The Evolution of Taxes and Hours Worked in Austria, 1970-2005*

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Abstract

Aggregate hours worked per working-age person decreased in Austria by 25% from 1970 to 2005. During the same time period, taxes increased, particularly the effective marginal tax rate on labor income. Using a standard general equilibrium growth model with taxes, I quantitatively assess the role played by the evolution of taxes on the evolution of hours worked in Austria. The model accounts for 76% of the observed decrease in hours worked per working-age person. My results are in line with other studies, such as Prescott (2002), which find taxes play an important role in explaining aggregate hours worked.

JEL Classification: E24, J22, E13
Keywords: taxes, labor supply, growth accounting, dynamic general equilibrium

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1 Introduction

In examining the causes of the differences in aggregate hours worked both across countries and within countries over time, macroeconomists find taxes play an important role. Prescott (2002) and Prescott (2004) argue tax rates account for much of the difference observed in hours worked between the United States and Europe. Ohanian, Raffo, and Rogerson (2008) expands Prescott's work to a larger set of countries over a longer time span and finds much of the variation in hours worked over time and across countries can be explained by taxes. Conesa and Kehoe (2008) take a more detailed look at the cases of Spain and France and also show taxes play an important role in explaining the fall in hours worked.

I build on the existing literature by analyzing the specific case of aggregate hours worked in Austria over the years 1970-2005. Austria is representative of the experience of many European countries. In 1970's Austria, hours worked per working-age person were higher than in the United States. By the year 2005, hours worked per working-age person in Austria had decreased by 25% and stood at a level lower than that in the United States. I study the question, "How well can the evolution of taxes account for the evolution of aggregate hours worked in Austria?"

My work differs from the previously mentioned literature in the following ways: Prescott (2002) only examines the effects of taxes on the differential in hours worked between France and the United States in a particular period of time. Prescott (2004) expands the analysis of the role played by taxes by comparing hours worked across a small group of countries, not including Austria, between two time periods. Ohanian, Raffo, and Rogerson (2008) considers a larger sample of countries, including Austria, across a longer time span but focuses on the effects on hours worked of a single tax wedge constructed from consumption tax rates and average labor income tax rates. I will focus on the changes in three different tax rates separately: consumption tax rates and marginal tax rates on labor and capital income. In addition, Ohanian, Raffo, and Rogerson (2008) lumps countries together and presents results averaged across groups, whereas I present more details related specifically to the Austrian case. Although my main focus is also hours worked, I show the effects of taxes on Austrian real GDP per working-age person and the capital-output ratio, which are not considered by Ohanian, Raffo, and Rogerson (2008). Lastly, I include sensitivity analysis not included in Ohanian, Raffo, and Rogerson (2008).

On the other hand, this paper closely relates to the work in Conesa and Kehoe (2008), essentially applying the methodology employed in that paper to the case of Austria over the period 1970-2005. The methodology used is the one developed by Kehoe and Prescott (2002) to study great depressions and is based on growth accounting and the dynamic general equilibrium growth model. Kehoe and Prescott (2007) contains a collection of papers employing a similar framework to study sixteen depressions throughout history and the world, including the cases of France, the United States, Japan, and Mexico. Cicek and Elgin (2011) represents a more recent application of this methodology for the case of Turkey. There are three steps to the methodology. First, growth accounting quantifies the contributions of total factor productivity (TFP), capital, and aggregate hours worked for the growth of output. Second, the neoclassical growth model serves as a theoretical framework for understanding the dynamics of the economy. The central feature of the model is a representative household which takes the evolution of taxes and TFP as given and chooses sequences of consumption, hours worked, and capital to maximize utility. Third, the growth model is calibrated and used to conduct numerical experiments. The numerical experiments generate model data which can then be compared to the actual data observed in the economy. As Kehoe and Prescott (2002) point out, the methodology functions as a diagnostic tool, relying on macro data and a macro model to determine the factors of the economy requiring more detailed study.

The growth accounting for Austria reveals a large divergence between TFP and output per working-age person. The divergence results from the steady decline in hours worked in Austria from 1970 to 2005. Austria contrasts with the experience of the United States. In the United States, hours worked per working-age person remain fairly constant and have even increased since the early 1980's. The growth accounting for Austria is, however, in line with other European countries experiencing large declines in hours worked, such as Spain, France, and Finland.[1]

I find the neoclassical growth model augmented with taxes does a good job of replicating the data from my growth accounting exercise. In order to perform this experiment, I exogenously set the consumption tax rate and the effective marginal tax rates on labor and capital income to the rates found in the data. The model with these actual tax rates accounts for 76% of the fall in

[1] See Conesa and Kehoe (2008) for a similar growth accounting decomposition of Spain and France. See Conesa, Kehoe, and Ruhl (2007) for the case of Finland.

hours worked observed in Austria over the period 1970-2005. I show the necessity of augmenting the model with the sequences of actual tax rates by conducting an additional experiment which fails to replicate the experience of the Austrian economy. I test the performance of a model with constant tax rates against the data. This experiment fails to match the data as well as the model with the sequences of the actual tax rates found in the data. My results support the evidence found in the literature mentioned earlier.

I do not wish to claim other labor market frictions or institutions play no role in explaining the evolution of hours worked in Austria. However, as Conesa and Kehoe (2008) point out, to the extent that the development of such institutions coincides with the increase in taxes, these explanations would be correlated with the evolution of taxes in Austria. My analysis also says nothing about the distribution of hours worked within the working-age population. For example, labor force participation among the elderly remains low in Austria. The pension system in Austria is one of the more generous and complete in Europe, widely recognized as unsustainable, and currently in a state of on-going reform.[2]

The remainder of the paper is organized as follows: Section 2 contains the growth accounting exercise. In Section 3, I describe the neoclassical growth model with taxes. Section 4 presents the calibration, results of the numerical experiments, and sensitivity analysis. Section 5 concludes.

