Dynamic Scoring of Tax Reform in the Open Economy*

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Abstract

We examine dynamic revenue effects of a permanent tax cut on labor and capital income using a small open two-sector dynamic general equilibrium model. We use a dynamic scoring technique to calculate long-run as well as transitional effects on fiscal revenue when a tax cut is financed by either a lump-sum tax or consumption tax. Simulation results show that the revenue loss from an income tax cut becomes substantially smaller when agents can use international financial markets compared to the case of the closed economy. Second, responses of tradable and nontradable sectors to the capital income tax cut display a stark contrast in both long-run equilibrium and transitional dynamics due to different factor intensities. Third, capital income tax cut (in particular, in the tradable sector) is the most efficient policy instrument in terms of minimizing fiscal revenue loss from a tax cut.

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1. Introduction

A number of economists have studied the magnitude and duration of the effects of tax cuts, in particular how economic activities and welfare change over time following a temporary or permanent tax cut. One of the key questions in the field of public finance is how much a tax cut pays for itself. A tax cut boosts economic activities and therefore increases tax bases, which positively contributes to tax revenue despite a decrease in tax rate. A conventional method of revenue estimation—static scoring—ignores this dynamic effect through changes in tax bases over time. Moreover, a simple analysis of tax cuts using a static model cannot provide accurate forecasts of tax revenue and budget balances over time, as economic activities such as investment and savings have intertemporal components.[1]

Dynamic scoring, on the other hand, calculates revenue effects of a proposed tax policy using dynamic macroeconomic models, in which change in tax rates generate feedback to tax revenues through changes in tax base over time.[2] For example, a tax cut in capital income (or other distortionary taxes) tends to reduce tax revenue on impact but it increases tax base (and tax revenue) over time because a tax reduction in capital income enhances economic activities such as investment.[3] For this reason, dynamic scoring would be a more effective technique to evaluate dynamic revenue effects than static scoring.[4]

This paper studies the effects of tax reforms using a small open two-sector dynamic general equilibrium model. We focus on the effects of a permanent cut in capital income tax and labor income

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[1] Most static scoring studies have employed a conventional general equilibrium model and simply analyzed economic activities in pre- and post-tax reform periods.

[2] Dynamic scoring considers both steady state and transitional paths of variables. Dynamic scoring literature is directly related to the literature on Laffer curve, a relationship between tax revenues and tax rates. For the analysis on dynamic Laffer curve, see Novales and Ruiz (2002) and Trabandt and Uhlig (2011).

[3] The first effect of a tax cut is called static scoring, while the second effect (related to an increase in tax base) is called the feedback (dynamic) effect. Compared to dynamic scoring, static scoring tends to overestimate the fiscal revenue loss from a tax cut as it disregards changes in tax base.

[4] See, for example, Auerbach (2005), Mankiw and Weinzierl (2006), Leeper and Yang (2008), and Strulik and Trimborn (2012).

tax (financed by an increase in either lump-sum tax or consumption tax) on tax revenues, budget balances and external balances. Compared to previous literature in dynamic scoring, the model employed in this paper has several advantages. First, while the existing literature typically uses a closed-economy model, this paper uses an open-economy model with trade in goods and financial assets, which enables us to analyze the effects of tax policy on variables such as current account and net foreign asset positions.[5] Second, unlike the previous literature, we adopt a two-sector model (tradable and nontradable sectors) which allows us to further look into the effects of a tax cut on sectoral shift of resources. In particular, we can analyze differences in a way that each sector (tax base) responds to changes in tax rates. This framework is ideal for analyzing a small open economy with large trade sectors.

Several findings emerge in this paper. First, the revenue effects in an open economy are much larger than those in a closed economy. For example, dynamic scoring suggests that a 1% cut in labor income tax financed by lump-sum tax recovers around 80% of the revenue loss in the closed economy, whereas it recovers around 98% in the open economy. In the case of a 1% cut in capital income tax, it leads to 81% revenue recovery in the closed economy, but 121% (in fact, budget surplus) in the open economy. These numbers are much larger than those documented in earlier studies.[6] These large feedback effects are due to specific features of the model---an open economy multi-sector model.

Second, feedback effects are different in tradable and nontradable sectors. In both open and closed economies, a tax cut generates much larger feedback effects in the tradable sector than nontradable sector and the absolute amount of long run revenue recovery is quite significant in the tradable sector. In contrast, a 1% capital tax cut in the nontradable sector generates negative dynamic effects in the long run. For example, a 1% tax cut in capital income in the tradable sector results in around 125% (88%) revenue recovery compared to static scoring in the open (closed) economy whereas a 1% tax cut in the nontradable sector capital shows about -5% (-8%) recovery in the open (closed)

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[5] Some earlier papers have used an open economy setup. See, for example, Mendoza and Tesar (1998, 2005).

[6] Mainkiw and Weinzierl (2006) use a neoclassical growth model calibrated to US data and report that permanent reductions in capital (labor) income tax rates expand the tax base enough to offset 53% (17%) of the revenue loss. Leeper and Yang (2008) examine dynamic scoring of 1% reduction in labor and capital income taxes, financed by lowering lump-sum transfers, lowering government spending or increasing a consumption tax. They report that capital (labor) tax cut recovers 95% (47%) of revenue loss when financed by lump-sum transfers.

economy. These results imply that a tax cut in the tradable sector is more effective than that in the nontradable sector due to high capital intensity in the tradable sector. Changes in relative price play a major role in determining transitional dynamics of tax revenues and budget balances.

The paper is organized as follows. Section 2 lays out a small open two-sector dynamic general equilibrium model. Section 3 calibrates the model with explanations on deep parameters. Section 4 provides the main results from various exercises and presents results from sensitivity check. Section 5 concludes.

2. The Model

The model consists of two sectors with an interaction of households, firms and government. Households consume two goods, tradable and nontradable goods, and supply labor and capital to firms. Their labor income and capital income are subject to tax and the households pay tax on their consumption as well. Firms use two factors, labor and capital, to produce two final goods, tradable and nontradable goods. The model allows for both current account and financial account transactions, which permits households to borrow and lend in international financial markets using one-period risk-free bonds. The government finances an exogenous stream of expenditures through domestic taxes.

A representative household solves the following problem

(1) $$Max \sum_{t=0}^{\infty} \beta^t U\left(c_t, h_{xt}, h_{nt}\right), \quad \text{where } U = \frac{\left[c_t^{\theta}\left(1-h_{xt}-h_{nt}\right)^{1-\theta}\right]^{1-\sigma}}{1-\sigma},$$

subject to the budget constraint

(2) $$(1+\tau_{ct})p_t c_t + i_{xt} + p_{nt} i_{nt} + B_{t+1} = (1-\tau_{ht})(w_{xt}h_{xt} + p_{nt}w_{nt}h_{nt})$$
$$+[(1-\tau_{kt}^{x})r_{xt} + \tau_{kt}^{x}\delta_x]k_{xt} + [(1-\tau_{kt}^{n})r_{nt} + \tau_{kt}^{n}\delta_n]p_{nt}k_{nt} + p_{nt}T_t + R_t B_t,$$

where $w_{xt}, r_{xt}, h_{xt}, i_{xt}, k_{xt}$ $(w_{nt}, r_{nt}, h_{nt}, i_{nt}, k_{nt})$ are wage rate, rental rate, hours worked, investment and capital for the tradable (nontradable) sectors. σ is the curvature parameter of the utility function and β is the discount factor. $\delta_x(\delta_n)$ is depreciation rate for the tradable (nontradable) sector. The price of composite consumption good c_t is p_t. B_t is the international bonds and therefore denotes the net quantity purchased in period *t* maturing in *t+1*. R_t is the exogenously determined gross interest rate on bonds. T_t is the net transfer from the government in a lump-sum fashion, and τ is tax rates (τ_{ht}= labor income tax, τ_{kt}^{n}= tax on capital income from the nontradable sector, τ_{kt}^{x}= tax on capital income from the tradable sector, and τ_{ct}= consumption tax). Investment tax credit is incorporated in the budget constraint. All the prices are normalized in terms of tradable good (p_{xt}), which means that p_{nt} is the price of the nontradable good in terms of the price of the tradable good (reciprocal of the real exchange rate).

