

Brendler, Pavel; Abraham, Arpad; Carceles, Eva

**Conference Paper**

## Corporate Tax Reforms With Policy Uncertainty

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2019: 30 Jahre Mauerfall - Demokratie und Marktwirtschaft - Session: Macroeconomics V, No. F04-V1

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Brendler, Pavel; Abraham, Arpad; Carceles, Eva (2019) : Corporate Tax Reforms With Policy Uncertainty, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2019: 30 Jahre Mauerfall - Demokratie und Marktwirtschaft - Session: Macroeconomics V, No. F04-V1, ZBW - Leibniz-Informationszentrum Wirtschaft, Kiel, Hamburg

This Version is available at:

<https://hdl.handle.net/10419/203619>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

# Corporate Tax Reforms With Policy Uncertainty\*

Árpád Ábrahám

European University Institute

Pavel Brendler

University of Bonn

Eva Cárceles

Stony Brook University

March 1, 2019

## Abstract

One important feature of tax reforms, in particular corporate tax reforms, is the uncertainty surrounding them. Are they going to be permanent or are they likely to be withdrawn by the subsequent government? The expected duration of the reform is important because it affects households' economic decisions, their expected welfare and ultimately their political support for the reform. We use a framework with heterogeneous agents who face uninsurable labor productivity shocks and a representative firm who pays capital adjustment costs. The model is calibrated to the U.S. in 2016. Our revenue-neutral reform eliminates corporate taxes on firm's profits at the cost of more progressive taxes on households' labor incomes. The duration of this reform is uncertain, since it can be repealed at given points in time in the future. Using this framework, we analyze the effect of uncertainty in reform duration on the political support for the reform.

**Key words:** Incomplete markets, Heterogeneous agents, Policy uncertainty, Tax reform.

**JEL codes:** E20, E44, H24, H31.

---

\*We are thankful to Christian Bayer, Gianluca Clementi, Joachim Jungherr and Gianluca Violante for useful comments and suggestions.

# 1 Introduction

Tax reforms, in particular corporate tax reforms, are constantly on policy agenda in most developed countries. One important feature of these reforms is the uncertainty surrounding them. Are they going to be permanent or are they likely to be withdrawn by the subsequent government? The expected duration of the reform is important because it affects households' economic decisions, their expected welfare and ultimately their political support for the reform. The support for the reform might change significantly if the doubt about permanency of the reform among households is sufficiently strong.

Uncertainty surrounding policy proposals is particularly interesting in the U.S. setting for two reasons. First, even those reforms that have an “expiration date” can be extended by the next administration. For example, the President George W. Bush’s Jobs and Growth Tax Relief Reconciliation Act of 2003 was set to expire after 2010, but it ended up being extended during the presidency of Barack Obama. Second, reforms that were originally designed to be “permanent” face the risk of being withdrawn by subsequent governments, especially if the administration changes from a liberal to a conservative government or vice versa. Consider, for example, the recent attempts by the President Donald Trump to abolish “Obamacare”.

In this paper, we evaluate the effects of policy uncertainty using a general equilibrium model in which households face uninsurable idiosyncratic labor income risk. In addition to risky labor income, households receive capital income from owning shares in a representative firm. The firm in our model owns the capital stock and undertakes investment in order to maximize the shareholder value.<sup>1</sup> One important assumption is that the firm faces capital adjustment costs. The government taxes labor income and corporate profits. We calibrate this model to the income distribution in the U.S. in 2016.

Then we introduce the following tax reform. The government makes an unexpected announcement that it is going to eliminate corporate taxes. We

---

<sup>1</sup>Our framework is equivalent to a model with static firms that rent capital from consumers.

model policy uncertainty as uncertainty about the expected duration of this reform. More specifically, we assume that at two points in time in the future (which can be thought of as periods in which congressional elections take place) the reform might be either extended or repealed with some exogenous probabilities. If the reform is repealed in either of the two periods, the corporate tax rate reverts immediately and irreversibly to that in the pre-reform steady state. If the reform is extended, it continues but might be repealed at a later point in time. If the reform continues after the second point, it is reverted with certainty after a given number of periods. Ex-ante, all agents know the points in time when the uncertainty is going to be revealed, as well as the probability distribution. In order to analyze the effects of policy uncertainty on public support, we choose as a benchmark the model without uncertainty, in which timing of the corporate tax reform is the same as the expected duration of the reform in the model with uncertainty.

We model the corporate tax reform as revenue neutral, so that the only way to recover the lost revenue for the government is to adjust the labor income tax. For our reform to have a critical mass of political support among households, we follow [Abraham & Carceles-Poveda \(2006\)](#) and assume that elimination of corporate taxes is accompanied by a transformation of the linear labor tax system into a progressive tax system, when we keep the labor taxes constant for low productivity agents and increase the tax rate for medium-to-high productivity households. The key is that high income agents tend to hold a larger fraction of equity in the firm, so this reform has the advantage that the beneficiaries of the reform also pay its costs.

This modeling framework is appealing for our analysis for several reasons. First, this model generates large heterogeneity in households' most preferred labor tax and corporate tax policies and therefore allows for a rigorous analysis of public support for reforms that involve these two tax instruments. Second, this model is able to generate a realistic income and wealth distribution meaning a realistic distribution of most preferred labor tax and corporate tax policies among households. Finally, the assumption of capital adjustment costs in the firm's maximization problem allows us to study the interesting

interaction between the expected duration of the corporate tax reform and the firm's optimal investment policy.

Our preliminary results are as follows. Relative to the pre-reform steady state, the corporate tax reform *without* policy uncertainty generates an overall welfare loss of 0.28 percent (in consumption equivalence) and the total support among agents of 33 percent. The reform is largely supported by low productivity agents, since the labor tax is kept unchanged for them and they benefit from rising after tax wages. Also, asset-rich individuals of all productivity levels benefit from a higher after-tax saving interest rate. Nevertheless, the reform generates an overall loss, mostly because of the asset-poor agents of medium-to-high productivity, for whom the cost of lower after-tax wages outweighs the benefit of higher after-tax interest rates.

Once we introduce policy uncertainty, however, almost 67 percent of households would prefer the reform with uncertain duration to the reform without uncertainty. This large change in support is caused by two distinct channels attributed to policy uncertainty. The first channel is rather mechanical. If uncertainty places a higher probability mass on a transition path associated with higher aggregate welfare, then, everything else equal, the political support for the reform with uncertain duration will naturally be higher. This channel is present in our model, since we assume that at a certain point in time there is a positive chance that the reform is going to continue, while the reform is abolished for sure at the same point in time in the model without uncertainty. These are the asset-poor agents of medium-to-high productivity who were against the reform without uncertainty but who now opt for the reform with uncertain duration because they expect to have more time to accumulate large assets and benefit from higher after-tax returns on saving.

The second channel is conceptually different and operates through capital adjustment costs. Intuitively, in a model with no capital adjustment costs, the optimal path under a reform that is repealed for sure shortly after being implemented would be an initial asset accumulation and later asset reduction. However, this would be very costly once we allow for the capital formation friction. On the contrary, in case of a reform that is repealed for sure in

the far future, agents would target a higher long run (average) level of assets and they would not try to reduce assets afterwards, leading to higher overall savings. In other words, we can expect to obtain different transition paths of economic variables for these two reforms. With policy uncertainty, the transition path of economic decisions would be a “linear combination” of these paths under perfect foresight. Therefore, policy uncertainty will matter more if these deterministic paths of economic decisions until the point of the revelation of uncertainty are different. At the current stage of research, however, we have not conducted experiments with capital adjustment costs, though the model environment already contains analytical results incorporating this financial friction. We are currently working to obtain numerical results for this case.

