

# Revenue neutral shifts in the tax structure: experiments with a dynamic general equilibrium model

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This article presents some estimations of how a shift in the base of taxation from labour to consumption would affect the performance of the Finnish economy. The basic tool of analysis is the dynamic general equilibrium model (Aino) developed at the Bank of Finland. The calculations within the model framework take account of the effects of changing the tax base on the behaviour of economic agents. Households here choose their consumption expenditures and labour supplies, and firms set the demand for labour and prices so as to maximise profits. Households are aware of the public-sector inter-temporal budget constraint, eg the impact of a deficit on general government debt and hence on government's future room to manoeuvre. In the model, changes in taxes impact on the economy via relative prices. Changes in relative prices are transmitted to the labour and commodity markets when they influence the decisions of households and firms.

Our calculations show that the macroeconomic effects of an assumed tightening of consumption taxation depend on the other compensations made in general government finances. If the additional revenue generated by the hike in consumption taxes is used to ease households' labour taxation, consumption, output, and employment all increase in the long run. The primary reason for this (perhaps somewhat surprising) result is that the supply effect of lower taxes on labour will clearly outweigh the negative consumption effect of higher consumption taxes. Reducing labour taxes is an effective means of raising

employment. It is noteworthy that a hike in consumption taxes actually leads to a net increase in consumption if the additional revenue is used to reduce the tax on labour. Employment and consumption will be boosted even more if the increase in consumption taxes is compensated by a reduction in indirect labour costs, stimulating demand for labour.

Our results are quite similar to those derived from the European Central Bank's NAWM (New Area Wide Model). For example, one such study (Coenen, McAdam and Straub 2006) also found that using an increase in consumption taxes to finance a reduction in indirect labour costs would raise employment, output and consumption. The similarity in results is hardly surprising, as both models are based on the neoclassical modelling legacy. The differences are due to differences in assumptions as to economic agents' preferences, heterogeneity and the structure of production technology. Differences in the modelling of nominal and real rigidities also account for some of the variation in results.

In this article we examine the general effects of a change in consumption taxation. We thus do not attempt to answer directly questions raised in recent discussions on a possible reduction in value-added tax (VAT) on food. It would nonetheless seem reasonable to apply the analysis of this study regarding the general effects of a change in the tax base also in comparing the impacts of reducing food VAT versus labour taxes. Questions

about income-redistributive effects that have been raised in discussions on food VAT are not addressed in this article, as the Aino model is not designed to answer such questions.

### General equilibrium effects of taxation

To better understand the effects of consumption taxes and labour taxes, it is useful to examine the dynamic equilibrium between households' consumption and labour supply, which can shed light on dynamic decision-making regarding consumption and labour supply (or leisure). Such decision-making can be analysed in terms of marginal conditions derived from households' inter-temporal maximisation of utility. The household's consumption and leisure at a point in time, as well as the time-path of consumption, are determined once we assume knowledge of the current prices of leisure and consumption at the moment of decision and of the mechanism by which households form expectations of future prices. In other words, these marginal conditions determine the *intra*-temporal structure of households' consumption and leisure and the *inter*-temporal structure of consumption. Households use their available time for leisure and work, so that working time is simply the residual after allotting time for leisure.

In the labour-supply equilibrium, households' intra-temporal marginal rate of substitution between consumption and leisure is equal to the after-tax real wage rate. The rate of substitution between consumption and leisure indicates the willingness of

households, given their level of income or wealth, to trade off consumption for leisure time while remaining at a given level of utility. Likewise, in dynamic consumption equilibrium, the inter-temporal rate of substitution between today's and tomorrow's consumption must equal the inter-temporal price of consumption, ie the real interest rate. This famous Euler consumption condition also determines households' savings, because the inter-temporal rate of consumption reflects households' willingness to give up some consumption today in favour of more tomorrow. In other words, the inter-temporal rate of substitution indicates households' propensity to save a part of their wealth to spend on future consumption.

Thus, households will alter their leisure-time behaviour, and hence their consumption spending, if the after-tax real wage rate changes. Such changes can occur, for instance, because of changes in labour or consumption taxes. An increase in labour taxes reduces workers' absolute disposable income and an increase in consumption taxes raises the relative price of consumption. On the other hand, households will consume later or sooner, depending on whether real interest rates rise or fall. The real interest rate is to a first order approximation, the difference between the nominal interest rate and the expected inflation rate.