The laws of motion for capital in each sector are subject to adjustment costs as in Baxter and Crucini (1993)

(3) $$k_{x,t+1} = (1-\delta_x)k_{xt} + \phi\left(\frac{i_{xt}}{k_{xt}}\right)k_{xt},$$

(4) $$k_{n,t+1} = (1-\delta_n)k_{nt} + \phi\left(\frac{i_{nt}}{k_{nt}}\right)k_{nt},$$

where $\phi(\cdot)$ is the adjustment cost function with the following properties: $\phi(\cdot) > 0$, $\phi'(\cdot) > 0$ and $\phi''(\cdot) < 0$.

A composite consumption good consists of two goods, tradable (c_{xt}) and nontradable (c_{nt}) goods. The optimal consumption level of the tradable and nontradable goods can be derived from the expenditure minimization problem which yields the following expressions

(5) $$c_{xt} = b_x^{\frac{1}{\gamma}}\left(\frac{1}{\mu_t}\right)^{-\frac{1}{\gamma}}c_t,$$

(6) $$c_{nt} = b_n^{\frac{1}{\gamma}}\left(\frac{p_{nt}}{\mu_t}\right)^{-\frac{1}{\gamma}}c_t,$$

(7) $$p_t = \left(b_x^{\frac{1}{\gamma}} + b_n^{\frac{1}{\gamma}}p_{nt}^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}}.$$

Firms face the following profit maximization problems

(8) $$Max\ \Pi_t^x = y_{xt} - w_{xt}h_{xt} - r_{xt}k_{xt}, \quad \text{where}\ y_{xt} = A_{xt}k_{xt}^{\mu}h_{xt}^{1-\mu},$$

(9) $$Max\ \Pi_t^n = y_{nt} - w_{nt}h_{nt} - r_{nt}k_{nt}, \quad \text{where}\ y_{nt} = A_{nt}k_{nt}^{\alpha}h_{nt}^{1-\alpha},$$

where $\Pi_t^x(\Pi_t^n)$ and $y_{xt}(y_{nt})$ denote the profit and output of the tradable (nontradable) sector and $\mu(\alpha)$ indicates the capital share of the tradable (nontradable) sector. A_{xt} and A_{nt} are defined as productivity in production functions and are assumed to be constant at one in this deterministic model.

The government's budget constraint is

(10) $$\tau_{ct}p_tc_t + \tau_{ht}(w_{xt}h_{xt} + p_{nt}w_{nt}h_{nt}) + \tau_{kt}^x(r_{xt} - \delta_x)k_{xt} + \tau_{kt}^n(r_{nt} - \delta_n)p_{nt}k_{nt} = p_{nt}G_{nt} + p_{nt}T_t,$$

where G_{nt} is exogenous government spending on the nontradable good. Combining the household's budget constraint with the government's budget constraint yields the following aggregate budget constraints

(11) $$y_{nt} = c_{nt} + i_{nt} + G_{nt},$$

(12) $$y_{xt} + R_tB_t = c_{xt} + i_{xt} + B_{t+1}.$$

We solve the model using a linearization method around the deterministic steady state. However, since we focus on the effects of permanent changes in tax rates, steady state values change and the conventional linearization around the initial steady state would generate large approximation errors if the new steady state moves away from the initial one. For this reason, we need to linearize the model around the new steady state after a permanent tax cut is implemented. The problem is that the new steady state value of asset holding is not known due to the indeterminacy problem in the open economy model with bonds.[7] We overcome this problem by using a double shooting algorithm employed by

[7] See Kim and Kose (2003).

Mendoza and Tesar (1998) and Gorodnichenko et al. (2012).[8] This shooting algorithm enables us to address the issue of indeterminacy of the post-reform steady state value of asset holdings.

3. Calibration

We calibrate the most model parameters based on the data of Korea and adopt some parameter values from the previous literature. Korea is an ideal country for this exercise as it is a small open economy with large trade sectors and open capital markets. Table 1 reports the parameters and steady state values of the benchmark model. The discount factor β is set at 0.96 to match the annual steady state world real interest rate of 4%. The share of consumption in Cobb-Douglas utility, θ is set at 0.34.[9] The value of risk aversion parameter σ is equal to 2.6 to match the intertemporal elasticity of substitution in the Korean data (Kim and Chang, 2008), which is close to the average value reported in the panel study by Ostry and Reinhart (1992).

Share parameters b_x and b_n in the CES form of consumption function are set to match the actual consumption shares in the data. The data show that the consumption share of the tradable and nontradable goods is 48% and 52%, respectively.[10] The value of γ (inverse of the elasticity of substitution in aggregate consumption) is set at 0.782, which is very close to the value used by Mendoza (1992) and Ostry and Reinhart (1992). We set the depreciation rate at 10% for both production sectors, which is a commonly used value in the literature. The elasticity of the marginal adjustment cost function η of the tradable and nontradable sectors is set to 3, to match the volatility of investment in the data. The capital share in the tradable sector μ is set at 0.63 following Kim and Ahn (2005). The capital share in the nontradable sector α is set at 0.34 to match the average labor income share in services sector in the Korean data during the 2000-2007 periods.[11]

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[8] Mendoza and Tesar (1998) employ the shooting method to examine the various tax policies for U.S. and European countries. Gorodnichenko et al. (2012) also use the shooting algorithm to study Finnish depressions during early 1990s.

[9] See Park and Shin (2000).

[10] The consumption share data are based on the Korean Standard Industry Classification (KSIC) in which the industries are classified at the 2 digit level with 36 sectors. See Kim and Kose (2014) for detailed explanations.

[11] This number is close to the one used in Jonsson (2005). The average labor share in services sector ranges from 40% in the 1970s to 65% in the 2000s in Korea (Kim and Chang, 2008).

Measuring aggregate tax rates is a complex and difficult task and there is little consensus on effective tax rate measures. Mendoza et al. (1994) calculated effective tax rates for G-7 countries by dividing actual tax payments by corresponding national accounts. These effective tax rates reflect government policies on tax credits, deductions, and exemptions as well as information on statutory tax rates. Moreover, they are consistent with the concept of aggregate tax rates at the national level and with the assumption of representative agents. In this paper, we follow the method in Mendoza et al. (1994) and calculate the aggregate effective tax rates of Korea.

Data show that the computed tax revenues from consumption, labor income and capital income taxes are 37%, 35% and 28%, respectively.[12] The effective tax rates in Korea are set at 14%, 11% and 34% for consumption, labor and capital income tax, respectively, in order to match the computed tax revenue shares. We use these values for the steady state tax rates (τ_c, τ_l and τ_k) in the model economy. Table 2 reports the range of effective tax rates for the G7 and OECD countries from Mendoza et al. (1994) and Carey and Tchilinguirian (2000). Based on the report for the effective tax rates, the labor income tax rate in Korea seems to be lower than that in G7 and OECD countries whereas consumption and capital income tax rates lie on the ranges of G7 and OECD countries.

The government expenditure on the nontradable sector G_n over y_n is set at 36.7% to match the government expenditure over GDP ratio at 19.24%, which allows the government budget to be balanced under the steady state value. The initial asset holding position (which is a free parameter) is set to zero and p_{xt} is set to one.

4. Main results

We conduct two policy experiments—a cut in labor income tax and a cut in capital income tax—and examine how macroeconomic variables, in particular tax revenue and budget balance, change over time. Lost revenues by labor and capital income tax cut are financed by either an increase in a lump-sum tax or consumption tax. We measure the effects of a tax cut on fiscal balance by using both dynamic scoring and static scoring.