Despite the illustrated importance of policy uncertainty, there has been little research studying the economic and welfare effects of this type of policy uncertainty in quantitative macroeconomic models with heterogeneous households. The previous literature on income tax reforms, such as [Domeij & Heathcote \(2004\)](#), [Conesa & Krueger \(2006\)](#), [Conesa et al. \(2009\)](#) and [Abraham & Carceles-Poveda \(2006\)](#), has studied the aggregate and distributional effects of either ex-ante and ex-post permanent income tax reforms or the reforms, in which the timing of the policy switch is fully known to the public at the beginning of the reform. [Anagnostopoulos et al. \(2012\)](#) and [Carceles-Poveda & Coen-Pirani \(2009\)](#) study the effects of corporate and dividend tax reforms on capital accumulation. Again, the reforms in these papers are deterministic.

A few notable exceptions in the literature include [Caliendo et al. \(2015\)](#) and [Kitao \(2018\)](#) which address the uncertainty surrounding sustainability of Social Security. [Calvo & Drazen \(1997\)](#) focus on the uncertain duration of trade liberalization policies.

## 2 Model

Our baseline model without policy uncertainty is a simplified version of [Anagnostopoulos et al. \(2012\)](#). We consider an infinite horizon economy with production, idiosyncratic labor productivity shocks and sequential asset trade.

The economy is populated by a government, a representative firm and a continuum (measure 1) of infinitely lived households.

## 2.1 Households

Households are endowed with one unit of time which they supply inelastically to the firm. Each period, household receives a stochastic labour productivity shock  $\epsilon$ . This shock is i.i.d. across households and it follows a Markov process with transition matrix  $\Pi(\epsilon'|\epsilon)$  and  $S_\epsilon$  possible values that are assumed to be strictly positive. Household's pre-tax earnings are given by  $w_t\epsilon$ , where  $w$  is a wage rate per efficiency unit of labor. Households pay a linear tax  $\tau_l$  on their earnings.

To insure against their idiosyncratic labor income risk, we assume that households can trade (borrow or save) in stocks of a representative firm. The number of stocks held at the beginning of period  $t$  is denoted by  $s_t$ . Stocks can be traded between households at a competitive price  $p_t$  and the ownership of stocks entitles the shareholder to a dividend per share of  $d_t$ . There is no aggregate uncertainty, implying that dividends, the stock price and hence the return on the stock are certain.

Preferences over consumption  $c$  are assumed to be of the following form:

$$u(c_t) = \frac{c_t^{1-\sigma}}{1-\sigma} \quad (1)$$

where  $\sigma$  is the level of risk aversion.

The government levies proportional taxes on labor income at a rate of  $\tau_{l,t}$ . Households can use their after-tax income to purchase consumption goods or to purchase additional stocks. Agent's per-period budget constraint reads:

$$c_t + p_t s_{t+1} = (1 - \tau_{l,t})w_t\epsilon + (d_t + p_t) s_t \quad (2)$$

We implicitly assume that there are no capital or dividend taxes. At each

date, households also face a no short-selling constraint on stocks:

$$s_{t+1} \geq 0. \quad (3)$$

The presence of this constraint will allow us to have a well-defined firm objective on which all the shareholders agree, despite the market incompleteness. Individuals choose how much to consume and how many stocks to buy in each period taking as given the sequence of prices, dividends and tax rates  $(w_t, p_t, d_t, \tau_{l,t})_{t=0}^{\infty}$ .

The Euler equation for an unconstrained household with  $s_{t+1} > 0$  reads:

$$u'(c_t) = \beta E_t [u'(c_{t+1})R_{t+1}] \quad (4)$$

where  $u'$  denotes the marginal utility of the agent and

$$R_{t+1} \equiv \frac{d_{t+1} + p_{t+1}}{p_t} \quad (5)$$

We can write down the household's problem as a dynamic programming problem. Let  $\Psi(\epsilon, s)$  be the current joint distribution over individual shocks and share holdings. Then the dynamic programming problem reads:

$$V(\epsilon, s; \Psi) = \max_{c, s'} u(c) + \beta E_t [V(\epsilon', s'; \Psi')] \quad (6)$$

subject to the constraints (2-3), where  $\beta \in (0, 1)$  is the subjective discount factor and  $E_t$  denotes the expectation conditional on information at date  $t$ .

Let  $a_{t+1} \equiv p_t s_{t+1}$  denote the value of assets acquired by agent at time  $t$ . We can re-write agent's budget constraint in eq. (2) in a more usual way:

$$c + a_{t+1} = (1 - \tau_{l,t})w_t \epsilon + R_t a_t \quad (7)$$

This clarifies that what matters for household consumption and savings decision is the after tax return  $R_t$  as opposed to  $p_t$  and  $s_t$  separately.

Taking  $(\tau_{l,t}, R_t, w_t)$  as given, households solve:



$$V(\epsilon, a; \Psi) = \max_{c, a'} \{u(c) + \beta E_t[V(\epsilon', a'; \Psi')]\} \quad (8)$$

subject to the budget constraint in eq. (7) and the no short-selling constraint on stocks:

$$a' \geq 0.$$

Denote  $a(\epsilon, a; \Psi)$  and  $c(\epsilon, a; \Psi)$  the individual optimal saving and consumption choices, respectively.

## 2.2 Price-dividend mapping

Before proceeding with the description of the firm, the relationship between stock prices and future dividends is derived, which will be called the price dividend mapping. This mapping is used in the following subsection to define the value of the firm and to derive the relationship between physical capital and the stock price.

From the derived household Euler condition in eq. (4), the expected intertemporal marginal rates of substitution for all unconstrained households are equalized and they are equal to the reciprocal of the gross return from the stock between  $t$  and  $t + 1$ :

$$R_{t+1} = \frac{u'(c_t)}{\beta E_t[u'(c_{t+1})]}$$

Using this relationship together with the definition of gross return in eq. (5) and assuming that there are no-bubbles, the stock price can then be written as a function of dividends as follows:

$$p_t = \sum_{j=1}^{\infty} \left( \prod_{i=0}^{j-1} \frac{1}{1 + r_{t+1+i}} \right) d_{t+j}. \quad (9)$$

## 2.3 Production

The representative firm owns the aggregate capital stock  $K_t$ , hires labor and combines these two inputs to produce output goods using a constant returns

to scale technology:

$$Y_t = K_t^\alpha L_t^{1-\alpha}, \quad (10)$$

where  $L_t$  is the aggregate effective labor  $\alpha$  is the capital elasticity. Capital depreciates at the rate  $\delta \in [0, 1]$ .

The firm's profits before taxes are given by:

$$\pi_t = Y_t - w_t L_t = K_t^\alpha L_t^{1-\alpha} - w_t L_t. \quad (11)$$

The total number of stocks outstanding is normalized to one and the firm is assumed to have no access to additional sources of external finance, namely, it cannot issue new equity or debt. Thus, investment has to be financed solely using retained earnings. The firm's financing constraint therefore reads:

$$d_t = (1 - \tau_{c,t})\pi_t + \tau_{c,t}\delta K_t - I_t \quad (12)$$

where  $\tau_{c,t}$  is a proportional corporate tax rate and  $I_t$  is gross investment. The implicit assumption is that depreciation reduces the amount of corporate taxes a company pays.

