Taxation and Economic Performance: A Cross-Country Comparison and Model Sensitivity Analysis

by

Jing Xu*

Department of Finance, Canada

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Résumé

Cet article est un complément au modèle de croissance endogène à deux secteurs avec dépenses gouvernementales et taxation qui a été élaboré par Xu en 1997. Cet article étudie notamment la sensibilité des résultats du modèle de Xu aux paramètres de préférences, de technologies et de politiques.

Les paramètres politiques sont les taux de taxation sur les revenus en capital, les revenus du travail et les ventes ainsi que les pourcentages de recettes fiscales affectées aux diverses catégories de dépenses gouvernementales. Afin d'évaluer comment ces paramètres modifient l'impact d'un changement dans la politique de taxation sur la croissance économique, cet article compare les effets des taxes sur la croissance de trois économies ayant des structures fiscales différentes. Par exemple, l'économie canadienne a un taux relativement élevé de taxation sur les revenus en capital mais des taux de taxation peu élevés sur les revenus du travail et les ventes tandis que l'économie française a des taux d'imposition relativement élevés sur les revenus du travail et les ventes mais un taux d'imposition peu élevé sur les revenus en capital. Par contre, l'économie suédoise a des taux d'imposition élevés sur les revenus en capital, les revenus du travail et les ventes. Ces structures fiscales représentent les trois cas typiques des structures fiscales des pays de l'OCDE.

Parmi les rares articles qui étudient la sensibilité des résultats de simulations aux paramètres de préférences et de technologies, le plus connu est celui de Stokey et Rebelo (1995). Ces auteurs évaluent quatre modèles de croissance endogène avec taxes, et concluent que les parts des facteurs de production, les taux de dépréciation, les élasticités de substitution intertemporelle, et l'élasticité de l'offre de travail sont tous importants pour déterminer les effets de la croissance sur la réforme de la fiscalité.

Le modèle de Xu (1997) se distingue par le fait qu'il considère les investissements des secteurs privé et public comme des intrants dans les technologies de production du capital physique et humain et qu'il a une structure fiscale beaucoup plus détaillée que celle des autres modèles existants dans la littérature. Il est donc important de connaître si les résultats quantitatifs du modèle sont sensibles aux paramètres et à ces caractéristiques particulières.

Cet article démontre que les taux de taxation et les rapports dépenses/revenus gouvernementaux modifient l'impact économique d'un changement dans la politique de taxation. Parmi les autres paramètres importants qui modifient cet impact, il y a l'élasticité de substitution intertemporelle, les taux de dépréciation du capital physique et humain et les coefficients des intrants privés et publics dans les fonctions de production. En particulier, la part du capital physique dans le secteur du capital humain est celui qui a le plus de répercussions sur les résultats quantitatifs.

Les résultats des simulations pour les trois économies suggèrent que la taxe sur les revenus en capital est plus distortionnaire que ceux de la taxe sur les revenus du travail ou ceux de la taxe de vente et que la taxe de vente est la moins distortionnaire. Ce classement est conforme à celui du résultat standard que l'on retrouve dans les ouvrages sur la croissance néoclassique. Les résultats mettent aussi l'accent sur l'importance de modéliser les répercussions des changements fiscaux sur les dépenses gouvernementales. Il est tout particulièrement à noter que l'impact des changements fiscaux sur les revenus du gouvernement et la façon dont ces revenus sont utilisés peuvent avoir d'importantes conséquences sur les résultats. Les réductions des dépenses gouvernementales dans le secteur produisant le capital humain ont les effets à long terme les plus négatifs sur la croissance.

Abstract

This paper is a companion to the two-sector, computable endogenous growth model of government spending and taxation developed by Xu (1997). This paper studies the sensitivity of the results to the model's preference, technology, and policy parameters.

The policy parameters are the capital and labour income tax rates, the sales tax rate, and the percentages of total tax revenue used for different types of government spending. To see how different values of these parameters affect the way changes in tax policy influence growth, the paper compares the effects of taxes on growth in three economies with different tax structures. The Canadian economy has a relatively high capital income tax rate with low labour income tax and sales tax rates, the French economy has relatively high labour income and sales tax rates with low capital income tax rate, and the Swedish economy has high capital and labour income tax with high sales tax rate. Each of these countries' tax structures is a representative type among OECD countries.

Of the few papers that study the sensitivity of model results to preferences and technology parameters in the endogenous growth literature, the best known is by Stokey and Rebelo (1995). They assessed four endogenous growth models with taxes and found that factor shares, depreciation rates, the elasticity of intertemporal substitution, and the elasticity of labour supply are important for determining the growth effects of tax reform.

The Xu (1997) model is distinctive: it includes private and public investments as inputs to the physical and human capital production technologies, and considers more taxes and expenditure types than other studies in the literature. Therefore, it is important to know whether the model's quantitative results are sensitive to these unique features and parameter values.

This paper finds that a country's tax rates and expenditure/revenue ratios have an impact on the growth effects of tax policy changes. Other critical parameters important for determining growth effects include the elasticity of intertemporal substitution, depreciation rates of physical and human capital, the coefficients of private inputs, and aggregate public inputs in private production. In particular, the physical capital share in the human-capital sector has the most impact on the quantitative results.

The simulation results for the three economies suggest that the capital income tax is more distorting than either labour income or sales taxes, and the sales tax is the least distorting. This ranking is consistent with the standard result in the neo-classical growth literature. The results also emphasize the importance of modelling the impacts of tax changes on government expenditure. In particular, the revenue effects of tax changes and the use to which the revenue is put can have important implications for the results, with spending reductions in the human capital sector having the most negative long-run growth effects.

1. Introduction

Xu (1997) developed a computable endogenous growth model of government spending and taxation, and applied it to the Canadian economy. As a companion piece, this paper studies the sensitivity of the results to the model's preference, technology, and policy parameters, so as to judge the robustness of the model's simulation results.

These policy parameters are the capital and labour income tax rates, sales tax rate and percentages of total tax revenue used for four types of government spending. The model groups all taxes into one of these three categories:

1. capital income: tax rate defined as personal and corporate taxes paid on capital income as a per cent of overall profits,
2. labour income: tax rate defined as the sum of wage income taxes and payroll taxes (social security contributions) as a per cent of total labour compensation,
3. sales: tax rate defined as value-added, sales, and excise taxes as a per cent of pre-tax expenditure.