2 Growth Accounting

The growth accounting for Austria is based on the standard theoretical framework of the neoclassical growth model, as in Kehoe and Prescott (2002), and is intended to detect deviations from balanced growth behavior. The model contains an aggregate production function taking the Cobb-Douglas form,

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}, \tag{1}$$

where Y_t is output, A_t is TFP, K_t is capital input, L_t is labor input, and $1-\alpha$ is labor's share of income. If both the growth in TFP and the growth in working-age population, N_t, are assumed to be constant,

[2] See Hofer and Koman (2006) for an overview of the Austrian pension system.

$$A_{t+1} = g^{1-\alpha} A_t, \tag{2}$$

$$N_{t+1} = \eta N_t, \tag{3}$$

then there is a balanced growth path where output per working-age person, $\frac{Y_t}{N_t}$, grows at the rate $g-1$; the capital-output ratio, $\frac{K_t}{Y_t}$, is constant; and hours worked per working-age person, $\frac{L_t}{N_t}$, are constant.

Kehoe and Prescott (2002) then rewrite the aggregate production function (1) as the following:

$$\frac{Y_t}{N_t} = A_t^{\frac{1}{1-\alpha}} \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{L_t}{N_t}\right), \tag{4}$$

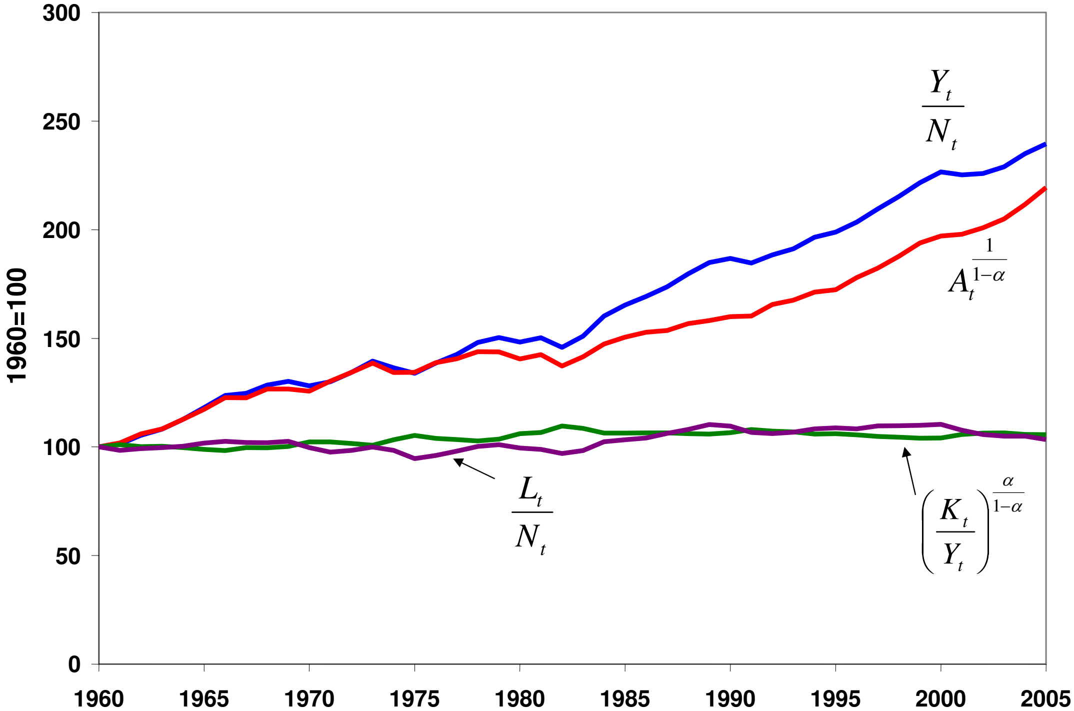
which decomposes output per working-age person, $\frac{Y_t}{N_t}$, into a productivity factor, $A_t^{\frac{1}{1-\alpha}}$; a capital factor, $\left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}$; and a labor factor, $\frac{L_t}{N_t}$. On a balanced growth path, growth in output per working-age person arises from changes in the productivity factor, as both the capital and labor factors remain constant. In order to show the usefulness of this decomposition, consider the case of the United States. Figure (1) reports the data for the United States over the period 1960-2005. Growth in the United States appears close to balanced, particularly over the period 1960-1983. During these years, growth in $\frac{Y_t}{N_t}$ is close to growth in $A_t^{\frac{1}{1-\alpha}}$, while $\left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}$ and $\frac{L_t}{N_t}$ remain fairly constant. However, after 1983, the United States growth path becomes less balanced. $\frac{Y_t}{N_t}$ grows faster than $A_t^{\frac{1}{1-\alpha}}$, which is driven by the gradual increase in $\frac{L_t}{N_t}$.

In order to perform the growth accounting decomposition for Austria, data needs to be collected for the series of output, capital stock, working-age population, and hours worked. A value for labor's share of income also needs to be assigned. The series of TFP can then be calculated using these series and the labor share of income. The appendix contains additional information on the data used throughout this paper and their sources.

The national accounts for Austria do not report a series for the capital stock, so I construct the series using the perpetual inventory method,

$$K_{t+1} = (1-\delta)K_t + X_t, \tag{5}$$

Figure 1: United States Growth Accounting



where δ denotes a constant depreciation rate of capital and X_t is investment. The capital stock series can then be accumulated from data on investment and values for δ and an initial capital stock. The value of δ is chosen to match the average ratio of depreciation to gross domestic product (GDP) in the data over the calibration period 1970-2005. In Austria, the average ratio of depreciation to GDP over the years 1970-2005 is