There are adjustment costs to investment denoted by  $\phi(I_t/K_t)K_t$ . Investment expenditures increase firm's capital stock by:

$$K_{t+1} = (1 - \delta)K_t + \phi(I_t/K_t)K_t \quad (13)$$

The firm's objective is to maximize its market value for the shareholders. In general, when markets are incomplete, maximizing the value of the firm is not an objective to which all shareholders would agree. However, [Carceles-Poveda & Coen-Pirani \(2009\)](#) show that, even under incomplete markets, shareholder unanimity can be obtained if the technology exhibits constant returns to scale and short-selling is not allowed. These two assumptions are maintained throughout the paper.

The value of the firm at time  $t$  can be written as:

$$W_t = d_t + p_t,$$

where  $d_t$  is given by eq. (12) and  $p_t$  is defined in eq. (9).

Maximizing  $W_t$  subject to eq. (9) and (11)-(13) with respect to  $L_t$ ,  $I_t$  and  $K_{t+1}$ , respectively, leads to a set of first-order conditions:

$$w_t = (1 - \alpha)(K_t/L_t)^\alpha \quad (14)$$

$$q_t = \frac{1}{\phi'(I_t/K_t)} \quad (15)$$

$$q_t = \frac{1}{R_{t+1}} \left[ (1 - \tau_{c,t+1})\alpha K_{t+1}^{\alpha-1} L_{t+1}^{1-\alpha} + \tau_{c,t+1}\delta + \right. \quad (16)$$

$$\left. + q_{t+1}(1 - \delta - \phi'(I_{t+1}/K_{t+1})(I_{t+1}/K_{t+1}) + \phi(I_{t+1}/K_{t+1})) \right] \quad (17)$$

From the first first-order condition we have that:

$$\pi_t = Y_t - w_t L_t = \alpha Y_t \quad (18)$$

The last first-order condition can be re-written as:

$$q_t = \frac{1}{R_{t+1}} \left[ (1 - \tau_{c,t+1})\alpha K_{t+1}^{\alpha-1} L_{t+1}^{1-\alpha} + \tau_{c,t+1}\delta - \frac{I_{t+1}}{K_{t+1}} + q_{t+1} \left( 1 - \delta + \phi\left(\frac{I_{t+1}}{K_{t+1}}\right) \right) \right] \quad (19)$$

The last expression together with eq. (9) imply the following relationship between aggregate capital  $K_{t+1}$  and the stock price  $p_t$ , where we multiplied both sides of the equation by  $K_{t+1}$  in line 2, used eq. (18) and eq. (13) as well as the expression for dividend in eq. (12) in line 3:

$$\begin{aligned} q_t &= \frac{1}{R_{t+1}} \left[ (1 - \tau_{c,t+1})\alpha K_{t+1}^{\alpha-1} L_{t+1}^{1-\alpha} + \tau_{c,t+1}\delta - \frac{I_{t+1}}{K_{t+1}} + q_{t+1} \left( 1 - \delta + \phi\left(\frac{I_{t+1}}{K_{t+1}}\right) \right) \right] \\ q_t K_{t+1} &= \frac{1}{R_{t+1}} \left[ (1 - \tau_{c,t+1})\alpha Y_{t+1} + \tau_{c,t+1}\delta K_{t+1} - I_{t+1} + q_{t+1} \left( (1 - \delta)K_{t+1} + \phi\left(\frac{I_{t+1}}{K_{t+1}}\right)K_{t+1} \right) \right] \\ q_t K_{t+1} &= \frac{1}{R_{t+1}} [d_{t+1} + q_{t+1}K_{t+2}] \end{aligned}$$

Iterating on this equation delivers, using the definition of dividend from eq. (12) and the price-dividend mapping in eq. (9):

$$q_t K_{t+1} = p_t \quad (20)$$

Recall that the number of shares is normalized to one. This condition describes the relationship between the value of assets inside the firm (i.e.  $K_{t+1}$ ) and the market value of stocks to investors (i.e.  $p_t$ ). The aggregate supply of equity to investors is equal to the market value of all stocks, i.e.

In the absence of adjustment costs,  $q_t = 1$ . This implies that the value of the capital inside the firm is equal to the value of the firm's equity. In that case, our model is equivalent to a standard incomplete markets economy like the one in [Aiyagari \(1994\)](#). With adjustment costs, however, a unit of capital in the firm is now worth more than one unit to the shareholders, i.e.  $q_t > 1$ .

## 2.4 Government

At each period  $t$ , the government collects two types of taxes: the labor income taxes and the corporate taxes. The government makes no transfers to households, so all the tax revenues are spent on wasted government expenditures  $G_t$  which are given by:

$$G_t = \tau_{l,t} w_t L_t + \tau_{c,t} (\pi_t - \delta K_t) \quad (21)$$

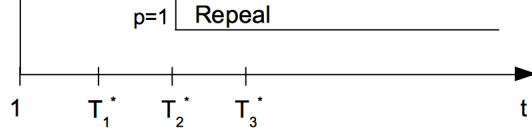
We consider three types of corporate tax reforms by the government which we describe below.

## 2.5 Reforms

Our reform eliminates the tax on corporate income, i.e.  $\tau_{c,t} = 0$ . The reform is unanticipated. It is announced at time  $t = 1$  and becomes effective the next period after the announcement. Our reform is revenue neutral, in the sense that the government is committed to providing the same level of government expenditures  $\bar{G}$  as prior to the reform. We assume that this is the labor tax rate,  $\tau_{l,t}$ , that adjusts to balance the government budget. All the remaining parameters of the model remain unchanged.

The duration of the corporate tax reform is crucial in our analysis. We consider two alternative cases. In the first case, the timing of the reform

Reform with certain duration:



Reform with uncertain duration:

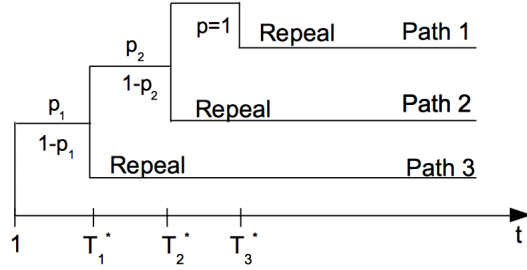


Figure 1: Timing of the reform with certain and uncertain duration

is certain. More specifically, the reform continues until it is abolished with probability one in period  $T_2^* > 1$ . When the reform is repealed, the corporate tax rate reverts immediately and irreversibly to that in the initial steady state. When  $T_2^*$  is very large, the reform is close to being permanent. Ex-ante, all agents know the duration of the reform. This scenario is described in the upper schedule of figure 1.

In the second case, the duration of the reform is uncertain. More specifically, in period  $T_1^* < T_2^*$ , the reform continues with probability  $p_1$ , while the reform is irreversibly repealed with probability  $1 - p_1$ . If the reform continues, it is going to be irreversibly repealed in period  $T_2^*$  (the same period as in the previous case without uncertainty for the reasons explained below) with probability  $p_2$ . If not, the reform continues until period  $T_3^* > T_2^*$ , when it is irreversibly abolished with certainty. Of course, the reforms in both cases become identical when  $p_1 = 1$  and  $p_2 = 0$ . Ex-ante, all agents know  $T_1^*, T_2^*, T_3^*$  as well as the probability distributions  $p_1, p_2$ . This scenario is shown in the

lower schedule of figure 1.

