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Dynamic Welfare Effects of Tax Reform: Case of Korea

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세제개편이 한국경제에 미치는 효과에 대한 동적분석

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ABSTRACT

This paper analyzes welfare effects of revenue neutral tax reform using a small open economy dynamic general equilibrium model. We apply this model to the Korean data and examine welfare effects of various tax reforms; removal of capital income tax and/or labor income tax financed by consumption tax. We investigate both long run equilibrium and transitional dynamics. The results suggest that there are sizable welfare gains (1-3% of lifetime consumption) when factor income taxes are replaced by consumption tax. Overall gains are generated by long run gains despite short run welfare losses. However, there is welfare loss when capital income tax is replaced by labor income tax.

본 논문은 조세제도의 개편이 (기존의 세수를 유지하는) 경제 및 효용에 미치는 영향에 대해 소국경제를 위한 동적 일반균형 모델을 한국경제에 적용하여 분석한다. 여러 가지의 조세제도 개편의 효과를 분석하는데, 특히 기업의 법인세나 가계의 근로소득세를 소비세(부가가치세)로 대체하는 경우 단기 및 장기적으로 어떠한 효과가 있는가를 살펴본다. 모델의 결과에 따르면 이같은 세제개편은 대체로 경제 전체의 효용을 1~3% 정도 증가시킨다. 단기적으로는 경제가 나빠지지만 장기적인 이익이 단기적인 효용감소를 능가한다. 하지만, 기업의 법인세를 낮추고 이를 가계의 근로소득세로 대체할 경우, 경제 전체의 효용은 낮아진다.

I. Introduction

One of the key policy questions in macroeconomics is the optimal tax structure. In particular, many economists have analyzed welfare effects of tax reforms (Lucas 1990, Greenwood and Huffman 1991) such as a removal of capital income tax replaced by consumption tax.[1] These studies showed that the removal of capital income tax reduces distortions in the production sector and increases investment, which results in substantial welfare gains. While most studies on this subject used closed economy model, Mendoza and Tesar (1998) used a two country setup and examined how welfare consequences of tax reforms change when countries can trade in world capital markets. They showed that the possibility of international borrowing and lending can provide larger welfare gains from tax reform in the expense of foreign countries, compared to the closed economy case.

This paper investigates welfare effects of potential tax reforms using a small open economy model calibrated to the Korean data. The model exhibits unique characteristics of a small open economy with large trade sectors such as Korea. Government implements revenue neutral tax policy reforms using three types of tax instruments---labor income tax, capital income tax, and consumption tax. In particular, I examine dynamic welfare effects of capital income tax reform; a reduction in capital income tax rate compensated by an increase in other tax rates in the economy such as consumption or labor income taxes. I also experiment with a reduction in labor income tax replaced by consumption tax. First, I calculate the exact magnitude of changes in consumption tax rates that can satisfy intertemporal government budget constraint under the tax reform. Then, we simulate the model to trace the optimal responses of the main macroeconomic variables over time to such tax reforms and provide quantitative assessment of welfare effects of such tax reforms. Eventually, this paper can provide policy implications on the optimal tax design problem in Korea.

While the tax reform issues have been rigorously debated in policy circles, only a few studies have examined the impact of fiscal reform programs using an open economy dynamic multi-good general equilibrium model. Most existing models in tax literature are limited to static partial equilibrium models and unable to reflect efficiency gains associated with accumulation of capital. This is a particularly important issue since capital income tax affects transitional dynamics pertaining to the implementation period of a reform program. Moreover, international trade in financial assets has not been considered in previous models despite that it is crucial to consider international borrowing and lending channel to analyze a small open economy such as Korea.

Simulation results show that revenue neutral capital income tax reform generates sizable welfare gains (1.4% increase in lifetime consumption) when lost revenue is financed by consumption tax. However, when capital income tax is replaced by labor income tax, overall welfare slightly decreases. Negative effects of an increase in labor income tax exceed positive effects of capital income tax removal. Removal of labor income tax financed by consumption tax generates similar welfare gains (1.4%), while the removal of both capital and labor income taxes (financed by consumption tax) generates large welfare gains (about

[1] See, for example, Jorgenson and Yun (2001), Auerbach and Hassett (2005), and Feldstein (2006).

3% of lifetime consumption).

The rest of this paper is organized as follows. Section 2 introduces model with consumers, firms and government. Section 3 explains solution method adopted in this paper, in particular shooting algorithm. Section 4 describes model parameters and calibration for the simulation exercises. Section 5 presents the main results of the paper including welfare analysis and impulse responses of main macro variables to various tax policy combinations. Section 6 concludes the paper.