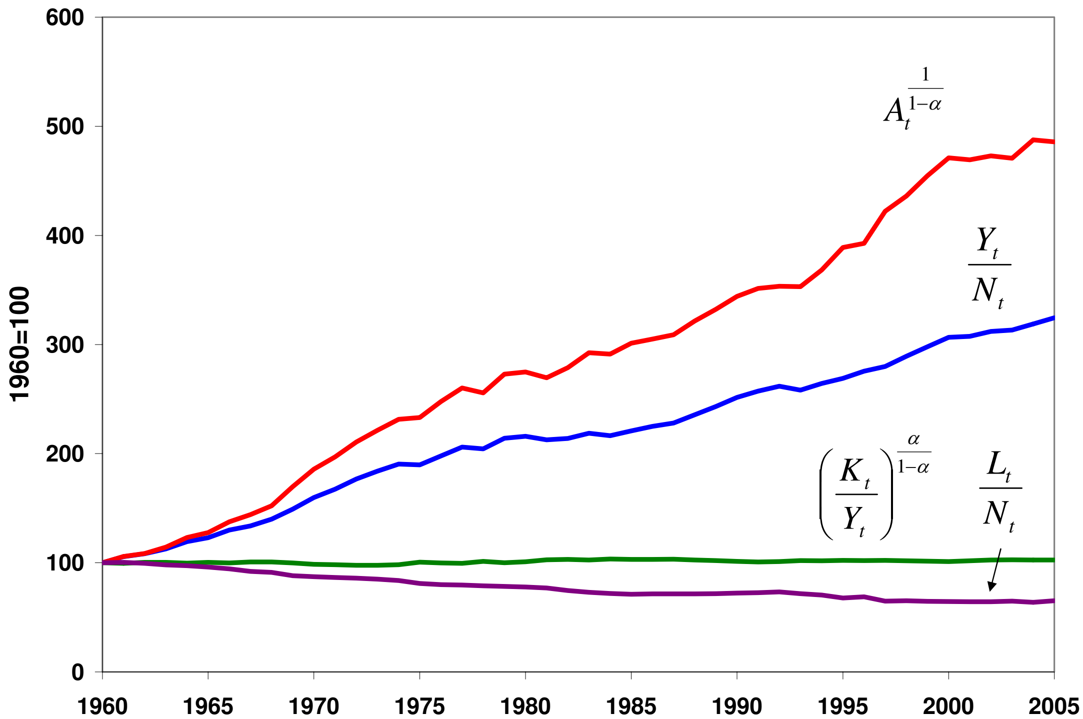
$$\frac{1}{36}\sum_{t=1970}^{2005}\frac{\delta K_t}{Y_t} = 0.1388. \tag{6}$$

The value of the initial capital stock is chosen so that the capital-output ratio in the initial period, 1960, matches the average capital-output ratio over a reference period, 1961-1970:

$$\frac{K_{1960}}{Y_{1960}} = \frac{1}{10}\sum_{1961}^{1970}\frac{K_t}{Y_t}. \tag{7}$$

The equations (5), (6), and (7) make up a system that can be solved to find the capital stock

Figure 2: Austria Growth Accounting



series and the value of δ. The calibrated value for δ in Austria is 0.0382.

The labor income share can be measured directly from the Austrian data over the years 1970-2005. My calculations for the labor income share yield an average value of 0.6896, which translates into a capital income share, α, of 0.3104. The Austrian value of the capital income share is in line with the results in Gollin (2002), which suggest a common value of $\alpha = 0.3$ across countries.

Only the TFP series remains to be calculated in order to report the growth accounting for Austria. This is done by simply rearranging the aggregate production function (1) and using the measures of output, capital stocks, hours worked, and the labor income share to solve for the following:

$$A_t = \frac{Y_t}{K_t^{\alpha} L_t^{1-\alpha}}. \tag{8}$$

Figure (2) displays the growth accounting decomposition (4) for Austria over the period 1960-

2005. Three observations are of note. First, the overall effects of the Austrian *Wirtschaftswunder* are clearly present. The *Wirtschaftswunder*, or economic miracle, refers to the period of economic recovery and expansion in Germany and Austria after World War II. Austrian output per working-age person, $\frac{Y_t}{N_t}$, grows at an average annual rate of 2.7% over the entire period 1960-2005. During the years 1960-1980, a period coinciding more closely with the actual *Wirtschaftswunder*, growth in $\frac{Y_t}{N_t}$ is even faster, averaging an annual rate of 3.9%. Second, in contrast to the United States experience, the Austrian growth path displays large deviations from balanced growth after 1965, as evidenced by the divergence of output per working-age person, $\frac{Y_t}{N_t}$, and the productivity factor, $A_t^{\frac{1}{1-\alpha}}$. Third, this deviation from balanced growth occurs due to the steady fall in aggregate hours worked per working-age person, $\frac{L_t}{N_t}$. Hours worked in Austria fall by 35% from 1960 to 2005. From 1970-2005, the period of focus in this paper, hours worked in Austria fall by 25%. The decrease in hours worked per working-age person in Austria is in line with the experiences of other European countries. This paper's main purpose is to understand the role played by taxes in explaining the decrease in hours worked in Austria by testing a model with taxes against the data presented in this growth accounting exercise. I now turn to describing such a model.

3 Model

The economic environment is that of the simple dynamic general equilibrium model augmented with taxes. A representative household takes the evolution of taxes and TFP as given and chooses sequences of consumption, hours worked, and capital to maximize utility. A representative firm produces output with an aggregate technology, taking prices as given. Government collects proportional taxes on consumption, labor income, and capital income and rebates the proceeds to the household in a lump-sum fashion, making sure to balance its budget.

Specifically, the representative household chooses sequences of aggregate consumption, C_t; aggregate capital stocks, K_t; and aggregate hours worked, L_t, to solve the following maximization problem:

$$\max \sum_{t=T_o}^{\infty} \beta^t \left[\gamma \log C_t + (1-\gamma)\log(\bar{h}N_t - L_t)\right] \tag{9}$$

$$\text{s.t. } (1+\tau_t^c)C_t + K_{t+1} = (1-\tau_t^l)w_t L_t + [1+(1-\tau_t^k)(r_t-\delta)]K_t + T_t, \tag{10}$$

$$C_t, K_t, L_t \geq 0, \tag{11}$$

$$L_t \leq \bar{h} N_t, \tag{12}$$

$$K_{T_o} \text{ given}, \tag{13}$$

where β, $0 < \beta < 1$, is the discount factor; γ, $0 < \gamma < 1$, is the consumption share; and $\bar{h}$ is an individual's time endowment of hours available for market work. Equation (10) represents the household's budget constraint. τ_t^c, τ_t^l, and τ_t^k are the tax rates on consumption, labor income, and capital income. w_t and r_t are the wage rate and rental rate. δ, $0 < \delta < 1$, is the depreciation rate. T_t is the lump-sum transfer from the government. The inequalities represented in (11) are the nonnegativity constraints on consumption, capital stocks, and hours worked. Inequality (12) constrains the household's choice of aggregate hours worked, since the total number of hours available for work is $\bar{h} N_t$. Finally, (13) is the constraint on the initial stock of capital.