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[12] Data are taken from the 2004 National Income Accounts and Revenue Statistics by the OECD.

4.1. Labor income tax cut

4.1.1. Financed by lump-sum tax

In this section, we consider a 1% tax cut in labor income (from 11% to 10%) financed by a lump-sum tax. The top panel in Tables 3 reports long-run steady state changes in tax base and tax revenue in both open and closed economies. The reported numbers are percentage changes between the initial and new steady states. The results exhibit significant feedback effects as all three tax bases increase in the long run—consumption tax base by 0.71%, labor income tax base by 1.01% and capital income tax base by 1.26%, respectively in the open economy. Tax bases increase more in the open economy compared to the closed economy. Consumption smoothing channel through international borrowing allows agents to take advantage of a tax cut more actively than the case of the closed economy. For instance, tax bases on labor and capital income taxes rise by 0.80% under the closed economy, while they rise by 1.01% and 1.26% in the open economy, respectively.

The top panel in Table 3 also shows how tax revenues change under dynamic scoring compared to static scoring. Under static scoring, labor income tax revenue decreases, while consumption and capital income tax revenues stay unchanged. However, under dynamic scoring, since tax bases change, all three tax revenues change. The total tax revenue under dynamic scoring decreases by 1.76% from the initial steady state, while it decreases by 2.71% under static scoring. Comparing the actual tax revenues in the new steady state, tax revenue under dynamic scoring in the open economy (closed economy) is 54% (40%) larger than that under static scoring. This suggests that static scoring overestimates revenue loss from a tax cut by a significant amount. Lump-sum taxes in the open economy (closed economy) need to increase by 0.09% (0.10%) in the long run to finance the revenue losses from a tax cut in labor income. Note that the lump-sum tax revenue is not included when we calculate total tax revenue. Lump-sum tax financing is equivalent to bond financing by government. That is, government borrows from households by using one period government bond (this is different from international bond that households trade). Therefore, lump-sum tax revenue is considered as government borrowing, not part of total tax revenue.[13]

[13] See Mendoza and Tesar (1998) for detailed explanation.

Figure 1 displays transitional dynamics (impulse response to a 1% tax cut in labor income) of macro and fiscal variables in both open and closed economies. One percent tax cut in labor income increases output, consumption and investment in both open and closed economies steadily over time. Total tax revenue initially decreases by 2% but slowly improves over time in both economies. Budget balance (over GDP) also decreases by 0.4% but slightly improves over time. However, both tax revenue and budget balance stay in deficit throughout the whole period.

Fiscal health of the government measured by tax revenue and budget deficit is slightly better in the open economy compared to the closed economy. For example, with a 1% labor income tax cut, tax revenue in both open and closed economies drops to a similar level on impact, but the size of recovery in the open economy is larger than that in the closed economy over time. Figure 1 also shows responses of sectoral variables to a labor income tax cut. In the open economy, output, consumption and investment in the export sector increase more than those under the closed economy. This is because agents can take advantage of a lower labor income tax rate and produce more of tradable goods without sacrificing consumption through international borrowing. Trade balance shows initial deficit representing international borrowing for consuming tradable good. Responses in the nontradable sector are similar in open and closed economies due to resource constraint in the nontradable sector.

4.1.2. Financed by consumption tax

We compare how the previous results change when the government raises a consumption tax instead of the lump-sum tax to finance lost tax revenue. We calculate the necessary amount of increase in a consumption tax rate by using a double shooting algorithm. A one percent tax cut in labor income can be compensated fully by an increase in consumption tax from 14% to 14.94%.[14] The top panel in Table 4 shows the result of a 1% tax cut in labor income financed by a consumption tax. A noticeable difference between two financing schemes shows up in tax revenue and budget balance. In the case of lump-sum tax financing, a 1% tax cut in labor income generates only small revenue recoveries in both open and closed economies as shown in Figure 1. This is because lump-sum tax revenue is not included in total tax revenue as it is considered as government debt in this paper. Figure 2 shows that

[14] Note that the necessary amount of increase in the consumption tax rate is calculated to match intertemporal budget constraint (for 100 years), not period-by-period budget balance, and we consider only time-invariant one-time change in tax rate. Therefore, lump-sum taxes or transfers are used to match budget balance in every period.

consumption tax financing produces much larger recoveries so that revenues in both economies can be fully recovered (even exhibit budget surplus). An increase in consumption tax revenue increases total tax revenue more than compensating the lost revenue from a labor income tax cut. For example, under lump-sum tax financing, consumption tax revenue increases by 0.71% (Table 3) but under consumption tax financing it increases by 6.91% (Table 4).

On the other hand, tax revenue from labor income and capital income are lower under consumption tax financing compared to lump-sum tax financing, even though the shapes of transitional dynamics look quite similar to each other. For instance, the tax base on labor (capital) income rises by 0.27% (0.34%) in the long run when financed by a consumption tax (Table 4), while it increases by 1.01% (1.26%) in the long run when financed by a lump-sum tax (Table 3). An increase in consumption tax reduces consumption and therefore production activities, which in turn lowers tax bases and revenues in labor and capital income.

Figure 2 exhibits transitional dynamics of fiscal and macro variables of a labor income tax cut accompanied by a rise in a consumption tax. Most plots show similar movements to those under lump-sum tax financing, but the magnitude of changes are slightly different. For example, trade balance deficit under consumption tax financing is much smaller than that in lump-sum tax financing. An increase in consumption tax lowers demand for consumption on tradable goods, which lowers the incentive to import.

4.2. Capital income tax cut in both sectors

4.2.1. Financed by lump-sum tax

We simulate the model economy by lowering a capital income tax by 1% (from 34% to 33%) in both tradable and nontradable sectors. The middle panel in Table 3 presents the results. As in the case of a labor income tax cut, there are significant dynamic feedback effects. For example, dynamic scoring exhibits 0.24% increase in tax revenue in the long run, which implies that a capital income tax cut actually raises tax revenue in the long run. It implies that the feedback effect of a 1% tax cut in capital income is much more significant than that of a 1% tax cut in labor income. This result is also supported by the magnitude of self-financing. A capital income tax cut exhibits 121% (81%) of self-financing in the open (closed) economy and these numbers are much greater than those in the case of labor income tax cut. The fact that the capital income tax cut in the open economy leads to self-financing in excess of 100% implies that the economy is on the "slippery side" of the Laffer curve. However, under static scoring, a 1% capital income tax cut produces 0.96% revenue loss in the open economy.

The results also show that a tax cut in capital income leads to a higher increase in tax base in the tradable sector than in the nontradable sector, irrespective of a financing scheme or openness of economy. For example, in Table 3, the capital income tax base in the tradable sector increases by 2.20% (0.43%), while in the nontradable sector it increases by -0.03% (0.16%) in the open economy (closed economy). Since the tradable sector uses capital more intensively than the nontradable sector, a capital income tax cut benefits the tradable sector more than the nontradable sector, which moves resources from the nontradable to tradable sector.

Figure 3 supports the arguments above: resource shift from the nontradable sector to the capital-intensive tradable sector. Output, consumption, investment and hours worked in the tradable sector jump up at the impact of a tax cut and increase gradually to the new steady states under both open and closed economies. However, the same variables in the nontradable sector show a sharp increase right after the tax cut, but they gradually decrease over time. Hence, the main source of revenue gains is coming from the tradable sector. Figure 3 also shows that the tax revenue initially decreases to -0.6% (-0.9%) but increases over time to 0.2% (-0.2%) in open economy (closed economy). In the open economy, tax revenue becomes positive after 40 periods.