The model includes four types of government spending:

1. lump-sum transfers to households,
2. final goods sector-specific spending (such as government expenditures on resource conservation and industrial development),
3. human capital sector-specific spending (such as government expenditures on health, education, recreation and culture, and research establishments), and
4. pure public spending (such as expenditures on protection of persons and property, transportation, communications, environment, and regional planning and development).

To see how different tax/expenditure structures influence the growth effects of tax/expenditure policy changes, this paper compares the growth effects of taxes across three economies. These three economies have different tax structures characterized by:

1. relatively high capital income tax rate and low labour income and sales tax rates (represented by the Canadian economy),
2. relatively high labour income and sales tax rates and a low capital income tax rate (represented by the French economy), and
3. high capital, labour income and sales tax rates (represented by the Swedish economy).

Our results of the growth effects of various balanced-budget tax/expenditure changes in the three economies have been used by the OECD Secretariat, and included in the Secretariat 1997 document "Taxation and Economic Performance".

1.1 Overview of the Literature

Of the few papers that have studied the sensitivity of model results to preferences and technology parameters, the best known is by Stokey and Rebelo (1995). Their work is motivated by the wide range of estimates of potential growth effects from tax reform. Lucas

(1990), for example, finds that eliminating capital taxes and raising labour taxes in a revenue-neutral way would change the steady-state U.S. growth rate by only 0.03 of a percentage point. Stokey and Rebelo (1995), who modified the Lucas model with inelastic labour supply, estimate that eliminating all distorting taxes would not affect long-run growth. In contrast, Jones, Manuelli, and Rossi (1993) conclude that eliminating all distorting taxes could raise the growth rate by eight percentage points. To determine why these results vary, Stokey and Rebelo (1995) assessed four endogenous growth models with taxes and found that factor shares, depreciation rates, the elasticity of intertemporal substitution, and the elasticity of labour supply are important for determining the growth effects of tax reform.

The Xu (1997) model extends the literature by including private and public investment as inputs to the physical and human capital production technologies. It also considers more taxes and expenditure types than other studies. Therefore, it is important to find out whether the quantitative results of the Xu (1997) model are sensitive to its unique features and parameter values. That is the focus of this paper.

1.2 Organization of this Paper

Section II briefly describes the model structure. Section III studies the growth effects of alternative tax and expenditure policies across the three economies. Section IV identifies critical parameters from the model’s unique preference and technology features, and also verifies the importance of the model's more general parameters that Stokey and Rebelo (1995) identified as critical. This section also compares the impacts on the results from all the critical parameters. Section V states conclusions and implications.

2. The Model

The model developed in Xu (1997) can be briefly described as follows. There are a constant, large number of identical, infinitely lived agents in the economy, and each agent is endowed with one unit of time in each period. The representative household supplies physical capital and effective labour (combining labour time and human capital), receives capital and labour income and government transfers, and pays sales, capital and labour income taxes. The household’s after-tax income finances its consumption as well as its physical and human capital investment. It obtains utility from final goods consumption, and leisure activity (using leisure time and human capital).

The representative household chooses goods, leisure, and investment based on the solutions of its optimisation problem:

$$\text{Max} \quad U = \sum_{t=0}^{\infty}(1+r)^{-t}\frac{\left[C_t^{w} L_t^{1-w}\right]^{1-s}}{1-s} \tag{1}$$

subject to

$$(1+t_t^{s})(C_t+I_t)+P_t I_t^{H} = (1-t_t^{r})r_t K_{t-1}+(1-t_t^{w})w_t(1-l_t)H_{t-1}+TR_t+p_t \tag{2}$$

$$K_t = I_t+(1-d_k)K_{t-1} \tag{3}$$

$$H_t = I_t^{H}+(1-d_H)H_{t-1} \tag{4}$$

where C_t is consumption per capita at time *t* (the only consumption good is measured in units of final output), and L_t is leisure activity. The parameter σ is the reciprocal of the intertemporal elasticity of substitution, ρ is the positive and constant rate of time preference, and ω is a utility function weight parameter that satisfies $0 < w < 1$.

Equation (2) is the household's budget constraint, equation (3) is its physical and (4) its human capital accumulation constraints. In these constraints, t_t^s, t_t^r, and t_t^w are sales, capital income and labour income tax rates in period *t*; P_t is the relative price of human capital in terms of final goods, and r_t and w_t are gross of tax real rates of return on capital and effective labour. TR_t is government transfers, and p_t denotes profits that the household receives from firms. The depreciation rates of physical and human capital d_k and d_H are assumed to be constant over time. Physical and human capital investments in period *t* are denoted as I_t and I_t^H, respectively.

The leisure activity in the utility function is described by the following function:

$$L_t = l_t H_{t-1}^e \tag{5}$$

where l_t is the household's raw time of leisure and H_{t-1} its human capital stock accumulated by the end of period t-1 that is available for period t activities. When $e = 0$, the leisure activity is simply raw leisure time; when ε >0, the leisure activity is quality time associated with human capital.

The government levies a capital income tax, a labour income tax, and a sales tax. The revenue generated at the end of period *t* finances lump-sum transfers to households in the same period, as well as three types of investments that generate final goods sector-specific spending, human capital sector-specific spending, and pure public spending that will be used for period *t+1* production. Examples of pure public spending include expenditures on protection of persons and property, transportation, communications, environment, and regional planning and development. Final goods sector-specific spending is government expenditures on resource conservation and industrial development. Government expenditures on health, education, recreation and culture, and research establishments are examples of human capital sector-specific spending.

The government budget constraint at t is given by:

$$I_{G_I t} + I_{G_H t} + I_{Gt} + TR_t = t_t^s(C_t + I_t) + t_t^r r_t K_{t-1} + t_t^w w_t (1 - l_t) H_{t-1} \equiv GR_t \tag{6}$$

where GR_t denotes total government tax revenue generated at the end of period *t*. $I_{G_I t}$, $I_{G_H t}$ and I_{Gt} are government investments in the form of sector-specific spending on final goods, human capital, and pure public spending, respectively.

