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Can welfare states outgrow their fiscal sustainability problems?

Abstract:
The paper analyses the fiscal effects of productivity shifts in the private sector. Within a stylized model with inelastic labour supply, it shows that productivity shifts in sectors producing non-traded goods (N-sector) are irrelevant for the tax rates necessary to meet the government budget constraint. Also productivity shifts in the traded goods sector (T-sector) have a neutral fiscal effect, provided that the wage dependency of the tax bases and government expenditures are equal. If the wage dependency of expenditures exceeds that of revenues, tax rates must be increased in order to restore the government budget constraint. Simulations on a CGE model of the Norwegian economy confirm the theoretical results, and demonstrate that productivty growth on balance has an adverse fiscal effect. Moreover, the necessary increase in the tax rates of a productivity improvement in the T-sector is three times as high as the corresponding effect of a comparable productivity shift in the N-sector.

Keywords: Fiscal sustainability, productivity growth, general equilibrium

JEL classification: H30, J18

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1 Introduction

Most industrial countries are likely to face severe fiscal sustainability problems due to substantial ageing of their populations over the next fifty years, given prolongation of the present fiscal policy and welfare schemes.[1] The fiscal sustainability problem is likely to be particularly severe in the Scandinavian welfare states where the government provides relatively generous and highly non-actuarial pensions and most of the health and care services.[2]

Fiscal sustainability is often analysed by considering the conditions for stabilizing the ratio between government debt and GDP, see e.g. Roux (1993), Hemming and Miranda (1991), and Cronin and McCoy (2000). The latter paper claims that this debt ratio is the conventional indicator of fiscal sustainability. Fiscal sustainability indicators denoted in terms of ratios to GDP are often associated with the so called OECD-Method of assessing fiscal sustainability, which draws on Blanchard, Chouraqui, Hagemann and Sartor (1990). Bentz and Fetzer (2004) provide a discussion of this method and compares it with Generational Accounting. As made explicit in Goldfajn (2002), the rationale for considering this ratio is a positive relationship between GDP and the primary budget surplus, which can be motivated by the positive correlation between GDP and the tax bases. In such a highly simplified framework, accelerated economic growth in the private sector improves fiscal sustainability - by assumption.

In more sophisticated analyses, based on generational accounting or CGE models, productivity growth in the private sector (not in the government service sectors e.g. as a result of Baumol's disease), has different effects on government revenues and expenditures, making the budget effect less obvious. However, most studies find that productivity growth contributes, *cet. par.*, to mitigate the problems of fiscal sustainability through expansion of tax bases. For example Gokhale and Raffelhüschen (1999) suspects budget projections

[1] See Chauveau and Loufir (1995), OECD (1998, 2000, 2001), the European Commission (2001), McMorrow and Roeger (2002) and Visco (2002) for international comparisons of quantitative assessments of the fiscal and macroeconomic consequences of ageing. Kotlikoff, Smetters and Walliser (2001), Kotlikoff (2001) and Feldstein (2005) estimate the fiscal gap in the US. Kotlikoff and Burns (2004) provide a popular exposition of the long-term fiscal challenges facing the US. Beetsma, Bettendorf and Broer (2003) and The Danish Welfare Commission (2004) estimate the need for raising the tax burden in the Netherlands and Denmark, respectively. Andersen, Jensen and Pedersen (2004) provide a review in English of the fiscal sustainability assessment made in the Danish Welfare Commission (2004).

[2] This also includes Norway, although the high state petroleum revenues makes Norway a fiscal outlier measured by the current government wealth accumulation. However, Norway faces a sharp increase in government expenditures when ageing sets in after 2010, and the current fiscal policy is not sustainable, see Heide, Holmøy, Solli and Strøm (2006).

for the U.S. to be too optimistic because they find the projected productivity growth to be higher than warranted by U.S. experience. Using a large CGE model, Kotlikoff, Smetters, and Walliser (2001) find that a productivity-driven decline (increase) in the real wage growth contributes to the increase (decrease) in the future tax rates necessary to meet the intertemporal government budget constraint. With reference to these simulation studies, Kotlikoff (2001, pp. 37) concludes: "A higher rate of technological progress improves, but doesn't fundamentally alter, the demographic transition." Heald (2005) reviews long run projections for the UK presented in Treasury (2004), which show that higher productivity reduces the future need for fiscal tightening. Cronin and McCoy (2000) find the same pattern in alternative long run projections of the Irish economy.

These results may leave the impression that a positive correlation between productivity growth in the private sector and the fiscal stance is a robust "law". Policy makers may even consider future fiscal sustainability problems to be overrated to the extent that they regard productivity growth projections to be negatively biased.

However, also government expenditures are likely to be positively related to the productivity level in private sectors. To the extent that productivity growth increases the general wage rate, the government wage bill increases. The more so, the less is the intersectoral wage dispersion in the economy. Moreover, wage indexation of government cash transfers implies that the additional income caused by productivity improvements are spread automatically to all citizens, not only to the more productive workers.[3] In result, the fiscal effect of economic growth is ambiguous as discussed in Andersen and Pedersen (2006a, 2006b) and Heide, Holmøy, Solli and Strøm (2006). For respectively Denmark and Norway, these studies find that improved productivity in the private sector has an adverse fiscal effect in the sense that at least one tax rate must be increased to restore fiscal sustainability. Galasso (1999) derives the same conclusion for the social security tax rate, but his model takes into account that the equilibrium solution for this tax rate also reflects a majoritarian voting game.

