Master Thesis:
German Tax Reforms and the Value of German Corporations

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Abstract

Growth model is widely used as a tool of macroeconomics and public finance. In the thesis, a standard neoclassical growth model with four exogenous permanent tax shocks is built to analyze the relationships between tax rates and corporate evaluations. By using Toolkit, the model simulates the impulse responses of price of shares and other economic behavior variables to the tax shocks (corporation income tax, personal income tax, consumption tax, and dividend income tax). The outcome shows that price of shares has positive relationships with all four tax rates. The changes in tax policy do affect economic behaviors of the households and the firms, such as consumption, output, wage, labor, debt, new investment and dividend payment.

Key words: Tax Reforms, Growth Model, Corporate Evaluations, Toolkit

Contents

1 Introduction

Since the unification of eastern and western Germany, the value of German stock market relative to gross domestic product (GDP) has varied and varied a lot (see Figure 1). Both GDP and capital stock experience increase every year. But apparently the speed of the increase in capital stock is slower than that in GDP. Thus, the ratio of capital stock relative to GDP in Germany decreases from 3.35 in 1991 to 2.93 in 2006.

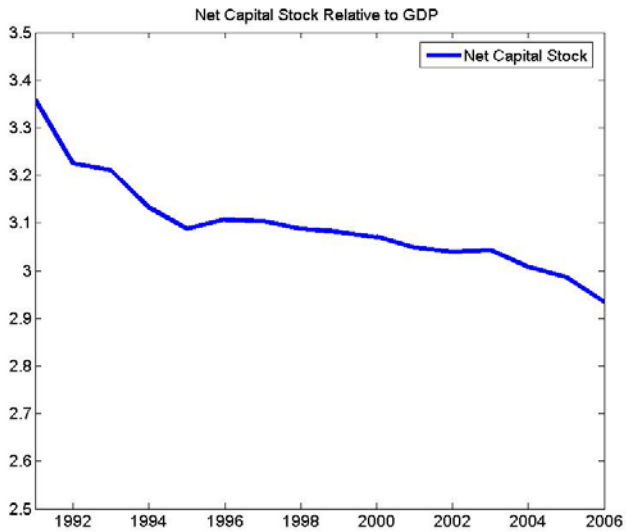

Figure 1: Value of German Corporations, 1991-2006
Data source: European Commission, AMECO

However, based on the study of McGrattan and Prescott (2005), the ratio of capital stock relative to GDP in the Unite States is quite different from that in Germany (see Figure 2). At first, the ratio in the United States (0.50-2.00) is much smaller than that in Germany (2.93-3.35). Secondly, corporate valuations (relative to GDP) rose from about 0.50 in the mid-1980's to 2.00 in the mid-1990's in the United States. While corporate valuations kept decreasing since the mid-1990's. The ratio decreased from about 2.00 to almost 1.50 in 2000. Of course, many factors have impacts on corporate valuations, such as economic environment, political environment, confidence of the shareholders, development of technology, and so on. McGrattan and Prescott (2005) point out that one factor affects strongly corporate valuations. It is a country's tax and regulatory system. Their opinion is that the American taxation system has changed a lot since 1960. So did

the corporate valuations. Therefore, there must be a relationship between the taxation system and corporate valuations.

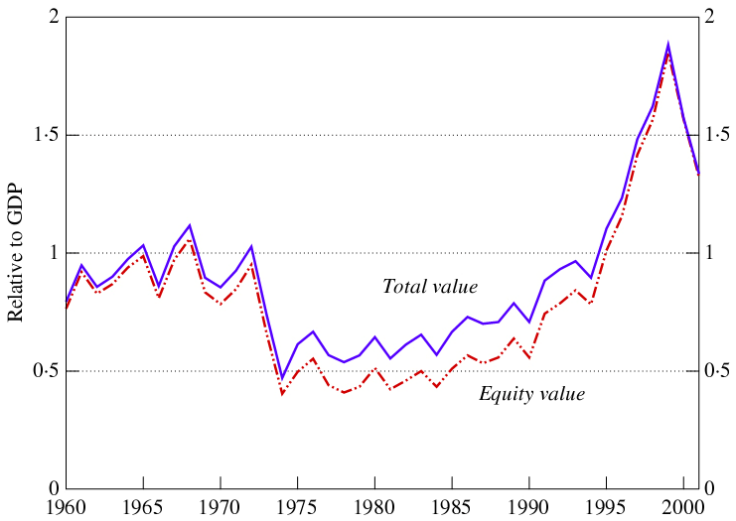

Figure 2: Value of U.S. corporations, 1960-2001
Resource: McGrattan and Prescott (2005)

Similar to the American taxation system, German taxation system has varied a lot, especially since the tax reform 2000. It is necessary to analyze whether there is a relationship between German taxation system and German corporate valuations. In my thesis, I follow the primary idea of McGrattan and Prescott – the taxation system does affect the corporate valuations – and study how German tax reforms impact German corporate valuations and how agents reflect to the tax reforms: the economic behaviors of individuals and corporations.

There is large literature on the effects of tax reform on German economy and on the effects of fiscal policy within growth model.

After the German tax reform is implemented, many researches focus on the German tax reform or German tax system. Bach, Seidel and Teichmann (2000) first predict the impacts of the tax reform 2000. Their conclusion is that a positive macroeconomic effect is to be expected from the tax reform as a whole. But they also point out that if the tax reform is implemented, pressure could arise in the longer run to apply the new lower rates of tax not only to retained profits but also to distributed profits and other capital income. There is a very real danger that the tax reform 2000 marks the first step down the road towards a dual income tax system.

Keen (2002) describes and evaluates the tax reform 2000. The paper assesses the likely impacts on investment and labor supply, and focuses particularly on key structural reform: the end of imputation, and the abolition of tax on corporate holdings in other corporations. They believe that the tax reform 2000 is essentially a traditional rate-cutting, base-broadening reform. It marks a radical and constructive shift in German tax policy. There may be little effect on levels of real investment and on labor supply at all, but the highest incomes. Germany will be a more attractive place for international investors, the allocation of investment will be improved, the cut in the top rate will help retain and motivate skilled workers and entrepreneurs, and the reduction in average rates of personal income taxes is likely to feed helpfully into participation decisions and employment bargaining.

Based on a general equilibrium model of OECD economy, Sorensen (2002) shows that tax reform 2000 will raise domestic economic activity and welfare and produce a non-negligible gain in economic efficiency. The efficiency gain will come mainly from lower corporation and personal income tax rates, whereas the much disputed dividend tax reform seems to be slightly welfare-reducing, because it partly reinstates the double taxation of dividends. However, the impact will be limited.

Haan and Steiner (2004) employ microsimulation techniques to estimate behavioral effects of the tax reform using a discrete choice labor supply model. They find that the total effect of the tax reform on the net household's income amounts on average to € 850, which implies a relative increase of 3.29%. Cash gains of the tax reform are strictly increasing in the level of taxable income implying an increase in income inequality as a consequence of the tax reform. Regarding to the fiscal effects of the reform, they estimate the tax reform induces a total loss in personal income tax revenue by about € 33 billion. As the labor supply estimation indicates, additional participation and hours of work reduce the revenue loss by approximately € 2 billion.

All in all, so many researches focus on the impacts of the German tax reform. But quantitative research is quite few.

On the other hand, growth theory is widely used in quantitative studies on macroeconomics and public finance. Baxter and King (1993) study four classic fiscal-policy experiments within a quantitatively restricted neoclassical model. They find

that permanent changes in government purchases have important effects on macroeconomic activity when these are financed by lump-sum taxation, can lead to short-run and long-run output multipliers that exceed 1, and induce larger effects than temporary changes; the financing decision is quantitatively much more important than the direct resource cost of changes in government purchases; and public investment has dramatic effects on private output and investment.

Prescott (2004) also uses growth theory to analyze the effects of labor taxes on labor supply for the United States and European countries. He finds that Europeans work much less than Americans because labor taxes in European countries have raised more.

Trabandt and Uhlig (2006) examine the shape of the Laffer curve quantitatively in a simple neoclassical growth model for the United States and EU-15 economy. They find that since 1975 the EU-15 area has moved closer to the peaks of their Laffer curves. The slope of the Laffer curve in the EU-15 economy is much flatter than in the United States.

Although many researches are related with the German tax reform, and growth theory is widely used in research area in macroeconomics and public finance, these researches do not connect the reform with economic behaviors of individuals and corporations. Furthermore, the study on the relationship between tax and regulatory system and the corporate valuations is much less. McGrattan and Prescott (2005) find that the changes in the tax and regulatory system significantly affect the corporate valuations based on growth theory. The results of the United States and United Kingdom approve their idea. From the growth model, they derive the relationships between tax rates and corporate valuations. The corporate valuations are negatively related with the tax rates on distribution and corporation income and subsidy rate on tangible investment.

$$v_t = (1-\tau_{dist})[(1-\tau_{subs})k_{m,t+1} + (1-\tau_{corp})k_{u,t+1}]$$

where v_t, $k_{m,t+1}$ and $k_{u,t+1}$ denote the price per share, tangible assets, and intangible assets. τ_{dist} and τ_{corp} denote the tax rates on distribution and corporation income, while τ_{subs} denotes subsidy rate on tangible investment.

The thesis is in line with McGrattan and Prescott's findings that corporate valuations have relationships with the tax rates. Therefore, the initial assumption is that the changes in tax rates do affect the corporate valuations. How the changes in tax rates affect the

corporate valuations, and how the agents (the households and the firms) reflect with these changes are studied.

The structure of the thesis is organized as follows. The first section is the introduction, which reviews briefly former researches about German tax reform and growth theory that is used in the analysis. In the second section the German tax reforms are shortly reviewed, especially tax reform 2000. The third section is model settings and analysis. I set up the model and deal with it to get equilibrium condition. The results are analyzed in the fourth section. The last section is conclusion and remarks.

2 German Tax Reforms[1]

In this section I primarily focus on the main tax reforms after the unification that have been implemented (the tax reform 2000 and consumption tax reform 2007) and will be implemented soon (the tax reform 2008). On 6th July, 2000, the Bundestag passed the Tax Reduction Act. On 14th July, it was approved by the Bundesrat. The Tax Reform 2000 became reality. The law entered into force on 1st January, 2001 and was fully implemented on 1st January, 2005. The tax reform 2000 has brought fundamental changes to the German tax system. Haan and Steiner (2004) point out that the tax reform 2000 will reduce the tax burden in total by about € 57 billion, of which about € 32 billion is due to the reduction of personal income taxes, and the rest to reduction in the taxation of corporations. Families, wage and salary earners and small and medium-sized businesses are the main beneficiaries of the reform.