4.2.2. Financed by consumption tax

In this case, a 1% tax cut in capital income is fully compensated by an increase in consumption tax by 14.38% (14.40%) in the open economy (closed economy) to balance the government intertemporal budget constraint. With an increase in consumption tax, dynamic revenue effects are much larger than those with the case of lump-sum tax financing. For example, Table 4 shows that in the open economy (closed economy), the total tax revenue increases by 0.97% (0.67%) in the long run, mostly driven by an increase in consumption tax revenue by 3.24% (3.54%). Other tax revenues become slightly lower than lump-sum tax financing.

As in the case of labor income tax cut, Figures 3 and 4 show that the impulse responses are similar in both lump-sum tax financing and consumption tax financing, except for the tax revenue and budget balance. Total tax revenue in the case of consumption tax financing increases at the impact and continues to increase by almost 1% in the long run. Despite a drop in capital income tax, an increase in consumption tax revenue (more than 3%) dominates and generates a large increase in the total tax revenue.

Comparing dynamic and static scoring numbers shows that dynamic revenue effects are significant due to increases in tax bases over time, even though static scoring also shows positive gains. For example, dynamic scoring in the open economy shows 0.97% tax revenue gain, while static scoring only renders the tax revenue up by 0.05%. Under the closed economy, dynamic (static) scoring suggests an increase by 0.67% (0.11%).

Next, we compare dynamic scoring of labor income tax cut and capital income tax cut. In both closed and open economies, a capital income tax cut generates much less negative impact on tax revenue than a labor income tax cut (under both lump-sum tax financing and consumption tax financing). For example, in the open economy (closed economy), a 1% labor income tax cut generates -1.76% (-1.94%) total tax revenue gain under lump-sum financing, while a 1% capital income tax cut generates 0.24% (-0.16%) tax revenue gain. Results are similar in the case of consumption tax financing. In sum, we can conclude that the capital income tax cut brings better results in terms of tax revenue than the labor income tax cut.

In all cases, responses of budget balance/GDP are different from those of tax revenues. Even though the government spending (G_n) is fixed at the pre-reform state, because government spending is only on the nontradable good, changes in the relative price affect the actual government spending (p_nG_n). In particular, in the open economy, the price of nontradable good increases on impact in all cases more than the case of the closed economy. Increased imports of tradable good (trade balance deficit) lower (raise) the relative price of tradable (nontradable) good. Therefore, the budget balance initially decreases more in the open economy on impact than that in the closed economy.

4.3. Capital income tax cut in one sector only

Now, we implement a capital income tax cut in one sector only (either tradable or nontradable sector) and examine how much resources shift between the two sectors and how these affects fiscal revenue. For this exercise, we only consider a lump-sum tax as a financing scheme. The bottom panel in Table 3 presents the results. The numbers without parentheses indicate the case of a capital income tax cut in the tradable sector, while those in parentheses are the case of the nontradable sector. When a capital income tax is lowered in the tradable sector, there is a significant resource shift from the nontradable to tradable sector, as shown in Figure 5. In the open economy, output, consumption and investment in the nontradable sector all decrease by around 0.35%, while those variables in the tradable sector increases by 3.10%, 0.90% and 3.70%, respectively.

Table 3 also shows that all tax bases increase, in particular there is a substantial increase in the capital income tax base in the tradable sector (2.17%) in the open economy. Dynamic scoring in the open economy shows that the total tax revenue increases by 0.64%, while static scoring shows a decrease of 0.60%. A decrease in capital income tax revenue is compensated by an increase in consumption and labor income tax revenues, producing overall gain in the tax revenue. In the closed economy, resource shift from the nontradable to tradable sector is limited and the positive responses of tax base and revenue in capital income are significantly lowered. Therefore, dynamic scoring shows that total tax revenue increases only by 0.28%, which is much lower than the case of the open economy (0.64%). Figure 5 shows that the dynamics of tax revenue and budget balance is similar to the case of capital income tax cut in both sectors.

As shown at the bottom panel in Table 3, when a capital income tax cut is implemented in the nontradable sector, consumption and capital income tax bases decrease by 0.07% and 0.23%, respectively and the labor income tax base only slightly increases by 0.18%. Therefore, capital income tax revenue in the nontradable sector decreases by 3.58% and total tax revenue decreases by 0.41%. Since a tax cut is implemented in the nontradable sector, there is not much difference between the open and closed economies in terms of sectoral responses and fiscal balances. Total tax revenue in the open economy decreases by 0.41%, while in the closed economy, it decreases by 0.43%. This observation is confirmed in Figure 6.

4.4. Sensitivity analysis

In this section, we analyze how the main results change when we change the key parameter values. In particular, we change two parameter values: capital share in the tradable sector production (μ) and the elasticity of substitution between tradable and nontradable goods in utility function ($1/\gamma$). Table 5 shows the results when the benchmark capital share in the tradable sector is lowered from 0.63 to 0.4.

The table reports the long run impact on tax bases and revenues when we lower capital income tax on the tradable, nontradable and both sectors by 1% financed by a lump-sum tax. Most tax bases and revenues exhibit more negative impacts from a tax cut than the benchmark case in both open and closed economies. When the capital share in the tradable sector production is low, tradable sector does not enjoy the comparative advantage from high capital intensity as much as before and the benefits from lowering capital income tax become much smaller. Therefore, the assumption of high capital intensity in tradable sector is crucial in dynamic scoring results in this model.

Table 6 reports the results when we lower the elasticity of substitution between tradables and nontradables (γ changes from 0.782 to 1.2 because $1/\gamma$ is the elasticity of substitution). With a lower elasticity, there is less substitution of resources between the two sectors and the negative effects on tax revenue from a tax cut in labor and capital income increase. This negative effect is more apparent in the case of labor income tax cut, which directly affects the labor choice and utility.

5. Conclusion

We examine dynamic revenue effects of a permanent tax cut in labor and capital income using a small open two-sector dynamic general equilibrium model. We evaluate the consequences on tax revenue using dynamic scoring instead of static scoring. All the results show that the feedback effect is not negligible and static scoring overestimates the revenue loss from a tax cut, in particular in the case of a capital income tax cut.

Several findings emerge. First, positive feedback effects on tax revenue from a tax cut are much higher in the open economy than in the closed economy. Households do not need to sacrifice consumption in order to take advantage of a tax cut and produce more as they can rely on international borrowing. Second, sectoral responses to a capital income tax cut exhibit a stark contrast in tradable and nontradable sectors. Since the tradable sector is capital intensive in this model, there is a significant resource shift from the nontradable to tradable sector when there is a capital income tax cut. This result provides policy implication that if the government can implement a selective capital income tax cut in different sectors, a tax cut in the tradable sector generates better revenue effects than the case of a tax cut in the nontradable sector.

Overall, we make two contributions in the literature. First, we use a multi-sector model to estimate sectoral responses to a tax cut. Distinguishing tradable and nontradable sector is important in measuring accurate revenue effects as these two sectors show quite different responses to a tax cut. Second, using an open economy model with international borrowing is important in deriving accurate revenue effects, especially for small open economies such as Korea. Several extensions are possible. We can apply the same model to estimate revenue effects of a tax hike as shortage of fiscal revenue has been the main political issue in many countries since the global financial crisis. We can also apply this model to estimate welfare effects of tax reform.

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Table 1. Deep parameters and steady states

Parameters	***Description***	***Benchmark Values***
Preference		
β	Discount factor (annual)	0.96
σ	Inverse of the intertemporal elasticity of substitution	2.60
θ	Share of consumption in the utility function	0.34
γ	Coefficient of elasticity of substitution b/w tradable and nontradable goods	0.782
b_x	Weight of tradable good	0.48
b_n	Weight of nontradable good	0.52
Technology		
	Tradable Sector	
μ	Share of capital income	0.63
δ_x	Depreciation rate (annual value)	0.10
η_x	Elasticity of marginal adjustment cost function	3.00
	Nontradable Sector	
α	Share of capital income	0.34
δ_n	Depreciation rate (annual value)	0.10
η_n	Elasticity of marginal adjustment cost function	3.00
Other Steady States		
g_n	Government expenditure (ratio of GDP)	19.24%
nx	Net exports (ratio of GDP)	0
p_x	Price of tradable good	1
Tax Rates		
τ_c	Consumption tax	14%
τ_h	Labor income tax	11%
τ_k^x, τ_k^n	Capital income tax	34%

Table 2. Tax rates in selected countries

Average effective tax rates (%)			
	C-tax rate	***L-tax rate***	***K-tax rate***
Korea	14	11	34
G-7 countries in Mendoza et al. (1994)			
Average	12	36	31
Range	5～20	22～42	24～55
OECD countries in Carey and Tchilinguirian (2000)			
average	17	37	35
range	5～33	9～48	16～51

Note: C-tax, L-tax and K-tax denote consumption tax, labor income tax and capital income tax, respectively. .