The purpose of this paper is to examine more thoroughly how and why different productivity shifts affect a tax rate (levied on labour income) that adjusts endogenously to meet the government budget constraint. More precisely, I try to answer the questions: 1) Does productivity growth in the private sector mitigate or reinforce fiscal sustainability problems? 2) To what extent do the fiscal effects of productivity growth depend on which sectors that experience higher productivity? 3) What are the basic determinants of the fiscal effects of productivity growth? 4) How strong are these effects? A precise analysis of

[3] Raffelhüschen (2002) points out how the results of generational accounting depend crucially on wether government welfare payments are indexed to wages or consumer prices.

these questions is lacking in the studies referred to above.

As indicated above the answer to the first question will depend on the wage dependency of the different budget components. As to the second question my hypothesis is that productivity growth in sectors producing traded goods (T-sectors) will have a stronger fiscal effect than comparable productivity growth in sectors producing non-traded goods (N-sectors). The motivation for this hypothesis is the textbook model of the small open economy (SOE). In the SOE-model the equilibrium wage rate is determined by the world prices of outputs and the productivity in the T-sectors, cf. the factor price equalization theorem. On the other hand, productivity growth in N-sectors will be shifted forwards to lower product prices. This affects the budget surplus through a decline in the base of indirect taxes, as well as the outlays of government spending on a given volume of non-traded goods. However, my conjecture is that these effects will be smaller than the effects induced by a higher wage rate. An explanation of the basic determinants of the fiscal effects of productivity growth, called for in the third question above, warrants a comparative statics analysis of a stylized model. On the other hand, the strength of the various effects (question four) can only be estimated by simulations on an empirical model. Since this paper is confined to long run effects, a CGE model is the appropriate tool. Designed properly, the CGE model should capture country specific characteristics that is *a priori* likely to affect the necessary adjustment of the tax rate to productivity shifts. Specifically, such relevant characteristics include the wage dependency of the various government revenue and expenditure components.

In line with these considerations this paper relies on both a formal model analysis, as well as relevant simulation experiments on a large scale CGE model of a particular economy, Norway. It should be stressed that the analytical model is not arbitrarily specified. Rather, it represents an almost embarrassing simple model of the much more complex CGE model. It is designed with the particular purpose to provide a stringent and transparent explanation of the most important equilibrium effects of those included in the CGE model. In this respect the paper is intended to be an improvement compared to studies relying on either simulations of highly complex and non-transparent CGE models that are hard to understand and verify, or on analytical discussions of highly stylized models ruling out potentially important mechanisms.

The analysis pays particular attention to the fiscal effects of general equilibrium adjustments of the wage rate, which represents the real exchange rate. In particular, it addresses the price effects of the wage adjustments. It also examines the more familiar wage effect on the tax bases through labour supply, but for the sake of expositional clarity, I have chosen to incorporate the complexities generated by endogenous labour supply responses

to a separate section. Both the attention paid to price effects on the government budget due to wage rate adjustments, as well as the particular CGE model used in this paper, make this paper related to Holmøy (2006).

The rest of the paper is organized as follows. Section 2 sets up a theoretical model, which is stripped down to the minimum ingredients necessary to explain the fiscal effect of productivity shifts in, respectively, the T- and the N-sectors. Section 3 extends the model to include endogenous labour supply responses. Section 4 demonstrates the empirical strength of different fiscal effects by presenting results of relevant simulation experiments on a realistic general equilibrium model of the Norwegian economy. Section 5 summarizes the conclusions.

2 A Stylized model

We consider a static model of a small open economy with two sectors producing, respectively one traded (T) and one non-traded (N) good with labour as the only input. There are constant return to scale in both sectors. A representative consumer supplies an exogenous amount of labour and has homothetic preferences over the N-and the T-good. World prices and the exchange rate are exogenous and normalised to unity. The government produces some services by using labour, the quantity of which has no effect on the demand functions for imports and the N-good. It finances the wage costs by collecting taxing on labour income and consumption. In addition, the government owns an exogenous endowment of a tradable, possibly different from the other goods. This endowment may be interpreted as e.g. property rights of natural resources such as oil and/or predetermined financial claims on the rest of the world. The wealth associated with this endowment may be negative, e.g. if the government sector uses imports to produce services or is indebted to foreigners.

The model consists of the following 8 equations:

$$X_T = A_T L_T \tag{1}$$

$$C_N = A_N L_N \tag{2}$$

$$W = A_T \tag{3}$$

$$P_N = \frac{W}{A_N} \tag{4}$$

$$t_C \left(C_T + P_N C_N\right) + t_L W L + O = W L_G \tag{5}$$

$$\left(1 + t_C\right)\left(C_T + P_N C_N\right) = \left(1 - t_L\right) W L \tag{6}$$

$$\frac{C_T}{C_N} = P_N^{\sigma} \tag{7}$$

$$L_T + L_N + L_G = L \tag{8}$$

X_T is output of the traded good. C_N denotes output and consumption of the non-traded good, and C_T is consumption of the T-good. The utility function is a homothetic CES utility function with σ as the elasticity of substitution between the T- and the N-good. Units are chosen so that the preferences over the two goods are symmetric. L is total employment, L_G, L_T and L_N is employment in, respectively, the government sector, the T- and the N-sector. A_i is labour productivity in sector $i = T, N$. P_N is the price of the N-good. W is the wage rate paid by producers. O is the value of the exogenous amount of another tradable owned by the government, denominated in terms of the T-good. t_L and t_C are, respectively, the tax rates on labour income and consumption.