For the described reform to have a chance to increase aggregate welfare both in the short and long run, we follow [Abraham & Carceles-Poveda \(2006\)](#) and assume that elimination of corporate taxes is accompanied by a transformation of the linear labor tax system into a progressive tax system. In particular, the government keeps the tax rate of the lowest two income groups the same and increases labor taxes for all other agents. In what follows,  $\tau_{l,t}^l$  and  $\tau_{l,t}^h$  denote the labor tax rates faced by the two lowest productivity groups (as explained below) and by the rest, respectively. The key is that high income agents tend to have higher asset income, so this reform has the advantage that the beneficiaries of the reform also pay its costs.

Computationally, there will be several transition paths of the economy in case of policy uncertainty. To be precise, there will be one path from period 1 to period  $T_1^*$ , two paths from period  $T_1^*$  to period  $T_2^*$  and three paths from period  $T_2^*$  onwards. The three paths are labeled accordingly in figure 1.

At time  $t = T_2^* - 1$ , the value function of the agent reads:

$$\begin{aligned} V(\epsilon, a; \Psi_{T_2^*-1}, \mathcal{P}_{T_2^*-1}) &= \max_{c, a'} u(c) \\ &+ \beta \times p \times E_{T_2^*-1} \left[ V^{cont.}(\epsilon', a'; \Psi_{T_2^*}, \mathcal{P}_{T_2^*}^{cont.}) \right] \\ &+ \beta \times (1 - p) \times E_{T_2^*-1} \left[ V^{stop}(\epsilon', a'; \Psi_{T_2^*}, \mathcal{P}_{T_2^*}^{stop}) \right] \end{aligned}$$

where  $\mathcal{P}_{T_1^*}^{cont.} = \{\tau_{c,t}, \tau_{l,t}^h\}_{t=T_2^*}^T$  is a vector capturing the future paths of corporate tax rates and the labor tax rates at time  $T_2^*$ , once it is known that the reform is going to continue ( $\mathcal{P}_{T_2^*}^{stop}$  in case the reform stops), and  $V^{cont.}(\epsilon, a; \Psi_{T_2^*}, \mathcal{P}_{T_2^*}^{cont.})$  denotes the continuation value associated with the reform continuing at time  $T_2^*$  ( $V^{stop}$  in case the reform is repealed).

The value function of the agent at time  $t = T_1^*$  can be written in a similar way as above.

## 2.6 Equilibrium

The aggregate demand for assets by the households equals:

$$A_{t+1} = \int_{\epsilon, a} a_{t+1}(\epsilon, a; \Psi_t) d\Psi_t(\epsilon, a). \quad (22)$$

Using the definition  $a_{t+1} \equiv p_t s_{t+1}$  and the fact that the total number of shares is normalized to one, we have that the market value of the firm equals the total demand for assets by the households:

$$A_{t+1} = p_t.$$

Given  $q_t$ , condition (15) pins down the firm's desired capital stock  $K_{t+1}$ .

An equilibrium is a set of tax rates  $(\tau_{l,t}, \tau_{c,t})$ , a sequence of prices  $\{r_t\}_{t=0}^{\infty}$  and  $\{w_t\}_{t=0}^{\infty}$ , a sequence of individual decision rules  $\{a_{t+1}(\epsilon, a; \Psi_t)\}_{t=0}^{\infty}$  and  $\{c_t(\epsilon, a; \Psi_t)\}_{t=0}^{\infty}$ , a sequence of aggregate capital and labor,  $\{K_t\}_{t=0}^{\infty}$  and  $\{L_t\}_{t=0}^{\infty}$ , and an initial distribution of households across states,  $\Psi_0$ , such that:

- Given  $(\tau_{l,t}, R_t, w_t)$ , the individual decision rules  $\{a_{t+1}(\epsilon, a; \Psi_t)\}_{t=0}^{\infty}$  and  $\{c_t(\epsilon, a; \Psi_t)\}_{t=0}^{\infty}$  solve the household maximization problem in eq. (6).
- The labor market clears according to eq. (14) with the aggregate supply of effective labor given by:

$$L_t = \int_{\epsilon, a} \epsilon d\Psi_t(\epsilon, a).$$

- Given  $q_t$ , the aggregate demand for assets by the households equals the aggregate supply of equity by the firm:

$$A_{t+1} = q_t K_{t+1}$$

where the demand for assets,  $A_{t+1}$ , is given by eq. (22),  $K_{t+1}$  comes from the firm's first-order condition (15).

- Tobin's  $q_t$  is given by eq. (20).

- The gross return on holding equity,  $R_{t+1}$ , is defined by eq. (5), where  $d_t$  comes from eq. (12) and  $I_t$  is implicitly defined by eq. (13) through the capital adjustment cost function.
- The goods market clears according to the aggregate resource constraint

$$C_t + G_t + K_{t+1} - (1 - \delta)K_t + \tilde{\Phi}_t = w_t L_t + (r_t + \delta)K_t \quad (23)$$

where  $K_0$  is given and

$$\tilde{\Phi}_t = \int_{\epsilon, a: a_{t+1}(\epsilon, a; \Psi_t) - a_t < 0} \Phi(a_t, a_{t+1}) d\Psi_t(\epsilon, a)$$

is the total stock of assets spent on transaction costs and

$$C_t = \int_{\epsilon, a} c_t(\epsilon, a; \Psi_t) d\Psi_t(\epsilon, a)$$

is the aggregate consumption.

- The government budget constraint in eq. (21) is satisfied.

### 3 Calibration of the benchmark model

#### 3.1 Model parameters

One of the main objectives of the calibration is that the model in steady state matches the earnings and wealth distribution in the US. In addition, we target several aggregate statistics, such as the interest rate, the labor share and the investment and capital to output ratios in the US data.

We assume that the economy is in a steady state. The time period is assumed to be one year. The parameters determined outside the model are presented in table 1. We set the coefficient of risk aversion,  $\sigma$ , to 2.0. In the production function,  $\alpha = 0.36$  is chosen to match the labor share of 0.64 in the U.S. data and the technology parameter  $A$  is normalized to 1.0. The depreciation rate is set to  $\delta = 0.08$  to match the annual investment to capital



ratio in the U.S. The values for the corporate tax rate,  $\tau_{c,0}$ , and the labor tax rate,  $\tau_{l,0}$ , are obtained outside the model. In particular,  $\tau_{a,0}$ , is set to 40 percent and the labor tax rate is set to 27.7 percent following [Abraham & Carceles-Poveda \(2006\)](#).

We parametrize the adjustment cost function in eq. (10) as follows:

$$\phi(I_t/K_t) = \frac{\gamma_1}{1-\zeta}(I_t/K_t)^{1-\zeta} + \gamma_2$$

where  $\zeta > 0$  and  $\gamma_1 \geq 0$ . We want adjustment costs of capital to play no role in the steady state of the model. This implies that  $q_t$  in eq. (15) must be equal to one and  $I$  in eq. (13) must be equal to  $\delta K$ . This requires that:

$$\gamma_1 = \delta^{-\zeta}$$

and

$$\gamma_2 = \frac{-\delta\zeta}{1-\zeta}$$

At the current stage of our research, however, we abstract from the capital adjustment costs and present all the results below assuming that  $\gamma_1 = \gamma_2 = 0$ .

