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# The short- and long-run tax revenue response to changes in tax bases

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## Abstract

This paper examines the short- and long-run behavior of tax receipts with regard to their tax bases. In addition, the possibility of asymmetries in tax responses is explicitly included. The methodology is applied to the three main tax categories in the Netherlands for the period 1971-2005, after removing effects from discretionary measures. The outcomes indicate that short-term elasticities can deviate markedly from long-term ones. Furthermore, short-term elasticities tend to be smaller in less favorable circumstances. Ignoring such differences between various elasticity measures may contribute to adverse revenue surprises.

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## 1. Introduction

The responsiveness of government tax revenues to macroeconomic developments is a key input variable for budgetary policy, used for instance by governments in forecasting revenue growth when preparing budgets. In addition, it plays an important role in cyclically adjusting budget balances. The relevance of accurate tax elasticities was highlighted in the mid 2000s when tax receipts in many countries improved by more than could be accounted for by combining economic growth rates with standard elasticities.

Tax elasticities are usually assumed constant over time although there are good economic grounds to expect them to fluctuate over time. For instance, growth of household income growth in the short term may affect the more luxurious consumption items more than proportional, causing an increase in the short-term elasticity as these items are taxed more heavily than basic consumption goods. Also, the short-run tax response may be asymmetric, the elasticity value being different in times of high growth than in periods of low growth, for instance because of tax evasion intensifying in periods of below-average growth, but staying at that level in subsequent period of above-average growth.

Ignoring short-term dynamics in elasticities leads to biased fiscal indicators based on cyclically-adjusting budget balances. Short-term variations in elasticity values also present a nuisance for countries and states complying with fiscal rules for achieving a certain budget deficit (e.g. a nominally balanced budget as in many US states), leading to a preference for countercyclical elasticities (see for instance Fox and Campbell, 1984). Finally, from a longer-term perspective, differences in short- and long-term elasticities allow circumventing a trade-off between tax revenue growth and stability of tax revenues: in principle, high (long-term) growth rates can be combined with short-term stability in taxes, and vice versa; an appropriate selection of taxes may deliver a tax portfolio closer to the tax frontiers, taking account of preferences regarding tax revenue growth and stability (see Seyfried and Pantuosco, 2003, for an application to US state taxes).

This article focuses on estimating short- and long-run tax elasticities, the latter often being neglected, especially in European research. Another contribution of this paper is that we take into account possible sources of bias and inconsistency in long-run estimates of co-integrated relations. Finally, apart from error-correction, our short-term estimates also allow for asymmetric responses in tax revenues. This methodology is applied to the Netherlands, having a unique database on discretionary tax measures, allowing for deriving tax revenue series that reflect endogenous tax revenue growth.

The outline of this paper is as follows. Section 2 discuses the methodology used for estimating short-term and long-term elasticities of tax receipts. Section 3 contains the estimation outcomes for the three tax categories distinguished (value-added tax, personal income tax, and corporate income tax). The final section contains our conclusions.

## 2. Methodology

The focus of this article is on the base elasticity of taxes, measuring the endogenous growth in tax receipts following a 1% change in the tax base. The short-term elasticity measures the immediate change in tax receipts if the tax base

changes by 1 per cent, while the long-term elasticity gives the ultimate tax level following a change in the tax base by 1 per cent. Differences between short- and long-run elasticities can be expected especially for cyclically-sensitive taxes, fluctuating in line with the business cycle.