Table 3. Long-run effects of a tax cut: *lump-sum tax financing*

	Labor income tax cut			
Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.71		0.80	
L-tax	1.01		0.80	
K-tax	1.26		0.80	
K_x*-tax*	1.60		0.80	
K_n*-tax*	0.71		0.80	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	0.71	0.00	0.80	0.00
L-tax	-8.18	-9.09	-8.37	-9.09
K-tax	1.26	0.00	0.80	0.00
K_x*-tax*	1.60	0.00	0.80	0.00
K_n*-tax*	0.71	0.00	0.80	0.00
Total tax revenue	-1.76	-2.71	-1.94	-2.71
	Capital income tax cut in both sectors			
Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.72		0.91	
L-tax	1.66		1.18	
K-tax	1.37		0.33	
K_x*-tax*	2.20		0.43	
K_n*-tax*	-0.03		0.16	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	0.72	0.00	0.91	0.00
L-tax	1.66	0.00	1.18	0.00
K-tax	-1.62	-2.94	-2.62	-2.94
K_x*-tax*	-0.81	-2.94	-2.52	-2.94
K_n*-tax*	-2.97	-2.94	-2.79	-2.94
Total tax revenue	0.24	-0.96	-0.16	-0.96
	Capital income tax cut in the tradable sector (nontradable sector)			
Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.79 (-0.07)		0.97 (-0.06)	
L-tax	1.47 (0.18)		1.03 (0.15)	
K-tax	1.60 (-0.23)		0.64 (-0.30)	
K_x*-tax*	2.17 (0.03)		0.53 (-0.10)	
K_n*-tax*	0.64 (-0.66)		0.82 (-0.65)	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	0.79 (-0.07)	0.00 (0.00)	0.97 (-0.06)	0.00 (0.00)
L-tax	1.47 (0.18)	0.00 (0.00)	1.03 (0.15)	0.00 (0.00)
K-tax	-0.29 (-1.32)	-1.84 (-1.10)	-1.22 (-1.39)	-1.84 (-1.10)
K_x*-tax*	-0.84 (0.03)	-2.94 (0.00)	-2.43 (-0.10)	-2.94 (0.00)
K_n*-tax*	0.64 (-3.58)	0.00 (-2.94)	0.82 (-3.57)	0.00 (-2.94)
Total tax revenue	0.64 (-0.41)	-0.60 (-0.36)	0.28 (-0.43)	-0.60 (-0.36)

Note: 1. All the results are obtained from a 1% permanent tax cut.

2. C-tax, L-tax, K-tax, K_x*-tax and* K_n*-tax indicate consumption tax, labor income tax, capital income tax in both sectors, capital income tax in the tradable sector and capital income tax in the nontradable sector, respectively.*

3. "Dynamic" and "Static" denote dynamic scoring and static scoring.

Table 4. Long-run effects of a tax cut: *consumption tax financing*

Labor income tax cut

Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.19		0.21	
L-tax	0.27		0.21	
K-tax	0.34		0.21	
K_x*-tax*	0.42		0.21	
K_n*-tax*	0.19		0.21	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	6.91	6.71	6.94	6.71
L-tax	-8.85	-9.09	-8.90	-9.09
K-tax	0.34	0.00	0.21	0.00
K_x*-tax*	0.42	0.00	0.21	0.00
K_n*-tax*	0.19	0.00	0.21	0.00
Total tax revenue	0.06	-0.20	0.01	-0.20

Capital income tax cut in both sectors

Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.51		0.66	
L-tax	1.35		0.93	
K-tax	0.99		0.08	
K_x*-tax*	1.72		0.18	
K_n*-tax*	-0.24		-0.09	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	3.24	2.71	3.54	2.86
L-tax	1.35	0.00	0.93	0.00
K-tax	-1.98	-2.94	-2.86	-2.94
K_x*-tax*	-1.27	-2.94	-2.76	-2.94
K_n*-tax*	-3.17	-2.94	-3.03	-2.94
Total tax revenue	0.97	0.05	0.67	0.11

Note: 1. All the results are obtained from a 1% permanent tax cut.

2. C-tax, L-tax, K-tax, K_x*-tax and* K_n*-tax indicate consumption tax, labor income tax, capital income tax in both sectors, capital income tax in the tradable sector and capital income tax in the nontradable sector, respectively.*

3. "Dynamic" and "Static" denote dynamic scoring and static scoring.

4. The new consumption tax rate that fully covers the revenue loss from labor income tax cut is 14.94% in both open and closed economies. In the case of capital income tax cut, the compensating consumption tax for the open (closed) economy is 14.38% (14.40%).

Table 5. Sensitivity analysis for a change in capital share (μ=0.4) in the tradable sector

— lump-sum tax financing —

	Capital income tax cut in the tradable sector			
Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.32 (0.79)		0.37 (0.97)	
L-tax	0.52 (1.47)		0.42 (1.03)	
K-tax	0.21 (1.60)		0.08 (0.64)	
K_x*-tax*	0.12 (2.17)		-0.31 (0.53)	
K_n*-tax*	0.27 (0.64)		0.32 (0.82)	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	0.32 (0.79)	0.00 (0.00)	0.37 (0.97)	0.00 (0.00)
L-tax	0.52 (1.47)	0.00 (0.00)	0.42 (1.03)	0.00 (0.00)
K-tax	-0.91 (-0.29)	-1.12 (-1.84)	-1.04 (-1.22)	-1.12 (-1.84)
K_x*-tax*	-2.82 (-0.84)	-2.94 (-2.94)	-3.24 (-2.43)	-2.94 (-2.94)
K_n*-tax*	0.27 (0.64)	0.00 (0.00)	0.32 (0.82)	0.00 (0.00)
Total tax revenue	0.09 (0.64)	-0.28 (-0.60)	0.04 (0.28)	-0.28 (-0.60)
	Capital income tax cut in the nontradable sector			
Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	-0.09 (-0.07)		-0.07 (-0.06)	
L-tax	0.18 (0.18)		0.14 (0.15)	
K-tax	-0.40 (-0.23)		-0.45 (-0.30)	
K_x*-tax*	0.05 (0.03)		-0.11 (-0.10)	
K_n*-tax*	-0.68 (-0.66)		-0.66 (-0.65)	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	-0.09 (-0.07)	0.00 (0.00)	-0.09 (-0.07)	0.00 (0.00)
L-tax	0.18 (0.18)	0.00 (0.00)	0.18 (0.18)	0.00 (0.00)
K-tax	-2.21 (-1.32)	-1.82 (-1.10)	-2.21 (-1.32)	-1.82 (-1.10)
K_x*-tax*	0.05 (0.03)	0.00 (0.00)	0.05 (0.03)	0.00 (0.00)
K_n*-tax*	-3.60 (-3.58)	-2.94 (-2.94)	-3.60 (-3.58)	-2.94 (-2.94)
Total tax revenue	-0.51 (-0.41)	-0.45 (-0.36)	-0.51 (-0.41)	-0.45 (-0.36)
	Capital income tax cut in both sectors			
Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.24 (0.72)		0.31 (0.91)	
L-tax	0.70 (1.66)		0.56 (1.18)	
K-tax	-0.19 (1.37)		-0.37 (0.33)	
K_x*-tax*	0.18 (2.20)		-0.42 (0.43)	
K_n*-tax*	-0.41 (-0.03)		-0.34 (0.16)	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	0.24 (0.72)	0.00 (0.00)	0.31 (0.91)	0.00 (0.00)
L-tax	0.70 (1.66)	0.00 (0.00)	0.56 (1.18)	0.00 (0.00)
K-tax	-3.12 (-1.62)	-2.94 (-2.94)	-3.30 (-2.62)	-2.94 (-2.94)
K_x*-tax*	-2.77 (-0.81)	-2.94 (-2.94)	-3.35 (-2.52)	-2.94 (-2.94)
K_n*-tax*	-3.34 (-2.97)	-2.94 (-2.94)	-3.28 (-2.79)	-2.94 (-2.94)
Total tax revenue	-0.42 (0.24)	-0.72 (-0.96)	-0.49 (-0.16)	-0.72 (-0.96)

Note: 1. Numbers in parentheses indicate the benchmark values for the corresponding sector.