Parameter	Description	Value
$\sigma$	risk aversion	2.0
$\alpha$	capital share	0.36
$A$	technology parameter	1.0
$\delta$	depreciation rate	0.08
$\tau_{c,0}$	corporate tax rate	0.4
$\tau_{l,0}$	labor tax	0.277
Capital adjustment costs:		
$\gamma_1$	level	0.0
$\zeta$	curvature	2.0
$\gamma_2$	intercept	0.0

Table 1: Parameters determined outside the model

We calibrate the process for  $\epsilon$  outside the model to match the earnings inequality. Table 2 shows the resulting earnings process, which is a seven state

Markov chain. The table displays the shock values, the stationary distribution and the transition matrix. In our simulations, we refer to the agents facing the bottom two shocks as the low productivity agents (for whom the labor tax remains constant during reforms), and to the remaining agents as high productivity agents (for whom the labor tax increase).

$\epsilon$ :	0.10	0.22	0.58	1.31	2.91	8.99	16.02
	0.9400	0.0213	0.0387	0	0	0	0
	0.0265	0.8500	0.1235	0	0	0	0
	0	0.0667	0.9180	0.0153	0	0	0
$\pi(\epsilon'   \epsilon)$ :	0	0	0.0666	0.8669	0.0665	0	0
	0	0	0	0.1334	0.8000	0.0666	0
	0	0	0	0	0.1235	0.8320	0.0445
	0	0	0	0	0	0.2113	0.7887

Table 2: Transition matrix  $\Pi(\epsilon'|\epsilon)$

The discount factor,  $\beta = 0.93$ , is calibrated inside the model to match the capital to output ratio reported for the U.S. in [Cooley & Prescott \(1995\)](#).

### 3.2 Pre-reform steady state

Table 3 shows the values for the key model variables in the pre-reform steady state.

$K$	$C$	$Y$	$\tau_c, \%$	$\tau_l^h, \%$	$r, \%$	$r(1 - \tau_c), \%$	$w$	$w(1 - \tau_l^h)$	$G$
6.77	1.03	1.99	40.00	27.70	2.58	1.55	1.27	0.92	0.42

Table 3: Key model variables in the pre-reform steady state

### 3.3 Model fit

In order to evaluate the performance of the benchmark model economy, we use the Survey of Consumer Finances from 2016 to compute the moments of

income, earnings and wealth distributions in the data. Appendix A describes the sample selection criteria in detail.

Table 4 shows how the current benchmark model matches the pre-government income and earnings inequality. Table 5 shows how the current benchmark model matches the inequality in wealth.

	Q1	Q2	Q3	Q4	Q5	Gini
Earnings						
Data	1.54	6.93	12.67	17.96	60.90	0.55
Model	3.27	7.28	13.39	9.65	66.42	0.59
Income						
Data	1.61	6.29	11.71	17.37	63.01	0.57
Model	3.14	7.80	10.98	10.89	67.20	0.60

Table 4: Pre-government earnings and income inequality in the data and in the benchmark model

	Q1	Q2	Q3	Q4	Q5	Gini
Data: Net worth	-0.92	0.54	2.71	8.25	89.42	0.84
Data: Net financial wealth	-5.01	-0.41	0.51	5.90	99.01	0.84
Model	0.32	1.60	3.59	7.03	87.46	0.79

Table 5: Wealth inequality in the data and in the benchmark model

## 4 Results

### 4.1 Reform with certain duration

#### Transitional dynamics

This section analyzes the welfare implications of the corporate tax reform with certain duration (refer to upper schedule of figure 1 for the timing of the reform). We assume that the reform lasts for 20 periods, i.e.  $T_2^* = 20$ .

Figure 2 displays the transitional dynamics results for some key model variables. The paths of the variables are normalized by the value of the corre-

sponding variable in the initial steady state. The latter was shown in table 3. Figure 3 shows the transitional dynamics results for the pre-tax and after-tax interest rates as well as the labor taxes for high productivity agents in percent. The vertical dashed lines in both figures correspond to period  $T_2^*$ .

As we see, aggregate capital increases smoothly up to several periods prior to the expiration of the reform. This is due to the elimination of corporate taxes, which leads to an increase in the after-tax interest rate. The figure also reflects a sharp decrease in after tax wages for high productivity agents due to the initial increase in labor income taxes except for the two lowest productivity groups. Note that the after tax wage for these agents,  $(1 - \tau_{l,t}^h)w_t$ , drops in spite of higher gross wages. Shortly before the reform expiration, the aggregate capital starts to gradually decline and ultimately goes back to the pre-reform level.

### Welfare effects

Figure 9 shows welfare changes in consumption-equivalent terms from the reform relative to the pre-reform steady state at time  $t = 1$ . In the figure we plot the gains and losses by asset holdings,  $a$ , and labor productivity  $\epsilon$ . To compute the welfare effects, we quantify the welfare change for each individual of type  $(a, \epsilon)$  by asking: By how much (in percent) has this individual's consumption to be increased in all future periods and contingencies in the benchmark model economy, so that her expected future utility equals that under the reform. This figure is important for two reasons. It shows who are the agents who would be in favor and against the reforms. Also, it indicates whether these reforms could have public support or not.

Several important observations emerge from the figure. First, the lowest productivity group supports the reform for any asset level, while the second lowest income group (not in the figure) supports it for almost all positive asset levels. Since the labor taxes are kept the same for both these groups, their after tax wages do not drop upon impact. Moreover, since shocks are persistent, they expect to see increasing after tax wages during the transition

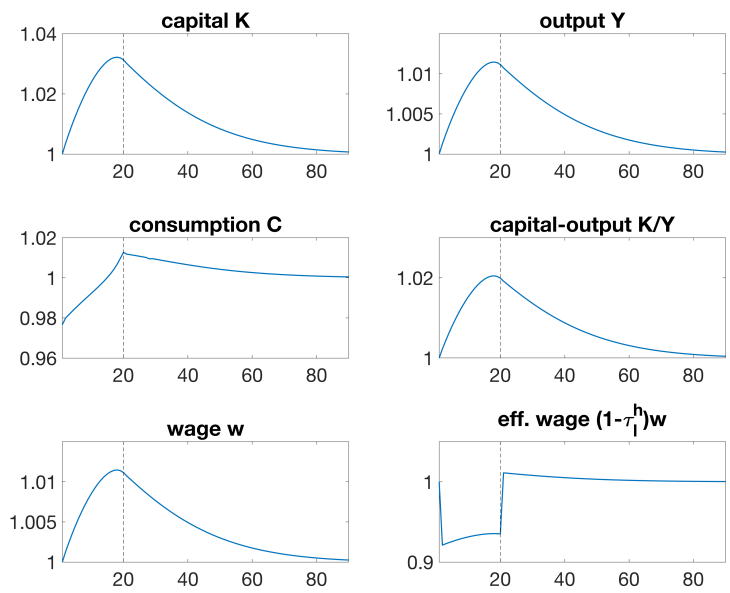


Figure 2: Transitional dynamics of some key model variables in case of reform without uncertainty (normalized by the value of the corresponding variable in the initial steady state)