2.1 Reduction of Personal Income Tax

The main changes in the personal income tax (PIT) were the sequenced cut in marginal tax rates, the increase in the basic allowance, and the reduction in the level at which the highest marginal rate and the entry-level rate applied (see Figure 3). The goal of the reform was to send a powerful growth signal to consumers and investors which, in turn, boosted domestic growth in particular, promoted job creation and increased the incentives to take up legal employment.

Tax reform 2000 has significantly lowered the rates of the income tax in several stages. The entry-level tax rate was reduced from 25.9% in 1998 to 22.9% in 2002, and finally 15.0% in 2005. The top marginal rate was cut, also step by step, from 53.0% in 1998 to 51.0% in 2002, and finally 42.0% in 2005. Over the same period, the basic personal allowance was increased from € 6,322 in 1998 to €7,235 in 2002, and finally € 7,664 in 2005. Since 2005, the top rate was applied only to taxable income in excess of € 52,152.

[1] Material about tax reform 2000 comes from Federal Ministry of Finance and Keen (2002).

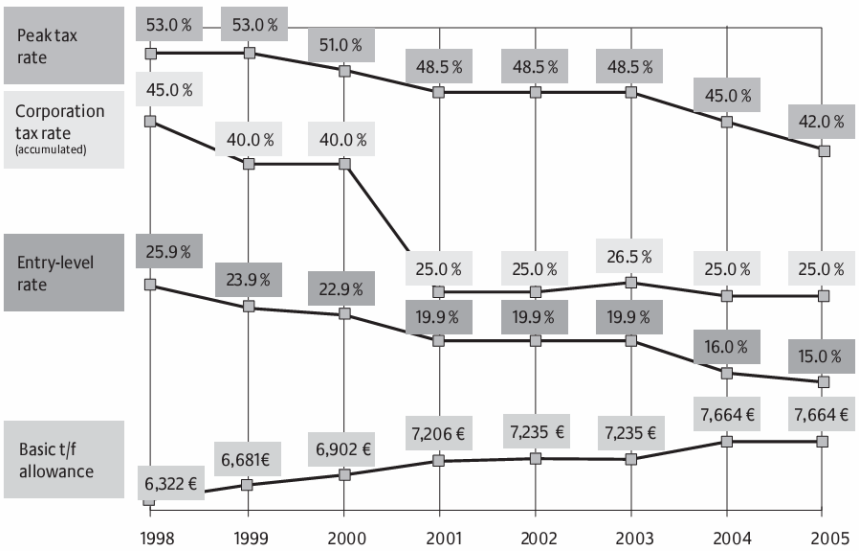

Figure 3: Development of tax rates and basic allowance, 1998-2005
Source: Federal Ministry of Finance

Figure 4 illustrates the changes in marginal tax rates between 1998, prior to the start of the reform, and 2005, at the end of the reform. At the two extremes of this distribution, the cuts in the marginal rates are large (25.9-15.0; 53.0-42.0). However, at intermediate income levels – in which many taxpayers are likely to be located – the cuts are less significant. The rate cuts reduced the tax charge on all payers of income tax, affording the greatest relief to employees and families with low and medium incomes as well as small and medium-sized unincorporated businesses.

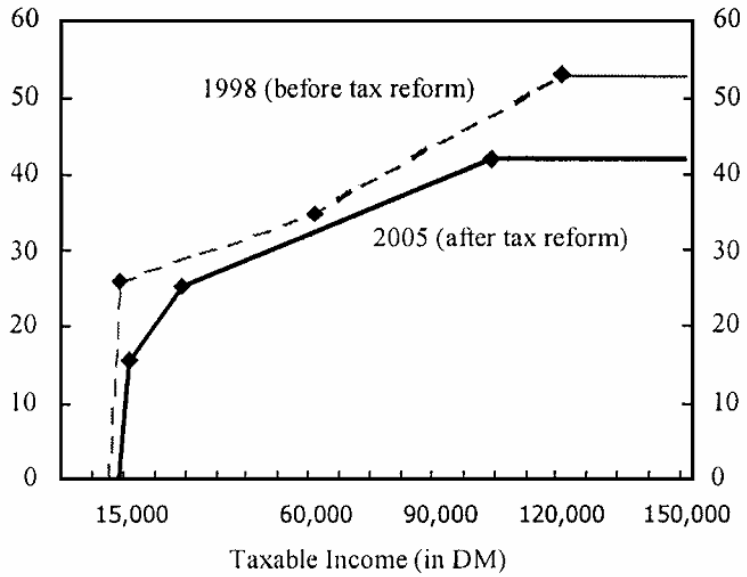

Figure 4: Marginal income tax rates.
Source: Keen (2002)

2.2 Reduction of Corporation Income Tax

The deepest structural reform was the corporation income tax (CIT). Before 2001 German corporation income taxes were calculated according to a split rate system – 40.0% on retained profits and 30.0% on distributed profits. This method has been replaced by a single tax rate.

The corporation income tax rate was cut from the above mentioned rates of 40.0% and 30.0% to a uniform rate of 25.0% since 2001. In 2003, the federal government decided to raise the corporation income tax rate by 1.5% to 26.5% against the background of the flood catastrophe. The corporation income tax rate returned to 25.0% since 2004.

2.3 The Changes in the System of Taxing Shareholders

Regarding to the taxation of dividends, the full imputation system – the corporation income tax paid on distributed profits being treated as a prepayment of the shareholder's liability to personal income tax on those dividends – was replaced by the so-called "half-income" system, to make cross-border investment within Europe more attractive. Under this system, only half of the distributed profits of a corporation were included in the shareholder's personal income tax base. This provision entered into force in 2002.

2.4 Tax Reform has no End

From 1st January, 2007 value added tax rate (VAT, or consumption tax rate) increased from 16.0% to 19.0%. On 25th May, 2007 the Bundestag passed the German Tax Reform 2008 bill. The new rules will become effective on 1st January, 2008.

The main change in the tax reform 2008 is a significant cut in tax rates for corporate taxpayers. Today, the average combined corporation income tax and trade tax rate for corporate taxpayers is around 39.0%. As trade tax rates are set by municipalities, the exact rate depends on the municipality where the business is located. After the tax reform 2008, the combined average corporation income tax and trade tax will be reduced to

around 29.0%. Whereas trade tax rates will stay more or less unchanged, the corporation income tax will be reduced from today's rate of 25.0% to 15.0% in 2008. Surcharge of 5.5% on corporation income tax will keep unchanged. Therefore, effective corporation income tax will decrease to 15.825% (from currently 26.375%). Current calculations show that the planned corporation tax reform will appreciably relieve the German economy. By improving its status as a fiscal location, Germany will make a big leap forward by international comparison. All the small and medium-sized enterprises will be the big winners, because the rate cuts will have their effect for enterprises of this size, while essential elements of the counter-financing will not affect them, since they will be exempted due to allowable deductions and tax-free amounts.

Another dramatic change is taxation of private capital investment income. Private investors' capital investment income (effective on 1st January, 2009) will no longer be subject to their progressive individual income tax rate, but will instead be subject to a 25% flat tax rate (plus surcharge and church tax). The half-income taxation system on dividends will be abolished. Capital investment income is defined as interest and dividend income as well as capital gains (except from real estate).

3 The Growth Model

A standard neoclassical growth model with preferences, technology, and budget constraints for the households, the firms, and the government is used. There are three sectors in the model: 1) the households, who consume the final goods, provide labor, buy shares of the firms, receive wage and dividend payment from the firms, and borrow money from the government; 2) the firms, which hire labor, produce the final goods, issue the stocks to get capital, pay wage to the households, and distribute dividends to the shareholders; and 3) the government, which pays government transfer to the households, collects taxes from the households (VAT, PIT etc.) and the firms (CIT etc.), and lends money to the households. To simplify the model, I combine financial institutions with the government. It means that the households can only borrow money from the government. In addition, Germany is simply assumed as a closed economy. There is no international trade and investment. Time is discrete and infinite, $t = 0,1,...,\infty$. The households, the firms, and the government would exist for ever. Finally, there is no uncertainty.

3.1 Model Representation

The households have preferences over sequences of consumption and labor, and maximize their lifetime utility by deciding consumption, labor, number of shares and debt subject to their budget constraint. Here the simplest natural-logarithm utility function is used. The utility depends positively on privately provided consumption and leisure of the households. In the thesis, the initial assumption is that the sum of labor and leisure is equal to 1.

Thus, the utility function is as follows.

$$u(c_t, l_t) = \log c_t + \log l_t \tag{1}$$

$$l_t + n_t = 1 \tag{2}$$

where t indexes time, c_t, l_t and n_t denote consumption, leisure and labor supply.

Since $l_t + n_t = 1$, I substitute l_t as $1 - n_t$ into the utility function and get utility function that depends on consumption and labor as follows.

$$\max_{c_t, n_t, s_t, b_t} \sum_{t=0}^{\infty} \beta^t u(c_t, n_t) = \sum_{t=0}^{\infty} \beta^t (\log c_t + \log(1-n_t)) \tag{3}$$

$$s.t.$$

$$(1+\tau_t^c)c_t + v_t(s_t - s_{t-1}) + R_t b_{t-1} = (1-\tau_t^d)d_t s_{t-1} + (1-\tau_t^n)w_t n_t + \psi_t + b_t \tag{4}$$

This constraint says that the expenditures must be equal to after-tax income. Expenditures of the households are consumption c_t , purchases of shares in stocks, $v_t(s_t - s_{t-1})$, and gross payment of the loans, $R_t b_{t-1}$, where v_t is price of shares, s_t denotes the number of the shares that the households are holding at time period t, R_t is gross interest rate, and b_t is debt that the households borrow from the government. Here s_t is a decimal fraction from 0 to 1. Receipts of the households are wage, dividend payment from the firms, and government transfer. w_t , d_t , and ψ_t denote the wage rate, dividend payment, and lump-sum government transfer. The households have to pay taxes on consumption at a rate equal to τ_t^c , on personal income at a rate equal to τ_t^n , and on dividend income at a rate equal to τ_t^d . It is assumed that initial value of debt b_{-1} is equal to zero, and when the time goes to infinity, $\lim_{t\to\infty} p_t b_t = 0$.

The firms have capital and hire labor to produce final goods with a constant returns-to-scale Cobb-Douglas production function,

$$y_t = z_t k_{t-1}^{\theta} n_t^{1-\theta}$$

where z_t denotes technology shock at time period t, and k_{t-1} denotes assets of the firms at the end of time period t-1, which will be used at time period t.