(1) and (2) are the production functions in the T- and N-sector, assuming equilibrium in the market for the N-good. (3) and (4) follow from perfect competition in both sectors. (5) is the government budget constraint, and (6) is the budget constraint of the representative consumer. We shall let t_L be the fiscal instrument that endogenously adjusts to meet this constraint. (7) follows from the first order condition for utility maximization, reflecting that the consumption tax rate is levied both on imports and the N-good. (8) is the labour market equilibrium condition. O, L, L_G, t_C and $P_T = 1$ are exogenous. The model determines the 8 endogenous variables X_T, L_T, L_N, P_N, W, C_N, C_T and t_L. We shall examine how changes in A_T and A_N affect t_L.

Define the effective aggregate tax rate $\tau \equiv \frac{t_L + t_C}{1 + t_C}$. The solution for τ is found directly by inserting the private budget constraint into the government budget constraint, and using $W = A_T$:

$$\begin{aligned} t_C \left(C_T + P_N C_N\right) + t_L W L + O &= W L_G \Leftrightarrow \\ t_C \left(\frac{1 - t_L}{1 + t_C}\right) W L + t_L W L &= W L_G - O \Leftrightarrow \\ \tau &= \frac{1}{L}\left(L_G - \frac{O}{A_T}\right) \end{aligned} \tag{9}$$

Contingent on the assumptions underlying the model above, (9) proves the following conclusions:

1. The productivity in the N-sector is irrelevant for t_L and τ.
2. If $O = 0$, t_L and τ also become independent of A_T: $\tau|_{O=0} = \frac{L_G}{L}$.
3. When $O > 0$, productivity growth in the T-sector makes it necessary to raise the tax rate.

The intuition behind conclusion (2) is that when $O = t_C = 0$, both government revenue and expenditure are proportional to W, and their initial values are equal. With exogenous labour supply, government labour cost being the only expenditure, and uniform wage rates in all sectors, W is the only endogenous variable affecting t_L. Consequently, any change in W will be budget neutral.

The intuition behind conclusion (3) is that when $O > 0$, increased A_T reduces $\frac{O}{A_T}$, i.e. the real value of O in terms of the government wage bill. The tax base of t_L increases by the same proportion as the government wage bill when a higher A_T raises W. But the absolute increase in revenue is smaller since the initial expenditure exceeds the tax revenue by O. Conversely, when $O < 0$ productivity growth in the T-sector allows for a tax rate reduction.

As to conclusion (1) it follows from the independence between the wage rate and A_N that productivity growth in the N-sector affects neither government expenditure nor the labour income tax revenue. It is less obvious that the revenue from the consumption tax is invariant to A_N. The intuition behind this result is that although an increase in A_N will raise C_N due to both an income effect and a substitution effect caused by the fall in the relative price of P_N, the reduction of P_N also reduces the current value of the consumption tax base. The two effects cancel out. This is shown formally in the Appendix. Here it is shown that the equilibrium consumption tax base equals

$$C_T + P_N C_N = A_T (L - L_G) + O, \tag{10}$$

which is independent of A_N.

Although the model is very simple, flexible interpretation of the variables extends the relevance of the conclusions. First, recall that O captures the initial government endowment/income of a traded good, including revenue from sales of natural resources, use of imports in the production of public services, and predetermined financial claims on or debt to the rest of the world. Second, wage indexed transfers, e.g. public pension benefits, from the government to the household can be interpreted as parts of WL_G. To see this, let N be the exogenous number of transfer recipients and b the individual benefit ex ante wage indexation. Government expenditures now equals $W(L_G + bN)$, which plays exactly the same role as WL_G in the model above. It is straightforward to show that the price reduction caused by higher A_N will contribute to reduce the tax rate if the tax financed transfers to the consumer are indexed completely or partly (through e.g. P) to P_N.

It is also straightforward to introduce government purchases of goods in the model. Let G_T and G_N denote government purchases of, respectively, the T- and the N-good.

Combining the private and government budget constraints, the tax rate becomes

$$\tau \equiv \frac{t_L + t_C}{1 + t_C} = \frac{1}{L}\left(L_G + \frac{G_N}{A_N} - \frac{O'}{A_T}\right),$$

where $O' \equiv O - G_T$. Now productivity growth in the N-sector reduces the tax rate. However, the reason is that the price of the N-good falls relative to government revenues. As showed above, the expansionary volume effect on the tax base is cancelled out by other effects. Still, productivity growth in the T-sector requires an increase in the tax rate when $O' > 0$.

3 Endogenous labour supply

We now introduce endogenous labour supply. We assume a nested CES utility function $U = U(C, F)$, where F is leisure and C is the subutility $C = C(C_T, C_N)$. As above $C()$ is homothetic, whereas the income elasticities for C and F may deviate from unity.

In addition to equations (1) - (5) above, the model now includes the equations:

$$P = (1 + t_C) P(1, P_N) = (1 + t_C)\left(1 + P_N^{1-\sigma_C}\right)^{\frac{1}{1-\sigma_C}} \tag{11}$$

$$C_T = P^{\sigma_C} C \tag{12}$$

$$C_N = \left(\frac{P_N}{P}\right)^{-\sigma_C} C \tag{13}$$

$$L_T + L_N + L_G = l(\omega, \omega T), \tag{14}$$

$$C = \omega l(\omega, \omega T), \tag{15}$$

where $\omega = \frac{(1-t_L)W}{(1+t_C)P}$ is the net of tax consumer real wage rate. P is the ideal consumer price index of the composite of imports and the N-good. (12) and (13) are the compensated demand functions contingent on C. $l(\omega, \omega T)$ is the uncompensated labour supply function derived from

$$\text{Max}_L\ U(C, F)\ \text{ s.t. } C + \omega F = \omega T\ \Rightarrow L = T - F(1, \omega, \omega T) = l(\omega, \omega T).$$

(15) summarizes the private budget constraint. Define $\hat{l}_\omega$ as the uncompensated labour supply elasticity wrt. ω. From the Slutsky equation $\hat{l}_\omega = -\frac{F}{L} e_{F\omega} = -\frac{F}{L}\varepsilon_{F\omega} - \frac{F}{T} E_F$, where $e_{F\omega}$ and $\varepsilon_{F\omega}$ are, respectively, the uncompensated and compensated wage elasticities of leisure, and E_F is the income elasticity of leisure.