The above explanation of household consumption and labour supply equilibrium is in essence dynamic because it derives from the household's dynamic optimisation

problem. The equalities of intra- and inter-temporal marginal rates of substitution and relative prices relating to the equilibrium situation are set out below mathematically.

**Intra-temporal condition for labour-supply equilibrium**

$$\frac{u_L(C_t, 1-L_t)}{u_C(C_t, 1-L_t)} = \frac{(1-\tau_t^{w,l}-\tau_t^{w,sc})W_t}{(1+\tau_t^c)P_t}$$

Here,  $C_t$  denotes consumption,  $1-L_t$  leisure time ( $L_t$  is the quantity of labour supplied),  $\tau_t^{w,l}$  the labour tax rate,  $\tau_t^{w,sc}$  the worker's rate of social security contributions from wages,  $\tau_t^c$  the consumption tax rate,  $W_t$  the nominal wage rate, and  $P_t$  the price level. The LHS of the equation is the marginal rate of substitution between leisure and consumption, and the RHS is the effective after-tax real wage rate.  $u_L$  and  $u_C$  denote the marginal utilities of leisure time and consumption, ie the partial derivatives of the household's utility function with respect to leisure and consumption. The RHS can be seen to represent the household's effective purchasing power from wages, also referred to as the 'consumption wage'.

**Inter-temporal Euler condition: dynamics of consumption**

$$E_t \left[ \frac{\beta u_C(C_{t+1}, 1-L_{t+1})}{u_C(C_t, 1-L_t)} \frac{(1+\tau_t^c)P_t}{(1+\tau_{t+1}^c)P_{t+1}} \right] = \frac{1}{R_t}$$

The LHS is the expected ratio of marginal utilities of tomorrow's to today's consumption. The symbol  $E$  is the mathematical expectation operator, and  $\beta$  denotes the discount factor,

reflecting household impatience regarding consumption.  $R$  on the RHS is the nominal gross interest rate between period  $t$  and  $t+1$ . This means that  $R-1$  is the nominal interest rate for time  $t$  to time  $t+1$  and is equal to the nominal yield on a one-euro investment in the money market. Multiplying the reciprocal of the nominal gross interest rate by the ratio of tomorrow's and today's price levels yields the relative price of tomorrow's consumption, ie the price of tomorrow's consumption in terms of today's consumption. The product

$$\left( \frac{1 + \tau_t^c}{1 + \tau_{t+1}^c} \right) \left( \frac{R_t}{P_{t+1} / P_t} \right)$$

could justifiably be labelled the effective real interest rate.

The labour-supply equilibrium indicates how taxation the factor

$$\frac{1-\tau_t^{w,l}-\tau_t^{w,sc}}{1+\tau_t^c}$$

distorts the relative price of consumption versus leisure time. A higher tax rate on consumption  $\tau_t^c$  or labour

$$(\tau_t^{w,l} + \tau_t^{w,sc})$$

will lower the relative price of leisure time. Because leisure becomes more attractive when the tax rate increases, households reduce the quantity of labour supplied. The magnitude of the labour-supply effect of a tax hike depends on the elasticity of the labour supply. In the Aino model, the Frisch-elasticity (elasticity of labour supply with respect to the real wage rate at a given level of the marginal utility of wealth) is about 0.30.

According to the Euler condition, a change in consumption taxes will have an impact on the effective real interest rate and thus on the consumption dynamics. It is worth emphasising that expected changes in consumption taxes in particular will affect the dynamics of private consumption. The term

$$\left( \frac{1 + \tau_t^c}{1 + \tau_{t+1}^c} \right)$$

reveals the effect of a possible change in future consumption taxes on households' perception of the relative price of tomorrow's versus today's consumption. It also shows that even a random fluctuation in consumption taxes will affect households' consumption decisions.