At each time period t, dividend payment to the households is equal to what the firms have after they pay wage, taxes, and make new investment. It means that the firms distribute all the after-tax profits after making new investment. There is no profit retention. The firms pay taxes on corporation income at rate τ_t^i . The dividend payment is given by

$$d_t = (y_t - w_t n_t - \delta k_{t-1})(1-\tau_t^i) + \delta k_{t-1} - x_t \tag{5}$$

where x_t denotes new investment. δ denotes deprecation rate. The firms pay corporation income tax at a rate of τ_t^i . It is assumed that initial value of assets k_{-1} is equal to zero.

The firms choose capital and labor to maximize the present value of dividend payment net of taxes paid by the households on dividend income:

$$\max_{k_t, x_t} \sum_{t=0}^{\infty} p_t d_t (1-\tau_t^d) \tag{6}$$

$$s.t.\ \ k_t = (1-\delta)k_{t-1} + x_t \tag{7}$$

The government budget constraint says that government expenditures must be equal to government income. The government collects taxes from the households (consumption tax, personal income tax and dividend income tax) and the firms (corporation income tax), receives interest and debt payment from the households. The government pays government transfer and provides loans to the households.

$$\psi_t + b_t = \tau_t^c c_t + \tau_t^d d_t s_{t-1} + (y_t - w_t n_t - \delta k_{t-1})\tau_t^i + \tau_t^n w_t n_t + R_t b_{t-1} \tag{8}$$

3.2 The Equilibrium

In equilibrium, the households choose consumption, labor, number of shares and debt to maximize their preferences, the firms maximize the present value of distributions after the households pay taxes on dividend payment, and the government sets tax policies to satisfy its budget constraint. And market-clearing in equilibrium requires that labor market clears (In equilibrium, labor supply should be equal to labor demand. This condition has been used in the model settings, because the same notations for labor supply and labor demand are used.); the equity market clears; and the goods market clears:

$$s_t = 1 \tag{9}$$

$$x_t + c_t = y_t \tag{10}$$

The technical Appendix A shortly summarizes the process how the steady states are derived. I assume that the steady states of labor $\overline{n}$ and government transfer $\overline{\psi}$ are given.

The tax system is also given. And the tax rates (corporation income tax rate, personal income tax rate, dividend income tax rate, and consumption tax rate) are looked as exogenous permanent shocks. Here average personal income tax rate is calculated by the model. Average personal income tax is used instead of marginal tax rate based according to the arguments of Uhlig (1999).

The Appendix B shows all the equations that describe the stationary equilibrium. For the dynamic analysis, I log-linearize the equations around the steady states (see Uhlig, 1999 and Appendix C).

3.3 Calibration and Parameterization

I calibrate the model using data of Germany from 1997 to 2006. All the data comes from AMECO database of the European Commission.

Because a "solidarity surcharge" of 5.5 % is levied on the corporation income tax, effective corporation income tax should equal to original corporation income tax rate multiplied by (1+5.5%). Here, the autocorrelation of technology shock is set to be 0.95. Since all the tax shocks will last permanently, the autocorrelations of the tax shocks is equal to 1. All the standard deviations of the shocks are the same (0.1%). For normalization, $\overline{z}$ is equal to 1. The steady state of labor $\overline{n}$ is 0.22, and capital share θ is 0.36. Both of them come from Trabandt and Uhlig (2006). The settings are summarized in Table 1.

Table 1: the Parameter Settings in the Model

Parameter	Value	Description
ρ_z	0.95	Autocorrelation of technology shock
ρ_d	1	Autocorrelation of tax shock on dividend income
ρ_c	1	Autocorrelation of tax shock on consumption
ρ_i	1	Autocorrelation of tax shock on corporation income
ρ_n	1	Autocorrelation of tax shock on personal income
σ_z	0.1	Standard deviation of technology shock (%)

σ_d	0.1	Standard deviation of tax shock on dividend income (%)
σ_c	0.1	Standard deviation of tax shock on consumption (%)
σ_i	0.1	Standard deviation of tax shock on corporation income (%)
σ_n	0.1	Standard deviation of tax shock on personal income (%)
$\overline{z}$	1	Normalization
$\overline{n}$	0.22	Steady state of labor
θ	0.36	Capital share in production

4 Application to Germany

The following section discusses the outcome of the model. The model treats the changes in tax rates as exogenous permanent shocks. There are four tax shocks (consumption tax shock $\tilde{\tau}_t^c$, corporation income tax shock $\tilde{\tau}_t^i$, dividend income tax shock $\tilde{\tau}_t^d$ and personal income tax shock $\tilde{\tau}_t^n$) and one technology shock $\hat{z}_t$ in the model. The impulse responses show how tax reforms affect the corporate equity values, and how the households and the firms respond to the different shocks. I concentrate on the reduction of corporation income tax, personal income tax and dividend income tax in the tax reform 2000, the increase in consumption tax in 2007 and reduction of corporation income tax and dividend income tax in the tax reform 2008.

Here, Toolkit developed by Prof. Uhlig's group is used. Toolkit can analyze the growth model by showing the impulse response to a shock. The impulse response shows how the variables respond to the shock when the model gets a positive exogenous shock. The vertical axis shows how much the other variables deviate from their steady states if the shock increases by 1.0%. The horizon axis means time periods. One can see how the response changes during different time periods.

4.1 Tax Reform 2000

To analyze the effects of reduction of corporation income tax, personal income tax and dividend income tax in the tax reform 2000, I value all the parameters dependent on the situation in 2000, since the tax reform 2000 was implemented on 1st January, 2001. The steady state of government transfer relative to GDP $\overline{\psi}$ is 0.2304. The steady state of gross interest rate $\overline{R}$ in 1999 is 1.0526. The steady state of corporation income tax rate $\overline{\tau}^i$ is 40.0%. Surcharge is still 5.5%. Thus the effective corporation income tax rate should be 42.2%. Since the full imputation system still works in 2000, the steady state of tax rate on dividend income $\overline{\tau}^d$ should be equal to corporation income tax rate. Consumption tax $\overline{\tau}^c$ is still unchanged (16.0%). The depreciation rate δ should be 0.04 in 2000. Other

parameters follow the settings in section 3.3. Table 2 summarizes the settings.

Table 2: Parameter Settings for Tax Reform 2000

Parameter	Value	Description
$\bar{R}$	1.0526	Gross interest rate in 2000
$\bar{\psi}$	0.2304	Government transfer relative to GDP
$\bar{\tau}^{i}$	42.2%	Steady state of effective tax rate on corporation income
$\bar{\tau}^{d}$	40.0%	Steady state of tax rate on dividend income
$\bar{\tau}^{c}$	16.0%	Steady state of tax rate on consumption
δ	0.04	Depreciation rate

After the tax reform 2000 corporation income tax rate decreases from 40.0% to 25.0%, tax rate on dividend income also declines from 40.0% to half of personal income tax rate, and the basic and top rates of personal income tax also decrease. Finally, it led to reduction of average personal income tax. The impulse responses show how consumption, labor, output, wage, debt, and price of shares respond to the changes in corporation income tax, personal income tax, and dividend income tax.

4.1.1 Reduction in Corporation Income Tax rate

Figure 5 and 6 illustrate the impulse responses of consumption, output, wage, labor, debt, price of shares, dividend payment, capital, and new investment to a corporation income tax shock. From Figure 5 and 6, we know that wage, price of shares, and dividend payment have positive relationships with corporation income tax rate. Consumption, output, labor, debt, capital, and new investment have negative relationships with corporation income tax rate. Since corporation income tax rate decreases after the tax reform 2000, the firms pay less tax on corporation income. Therefore, the firms increase output to get more profits. The increase in output leads to the rise in labor, which results in the fall in wage. Meanwhile, the increase in output also leads to the increase in consumption. The households consume more, but get lower wage. It is the reason why debt grows sharply.

The tax cut in corporation income results in the decrease in price of shares. The impulse response shows the relationship between corporation income tax rate and corporation valuations opposite to the conclusion of McGrattan and Prescott (2005). The outcome shows that price of shares is positively related with the corporation income tax, while McGrattan and Prescott (2005) get a negative relationship.

The impulse responses of dividend payment, capital, and new investment answer why price of shares has a positive relationship with corporation income tax. When corporation income tax rate decreases, dividend payment also decreases, but new investment and capital increase. We know that output grows. The firms need more input to produce more final goods. So the increases in new investment and capital are reasonable. It also leads to the fall in dividend payment. This is the reason why price of shares decreases. Normally, dividend payment is a signal of situation of the firms. If the firms declare that they will decrease dividend payment. It may affect the shareholders' confidence in the firms. It may lead to the decrease in price of shares.