Each type of government investment takes a fraction of the total tax revenue. Define $I_{G_I t} = l_{It} GR_t$, $I_{G_H t} = l_{Ht} GR_t$, and $I_{Gt} = l_{Gt} GR_t$, where $0 \le l_{It} < 1$, $0 \le l_{Ht} < 1$, $0 \le l_{Gt} < 1$, and $0 \le l_{It} + l_{Ht} + l_{Gt} \le 1$.

The laws of motion of the three types of government capital are as follows:

$$G_{It} = I_{G_I t} + (1 - d_{G_I})G_{It-1} \tag{7}$$

$$G_{Ht} = I_{G_H t} + (1 - d_{G_H})G_{Ht-1} \tag{8}$$

$$G_t = I_{Gt} + (1 - d_G)G_{t-1} \tag{9}$$

where d_{G_I}, d_{G_H}, and d_G are the constant depreciation rates of the corresponding capital stocks.

There are two production sectors:

1. the *final-goods sector*, which uses capital, effective labour, pure public spending, and final-goods sector-specific spending to produce final goods for consumption and physical investment; and
2. the *human-capital sector*, which uses capital, effective labour, pure public spending, and human-capital sector-specific spending to produce new human capital.

The technology of the human-capital sector is given by the following equation:

$$Y_t^H = A_H \left[(1 - f_t)K_{t-1}\right]^{1-a-b} \left(G_{Ht-1}^{x} G_{t-1}^{1-x}\right)^{a} \left[(1 - l_t - N_t)H_{t-1}\right]^{b} \tag{10}$$

where A_H is a technology parameter, f_t is the market proportion of total physical capital stock used to produce final goods in period t, N_t is the hours spent on final goods production, α is the coefficient of total public spending (in terms of final goods) provided to human capital production, ξ is the coefficient of human-capital sector-specific public capital, and β is the coefficient of effective labour in this sector.

The production function of the final-goods sector is:

$$Y_t^I = A_I \left(f_t K_{t-1}\right)^{1-h-g} \left(G_{It-1}^{q} G_{t-1}^{1-q}\right)^{h} \left(N_t H_{t-1}\right)^{g} \tag{12}$$

where A_I is a technology parameter, η is the coefficient of total public services (in terms of final goods), θ is the coefficient of final-goods sector-specific public capital, and γ is the coefficient of effective labour in the sector.
All the markets are assumed to be perfectly competitive. Producers in each sector make their production decisions to maximise profits. GDP in this economy is defined as total final output. The competitive equilibrium solutions can be obtained as in Xu (1997).

3. Tax Policy Regimes and Economic Growth: an Cross-Country Comparison

3.1 Parameter values and calibrated benchmark cases

This section examines the dynamic effects of balanced-budget tax and expenditure changes in Canada, France and Sweden, as representative types among OECD countries. Canada has relatively high capital income tax and low labour income tax and sales tax rates, while France has relatively high labour income and sales tax rates and a low capital income tax rate, and Sweden has high rates of all three taxes.

The capital income tax rate is defined as personal and corporate taxes paid on capital income as a per cent of overall profits. The labour income tax rate is the sum of wage income taxes and payroll taxes (social security contributions) as a per cent of total labour compensation. The sales tax rate is defined as value-added, sales, and excise taxes as a per cent of pre-tax expenditure.

The following simulations investigate how the growth rate of GDP, the rate of return on capital, private consumption and savings, and the physical and human capital stocks behave along dynamic transitions.

The policy regimes considered here include:

1. balanced-budget shifts from one tax to another of 1 per cent of benchmark GDP per unit of human capital ($\overline{GDP}$),
2. a 1 per cent of benchmark $\overline{GDP}$ cut in each tax accompanied by balanced-budget cuts in each initial individual spending category, respectively, and
3. a 1 per cent of benchmark $\overline{GDP}$ cut in each tax accompanied by cutting initially all the three types of spending by the same proportion, which maintains a balanced budget.

In the tax shift experiments, one tax rate is permanently reduced, while another is permanently increased, with subsequent adjustments in government spending to maintain a balanced budget. Thus spending may ultimately rise or fall, depending on induced revenue effects. In the other experiments, a tax rate is permanently lowered, while the initial spending in a given category (or all categories) is reduced so that the category (or categories) bears the initial burden of maintaining a balanced budget. If the ultimate induced revenue effect is positive, government spending will be higher in the long run. Since government spending can affect growth, these channels can be important.

The parameter values used for the simulations are presented in Table 3.1 which gives taste and technology parameters and Table 3.2 which shows policy parameters including tax rates and percentages of government expenditures on different functions. The policy parameters are calculated based on 1994 data. Xu (1997) explains the methodology.

Goods consumption is assumed to take a weight of 2/3 in the utility function, with the rest going to leisure activity. The share parameters of effective labour in both sectors are 2/3. Government capital is assumed to depreciate at the same rate as private physical capital.

Table 3.1. Taste and Technology Parameters

Variable		Canada	France	Sweden
ρ	rate of time preference	0.012	0.012	0.012
$1/\sigma$	intertemporal elasticity of substitution	0.55	0.55	0.68
ε	leisure quality parameter	0.15	0.15	0.15
ω	utility function weight	2/3	2/3	2/3
A_I	final-goods sector productivity	0.34	0.44	0.33
A_H	productivity of human-capital sector	0.55	0.54	0.545
d_K	depreciation rate of physical capital	0.07	0.062	0.055
d_H	depreciation rate of human capital	0.055	0.058	0.053
d_G	depreciation rate of government capital	0.07	0.062	0.055
γ	coefficient of effective labour in the final-goods sector	2/3	2/3	2/3
β	coefficient of effective labour in the human-capital sector	2/3	2/3	2/3
α	coefficient of aggregated public capital in the human-capital sector	0.25	0.25	0.25
η	coefficient of aggregated public capital in the final-goods sector	0.11	0.11	0.11
θ	coefficient of sector-specific public capital in the final-goods sector	0.55	0.55	0.55
ξ	coefficient of sector-specific public capital in the human-capital sector	0.75	0.75	0.75

