Dividend and Capital Gains Taxation under Incomplete Markets*

Alexis Anagnostopoulos†
SUNY at Stony Brook

Eva Cárceles-Poveda‡
SUNY at Stony Brook

Danmo Lin§
University of Maryland

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Abstract. The capital income tax cuts that were part of the Jobs and Growth Tax Relief Reconciliation Act of 2003 are expiring this year and the administration has to decide whether to extend them or not. This paper assesses the effects of these tax cuts in a calibrated dynamic general equilibrium framework with uninsurable labor income risk. In particular, it looks at the effects of dividend and capital gains taxes on investment and welfare in a framework where firms are the owners of capital and make investment decisions to maximize their market value. While the effects of capital gains taxes are qualitatively similar to those found when households own the capital, we find that the effects of dividend taxes are different. Surprisingly, a dividend tax cut leads to a reduction in investment. The reason is that it raises the market valuation of the existing capital stock and households require a lower capital stock to maintain the same level of wealth. As a consequence, dividend tax cuts are welfare reducing in the long run, not only because of the traditional reasons of redistribution from the poor to rich, but also because of a fall in aggregate production and consumption. Taking into account the transition mitigates the losses. Still, with our benchmark calibration, a reduction of dividend and capital gains taxes from 31% and 24% to 19% leads to a reduction of more than 0.5% in aggregate welfare in consumption equivalent terms.

Keywords: Incomplete Markets, Tax Reform, Dividend Taxes, Capital Gains Taxes.

JEL Classification: E23, E44, D52

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†*Correspondence:* Department of Economics, State University of New York, Stony Brook NY-11794-4384. *Tel:* 16316327537, *Email:* aanagnostopo@notes.cc.sunysb.edu.

‡*Correspondence:* Department of Economics, State University of New York, Stony Brook NY-11794-4384. *Tel:* 16316327533, *Email:* ecarcelespov@notes.cc.sunysb.edu. *Web:* http://ms.cc.sunysb.edu/~ecarcelespov/.

§*Correspondence:* Robert H. Smith School of Business, University of Maryland, *Email:* danlin@rhsmith.umd.edu .

1. Introduction

In 2001, the Bush Administration introduced the Economic Growth Tax Relief Reconciliation Act (EGTRRA) which, amongst other reforms, lowered dividend and capital gains taxes. In 2003, the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) accelerated the EGTRRA provisions and introduced further reductions in dividend and capital gains taxes. These two acts are expected to sunset this year and the current administration has to decide whether to extend them or not. This paper attempts to shed light into the quantitative effects of these capital income tax changes using a dynamic stochastic general equilibrium model that is calibrated to US data.

Discussions on tax policy, especially capital income tax policy, have always been politically divisive. One of the reasons is that economic theory provides arguments for both sides of the discussion. On the one hand, reductions in capital taxes are viewed as providing incentives for investment and, hence, leading to higher economic growth. On the other hand, reductions in capital taxes are viewed as negative because of the resulting increase in budget deficits as well as in inequality. Although there seems to be a presumption that reductions in capital taxes would disproportionately favor the wealthiest part of the distribution, it is well known that those relying mainly on labor income could also see substantial benefits arising from the general equilibrium effects of increased investment on wages and employment. In this paper, we aim to disentangle the theoretical effects of changes in dividend and capital gains taxes but also to provide a quantitative analysis of the size of the costs and benefits associated with these reforms.

To that end, we build a general equilibrium economy in which households face uninsurable idiosyncratic labor income risk. In addition to risky labor income, households receive capital income from owning shares in firms. Both labor income and capital income are taxed by the government. Importantly, the government taxes both dividends and capital gains, potentially at different rates. Firms in our model undertake investment with a view to maximizing shareholder value. We use the results in Cárceles-Poveda and Coen-Pirani (2009) to ensure shareholder unanimity with respect to this objective despite the presence of shareholder heterogeneity and market incompleteness. Two assumptions are crucial for this: constant returns to scale production and no short-selling constraints. We calibrate the model to US data and compute long run steady states as well as transitions.

Our results regarding steady states are as follows. A reduction in dividend tax rates has the surprising effect of reducing steady state investment and capital stock. The reason is that this tax change raises the market valuation of the existing capital stock and, hence, household's wealth. Households, facing the same level of uncertainty as before, now hold too much wealth compared to the optimum and desire a reduction in the aggregate capital stock. In equilibrium, this leads to an increase in the return on the riskless asset and a decrease in the capital stock. This suggests that a reduction in dividend taxes might have the exact opposite effects on investment to those intended. It also has sharp predictions regarding the welfare consequences of the dividend tax decrease. Whereas previous studies of capital income taxation[1] tend to find that negative distributional effects of such reforms are partially mitigated

[1] See e.g. Aiyagari (1995), Domeij and Heathcote (2004) and Abraham and Carceles-Poveda (2010).

by the implied increased efficiency, we find that both efficiency and distribution go in the wrong direction. Specifically, when we decompose the welfare effects into "aggregate" and "distributional" components, following the methodology proposed by Domeij and Heathcote (2004), we find that both of these components are negative. The "aggregate" component refers to the welfare effect arising from a change in aggregate consumption, for a given distribution of consumption across households. Here, aggregate capital falls and so does long run aggregate consumption, so this effect is unambiguously negative. The "distributional" component captures the effect of changes in the distribution of consumption and is computed as a residual. In line with previous studies, we find that the distributional component of the reform is negative. The reason is straightforward. A reduction in dividend taxes benefits households in the upper tail of the wealth distribution and hurts those in the lower tail. In turn, the marginal utility of the latter households is higher (and there is more of them) so that aggregate welfare falls. Because of the fall in capital this negative redistribution is more pronounced than in previous studies, since the bottom of the wealth distribution, which relies mostly on labor income, now faces an endogenous, general equilibrium effect on wages that is also negative.

Turning to the effects of a reduction in capital gains tax rates, we find a positive effect on the capital stock and a small but positive effect on welfare. Contrary to the dividend tax, the capital gains tax acts as a standard capital income tax, effectively reducing the after tax return of capital. A decrease in such a tax, has an unambiguous positive effect on investment and hence on aggregate consumption and on the aggregate component of welfare. In addition, there are no negative distributional effects in the steady state. The reason is that the government raises no revenues from capital gains taxation at steady state, since stock prices are constant, so the decrease in capital gains tax does not have a direct effect on the government's budget. However, the indirect effect, through an increase in investment and, thus, wages is actually positive. Therefore the capital gains tax reduction actually improves the government budget and it allows for lower labor income tax rates. As a result, the distributional component of welfare is also positive. Overall, we conclude that reducing capital gains taxes is welfare improving in the long run.

When the dividend and capital gains taxes are reduced simultaneously, the dividend tax cut effects dominate and the overall effect is a reduction in aggregate social welfare. The dividend tax cut dominates for two reasons: first, as explained above, steady state effects of capital gains taxes are only of second order. Second, the actual reduction in the capital gains tax rate in the 2003 reform was smaller than the one on dividends.

Looking at steady states allows us to clarify the intuition for our results and understand the qualitative mechanisms taking place in our model. However, for obtaining a quantitative assessment of the welfare effects of the tax reform it is imperative that we consider the transition. In fact, it is well known that results about the long run are often mitigated and sometimes even reversed when the short run effects are included. In our case, it is clear that this could be so. After all, a reduction in the capital stock arising from the dividend tax cut will reduce aggregate consumption in the long run but increase aggregate consumption in the short run. We therefore conduct our experiment including the transition period. The experiment is as follows. The economy begins at a steady state with dividend taxes that are equal to 31% and capital gains taxes that are equal to 24%. These are the marginal tax rates before the Bush dividend tax cuts. The two rates are then reduced to 19%, corresponding to the marginal tax rates after the reform. All the tax changes are assumed to be unexpected and perceived as permanent. Subsequently, the economy is simulated until convergence to the new steady state.