The representative firm produces output according to the production technology (1). A competitive environment, in which the firm earns zero profits and minimizes costs, gives rise to the pricing rules for the wage rate and rental rate:

$$w_t = (1-\alpha) A_t K_t^{\alpha} L_t^{-\alpha}, \tag{14}$$

$$r_t = \alpha A_t K_t^{\alpha-1} L_t^{1-\alpha}. \tag{15}$$

The feasibility constraint in the economy requires current output be divided between consumption and investment:

$$C_t + K_{t+1} - (1-\delta)K_t = A_t K_t^{\alpha} L_t^{1-\alpha}. \tag{16}$$

The government's budget constraint ensures the total tax receipts exactly equal the lump-sum transfers to the household:

$$\tau_t^c C_t + \tau_t^l w_t L_t + \tau_t^k (r_t - \delta) K_t = T_t. \tag{17}$$

Rebating all the tax receipts in a lump-sum fashion to the household is equivalent to viewing government expenditure as a substitute for private consumption. For instance, the tax revenue might be used to finance health care, unemployment insurance, or public schools. I return to this assumption in the sensitivity analysis in Section 4.3 by considering an alternative specification of wasteful government consumption.

Now, an equilibrium for this environment can be defined as follows:

> Given sequences of TFP, A_t; working-age population, N_t; consumption tax rates, τ_t^c; labor income tax rates, τ_t^l; and capital income tax rates, τ_t^k, for $t = T_o, T_o + 1, ...$ and an initial capital stock, K_{T_o}, an *equilibrium with taxes* is sequences of aggregate consumption, C_t; aggregate capital stocks, K_t; aggregate hours worked, L_t; wages, w_t; interest rates, r_t; and transfers, T_t, such that the following conditions hold:
>
> 1. Given wages, w_t, and interest rates, r_t, the representative household chooses consumption, C_t; capital, K_t; and hours worked, L_t, to maximize utility (9) subject to the budget constraint (10), the nonnegativity constraints (11), the upper bound on the total number of hours worked (12), and the constraint on the initial capital stock (13).
> 2. The wages, w_t, and interest rates, r_t, and the representative firm's choices of labor, L_t, and capital, K_t, satisfy the cost minimization and zero profit conditions (14) and (15).
> 3. Consumption, C_t; labor, L_t; and capital, K_t, satisfy the feasibility constraint (16).
> 4. Government transfers, T_t, satisfy the government's budget constraint (17).

These equilibrium requirements reduce to a system of equations which characterizes the equilibrium. Taking the first-order conditions of the household's maximization problem, I solve for the household's intertemporal and intratemporal conditions:

$$\frac{C_{t+1}}{C_t} = \beta \frac{1+\tau_t^c}{1+\tau_{t+1}^c}[1 + (1 - \tau_{t+1}^k)(r_{t+1} - \delta)], \tag{18}$$

$$(1-\tau_t^l)w_t(\bar{h}N_t - L_t) = \frac{1-\gamma}{\gamma}(1+\tau_t^c)C_t. \tag{19}$$

Plugging the firm's optimality conditions (14) and (15) into the household's optimality conditions (18) and (19), yields

$$\frac{C_{t+1}}{C_t} = \beta\frac{1+\tau_t^c}{1+\tau_{t+1}^c}[1+(1-\tau_{t+1}^k)(\alpha A_{t+1}K_{t+1}^{\alpha-1}L_{t+1}^{1-\alpha}-\delta)], \tag{20}$$

$$(1-\tau_t^l)(1-\alpha)A_tK_t^{\alpha}L_t^{-\alpha}(\bar{h}N_t - L_t) = \frac{1-\gamma}{\gamma}(1+\tau_t^c)C_t, \tag{21}$$

which, combined with the feasibility constraint (16) and government budget constraint (17), is the system of equations characterizing the equilibrium of the model. I use this system when computing the equilibrium of the model in my numerical experiments.[3]

4 Numerical Experiments

The numerical experiments I perform compare the data to two theoretical economies with different tax scenarios. The first is a model with constant taxes in which τ_t^c, τ_t^l, and τ_t^k are set to the rates observed in the data in 1970. The second is a model with taxes in which the evolution of τ_t^c, τ_t^l, and τ_t^k follows the actual evolution of the rates as measured in the data. The theoretical economies will determine the equilibrium evolution of the endogenous variables given a set of calibrated parameters and the evolution of the exogenous variables. The exogenous variables are the sequences of TFP, working-age population, and the taxes rates. The numerical experiments will then allow me to compare the evolution of the aggregate variables implied by the model with those actually observed in the data. The aggregates I compare are real GDP per working-age person, the capital-output ratio, and, of course, hours worked per working-age person.

[3]See Conesa, Kehoe, and Ruhl (2007) for a detailed discussion on solving models of this type. Accompanying documentation can be accessed online at www.greatdepressionsbook.com.

4.1 Calibration

Following the methodology in Mendoza, Razin, and Tesar (1994), I use data on aggregate tax collections to calculate the sequences of effective tax rates τ_t^c, τ_t^l, and τ_t^k. However, I follow other recent macroeconomic studies in deviating from the procedure in Mendoza, Razin, and Tesar (1994) in two important respects.[4] First, I attribute a fraction of household's non-wage income to labor income. Second, I measure effective marginal tax rates instead of effective average tax rates.

The theoretical framework developed in Section 3 motivates the choice of focusing on effective marginal tax rates. The representative household's decisions take place at the margin, as shown in equations (20) and (21). Given the progressivity of income taxes, the estimates of the income taxes need to be adjusted. In principle, I should use micro data, such as a representative sample of tax records, to estimate effective income tax functions to perform my adjustments. Conesa and Kehoe (2008) does exactly this for the case of Spain. Conesa and Kehoe (2008) multiplies average income taxes by a factor of 1.83 to obtain marginal tax rates for Spain. In the case of Austria, I simply follow Prescott (2002) and Prescott (2004) for the United States case and multiply average income taxes by a factor of 1.6 to obtain marginal tax rates. Conesa, Kehoe, and Ruhl (2007) adopt the same procedure for the case of Finland. Figure (3) graphs τ_t^c, τ_t^l, and τ_t^k for Austria over the period 1970-2005. A key observation in Figure (3) is that the effective marginal tax rate on labor income trends upward over the 35 year period, from a low of 0.36 in 1970 to a high of 0.54 in 1997. Detailed information on the construction of the tax rates appears in the appendix.