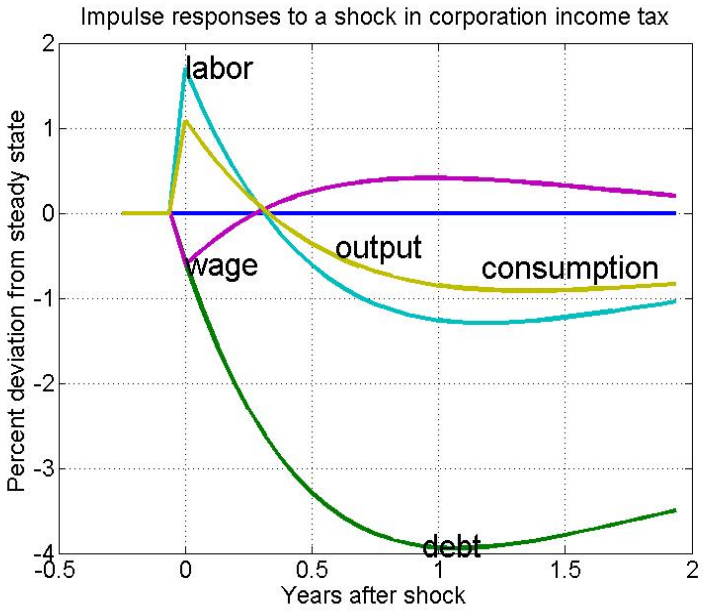

Figure 5: the impulse responses to a shock in corporation income tax

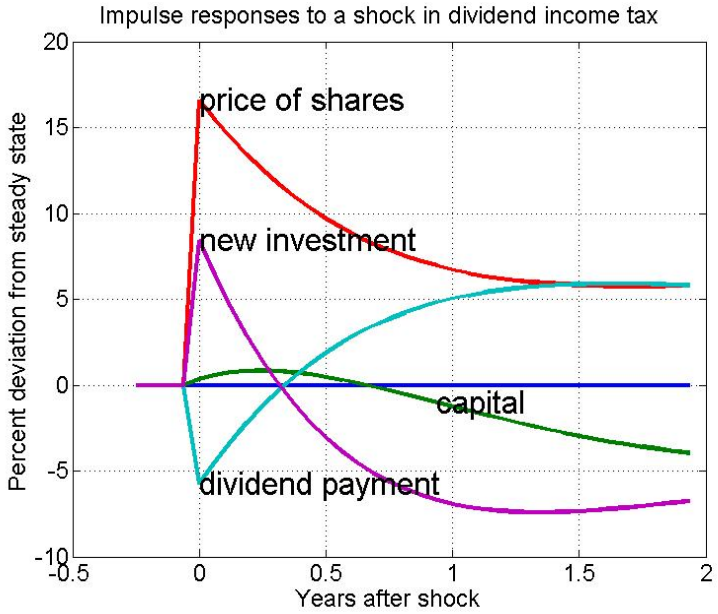

Figure 6: the impulse responses to a shock in corporation income tax

4.1.2 Reduction in Personal Income Tax

Figure 7 and 8 tell us that the decrease in personal income tax rate leads to the decrease in wage, price of shares, dividend payment, capital, and new investment and the increase in consumption, output, labor, and debt. Because of reduction of personal income tax rate, the households have more money to deal with if the income is unchanged. Thus, consumption grows. The firms need to increase output to satisfy the increased demands. To produce more final goods, the firms need more workers. Therefore, labor increases. The rise in labor makes wage lower. The households consume more, but receive less. So they have to borrow more money. Keen (2002) also gets similar conclusion that the decline in average personal income tax rate brought about by the tax reform 2000 will tend to generates substitution effects that point to an increased labor supply.

Figure 8 displays the effect of a shock in personal income tax on price of shares. Because the average personal income tax decreases after the tax reform 2000, price of shares falls. As we know, output grows. It means that the firms performance well. It should lead to increase in price of shares.

The impulse responses of dividend payment, capital, and new investment do not give us meaningful explanation (see Figure 8). As personal income tax rate decreases,

dividend payment, capital and new investment decrease too. Meanwhile, output increases. How do the firms finance their output booming? In the model, the firms distribute all the net profit after making new investment. Therefore, the decrease in new investment should result in the rise in dividend payment. Since the impulse response shows that dividend payment would decrease too, the only possible explanation is that the firms retain some of their profits to increase their output.

The reason why price of shares decreases is that the firms performance well, but they decrease dividend payment on contrary. The firms, which performance well, decrease dividend payment, capital and new investment to get more profit retention. It might lead to the decrease in price of shares.

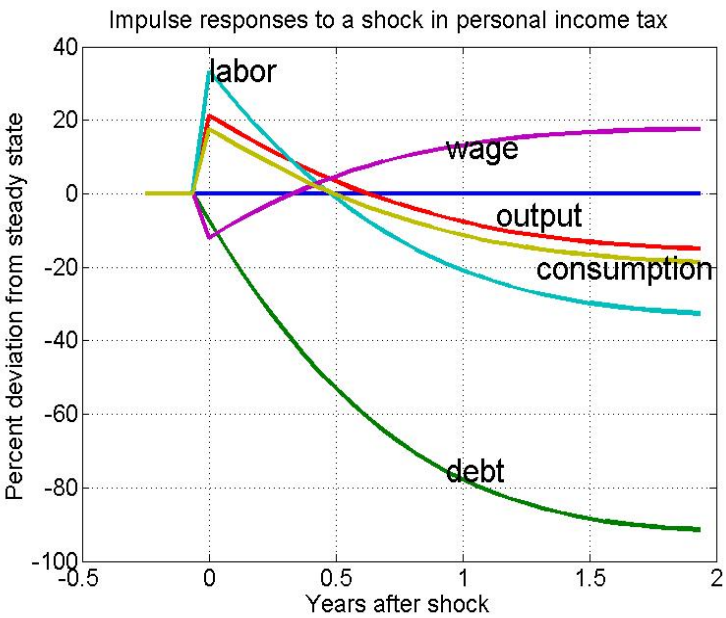

Figure 7: the impulse responses to a shock in personal income tax

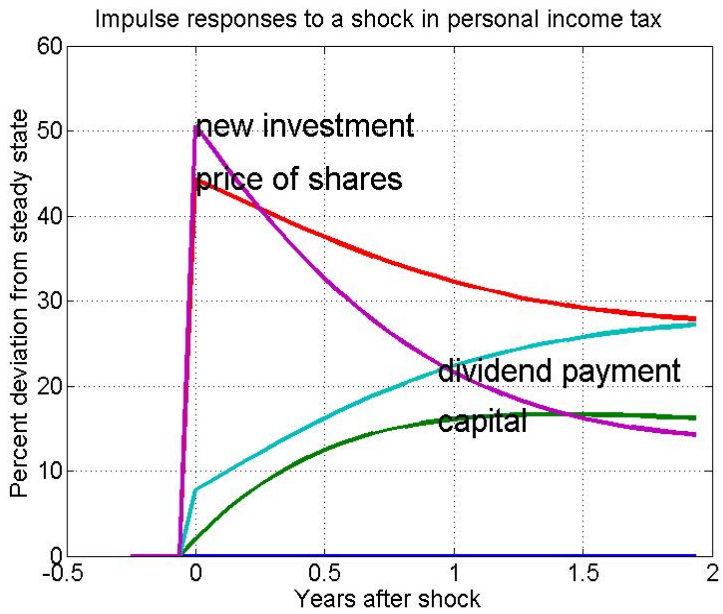

Figure 8: the impulse responses to a shock in personal income tax

4.1.3 Reduction in Dividend Income Tax

From the tax reform 2000, we also know that the half-income tax system replace the full imputation system. Indeed, it leads to the decrease in dividend income tax rate. Figure 9 and 10 show that dividend income tax rate has positive relationship with wage, price of shares, and dividend payment and negative relationships with consumption, output, labor, debt, capital and new investment. Due to reduction of dividend income tax rate, the shareholders get more after-tax dividends relatively. The households get more money at their disposal. Therefore, consumption increases. It leads to the rise in output, which results in the increase in labor. Wage falls, as labor increases. The decline in wage results in the increase in debt.

Since the dividend income tax rate has a positive relationship with price of shares, the decrease in dividend income tax rate leads to the fall in price of shares. Here, we get similar results with corporation income tax shock and personal income tax shock. Output increases, but price of shares decreases.

Figure 10 tells us why price of shares decreases. The increase in output leads to the increases in new investment and capital, which lead to the decrease in dividend payment. Thus, the decrease in dividend payment is the only explanation of the decrease in price of

shares.

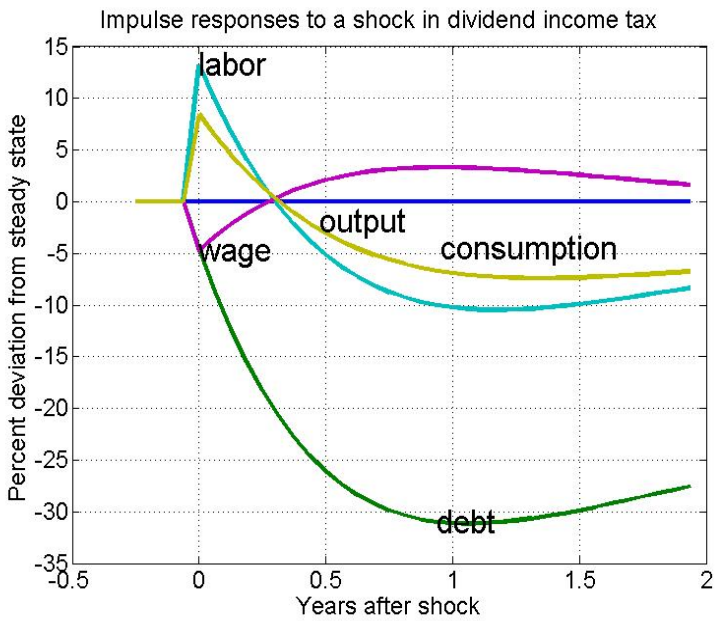

Figure 9: the impulse responses to a shock in dividend income tax

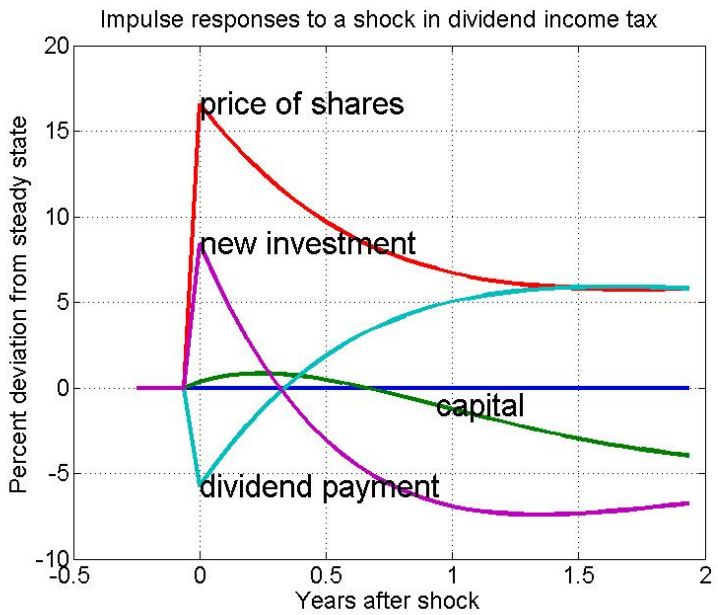

Figure 10: the impulse responses to a shock in dividend income tax

Therefore, the decreases in corporation and personal income tax rates and dividend income tax rate lead to the decrease in price of shares and wage, and the increase in

consumption, output, labor and debt. But the firms reflect the shocks differently. For the reduction of corporation income tax rate and dividend income tax rate, the firm decrease dividend payment, but increase new investment and capital. For the reduction of personal income tax rate, the firms also decrease dividend payment, but decline new investment and capital at the same time.