Ⅱ. Model

We construct a dynamic general equilibrium model applied to a small open economy that captures the main structural characteristics of developing countries. This model provides a laboratory environment in which we can conduct computational experiments to evaluate the welfare implications of various combinations of tax policies.

The model allows the interaction of households, firms and government. Households consume three goods---exportable, importable and nontraded goods---and supply labor and capital to firms. Their labor income and capital income are subject to tax and the households also pay tax for their consumption. The model incorporates both current account and capital account transactions by allowing households to borrow and lend in international financial markets using one-period risk-free bonds (incomplete financial markets). Firms use labor and capital to produce nontraded and exportable goods. We assume that capital good that is used to produce exportable good is imported, while capital for the production of nontraded good is domestically produced. The government must finance an exogenous stream of expenditures through domestic taxes.

1. Consumer

Two production sectors exist in domestic economy: exportable good sector (x) and nontraded good sector (n), while consumers consume an additional imported good (m). We reduce the multi-good problem into a single good problem by using composite commodities. Price of composite consumption good c (consists of consumption of good x,n, and m) is p (which can be interpreted as CPI and real exchange rate since p_m is a numeraire).

A representative consumer solves

$$\max E_0 \sum_{t=0}^{\infty} \beta^t U_t, \text{ and } U_t = \frac{\left(c_t^{\ \theta}(1-h_{xt}-h_{nt})^{1-\theta}\right)^{1-\sigma}}{1-\sigma}, \tag{1}$$

subject to the budget constraint

$$(1-\tau_{lt})(p_{xt}w_{xt}h_{xt}+p_{nt}w_{nt}h_{nt})+\left[(1-\tau_{kt}^{n})r_{nt}+\tau_{kt}^{n}\delta_{n}\right]p_{nt}k_{nt}+$$
$$\left[(1-\tau_{kt}^{x})r_{xt}+\tau_{kt}^{x}\delta_{x}\right]p_{xt}k_{xt}+p_{nt}T_{t}+B_{t}=(1+\tau_{ct})p_{t}c_{t}+p_{nt}i_{nt}+i_{xt}+v_{t}+R_{t}B_{t+1} \quad (2)$$

and capital accumulation equations

$$k_{n,t+1}=(1-\delta_{n})k_{nt}+k_{nt}\phi\left(\frac{i_{nt}}{k_{nt}}\right), \quad (3)$$

$$k_{x,t+1}=(1-\delta_{x})k_{xt}+k_{xt}\phi\left(\frac{i_{xt}}{k_{xt}}\right), \quad (4)$$

where B_t denotes the quantity of discount bonds purchased in period t maturing in t+1, R_t is the bond price, T_t is the net transfers from governments in a lump-sum fashion, and τ is tax rates (τ_l= labor income tax, τ_{nk}= tax on capital income from nontraded sector, τ_{xk} = tax on capital income from exportable sector, and τ_c = consumption tax). B_t is the international bonds and therefore denotes the net quantity purchased irrespective of the issuing country. Note that bonds are priced in terms of import goods and net transfers are in terms of nontraded goods. Investment tax credit is incorporated in the budget constraint. All the prices are normalized in terms of import goods (p_m)--which means that p_x is price of export good in terms of import good---the terms of trade---and p_n is price of nontraded good in terms of import good. Note that i_{xt}, k_{xt}, and v_t are imported goods with price pm.

Composite good c_t consists of consumption on three goods, c_m, c_n, and c_x as follows:

$$c_{t}=\left[b_{x}c_{xt}^{1-\gamma}+b_{m}c_{mt}^{1-\gamma}+b_{n}c_{nt}^{1-\gamma}\right]^{\frac{1}{1-\gamma}},\ b_{x}+b_{m}+b_{n}=1. \quad (5)$$

Total expenditure on consumption can be expressed as the sum of expenditure on each good:

$$p_{t}c_{t}=c_{mt}+p_{nt}c_{nt}+p_{xt}c_{xt}, \quad (6)$$

where p_t is the price of composite good c_t.

Maximizing (5) subject to (6) yields an equilibrium expression for relative demand for each consumption good and the price of the composite consumption good:

$$\frac{c_{xt}}{c_t} = b_x^{\frac{1}{\gamma}} \left(\frac{p_{xt}}{p_t} \right)^{-\frac{1}{\gamma}}, \tag{7}$$

$$\frac{c_{mt}}{c_t} = b_m^{\frac{1}{\gamma}} \left(\frac{1}{p_t} \right)^{-\frac{1}{\gamma}}, \tag{8}$$

$$\frac{c_{nt}}{c_t} = b_n^{\frac{1}{\gamma}} \left(\frac{p_{nt}}{p_t} \right)^{-\frac{1}{\gamma}}, \tag{9}$$

$$p_t = \left[b_x^{\frac{1}{\gamma}} p_{xt}^{\frac{\gamma-1}{\gamma}} + b_m^{\frac{1}{\gamma}} + b_n^{\frac{1}{\gamma}} p_{nt}^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}}. \tag{10}$$