The transitional path is as expected. Aggregate capital falls monotonically to the new steady state. Aggregate consumption initially increases as the economy starts dissaving but eventually falls below the original level as production is reduced due to lower investment. Overall, welfare falls by approximately 0.5% (in terms of consumption equivalents). The decomposition shows a positive aggregate effect arising from the immediate consumption hike, but a larger negative distributional effect. In terms of winners and losers, we find that individuals at the low end of labor productivity and those holding zero or very few stocks stand to lose from the reform, whereas those holding a lot of stocks stand to gain. In terms of "political support", we find that only 20% of the population experiences a welfare improvement.

Related Literature. From a theoretical perspective, this paper can be seen as bridging the gap between two strands of literature. The first strand includes the articles that analyze optimal taxation and/or tax reforms in the presence of heterogeneity and uninsured idiosyncratic risk (see e.g. Aiyagari (1995), Domeij and Heathcote (2004) and Ábrahám and Cárceles-Poveda (2010)). Our paper is most closely related to this literature and our methodology is directly borrowed from those articles. A purely cosmetic difference is in our choice of modelling firms as the owners of the capital stock, which we view as the most natural setup in which to think of dividend and capital gains taxes.[2] Our only substantial difference arises from our explicit modelling of dividends and capital gains taxes as opposed to a general capital income tax.

The second strand of the literature is the one focusing on the effects of dividend taxes on capital accumulation and the stock market in a framework with no household heterogeneity. McGrattan and Prescott (2005), Santoro and Wei (2009a) and Gourio and Miao (2008) show that, in such a setting, a constant flat-rate dividend tax is not distortionary. Subsequently, several modifications have been applied to the representative agent framework which render the dividend tax distortionary. For example, if households and firms face a non-constant dividend tax rate profile (for example because the tax reform is only temporary), then these taxes will affect capital accumulation.[3] In this paper, however, we abstract from this by assuming dividend taxes are changed permanently and unexpectedly.

Another important consideration in determining whether dividend taxes are distortionary relates to one's view about what is the marginal source of financing for corporations. Following Poterba and Summers (1983), if the marginal source of financing is new equity (traditional

[2] An equivalent formulation that is more standard in the literature with static firms that rent capital from consumers is available upon request. See Carceles-Poveda and Coen Pirani (2010) for a general equivalence result with incomplete markets.

[3] A non-constant dividend tax profile is introduced by McGrattan (2009), by Gourio and Miao (2008) and, indirectly, by Santoro and Wei (2009b).

view), then a decrease in dividend taxes increases investment. Alternatively, if the marginal source of financing is retained earnings (new view), then dividend taxes do not distort investment decisions.[4] In an interesting recent article, Gourio and Miao (2010) find distortionary effects of dividend taxes by allowing for firm heterogeneity. Mature firms, which are in the dividend paying stage of their life cycle, conform to the new view and are not directly affected by constant dividend taxes. Growing firms, however, conform to the traditional view and are affected. Overall, they find that a reduction in dividend taxes increases investment by directly affecting growing firms and by changing the composition of firms in the economy. In our setting, however, the representative firm conforms to the new view and acts as a mature, dividend paying firm, implying that those effects are absent.[5]

To summarize, our point of departure is a benchmark model where firms conform to the new view, dividend tax changes are permanent and unexpected and, as a result, in the absence of household heterogeneity these changes have no effect on capital. We then add household heterogeneity and find that a decrease in dividend taxes, *decreases* investment and the long run capital stock.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 discusses the theoretical effects of the tax cuts and provides intuition for the results. In Section 4, we calibrate the model to US data and provide a quantitative evaluation of the welfare implications of the Bush tax reforms both in the long run and along the transition. Section 5 conducts some sensitivity analysis and Section 6 summarizes and concludes.

2. The Model

We consider an infinite horizon economy with endogenous production and uninsurable labor income risk. The economy is populated by a continuum (measure 1) of infinitely lived households that are indexed by $i \in I$, a representative firm that maximizes its market value and a government that maintains a balanced budget. Time is discrete and indexed by $t = 0, 1, 2, ...$

2.1. Households.

Households have identical additively separable preferences over sequences of consumption $c_i \equiv \{c_{it}\}_{t=0}^{\infty}$ of the form:

$$U(c_i) = E_0 \sum_{t=0}^{\infty} \beta^t u(c_{it}), \tag{1}$$

[4] Although Poterba and Summers (1983) seem to find evidence against the new view and in favor of the traditional view, recent work by Auerbach and Hassett (2005), that focuses specifically on the 2003 JGTRRA reform, finds evidence in support of the new view, which is the one we adopt in the present paper. In addition, Sinn (1991) finds that "*...most corporate equity capital is generated by internal investment rather than new share issues*", a fact also supporting the new view. The recent theoretical literature discussed above seems to have adopted this view, at least as a benchmark.

[5] Since we introduce household heterogeneity we need to abstract from firm heterogeneity in order to maintain tractability. In this sense, our work is complementary to the one by Gourio and Miao (2010). Given a representative firm framework, it also seems reasonable to assume the firm is mature, particularly in light of Gourio and Miao's (2010) finding, using Compustat data, that the overwhelming majority of investment is carried out by these types of firms.

where $\beta \in (0,1)$ is the subjective discount factor and E_0 denotes the expectation conditional on information at date $t = 0$. The period utility function $u(\cdot) : \mathbb{R}_+ \rightarrow \mathbb{R}$ is assumed to be strictly increasing, strictly concave and continuously differentiable, with $\lim_{c_i \rightarrow 0} u'(c_i) = \infty$ and $\lim_{c_i \rightarrow \infty} u'(c_i) = 0$.

Each period, households can only trade in stocks of the firm to insure against uncertainty. We denote by s_{it-1} the number of stocks held at the beginning of period t. Stocks can be traded between households at a competitive price of p_t and the ownership of stocks entitles the shareholder to a dividend per share of d_t. We assume that there is no aggregate uncertainty, implying that dividends, the stock price and hence the return on the stock are certain.

In addition to asset income, household $i \in I$ earns labor income. We assume that all households supply a fixed amount of labor (normalized to one) but their productivity, ϵ_{it}, varies stochastically. This productivity is i.i.d. across households and follows a Markov process with transition matrix $\Pi(\epsilon'|\epsilon)$ and S_ϵ possible values. Individual labor income is thus equal to $w_t \epsilon_{it}$, where w_t is the aggregate wage rate.

The government levies proportional taxes on labor income, dividend income and capital gains income at the rates of τ_l, τ_d and τ_g respectively. Households can use their after-tax income from all sources to purchase consumption goods or to purchase additional stocks. The households' budget constraint can thus be expressed as:

$$c_{it} + p_t s_{it} = (1 - \tau_l) w_t \epsilon_{it} + ((1 - \tau_d) d_t + p_t)\, s_{it-1} - \tau_g\, (p_t - p_{t-1})\, s_{it-1}. \tag{2}$$

Note that we have simplified in assuming capital gains taxes are paid on an accrual basis and that capital losses are subsidized at the same rate[6]. At each date, household $i \in I$ also faces a no short-selling constraint on stocks:

$$s_{it} \geq 0 \tag{3}$$

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 given prices, dividends and tax rates $\{p_t, w_t, d_t, \tau_d, \tau_l, \tau_g\}_{t=0}^{\infty}$.