Table 3.2. Tax Rates and Percentages of Government Spending

Variable		Canada	France	Sweden
t_r	capital income tax rate	0.46	0.24	0.49
t_w	labour income tax rate	0.29	0.45	0.48
t_s	sales tax rate	0.10	0.18	0.23
l_I	proportion of government spending in final-goods sector	0.04	0.03	0.10
l_H	proportion of government spending in human-capital sector	0.19	0.17	0.21
l_G	portion of pure public spending	0.18	0.19	0.15

Most taste and technology parameters for Canada, including the rate of time preference, the intertemporal elasticity of substitution, the human capital depreciation rate, the two sectors' productivity, and the coefficients α, η, θ and ξ, are calibrated to generate a steady-state growth rate of 2.64 percent, a gross rate of return on capital of 19 percent, a private consumption over GDP ratio of 0.67, and a private investment over GDP ratio of 0.14. These are very close to the observed values for the Canadian economy in1994[1].

Since the focus of this paper is on the growth effects of taxation across three economies with different tax structures, the taste and technology parameters used for simulating the French and Swedish economies are kept as close as possible to the Canadian values. In particular, the rate of time preference, the coefficient of human capital in leisure activity that generates quality time leisure, and the weights on consumption and leisure in the households' utility function are the same in the three economies. On the supply side, the coefficients of inputs are the same across all three economies. The remaining parameters for the French and Swedish economies are calibrated to generate long-run growth rates and private consumption and investment to GDP ratios that reflect the observed values in the 1994 French and Swedish economies. The benchmark steady-state growth rates are 2.24 per cent for France and 2.3 per cent for Sweden. In Sweden, higher average tax rates lead to a higher calibrated intertemporal elasticity of substitution.

Table 3.3 presents the benchmark values of growth rates, the gross rates of return on capital, and the ratios of private consumption and investment to GDP in the three economies.

Table 3.3. Benchmark Growth Rate, Rate of Return on capital, Private Consumption/GDP Ratio and Private Investment/GDP Ratio

Values	Canada	France	Sweden
Growth rate	0.0264	0.0224	0.02304
Rate of return on capital	0.1900	0.1511	0.1834
Private consumption to GDP ratio	0.6700	0.6200	0.5600
Private investment to GDP ratio	0.1400	0.1450	0.1100

In all the simulation exercises, a permanent fiscal policy change is announced at the beginning of period 1 (year 1), and executed in that period. When a change in a distorting tax is announced, the producers in each sector adjust their market demand for physical and human capital accordingly. This affects the output of final goods and human capital that will be invested in future human capital production. The input adjustment also affects both the gross and after-tax net rate of return on capital, which influence households' consumption and saving decisions. The after-tax net rate of return on capital is a key determinant of growth. The rate of return on capital can be further affected by changes in productive government spending.

3.2 Simulation results

Table 3. summarizes the simulation results from examining fifteen tax and expenditure policy experiments for each country. The growth rate effects of each policy change are represented by the percentage point difference between the growth rate at each point in time, and the benchmark steady-state growth rate.

[1] The user cost of capital in Canada is estimated to be 18 percent. The observed ratios of private consumption to GDP and of private investment to GDP are 0.60 and 0.15, respectively.

3.3 Fifteen cross-country comparisons

(1) shift from capital income tax to sales tax

The transitional dynamics of the three economies can be described as follows. A lower capital income tax rate encourages households to invest. The final-goods sector thus grows much faster than the human-capital sector, although both physical and human capital stocks continue to grow. Higher capital and labour incomes boost total government revenue. Given the fixed proportions of government spending, each spending category also increases. In the long run, the marginal product of capital falls, which stimulates human capital production and investment. Some resources move from the final-goods sector to the human capital sector. As a result, the new steady-state growth rate is lower than the medium-term GDP growth rate, but higher than the benchmark growth rate.

The growth impacts are smallest for France and greatest for Sweden, because the French capital income tax rate is the lowest, and its sales tax is higher than that in Canada. Accordingly, the benefit of the tax shift is smaller. Since the Swedish capital income tax rate is the highest, lowering the tax rate benefits its economy most. The positive growth impact of a lower capital income tax rate strongly dominates the negative impact of a higher sales tax, even though the Swedish sales tax rate is also the highest of the three countries. Moreover, model calibration based on Swedish data suggests a larger intertemporal elasticity of substitution than for the other two economies. The tax shift would thus boost Swedish growth most.

(2) shift from capital income tax to labour income tax

The transitional dynamics are similar to the first case, except that the growth slowdown occurs later, because human capital investment is discouraged by the higher labour income tax rate. The resource reallocation from the final-goods sector to the human-capital sector is delayed.

Since France has higher labour income tax and lower capital income tax rates than Canada, the transitional growth gains are smaller in France than in Canada. In Sweden, the capital income tax rate reduction provides strong incentives to invest, and has a large positive impact on economic growth. However, this tax shift discourages human capital accumulation. Overall, the positive effect dominates.

(3) shift from labour income tax to sales tax

A lower labour income tax rate leads to increased labour supply and human capital investment, while a higher sales tax negatively affects households’ demand for final goods. Thus the human capital stock grows faster. The increased labour supply and human capital stock raise the marginal product of physical capital, which encourages investment. Final output then grows faster. Faster capital stock growth drives down its marginal product, so that some resources move to human capital production, and final output growth eventually slows slightly.