Using $\tau \equiv \frac{t_L+t_C}{1+t_C}$, ω can be written in terms of τ and productivity parameters:

$$\omega = \frac{(1-t_L)\,W}{(1+t_C)\,P} = \frac{(1-\tau)\,A_T}{P\left(P_T, \frac{A_T}{A_N}\right)}. \tag{16}$$

Taking this into account, the tax rate consistent with general equilibrium is implicitly determined by

$$\tau l\left(\omega, \omega T\right) = L_G - \frac{O}{A_T}. \tag{17}$$

Let $R(\tau) = \tau l\left((1-\tau)\frac{W}{P}, (1-\tau)\frac{WT}{P}\right)$ denote the Laffer-curve associated with τ. The Laffer-curve takes W and P as given. In relative terms, its slope is $\hat{R}_\tau \equiv \frac{\partial R(\tau)}{\partial \tau}\frac{\tau}{R} = 1 - \frac{\tau \hat{l}_\omega}{1-\tau}$. Assuming the economy being at the increasing part of the Laffer-curve implies

$$\hat{R}_\tau > 0 \Leftrightarrow \hat{l}_\omega < \frac{1-\tau}{\tau} = \frac{1-t_L}{t_L+t_C}. \tag{18}$$

Is it restrictive to assume $\hat{R}_\tau > 0$? To answer this, first note that the maximum value of $\hat{l}_\omega$ is negatively related to the tax rates, since $\frac{1-\tau}{\tau}$ is decreasing in τ (and t_L and t_C). Second, note that t_L should include all tax rates levied on labour income, including the payroll tax rate and the tax element in mandatory non-actuarial public pension contributions. Third, means-testing of several government cash transfers implies significant effective taxation of labour.[4] Fourth, due to ageing future tax rates are likely to be significantly higher than the present ones, and they are the most relevant when evaluating the likelihood of $\hat{R}_\tau > 0$ in the context of the present paper. Fifth, the low positive estimates on $\hat{l}_\omega$ found in most empirical studies of labour supply, relate to the labour supply decision at the internal margin. Labour supply is found to be much more responsive to economic incentives at the extensive margin, including retirement, see e.g. Heckman (1993) and Gruber and Wise (2004).

Taking Norway as an example, realistic estimates of present tax rates would be $t_C = 0.2$, $t_L = 0.5$ (including only the personal income tax and the payroll tax), which implies $\frac{1-\tau}{\tau} = 0.7$. According to the projections in Heide, Holmøy, Solli and Strøm (2006) t_L would have to increase to about 0.6 in 2050, which implies that $\frac{1-\tau}{\tau} = 0.5$. Still, this critical value is significantly higher than most estimates of $\hat{l}_\omega$, see Dagsvik and Jia (2006) and Aaberge, Colombino, Holmøy, Strøm and Wennemo (2006). In the latter study the aggregate $\hat{l}_\omega$ varies between 0.12 and 0.14.

[4] See e.g. Mogstad, Solli and Wist (2006) for a survey of the effective taxation implicit in Norwegian welfare schemes.

The necessary adjustment of τ to exogenous marginal changes in the productivity parameters is found by differentiation of (17) wrt. τ, A_T and A_N:

$$\begin{aligned} d\tau L + \tau \hat{l}_\omega L \frac{d\omega}{\omega} &= OdA_T \Leftrightarrow \\ d\tau &= \frac{1}{\hat{R}_\tau}\left[\left(\frac{O}{L} - \tau \hat{l}_\omega \theta_T\right) dA_T - \tau \hat{l}_\omega \theta_N dA_N\right]. \end{aligned}$$

where we have used that $\frac{d\omega}{\omega} = -\frac{d\tau}{1-\tau} + \theta_T dA_T + \theta_N dA_N$, where θ_i is the budget share of good $i = T, N$. $\hat{A}_i = \frac{dA_i}{A_i} = dA_i$ when $A_i = 1$, $i = T, N$ initially. The partial derivatives become

$$\frac{\partial \tau}{\partial A_T} = \frac{\frac{O}{L} - \tau \hat{l}_\omega \theta_T}{\hat{R}_\tau} = \frac{\frac{O}{L} - \tau \hat{l}_\omega \theta_T}{1 - \frac{\tau \hat{l}_\omega}{1-\tau}}, \tag{19}$$

$$\frac{\partial \tau}{\partial A_N} = -\frac{\tau \hat{l}_\omega \theta_N}{\hat{R}_\tau} = -\frac{\tau \hat{l}_\omega \theta_N}{1 - \frac{\tau \hat{l}_\omega}{1-\tau}}. \tag{20}$$

(20) is the simplest one of these expressions. Compared to the quite realistic case of inelastic labour supply discussed above, an endogenous labour supply response may force τ in either direction. $\frac{\partial t_L}{\partial A_N} > 0$ for $\hat{l}_\omega < 0 \vee \hat{l}_\omega > \frac{1-t_L}{t_L+t_C}$. As $\left|\hat{l}_\omega\right| \to \infty$, $\frac{\partial \tau}{\partial A_N} \to \theta_N (1-\tau)$. On the other hand, $0 < \hat{l}_\omega < \frac{1-t_L}{t_L+t_C} \Leftrightarrow \frac{\partial \tau}{\partial A_N} < 0$. The intuition is that an increase in A_N raises ω through a drop in P_N. When the income effect on labour supply dominates the substitution effect, so that $\hat{l}_\omega < 0$, the tax base of the labour income tax declines. Also the base of the consumption tax falls, since (10) implies $C_T + P_N C_N = A_T (l(\omega, \omega T) - L_G) + O$. *Cet. par.*, raising t_L increases the tax revenue directly, as well as indirectly through increased tax bases.