4.2 Consumption Tax 2007

The steady state of effective corporation income tax rate $\overline{\tau}^{i}$ is equal to 26.375%. Under the half-income system, the steady state of dividend income tax rate $\overline{\tau}^{d}$ should be equal to $\frac{1}{2}\overline{\tau}^{n}$. The steady state of gross interest rate $\overline{R}$ is 1.0448 on average. The steady state of government transfer relative to GDP is 0.2352 on average. The depreciation rate δ should be 0.03. The rest of steady states and parameters are consistent with the settings in section 3.3. Table 3 summarizes the settings for consumption tax rate cut.

Table 3: Parameter Settings for Tax Reform 2007

Parameter	Value	Description
$\overline{R}$	1.0448	Average gross interest rate from 1997 to 2006
$\overline{\psi}$	0.2352	Average government transfer relative to GDP
$\overline{\tau}^{i}$	26.375%	Steady state of effective tax rate on corporation income
$\overline{\tau}^{d}$	$\frac{1}{2}\overline{\tau}^{n}$	Steady state of tax rate on dividend income
$\overline{\tau}^{c}$	16.0%	Steady state of tax rate on consumption
δ	0.03	Depreciation rate after tax reform 2000

From 1st January, 2007 the consumption tax rate increased 3.0% from 16.0% to currently 19.0%. That means the goods become relatively more expensive. The disposable income of the households decreases. Therefore, consumption decreases (see Figure 11). And the firms have to decrease output, since demand is shrinking. The decrease in output directly leads to decrease in labor. The firms do not need that much

labor any more. Since labor decreases, wage should increase. Thus, the households do not need to borrow too much money. The loans decline. Botman and Danninger (2007) also get the conclusion that the consumption tax hike temporarily dampens growth in 2007, but lower payroll taxation and anticipatory effects of the corporation income tax cut in 2008 substantially reduce the magnitude of this effect. Their model suggests that the 2007 tax relief package would also reduce consumption.

There is a positive relationship between consumption tax rate and price of shares (see Figure 12). It means price of shares should increase since consumption tax rate increases. We know that the increase in consumption tax rate leads to decrease in output. The firms can not performance better than before. It seems that price of shares should decrease. But the increase in dividend payment tells us why price of shares increases. Although output decreases, dividend payment, new investment and capital increase. These behaviors of the firms give the shareholders a strong signal that the firms will develop much better in the future. The confidence of the shareholders is increasing. So price of shares increases.

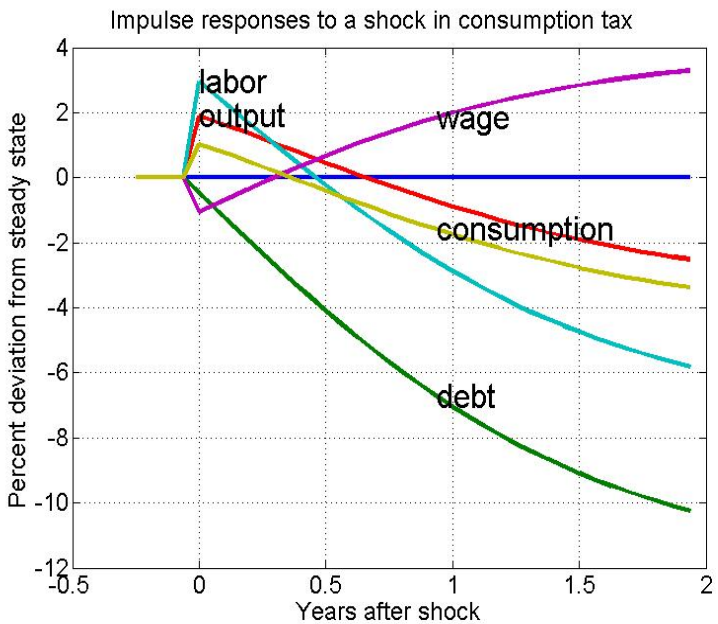

Figure 11: the impulse responses to a shock in consumption tax

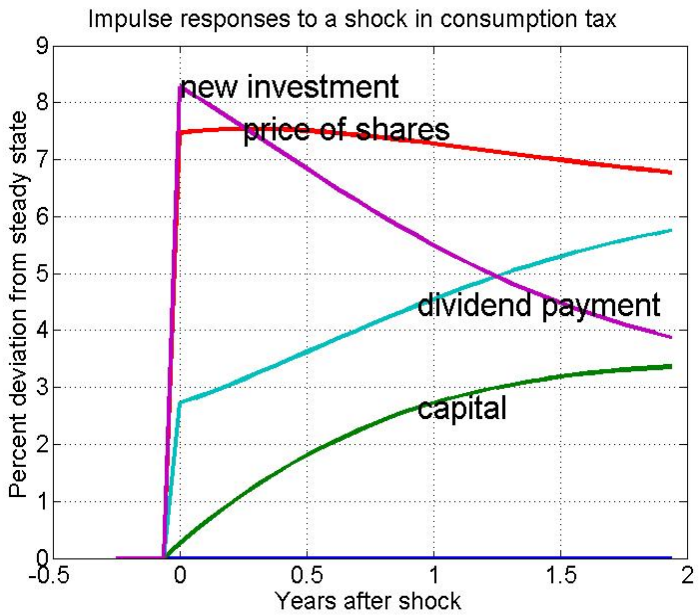

Figure 12: the impulse responses to a shock in consumption tax

Therefore, after consumption tax rate increases, the households get higher wage, and receive more dividends. But at the same time, they also borrow more money from the government, and cut their consumption. The firms reduce output. But price of shares increases.

4.3 Tax Reform 2008

Tax reform 2008 will be implemented in 1st January, 2008. Since it is impossible to get accurate data in 2007, all the steady states and parameters are consistent with the settings in section 4.2, besides the consumption tax rate. The consumption tax increased to 19.0% in 2007. So its steady state becomes 19.0%. Table 4 exhibits settings for tax reform 2008.

Table 4: Parameter Settings for Tax Reform 2008

Parameter	Value	Description
$\bar{R}$	1.0448	Gross interest rate
$\bar{\psi}$	0.2352	Government transfer relative to GDP
$\bar{\tau}^i$	26.375%	Steady state of effective tax rate on corporation income

$\overline{\tau}^{d}$	$\frac{1}{2}\overline{\tau}^{n}$	Steady state of tax rate on dividend income
$\overline{\tau}^{c}$	19.0%	Steady state of tax rate on consumption
δ	0.03	Depreciation rate

After tax reform 2008, corporation income tax will decrease to 15.0% (now 25.0%). For the dividend the half-income taxation system will be replaced by 25.0% flat-rate taxation system. From the model for reduction of consumption tax 2007, the steady state of tax rate on dividend income is 36.3%. It means that the tax reform 2008 will decrease the tax rate on dividend income. I will show how these two main changes affect consumption, labor, output, wage, debt, and price of shares.

4.3.1 Reduction in Corporation Income Tax

Corporation income tax rate has a positive relationship with wage, and negative relationships with consumption, output, labor and debt (see Figure 13). We can see that the impulse responses to corporation income tax rate shock in tax reform 2008 are similar with those in tax reform 2000 (see Figure 5). The decrease in corporation income tax rate will lead to the increase in wage, and the decrease in consumption, output, labor and debt. But the magnitude is different from that in 2000. If the corporation income tax rate decreases by 1.0%, wage will decrease by about 0.25%, consumption and output will increase by about 0.7%, labor will increase by about 0.9%, and debt will increase by 2.0%.

Corporation income tax rate has a positive relationship with price of shares (see Figure 14). Price of shares will fall after tax reform 2008, because the firms will pay less dividend payment to finance the increase in capital and new investment. The decrease in dividend payment is the reason why price of shares decreases, when corporation income tax rate decreases.

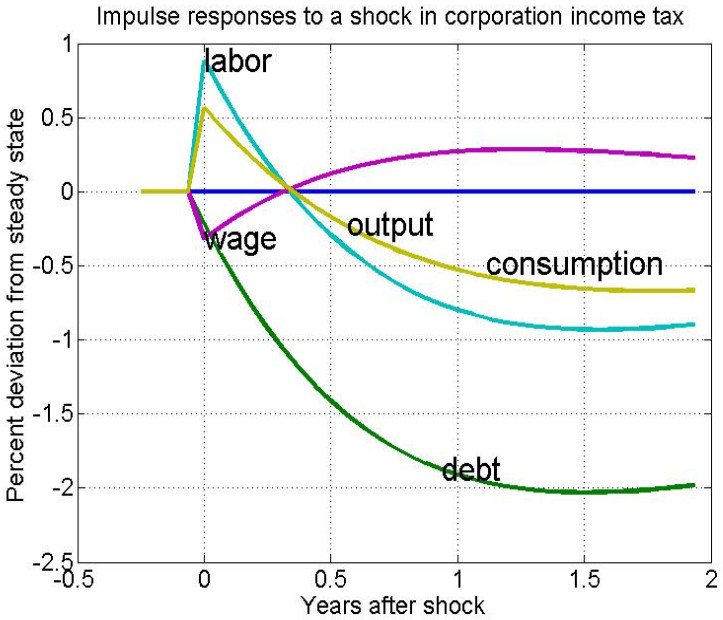

Figure 13: the impulse responses to a shock in corporation income tax

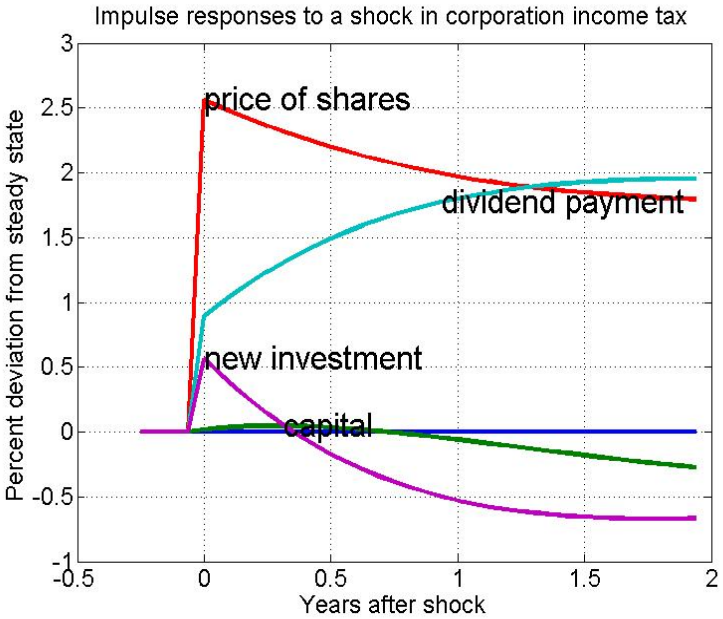

Figure 14: the impulse responses to a shock in corporation income tax

4.3.2 Reduction in Dividend Income Tax

Figure 15 and 16 illustrate how the households and the firms will respond to the cut in dividend income tax. The impulse responses are similar with those in tax reform 2000. If the dividend income tax rate decreases, wage will decrease, while consumption, output,

labor and debt will increase. Figure 16 reveals that dividend income tax rate has a positive relationship with price of shares. The firms will pay less dividend payment, and get more capital and new investment. Therefore, they can produce more final goods. The decrease in dividend payment results in the fall in price of shares, when dividend income tax rate decreases.