Table 6. Sensitivity analysis for a change in elasticity of substitution (γ=1.2)

— lump-sum tax financing —

Labor income tax cut				
Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.69 (0.71)		0.77 (0.80)	
L-tax	0.93 (1.01)		0.77 (0.80)	
K-tax	1.22 (1.26)		0.77 (0.80)	
K_x*-tax*	1.78 (1.60)		0.77 (0.80)	
K_n*-tax*	0.69 (0.71)		0.77 (0.80)	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	0.69 (0.71)	0.00 (0.00)	0.77 (0.80)	0.00 (0.00)
L-tax	-8.24 (-8.18)	-9.09 (-9.09)	-8.39 (-8.37)	-9.09 (-9.09)
K-tax	1.22 (1.26)	0.00 (0.00)	0.77 (0.80)	0.00 (0.00)
K_x*-tax*	1.78 (1.60)	0.00 (0.00)	0.77 (0.80)	0.00 (0.00)
K_n*-tax*	0.69 (0.71)	0.00 (0.00)	0.77 (0.80)	0.00 (0.00)
Total tax revenue	-2.08 (-1.76)	-2.99 (-2.71)	-2.24 (-1.94)	-2.99 (-2.71)
Capital income tax cut in both sectors				
Tax base (%)	***Open Economy***		***Closed Economy***	
C-tax	0.72 (0.72)		0.89 (0.91)	
L-tax	1.57 (1.66)		1.22 (1.18)	
K-tax	1.22 (1.37)		0.28 (0.33)	
K_x*-tax*	2.36 (2.20)		0.26 (0.43)	
K_n*-tax*	0.13 (-0.03)		0.29 (0.16)	
Tax revenue (%)	***Dynamic***	***Static***	***Dynamic***	***Static***
C-tax	0.72 (0.72)	0.00 (0.00)	0.89 (0.91)	0.00 (0.00)
L-tax	1.57 (1.66)	0.00 (0.00)	1.22 (1.18)	0.00 (0.00)
K-tax	-1.75 (-1.62)	-2.94 (-2.94)	-2.67 (-2.62)	-2.94 (-2.94)
K_x*-tax*	-0.65 (-0.81)	-2.94 (-2.94)	-2.69 (-2.52)	-2.94 (-2.94)
K_n*-tax*	-2.81 (-2.97)	-2.94 (-2.94)	-2.66 (-2.79)	-2.94 (-2.94)
Total tax revenue	0.24 (0.24)	-0.90 (-0.96)	-0.10 (-0.16)	-0.90 (-0.96)

Note: 1. Numbers in parentheses indicate the benchmark values for the corresponding sector.