Before proceeding with the description of the firm, we derive the price dividend mapping, which is the relationship between stock prices and future dividends. This will be useful later to define the value of the firm as well as to derive the relationship between physical capital and the stock price. To do this, we use the optimality conditions of the households. The optimal choice of stocks by any unconstrained household $i \in I$ with $s_{it} > 0$ requires the following optimality condition to hold:

$$p_t u_{c,it} = \beta E_t u_{c,i,t+1} \left[(1 - \tau_d)\, d_{t+1} + p_{t+1} - \tau_g\, (p_{t+1} - p_t) \right] \tag{4}$$

where $u_{c,it}$ represents the marginal utility of the agent. As usual, 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 $t+1$

$$1 + r_{t+1} \equiv \frac{u_{c,it}}{\beta E_t u_{c,i,t+1}} = \frac{\left[(1 - \tau_d)\, d_{t+1} + p_{t+1} - \tau_g\, (p_{t+1} - p_t) \right]}{p_t} \tag{5}$$

[6] For a way to model capital gains taxes on a realization basis see Kydland, Gavin and Pakko (2007).

Using this relationship, the absence of aggregate uncertainty and assuming that there are no-bubbles, the stock price can then be written as a function of dividends as follows[7]

$$p_t = \sum_{j=1}^{\infty} \left(\prod_{i=0}^{j-1} \frac{1}{1 + \frac{r_{t+1+i}}{1-\tau_g}} \right) \frac{1-\tau_d}{1-\tau_g} d_{t+j} \tag{6}$$

2.2. The Firm. The representative firm owns the capital stock K_t, hires labor and combines these two inputs to produce consumption goods using a constant returns to scale technology:

$$Y_t = AF(K_t, L_t)$$

where K and L are the aggregate capital and effective labor, while A is the total factor productivity, which is assumed to be constant. The total number of stocks outstanding is normalized to one and we assume that the firm has no access to additional sources of external finance, namely, it cannot issue new equity or debt. Thus the total wage bill and investment as well as the distributions of dividends to shareholders have to be financed solely using internal funds.[8] The firm is not allowed to use repurchases as a means of distributing profits to shareholders. The firm's financing constraint is therefore:

$$d_t + K_{t+1} - (1-\delta) K_t + w_t L_t = AF(K_t, L_t) \tag{7}$$

where $\delta \in [0,1]$ is the capital depreciation rate.

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, Cárceles-Poveda and 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. We maintain these two assumptions throughout the paper. Using the price-dividend mapping (6), the value of the firm at t can be written as:

$$V_t = \frac{1-\tau_d}{1-\tau_g} d_t + p_t = \sum_{j=0}^{\infty} \left(\prod_{i=0}^{j-1} \frac{1}{1 + \frac{r_{t+1+i}}{1-\tau_g}} \right) \frac{1-\tau_d}{1-\tau_g} d_{t+j}$$

Maximizing this objective subject to (7) leads to the aggregate labor demand equation:

$$w_t = AF_L(K_t, L_t) \tag{8}$$

Moreover, optimal investment dynamics are described by the capital Euler equation:

$$1 = \frac{1}{1 + \frac{r_{t+1}}{1-\tau_g}} \left(1 - \delta + AF_K(K_{t+1}, L_{t+1})\right) \tag{9}$$

As shown in Appendix A, this last expression together with (6) implies the following relation between aggregate capital and the stock price:

$$p_t = \frac{1-\tau_d}{1-\tau_g} K_{t+1} \tag{10}$$

[7] The derivation of the expressions in this section can be found in Appendix A.

[8] We do not allow firms to use repurchases as a means of distributing profits. See Gordon and Dietz (2009) for a discussion of alternative ways to ensure firms pay dividends.

2.3. Government. In each period t, the government consumes a constant amount G and taxes labor, dividend and capital gains income at the rates τ_l, τ_d and τ_g respectively. We assume that the government has a balanced budget. The government budget constraint is therefore given by:

$$G = \tau_d d_t + \tau_l w_t L_t + \tau_g (p_t - p_{t-1}) \tag{11}$$

2.4. Recursive Competitive Equilibrium. In the present framework, the aggregate state of the economy is given by the aggregate capital stock K and by the joint distribution Ψ of consumers over individual stock holdings s and idiosyncratic productivity status ϵ. Households perceive that Ψ evolves according to:

$$\Psi' = \Gamma(K, \Psi)$$

where Γ represents the transition function from the current aggregate state into tomorrow's wealth-productivity distribution. The aggregate capital stock evolves according to:

$$K' = \Phi(K, \Psi)$$

Since the individual state vector includes the individual labour productivity and stock holdings (ϵ, s), the relevant state variables for a household are summarized by the vector $(\epsilon, s; \Psi, K)$.[9]

Definition: Given the transition matrix Π, as well as an initial value for the aggregate capital stock K_0 and for the initial distribution of stocks and productivity Ψ_0, a *recursive competitive equilibrium* relative to a government policy $(\tau_d, \tau_g, \tau_l, G)$ consists of laws of motion Γ and Φ, stock price and wage functions $p(K')$ and $w(K)$, firm choices K', $L(K)$ and $d(K, K')$ and individual household policy functions $c(\epsilon, s; K, \Psi)$ and $s(\epsilon, s; K, \Psi)$, as well as associated value functions $V(\epsilon, s; K, \Psi)$ such that:

- *Optimal Household Choice:* Given prices and aggregates, the individual policy functions and the value functions $c(\epsilon, s; K, \Psi)$, $s(\epsilon, s; K, \Psi)$ and $V(\epsilon, s; K, \Psi)$ solve the problem of the households:

$$V(\epsilon, s; K, \Psi) = \max_{c, s'} \left\{ u(c) + \beta \sum_{\epsilon'|\epsilon} \Pi(\epsilon'|\epsilon) V(\epsilon', s'; K', \Psi') \right\} \text{ s.t.} \tag{12}$$

$$\begin{aligned} c + p(K')(s' - s) &= (1-\tau_l)\, w(K)\, \epsilon + (1-\tau_d)\, d(K, K') s - \tau_g \left(p(K') - p(K) \right) s \\ s' &\geq 0 \end{aligned}$$

$$\begin{aligned} \Psi' &= \Gamma(K, \Psi) \\ K' &= \Phi(K, \Psi) \end{aligned}$$

[9] Note that, contrary to a framework were households own the capital directly, the aggregate capital K contains additional information on top of Ψ. The additional information consists essentially of the past stock price, which could equivalently be used as a state variable instead of K.

- *Firm Value Maximization:* Given prices, K', $L(K)$ and $d(K,K')$ satisfy firm optimality and the firm's financing constraint:

$$\begin{aligned} p\left(K'\right) &= \frac{1-\tau_d}{1-\tau_g}K' \\ w(K) &= AF_L(K,L(K)) \\ d\left(K,K'\right) &= AF(K,L(K)) + (1-\delta)K - K' - w(K)L(K) \end{aligned}$$

- *Government Budget Balance:* Government spending equals government revenue:

$$G = \tau_l w(K)L(K) + \tau_d d\left(K,K'\right) + \tau_g\left(p\left(K'\right) - p(K)\right)$$

- *Market Clearing:* Prices are such that all markets clear:

$$\begin{aligned} \int s(\epsilon,s;K,\Psi)d\Psi(\epsilon,s) &= 1 \\ \int \epsilon d\Psi(\epsilon,s) &= L(K) \\ \int c(\epsilon,s;K,\Psi)d\Psi(\epsilon,s) + K' + G &= AF(K,L(K)) + (1-\delta)K \end{aligned}$$

- *Consistency:* Γ and Φ are consistent with the agents' optimal decisions.

3. A Qualitative Analysis

One of the main results in this paper is that, in the presence of uninsured idiosyncratic risk, a reduction in dividend taxes reduces the capital stock. This section explains why this has to be the case theoretically, while the following section evaluates the quantitative importance of this effect in the context of the 2003 tax reform both in the long run and throughout the transition. Our discussion in this section focuses on steady states.