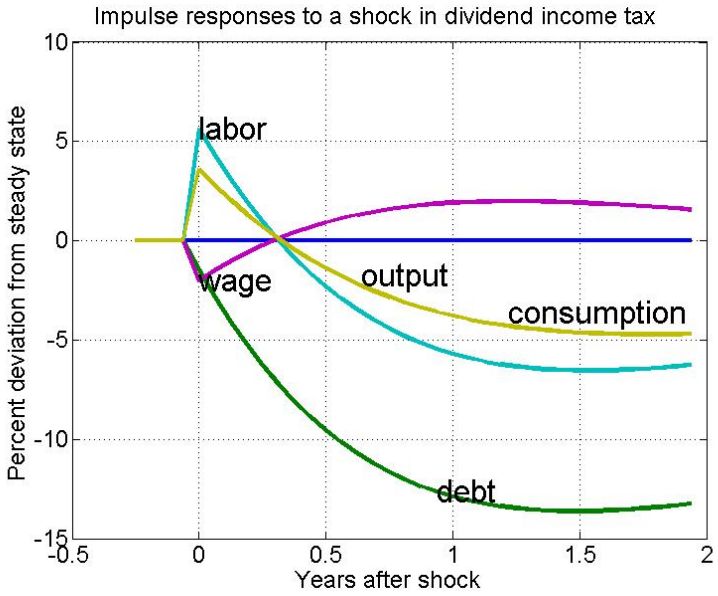

Figure 15: the impulse responses to a shock in dividend income tax

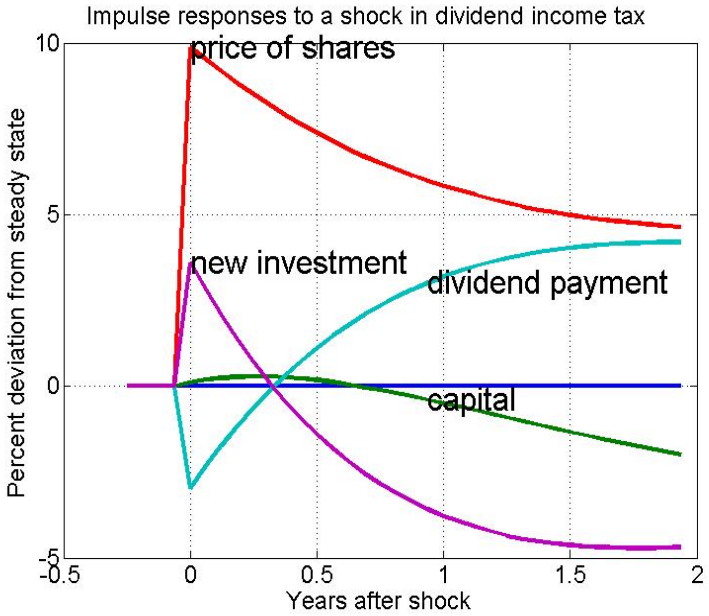

Figure 16: the impulse responses to a shock in dividend income tax

Therefore, the tax reform 2008 reduces corporation income tax rate and dividend income tax rate. All the impulse responses show similar patterns with those in the tax reform 2000. Both tax cuts will lead to the decrease in price of shares. At the same time, wage will increase, while consumption, output, labor and debt will decrease.

5 Conclusion and Remarks

Here, I have derived the simulation of a standard growth model – the standard tool of macroeconomics and public finance – for the value of German corporations and economic behaviors in the period of the tax reform 2000, 2007, and 2008. Given tax rate reforms, the model simulates that the shocks in tax rates have positive relationships with corporate valuations. The tax cuts in the tax reform 2000 and 2008 lead to the decrease in price of shares. While the increase in consumption tax rate in 2007 leads to the increase in price of shares.

Although the impulse responses of price of shares to the tax shocks are similar, the reasons why they happen are not exactly the same. For the cuts in corporation income tax rate and dividend income tax rate, the reason is that the firms increase capital and new investment, but decrease dividend payment because of the increased output. However, for the cut in personal income tax rate, the reason is that the firms decrease capital, new investment and dividend payment when they should increase output. For the increase in consumption tax rate, the firms increase dividend payment, though they have to cut output. It leads to the increase in price of shares.

The households and the firms exhibit similar responses to respective tax reforms. The cuts in corporation and personal income tax rates and dividend income tax rate lead to the decrease in wage, the increases in consumption, output, labor and debt. The increase in consumption tax rate leads to the increase in wage, and the decrease in consumption, output, labor and debt.

As Federal Ministry of Finance estimates, because of tax reform 2000, companies and consumers have appreciably more money at their disposal. This stimulates private consumption and eases the funding of investment – two essential requirements for promoting growth and employment. These have been proved by the model. Although the consumption tax reform 2007 will dampen consumption and labor, but still will stimulate new investment. The tax reform 2008 will further stimulate consumption, output, labor and new investment.

I have proved that the changes in tax policy are important for corporate evaluations. However, the results are totally different from the outcome of McGrattan and Prescott

(2005). Many reasons may lead to the difference. For example, although we both use growth theory, the analysis processes and tools are quite different. In my thesis toolkit is used, while McGrattan and Prescott use statistical comparison. On the other hand, the model in my thesis is quite simple. Many factors are neglected. It might result in inaccuracy of the model. For example, the steady state of personal income tax rate after the tax reform is calculated by the model. However, the value is extremely high, about 72%. As we know, the top rate of personal income tax is only 42% in 2005. Finally, growth theory is a parameter-sensitive model. The values of parameters highly affect the results. This might be another reason why the outcome of the thesis is different from that of McGrattan and Prescott.

Thus, in future research there are many factors to be added to get more perfect model, such as trade tax rate. In my model, the trade tax rate is neglected, since the tax rates are different in different lands. An average trade tax rate can be taken into account. Another factor is the roles of the financial institution. I assume that there is no financial institution, and the households can only borrow money from the government. The financial institutions may be introduced into the model, since they have played a very important role in the financial market. And the improvement in choosing parameters will be helpful.

Furthermore, different utility functions such as Cobb-Douglas utility function, power utility function can be used to get the most suitable utility function. Since the households can not live for ever, the limitation of the life may make their patterns different. An overlapping generation model may be helpful to solve this problem.

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7 Appendix

A. First-Order Conditions

1. Household Problem

Maximization problem of the households is to maximize (3) subject to (4). We get Lagrange function of the households:

$$L=\sum_{t=0}^{\infty}\beta^{t}((\log c_t+\log(1-n_t))-\lambda_t((1+\tau_t^c)c_t+v_t(s_t-s_{t-1})+R_t b_{t-1}-(1-\tau_t^d)d_t s_{t-1}-(1-\tau_t^n)w_t n_t-\psi_t-b_t))$$

The first-order conditions for the households respect to s_{t+1}, c_t, n_t, and b_t are that

$$\frac{\lambda_t}{\beta\lambda_{t+1}}=\frac{v_{t+1}+(1-\tau_{t+1}^d)d_{t+1}}{v_t} \tag{A.1}$$

$$\frac{1}{c_t}=\lambda_t(1+\tau_t^c) \tag{A.2}$$

$$\frac{1}{1-n_t}=\lambda_t(1-\tau_t^n)w_t \tag{A.3}$$

$$\frac{\lambda_t}{\beta\lambda_{t+1}}=R_{t+1} \tag{A.4}$$

Combining (A.1) and (A.4), we get

$$R_{t+1}=\frac{v_{t+1}+(1-\tau_{t+1}^d)d_{t+1}}{v_t} \tag{A.5}$$

2. Firm Problem

Maximization problem of the firms is to maximize (6) subject to (7). We get Lagrange function of the firms:

$$L=\sum_{t=0}^{\infty}p_t d_t(1-\tau_t^d)-\lambda_t((1-\delta)k_{t-1}+x_t-k_t)$$

The first-order conditions for the firms respect to x_t, k_t, and n_t are that

$$\lambda_t=-p_t(1-\tau_t^d) \tag{A.6}$$

$$\lambda_t + p_{t+1}(1-\tau_{t+1}^d)((\frac{\partial y_{t+1}}{\partial k_t}-\delta)(1-\tau_{t+1}^i)+\delta)-\lambda_{t+1}(1-\delta)=0 \tag{A.7}$$

$$w_t = (1-\theta)\frac{y_t}{n_t} \tag{A.8}$$

Plugging (A.6) into (A.7), we get

$$\frac{p_t}{p_{t+1}} = \frac{(1-\tau_{t+1}^d)(\frac{\partial y_{t+1}}{\partial k_t}(1-\tau_{t+1}^i)+1)}{(1-\tau_t^d)} = R_{t+1} \tag{A.9}$$

B. Steady States Equations

1. Steady States Equations

In steady states, all the variables do not depend on time period. So I replace x_t, x_{t+1} or x_{t-1} by $\overline{x}$. We get all the steady states equations as follows:

(1) $\overline{R} = \dfrac{\overline{v}+(1-\overline{\tau}^d)\overline{d}}{\overline{v}}$

(2) $\overline{R} = \dfrac{(1-\overline{\tau}^d)((1-\overline{\tau}^i)(\theta\frac{\overline{y}}{\overline{k}}-\delta)+1)}{(1-\overline{\tau}^d)}$

(3) $\overline{R} = \dfrac{\overline{\lambda}}{\beta\overline{\lambda}} = \dfrac{1}{\beta}$

(4) $\dfrac{1}{\overline{c}} = \overline{\lambda}(1+\overline{\tau}^c)$

(5) $\dfrac{1}{1-\overline{n}} = \overline{\lambda}(1-\overline{\tau}^n)\overline{w}$

(6) $\overline{w} = (1-\theta)\dfrac{\overline{y}}{\overline{n}}$

(7) $(1+\overline{\tau}^c)\overline{c}+(\overline{R}-1)\overline{b} = (1-\overline{\tau}^d)\overline{ds}+(1-\overline{\tau}^n)\overline{wn}+\overline{\psi}$

(8) $\overline{k} = (1-\delta)\overline{k}+\overline{x}$

(9) $\bar{b} + \bar{\psi} = \bar{\tau}^c \bar{c} + \bar{\tau}^d \bar{ds} + (\bar{y} - \bar{w}\bar{n} - \delta\bar{k})\bar{\tau}^i + \bar{\tau}^n \bar{w}\bar{n} + \bar{R}\bar{b}$

(10) $\bar{d} = (\bar{y} - \bar{w}\bar{n} - \delta\bar{k})(1 - \bar{\tau}^i) + \delta\bar{k} - \bar{x}$

(11) $\bar{y} = \bar{z}\bar{k}^{\theta}\bar{n}^{1-\theta}$

(12) $\bar{c} + \bar{x} = \bar{y}$

(13) $\bar{s} = 1$

2. Solving Steady States

Here, I assume that government transfer $\bar{\psi}$ and labor $\bar{n}$ are given. All policy instruments ($\bar{\tau}^i, \bar{\tau}^d$, and $\bar{\tau}^c$) and parameters are also given, and substitute everything in the allocation equations.