The firm's key decisions in the model are realised via the marginal conditions for labour demand and pricing. With the economy in equilibrium, firms will demand labour to the point where the marginal product of labour equals the real rental cost of labour. In a competitive equilibrium, commodity prices are determined by marginal costs of production. In an economy in which firms have pricing power, prices will exceed marginal costs. The greater the pricing power, the higher the economy's aggregate price level, at given marginal costs. Marginal costs are affected by both real wages and the rental cost of capital. Firms' rental costs of labour typically include, along with wages, indirect costs such as social security contributions. Thus a reduction in social security payments will reduce the marginal cost of labour and stimulate demand for labour. At its simplest, the relationship between

demand for labour and the real wage rate can be written as

$$Y_L = (1 + \tau^f) W_t / P_t$$

where the LHS is the marginal product of labour and the RHS the real rental cost of labour.  $\tau^f$  denotes what firms deduct from wages to make tax and other similar payments. The above marginal conditions relate the changes in relative prices to the quantitative changes that occur. The strength of the relative price effects (and hence of changes in taxation) on supply and demand decisions of households and firms depends primarily on household preferences and assumptions regarding the structure of output. The assumptions of the Aino model are described eg by Kilponen and Ripatti (2006a, b).

### Tax wedge

Besides affecting relative prices, taxes also affect the tax wedge, which expresses the difference between firms' effective (real) labour costs and what they pay to households in real after-tax wages. The size of the tax wedge can be written as

$$\nabla \equiv 1 - \frac{(1 - \tau_t^{u,l} - \tau_t^{u,sc})}{(1 + \tau_t^c)(1 + \tau^f)} \cong \tau_t^{u,l} + \tau_t^{u,sc} + \tau_t^c + \tau_t^f$$

The tax wedge in Finland is quite large by European standards, as can be seen from Table 1. In Finland in 2004 the wedge was nearly 66%, ie the fourth highest in the euro area.

The tax wedge is the sum of the distorting effects of taxes on labour supply and demand. Oversimplifying slightly, one can say that a narrowing of the tax wedge, eg in the context of tax

reform, bodes well for economic performance. The result is a reduction in the combined distorting effects on labour supply and demand. For example a revenue-neutral tax reform in which the consumption tax ( $\tau_t^c$ ) is increased may either expand or contract the tax wedge depending on how much the indirect costs of labour ( $\tau^l$ ) and/or income taxes ( $\tau^w$ ) are lowered. The degree to which the tax rate on labour can be lowered without changing tax revenue depends primarily on what happens to consumption, labour supply, wages and prices. These in turn depend on the above-mentioned assumptions on household preferences and technology.

### Macroeconomic effects of taxation

The main transmission channels of taxation in the general equilibrium

model were set out above in a fairly simplified manner. Taxation can also affect investment and domestic-foreign relative prices. The actual adjustment of the economy to a new equilibrium is a slow process due to the presence of nominal and real rigidities. Changes in taxes affect the balance between labour supply and demand via changes in real wages. In the short-run, real wages react to tax changes in a manner that depends on the assumptions regarding rigidities in nominal wages and prices. Nor can investment react immediately to changes in relative prices. Consumption and labour demand also require time to adjust, as consumer preferences change slowly and both recruitment and layoffs entail adjustment costs for firms.

Examination of such complex transmission mechanisms requires the

Table 1.

Estimated tax wedges in selected countries, 2004					
	Consumption tax	Income tax	Social security contributions		Tax wedge
			Employees	Employers	
<i>Euro area</i>					
<i>Austria</i>	20.0	8.4	14.0	22.5	64.9
<i>Belgium</i>	21.0	20.5	10.7	23.0	75.2
<i>Finland</i>	22.0	19.5	4.9	19.4	65.8
<i>France</i>	19.6	9.4	9.8	28.2	67.0
<i>Germany</i>	16.0	16.2	17.3	17.3	66.8
<i>Greece</i>	18.0	0.5	12.5	21.9	52.9
<i>Ireland</i>	21.0	9.6	4.5	9.7	44.8
<i>Italy</i>	20.0	14.0	6.9	24.9	65.8
<i>Luxembourg</i>	15.0	7.9	12.1	11.9	46.9
<i>Netherlands</i>	19.0	7.3	22.2	14.0	62.5
<i>Portugal</i>	19.0	5.1	21.1	17.0	62.2
<i>Spain</i>	16.0	9.7	4.9	23.4	54.0
<i>Average</i>	18.3	12.2	11.8	21.9	64.1
<i>United States</i>	7.7	15.4	7.1	7.1	37.3

*Tax wedges in the table have been calculated from tax rates using the formula described above.*  
Source: Coenen, McAdam and Straub 2006.

use of a dynamic general equilibrium model. The Bank of Finland's Aino model, which is based on Real Business Cycle theory, has been enriched by incorporating nominal and real rigidities. The model also accounts for heterogeneity among households so that structural changes in the tax system affect different households in different ways (see eg Kilponen and Ripatti 2006b).