To understand the effects of taxes on distributions on the capital stock, the three key equations are the stock Euler equation in (5), the capital Euler equation in (9) and the price-capital relationship in (10). The first one describes the optimal choice of stocks by households, the second one describes the optimal choice of capital by the firm, and the third one describes the relationship between assets inside the firm (the capital stock) and assets outside the firm (the market value of stocks). This last relationship provides the value of Tobin's $q = \frac{1-\tau_d}{1-\tau_g}$ and it states that one unit of capital inside the firm is valued at q by investors. If there are no taxes on capital gains and dividends, or if these two taxes are the same, then $q = 1$. This implies that the value of capital inside the firm is equal to the value of the firm's equity. In that case, our model is equivalent to an Aiyagari (1994) economy where households make the investment decisions.[10]

Before moving on to the main case where $q \neq 1$, it will be helpful to build the analogy between the standard Aiyagari model with static firms and our economy with dynamic firms in the benchmark case where $q = 1$. To that end, we first describe how to obtain the standard figure describing the equilibrium with incomplete markets (Figure 1) when firms and households trade in stocks rather than in physical capital stock.

[10] The equivalence between our setting with dynamic firms and the more familiar static-firm setting also holds with taxes.

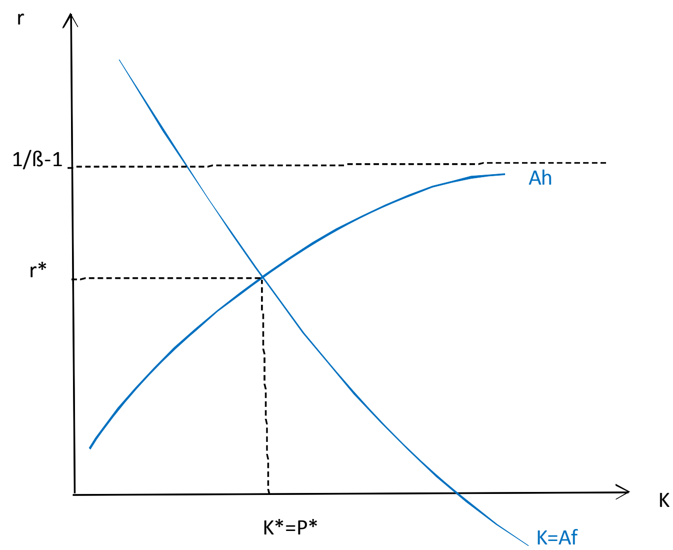

Figure 1

The curve labelled A_h represents equation (5), which is the total value of assets (wealth) desired by households as a function of the stock return r. Note that A_h is simply the stock price times the aggregate demand for stocks. In a standard Aiyagari economy, this would correspond to the aggregate demand for capital. As already shown by Aiyagari (1994), when markets are incomplete, the aggregate demand for assets is increasing in r and it tends to infinity as the return approaches the time preference rate $\frac{1}{\beta} - 1$ because of the precautionary savings motive. The curve labelled K represents equation (9), which is the firm's desired capital stock as a function of r. Finally, the curve labelled A_f represents the market value of assets supplied by the firm as a function of r. This is obtained in two steps. First, we obtain the firm's desired capital as a function of r from equation (9). Then, the market value A_f of this capital stock schedule is computed by multiplying it by q.[11]

In the benchmark case with $q = 1$, $p = K$ and the A_f schedule coincides with the K schedule, as in a standard Aiyagari economy. The equilibrium return r^* and the equilibrium value of assets held p^* are found at the intersection of the supply A_f and the demand A_h for stocks, while the equilibrium level of the capital stock can be read off the K curve once r^* is known. Now suppose there is a difference in dividend and capital gains tax rates and suppose for the sake of exposition that $\tau_d > \tau_g$ so that $q < 1$, as has been the case historically for the US. A unit of capital in the firm is now worth less than one unit to the shareholders. As a result, the value of stocks p and the value of the physical capital K invested by the firm will not be the same. Figure 2 shows how to obtain the equilibrium return in the stock market and the implied capital stock in such an economy. Similarly to the previous case, A_h is simply a depiction of the demand for wealth given by the stock Euler (5). To obtain the

[11] Recall that the aggregate supply of stocks is normalized to 1, so the value of the stocks supplied represented by A_f is simply the stock price p.

supply A_f, the first step is the same as before, namely, we plot the capital stock K given in (9). But when we translate this into the supply of assets by multiplying it by q, the A_f curve is now below the K curve because $q < 1$. The equilibrium in the stock market is (r^*, p^*) and the implied capital stock is $K^* = \frac{1-\tau_g}{1-\tau_d} p^*$.

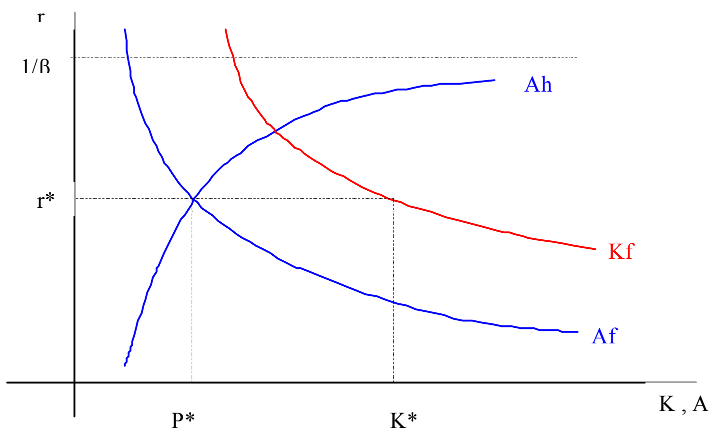

Figure 2

Consider now a decrease in τ_d, keeping τ_g fixed. Keeping everything else fixed[12], this has no direct effect on the K and A_h schedules but it does increase q and therefore shifts the A_f schedule to the right. The new A_f curve is the dashed line shown in Figure 3[13]. A decrease in dividend taxes raises the rate of return and, interestingly, has opposite effects on the stock price and the aggregate capital stock, raising the former and reducing the latter. The intuition is straightforward. At the prevailing rate r^*, households want to hold the same wealth as before and firms want to invest the same capital stock as before. But this capital stock is now valued more so that the supply of wealth is now higher. In order to induce households to hold more wealth, the return on stocks has to increase and this increase serves as the signal to the firm to start reducing the capital stock.

[12]Strictly speaking, keeping everything else fixed would require the introduction of individual specific lump sum taxes that would undo any effects the tax change has on budget constraints other than the stock price effect.

[13]Without loss of generality, the graphical depiction assumes that q does not rise above 1.

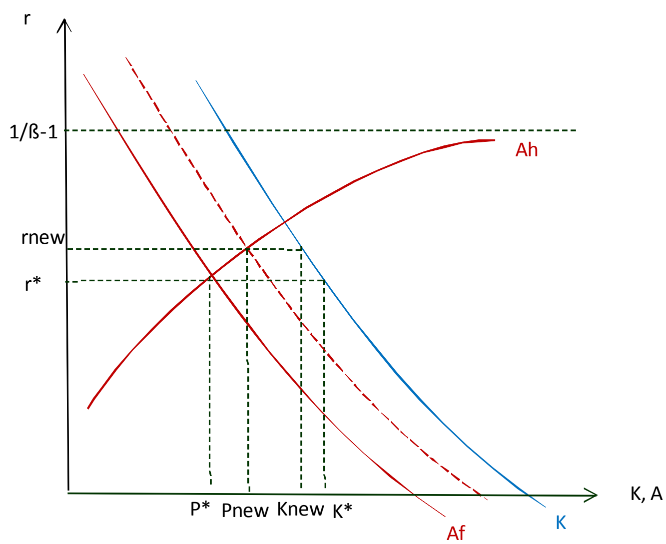

Figure 3

This result suggests that using a cut in dividend taxes as a way to promote investment can actually have negative effects on the capital stock and achieve the exact opposite effect. A crucial aspect required to yield this result is that the desired wealth held by households is not perfectly elastic, as it would be in a complete markets infinite horizon economy. This situation is depicted in Figure 4. After a decrease in the dividend tax, the stock price increases proportionally to the change in the tax. The wealth held by individuals is now higher than before, but agents are content to hold this higher amount of wealth as long as the return remains at the time preference rate. The end result is that capital (and all other variables except the stock price) is unaffected by the change in the dividend tax, which is not distortionary. This is the essence of Proposition 2 in McGrattan and Prescott (2005) and Proposition 1 in Santoro and Wei (2009).