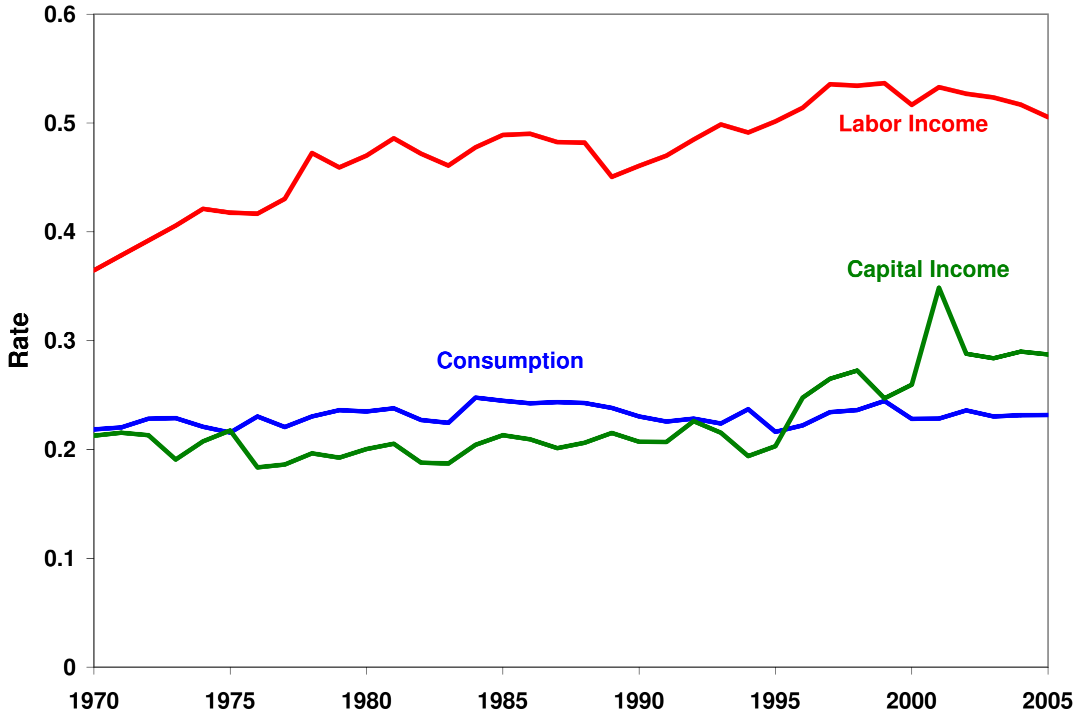
In the experiments with taxes, I adjust the series of TFP by modifying equation (8) to

$$A_t = \frac{C_t + X_t}{K_t^{1-\alpha} L_t^{\alpha}}, \tag{22}$$

where $C_t + X_t$ is real GDP at factor prices in the data. However, when I report the contribution of TFP to growth in the results section, I report the conventional measure of TFP,

[4]See, for example, Conesa, Kehoe, and Ruhl (2007), Conesa and Kehoe (2008), Prescott (2002), and Prescott (2004).

Figure 3: Effective Marginal Tax Rates in Austria



$$\hat{A}_t = \frac{\hat{Y}_t}{K_t^{1-\alpha} L_t^{\alpha}}, \tag{23}$$

where

$$\hat{Y}_t = (1 + \tau^c_{\bar{T}})C_t + X_t \tag{24}$$

is real GDP at market prices of the base year $\bar{T} = 2000$.

The exogenous sequence of the working-age population is that measured from the data in the growth accounting exercise. I assign a value of $\bar{h} = 100$ for an individual's time endowment of hours available for market work per week.

The remaining parameters are the initial capital stock, K_{T_o}; capital share, α; depreciation rate, δ; discount factor, β; and consumption share, γ. The initial capital stock is the 1970 value from the series of capital stocks calculated in the growth accounting exercise. The capital share and depreciation rate are also the same as in the growth accounting exercise, which means $\alpha = 0.3104$ and $\delta = 0.0382$. Rearranging equations (18) and (19) allows me to calibrate β and γ as follows:

$$\beta = \frac{(1+\tau^c_{t+1})C_{t+1}}{(1+\tau^c_t)C_t} \frac{1}{1+(1-\tau^k_{t+1})(r_{t+1}-\delta)}, \tag{25}$$

$$\gamma = \frac{(1+\tau^c_t)C_t}{(1+\tau^c_t)C_t + (1-\tau^l_t)w_t(\bar{h}N_t - L_t)}. \tag{26}$$

I calculate a vector of β's and γ's for the same period used to calculate δ and α, 1970-2005, and then take the average of these vectors to assign values to β and γ. The calibrated values of β and γ vary depending on the tax scenario of the numerical experiment. In the experiment with constant taxes, $\beta = 1.0023$ and $\gamma = 0.3682$. In the experiment with the actual tax rates, $\beta = 1.0030$ and $\gamma = 0.4163$. The calibrated values for β in the experiments with taxes are both greater than 1, which means the utility function (9) is potentially infinite. I avoid this problem by setting $\beta = 0.9990$ in the two tax experiments.[5]