Figure 1. 1% labor income tax cut: *lump-sum tax financing*

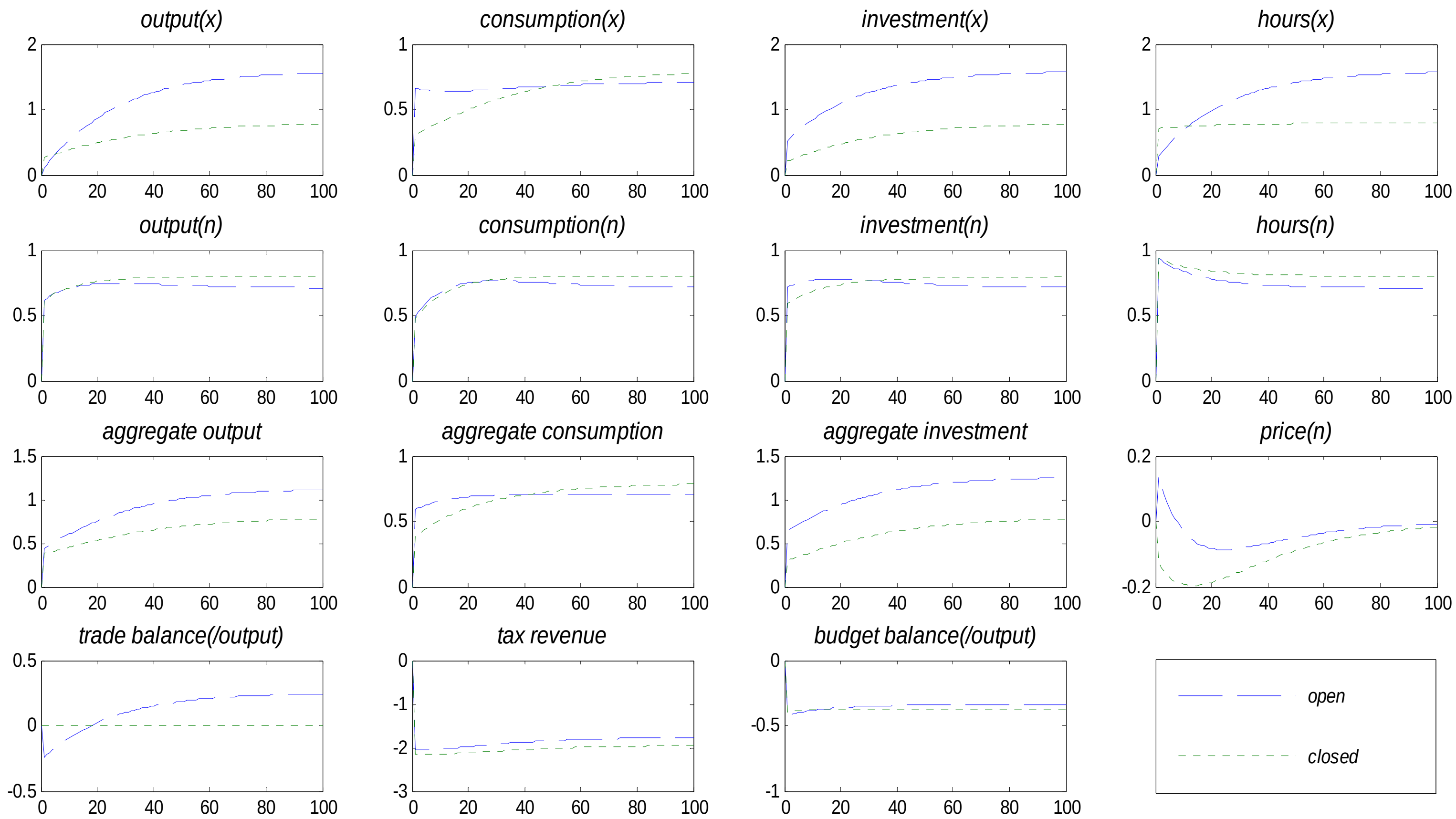

Figure 2. 1% labor income tax cut: *consumption tax financing*

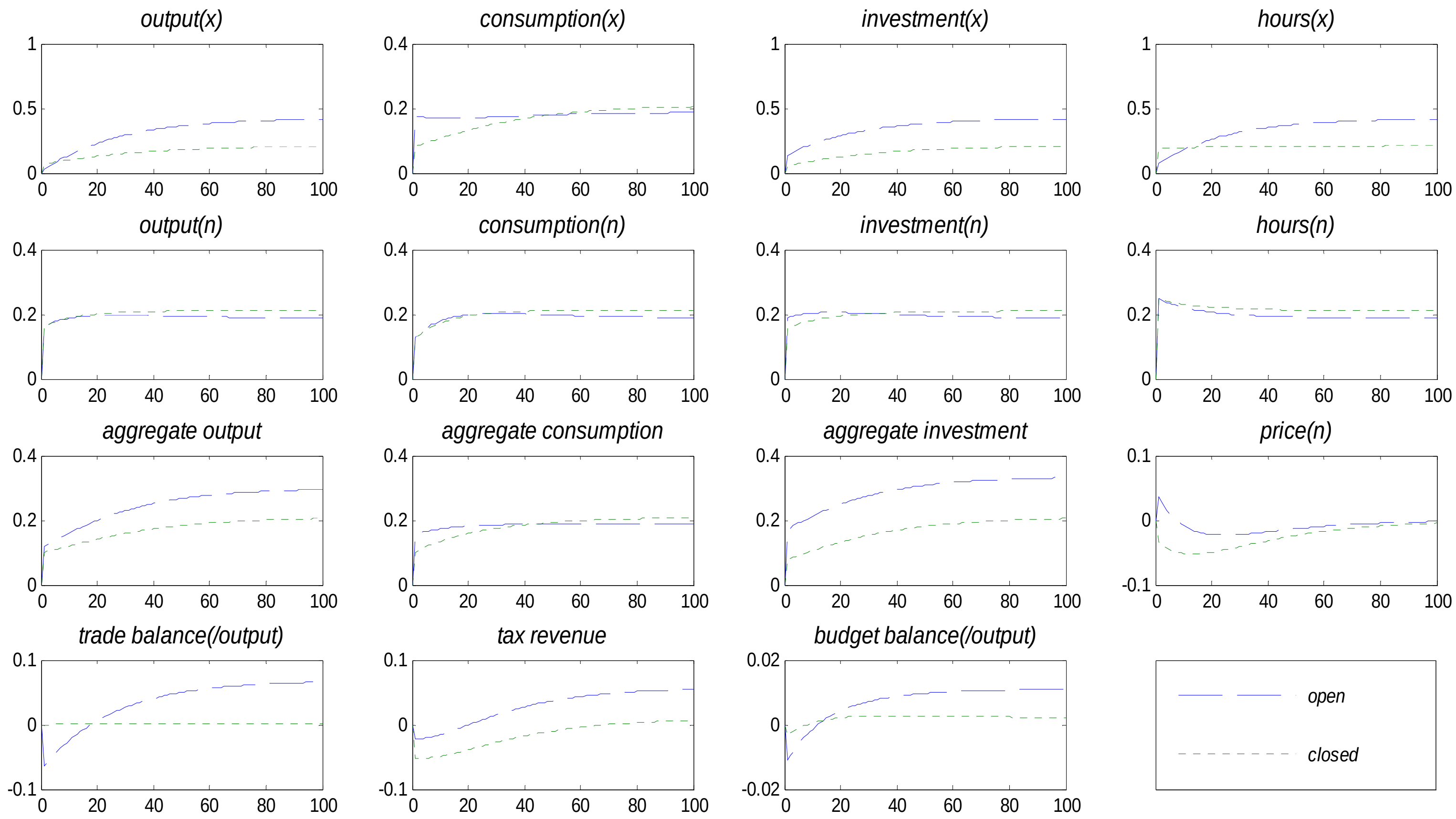

Figure 3. 1% capital income tax cut in both sectors: *lump-sum tax financing*

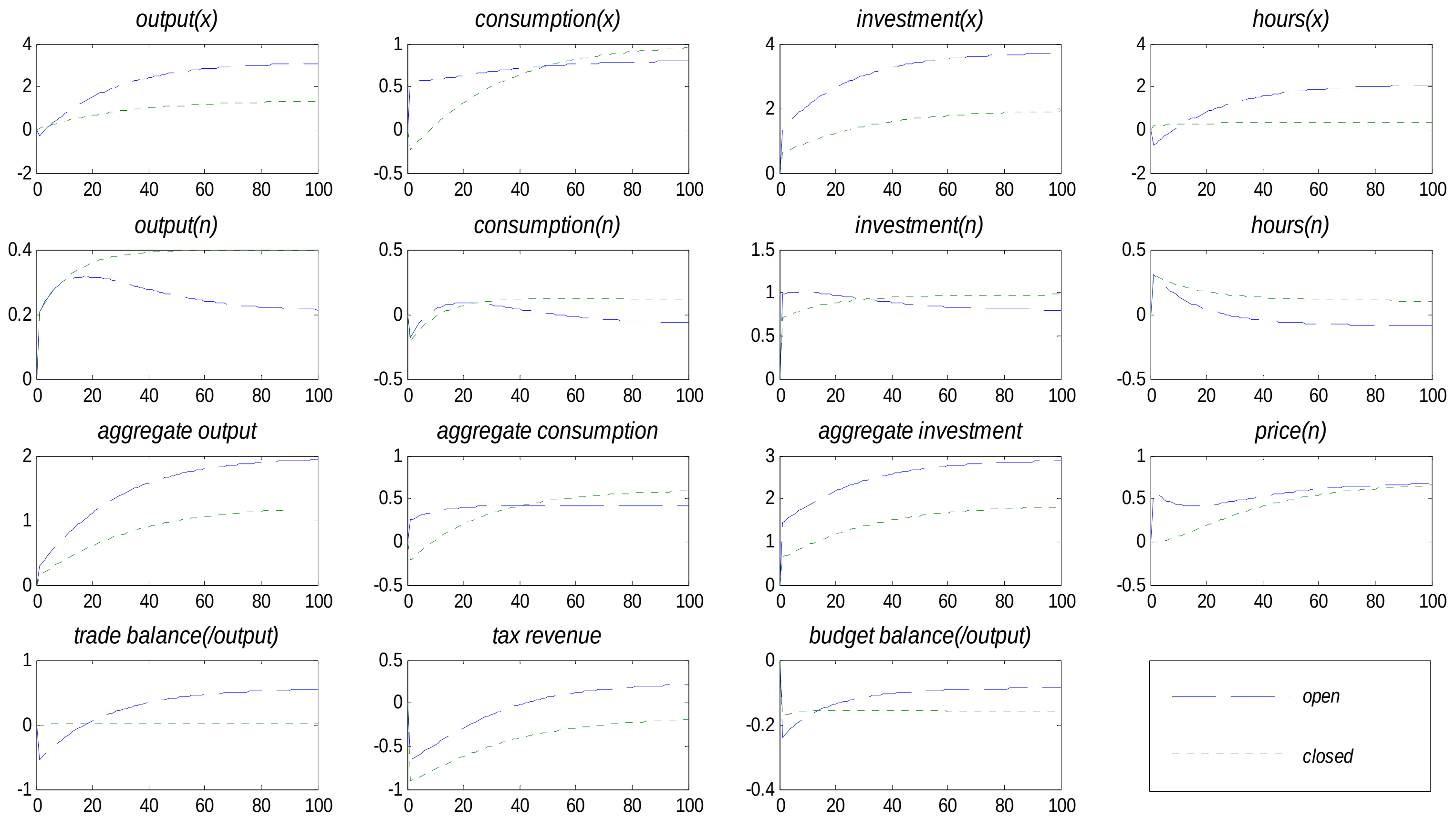