An alternative extreme would postulate that the desired wealth schedule A_h is perfectly inelastic. Indeed, this would be a formalization of the intuition given by Poterba and Summers (1983), who argue that " *If the desired wealth-to-income ratio is fixed, then an increase in the dividend tax, which reduces each capital good's market value, will actually* increase *equilibrium capital intensity*". This intuition is not borne out of their model, which conforms to the standard infinite horizon complete markets model and therefore predicts no effects of dividend taxes on the capital stock. But our Bewley economy delivers this intuitive result by allowing both the desired level of wealth and the return to be endogenously determined.

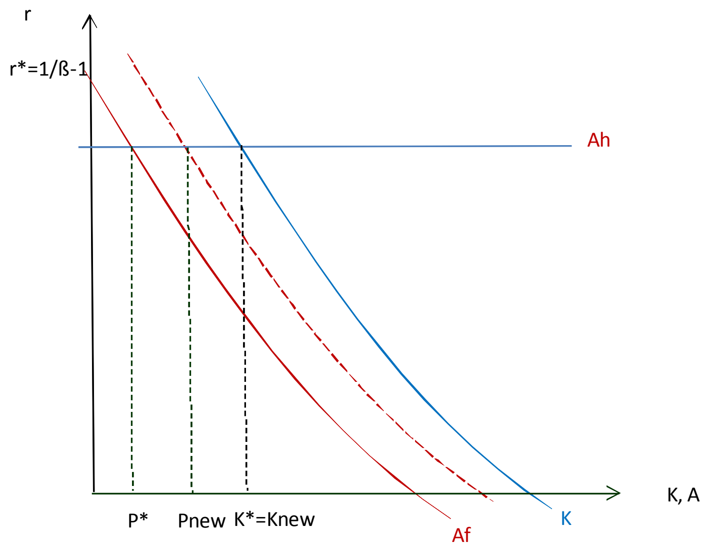

Figure 4

The preceding discussion essentially analyzes the effects of an increase in q. This can arise through any combination of changes in τ_d and τ_g that increases $\frac{1-\tau_d}{1-\tau_g}$. However, there are two important differences between the two tax changes. First, a reduction in τ_g reduces q and leads to the exact opposite effects to those discussed above. In particular, a decrease in τ_g, will raise the capital stock but reduce the stock price, ceteris paribus. Second, when τ_d falls but τ_g is kept fixed, the dividend tax change does not distort decisions in any other way and in particular it does not distort the capital Euler equation. This means that τ_d affects the equilibrium only through its effect on q. By contrast, a change in τ_g directly distorts the capital Euler equation and therefore has additional effects that are more closely related to the standard effects of capital taxes. In particular, a decrease in the capital gains tax rate reduces the cost of capital $\frac{r}{1-\tau_g}$ and this has the direct effect of shifting the K curve outwards. The implied wealth provided by the firm is therefore also shifted outward, keeping q fixed. So, the capital stock increases for two reasons after a decrease in τ_g, but the stock price could go either way depending on which effect is stronger.[14]

To summarize, in our economy, a reduction in dividend taxes reduces the capital stock and increases the stock price but a reduction in capital gains taxes increases the capital stock and has ambiguous effects on the stock price. In the tax reform experiment of the next section, both taxes fall, but τ_d falls by more than τ_g leading to a rise in q. This effect will thus be present but there are additional effects arising from the change in τ_g. The overall effect of a reform that reduces both is thus theoretically ambiguous and can only be obtained by quantifying these mechanisms. This is the objective of the following two sections.

[14] With complete markets, the q effect disappears, but the direct effect on the after tax return to capital is still present and, therefore, the capital gains tax will increase both the capital stock and the stock price unambiguously.

4. Quantitative Results

This section uses a calibrated version of our model to study the effects of the 2003 capital tax reforms. First, we discuss the calibration and solution method for the benchmark economy. Next, we study the effects of a reduction in taxes both in the steady state and during the transition.

4.1. Calibration. The time period is assumed to be one year. Preferences are of the CRRA class, $u(c) = \frac{\left[c^{1-\mu}-1\right]}{1-\mu}$, with a risk aversion of $\mu = 2$. The production function is Cobb-Douglas, $F(K, L) = AK^{\alpha}L^{1-\alpha}$ with $\alpha = 0.32$ and the technology parameter A is normalized so that output is equal to one in the steady state of the deterministic version of our economy. We choose a discount factor $\beta = 0.92$ to match an average capital to output ratio of 2.8. The depreciation rate is set to $\delta = 0.103$. Although this depreciation rate implies a very high investment to output ratio, it is chosen to match the average dividend to GDP ratio of 2.8% observed in NIPA data up to 2002.[15].

The idiosyncratic labor productivity process is taken from Davila et. al (2007). They construct the process so as to generate inequality measures for earnings and (endogenously) wealth that are close to US data using a very parsimonious model[16]. As shown in Table 1, this is achieved with a three-state Markov chain with a transition matrix $\mathbf{\Pi}(\epsilon'|\epsilon)$ exhibiting very strong persistence and productivity values $\boldsymbol{\epsilon}$ that assign productive individuals 46 times the productivity of unproductive individuals. The resulting stationary distribution is denoted by $\mathbf{\Pi}^*$ and is also displayed in Table 1.

Table 1: Earnings Process

$$\boldsymbol{\epsilon} = \begin{bmatrix} 1.00 & 5.29 & 46.55 \end{bmatrix}$$
$$\mathbf{\Pi}^* = \begin{bmatrix} 0.498 & 0.443 & 0.059 \end{bmatrix}$$
$$\mathbf{\Pi}(\epsilon'|\epsilon) = \begin{bmatrix} 0.992 & 0.008 & 0.000 \\ 0.009 & 0.980 & 0.011 \\ 0.000 & 0.083 & 0.917 \end{bmatrix}$$

We take our tax rates from Feenberg and Coutts (1993).[17] These are Federal plus State marginal tax rates for wages, qualified dividends and long term capital gains respectively. For our benchmark economy we use $\tau_l = 0.28$, $\tau_d = 0.31$ and $\tau_g = 0.24$ which are the values reported for 2002.[18] With these taxes, the implied government to output ratio before the reform is equal to 20%, which is very close to the government to output ratio of 19% in the US. Feenberg and Coutts report marginal tax rates of 18.42 and 19.64 respectively for

[15] In a previous version of the paper we calibrated the capital depreciation rate to match the investment to GDP ratio which resulted in a much higher dividend to GDP ratio. This, in turn, led to much larger effects of changes in dividend taxation. In this sense, our current calibration biases the quantitiative significance of our results downwards.

[16] For details on this see also Diaz, Pijoan-Mas, Rios-Rull (2003) and Castaneda, Diaz-Gimenez and Rios-Rull (2003).

[17] The data we use can be downloaded from http://www.nber.org/taxsim.

[18] Using an average of the tax rates for years 1997 to 2002 gives essentially the same numbers.

2003. Since the intention of the reform was to equalize the two tax rates, and since the case of equal tax rates is the standard theoretical benchmark with $p = K$, it seems natural to choose equal rates after the reform. Thus we assume dividend and capital gains tax rates are reduced to $\tau_d = \tau_g = 0.19$. In our main reform experiment, the labor tax rate adjusts to balance the budget but we also consider an alternative reform where the lost government revenue is covered using lump sum taxes.

