collection not attributable to domestic final consumption, intermediate consumption or capital formation. It includes the effects of VAT-liable exports, such as cross border shopping by nonresidents for fuel (“gas pump tourism”) reflecting lower VAT and excise rates than neighboring countries, and “e-VAT” collection, which is VAT levied on electronic commerce within EU taxed at origin rather than at destination. The large amount of VAT collections from these transactions resulted in the high C-efficiency ratio in Luxembourg, and recent buoyant increases in e-VAT collections caused higher C-efficiency and a lower policy gap.⁴⁴

The factors related to some structural changes in economic situations have not been necessarily relevant to VAT policy changes, but have contributed to the cumulative changes in policy gaps and C-efficiency ratios in many countries.

⁴⁴ See IMF (2015c) for further explanation. It shows that the e-VAT revenue in Luxembourg increased from about 0.4 percent of GDP in 2005 to 2.3 percent of GDP in 2014, but new EU rules adopted in 2008 will shift VAT on e-commerce from domicile of seller to residency of purchaser, and significantly reduce e-VAT collections in Luxembourg after 2015.

**Figure 10. Cumulative Changes in Policy Gap:
Decomposition of Behavior-Induced Changes**



Source: Author's calculations.

APPENDIX V. HOUSEHOLD CONSUMPTION RATIO ON OUTPUT GAPS

Table 7 shows the results of regression for the share of household consumption to total consumption (including government final consumption) on output gaps following the model below:

$$\Delta \left(\frac{FCH_{i,t}}{FC_{i,t}} \right) = \theta_i + \rho_1 \left(\frac{FCH_{i,t-1}}{FC_{i,t-1}} \right) + \rho_2 \Delta og_{i,t} + u_{i,t}.$$

Here, $FCH_{i,t}$ stands for total household final consumption, while $FC_{i,t}$ is total final consumption. For the full sample (column [A1]), as well as for two groups with different VAT legislations on reduced rates according to Section IV.C (columns [A2] and [A3]), the share of household consumption in total consumption is positively correlated with output gaps.

Table 7. Share of Household Consumption on Output Gaps

	[A1]	[A2]	[A3]
	FCH/FC	FCH/FC	FCH/FC
	[Full Sample]	[With Reduced Rates]	[No Reduced Rate]
Lagged Dependent Variable	-0.2382*** [0.0273]	-0.2207*** [0.0295]	-0.3054*** [0.0660]
Δ Output Gap	0.0934*** [0.0119]	0.0965*** [0.0167]	0.0899*** [0.0181]
Constant	0.1699*** [0.0196]	0.1558*** [0.0210]	0.2242*** [0.0485]
Observations	378	280	98
R-squared	0.2812	0.2528	0.3461

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

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