When $\hat{l}_\omega > 0$, the increase in ω caused by the fall in P_N raises L and the tax bases. As long as the uncompensated labour supply function is not "too" wage elastic, i.e. as long as $0 < \hat{l}_\omega < \frac{1-t_L}{t_L+t_C} \Leftrightarrow \hat{R}_\tau > 0$, the government budget constraint is restored by reducing t_L.

The peak of the Laffer curve $\hat{l}_\omega = \frac{1-t_L}{t_L+t_C}$ represents a knife-edge on which the tax revenue is invariant to marginal changes in the tax rates. When $\hat{l}_\omega > \frac{1-t_L}{t_L+t_C}$, the tax rates exceeds the peak of the Laffer-curve, and reducing the budget surplus back to zero requires an increase in the tax rate. It is striking that a relatively small increase in $\hat{l}_\omega$ from the range of the typical estimates brings the economy from a situation where no tax rate adjustment is required to counteract the budget effect of changes in A_N, to situations where even unrealistically large tax rate adjustment is unable to restore government budget balance. Moreover, a small changes in $\hat{l}_\omega$ from one side of the knife-edge to the other call for widely different signs of the large tax rate adjustments.

Figure 1. **The necessary tax rate adjustment to marginal productivity improvements in the N-sector (dt/dAN) as a function of the uncompensated labour supply elasticity (lw)**.

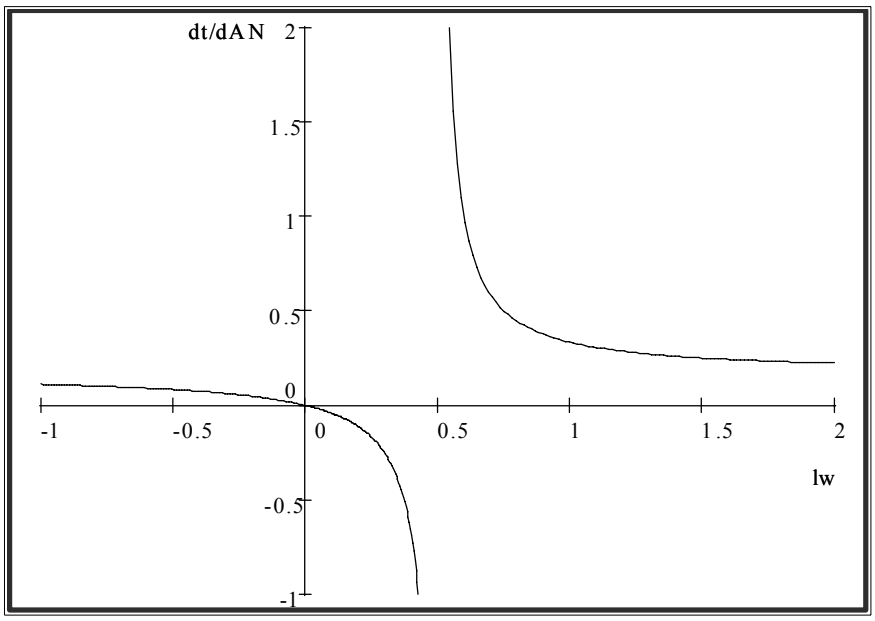

Figure 1 summarizes this discussion of $\frac{\partial t_L}{\partial A_N}$. It graphs $\frac{\partial t_L}{\partial A_N}$ as a function of $\hat{l}_\omega$ in the particular case where $t_L = 0.6$, $t_C = 0.2$ (so that $\tau = 2/3$) and $\theta_N = 0.5$ initially, which implies a vertical asymptote at $\hat{l}_\omega = 0.5$, and a horizontal asymptote at 0.17. Realistic tax rates and most econometric estimates $\hat{l}_\omega$ suggest that most economies would be positioned on the part of the depicted locus where $\frac{\partial t_L}{\partial A_N} < 0$. The simulations reported in the next section confirm that this is the case for Norway.

The labour supply response may also change the sign of $\frac{\partial \tau}{\partial A_T}$ compared to the case when $\hat{l}_\omega = 0$. (19) shows that $\frac{\partial \tau}{\partial A_T} < 0$ when the non-tax net revenue is not too large, i.e. when $0 < \frac{O}{\tau L \theta_T} < \frac{1-\tau}{\tau} \Leftrightarrow 0 < \frac{O}{C_T} < 1$ (since $A_T = W = P_T = 1$ initially), and $\frac{O}{\tau L \theta_T} < \hat{l}_\omega < \frac{1-t_L}{t_L+t_C} \Leftrightarrow \hat{R}_\tau > 0$. In this case the expansion of the tax bases caused by the increase in ω, dominates the negative budget effect of the increase in the wage rate. When $0 < \hat{l}_\omega < \frac{O}{\tau L \theta_T}$, the labour supply growth mitigates the necessary increase in τ, whereas the increase in τ is reinforced when $\hat{l}_\omega < 0$.