Table 3.4. Long-Run Real GDP Growth Rate Impacts of Alternative 1 per cent of $\overline{GDP}$ Tax/Expenditure Shifts (Percentage Point Difference)

Policy Change	Country	Year 10	Year 30	New steady state
(1) Shift from capital to sales taxes	Canada	*0.0344*	*0.0311*	*0.0302*
	France	*0.0311*	*0.0265*	*0.0253*
	Sweden	*0.0768*	*0.0519*	*0.0481*
(2) Shift from capital to labour taxes	Canada	*0.0065*	*0.0127*	*0.0116*
	France	*0.0015*	*0.0091*	*0.0076*
	Sweden	*0.0674*	*0.0665*	*0.0631*
(3) Shift from labour to sales taxes	Canada	*0.0412*	*0.0404*	*0.0406*
	France	*0.0611*	*0.0599*	*0.0602*
	Sweden	*0.0479*	*0.0548*	*0.0561*
(4) Cut in capital taxes and initial pure public goods spending	Canada	*0.0139*	*0.0126*	*0.0113*
	France	*0.0166*	*0.0196*	*0.0185*
	Sweden	*0.0555*	*0.0558*	*0.0546*
(5) Cut in capital taxes and initial human capital spending	Canada	*0.0148*	*0.0037*	*0.0031*
	France	*0.0105*	*0.0143*	*0.0138*
	Sweden	*0.0396*	*0.0539*	*0.0536*
(6) Cut in capital taxes and initial transfers	Canada	*0.0360*	*0.0406*	*0.0395*
	France	*0.0249*	*0.0331*	*0.0318*
	Sweden	*0.0391*	*0.0436*	*0.0412*
(7) Cut in capital taxes and all initial public spending	Canada	*0.0267*	*0.0267*	*0.0256*
	France	*0.0208*	*0.0265*	*0.0253*
	Sweden	*0.0443*	*0.0480*	*0.0466*
(8) Cut in labour taxes and initial pure public goods spending	Canada	*0.0149*	*-0.0006*	*-0.0024*
	France	*0.0519*	*0.0382*	*0.0370*
	Sweden	*0.0537*	*0.0370*	*0.0339*
(9) Cut in labour taxes and initial human capital spending	Canada	*0.0701*	*-0.0313*	*-0.0317*
	France	*0.1235*	*0.0317*	*0.0310*
	Sweden	*0.1327*	*0.0611*	*0.0576*
(10) Cut in labour taxes and initial transfers	Canada	*0.0840*	*0.0773*	*0.0771*
	France	*0.1295*	*0.1166*	*0.1159*
	Sweden	*0.1459*	*0.1310*	*0.1299*
(11) Cut in labour taxes and all initial public spending	Canada	*0.0588*	*0.0389*	*0.0371*
	France	*0.1018*	*0.0802*	*0.0781*
	Sweden	*0.1133*	*0.0920*	*0.0892*
(12) Cut in sales taxes and initial pure public goods spending	Canada	*-0.0307*	*-0.0424*	*-0.0444*
	France	*-0.0177*	*-0.0232*	*-0.0244*
	Sweden	*-0.0116*	*-0.0221*	*-0.0247*
(13) Cut in sales taxes and initial human capital spending	Canada	*-0.0032*	*-0.0660*	*-0.0661*
	France	*0.0012*	*-0.0436*	*-0.0435*
	Sweden	*0.0151*	*-0.0212*	*-0.0223*
(14) Cut in sales tax and initial transfers	Canada	*0.0216*	*0.0219*	*0.0215*
	France	*0.0214*	*0.0228*	*0.0223*
	Sweden	*0.0268*	*0.0264*	*0.0256*
(15) Cut in sales taxes and all initial public spending	Canada	*0.0037*	*-0.0074*	*-0.0089*
	France	*0.0084*	*0.0021*	*0.0007*
	Sweden	*0.0159*	*0.0085*	*0.0068*

Canada experiences the smallest growth gains along the transitional path because its original labour income tax rate is much lower than those of France and Sweden. Since Sweden has the highest sales tax rate, any further increases generate a stronger negative growth impact that offsets part of the positive impact of a lower labour income tax rate. Sweden's growth gains are thus smaller than those in France.

(4) cut in capital income tax, accompanied by a pure public spending cut

Although cutting public spending has negative impacts on production in both sectors, the higher after-tax rate of return stimulates investment. As a result, the GDP growth rate increases. Subsequent dynamics are as in case 3.

Because of their different tax structures, a 1 per cent of $\overline{GDP}$ cut in France implies a larger percentage decrease in the capital income tax rate than in Canada. The tax cut increases the Swedish growth rate most.

(5) cut in capital income tax, accompanied by a human capital sector-specific spending cut

The transitional dynamics for the three countries have the same patterns as case (4).

(6) cut in capital income tax, accompanied by a lump-sum transfer cut

The transitional dynamics are similar to cases (4) and (5), except that the increase in the new steady-state growth rate is larger, because cutting transfers has no negative impacts on private production; while cutting either of the other two types of spending negatively affects long-run growth.

The higher a country's initial capital income tax rate, the greater the effect of a given tax reduction.

(7) cut in capital income tax, accompanied by the same proportional cut in all the types of government spending

The transitional dynamics are a mix of cases (4),(5) and (6). In particular, after some periods of faster GDP growth, the positive growth impact of the tax cut, supported by cutting transfers, offsets the negative growth effects of the productive spending cut. The growth rate increments are smallest in France and largest in Sweden.

(8) cut in labour income tax, accompanied by a pure public spending cut

A lower labour income tax encourages more effective labour supply. Given limited hours available for work, this is achieved by increasing human capital investment.
Higher effective labour supply growth raises the marginal product of capital, which boosts households' incentives to invest. More resources are used to produce final goods, and GDP growth increases. However, the rate of return on capital ultimately falls below the benchmark level, and steady-state growth is slightly lower than the benchmark case.

Despite similarities across the transitional dynamics of the three economies, their different tax structures lead to very different long-run effects. Both France and Sweden have higher labour income tax rates than Canada. The tax cut raises their long-run growth, but lowers it in Canada.

(9) cut in labour income tax, accompanied by a human capital sector-specific spending cut

The transitional growth rate swings around the benchmark rate are larger than in case (8) because of the reduction in human-capital sector-specific spending. In particular, while a lower labour income tax rate encourages human capital accumulation, the spending cut lowers the marginal products of both capital and effective labour. As increasing effective labour in the final goods sector raises the rate of return on capital, a larger proportion of total resources than in case (8) is used to produce final goods.

(10) cut in labour income tax, accompanied by a lump-sum transfer cut

This case follows a similar pattern, except that transitional Canadian growth rates are always higher than in the benchmark case, because the transfer cut has no negative impact on production. The growth gains are still the largest for Sweden and smallest for Canada, due to their different tax rates.