4.2. Solution Method. To solve the model, we use a policy function iteration algorithm that is described in detail in Appendix B. In order to evaluate the welfare effect of tax reforms, we have also computed the transition of our economy between the stationary distributions of the pre reform and the post reform steady states. The extra difficulty of this exercise is that factor prices and the distribution of individuals over asset holdings and labor income change during the transition.

4.3. Welfare Effects of Tax Reforms.

Long Run. This section analyzes the long run implications of revenue neutral tax reforms that reduce dividend and (or) capital gains taxes at the expense of higher labor income taxes. To isolate the effects of each of these tax changes, we start by analyzing a reduction in dividend taxes and capital gains taxes separately. First, we consider the effects of a reduction in the dividend tax rate while maintaining the capital gains tax at $\tau_g = 0.24$ (reform 1). Next, we consider a reform that reduces capital gains taxes while keeping dividend taxes at the original level of $\tau_d = 0.31$ (reform 2). Finally, we consider the full tax reform in which both the dividend and the capital gains taxes are reduced to 19% (reform 3). In all the reforms we consider, the government is required to maintain a balanced budget for the same level of government spending as in the benchmark economy. This implies that labor taxes have to be adjusted upwards unless the reform is self-financing (see reform 2).

Table 2 reports the steady state results for the three experiments. The first column displays the results in the benchmark economy and the other three columns display the resulting long run steady state values after each of the reforms. The different rows display the tax rates (τ_d, τ_g, τ_l), the stock return r, the level of output Y, the aggregate capital K, the stock price p, the aggregate wage rate and dividends before taxes (w, d) and after taxes $((1-\tau_l)\, w, (1-\tau_d)\, d)$ as well as three measures of the long run welfare effects of the reform. First, we compute the welfare change λ, in consumption equivalent terms, based on a utilitarian social welfare function. Second, we follow Domeij and Heathcote (2004) and decompose the total consumption equivalent variation into an aggregate component $\hat{\lambda}$ and a distributional component $\tilde{\lambda}$.[19]

[19] The exact computations used are given in Appendix C. See also Domeij and Heathcote (2004) for more details.

Table 2: Long run effects of tax reforms

	Benchmark	After Reform 1	After Reform 2	After Reform 3
(τ_d, τ_g, τ_l)	$(0.31, 0.24, 0.28)$	$(0.19, 0.24, 0.29)$	$(0.31, 0.19, 0.28)$	$(0.19, 0.19, 0.29)$
r	0.7	1.3	0.55	1.2
Y	1.36	1.32 (−3%)	1.38 (+1.5%)	1.33 (−1.8%)
K	3.82	3.46 (−9.4%)	3.99 (+4.2%)	3.62 (−5%)
p	3.47	3.69 (+6%)	3.40 (−2.3%)	3.62 (+4%)
w	0.166	0.160 (−3.6%)	0.168 (+1.2%)	0.163 (−1.8%)
$(1-\tau_l)w$	0.119	0.114 (−4.4%)	0.121 (+1.7%)	0.116 (−2.4%)
d	0.038	0.062 (+39%)	0.027 (−31%)	0.052 (+36%)
$(1-\tau_d)d$	0.026	0.050 (+48%)	0.019 (−27%)	0.042 (+62%)
ce total λ	0	−3.0%	0.9%	−1.9%
ce aggregate $\hat{\lambda}$	0	−0.8%	0.2%	−0.5%
ce distribution $\tilde{\lambda}$	0	−2.3%	0.7%	−1.4%

Reform 1 reduces τ_d from 0.31 to 0.19. Despite the large reduction in the tax rate, the effect on the government budget is quite small because we have calibrated our economy so that dividend income is a small percentage of GDP. As a result, the government can balance the budget by a very small increase in the labor tax rate, from 0.28 to 0.29. As described in the previous section, the decrease in τ_d raises the market value of capital and thus the value of the assets held by individuals. This leads to an increase in the rate of return and a decrease in the capital stock. In addition, there is a secondary channel through which the capital stock is reduced. The reform leads to a change in the composition of income with labor income, which is risky, becoming a smaller fraction of the total. This is both because of taxation shifting from capital to labor and because of the endogenous response of before-tax wages and dividends. Both mechanisms increase capital income and reduce labor income, thus reducing the amount of risk faced by households and, consequently, reducing precautionary savings. Overall, the capital stock falls by more than 9% while, at the same time, the stock price rises by 6%.

Comparing welfare measures across steady states we find that total welfare is reduced by 3%. This can be decomposed into an aggregate and a distributional component following Domeij and Heathcote (2004). Whereas they find a positive aggregate effect and a negative distributional effect of a reduction in capital income taxes, our finding is that both components are negative. The negative aggregate welfare effect is a direct result of the reduction in the capital stock which, in the long run, reduces output and aggregate consumption.[20] The distributional effect is negative for reasons similar to those found in the previous literature on capital taxation. As labor income is reduced relative to capital income, individuals at the low end of the wealth distribution suffer welfare losses whereas those at the high end enjoy welfare gains. Given a utilitarian welfare function, and a strictly increasing marginal utility, the loss of the wealth-poor section of the population is reflected more strongly in the aggre-

[20] As Davila et al. (2007) have shown, a reduction in precautionary savings is not efficient. In fact, the constrained efficient allocation would require more capital than the market allocation.

gate welfare measure. In sum, the reduction in the dividend tax increases the stock price and it reduces both the aggregate capital stock and total welfare due to negative aggregate and distributional effects.

In many respects, the capital gains tax rate reduction works in the opposite direction. Focusing on the results from reform 2, we see an increase in the capital stock and a decrease in the rate of return. The stock price falls, because the effect from the decrease in q dominates the counteracting effect of the decrease in the cost of capital, which pushes the capital demand schedule (and thus the price) upwards. As the capital stock increases, that also implies an increase in the marginal product of labor which increases labor income. Notice that the labor tax rate is effectively unchanged which reflects the fact that the government collects no revenues from taxing capital gains at steady state. Thus, the reduction in the capital gains tax rate does not deteriorate the government's budget. In fact, because wages increase as a result of the reform, the government can collect higher revenues from labor taxes and the labor tax rate that balances the budget is slightly lower (not seen up to the second digit reported). This reform is therefore self-financing at steady state. Overall, the welfare effects of the capital gains tax decrease are positive but smaller than in the case of dividend taxes. This largely reflects the fact that the capital gains tax rate falls by less than the fall in the dividend tax in the first reform. In sum, the decrease in the capital gains tax decreases the stock price and it increases both the aggregate capital stock and the total welfare due to positive aggregate and distributional effects.

Once the two separate changes have been understood, the full reform (reform 3) follows easily. The effects of the reform are qualitatively the same as the dividend tax cut, but quantitatively less strong because the capital gains tax rate reduction partly mitigates these effects. Quantitatively, we find a 5% reduction in the long run capital stock, a 4% increase in stock prices and a negative long run welfare effect equivalent to a 2% permanent reduction in consumption, arising both from reduced efficiency and reverse redistribution.

While looking at steady states provides important insights into the mechanisms taking place in our model, it is also important to take into account the transitional effects of the tax reforms we consider. In fact, it is well known that results about the long run are often mitigated, and sometimes even reversed, when the short run effects are included. In our case, this could clearly be the case, since the reduction in the aggregate capital stock arising from the reform will reduce aggregate consumption in the long run but increase it in the short run. We investigate this further in the next section.

Transition. In this section, we discuss the transitional paths for the full reform (Reform 3) only. We assume that the economy begins at a steady state with dividend taxes that are equal to 31% and capital gains taxes that are equal to 24%. These taxes are unexpectedly and permanently reduced to 19% and 19% respectively and the economy is simulated until convergence to the new steady state. Labor taxes are adjusted in every period of the transition to keep the government budget balanced.