2. Firms

Production functions for nontraded and exportable goods are

$$y_{nt} = A_{nt} k_{nt}^{\alpha} (h_{nt})^{1-\alpha}, \tag{11}$$

$$y_{xt} = A_{xt} h_{xt}^{\mu} \left[m(k_{xt})^{1-\psi} + (1-m)(v_t)^{1-\psi} \right]^{\frac{1-\mu}{1-\psi}}, \tag{12}$$

No profit conditions are

$$y_{nt} = r_{nt} k_{nt} + w_{nt} h_{nt}, \tag{13}$$

$$p_{xt} y_{xt} = r_{xt} k_{xt} + p_{xt} w_{xt} h_{xt} + v_t, \tag{14}$$

where v denotes the imported intermediate good used to produce export good. A_{nt} and A_{xt} are defined as productivity in production function which is assumed to be constant at one in this deterministic model.

3. Government

Government budget constraint is

$$(1+\tau_{ct})\,p_t c_t + \tau_{lt}(p_{xt}w_{xt}h_{xt} + p_{nt}w_{nt}h_{nt}) + \tau_{kt}^{n}(r_{nt}-\delta_n)\;p_{nt}k_{nt} + \tau_{kt}^{x}(r_{xt}-\delta_x)\;p_{xt}k_{xt} = G_{mt} + p_{nt}G_{nt} + p_{nt}T_t \quad (15)$$

where G_m and G_n are exogenous government spending on imported and nontraded goods, respectively. T_t is net lump-sum transfers (denominated in nontraded goods) to the consumers.

We can combine the government's budget constraint with the consumer's budget constraint and construct the two simplified aggregate budget constraints for nontraded and traded sectors as follows:

$$y_{nt} = c_{nt} + i_{nt} + G_{nt} \quad (16)$$

$$p_{xt}y_{xt} + B_t = c_{mt} + p_{xt}c_{xt} + i_{xt} + v_t + G_{mt} + R_t B_{t+1} \quad (17)$$

Ⅲ. Solution Method

The exercise that we are interested in this paper is to derive conditional changes in welfare (between pre- and post-reform states) and to derive transitional paths of main economic variables. First, we combine all first order conditions for consumers, firms and government and construct a large system of nonlinear equations. We can calculate the analytical solutions for the steady states in the pre-reform state. In order to derive solutions of this dynamic system, we employ a linear approximation method around the deterministic steady state because these types of nonlinear equation system cannot be solved analytically. However, linearization around the initial steady state can generate large approximation errors because new tax rates change the steady states and the model economy evolves away from the initial steady state. Therefore, we need to linearize around the new steady states. However, we do not know the new steady state value of asset holdings because of indeterminacy that arises in the incomplete market models with bonds.[2]

In order to control this problem, we adopt the shooting algorithm as in Mendoza and Tesar (1998) and calculate the appropriate value for the post-reform steady state asset holding position that is consistent with the debt-accumulation dynamics of the pre-reform equilibrium.[3] Detailed algorithm is as follows. We first assume that the post-reform steady state value of bond holding is equal to initial value and linearize the model around the post-reform steady state. Then, we undertake the policy experiment and simulate the model for 2500 periods, and calculate the new bond holding that is consistent with debt-accumulation dynamics. We update the post-reform steady state bond holding with this value and repeat this algorithm until bond holding converges to a fixed point.

[2] Refer to Kim and Kose (2003) for the analysis of nonstationarity and linearization issues.

[3] In Mendoza and Tesar (1998), they use the shooting algorithm to study the effects of various types of tax policy combinations. We use the same shooting logic for our simulation.

Fiscally responsible tax reform assumes that when one tax rate changes, government changes other tax rates to maintain intertemporal government budget constraint. We hold government spending and lump-sum transfers constant at the pre-reform level. In order to calculate the appropriate amount of tax rate changes that satisfy intertemporal government budget constraint, we adopt the second shooting algorithm. The algorithm checks whether the intertemporal budget constraint holds at a given asset holding position and tax rates. If not, the algorithm updates the appropriate changes in tax rates. We assume that the government life span is 200 quarters (50 years) to simulate the intertemporal budget constraint. Finally, we combine the two shooting algorithms to ensure that both tax rate and long run bond holding positions are consistent with the model solution.