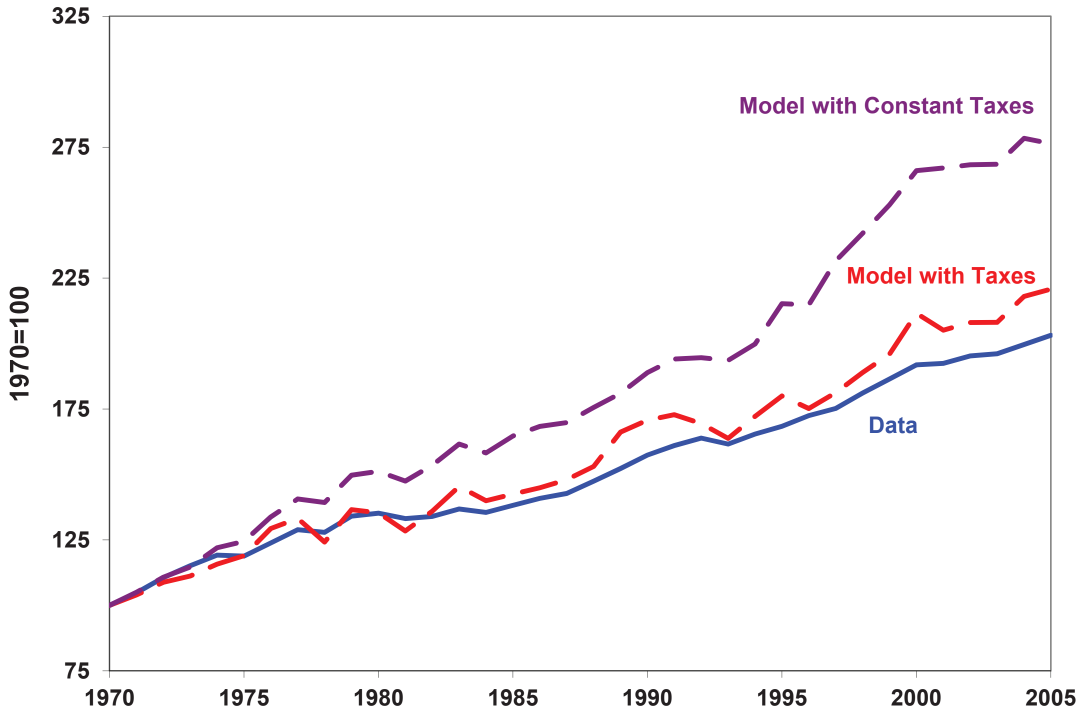
4.2 Results

Figures (4) - (6) and Table (1) compare data from the Austrian economy with the corresponding results from the numerical experiments. Figure (4) compares the growth of the Austrian economy from 1970 to 2005 with the growth of the two theoretical economies over the same period. The model with constant taxes predicts a noticeably larger increase in real GDP per working-age person than actually occurred in Austria. The model with taxes, however, predicts a path for real GDP per working-age person which is much more in line with the actual experience of the Austrian economy. This result suggests models based on the evolution of TFP alone are inadequate for understanding recent growth in Austria. Indeed, the graph highlights the importance of recognizing the role played by the evolution of taxes in the Austrian economy since 1970.

Figure (5) compares the data on the evolution of hours worked per working-age person in Austria with the results implied by the two theoretical economies. The model with constant

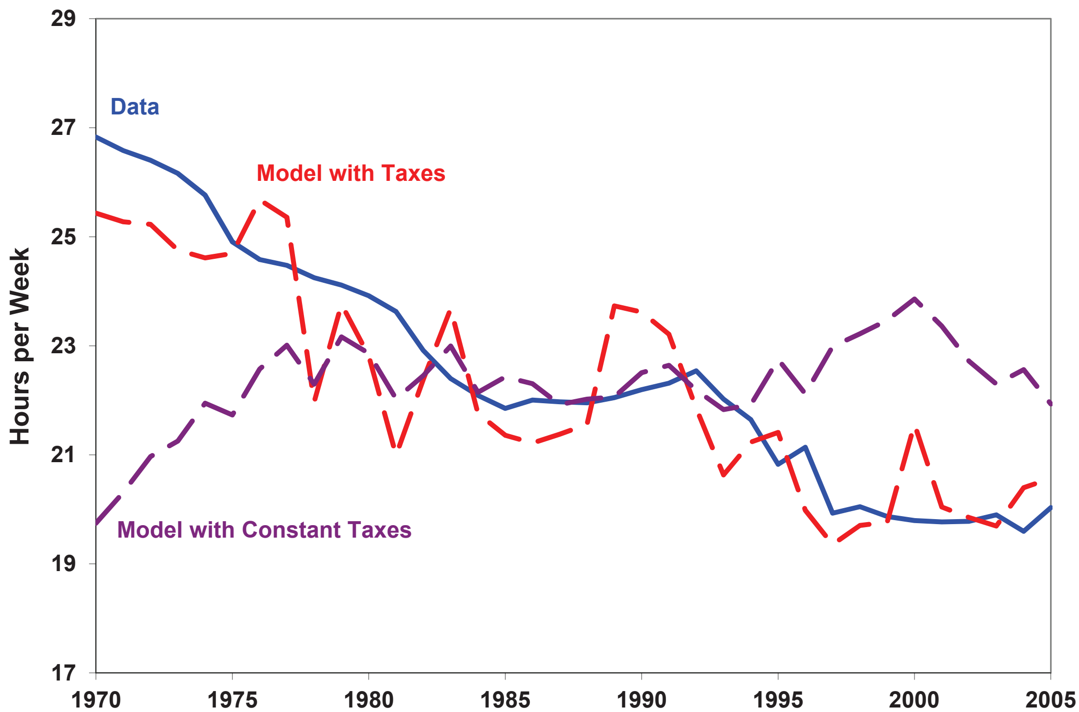
[5] See Conesa, Kehoe, and Ruhl (2007) for further discussion on this issue.

Figure 4: Real GDP per Working-Age Person in Austria



taxes fails to account for the fall in hours worked seen in the data. The series of hours worked generated by the model with constant taxes remains fairly constant. The key point here is that the mere presence of distortions is not enough to generate the evolution of hours worked seen in the data. The actual evolution of taxes is important for generating the fall in hours worked, as seen by the series implied by the model with taxes. Figure (5) shows the model with taxes does a good job accounting for the magnitude of the decrease in hours worked in Austria from 1970 to 2005. In the data, hours worked per working-age person in Austria fall by 25% from 1970 to 2005, whereas in the model with taxes they fall by 19%. Hours worked in the model with taxes also seems to qualitatively match the evolution of hours worked in the data, though the hours worked in the model with taxes fluctuate more than those in the data. The qualitative similarities are evident if the series in Figure (5) are divided into four period: 1970-1985 coincides with a steady fall in hours worked, hours worked remain constant or increase during the years 1985-1992, the years 1992-1997 see another fall in hours worked, and 1997-2005 is another period

Figure 5: Hours Worked per Working-Age Person in Austria



of roughly constant hours worked. These four periods are also identifiable in the series of labor income tax rates presented in Figure (3).

Both models predict similar results with respect to capital deepening. Figure (6) graphs the evolution of the capital-output ratio in Austria and the capital-output ratios implied by the two numerical experiments. The two models generate smaller capital-output ratios than those found in the data.

Finally, Table (1) presents the quantitative implications of the numerical experiments by comparing the growth accounting in the data with the growth accounting in each of the two theoretical economies. For ease of exposition, I take the natural logarithm of equation (4):

$$\log\frac{Y_t}{N_t} = \frac{1}{1-\alpha}\log A_t + \frac{\alpha}{1-\alpha}\log\frac{K_t}{Y_t} + \log\frac{L_t}{N_t}. \tag{27}$$

Output per working-age person now decomposes into three additive factors. The numbers in Table (1) can be viewed as growth rates, as they are average annual changes multiplied by 100.