Long-term elasticities can be estimated as follows:

$$\log T_{05,t} = \theta + \delta \log B_t + \gamma_t \quad (1)$$

With $T_{05,t}$ = tax revenue in year *t* adjusted for discretionary measures
$\theta$ = intercept
$B_t$ = tax base in year *t*
$\gamma$ = error

while for the short-term elasticity, a difference-equation is taken to arrive at stationary series:

$$\Delta \log T_{05,t} = \alpha + \beta.\Delta \log B_t + \varepsilon_t \quad (2)$$

Making the distinction between short- and long-term elasticity values is a valid exercise provided the level of tax receipts and the tax base are co-integrated, and the difference-equation is stationary. The error-correction term derived from long-term equation (1) then can be added to the short-term equation, reflecting that deviations from the long-run tax path may have an impact on short-term tax receipts:

$$\Delta \log T_{05,t} = \alpha + \beta.\Delta \log B_t + \lambda. \gamma_{t-1} + \varepsilon_t \quad (3)$$

with $\lambda$ being the adjustment parameter, indicating the percentage of last year's deviation from the long-term tax level that is corrected in the current period. Short-term changes in tax revenues thus may arise from two channels: a direct one, via changes in the tax base, and an indirect one, via deviations from the longer-term tax path. As a result, a tax base may decline but tax revenues may nevertheless increase.

This approach can be refined by allowing the tax response to the base to vary with the sign of the error-correction term, being different on both sides of the attractor (also see Granger and Lee, 1989). In addition, the error-correction adjustment may differ in magnitude depending on whether deviations from the longer-term tax level are positive or negative. Equation 4 shows how such asymmetries can be tested, by adding a dummy variable with value 1 in case of a positive error-correction term, akin to Bruce *et al.* (2006). The interaction between, on the one hand, this dummy and, on the other hand, the tax base and the error-correction term, captures the possible asymmetries. However, as elasticity-values are state-dependent in this approach, a potential drawback is that outcomes are less transparent (Dye, 2004).

$$\Delta \log T_{05,t} = \alpha + \beta.\Delta \log B_t + \sigma. D_{ec}.\Delta \log B_t + \lambda. \gamma_{t-1} + \pi. D_{ec,t-1}. \gamma_{t-1} + \varepsilon_t \quad (4)$$

With $D_{ec,}$ = dummy with value 1 if the error-correction term is positive, and 0 otherwise.

To correctly measure *endogenous* growth of tax receipts, the effects of discretionary measures on tax revenues need to be removed. To this end, we use the proportional adjustment method (Prest, 1962), which can be expressed as:

$$T_{05,t} = \frac{T_t * T_{t+1} * \ldots\ldots * T_{05}}{T_{t,t+1} * \ldots . * T_{04,05}} \qquad (5)$$

with $T_{05,t}$ = tax revenue in year $t$ if tax structure of year 2005 would prevail
$T_t$ = actual tax revenue in year $t$
$T_{t,t+1} = T_t - D_t$
$D_t$ = amount of discretionary measures taken in year $t$

Underlying equation 5 is the assumption that the effect of discretionary measures increases over time in line with the tax revenue growth. This approach results in a constant long-term elasticity which facilitates the estimation process.

## 3. Data and estimation results

The approach outlined above was applied to the Netherlands, given that this is one of the few countries having long time series on discretionary measures. The Dutch ministry of finance has a database with (ex-ante) annual amounts of discretionary measures per individual tax category as of 1970, having the advantage of going back relatively far and of being consistent over time.

In particular, we use Dutch central government tax receipts on accrual-base, and distinguish value-added tax (VAT), personal income tax (PIT) and corporate income tax (CIT). The PIT includes the wage tax, which is a withholding tax for the personal income tax, taxation of non-wage income of individuals, as well as business income from retail business. The corporate income tax includes profits from all (large) corporations. In 2005, the VAT, the PIT and the CIT accounted for 32%, 26% and 16% of total central government tax revenues respectively. The remaining 26% that fall outside the scope of our analysis mainly reflect excise duties and dividend-withholding taxes. Table 1 shows the growth of tax receipts as per cent of GDP, distinguishing between effects of measures and endogenous growth. It indicates that the two income taxes increased autonomously, indicating a progressive nature, but the revenue of the value-added tax would actually have decreased as a per cent of GDP but for the discretionary measures taken.