Ⅳ. Calibration

We calibrate the parameter and steady state values of the economy by adopting commonly used values for developing countries in the literature. In the benchmark experiments, we use the following parameter values, reported in the Table 1. We fix the value of β 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. The value of risk aversion parameter σ is equal to 2.61 which is the estimate from the panel study by Ostry and Reinhart (1992).

Shares parameters (b_m, b_n, b_x) in the CES form consumption function are set to match the actual consumption shares in the data. The data show that the consumption share of export good is 11%, import good share is 21% and the nontraded good share is 68%.[4] The value of γ (inverse of the elasticity of substitution in the aggregate consumption) is set at 0.782 which is very close to the value used by Obstfeld and Rogoff (2001).

We set the depreciation rate at 13% for both production sectors, which is estimated by the Bank of Korea and also within a range of commonly used values in the literature. The elasticity of the marginal adjustment cost function η of the exportable and nontraded sectors is set to 3, to match the volatility of investment in the data. Labor share in the export good production ω is set at 0.2. Others have used numbers ranging from 0.12 to 0.45 (Kouparitsas, 1997). Share of capital against the imported intermediate good m is set at 0.55 (Kose, 2002). Elasticity of substitution between capital and imported intermediate good ψ is set at 1.35 following Kose (2002). Capital share in the non-traded good sector, α, is set at 0.7. This number is set rather high compared to other studies in order to match the tax revenue structure in Korea. Data shows that tax revenue from consumption, labor income and capital income taxes are 35%, 40%, 25%, respectively. The current .parameter values match this tax revenue structure.

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

[4] We take the averages of the consumption shares between 1985 and 1996. Details of how we construct the sectoral production and employment data are reported in Kim and Ahn (2004).

<Table 1> Parameters and steady state values of the model

Parameter	Description	Parameter Values
Preferences		
	Discount factor, annual	0.96
	Coefficient of relative risk aversion	2.61
	Share of consumption in utility function	0.34
	Inverse of elasticity of substitution	0.78
b_m	Weight of importable goods (in consumption)	0.21
b_x	Weight of exportable goods (in consumption)	0.11
b_n	Weight of nontraded goods (in consumption)	0.68
Technology		
Exportable Goods Sector		
μ	Share of labor income	0.20
	Coefficient of intratemporal elasticity of substitution	1.35
m	Weight of capital input in the CES composite	0.55
$_x$	Depreciation rate, annual	0.13
$_x$	Elasticity of marginal adjustment cost function	3
Nontraded Goods Sector		
a	Share of capital income	0.70
$_n$	Depreciation rate, annual	0.13
$_n$	Elasticity of marginal adjustment cost function	3
Other steady state values		
g_m	Government expenditure in importables (ratio of $pxyx$)	13.5%
g_n	Government expenditure in nontradables (ratio of yn)	13.5%
T	Net transfers (ratio of y)	
nx	Net exports (ratio of y)	0
p_x	Price of exportable good (index)	1
Tax rates		
c	Consumption tax	17.5%
l	Labor income tax	16.1%
kx	Capital income tax in exportable sector	21.8%
kn	Capital income tax in nontraded sector	21.8%

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.[5] In this paper, we follow the method in Mendoza et al. (1994) and calculate the aggregate effective tax rates of Korea. Data are taken from the 2004 National Income Accounts and Revenue Statistics by the OECD.

The effective consumption tax rate is measured by dividing actual consumption tax payment (general taxes on goods and services + excise taxes + import duties) by pre-tax value of consumption (private final consumption expenditure + government final consumption expenditure -- compensation of government employees - consumption tax payment). One problem in measuring labor and capital income tax rates is that the government does not provide a breakdown of income tax revenue according to its sources, whether it is from labor or capital income. Therefore, we first measure general income tax rate of the household assuming that all sources of the household income are taxed at the same rate. Household's overall income is estimated by taking the sum of wages and salaries, operating surplus and net property income of the households. We can calculate the effective income tax rate by dividing household income tax revenue by the overall household income, which is around 10.7% in 2004. Labor income tax rate can be calculated by dividing total labor income tax payment (income tax rate multiplied by wage and salaries + all social security contributions) by the tax base (wage and salaries + employer's social security contributions + payroll taxes). Capital income tax payment is the sum of all corporate tax payments (including taxes on immovable properties and financial and capital transactions). Tax base is operating surplus of all corporations. We can calculate the effective capital income tax rate by dividing tax payment by tax base.

Table 2 reports the properties of tax rates of Korea in comparison to G-7 countries. Effective tax rates in Korea (in 2004) are 17.5%, 16.1% and 21.8% for consumption, labor and capital income tax, respectively. We use these values for the steady state tax rates (τ_c, τ_l and τ_k) in the model economy. Average tax rate for consumption in Korea is higher than G-7 countries, while both labor and income tax rates are much higher in G-7 countries (G-7 averages are 36% and 38%, respectively) than in Korea. Note that G-7 data are from 1996, so the tax rates can be lower in 2004 in these countries.