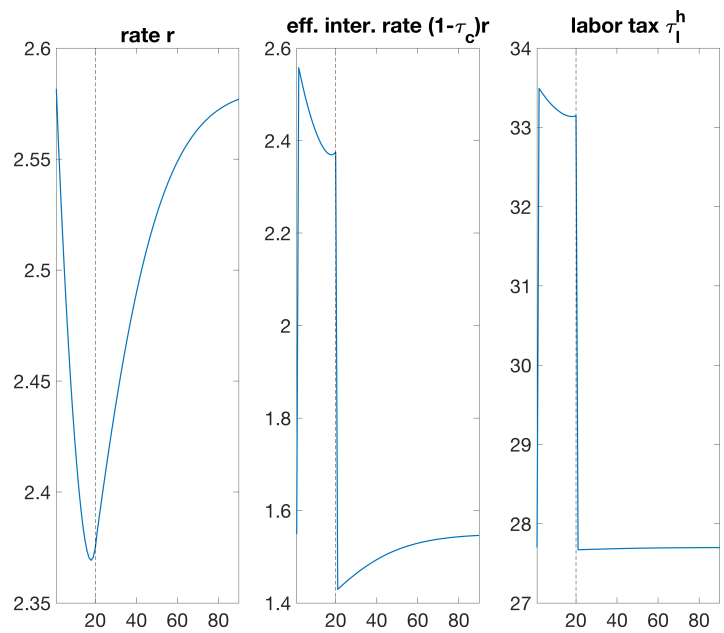


Figure 3: Transitional dynamics of pre-tax and after-tax interest rates and labor tax rate for the high productivity agents (in percent) in case of reform without uncertainty

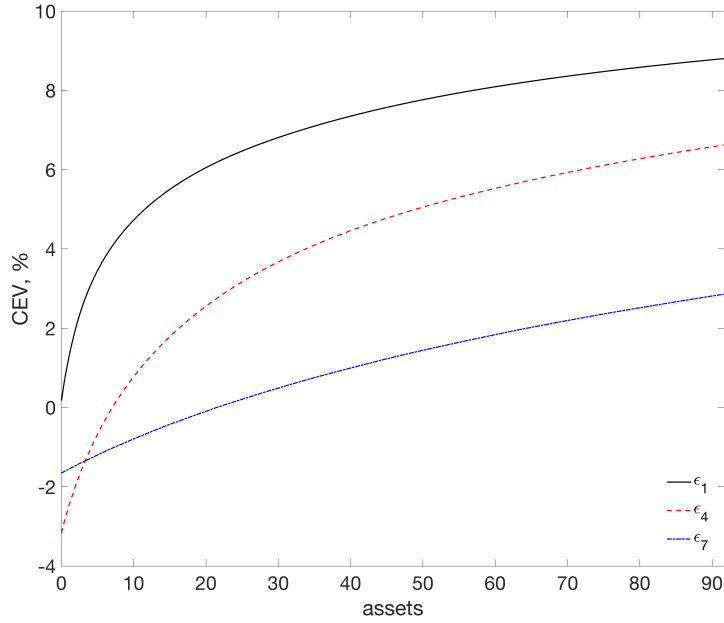


Figure 4: Welfare gains and losses from the reform without uncertainty relative to the pre-reform steady state by asset holdings,  $a$ , and productivity,  $\epsilon$ , at time  $t = 1$  (CEV, %)

because aggregate capital will increase. Second, we see that the higher is the asset wealth of a given individual, the more she prefers the reform. This is not surprising, as agents with a higher asset wealth benefit from a higher after-tax saving interest rate. Third, for agents with medium-to-high asset levels, the lower is the labor income of a given individual, the more he/she favors the reform. This is because among agents with the same asset level, agents with lower income levels rely less on labor income in relative terms and therefore the increase in labor income taxes (if it applies) hurts them the least.

Table 6 displays welfare gains in consumption equivalent terms aggregated within the quintiles of the pre-reform wealth distribution. Table 7 shows welfare gains computed within each of the productivity groups. As can be seen, the reform leads to an overall loss of 0.28 percent. The table also shows that

	Quintiles of initial wealth distribution					
	Q1	Q2	Q3	Q4	Q5	All
Welfare (transition), %	-0.74	-1.35	-1.30	-0.56	2.63	-0.28
Political support, %						32.84

Table 6: Welfare effects of the reform without uncertainty relative to the pre-reform benchmark (CEV, %) at time  $t = 1$ , by assets holdings

the total support for the reform among the agents is almost 33 percent.

	Productivity			
	Low ( $\epsilon_1, \epsilon_2$ )	Medium ( $\epsilon_3, \epsilon_4, \epsilon_5$ )	High ( $\epsilon_6, \epsilon_7$ )	All
Share of agents, %	32.52	63.92	3.56	100.00
Welfare (transition), %	0.18	-0.65	2.13	-0.28

Table 7: Welfare effects of the reform without uncertainty relative to the pre-reform benchmark (CEV, %) at time  $t = 1$ , by labor productivity

## 4.2 Reform with uncertain duration

### Transitional dynamics

Now we analyze the corporate tax reform with an uncertain duration, whose structure was described in the lower schedule of figure 1. We parametrize the model as follows:  $T_1^* = 10$ ,  $T_2^* = 20$ ,  $T_3^* = 30$ ,  $p_1 = 2/3$  and  $p_2 = 1/2$ . The choice of these parameter values will be explained below.

Figure 7 shows the transitional dynamics results of the key model variables. As before, the paths of the variables are normalized by the value of the corresponding variable in the initial steady state. Figure 7 shows the transitional dynamics results for the interest rates and the labor tax, where the paths are shown as percentage point differences from the initial steady state. The vertical dashed lines in both figures correspond to periods  $T_1^*$ ,  $T_2^*$  and  $T_3^*$ .

Each time the agents learn that the corporate tax reform is not repealed, they reduce their consumption and accumulate more assets. This leads to a gradually rising aggregate capital stock and output. In fact, a delay in

the reform is a major incentive for agents to save because of higher after-tax returns on savings. This is despite the fact that high productivity agents, who are the major drivers of capital accumulation, face lower after-tax wages while the reform is in place. The aggregate capital reaches its peak when the reform turns out to last the longest (Path 1). Each time the reform is reverted, agents adjust their optimal consumption-savings behavior by consuming more. Quantitatively, the adjustment in consumption is the smallest when the reform is reverted at time  $T_3^*$  because there is no uncertainty about this event.

In order to understand the effects of policy uncertainty on the paths of aggregate variables, we compare the transitional dynamics results in the model with policy uncertainty to the ones in the model without policy uncertainty discussed in section 4.1. Recall that in the latter model the reform lasted for 20 periods. At the same time, observe that the expected (as of  $t = 1$ ) duration of the reform in the model with policy uncertainty given our parametrization of  $(T_1^*, T_2^*, T_3^*, p_1, p_2)$  is the same because  $10 [1 + 2/3 + (1/2) \times (2/3)] = 20$ .

Figure 7 shows the transitional dynamics results of the key model variables. As opposed to the previous graphs, the paths of the variables are now expressed as percentage differences from the corresponding benchmark paths without uncertainty. Figure 8 shows the transitional dynamics of pre-tax and after-tax interest rates as well as the labor tax as a percentage point difference from the paths of corresponding variables in the benchmark model.