Figure 4. 1% capital income tax cut in both sectors: *consumption tax financing*

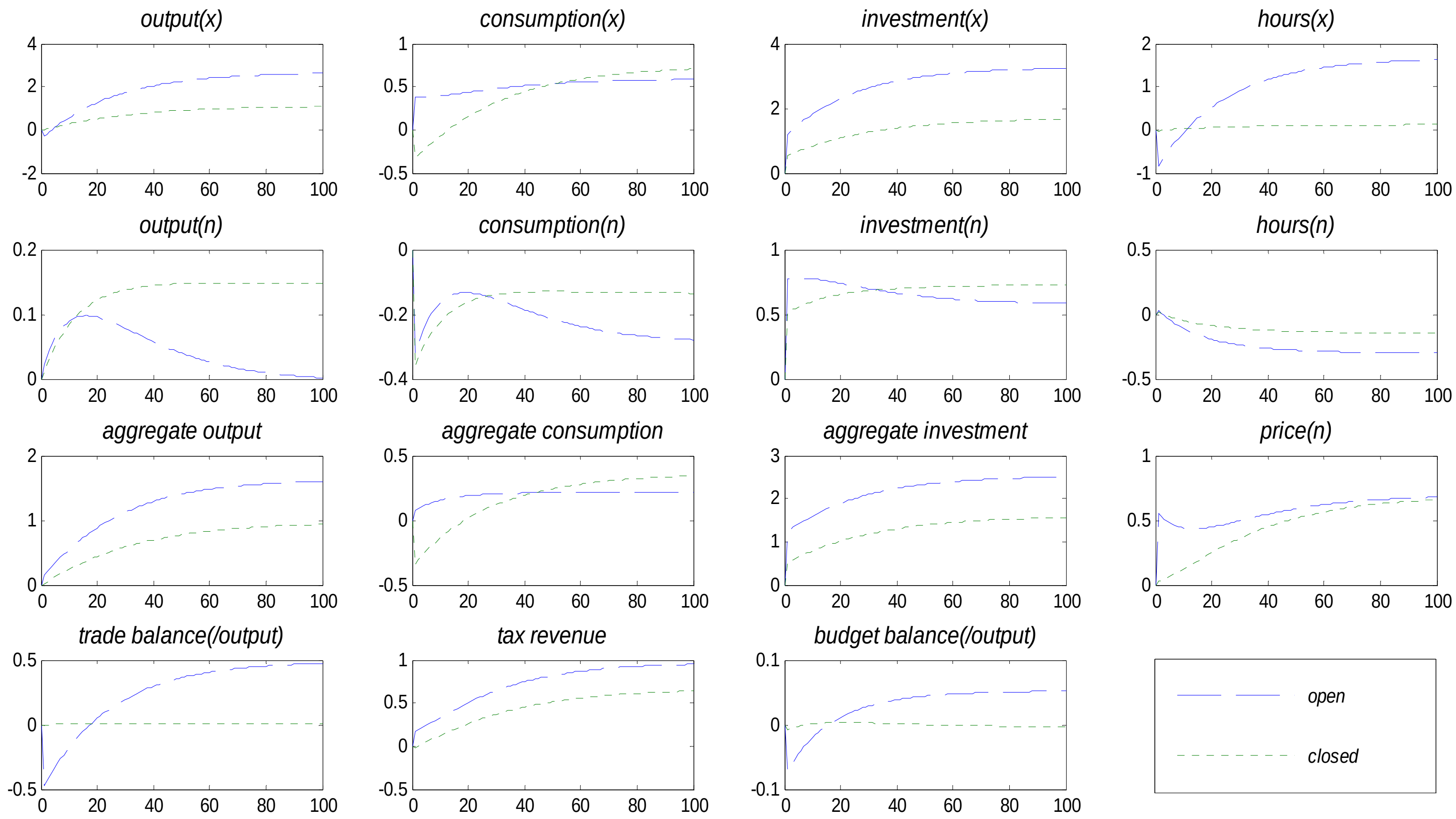

Figure 5. 1% capital income tax cut in the tradable sector: *lump-sum tax financing*

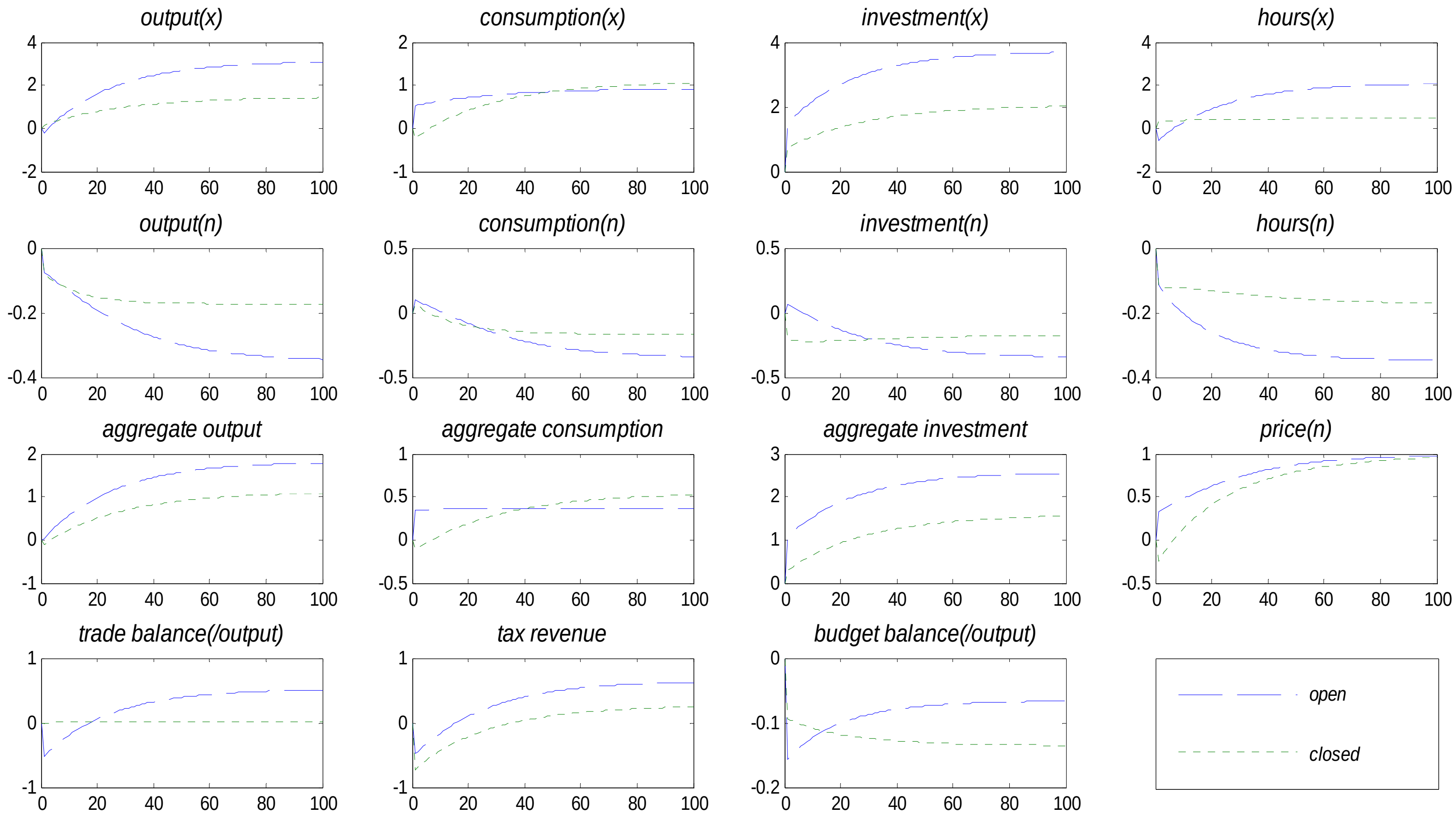

Figure 6. 1% capital income tax cut in the nontradable sector: *lump-sum tax financing*