For completeness, we find the necessary tax rate adjustment to an equal marginal productivity improvement, dA, from $A_T = A_N = 1$ in both sectors, by adding the partial

derivatives:

$$\frac{\partial \tau}{\partial A} = \frac{\partial \tau}{\partial A_T} + \frac{\partial \tau}{\partial A_N} = \frac{\frac{O}{L} - \tau \hat{l}_\omega \theta_T - \tau \hat{l}_\omega \theta_N}{1 - \frac{\tau \hat{l}_\omega}{1-\tau}} = \frac{\frac{O}{L} - \tau \hat{l}_\omega}{1 - \frac{\tau \hat{l}_\omega}{1-\tau}} \tag{21}$$

4 Empirical assessments

4.1 A CGE model of the Norwegian economy

This section provides estimates of the fiscal significance of productivity growth in private industries based on a large scale CGE model of the Norwegian economy, MSG6. The MSG6 simulations are complementary to the stylized model analysis above by including a wide range of realistic effects ignored in the stylized model. On the other hand, the specific design of the stylized model is chosen in order to capture those mechanisms that have proven to be empirically most significant for the problem studied in this paper. In combination, the formal analysis and the MSG6 simulations are intended to provide both realistic estimates of the main fiscal effects of productivity shifts, as well as a precise explanation and discussion of the nature of the empirically most important effects.

My conjecture is that the relevance of an empirical model may be even greater for the question analysed in this paper than for many other problems in the applied literature on taxation. The analysis above supports this view by showing that the initial shares of wage dependent revenues and expenditures in the government budget are crucial for the magnitude of the fiscal effect of the productivity shifts. Important sources to country differences here include wage or price indexation of public pension benefits, and the government budget share of rents from natural resources.

I confine the description of MSG6 to the characteristics most important for our analysis. A comprehensive description is given in Heide, Holmøy, Lerskau and Solli (2004).

The following characteristics of the stylized model are shared by MSG6: The nominal exchange rate and all world prices of exports and imports are exogenous; labour is internationally immobile; all goods, services and production factors are perfectly mobile between industries within the economy; supply equals demand in all markets in all periods; a representative consumer adjusts consumption and labour supply to maximize utility, and the uncompensated wage elasticity equal to 0.1; producers maximize the value of firms; both producers and consumers consider imports of manufactures and services as close but imperfect substitutes for the corresponding deliveries from Norwegian firms; the balanced trade constraint is met by endogenous wage adjustment ensuring competitive profitability in a sufficiently large production of traded goods. The model is closed by letting endogenous payroll tax rate adjustment balance the government budget.

In order to serve as a realistic description of how the Norwegian economy works in the long run, MSG6 is much more complex than the stylized model in several respects:

1. MSG6 provides a rather disaggregated description of the Norwegian economy, specifying 60 commodity groups.

2. MSG6 is dynamic; the consumer maximizes an intertemporal utility function, and producers maximize the present value of the net-of-tax cash flow to the owners. Agents have access to the international credit market, and the world interest rate is exogenous to the Norwegian economy. Consumers and producers have perfect foresight. The balanced trade constraint takes the form of a non-Ponzi game condition on net foreign debt.

3. MSG6 takes into account that firms employ goods as intermediaries and capital goods in addition to labour.

4. Producers of manufactures and tradable services allocate their output between the domestic and the foreign market. It is costly to change the output composition between these markets. Whereas domestic firms are price takers in all factor markets and the export markets, they participate in Large Group Monopolistic Competition with free entry/exit in the domestic markets.

5. The production functions in most private industries exhibit decreasing returns to scale. The scale elasticities vary between 0.85 and unity. See Bye, Holmøy and Heide (2006) for a discussion and a justification of the scale properties in MSG6.

6. In all scenarios below the fiscal policy rule adopted in 2001 is followed. Strictly, this rule implies that the annual government petroleum revenue is transferred to the Government Pension Fund - Global (GPFG), and that only an estimated real return of 4 percent of the fund can be used to finance the non-petroleum budget deficit. In order to meet the resulting time path of the government budget surplus, the payroll tax rate adjusts annually. The payroll tax rate, rather than the tax rate on personal labour income is chosen as the endogenous fiscal instrument, because it is a very broad and flat tax on labour income, whereas the personal income tax system is much more complex. The qualitative results from the formal analysis above are not affected by replacing the labour income tax rate by a payroll tax rate.

4.2 Simulation results

The scenarios associated with productivity shifts are compared to a *baseline scenario* based on prolongation of the present fiscal and welfare policy, including present tax rates in real

terms, the present public pension system and other welfare schemes, and wage indexation of most cash transfers from the government to households. See Heide, Holmøy, Solli and Strøm (2006) for more details.

The productivity shift scenarios are identical to the baseline scenario except for the productivity assumptions. In the *T-scenario* the level of the total factor productivity (TFP) index in three sectors producing mostly traded goods (Metals, Chemicals and Pulp and Paper) are permanently increased by 10 percent. In the *N-scenario* the corresponding TFP-shift is experienced by the Construction sector, producing mainly non-traded goods. The particular choice of the three T-sectors is motivated by the fact that the total gross production value in these sectors was about equal to that of the Construction sector in 2005. In a very simple model this would imply that the macroeconomic effects of the two TFP-shifts were similar.

The simulation results reported in Table 1 confirms that the two TFP-shifts have about the same effects on the macroeconomic aggregates, such as private consumption, employment and the real wage rate. There are two basic reasons why the N-scenario is somewhat more expansionary than the T-scenario. First, the rise in the consumer real wage rate is stronger in the N-scenario, basically because the necessary increase in the payroll tax rate is lower. Since government real spending, as well as the government budget surplus, follow identical time paths in all scenarios, the positive substitution effect on labour supply is strongest in the T-scenario, whereas the negative income effects are more equal. Note that the income effects on labour supply dominate the substitution effects in both productivity shifts. These income effects include the effects of both higher consumer real wage, higher capital income and higher wage indexed cash transfers. Second, the N-sector (Construction) grows relatively to the three T-sectors along the baseline scenario. Consequently, the amount of resources experiencing increased productivity is greater in the N-scenario than in the T-scenario.