#### Long-term effects

Table 2 presents estimated long-term effects that a percentage point increase in the consumption tax will have on the key variables in the Aino model. A rise in the consumption tax means an increase in tax revenue, so that revenue neutrality requires an assumption as to the use of the extra revenue. Our calculations include three options for use of the extra revenue: a reduction in the tax on earned income; a reduction in indirect labour costs; or lump-sum transfers to households. The third option will indicate the magnitude of impact on the equilibrium position of the economy that will result from distortions in relative prices caused solely by the consumption tax. As regards the first two options, the distortion in relative prices derives from the assumed combination of measures taken.

In examining all three options, it is assumed that the debt-to-GDP ratio of the public sector remains unchanged. It is further assumed for the first two options that public consumption expenditure is fixed. The economy is assumed to be initially in a long-term equilibrium position, and the model is calibrated so

that long-term equilibrium values of key variables accord with conditions in the Finnish economy in 1995–2005.

In analysing long-term effects it is useful to begin with the case in which the increase in consumption tax is matched by extra transfers to households (Table 2, column 3). A percentage point increase in consumption tax leads to roughly 0.5% decreases in both consumption and output. Behind the decline in consumption is a nearly 0.2 percentage point decrease in the real wage rate and a rise in the price of consumption relative to leisure time. The increased attractiveness of leisure is reflected in the supply of labour, and employment rate declines by about 0.25 percentage point. Since employment pension contributions are endogenously determined in the model by the pension funds' budget constraint, the decline in employment requires an increase in pension contribution of almost 0.1 percentage point. This expands the tax wedge by more than a percentage point. The consequences for exports, imports and investment are also substantial. Imports decline slightly because of the softening of consumption demand. Exports also decline as the relative price of export goods increases.

Nonetheless, shifting the base of the tax system to consumption is not necessarily a bad thing for the economy. The crux of the matter is how the tax reform is realised. The first two columns of Table 2 clearly show that if the increase in the consumption tax is used to finance a reduction in taxes on labour, the combined effect is an increase in both output and employment. If a

permanent increase in the tax on consumption is used to finance a reduction in taxes on earned income, the economy moves to an equilibrium in which consumption and output are just over 0.5% higher than in the initial situation. These results are broadly the opposite of those of the above calculation (option 3). The primary reason for the reversal is that the positive supply effects of reducing labour taxation clearly exceed the negative effects of the rise in consumption tax. This is reflected in the fact that one result of the tax reform is a shrinking of the tax wedge by nearly a full percentage point.

The effects are particularly pronounced if the hike in the consumption tax is used to finance a reduction in indirect labour costs. A percentage point rise in consumption tax enables a notable reduction in indirect labour costs – just over 3 percentage points – as well as a narrowing of the tax wedge by 3 percentage points.

#### Dynamic effects of changing the tax structure

We have so far examined the long-term effects of shifting the base of the tax system to consumption. But typically the adjustment of the economy to tax

Table 2.

	Revenue-neutral compensation		
	Reduction in income tax	Reduction in indirect labour costs	Increase in income transfers
Output	0.53	0.70	-0.52
Consumption	0.63	1.05	-0.51
People of working age	0.75	1.00	-0.34
Older people	0.37	1.17	-0.89
Investment	0.48	0.68	-0.48
Exports	0.20	0.11	-0.27
Imports	0.20	0.45	-0.13
Employment rate, % points.	0.25	0.32	-0.24
People of working age, % points	0.16	0.28	-0.19
Older people, % points	0.09	0.04	-0.06
Real wages, % points	-0.31	0.30	-0.25
Real wages after tax, % points	0.16	0.07	-0.17
Labour costs, % points	-0.02	-0.01	0.02
Tax wedge, % points.	-0.95	-2.98	1.07
Consumption tax	1.00	1.00	1.00
Income tax	-1.88	0.00	0.00
Employees' pension contributions	-0.06	-0.67	0.07
Employers' soc. security payments	0.00	-3.31	0.00
Employers' pension contributions	0.00	0.00	0.00

Effects are presented as percentage-point or percentage deviations from the long-term steady state.