The paths for some of the key aggregate variables, expressed as a percentage of their initial value, are displayed in Figures 5 and 6. The transitional paths are as expected. Aggregate capital decreases monotonically to the new steady state. The initial response of stock prices is large, as q has suddenly risen while the capital stock has not had time to adjust. As the economy reduces its capital stock, stock prices fall towards a new steady state, which is higher than the old one. The aggregate wage rate follows a decreasing path, similar to the one of the aggregate capital stock. The same is true for the after tax wage, but the decrease in this is larger due to the higher labor income tax rate. Per share dividends also rise sharply as investment is reduced and after tax dividends rise even more because the tax rate has fallen. The subsequent downward adjustment in the capital stock brings dividends down, although they remain significantly above the pre-reform level even in the long run.

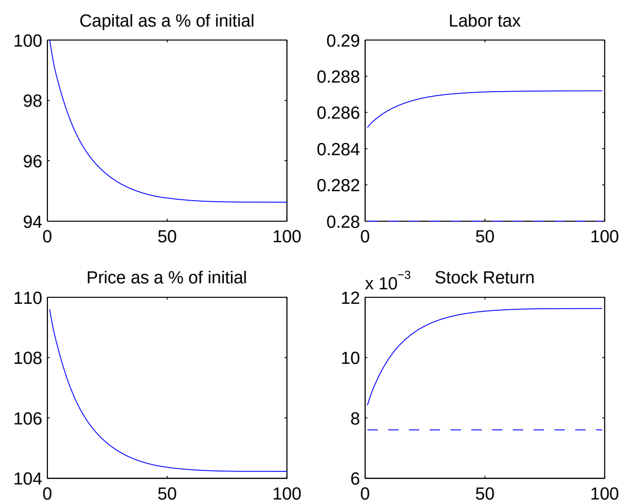

Figure 5: Aggregate Variable Transition Paths

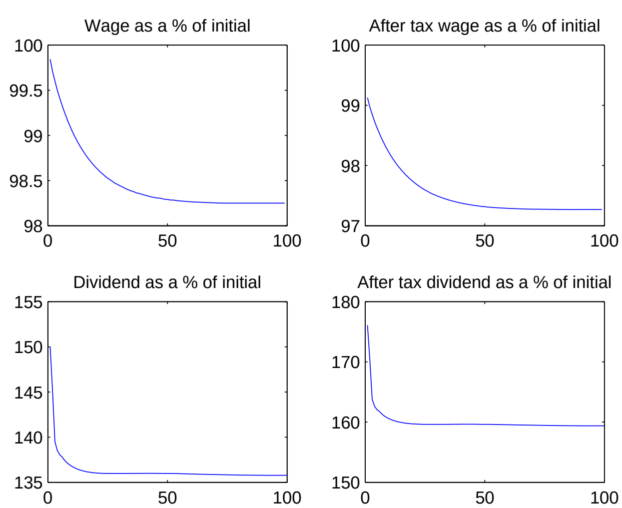

Figure 6: Aggregate Variable Transition Paths

The sharp initial increase in after-tax dividends resulting from lower investment is also reflected in the path for aggregate consumption displayed in the upper panel of Figure 7. The initial increase is approximately 3%, but aggregate consumption starts falling as the capital stock decreases. Eventually, aggregate consumption falls below the original steady state and , in the long run, settles at a level approximately 0.5% below the pre-reform level.

This lower level of aggregate consumption in the long run is what leads to a negative aggregate welfare effect in the long run. The welfare effects along the transition are depicted in the lower panel of Figure 6. The decrease in welfare when the transition effects are taken into account is just above 0.5% of consumption. This is much less than the long run decrease of 1.9% because of the temporary increase in aggregate consumption. In fact, the time path of welfare gains follows closely the time path of aggregate consumption. Performing a decomposition of the welfare gains reveals positive aggregate welfare gains of approximately 1.8% when the transition is taken into account. This is because the decrease in long run consumption is dominated by the temporary increase in consumption in the short run. The distributional component on the other hand is negative and larger, -2.3%.

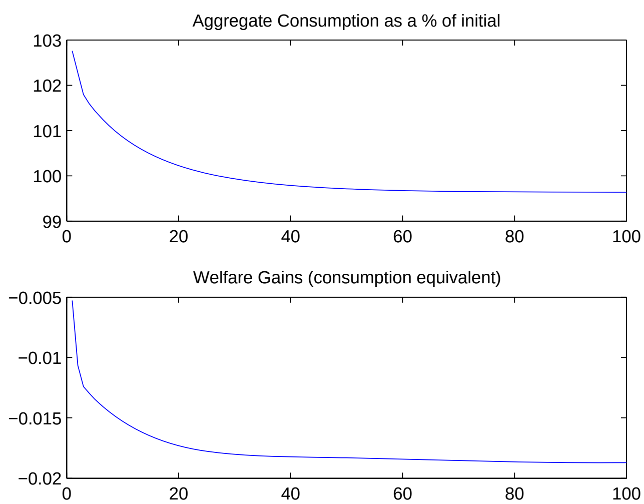

Figure 7: Aggregate Consumption and Welfare gains in the full reform

It will also be interesting to decompose the welfare gains across individuals. Figure 8 provides such a decomposition. Specifically, it displays the total welfare gains in consumption equivalent terms due to the full reform for individuals with different income shocks and asset levels. This figure is important for two reasons. It shows who gains and who loses from the reform and it also indicates whether these reforms could have public support or not.

A couple of important observations emerge from the figure. First, welfare gains are increasing in the amount of asset wealth held by an individual. Indeed, most individuals holding stocks gain from this reform and only some individuals holding no stocks (and some holding very few stocks) loose. This is not surprising, since the reform reduces the taxation of asset wealth and increases the stock return. Second, for those holding a large amount of asset wealth, the lower is their labor income, the more they benefit from 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 and the decrease in wages hurts them the least.

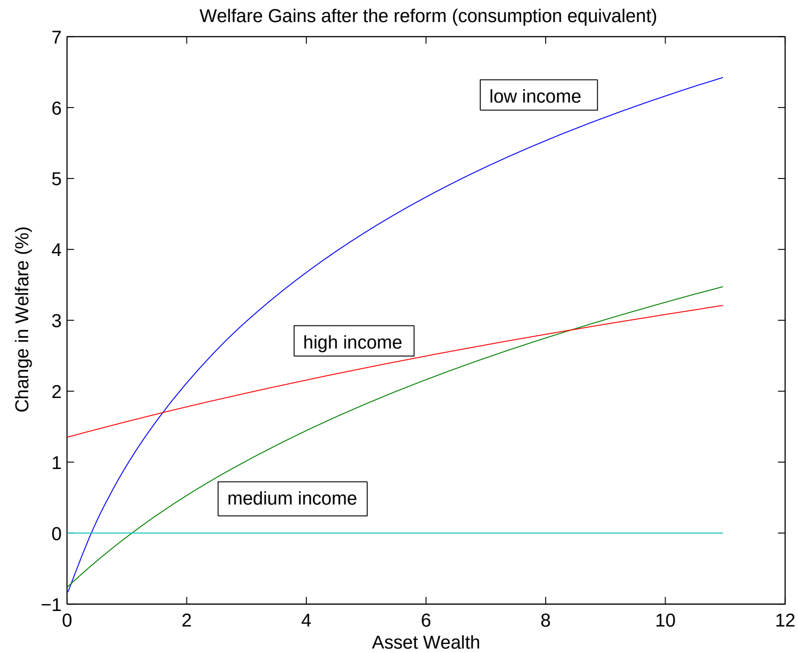

Figure 8: Individual Welfare Gains in the Full Reform

On the other hand, for those that hold little or no wealth, those with low labor income are mostly hurt. This is because those agents enjoy very low levels of consumption anyway and their marginal utility is very high. In addition, given the persistence of the labor productivity process, they are unlikely to benefit from low taxation of assets in the future either.