From (3): $\bar{R} = \frac{1}{\beta}$

From (2): $\frac{\bar{y}}{\bar{k}} = \frac{1}{\theta}(\delta + \frac{\bar{R} - 1}{1 - \bar{\tau}^i})$

From (11): $\bar{k} = (\frac{\bar{y}}{\bar{k}})^{\frac{1}{\theta - 1}}\bar{n}$ and $\bar{y} = (\frac{\bar{y}}{\bar{k}})\bar{k}$

From (8): $\bar{x} = \delta\bar{k}$

From (12): $\bar{c} = \bar{y} - \bar{x}$

From (6): $\bar{w} = (1 - \theta)\frac{\bar{y}}{\bar{n}}$

From (4) and (5): $\bar{\tau}^n = 1 - \frac{(1 + \bar{\tau}^c)(1 - \bar{n})\bar{c}}{\bar{w}}$

From (4): $\bar{\lambda} = \frac{1}{(1 + \bar{\tau}^c)\bar{c}}$

From (10): $\bar{d} = (1 - \bar{\tau}^i)(\bar{y} - \bar{w}\bar{n} - \delta\bar{k}) + \delta\bar{k} - \bar{x}$

From (1): $\bar{v} = \frac{1-\bar{\tau}^d}{\bar{R}-1}\bar{d}$

From (9): $\bar{b} = \frac{-(1+\bar{\tau}^c)\bar{c} + (1-\bar{\tau}^d)\bar{d} + (1-\bar{\tau}^n)\bar{w}\bar{n} + \bar{\psi}}{\bar{R}-1}$

C. Log-Linearization

Hat variables represent the percentage deviation from steady state: $\hat{x}_t = \frac{x_t - \bar{x}}{\bar{x}}$. Thus, every variable x_t can be expressed by $(1+\hat{x}_t)\bar{x}$. And tilde variables denote level deviations from steady state: $\tilde{x}_t = x_t - \bar{x}$.

(1) $0 = -\bar{R}\bar{v}\hat{R}_{t+1} + \bar{v}\hat{v}_{t+1} + (1-\bar{\tau}^d)\bar{d}\hat{d}_{t+1} - \bar{R}\bar{v}\hat{v}_t - \bar{d}\tilde{\tau}^d_{t+1}$

(2)
$$0 = -\bar{R}(1-\bar{\tau}^d)(1-\bar{\tau}^i)\hat{R}_{t+1} + (1-\bar{\tau}^d)(1-\bar{\tau}^i)\theta\frac{\bar{y}}{\bar{k}}\hat{y}_{t+1} + (1-\bar{\tau}^d)(1-\bar{\tau}^i)\theta\frac{\bar{y}}{\bar{k}}\hat{k}_t$$
$$-((\theta\frac{\bar{y}}{\bar{k}} - \delta)(1-\bar{\tau}^i)+1)\tilde{\tau}^d_{t+1} - (\theta\frac{\bar{y}}{\bar{k}} - \delta)(1-\bar{\tau}^d)\tilde{\tau}^i_{t+1} + \bar{R}(1-\bar{\tau}^i)\tilde{\tau}^d_t$$

(3) $0 = \hat{R}_{t+1} + \hat{\lambda}_{t+1} - \hat{\lambda}_t$

(4) $0 = \bar{c}(1+\bar{\tau}^c)\hat{c}_t + \bar{c}\bar{\lambda}(1+\bar{\tau}^c)\hat{\lambda}_t + \bar{c}\bar{\lambda}\tilde{\tau}^c_t$

(5) $0 = \bar{\lambda}\bar{w}(1-\bar{n})(1-\bar{\tau}^n)\hat{\lambda}_t - \bar{\lambda}\bar{w}\bar{n}(1-\bar{\tau}^n)\hat{n}_t + \bar{\lambda}\bar{w}(1-\bar{n})(1-\bar{\tau}^n)\hat{w}_t - \bar{\lambda}\bar{w}(1-\bar{n})\tilde{\tau}^n_t$

(6) $0 = -\hat{y}_t + \hat{w}_t + \hat{n}_t$

(7)
$$0 = \bar{c}(1+\bar{\tau}^c)\hat{c}_t + \bar{R}\bar{b}\hat{R}_t - \bar{d}(1-\bar{\tau}^d)\hat{d}_t - \bar{w}\bar{n}(1-\bar{\tau}^n)\hat{w}_t - \bar{w}\bar{n}(1-\bar{\tau}^n)\hat{n}_t$$
$$-\bar{\psi}\hat{\psi}_t - \bar{b}\hat{b}_t + \bar{R}\bar{b}\hat{b}_{t-1} + (\bar{d}(1-\bar{\tau}^d) - \bar{v})\tilde{s}_{t-1} + \bar{c}\tilde{\tau}^c_t + \bar{d}\tilde{\tau}^d_t + \bar{w}\bar{n}\tilde{\tau}^n_t$$

(8) $0 = -\bar{k}\hat{k}_t + (1-\delta)\bar{k}\hat{k}_{t-1} + \bar{x}\hat{x}_t$

(9)
$$0 = -\bar{\psi}\hat{\psi}_t - \bar{b}\hat{b}_t + \bar{c}\bar{\tau}^c\hat{c}_t + \bar{d}\bar{\tau}^d\hat{d}_t + \bar{\tau}^i\bar{y}\hat{y}_t + \bar{w}\bar{n}(\bar{\tau}^n - \bar{\tau}^i)\hat{w}_t + \bar{w}\bar{n}(\bar{\tau}^n - \bar{\tau}^i)\hat{n}_t$$
$$+\bar{R}\bar{b}\hat{R}_t + \bar{d}\bar{\tau}^d\tilde{s}_{t-1} - \delta\bar{\tau}^i\bar{k}\hat{k}_t + \bar{R}\bar{b}\hat{b}_{t-1} + \bar{d}\tilde{\tau}^d_t + (\bar{y} - \bar{w}\bar{n} - \delta\bar{k})\tilde{\tau}^i_t + \bar{w}\bar{n}\tilde{\tau}^n_t$$

(10)
$$0 = -\bar{d}\hat{d}_t + \bar{y}(1-\bar{\tau}^i)\hat{y}_t - \bar{x}\hat{x}_t - \bar{w}\bar{n}(1-\bar{\tau}^i)\hat{w}_t - \bar{w}\bar{n}(1-\bar{\tau}^i)\hat{n}_t + \delta\bar{k}\bar{\tau}^i\hat{k}_{t-1} + (-\bar{y} + \bar{w}\bar{n} + \delta\bar{k})\tilde{\tau}^i_t$$