The calculations assume a permanent one percentage point rise in consumption tax from the baseline. In the case where income transfers are increased, they are paid to the working-age population.

Source: Bank of Finland calculations.

restructuring is a slow process. The speed of adjustment is affected by price and wage flexibility and the way the real economy reacts to possible 'real rigidities'. The adjustment of the economy to the new equilibrium also depends heavily on how the tax reform is implemented over time. For example, an increase in consumption tax could be simultaneously matched by an easing of taxes on earned income. As an alternative, one could assume that taxation of earned income is changed slowly, with the extra revenue used (in the initial stage) to accumulate general government surpluses. If households behave in a non-Ricardian manner (as in the Aino model), the timing of compensation for the income tax affects the economy's path of adjustment to the new equilibrium.

Table 3 depicts the changes in values of key macroeconomic variables in the first five years after a percentage point increase in the consumption tax. The extra revenue is used to finance a phased reduction in taxes on earned income. Of the dynamic effects, we see first that the consequences of the tax-system change and resulting changes in relative prices for real economic variables are realised in a gradual process even though the hike in the consumption tax immediately raises the relative price of consumption. Consumption in particular reacts moderately at first, and the same is true of the after-tax real wage. Both of these reactions are reflections of the stickiness of nominal wages and the assumption that income tax is lowered slowly. The way consumption reacts is also affected

Table 3.

Dynamic effects of an increase in consumption tax	Years from a permanent increase in consumption tax			
	1	2	3	5
<i>Output</i>	0.05	0.18	0.29	0.39
<i>Consumption</i>	0.02	0.11	0.17	0.21
<i>Investment</i>	0.20	0.37	0.50	0.59
<i>Exports</i>	0.00	0.04	0.10	0.22
<i>Imports</i>	0.03	0.01	-0.03	-0.02
<i>Employment rate, % points</i>	0.03	0.13	0.19	0.24
<i>Real wages after tax, % points</i>	-0.03	0.07	0.10	0.11
<i>Labour costs, % points</i>	-0.01	-0.05	-0.07	-0.08
<i>Relative price of consumption</i>	1.30	1.33	1.35	1.36
<i>Real exchange rate</i>	0.02	0.11	0.21	0.27
<i>Tax wedge, % points</i>	0.16	-0.46	-0.67	-0.77
<i>Consumption tax</i>	1.00	1.00	1.00	1.00
<i>Income tax</i>	-0.84	-1.46	-1.67	-1.76
<i>Employees' pension contributions</i>	0.00	0.00	0.00	-0.01

*Effects are presented as percentage-point or percentage deviations from the long-term steady state. The calculations assume a permanent one percentage point rise in consumption tax from the baseline. Households are compensated for the increase in consumption tax with a gradual reduction in income tax.*

*Source: Bank of Finland calculations.*



by consumers' inter-temporal behaviour. Despite the increase in consumer prices, the consumption response is already moderately positive in the first year. This is a reflection of two factors. First, the rise in consumer prices initially accelerates consumer price inflation, thus lowering the real interest rate. In accord with the inter-temporal condition, consumers shift some of tomorrow's consumption to today. Secondly, as consumers look beyond the inter-temporal budget constraint they react to expected changes in the after-tax wage rate, so that the positive initial consumption response is partly due to households' anticipations of lower income taxes. Firms in turn anticipate an increase in demand, which spurs investment. These

forward-looking effects cause both output and employment to react at once in a positive manner, despite the initial moderate widening of the tax wedge.

Besides the positive effects on consumption, investment and employment, there are changes in foreign-domestic relative prices. This is a reflection of the change in the real exchange rate, as firms' marginal costs (and labour costs) decline moderately. The decline in marginal costs can be seen in the lower level of producer prices, which shows up as a weakening of the real exchange rate. Exports react very slowly to the change in the real exchange rate, due to the assumed sluggish adjustment of the export sector to the new price equilibrium.

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