**Table 1. 1971-2005 tax revenue growth: endogenous and discretionary effects, % (-point) of GDP**

| | 1971 tax ratio (1) | Effect of measures* (2) | Endogenous growth effect (3) | 2005 tax ratio (1)+(2)+(3)= (4) |
|---|---|---|---|---|
| VAT | 5.8 | 3.3 | -1.5 | 7.6 |
| PIT | 10.1 | -6.2 | 2.4 | 6.4 |
| CIT | 2.8 | -0.1 | 1.1 | 3.9 |
| Other | 5.0 | 7.9 | -6.5 | 6.4 |
| Total | 23.7 | 5.0 | -4.4 | 24.3 |

Note: Totals may deviate from the sum of components due to rounding.
* Including the effect of economic growth on the revenue changes from discretionary measures.

All tax variables, expressed in log-form, were tested for unit roots using the Augmented Dickey-Fuller (ADF) test (see Appendix 1). Stationarity was achieved after first-differencing. For two tax categories, this was only the case after shortening the sample, namely for the VAT (1980-2002) and the PIT (1975-2005). As to the explanatory variables, most series exhibited stationarity after first differencing. All estimates include an intercept.

As regards the long-run tax elasticity estimates, estimating equations in levels can give rise to biased estimates and inconsistent standard errors as levels of tax revenues and bases are non-stationary. Following Stock and Watson (1993), we use Dynamic OLS estimates (DOLS) to correct for the coefficient bias. Besides the current value, we use just one lead and one lag of the change in the independent variables to save on degrees of freedom.

$$\log T_{05,t} = \theta + \delta \log B_t + \Sigma^{1}_{j=-1} \text{ø } \Delta \log B_{t+j} + \gamma_t \qquad (6)$$

Furthermore, the Newey-West correction (Newey and West, 1987) was applied to reduce inconsistency of the estimates of the standard errors, similar to the approaches taken by Sobel and Holcombe (1996) and Bruce *et al.* (2006) for US tax series. Endogeneity of the tax base should not be problematic in this set-up as the tax receipts have been corrected for discretionary measures that could have an impact on the tax bases.

After estimating the long-term relation, we tested whether non-stationary variables are integrated using a stationarity test on the residuals from the long-term equations. The errors from the long-run equations were tested for stationarity using the ADF-test, which revealed satisfactory results (Appendix 2). In view of the limited size of our sample and possible non-linear adjustment that are known to reduce the power of the test (see e.g. Endes and Siklos, 2001), we did not opt for the Johansen cointegration test. Instead, there is a strong theoretical presumption of cointegration by the fact that the equations, while including behavioural elements, mostly are of an arithmetic nature as there is only limited possibility to avoid taxation if the taxable event increasing the tax base occurs.

Endogenous VAT receipts were related to private consumption, the main expenditure items on which VAT is levied. The coefficient 0.9 (see table 2, second column) is statistically significantly below unity. This may reflect the upward effect of higher excise duties levied on some products on inflation: while these increases are fully reflected in the price index, consumption may decrease in response, leading to less VAT receipts. The high value of the adjusted R-square reflects the fact that the estimates for the long-run elasticities are in log-levels.

Results for the short-term VAT elasticity (table 3, 3rd column) indicate that when revenues are below equilibrium, the elasticity reaches 0.64, while when it is above the elasticity rises to 1.10. Such pattern could reflect a shift in the consumption pattern towards more basic, low-taxed goods and services when consumption and VAT revenues are depressed, and postponement of consumption of luxury goods and services, being higher taxed by VAT.[1] No evidence of asymmetric effects in the error-correction terms was found.

[1] For the US, a number of studies also conclude rising household income elasticities for durable goods in case of economic expansions (see Fox and Campbell, 1984, and Otsuka and Braun, 1999).