We set the ratio of government expenditure in nontraded and imported goods at 13.5% of output. This number is derived by dividing total government spending by GDP in 2004. With given tax rates and government spending, the model generates the steady state aggregate transfers to the households at minus 1.6% of GDP. We use this number for the steady state value of T. Initial asset holding position (which is a free parameter) is set to zero. p_x is set to one (in the small open economy, price of exportable good is exogenously determined).

[5] These estimates, however, can be sensitive to cyclical factors and shocks to tax revenues and bases.

<Table 2> Comparison of effective tax rates of selected OECD countries (percentage points)

Country	Consumption tax	Labor income tax	Capital income tax
Canada	10.37	32.63	50.66
France	15.97	50.08	26.11
Germany	16.40	42.38	23.91
Italy	14.72	49.77	33.86
Japan	6.00	27.44	42.61
UK	15.25	24.41	47.17
US	5.47	27.73	39.62
average	***12.02***	***36.35***	***37.71***
Korea	**17.50**	**16.10**	**21.80**

Note: Reported tax rates are constructed by the method in Mendoza et al. (1994). Korean data are from 2004 and based on the OECD Revenue Statistics and National Accounts. Other OECD countries' data are from 1996 and taken from the updated version of Mendoza et al. (1994).

Ⅴ. The Effects of Tax Reforms

Tax reform in this paper is defined as the reduction in capital income tax rate and/or labor income tax rate. We analyze various levels of reduction; complete removal of capital and/or labor income tax, and reduction of tax rates to 10%. Since capital income tax is levied on capital in both export good and nontraded good productions and capital in exportable goods sector is imported, a uniform reduction in capital income tax in both sectors have complicated effects on the model economy. We assume that governments balance their intertemporal budget constraint by changing tax rates permanently. In other words, we only consider time-invariant one-time changes in tax rates. In particular, each tax reform in capital and labor income taxes is accompanied by changes in consumption tax rate. As a benchmark case, we analyze the tax reform financed by lump-sum taxes, which enable us to isolate the effects of tax reform from the effects of changes in other tax rates.

We first solve the pre-reform benchmark model to derive steady state values of the economy. Then, we use the double shooting algorithm to derive the necessary changes in tax rates to satisfy intertemporal government budget constraint after the tax reform. Table 3 reports the results. In case of a complete reduction in capital income taxes in both sectors, if the reform is financed by consumption tax, the new consumption tax rate should be 28.6%. If it is financed by labor income tax, the new tax rate should be 29% (an increase from 16.1% in the pre-reform state). When labor income tax is reduced to zero, consumption tax rate should increase to 30.7% in order to satisfy the intertemporal government budget constraint. When both capital

<Table 3> Calculating necessary changes in tax rates to maintain intertemporal government budget constraints

(reducing capital income tax)

kx, kn	Consumption tax	Labor income tax
21.8%	*17.5%*	*16.1%*
10%	23.5%	23.3%
0	28.6%	29.0%

(reducing labor income tax)

l	Consumption tax
16.1%	*17.5%*
10%	22.5%
0	30.7%

(reducing both capital and labor income tax)

k *l*	Consumption tax
	17.5%
10%	28.7%
0	42.8%

and labor income taxes are reduced to zero, the new consumption tax rate should be 42.8%. When the tax rates are reduced to 10%, necessary changes in other tax rates are less than the amounts in the case of a complete removal.

With this newly calculated tax rates, we analyze dynamic responses of the economy to the tax reform. We compare both changes in steady states and transitional dynamics. Following Lucas (1987), the welfare effect of the reform is measured as a constant percentage change in consumption that leaves the consumer indifferent between the lifetime utility in pre- and post-reform including the transitional periods (labor input is fixed at the pre-reform steady state). We further decompose welfare effects into long-run effects and transitional effects. Long run welfare effects measure differences in the life time utility in pre- and post-reform steady states, while transitional effects (or short-run effects) measure changes of welfare during the transitional periods from pre-reform to post-reform steady state equilibrium.

1. Comparison of welfare effects

Table 4 summarizes welfare effects of different combinations of tax rate changes. This section explains the table by comparing welfare gains of various tax policies,

<Table 4> Welfare gains from tax reform(percentage increase in lifetime consumption)

(removing capital income tax)

	Lump-sum tax	C-tax	L-tax
transitional gains	-1.05	-0.81	-0.57
long run gains	4.40	2.21	0.13
overall gains	3.35	1.40	-0.44

(removing labor income tax)

	Lump-sum tax	C-tax	
transitional gains	-0.32	-0.13	
long run gains	3.45	1.52	
overall gains	3.13	1.39	

(removing both capital and labor income tax)

	Lump-sum tax	C-tax	
transitional gains	-1.40	-1.00	
long run gains	7.77	3.95	
overall gains	6.37	2.95	

Note: C-tax: consumption tax, L-tax: Labor income tax

while the next section examines impulse responses of main macro variables to find out driving forces of these welfare results. The followings are four main results regarding welfare gains.