(11) cut in labour income tax, accompanied by the same proportional cut in all the types of government spending

The transitional dynamics in this case are a mix of cases (8), (9) and (10). In particular, after some periods of faster GDP growth, the positive impact of the tax cut on growth dominates the negative growth effects of the other spending cuts. The percentage point difference between the new and the benchmark steady states is not as large as in case (10), where there is no productive spending cut.

(12) cut in sales tax, accompanied by a pure public spending cut

The cut in public spending negatively affects the production of final goods and of new human capital. These negative effects dominate the positive growth effect of a lower sales tax. Transitional and steady-state GDP growth is thus lower for all three economies. The negative impacts on growth of the tax cut are the strongest in Canada, where the initial sales tax is the lowest among the countries considered.

(13) cut in sales tax, accompanied by a human capital sector specific spending cut

Although the Canadian transitional patterns are similar to case (12), the absolute magnitudes of growth rate changes differ, owing to the different choice of spending cuts. Since cutting human-capital sector-specific spending discourages human capital accumulation, it indirectly affects GDP growth through its impact on the effective labour input in final goods production. In contrast to case (12), where the spending cut directly affects final goods production, and the negative impact on human capital accumulation is not as strong, the growth decline in this case is initially relatively small, although larger in the long run.

The tax cut encourages investment and stimulates final goods production for both France and Sweden, which have higher sales tax rates than Canada. The net impact on growth is positive in the early stage of the transition, however, as in the case of Canada, the human-capital sector-specific spending cut discourages human capital accumulation. This has indirect long-term negative effects on GDP growth through its impact on the effective labour input in final goods production. Long-run growth falls most in Canada where the initial sales tax rate is the lowest, and least in Sweden, where the initial tax rate is the highest.

(14) cut in sales tax, accompanied by a lump-sum transfer cut

Since the transfer cut does not have the negative impacts of the other spending cuts, the result is faster GDP growth. The higher the initial sales tax rate, the larger the growth gain.

(15) cut in sales tax, accompanied by the same proportional cut in all the types of government spending

The transitional dynamics in this case are a mix of cases (12), (13) and (14). In Canada, the negative effects of cutting productive spending slightly dominate the positive effects of a lower sales tax rate. In contrast, the positive effects dominate slightly in France and Sweden, where the initial tax rates are higher.

3.4 Overview of cross-country comparisons

Overall, all of the long-run growth rate impacts are small, many of them below 0.05 percentage point. The largest impact is a 0.13 percentage point increase in the Swedish long-run growth rate in the case of lowering the labour income tax rate and household transfers so as to maintain a balanced government budget. Note that as all policy experiments lead to permanent changes in the growth rate, they eventually lead to significant changes in the level of output.

Shifting from capital income to sales taxes raises long-run growth in all countries. The shift increases savings and hence the accumulation of claims on physical assets and income. Higher after-tax returns to physical capital initially depress human capital accumulation. However, this is more than offset by the fact that higher incomes generate increased government revenue, which can then be partly allocated to the human-capital sector, leading ultimately to higher human capital accumulation and growth. Shifting from capital to labour income taxes also raises long-run growth, but by less than the shift to sales taxes. This is because a higher labour income tax directly reduces the incentive to invest in human capital. The capital income tax and initial spending reduction scenarios raise long-run growth for all countries. The channels are similar to those for the shifts from capital to sales tax. Government spending is higher in the long run, owing to the revenue gains associated with increased accumulated savings.

The labour income tax and initial spending reduction scenarios lead to positive long-run growth effects for France and Sweden, where the initial labour income tax rates are high. However, the results are mixed for Canada, which has a relatively low initial labour income tax rate. Cutting sales taxes and initial spending leads to negative long-run growth effects in most cases. The analysis is similar to that of the previous cases, except that sales taxes are less distorting than labour income taxes, hence the net effects are generally more negative.

4. Model Sensitivity Analysis

This analysis checks the sensitivity of the results to alternative choices for key parameters, in order to determine whether the simulation results are robust. The parameterization for the Canadian economy is used for the analysis.

As mentioned in the introduction, Stokey and Rebelo (1995) assessed the sensitivity of growth effects to several parameters, including the elasticities of substitution in production, factor shares, the elasticity of labour supply, the depreciation rates of physical and human capital, and the intertemporal elasticity of substitution. They found that the critical parameters were factor shares, depreciation rates, the elasticity of intertemporal substitution, and the elasticity of labour supply.

The Xu model features not only those parameters but also six parameters that do not appear in the models studied by Stokey and Rebelo (1995). These are the leisure quality parameter, the utility function weight on consumption, the coefficients of aggregate public capital in the two sectors, and the coefficients on sector-specific public capital in the two sectors.

Section 4.1 identifies critical parameters that affect the simulation results by re-simulating the model with different values of each key parameter and comparing the growth effects of a given tax experiment under different parameter values. Section 4.2 studies model sensitivity to those critical parameters by re-calibrating the model with each given value of the critical parameter in question, to maintain the benchmark steady-state growth rate. This re-calibration generates a new value for the final goods sector productivity parameter, A_I. Each tax experiment is performed with each pair of values for the critical parameter and A_I. The growth rate changes over transitional dynamics, and in the new steady state are compared with the model's original results. The comparisons allow us to see how a critical parameter can change the model results in terms of both direction and quantity.

4.1 Identifying critical parameters that affect the simulation results

The identification method follows Stokey and Rebelo (1995). To see whether varying a parameter value has any impact on the simulation results, each tax experiment is conducted using a different value for the parameter, while keeping all the other parameters at their benchmark values.

The tax policy changes include shifts from one tax to another, and reductions in each tax accompanied by proportional balanced-budget cuts in all types of spending. Table 4.1 summarises the new steady-state growth rate impacts generated in the six experiments for different values of each parameter, compared with those of original model in Xu (1997).

Table 4.1 also shows that specifying leisure enjoyment in terms of human capital related quality time or raw time does not significantly affect the growth impacts of tax and spending changes. Similarly, the coefficients of sector-specific public capital in both sectors and the utility function weight on consumption do not significantly affect the results. However, the coefficients on aggregate public capital in both sectors (α and η) do significantly affect the results.