**Table 2 Long-term elasticities for main tax categories, using Dynamic OLS and Newey-West adjustment.**

| Tax category | VAT | PIT | CIT |
|---|---|---|---|
| Intercept | 2.32<br>(15.8)*** | 1.40<br>(11.0)*** | 2.00<br>(27.7)*** |
| Main tax base:<br>Private consumption (VAT),<br>wage sum (PIT),<br>corporate profits (CIT) | 0.90<br>(6.2)*** | 1.57<br>(16.0)*** | 1.07<br>(21.4)*** |
| House price change | | -0.33<br>(-5.4)*** | |
| 2001 tax reform dummy | | 0.08<br>(9.5)*** | |
| Oil price | | | 0.03<br>(0.6) |
| Period | 1980-2002 | 1975-2005 | 1971-2005 |
| Adj. R2 | 0.99 | 0.99 | 0.97 |
| S.e. of regression | 0.007 | 0.020 | 0.045 |
| Number of observations | 23 | 31 | 35 |

Note: *, **, *** = significant at 10%, 5%, and 1% level respectively.

Turning to personal income taxation, the results indicate an overall long-term elasticity of 1.57 with regard to the wage-sum (Table 2, 3rd column), the above-unity value reflecting exemption thresholds and marginal rates increasing with income. A 2001 dummy measures ex-post corrections of revenues lost on account of the major tax reform in that year.

In the short-run equation (table 3, 4th column), the effect of changes in wages on tax revenues is higher than in the long-run equation, which may well reflect that employment in the short run is less flexible than in the long-run.[2] The error-correction term proved marginally significant, at close to 0.5, while no evidence of asymmetry was detected in either the tax base or in the error-correction term.

Analyzing and forecasting corporate income tax receipts is complicated, as reflected in the relatively low part of variance explained, on account of possibilities for carrying back and forward losses, and fiscal profits only being very roughly approximated by profits in national accounts. Oil prices were included as an additional variable to reflect the importance of natural gas exploitation for corporate revenues, with natural gas prices linked to oil price developments. One-year lagged corporate profits gave an elasticity value of 1.07 (table 2, 4th column), statistically significantly different from one, reflecting its slightly progressive nature resulting from somewhat lower corporate tax rates for smaller companies.

[2] The elasticity of tax revenues to employment is around 1 if the wage-earner earns an average income, while the elasticity with regard to income per earner is much higher reflecting progressive tax rates. Short-term economic fluctuations may have relatively little effect on employment, especially in Europe, for instance reflecting complex dismissal procedures or because employers use natural attrition.

As to the short-term elasticity, we observe again asymmetric behavior (table 3, 4th column), with profits spurring taxation in case of a positive error-correction term, likely reflecting a lack of possibilities to carry-back or carry-forward losses in good times. The lack of a significant effect in case of below-equilibrium tax receipts could reflect the possibilities for loss compensation.

**Table 3. Short-term elasticities for main tax categories**

| | | VAT | PIT | CIT |
|---|---|---|---|---|
| Short-term elasticity | Below long-term level | 0.64<br>(3.1)*** | 1.89¶<br>(5.1)*** | 0.12<br>(0.4) |
| | Above long-term level | 1.10***<br>(4.5)*** | | 0.90<br>(2.6)** |
| Adjustment parameter | | -0.94<br>(-4.4)*** | -0.49<br>(-1.9)* | -0.49<br>(-3.8)*** |
| Intercept | | 0.00<br>(0.5) | -0.02<br>(-1.9)* | 0.01<br>(1.4) |
| 2001 tax reform dummy | | | 0.08<br>(3.4)*** | |
| Δ oil price | | | | 0.11<br>(2.3)** |
| *PM: L-T elasticity* | | *0.90* | *1.57* | *1.07* |
| Adj. R2 | | 0.66 | 0.60 | 0.55 |
| S.e. of regression | | 0.0064 | 0.022 | 0.031 |
| Number of observations | | 21 | 30 | 34 |

Note: *, **, *** = significant at 10%, 5%, and 1% level respectively.
¶ No differentiation between above- and below the long-term level is applied as the two coefficients are not statistically different.