(1) Revenue neutral capital income tax reform (complete removal) generates sizable welfare gains when lost revenue is financed by consumption tax (1.4% increase in lifetime consumption). However, when lost revenue is financed by an increase in labor income tax, welfare gains become negative (a loss of 0.44 % of lifetime consumption).

(2) A complete removal of labor income tax financed by an increase in consumption tax generates a similar amount of welfare gains as in the case of capital tax reform (1.4%).[6] When both capital and labor income taxes are removed (financed by an increase in consumption tax), welfare gains become large (2.95% increase in lifetime consumption).

(3) All these gains in tax reforms financed by consumption tax are less than half of potential gains when lost revenue is recovered by lump sum taxes.

[6] The case of capital income tax financing is not analyzed because the model generates an explosive path for optimal solution under the current parameter values.

(4) In all cases, overall welfare gains consist of transitional welfare loss and large long run welfare gains.

2. Dynamics of welfare gains

In this section, we analyze the dynamic effects of various combinations of tax reforms; a removal of capital income tax, a removal of labor income tax, and a removal of both capital and labor income taxes financed by lump sum tax, consumption tax or labor income tax. Table 5 presents impact effects and long run effects of various tax reforms for each tax reform reported in table 4 (total seven cases). We analyze the effects of tax reforms on sectoral variables (output, consumption, wage, labor, investment, capital in each sector), aggregate variables (national income account items) and various external and internal balances (trade balance, tax revenue, fiscal balance).

We first analyze the case when capital income tax is replaced by lump sum tax. Responses of the sectoral variables match intuitive explanations. Without capital income tax, price of capital in the economy (r_x and r_n) decreases in the long run. Therefore, investment (and capital) in both exportable and nontraded sectors increases on impact (11-12%) and in the long run (26-43%). In the long run, factor inputs, output, consumption in all sectors increase. In exportable sector, there is a high level of substitution between labor and capital, and the production uses more capital and less labor on impact. In the nontraded sector, labor and capital inputs are complementary and both inputs increase on impact. Aggregate consumption, investment and output all increase in both short and long runs. Trade balance initially worsens as imports decrease less than a decrease in exports in the short run but it improves into surplus in the long run. This is because exportable sector capital is imported and a reduction in capital income tax prompts more import of this capital good. Tax revenue and fiscal balance initially decrease as capital income tax is removed, but they become positive as the economy grows.

When lost revenue is financed by consumption tax, an increase in consumption tax depresses an increase in consumption in both short run and long run, which results in much less welfare gains in both short and long run compared to the lump sum tax financing. Output and factor inputs in both sectors increase much less now. Optimal amount of leisure is higher now (both short and long run) as consumption becomes more expensive due to a tax hike.

We can observe dramatic changes in impulse responses when government finances removal of capital income tax with labor income tax. Government should increase labor income tax from 16.1% to 29%. Post-reform overall welfare now decreases by 0.44%. Negative effects of an increase in labor income tax exceed positive effects of capital tax removal. This is because capital stocks change from the second period (investment from the first period) but labor income tax changes labor input from the first period of the tax reform. Therefore, the effects of labor income tax hike dominate the first period's welfare. We can see this in the effects on labor input on impact; 15% and 4% decreases on impact in x and n sectors. Aggregate consumption decreases by large amounts in both short and long runs. On the other

<Table 5> Dynamic Effects of Tax Reform

CASE 1. No capital income tax(τk=0)

Welfare	Financed by lump-sum transfers	Financed by C-tax (C-tax: 17.5% to 28.6%)	Financed by L-tax (L-tax 16.1% to 29%)
Transitional	-1.05	-0.81	-0.57
Steady state	4.40	2.21	0.13
Net change	3.35	1.40	-0.44