Table 4.2 shows growth rate impacts (i.e., percentage point differences between new steady-state growth rates and the benchmark growth rate), given alternative choices of the intertemporal elasticity of substitution ($1/\sigma$), the rate of time preference (ρ), depreciation rates of physical and human capital, the coefficient of effective labour in the human capital sector (β), and that in the final goods sector (γ), respectively. With the exception of ρ, each of these parameters is critical to the model's results. This is consistent with Stokey and Rebelo's findings.

Table 4.1 Steady-State Growth Rate Impacts in Model Versions with Alternative Values of Unique Parameters

Experiment	Original Model	Modified Version with $\varepsilon=0$	Modified Version with $\alpha=0.15$	Modified Version with $\xi=0.55$	Modified Version with $\theta=0.75$	Modified Version with $\eta=0.20$	Modified Version with $\omega=0.50$
Shift from capital to sales taxes	*0.0302*	*0.0297*	***0.0451***	*0.0301*	*0.0297*	***0.0323***	*0.0259*
Shift from capital to labour taxes	*0.0116*	*0.0095*	***0.0193***	*0.0116*	*0.0113*	***0.0018***	*0.0078*
Shift from labour to sales taxes	*0.0406*	*0.0428*	***0.0370***	*0.0405*	*0.0401*	***0.0469***	*0.0368*
Cut in capital tax and all public spending	*0.0256*	*0.0258*	***0.0499***	*0.0255*	*0.0251*	***0.0204***	*0.0235*
Cut in labour tax and all public spending	*0.0371*	*0.0419*	***0.0521***	*0.0370*	*0.0366*	***0.0296***	*0.0409*
Cut in sales tax and all public spending	*-0.0089*	*-0.0068*	***0.0102***	*-0.0089*	*-0.0088*	***-0.0175***	*-0.0034*

Table 4.2. Steady-State Growth Rate Impacts in Model Versions with Alternative Values of General Parameters.

Experiment	Original Model	Modified Version with $1/s = 0.35$	Modified Version with $r = 0.02$	Modified Version with $d_k = 0.10$	Modified Version with $d_H = 0.07$	Modified Version with $b = 0.5$	Modified Version with $g = 0.5$
Shift from capital to sales taxes	0.0302	***0.0220***	*0.0301*	***0.0280***	***0.0285***	***0.0364***	***0.0207***
Shift from capital to labour taxes	*0.0116*	***0.0066***	*0.0102*	***0.0079***	***0.0097***	***0.0130***	***0.0188***
Shift from labour to sales taxes	*0.0406*	***0.0324***	*0.0431*	***0.0402***	***0.0381***	***0.0256***	***0.0439***
Cut in capital tax and all public spending	*0.0256*	***0.0181***	*0.0251*	***0.0227***	***0.0237***	***0.0360***	***0.0266***
Cut in labour tax and all public spending	*0.0371*	***0.0288***	*0.0387*	***0.0365***	***0.0352***	***0.0310***	***0.0432***
Cut in sales tax and all public spending	*-0.0089*	***-0.0075***	*-0.0097*	***-0.0094***	***-0.0085***	***0.0029***	***-0.0012***

In sum, the seven critical parameters that are important for the model's results are the intertemporal elasticity of substitution, the depreciation rates of physical and human capital, the coefficients of effective labour in the two sectors, and the coefficients on aggregate public capital in both sectors.

4.2 Sensitivity of model solutions to changes in critical parameters

This section tests the sensitivity of the model's numerical results to the benchmark values of critical parameters identified in the previous section. The objective is to see the pattern and magnitude of a critical parameter's impact on the simulation results. The policy shock involved is a shift from the capital income tax to the labour income tax of 1 per cent of $\overline{GDP}$. The experiments adjust each critical parameter around its benchmark value in the calibrated Canadian economy.

As the value of one critical parameter (for example, σ) is changed, re-calibration of the model to maintain the benchmark steady-state growth rate generates a different value of the final-goods sector's productivity parameter, A_I. The experiment is performed on each pair of values for A_I and the critical parameter in question (the pair σ, A_I, for example). The new steady state and transitional growth impacts can then be compared with those from Table 3.4. The comparisons in Tables 4.3 to 4.9 record the impacts of changing each of the seven critical parameters, respectively. The growth rate impact is represented by the percentage point difference between the rate at each corresponding point of time and the original benchmark growth rate (i.e., 2.64 per cent in the Canadian case). The shaded line in each table presents the results obtained with the original parameter values given in Tables 3.1 and 3.2, and is provided here for comparison purpose.

Tables 4.3 to 4.5 show that the growth rate impact is even smaller with a lower intertemporal elasticity of substitution (1/σ), a higher depreciation rate of capital, and a lower depreciation rate of human capital. This is because the tax change increases the incentive to invest in physical capital, however, this extra incentive is smaller the lower the intertemporal elasticity of substitution. Both a higher depreciation rate in physical capital and a lower depreciation rate in human capital have offsetting effects on the investment incentives generated by the tax shift.

Table 4.3 Real GDP Growth Rate Impacts of Capital and Labour Income Tax Shift with Changing s

1/s	A_I	**Year 10**	**Year 30**	**New Steady State**
0.62	0.31	0.0070	0.0133	0.0122
0.58	0.33	0.0068	0.0130	0.0119
0.55	0.34	0.0065	0.0127	0.0116
0.51	0.36	0.0062	0.0123	0.0112

Table 4.4 Real GDP Growth Rate Impacts of Capital and Labour Income Tax Shift with Changing d_K

d_K	A_I	Year 10	Year 30	New Steady State
0.091	0.357	0.0085	0.0103	0.0094
0.084	0.352	0.0080	0.0110	0.0100
0.07	0.34	0.0065	0.0127	0.0116
0.056	0.328	0.0044	0.0148	0.0136

Table 4.5 Real GDP Growth Rate Impacts of Capital and Labour Income Tax Shift with Changing d_H

d_H	A_I	Year 10	Year 30	New Steady State
0.07	0.453	0.0084	0.0143	0.0131
0.06	0.376	0.0071	0.0133	0.0121
0.055	0.34	0.0065	0.0127	0.0116
0.044	0.274	0.0057	0.0115	0.0106

Tables 4.6 and 4.7 reveal a negative relationship between the long-run growth effects and the coefficients of effective labour and aggregate public capital in the human- capital sector (β and α). This is because a larger value for either coefficient implies a smaller coefficient of physical capital in the human capital production function. The net gain to the economy from the tax shift is hence smaller, as is the long-run growth gain. Similarly, a larger coefficient of aggregate public capital in the final-goods sector (η) implies a smaller coefficient of capital in the sector. The tax shift is thus less beneficial for output growth (Table 4.8).