(11) $0 = -\hat{y}_t + \hat{z}_t + \theta \hat{k}_{t-1} + (1-\theta)\hat{n}_t$

(12) $0 = \overline{y}\hat{y}_t - \overline{x}\hat{x}_t - \overline{c}\hat{c}_t$

(13) $\tilde{s}_t = 0$

(14) $\hat{z}_{t+1} = \rho_z \hat{z}_t + \varepsilon_{z,t+1}$

(15) $\tilde{\tau}^n_{t+1} = \rho_n \tilde{\tau}^n_t + \varepsilon_{n,t+1}$

(16) $\tilde{\tau}^d_{t+1} = \rho_d \tilde{\tau}^d_t + \varepsilon_{d,t+1}$

(17) $\tilde{\tau}^c_{t+1} = \rho_c \tilde{\tau}^c_t + \varepsilon_{c,t+1}$

(18) $\tilde{\tau}^i_{t+1} = \rho_i \tilde{\tau}^i_t + \varepsilon_{i,t+1}$

D. Toolkit Code

Only the code for tax reform 2008 is attached. The other two codes are similar with it. The differences are noted as comments.

```
% This program calculates through growth model in my master thesis,
% "German Tax Reforms and the Value of German Corporations".
% First, parameters are set and the steady state is calculated. Next, the matrices are declared.
% In the last line, the model is solved and analyzed by calling DO_IT.M

disp('This program calculates through growth model');
disp('Hit any key when ready...');
pause;

% Setting parameters:

N_bar      = 0.22; % Steady state of employment
Z_bar      = 1; % Normalization of technology shock
R_bar      = 1.0448; % Steady state of gross interest rate: different in the other codes.
theta      = 0.36; % Capital share
delta      = 0.03; % Depreciation rate for capital
rho_z      = 0.95; % autocorrelation of technology shock
rho_d      = 1; % autocorrelation of tax shock on dividend income
rho_c      = 1; % autocorrelation of tax shock on consumption
rho_i      = 1; % autocorrelation of tax shock on corporation income
rho_n      = 1; % autocorrelation of tax shock on personal income
```

```
sigma_z      = 0.01; % Standard deviation of technology shock.    Units: Percent.
sigma_d      = 0.01; % Standard deviation of tax shock on dividend income
sigma_c      = 0.01; % Standard deviation of tax shock on consumption
sigma_i      = 0.01; % Standard deviation of tax shock on corporation income
sigma_n      = 0.01; % Standard deviation of tax shock on personal income
Tau_c_bar = 0.19; % Steady state of consumption tax rate: different in the other codes.
Tau_i_bar = 0.26375; % Steady state of corporation income tax rate: different in the other codes.
Fai_bar = 0.2352; % steady state of government transfer (relative GDP): different in the other codes.

% Calculating the steady state:

S_bar = 1;
beta = 1/R_bar;
Y_K_bar = (delta+(R_bar-1)/(1-Tau_i_bar))/theta;
K_bar = (Y_K_bar)^(1/(theta-1))*N_bar;
Y_bar = Y_K_bar*K_bar;
X_bar = delta*K_bar;
C_bar = Y_bar-X_bar;
W_bar = (1-theta)*Y_bar/N_bar;
Tau_n_bar = 1-(1+Tau_c_bar)*(1-N_bar)*C_bar/W_bar;
Tau_d_bar = Tau_n_bar/2; % Steady state of dividend income tax rate: different in the other codes.
```

```
Lamda_bar = 1/(C_bar*(1+Tau_c_bar));
D_bar = (1-Tau_i_bar)*(Y_bar-W_bar*N_bar-delta*K_bar)+delta*K_bar-X_bar;
V_bar = (1-Tau_d_bar)*D_bar/(R_bar-1);
B_bar = (Fai_bar-(1+Tau_c_bar)*C_bar+(1-Tau_d_bar)*D_bar+(1-Tau_n_bar)*W_bar*N_bar)
/(R_bar-1);

% Declaring the matrices.

VARNAMES = ['capital                    ',    %1
            'price of shares            ',    %2
            'number of shares           ',    %3
            'interest rate              ',    %4
            'debt                       ',    %5
            'output                     ',    %6
            'lamda                      ',    %7
            'labor                      ',    %8
            'wage                       ',    %9
            'dividend payment           ',    %10
            'new investment             ',    %11
            'government transfer        ',    %12
            'consumption                ',    %13
```

```
                'technology                  ',    %14
                'dividend income tax         ',    %15
                'consumption tax             ',    %16
                'corporation income tax      ',    %17
                'personal income tax         ',    %18
            ];

% Translating into coefficient matrices.
% Endogenous state variables "x(t)": k(t),v(t),s(t),r(t),b(t)
% Endogenous other variables "y(t)":y(t),lamda(t),n(t),w(t),d(t),x(t),fai(t),c(t)
% Exogenous state variables    "z(t)": log(z(t)),tau_d(t),tau_c(t),tau_i(t),tau_n(t).
% Switch to that notation.    Find matrices for format
% 0 = AA x(t) + BB x(t-1) + CC y(t) + DD z(t)
% 0 = FF x(t+1) + GG x(t) + HH x(t-1) + JJ y(t+1) + KK y(t) + LL z(t+1) + MM z(t)
% z(t+1) = NN z(t) + epsilon(t+1) with E_t [ epsilon(t+1) ] = 0,

% for    k(t)        v(t),     s(t),     r(t),              b(t)
AA = [0              0         0         0                  0          %equ4
      0              0         0         0                  0          %equ5
      0              0         0         0                  0          %equ6
      0              0         0         R_bar*B_bar   -B_bar      %equ7
```

```
        -K_bar     0        0        0                0          %equ8
        0          0        0        R_bar*B_bar      -B_bar     %equ9
        0          0        0        0                0          %equ10
        0          0        0        0                0          %equ11
        0          0        0        0                0          %equ12
        0          0        1        0                0          %equ13
      ];

BB_7_b = (1-Tau_d_bar)*D_bar-V_bar;
BB_9_k = -delta*K_bar*Tau_i_bar;

% for k(t-1)                v(t-1) ,s(t-1),              r(t-1),        b(t-1)
BB = [ 0                    0        0                   0              0                 %equ4
       0                    0        0                   0              0                 %equ5
       0                    0        0                   0              0                 %equ6
       0                    0        BB_7_b              0              R_bar*B_bar       %equ7
       (1-delta)*K_bar      0        0                   0              0                 %equ8
       BB_9_k               0        D_bar*Tau_d_bar     0              R_bar*B_bar       %equ9
       -BB_9_k              0        0                   0              0                 %equ10
       theta                0        0                   0              0                 %equ11
       0                    0        0                   0              0                 %equ12
```

```
    0          0      0          0          0          %equ13
  ];

CC_4_l = C_bar*Lamda_bar*(1+Tau_c_bar);
CC_4_c = CC_4_l;
CC_5_l = Lamda_bar*W_bar*(1-N_bar)*(1-Tau_n_bar);
CC_5_n = CC_5_l;
CC_5_w = CC_5_l;
CC_7_n = -W_bar*N_bar*(1-Tau_n_bar);
CC_7_w = CC_7_n;
CC_7_c = C_bar*(1+Tau_c_bar);
CC_9_y = Y_bar*Tau_i_bar;
CC_9_n = W_bar*N_bar*(Tau_n_bar-Tau_i_bar);
CC_9_w = CC_9_n;
CC_9_c = C_bar*Tau_c_bar;
CC_10_y = Y_bar*(1-Tau_i_bar);
CC_10_n = -W_bar*N_bar*(1-Tau_i_bar);
CC_10_w = CC_10_n;

%Order:y(t),   lamda(t)   n(t),   w(t),   d(t),   x(t),   fai(t),   c(t)
CC   = [ 0      CC_4_l    0       0       0       0       0       CC_4_c   %equ4
```

```
    0          CC_5_l     CC_5_n   CC_5_w    0        0          0          0          %equ5
    -1         0          1        1         0        0          0          0          %equ6
    0          0          CC_7_n   CC_7_w    0        0          0          CC_7_c     %equ7
    0          0          0        0         0        X_bar      0          0          %equ8
    CC_9_y     0          CC_9_n   CC_9_w    0        0          -Fai_bar   CC_9_c     %equ9
    CC_10_y    0          CC_10_n  CC_10_w   D_bar    -X_bar     0          0          %equ10
    -1         0          1-theta  0         0        0          0          0          %equ11
    Y_bar      0          0        0         0        -X_bar     0          -C_bar     %equ12
    0          0          0        0         0        0          0          0          %equ13
  ];

DD_4_c = C_bar*Lamda_bar;
DD_5_n = -W_bar*Lamda_bar*(1-N_bar);
DD_9_i = Y_bar-W_bar*N_bar-delta*K_bar;
DD_10_i =-DD_9_i;

% Order:log(zt)   tau_d(t)     tau_c(t)     tau_i(t)     tau_n(t)
DD = [  0          0            DD_4_c       0            0            %equ4
        0          0            0            0            DD_5_n       %equ5
        0          0            0            0            0            %equ6
        0          D_bar        C_bar        0            W_bar*N_bar  %equ7
```

```
        0          0          0          0          0          %equ8
        0          D_bar      0          DD_9_i     W_bar*N_bar  %equ9
        0          0          0          DD_10_i    0          %equ10
        1          0          0          0          0          %equ11
        0          0          0          0          0          %equ12
        0          0          0          0          0          %equ13
    ];

FF_2_r = -(1-Tau_d_bar)*(1-Tau_i_bar)*R_bar;

%order k(t+1),   v(t+1),   s(t+1)  r(t+1),        b(t+1)
FF = [  0        V_bar     0       -R_bar*V_bar    0        %equ1
        0        0         0       FF_2_r          0        %equ2
        0        0         0       1               0        %equ3
    ];

GG_2_k = -(1-Tau_d_bar)*(1-Tau_i_bar)*theta*Y_bar/K_bar;

%order   k(t),      v(t),          s(t) ,   r(t),   b(t)
GG = [   0          -R_bar*V_bar   0        0      0     %equ1
         GG_2_k     0              0        0      0     %equ2
```

```
        0        0        0        0        0    %equ3
    ];

%order   k(t-1),   v(t-1),   s(t-1)   r(t-1),   b(t-1)
HH = [   0        0        0        0        0   %equ1
         0        0        0        0        0   %equ2
         0        0        0        0        0   %equ3
    ];

JJ_1_d = (1-Tau_d_bar)*D_bar;
JJ_2_y = -(1-Tau_d_bar)*(1-Tau_i_bar)*theta*Y_bar/K_bar;

%Order: y(t+1),    lamda(t+1),   n(t+1), w(t+1),   d(t+1),    x(t+1),   fai(t+1)    c(t+1)
JJ = [   0        0        0        0        JJ_1_d   0        0        0        %equ1
         JJ_2_y   0        0        0        0        0        0        0        %equ2
         0        1        0        0        0        0        0        0        %equ3
    ];

%Order: y(t),    lamda(t),   n(t),    w(t),   d(t),   x(t),   fai(t)    c(t)
KK = [   0        0        0        0        0        0        0        0        %equ1
         0        0        0        0        0        0        0        0        %equ2
```

```
        0      -1      0      0      0      0      0      0      %equ3
    ];

LL_2_d = -((theta*Y_bar/K_bar-delta)*(1-Tau_i_bar)+1);
LL_2_i = -(theta*Y_bar/K_bar-delta)*(1-Tau_d_bar);

% Order:log(zt+1)    tau_d(t+1)    tau_c(t+1)    tau_i(t+1)    tau_n(t+1)
LL = [   0            D_bar         0             0             0          %equ1
         0            LL_2_d        0             LL_2_i        0          %equ2
         0            0             0             0             0          %equ3
    ];

MM_2_d = (1-Tau_i_bar)*R_bar;

%Order:log(zt),   tau_d(t),    tau_c(t),    tau_i(t),    tau_n(t)
MM = [ 0          0            0            0            0        %equ1
       0          MM_2_d       0            0            0        %equ2
       0          0            0            0            0        %equ3
    ];

NN = [rho_z   0      0      0      0
```

```
        0        rho_d 0        0        0
        0        0        rho_c 0        0
        0        0        0        rho_i    0
        0        0        0        0        rho_n
        ];

Sigma = [ sigma_z^2    0              0              0              0
          0            sigma_d^2 0    0              0              0
          0            0              sigma_c^2 0    0              0
          0            0              0              sigma_i^2    0
          0            0              0              0              sigma_n^2
        ];

% Setting the options:

[l_equ,m_states] = size(AA);
[l_equ,n_endog ] = size(CC);
[l_equ,k_exog    ] = size(DD);

PERIOD        = 16; % number of periods per year, i.e. 12 for monthly, 4 for quarterly
GNP_INDEX    = 3; % Index of output among the variables selected for HP filter
```

```
IMP_SELECT = [1 2 10 11]; %a vector containing the indices of the variables to be %plotted
%IMP_SELECT = [5 6 8 9 13 ];
DO_SIMUL      = 1; % Calculates simulations
SIM_LENGTH = 150;
DO_MOMENTS = 1; % Calculates moments based on frequency-domain methods
HP_SELECT    = 1:(m_states+n_endog+k_exog);% Selecting the variables for the HP Filter calcs.
DO_ENLARGE = 1;
DISPLAY_IMMEDIATELY = 1;

% Starting the calculations:

do_it;
```