Table 1 confirms the analytical results in Section 2: Both TFP-shifts require a higher tax rate, and the T-scenario requires a higher tax rate than the N-scenario. Measured in percentage points, the increase in the payroll tax caused by higher TFP in the N-sector is only 1/3 of the corresponding increase in the T-scenario. Compared to the macroeconomic effects, the differences in fiscal effects are strikingly large. Especially, the effects on gross revenues and gross expenditures are much greater in the T-scenario. The main reason is the one explained in Section 2: The value of higher TFP in the T-sector implies is shifted over to the price of the immobile resources, most notably labour. The increase in the wage rate brings about a close to proportional increase in tax bases and government expenditures. A crucial premise for this is wage indexation of most government transfers,

including public pension entitlements. On the other hand, TFP-growth in the N-sector leaves the unit labour cost and the wage rate nearly unaffected.

TFP-growth in both the T- and the N-sector has an adverse fiscal effect because 1) the wage rate increases in both experiments, and 2) wage dependent expenditures exceed wage dependent revenues along the baseline, basically because of the significant petroleum revenues collected by the Norwegian state. However, the latter inequality is more strongly magnified in the shift that generates the greatest increase in the wage rate.

The stylized model in Section 3 neglects the mechanisms that make the unit labour cost dependent on productivity in the N-sectors. In MSG6 two mechanisms produce this modest dependency. First, higher productivity in the N-sectors reduces the prices of domestically produced intermediaries and capital goods, which increases the competitive wage rate consistent with trade balance. Second, higher productivity raises income and demand, including demand for T-goods. With decreasing returns to scale, the increase in the T-good necessary to restore balanced trade requires a decline in the labour cost. The former effect dominates in the MSG6 simulation reported in Table 1.

Table 1. Long run macroeconomic effects in Norway of a 10 percent increase in TFP in T-sectors and N-sectors. Percentage deviations from the baseline scenario unless otherwise stated.

	T-scenario	N-scenario
Pay roll tax, percentage points	1.5	0.5
Total revenues, of which	5.4	0.3
Indirect taxes	3.4	-0.2
Direct taxes, net of petroleum revenues	7.2	0.5
Total expenditures, of which	5.9	0.3
Government consumption	6.2	0.8
Cash transfers to households	5.2	0.3
Private consumption	1.5	1.7
Employment	-0.7	-0.4
Wage cost per hour	6.5	0.8
Wage rate	5.4	0.4
Consumer real wage rate	1.6	2.0

5 Conclusions

This paper has tried to answer the questions: Does productivity growth in the private sector mitigate or reinforce fiscal sustainability problems? To what extent do the fiscal effects of productivity growth depend on which sectors that experience higher productivity? What are the determinants of the fiscal effects of productivity growth? How strong are these effects?

The answers are based on both a formal model analysis, as well as relevant simulation experiments on a CGE model of the Norwegian economy. It should be stressed that the model analysed formally is not arbitrarily specified. Rather, it represents a model of the much more complex CGE model, designed with the particular purpose to explain as transparent as possible the nature of the most important general equilibrium effects of those included in the CGE model. In this respect the paper is intended to be an improvement compared to studies relying on either simulations of highly complex and non-transparent CGE models that are hard to understand and verify, or on analytical discussions of highly stylized models ruling out potentially important mechanisms.

The analysis has paid particular attention to the fiscal effects of general equilibrium adjustments of the wage rate, which represents the real exchange rate. In particular, it has addressed the price effects of the wage adjustments. It also examines the more familiar wage effect on the tax bases through labour supply. The analysis justifies the following conclusions:

1. Given fixed employment, constant returns to scale and proportionality between the wage rate and all government budget components, the tax rate necessary to meet the government budget constraint is independent of the productivity in all private sectors.

2. If the government in addition receives a positive (negative) net revenue that is independent of the wage rate, productivity growth in the traded goods sector warrants an increase (decrease) in the tax rate. Still, productivity shifts in the sectors producing non-traded goods have a neutral budget effect, so they are irrelevant for the endogenous tax rate.

3. Compared to the quite realistic case of inelastic labour supply, an endogenous labour supply response may force the budget neutral tax rate in either direction. Increased productivity in either sector raises the consumer wage rate. When the uncompensated labour supply elasticity ($\hat{l}_\omega$) is negative, the labour supply response contributes to reduce the tax bases. In this case, the budget neutral tax rate must increase when

the productivity grows in the non-traded goods sector. The opposite is true when wage elasticity of labour supply is positive but less than what corresponds to the peak of the Laffer-curve. Higher productivity in the traded goods sector may now allow tax rate reduction when the wage independent net non-tax revenue is positive. This requires that the expansionary effect on the tax bases dominates the negative budget effect of a higher wage rate.

4. The Laffer-curve peaks at $\hat{l}_\omega = \frac{1-t_L}{t_L+t_C}$. This implies that the higher are the tax rates, the smaller must the positive labour supply elasticity be for the economy to be on the rising part of the Laffer-curve. For economies with relatively high tax rates, such as the Scandinavian welfare states, the peak of the Laffer-curve is reached for an uncompensated wage elasticity that is too close to the typical estimates to be disregarded as a theoretical curiosity.

5. The simulations on a CGE model of the Norwegian economy demonstrate that the price effect of endogenous wage adjustment is significantly more important than the labour supply effect. The uncompensated labour supply elasticity is here set to 0.1, in accordance with econometric studies of labour supply in Norway. However, this may change in the future as the increase in the old-age dependency ratio requires higher tax rates, cf. point 4.