Figure 6: Capital-Output Ratio in Austria

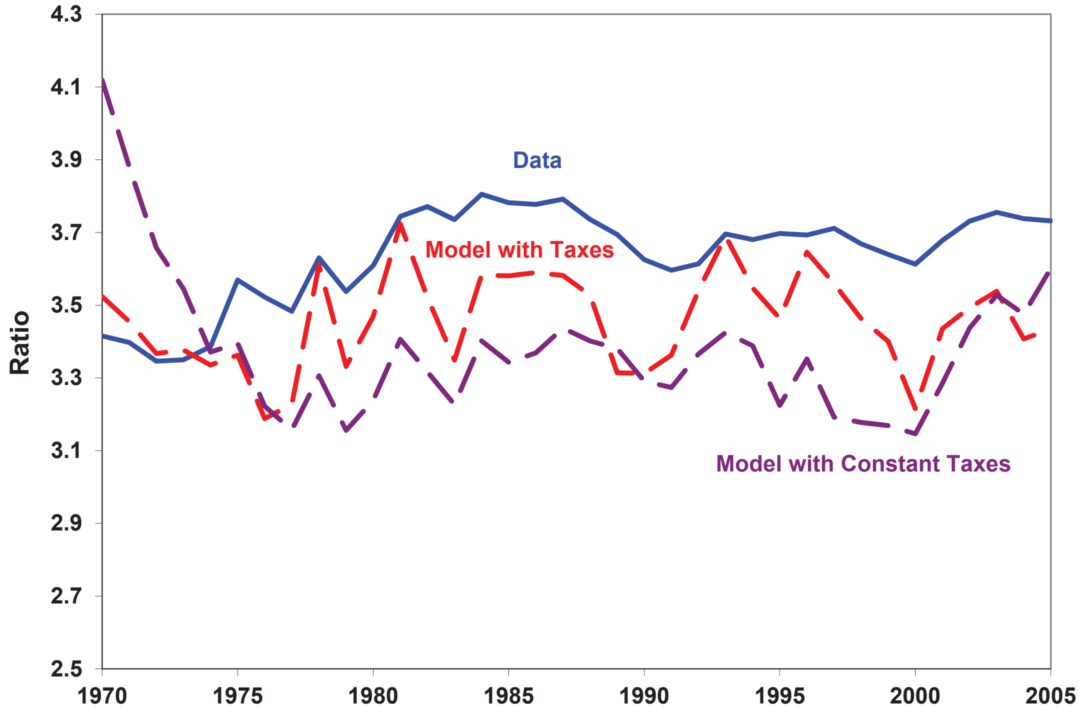


Table 1: Decomposition of Average Annual Changes in Real GDP per Working-Age Person in Austria (Percent)

	Data	Constant Taxes	Actual Taxes
1970-2005			
Change in Y/N	2.03	2.90	2.26
Due to TFP	2.75	2.78	2.90
Due to K/Y	0.11	-0.17	-0.03
Due to L/N	-0.83	0.30	-0.61

4.3 Sensitivity Analysis

Table 2 presents simulation results for different specifications of the model. The first two columns report the new calibrated values of β and γ under each specification. Since the calibrated values for β are often greater than 1, I set $\beta = 0.9990$ in most of the specifications. The remaining

Table 2: Sensitivity Analysis

	β	γ	Y/N 1970	Y/N 2005	K/Y 1970	K/Y 2005	L/N per week 1970	L/N per week 2005
Data	-	-	100	203	3.42	3.73	26.83	20.03
Constant Taxes	0.9990	0.3682	100	276	4.12	3.60	19.74	21.93
Actual Taxes	0.9990	0.4163	100	221	3.52	3.43	25.43	20.57
Only τ_t^c	0.9990	0.3706	100	278	4.10	3.57	19.82	21.92
Only τ_t^l	0.9990	0.4138	100	227	3.54	3.59	25.28	20.97
Only τ_t^k	0.9990	0.3682	100	268	4.11	3.47	19.82	21.54
$\delta = 0.05$	0.9990	0.4163	100	224	3.07	2.96	25.52	20.78
$\gamma = 0.8$	0.9990	0.8000	100	321	1.81	3.31	69.02	59.54
G_t	0.9925	0.3623	100	228	3.11	3.30	25.72	21.80
No Adjustment Factor	0.9990	0.3809	100	233	3.64	3.52	24.16	20.84
McDaniel (2007) Taxes	0.9990	0.3608	100	237	3.70	3.77	23.69	21.22

columns coincide with the aggregate variables from Figures 4 - 6 but only report the values of each variable in 1970 and 2005, not the entire time series. The first set of rows reproduces the values from the data, model with constant taxes, and model with actual taxes in Figures 4 - 6 as reference.

The second set of rows shows the contribution of each individual tax change, keeping the other taxes constant at the rate in the data in 1970, e.g. the row labeled *Only* τ_t^c considers the actual evolution of the tax rate on consumption and sets the tax rates on labor income and capital income equal to their values in 1970. These results suggest the evolution of τ_t^l drives the decline in hours worked. The overall fit of the model is also best in the case when τ_t^l evolves.

The third set of specifications considers the model with actual taxes subjected to different parameters and an alternative way of modeling government. In the row $\delta = 0.05$, I impose a higher depreciation rate. The only significant difference caused by this change is a decrease in the capital-output ratio. The row labeled $\gamma = 0.8$ considers a different labor supply elasticity by setting the consumption share $\gamma = 0.8$. Hours worked increase substantially in this case, as the household values consumption more than leisure. The role γ plays in the labor supply elasticity can be seen by the fact that hours worked decrease by a smaller percentage over the period than in the benchmark model with actual taxes, a 14% decline versus 19%. The row labeled G_t considers the case when all government consumption is wasted or enters the representative household's utility function as a public good. This is the opposite extreme of lump-sum transfers in the benchmark model. Modeling government in this way gives rise to new versions of the feasibility constraint (16) and government budget constraint (17):

$$C_t + K_{t+1} - (1-\delta)K_t + G_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{28}$$

and

$$\tau_t^c C_t + \tau_t^l w_t L_t + \tau_t^k (r_t - \delta) K_t = G_t. \tag{29}$$

Increases in taxes cause negative income effects when tax revenues are not transferred back to households, so households respond by increasing the number of hours worked. The results in row G_t show this movement and are consistent with the results presented in Conesa, Kehoe, and Ruhl (2007) for the case of Finland under the assumption of wasteful government consumption.