During the first 10 periods after the reform is implemented, aggregate capital stock is slightly lower, while aggregate consumption is slightly higher than in the benchmark model without uncertainty. This is understandable, since agents anticipate that there is a 1/3 chance that the reform is going to be repealed at time  $T_1^*$ , which makes investment less attractive. Their consumption-savings behavior, however, changes once agents learn at time  $T_1^*$  that the reform persists. In that case, they start over-saving relative to the benchmark model because there is now a 50 percent chance that the reform is going to continue after  $T_2^*$ , while the reform is sure to finish at the same time period in the case without uncertainty. Note that under Path 2, the aggregate



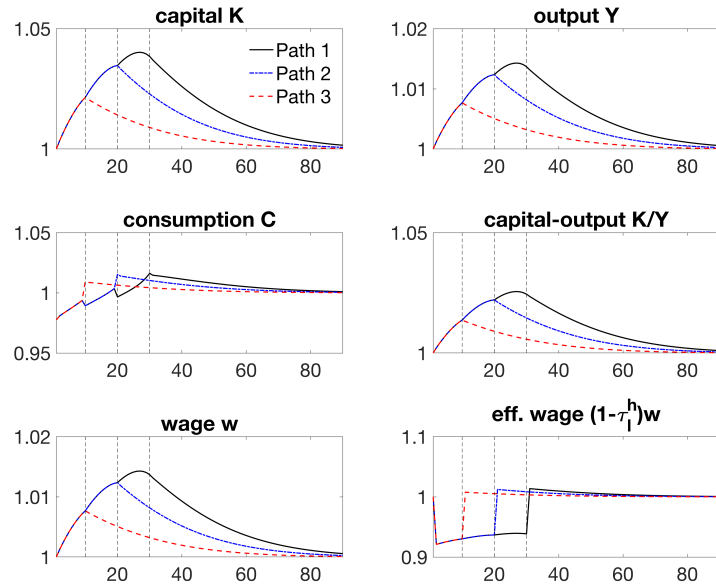


Figure 5: Transitional dynamics of some key model variables in case of reform with uncertainty (normalized by the value of the corresponding variable in the initial steady state)

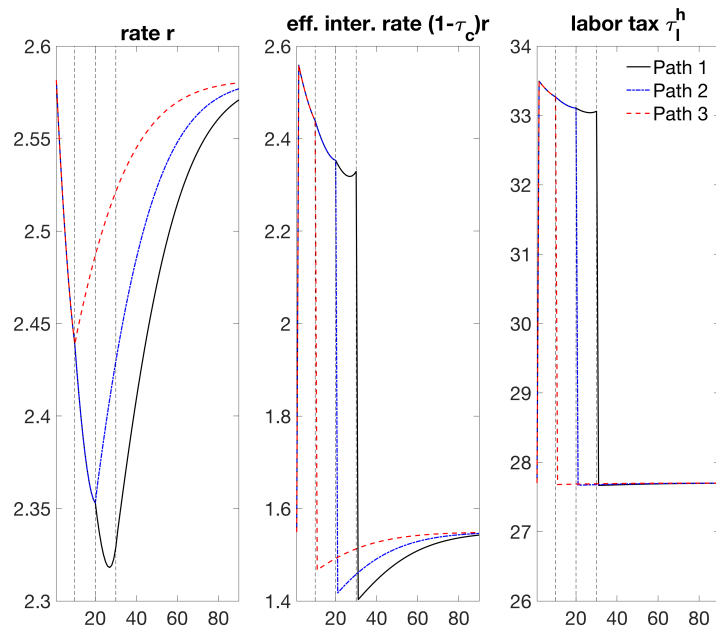


Figure 6: Transitional dynamics of pre-tax and after-tax interest rates and labor tax rate for high productivity agents in case of reform with uncertainty (in percent)

capital is slightly higher than under the benchmark transition.

### Welfare effects

In order to quantify welfare effects, we ask each individual in the model economy without policy uncertainty at time  $t = 1$  how much increase (or decrease) in consumption across all states is needed, so that she will be indifferent between her welfare in the transition without policy uncertainty and the transition that involves uncertainty. If, for example, the CEV for an individual is 0.1%, it means that she prefers an economy with uncertainty and needs to be compensated with a rise in consumption by 0.1%, so that her expected life-time utilities are the same in both economies.

Figure 9 depicts welfare gains and losses from the reform with uncertainty relative to the reform without uncertainty by agents' asset holdings and selected productivity levels at time  $t = 1$ .

Tables 8-9 show welfare gains computed within the quintiles of the pre-reform wealth distribution and within the productivity groups, respectively. As can be seen, the reform with uncertain duration leads to an overall gain of 0.01 percent and the total support for the reform of almost 67 percent.

	Quintiles of initial wealth distribution					All
	Q1	Q2	Q3	Q4	Q5	
Welfare (transition), %	0.04	0.07	0.06	0.01	-0.16	0.01
Political support, %						66.85

Table 8: Welfare effects of the reform with uncertainty relative to the reform without uncertainty (CEV, %) at time  $t = 1$ , by assets holdings

Figure 10 shows the transitional dynamics of welfare (in CEV, %) in the model with uncertainty relative to the transitional path of welfare in the model without uncertainty. Observe that the welfare effect in period  $t = 1$  in the figure corresponds to the welfare measure reported in tables 8-9.

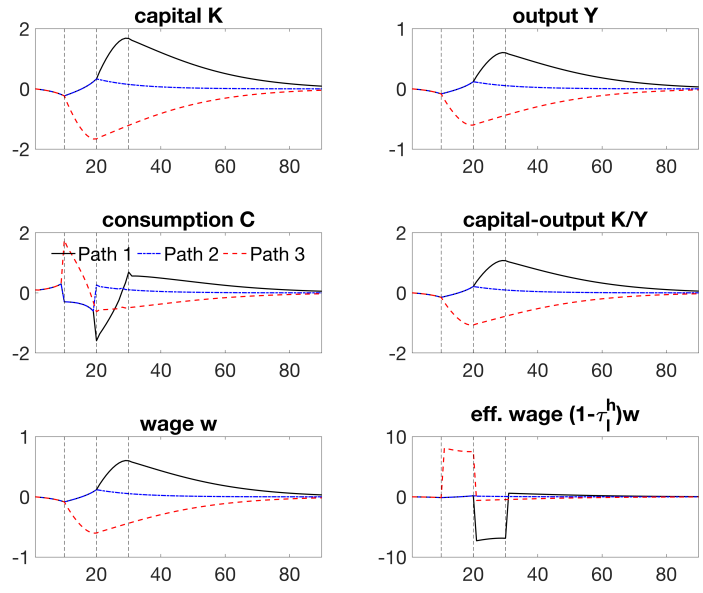


Figure 7: Transitional dynamics of some key model variables in case of reform with uncertainty as percentage differences from the corresponding benchmark paths without uncertainty

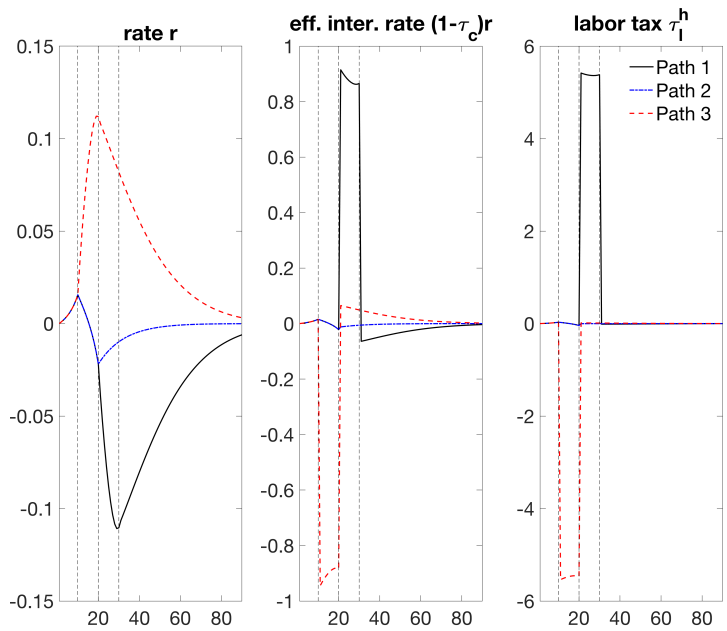


Figure 8: Transitional dynamics of pre-tax and after-tax interest rates and labor tax rate for high productivity agents in case of reform with uncertainty (as a percentage point deviation from the benchmark path without uncertainty)