The reaction of the growth effects to changes in the coefficient of effective labour in the final goods sector (γ) is more complicated, as shown in Table 4.9. A smaller γ, given η, implies a larger coefficient of physical capital in the final-goods sector. The growth gain from the tax shift that encourages savings and investment is larger in this case. However, for γ values larger than the original 2/3, there are other offsetting effects. On the one hand, an increased value of γ is associated with lower productivity and a smaller capital share in the final-goods sector, which reduces the rate of return on capital and has a negative impact on the growth gain. On the other hand, a higher γ raises the marginal productivity of physical capital, and boosts the growth gain. The net growth gain thus depends on the interaction of these offsetting effects. In particular, if γ is high enough (0.8 for example) so that the positive effect dominates, the growth gain is greater than in the original model; if the negative growth effect of a larger γ dominates, the growth gain is smaller, as in the case where γ equals 0.73.

Table 4.6 Real GDP Growth Rate Impacts of Capital and Labour Income Tax Shift with Changing b

b	A_I	Year 10	Year 30	New Steady State
0.73	0.199	0.0012	0.0037	0.0024
0.70	0.276	0.0084	0.0089	0.0077
0.67	0.34	0.0065	0.0127	0.0116
0.60	0.434	0.0062	0.0178	0.0168

Table 4.7 Real GDP Growth Rate Impacts of Capital and Labour Income Tax Shift with Changing a

a	A_I	**Year 10**	**Year 30**	**New Steady State**
0.3	0.328	0.0142	0.0054	0.0039
0.275	0.337	0.0099	0.0095	0.0083
0.25	0.34	0.0065	0.0127	0.0116
0.213	0.335	0.0032	0.016	0.015

Table 4.8 Real GDP Growth Rate Impacts of Capital and Labour Income Tax Shift with Changing h

h	A_I	**Year 10**	**Year 30**	**New Steady State**
0.13	0.36	0.0023	0.0101	0.0092
0.12	0.35	0.0044	0.0114	0.0104
0.11	0.34	0.0065	0.0127	0.0116
0.10	0.33	0.0083	0.0139	0.0127

Table 4.9 Real GDP Growth Rate Impacts of Capital and Labour Income Tax Shift with Changing g

γ	A_I	Year 10	Year 30	New Steady State
0.80	0.26	0.0084	0.0138	0.0132
0.73	0.30	0.0012	0.0117	0.0109
0.67	0.34	0.0065	0.0127	0.0116
0.60	0.37	0.0196	0.0163	0.0146

Table 4.6 also shows that the growth effects approach zero as β approaches its maximum value of one. If there is no government spending in the human-capital sector, β equals 1 and labour supply is inelastic, the technology of human capital production becomes Stokey and Rebelo's version of the Lucas (1990) model. Using Lucas' key assumption that human capital is only produced using human capital, Stokey and Rebelo (1995) found zero growth rate effects from eliminating all distorting taxes. In the Xu model, long-run growth is reduced most when new human capital is produced using only effective labour, because human capital accumulation is discouraged by the shift from capital income to labour income taxes. The growth gain from a lower capital income tax rate is offset more by the loss from a higher labour income tax rate. The differences between Xu's results and Stokey and Rebelo's findings can be explained by the different assumptions about the technologies of human capital production and tax policy experiments.

5. Conclusions

This paper has examined the growth effects of alternative tax/expenditure shifts in three OECD countries characterised by different tax structures, comparing both long-run effects and transitional dynamics.

The simulation results for the three countries suggest that the capital income tax is more distorting than either the labour income or sales taxes, and the sales tax is the least distorting. This ranking is consistent with the standard result in the neo-classical growth literature. However, the results emphasize how important it is to model the impacts of tax changes on government expenditure. In particular, the revenue effects of tax changes and the use to which the revenue is put can have important implications for the results. In this regard, spending reductions in the human capital sector have the most negative long-run growth effects in this model.

All of the long-run growth rate impacts are small -- many are below 0.05 percentage point. The largest impact is a 0.13 percentage point increase in the Swedish long-run growth rate in the case of lowering the labour income tax rate and household transfers so as to maintain a balanced government budget. The small growth effects are attributable to the interaction of the tax and expenditure impacts on growth. Modelling public investment in private production introduces second-round growth effects in government revenue and spending that are affected by tax changes. Since expenditure impacts have a time lag, transitional growth impacts can be larger. Note that as all policy experiments lead to permanent changes in the growth rate, they eventually lead to significant changes in the level of output.

Cross-country comparisons of the growth effects show that a country's initial tax rates and expenditure/revenue ratios affect the growth impacts of tax policy changes. In particular, although shifting from capital income to sales taxes raises long-run growth in all countries, the strongest gain occurs in Sweden, which has the highest initial capital income tax rate. France has the smallest growth gain and the lowest initial capital income tax rate. The labour income tax and initial spending reduction scenarios lead to positive long-run growth effects for France and Sweden, where the initial labour income tax rates are high, but produce mixed results for Canada, where there is a relatively low initial labour income tax rate. Cutting sales taxes and all initial public spending leads to negative long-run growth effects in Canada, where the initial sales tax rate is the lowest, and positive growth effects in France and Sweden, where initial sales taxes are relatively high.

The paper also identifies critical model parameters that affect the quantitative results. The coefficients of private inputs and aggregate public inputs in private production are important for determining growth effects. In particular, the physical capital share in the human capital production sector has the strongest impact on the results. More information about this parameter, as well as better measures of human capital, would thus be very useful to obtain more concrete estimates of the growth effects of tax and expenditure changes.

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