Generally, long-term elasticities are within the range for the short-term elasticities for the VAT. Noteworthy is the high value of the short-term elasticity of the personal income tax, above the long-term value, which can be explained by slow employment adjustment. Corporate income taxes, on the other hand, are less responsive in the short term than in the long term.

As a global check on the plausibility of the outcomes, we compared the results on (long-term) elasticity values with those derived by the OECD (Van den Noord, 2000), the ECB (Bouthevillain *et al.*, 2001), and the CPB (2004). It should be noted, however, that differences in estimation set-ups hinder a straightforward comparison. As to the VAT, all three assume unitary elasticity, whereas this paper finds a slightly lower value (0.9). A direct comparison of results for the personal income tax is complicated by these 3 organizations distinguishing between the employment elasticity of this tax (unitary elasticity) and the tax elasticity with regard to income per employed (elasticity 1.9 for the CPB, 2.6 for the OECD and the ECB). Our coefficient of 1.57 for the tax elasticity with regard to the wage sum is a weighted average of the two elasticities above. Finally, as regards the corporate tax, all three organizations again assume unitary elasticity, whereas we

find a slightly but statistically significantly higher value (1.07), which may capture the slightly progressive nature of this tax due to lower tax rates for small companies. The IMF (2004) also estimated responses of some Dutch tax receipts to their bases, concluding an elasticity of 1.1 for the personal income tax and 0.9 for the corporate income tax. However, they fail to correct the tax revenue growth for discretionary measures, and these coefficients therefore do not represent 'true' elasticities.

Finally, while using long-term values of base elasticities of taxes can generate errors in forecasting and analyzing public finance developments, it must be kept in mind that many other factors play a role here too, including forecasting errors in GDP, and measurement errors.

## 4. Conclusions

This paper finds evidence that short-term elasticities may deviate from long-term ones, with differences being especially large in "bad times" (tax receipts below the long-run value). This may indicate cautious or lagged responses of economic agents, taking short-term developments less-than-fully into account on a real-time basis. Ignoring deviations of short-term tax elasticities from long-term tax elasticities adds to creating 'budget surprises'. The outcomes also indicate asymmetry in tax-to-base elasticities in the value-added tax and the corporate income tax. The pro-cyclicality of these tax elasticities magnifies tax fluctuations, making it more difficult for policy-makers to control and to predict revenues, and thus public deficits and debt. At the same time, pro-cyclicality contributes to economic stabilization as effective tax rates automatically decline in "bad times", and vice versa. In addition, it reduces the costs of stabilization measures in terms of revenue foregone in times when it would be needed most. While our empirical evidence applies to the case of the Netherlands, there is no reason to assume that the underlying mechanisms (higher luxury consumption on good times, loss compensation in corporate taxation) should differ in other countries and states.

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**Appendix 1 Augmented Dickey-Fuller tests**

| | Estimation period | Level | Level with trend | First difference |
|---|---|---|---|---|
| Value added tax | 1980-2002 | 1.08 | -1.18 | -5.04*** |
| Corporate income tax | 1971-2005 | -2.13 | -3.33* | -4.89*** |
| Personal income tax | 1975-2005 | -2.90* | -3.76** | -3.96*** |
| Private consumption | 1980-2002 | 1.18 | -1.48 | -2.79* |
| Corporate profits | 1971-2005 | -2.05 | -2.27 | -4.42*** |
| Wages | 1975-2005 | -0.98 | -3.89*** | -2.94** |
| House price | 1975-2005 | -0.54 | -1.61 | -3.48** |
| Oil price | 1971-2005 | -1.97 | -2.07 | -5.35*** |

Note: *, **, *** = significant at 10%, 5%, and 1% level respectively.

**Appendix 2 Augmented Dickey-Fuller tests on residuals from long-term DOLS equations with Newey-West correction.**

| | Level |
|---|---|
| Value-added tax | -3.12*** |
| Personal income tax | -5.34*** |
| Corporate income tax | -4.08*** |

Note: *** = significant at 1% level. Results without intercepts (all insignificant).