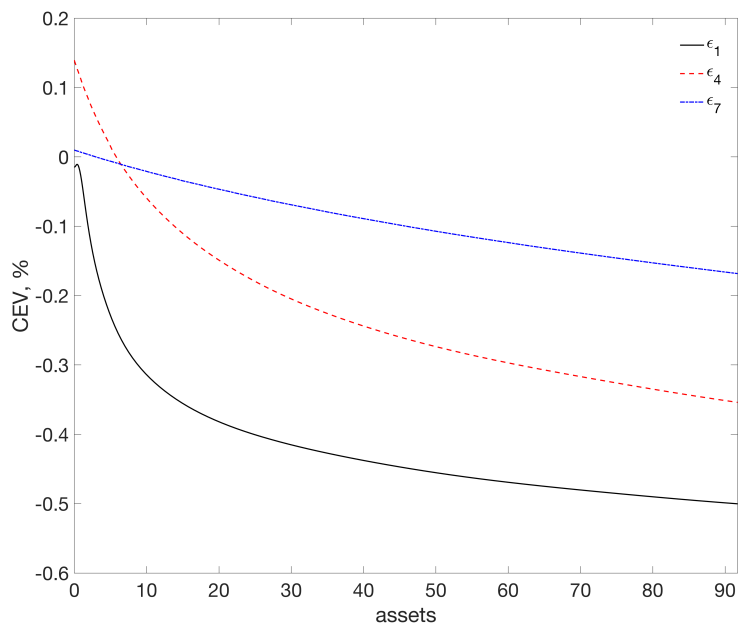


Figure 9: Comparison of welfare gains and losses from the reform with uncertainty relative to the reform without uncertainty by asset holdings,  $a$ , and productivity,  $\epsilon$ , at time  $t = 1$  (CEV, %)

	Productivity			All
	Low ( $\epsilon_1, \epsilon_2$ )	Medium ( $\epsilon_3, \epsilon_4, \epsilon_5$ )	High ( $\epsilon_6, \epsilon_7$ )	
Share of agents, %	32.52	63.92	3.56	100.00
Welfare (transition), %	0.01	0.01	-0.13	0.01

Table 9: Welfare effects of the reform with uncertainty relative to the reform without uncertainty (CEV, %) at time  $t = 1$ , by labor productivity

During the first 10 periods after the reform is implemented, the aggregate welfare (as measured by the CEV) is increasing. The high productivity agents, who gain from rising after-tax interest rates but lose from lower after-tax wages, now lose less because they have more time to adjust to the abrupt increase in labor taxes that occurred in period 1. The trajectory of aggregate welfare changes after realization of uncertainty in period  $T_1^*$ , when the welfare loss starts to increase (see Path 2 in figure 10) meaning that agents are willing to pay more for the reform without uncertainty. As time goes by, the reform with uncertainty becomes less attractive to those agents who benefitted from it at the beginning because the expected duration of the reform has become much shorter.

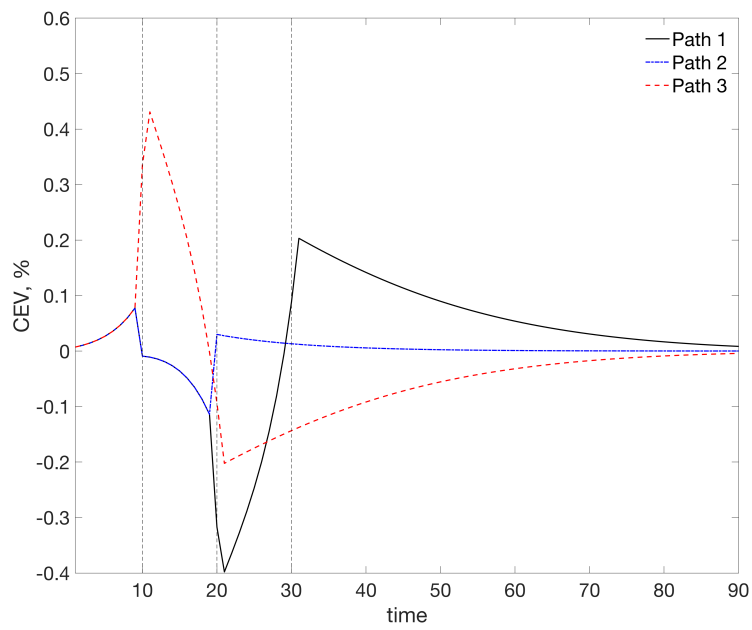


Figure 10: Transitional dynamics of welfare (in CEV, %) in the model with uncertainty relative to the transitional path of welfare in the model without uncertainty

## 5 Conclusions

TBA

## References

- Abraham, A. & Carceles-Poveda, E. (2006), ‘Endogenous incomplete markets, enforcement constraints, and intermediation’, *Theoretical Economics* **1**(4), 439–459.
- Aiyagari, S. R. (1994), ‘Uninsured Idiosyncratic Risk and Aggregate Saving’, *The Quarterly Journal of Economics* **109**(3), 659–684.
- Anagnostopoulos, A., Carceles-Poveda, E. & Lin, D. (2012), ‘Dividend and capital gains taxation under incomplete markets’, *Journal of Monetary Economics* **59**(7), 599–611.
- Caliendo, F. N., Gorry, A. & Slavov, S. (2015), The cost of uncertainty about the timing of social security reform, Working Paper 21585, National Bureau of Economic Research.
- Calvo, G. A. & Drazen, A. (1997), Uncertain duration of reform: Dynamic implications, Working Paper 5925, National Bureau of Economic Research.
- Carceles-Poveda, E. & Coen-Pirani, D. (2009), ‘Shareholders’ unanimity with incomplete markets’, *International Economic Review* **50**(2), 577–606.
- Conesa, J. C., Kitao, S. & Krueger, D. (2009), ‘Taxing capital? not a bad idea after all!’, *American Economic Review* **99**(1), 25–48.
- Conesa, J. C. & Krueger, D. (2006), ‘On the optimal progressivity of the income tax code’, *Journal of Monetary Economics* **53**(7), 1425–1450.
- Cooley, T. & Prescott, E. (1995), Economic growth and business cycle, *in* ‘Frontiers of business cycle research’, Princeton University Press.

Domeij, D. & Heathcote, J. (2004), ‘On the distributional effects of reducing capital taxes’, *International Economic Review* **45**(2), 523–554.

Kitao, S. (2018), ‘Policy uncertainty and cost of delaying reform: The case of aging Japan’, *Review of Economic Dynamics* **27**, 81–100.

## Appendix

### A Data

We use the Survey of Consumer Finances from 2016 to compute the moments of income, earnings and wealth distributions in the data. The unit of observation is a household. All dollar amounts are given for the 2015 calendar year. All dollar amounts are nominal. We assume that (pre-government) earnings equal the sum of (pre-government) wage income and the income from a sole proprietorship or a farm as well as income from other businesses or investments before taxes. We do not impose any restrictions on the amount of hours supplied by households. We define (pre-government) income as a sum of the following components:

- earnings (defined above);
- income from non-taxable investments such as municipal bonds, before deductions for taxes and anything else;
- income from other interest, before deductions for taxes and anything else;
- income from dividends, before deductions for taxes and anything else;
- net annual income from gains or losses from mutual funds or from the sale of stocks, bonds, or real estate, before deductions for taxes and anything else.

Since agents in our model are workers, we restrict attention to those households who are of age 25-60.