The last two rows in Table 2 present simulations of the model using different sequences of taxes. The row labeled *No Adjustment Factor* considers the same underlying sequences of taxes as the case with actual taxes but does not convert average income taxes to marginal tax rates by the adjustment factor of 1.6. The row labeled *McDaniel (2007) Taxes* uses the sequences of taxes constructed by McDaniel (2007) and used for the analysis in Ohanian, Raffo, and Rogerson (2008).[6] Again, the income tax rates are average tax rates. These last two simulations fit the data worse than the model with actual taxes. Real GDP per working-age person increases more than in the model with actual taxes, overshooting the data even more. The decline in hours worked is also not as steep. These results show the choice of the adjustment factor matters.

[6]See McDaniel (2007) for complete details, including a comparison with the procedure used in Mendoza, Razin, and Tesar (1994) for constructing average tax rates. Both the procedure I use and the one outlined in McDaniel (2007) improve upon the procedure in Mendoza, Razin, and Tesar (1994) by attributing a fraction of household's non-wage income to labor income.

5 Conclusion

The workhorse of modern macroeconomics is the general equilibrium growth model. It has been used to study business cycles, monetary policy, great depressions, and a host of other economic issues. I apply the model to the study of the Austrian economy. Calibrated to the Austrian experience, a simple dynamic general equilibrium growth model with taxes can account for 76% of the decrease in hours worked per working-age person observed in Austria over the years 1970-2005. My results support the conclusions of recent studies stressing the importance of taxes in explaining the evolution of hours worked.

The analysis presented here is silent about the distribution of hours worked within the working-age population. Prescott, Rogerson, and Wallenius (2009) find employment differences between four European countries (Belgium, France, Germany, and Italy) and the United States are concentrated among young and old workers. In the Austrian case, however, employment differences relative to the United States are concentrated solely among older workers. This feature of the Austrian data suggests an avenue for future research.

Appendix

The growth accounting exercises require the use of national accounts data and data on the labor force. The United States national accounts data are taken from the Bureau of Economic Analysis's *National Income and Product Accounts*, available at www.bea.gov, and the International Monetary Fund's (IMF) *International Financial Statistics* CD-ROM. The United States data on the labor force can be found in the Organisation for Economic Co-operation and Development's (OECD) *Population and Labour Force Statistics* online at www.sourceoecd.com. National accounts data for Austria are from three sources: the IMF's *International Financial Statistics*, the *Detailed Tables of Main Aggregates* in the OECD's *Annual National Accounts*, and Angus Maddison's *Historical Statistics for the World Economy: 1-2003 AD* online at www.ggdc.net/Maddison. Austrian data on the labor force are from the OECD's *Population and Labour Force Statistics* and the Conference Board and Groningen Growth and Development Centre's *Total Economy Database*. The *Total Economy Database* resides at www.conference-board.org/economics.

The Austrian data on the composition of government expenditure appearing in Figure (**??**) are from the OECD's *General Government Accounts*. The *General Government Accounts* are also available online at www.sourceoecd.org. Total government expenditure is broken down into different categories based on the United Nation's *Classification of the Functions of Government*.

Given the focus of this paper, a more detailed discussion regarding the construction of the Austrian tax rates seems appropriate. As mentioned in the text, I follow the procedure of previous studies, such as Conesa, Kehoe, and Ruhl (2007) and Conesa and Kehoe (2008). Calculating the effective marginal tax rates requires data on both tax revenue and the tax base. For the data on tax revenue, I use the OECD's *Details of Tax Revenues of Member Countries*. The tax base data are from the *Detailed Tables of Main Aggregates* in the OECD's *Annual National Accounts*. Both data sources are available online at www.sourceoecd.org. The following key defines the variables used to calculate the tax rates:

Tax Revenue Statistics

1100 = Taxes on income, profits, and capital gains of individuals,

1200 = Taxes on income, profits, and capital gains of corporations, 2000 = Total social security contributions,

2200 = Employer's contribution to social security,

3000 = Taxes on payroll and workforce,

4100 = Recurrent taxes on immovable property,

4400 = Taxes on financial and capital transactions,

5110 = General taxes on goods and services,

5121 = Excise taxes,

National Accounts

C_t^{HH} = Household final consumption expenditure,

C_t^{NPISH} = Final consumption expenditure of nonprofit institutions serving households,

CE_t = Compensation of employees,

$OSMI_t$ = Household gross operating surplus and mixed income,

δK_t^{HH} = Household consumption of fixed capital,

Y_t = GDP,

T_t = Taxes less subsidies,

δK_t = Consumption of fixed capital.

The consumption tax rates are computed as

$$\tau_t^c = \frac{5110 + 5121}{C_t^{HH} + C_t^{NPISH} - 5110 - 5121}. \tag{30}$$

In order to construct the tax rates on labor and capital income, I first calculate the marginal tax rate on household income. Second, I calculate the tax rates on labor and capital income by assigning the ambiguous income categories in the data to either labor or capital income. I set capital's share of income to be α, which is the same as that in the aggregate production function (1). The marginal tax rate on household income is

$$\tau_t^h = adj \frac{1100}{CE_t - 2200 + (OSMI_t - \delta K_t^{HH})}, \tag{31}$$

where adj is the adjustment factor taking the progressivity of the income taxes into account and converts the average tax rate to a marginal tax rate. In the case of Austria, I set $adj = 1.6$. The labor and capital taxes are then computed as follows:

$$\tau_t^l = \frac{\tau_t^h[CE_t - 2200 + (1-\alpha)(OSMI_t - \delta K_t^{HH})] + 2000 + 3000}{(1-\alpha)(Y_t - T_t)}, \tag{32}$$

$$\tau_t^k = \frac{\tau_t^h \alpha(OSMI_t - \delta K_t^{HH}) + 1200 + 4100 + 4400}{\alpha(Y_t - T_t) - \delta K_t}. \tag{33}$$

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