	impact	long-run	impact	long-run	impact	long-run
Sectoral variables (percentage changes)						
yx	-4.26	35.55	-4.79	25.34	-5.16	16.75
yn	3.23	17.59	0.93	11.90	-0.94	7.29
cx	12.80	7.34	4.78	0.40	-1.75	-5.22
cm	12.80	7.34	4.78	0.40	-1.75	-5.22
cn	-6.09	13.16	-8.69	5.85	-10.85	-0.08
hx	-12.28	21.25	-13.70	12.12	-14.70	4.43
hn	7.78	0.93	1.19	-3.95	-4.17	-7.91
wx	9.88	11.79	10.67	11.79	11.29	11.79
wn	-5.62	16.51	-1.15	16.51	2.83	16.51
ix	12.12	43.32	8.06	32.53	4.91	23.44
in	10.92	25.55	8.16	19.48	5.96	14.55
kx	0.00	43.32	0.00	32.53	0.00	23.44
kn	0.00	25.55	0.00	19.48	0.00	14.55
rx	-5.39	-6.34	-5.78	-6.34	-6.09	-6.34
rn	1.29	-6.34	-0.25	-6.34	-1.63	-6.34
v	-3.71	36.53	-4.18	26.25	-4.51	17.60
p	8.70	-2.78	6.62	-2.78	4.72	-2.78
pn	12.54	-4.05	9.53	-4.05	6.79	-4.05
Aggregate variables (percentage changes)						
Output	5.70	24.48	2.68	16.59	0.17	10.03
Consumption	7.96	8.18	1.54	1.19	-3.82	-4.47
Investment	20.51	28.23	14.93	20.72	10.35	14.51
Capital	8.28	28.23	6.29	20.72	4.48	14.51
Leisure	0.17	-3.23	1.72	-0.93	2.95	0.98
Aggregate variables (ratio of output, percentage point changes)						
Trade Balance	-3.66	2.95	-2.76	2.39	-2	1.84
Export	-5.79	3.09	-4.44	2.56	-3.26	2.03
Import	-2.10	0.16	-1.64	0.20	-1.21	0.23
Tax revenue	-3.08	-3.95	-0.35	-1.40	-0.17	-0.76
Fiscal balance	-0.86	0.12	-0.50	0.46	-0.49	0.50

<Table 5> Continue

CASE 2. No labor income tax (τl=0)

Welfare	Financed by lump-sumtransfers	Financed by C-tax (C-tax: 17.5% to 30.7%)
Transitional	-0.32	-0.13
Steady state	3.45	1.52
Net change	3.13	1.39

	impact	long-run	impact	long-run
Sectoral variables (percentage changes)				
yx	0.77	18.65	0.24	7.25
yn	3.93	9.98	1.51	3.84
cx	15.65	13.59	6.05	5.20
cm	15.65	13.59	6.05	5.20
cn	5.44	13.59	2.11	5.20
hx	2.32	18.65	0.74	7.25
hn	13.09	9.98	5.02	3.84
wx	-1.30	0.00	-0.46	0.00
wn	-8.33	0.00	-3.39	0.00
ix	5.34	18.65	1.87	7.25
in	3.83	9.98	1.44	3.84
kx	0.00	18.65	0.00	7.25
kn	0.00	9.98	0.00	3.84
rx	0.76	0.00	0.27	0.00
rn	3.57	0.00	1.45	0.00
v	0.67	18.65	0.21	7.25
p	4.78	0.00	1.99	0.00
pn	7.03	0.00	2.93	0.00
Aggregate variables (percentage changes)				
Output	5.86	14.43	2.31	5.59
Consumption	13.75	13.59	5.40	5.20
Investment	9.16	12.93	3.55	5.00
Capital	4.64	12.93	1.93	5.00
Leisure	-3.00	-4.70	-1.13	-1.82
Aggregate variables (ratio of output, percentage point changes)				
Trade Balance	-1.64	1.51	-0.65	0.65
Export	-2.68	1.46	-1.09	0.62
Import	-1.03	-0.05	-0.44	-0.02
Tax revenue	-3.40	-4.08	-0.17	-0.57
Fiscal balance	-0.04	0.04	-0.04	0.06

<Table 5> Continue

CASE 3. No labor income tax and capital income tax(τl=0, tk=0)

	Financed by lump-sum transfers	Financed by C-tax
Welfare		(C-tax: 17.5% to 42.8%)
Transitional	-1.40	-1.00
Steady state	7.77	3.95
Net change	6.37	2.95