6. Higher TFP in all private industries has an adverse fiscal effect in our simulations. When TFP is raised by 10 percent in traded goods sectors accounting for 6.6 percent of total gross production value (in 2005), the payroll tax rate must be raised from 31 to 32.5 percentage points in 2050. If the same TFP shift takes place in a non-traded goods sector of the same size, the corresponding increase in the payroll tax rate is only 1/3, i.e. 0.5 percentage points.

The strength of the fiscal effect of wage rate adjustments is likely to differ significantly between countries and over time, because it depends on both the magnitude of the change in the wage rate, as well as the initial wage dependency of the various budget components. Norway represents a very special case, foremost because of large government petroleum revenues. Moreover, the wage dispersion is relatively low and constant, the government employed as much as 27 percent of total man-hours in 2005, and government welfare transfers, including public pension entitlements, are generous and indexed to wages. The fiscal policy adopted since 2001 allows a substantial deficit of wage dependent government net revenues. In countries where both the government and the economy as a whole must serve substantial debt, wage dependent government net revenues may be positive. In such countries productivity growth will, *cet. par* reduce the necessary tax rates.

Higher productivity in the form discussed in this paper is manna from heaven. By definition, it allows improved average welfare in the countries experiencing it. The possible adverse fiscal effect of productivity growth does not change this. None of the conclusions in this paper are normative. But although productivity growth makes life easier for the average person, it is an important policy lesson that politicians cannot rely on growth to solve fiscal sustainability problems.

In most developed economies the service sector has absorbed an increasing share of the factor supplies over several decades. Traditionally, services have been regarded as less mobile internationally than manufactures and primary products. The conclusions in this paper suggest that this trend has contributed to mitigate the adverse fiscal effects of productivity growth, compared to a hypothetical more balanced sectoral growth path. However, globalization has increased international trade in services. *Cet. par.*, this makes the fiscal effect of productivity shifts in the T-sector more relevant for the aggregate picture.

It should be stressed that the conclusions above are confined to fiscal effects of productivity shifts in the private business sector. Obviously, productivity growth in government service production can improve the fiscal stance if it is used to reduce costs. However, as explained in Holmøy (2006) the general equilibrium adjustment of the wage rate may reduce the scope for tax rate reductions significantly compared to a naive estimate ignoring price effects. In this paper the assumptions of no productivity growth in the government sector has been made in order to highlight the more complex fiscal effects of productivity shifts in the private sectors. However, according to the hypothesis underlying the term "Baumol's Disease", the technological scope for productivity improvements is on average significantly lower in the service production typically provided by the government than in other sectors.

From a policy perspective the wage dependency of government cash transfers is the most disputable, and therefore the most interesting, link between productivity growth and fiscal sustainability. Full wage indexation implies that the relative material living standards between employed and unemployed individuals are maintained. The additional income earned by more productive workers are also shared by those who do not take part in the productivity improvement. Wage indexation of cash transfers are more common in the Nordic countries with a stronger tradition for equity than in e.g. the US and the UK, where price indexation of income replacement schemes is more usual. Less generous indexation seems to be a typical cost saving element in the wave of public pension reforms. For example, the proposed reform of the Norwegian public pension system includes a less

generous indexation than the present wage indexation.[5]

Since the fiscal effects of general equilibrium repercussions are likely to be highly country specific, relevant CGE models seem to be the appropriate tool for assessing the fiscal effects of productivity based growth. Probably, model based estimates will also be more respected by the public than more simple estimates, despite some loss of transparency. In light of both the possible magnitudes of the general equilibrium effects, and the unpopular fiscal policy decisions facing ageing economies, such as cost saving public pension reforms, it seems important to provide such a common understanding of the basic determinants of the future tax burden.

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[5] The Norwegian pension reform proposal suggests that the annual old-age pension benefit should be indexed by an unweighted average of the wage growth and the growth in the consumer price index. As long as wage indexation of the pension entitlements prevail, such a re-indexation in itself does not reduce the total government pension expenditures, since it affects only the time profile of the benefits; given that the average expected present value of benefits equal the average entitlements, the first-year benefit has to increase to compensate for lower growth in the benefits. However, in the Norwegian reform proposal the new indexation rule has a cost saving effect, since the first-year old age benefit (for a personal with maximum entitlements) is not supposed to change from the current system.

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Appendix 1: How the consumption tax base depends on productivity

The point of departure is the model with exogenous labour supply in Section 2. The base of the consumption tax can be written as

$$C_T + P_N C_N = \left(P_N^{\sigma} + P_N\right) C_N. \tag{22}$$

By appropriate substitutions into the labour market equilibrium condition, the solution for C_N is:

$$\begin{aligned} L_T + L_N &= L - L_G \Leftrightarrow \frac{C_T - O}{A_T} + \frac{C_N}{A_N} = L - L_G \Leftrightarrow \\ \frac{P_N^\sigma C_N}{A_T} + \frac{C_N}{A_N} &= L - L_G + \frac{O}{A_T} \Leftrightarrow \\ C_N &= \frac{A_T (L - L_G) + O}{P_N^\sigma + P_N}, \end{aligned} \tag{23}$$

where we have used that the national trade balance constraint, $C_T = A_T L_T + O$, follows from adding the two budget constraints yields. (When $= A_T = A_N = 1$ initially, $C_N = \frac{L - L_G + O}{2}$ due to symmetric preferences.) Using this expression for C_N, the equilibrium consumption tax base becomes:

$$C_T + P_N C_N = (P_N^\sigma + P_N) \left[\frac{A_T (L - L_G) + O}{P_N^\sigma + P_N} \right] = A_T (L - L_G) + O, \tag{24}$$

which is independent of A_N.

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