	impact	long-run	impact	long-run
Sectoral variables (percentage changes)				
yx	-2.98	55.34	-4.38	33.35
yn	8.05	29.51	2.73	16.34
cx	29.55	21.83	11.04	5.81
cm	29.55	21.83	11.04	5.81
cn	-0.87	28.44	-6.65	11.55
hx	-8.87	38.96	-12.61	19.28
hn	21.56	11.16	6.33	-0.14
wx	8.30	11.79	10.05	11.79
wn	-13.70	16.51	-4.68	16.51
ix	20.86	64.24	11.22	40.99
in	16.81	38.27	10.31	24.21
kx	0.00	64.24	0.00	40.99
kn	0.00	38.27	0.00	24.21
rx	-4.61	-6.34	-5.48	-6.34
rn	4.07	-6.34	0.96	-6.34
v	-2.60	56.47	-3.82	34.31
p	12.36	-2.78	8.26	-2.78
pn	17.83	-4.05	11.91	-4.05
Aggregate variables (percentage changes)				
Output	11.78	40.21	5.04	22.77
Consumption	20.88	22.79	6.57	6.65
Investment	31.94	43.40	19.29	26.60
Capital	11.77	43.40	7.86	26.60
Leisure	-3.12	-7.85	0.51	-2.73
Aggregate variables (ratio of output, percentage point changes)				
Trade Balance	-5.36	3.78	-3.47	2.84
Export	-8.26	3.79	-5.50	2.98
Import	-2.88	0.02	-2.00	0.17
Tax revenue	-6.83	-7.85	-0.35	-2.09
Fiscal balance	0.13	-0.08	-0.34	0.28

hand, the amount of leisure increases in both short and long runs, because people have less incentive to provide labor due to an increase in tax and the relative price of leisure becomes cheaper.

Next, we analyze the tax reform that removes labor income tax financed by lump sum or consumption tax. Removal of labor income tax (financed by either lump sum or consumption tax) does not change long run prices (including wages and rental rates). This is because there is no change in the intertemporal optimization conditions in the production sector. Both labor and consumption taxes work through intratemporal optimality conditions only. Wages decrease on impact because more labor is available due to labor income tax cut. Removal of labor income tax decreases the amount of leisure (agents now work harder) on impact and in the long run. Factor inputs, output and consumption (in both sectoral and aggregate data) increase. Financing by consumption tax decreases the magnitude of changes in all variables, compared to the case of lump sum tax financing.

The last two panels in table 5 show the case when both capital and labor income taxes are removed (financed by lump sum or consumption tax). Significant welfare gains are observed; 6.37% gain in lifetime consumption with lump sum tax financing and almost 3% gains with consumption tax financing. Directions of changes in most variables are all in the same line as expected.

3. Sensitivity Analysis

In this section, I change some key parameter values and examine how the main welfare results change. Results are reported in Table 6. I focus on the case of a complete removal of both capital and labor income taxes financed by an increase in consumption tax. First, I lower the depreciation rate in investment in both sectors to 7% (from 13%). Necessary changes in consumption tax rate (41%) are similar to the benchmark case (42.8%), while overall welfare gains increase from 2.95% to 4.36% of permanent consumption. This is due to a large increase in long run welfare gains. Low depreciation rates increase the persistence of capital accumulation and magnify the permanent effects of capital income tax cut. On the other hand, an increase in elasticity of marginal adjustment cost function (η=6 from 3) does not change the results much. This is because η mostly affects the volatility of investment, not the first order dynamics.

An increase in the share of labor income in export sector (μ=0.4 from 0.2) slightly lowers welfare gains to 2.29%, because capital income tax cut now has less positive effects with a larger labor share in production. Lowering capital income share in the nontraded sector (α=0.5 from 0.7) lowers overall welfare (2.45%) due to the same reason.

<Table 6> Sensitivity Analysis(Removing both capital and labor income taxes financed by an increase in consumption tax)

		Welfare Gains		
	new C-tax rate	Transitional	Long run	Overall
Original model	42.8%	-1.00	3.95	2.95
With low depreciation rate ($\delta = 5\%$)	41.0%	-1.24	5.61	4.78
With large labor share in EX-sector ($\mu = 0.4$)	40.6%	-2.08	4.37	2.70
With high elasticity in adjustment cost ($\eta = 6$)	42.6%	-1.42	4.46	3.47
With small share of capital income in NT sector ($\alpha = 0.5$)	41.5%	1.23	0.8	2.45

Note: welfare gains are percentage increase in lifetime consumption

Ⅵ. Conclusion

In this paper, we develop an intertemporal optimization model that is calibrated to the Korean economy and provide quantitative analysis on the effects of revenue neutral tax reforms (removal of capital and/or labor income taxes financed by an increase in consumption tax). The results show that such reforms can bring sizable welfare gains to the economy (1 - 3 percent increase in lifetime consumption). Since consumption tax is the least distortionary tax policy tool compared to factor income taxes, it is natural to observe welfare gains when the factor income taxes are replaced by consumption tax. These results, however, can change when economic structures change. For example, the results may change when capital in exportable sector domestically produced. There are several possible extensions of this paper; what are the effects of international capital market restrictions on the welfare effects of tax reform? What happens if there are collection costs in domestic taxes? This model and solution method can be easily applied to a specific country and provide realistic and quantitative welfare implications of various types of fiscal policies.

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