In terms of support for the reform, individuals at the low end of the wealth distribution and with low labor productivity would not support the reform. It turns out that the bulk of the distribution is actually concentrated in this region. When we aggregate over the population across asset levels and income levels using the stationary distribution of the pre-reform steady state, we find that the overall political support for the reform is 20 percent. In sum, this reform would not get wide political support, mostly because of the strong redistribution effects from the poor to the rich.

5. Robustness

In this section we investigate how two of our assumptions affect the results. In the first part, we consider using lump sum taxes to balance the budget instead of adjusting labor taxes after the reform. In the second, we vary the degree of risk aversion. Throughout the section we focus on steady state effects.

5.1. Using Lump Sum Taxes. Our tax reform experiment in Section 4 assumes that the government has a fixed exogenous spending level G and maintains a balanced budget.

Reductions in the taxation of dividends and capital gains are financed by increasing labor income taxes. Here we consider an alternative scenario, in which labor income taxes are kept fixed after the reform and the extra revenue is raised through the use of lump sum taxes. The results of this experiment are shown in Table 3. The second column (labelled 'Benchmark') is simply a repetition of the equilibrium values before the reform from Table 2. The third column shows the new steady state in this alternative experiment.

Table 3

	Benchmark	After Reform
(τ_d, τ_g, τ_l)	$(0.31, 0.24, 0.28)$	$(0.19, 0.19, 0.28)$
r	0.7	1.1
Y	1.36	1.34 (−1.1%)
K	3.83	3.67 (−4.2%)
p	3.48	3.67 (+5.5%)
w	0.166	0.164 (−1.2%)
$w * (1 - \tau_l)$	0.119	0.118 (−1%)
d	0.038	0.049 (+28%)
$d * (1 - \tau_d)$	0.026	0.039 (−50%)
cons. equiv. (ce), λ	0	−4.8%
ce aggregate, $\hat{\lambda}$	0	−0.3%
ce distributional, $\tilde{\lambda}$	0	−4.5%

Qualitatively, this alternative reform does not change the result of the previous section. The capital stock falls by slightly less and the stock price increases by slightly more. The most significant difference is in the welfare loss of the reform, which is now much larger due to a much larger distributional effect. To understand why this happens it is important to notice that labor supply is exogenous so the labor income tax rate does not directly distort the supply of labor. In fact, in the absence of heterogeneity, this tax would be non-distortionary and equivalent to a lump sum tax. In our economy with heterogeneity however, both the labor tax and the lump sum taxes affect allocations by changing the distribution of income. The question is which one has a stronger effect and why. An increase in labor tax rates has negative distributional effects in the sense that poorer households rely more heavily on labor income and are therefore hurt relatively more. Since these households have higher marginal utility, the effect on aggregate welfare is negative. But at least this tax is proportional to a household's labor income so, the level of taxes raised from poorer households is less than that raised from richer households. If instead the reform is financed by lump sum taxes that are equally spread across households, this negative distributional welfare effect is even stronger. This explains the difference that we see in Table 3.

We have also considered financing the reduction in capital taxes through an individual specific lump sum tax. This tax was constructed so that, at the pre-reform allocation, each household ends up with the same tax bill after the reform as before the reform. This would completely neutralize any effects dividend taxes except for the wealth effect operating through the change in q. But the increase in q means that the capital stock will still have to fall. Thus, welfare is still reduced in this case, albeit by less.

5.2. Varying Risk Aversion. It should be clear from the discussion in Section 3 that the slope of the A_h schedule is crucial for determining the magnitude of the wealth effect on the capital stock. The effect is zero when the slope is zero and it is maximized when the slope is infinite. Recall, in addition, that the reduction in the capital gains tax has a second effect on the capital stock that is actually positive and that survives a perfectly elastic A_h schedule. It follows that in the extreme case where A_h is perfectly elastic, this positive effect on the capital stock should dominate the negative wealth effect, whereas when A_h is very steep, the negative wealth effect should dominate. It turns out that the level of risk aversion has a direct effect on this slope. As the level of risk aversion is decreased, the asset demand schedule A_h moves to the left and the equilibrium capital stock is reduced. Importantly, the relevant section of the demand schedule, i.e. the section that lies to the right of the complete markets level of wealth, becomes flatter. In the limit, as $\mu \to 0$, the demand for assets approaches the complete markets demand schedule, which is perfectly elastic at $r = \frac{1}{\beta} - 1$. At that limiting point, the equilibrium level of the capital stock is simply the modified golden rule and there are no precautionary savings. The negative wealth effect is not present anymore and the reform increases the capital stock. When the level of risk aversion is increased above a threshold, the negative wealth effect dominates and the capital stock falls as a result of the reform. This reduction in the capital stock becomes larger as risk aversion is further increased. This intuition is borne out in the quantitative experiment described below.

Table 4 below presents the changes in the main variables of interest as well as the welfare gains or losses arising due to the reform in three different economies. The three economies differ in their level of risk aversion. We consider a case with low ($\mu = 0.5$) and a case with high ($\mu = 5$) risk aversion and compare to our benchmark economy ($\mu = 2$).[21]

Table 4: Long run effects of tax reform for different risk aversion

Risk Aversion	Low ($\mu = 0.5$)	Medium ($\mu = 2$)	High ($\mu = 5$)
$\Delta\tau_l$	+0.005	+0.01	+0.01
Δr	+0.1	+0.5	+0.82
$\%\Delta Y$	−0.3%	−1.8%	−3.8%
$\%\Delta K$	−0.8%	−5%	−11%
$\%\Delta p$	+9.2%	+4%	−2%
$\%\Delta w$	−0.5%	−1.8%	−3.7%
$\%\Delta(1-\tau_l)w$	−1%	−2.4%	−5%
$\%\Delta d$	+5.5%	+36%	72%
$\%\Delta(1-\tau_d)d$	+24%	+62%	101%

The changes in the labor tax rate and in the rate of return after the reform are reported in percentage points whereas the rest are reported as percent changes. Clearly, the effect

[21] For each μ, the pre reform economy is recalibrated to meet the calibration targets described in Section 4. Specifically, we modify the discount factor to obtain the same capital output ratio of 2.8.

of the reform on the capital stock is larger the larger is the value of μ. The threshold μ, at which the capital stock actually rises is below 0.5. The effect on the stock price changes sign, from an increase in the stock price for low and medium risk aversion to a decrease in the stock price when risk aversion is relatively high. At that extreme, the fall in the capital stock is so large that the increase in the valuation q of this capital is not enough to raise the price.

6. Conclusion

This paper studies the effects of reducing dividend and capital gains taxes. Our finding that reductions in these taxes lead to reverse redistribution, and hence are detrimental from the point of view of a utilitarian social welfare function, are in line with previous research on capital tax reforms. The new insight obtained by disaggregating capital taxes into dividend and capital gains taxes is that a dividend tax cut can have the exact opposite effect from the one intended, i.e. it can reduce investment instead of increasing it. We have explained this result using an analogy with the q theory of investment. We have also provided a quantitative assessment of the 2003 JGTRRA reform and found it to be welfare reducing, even after positive short run effects are taken into account. While our framework is relatively realistic, we have abstracted from several, potentially interesting aspects of such a reform which we briefly mention here.

Clearly, when studying a reform that perturbs labor taxes, there are potentially important endogenous adjustments in labor supply. We abstract from those by assuming labor supply is exogenous. In the absence of heterogeneity, simple intuition would suggest that, allowing for endogenous labor supply, the reform would introduce additional distortions and potentially decrease welfare further. With heterogeneity, this intuition is complicated by the fact that taxation has additional distributional effects.

Another simplification of our framework is that we assume flat rate taxes. Introducing progressivity in income taxation could allow for implementing such a reform without incurring welfare losses. This could be achieved by simultaneously increasing the progressivity of income taxes so that the negative redistribution is mitigated or even reversed, as in Ábrahám and Cárceles-Poveda (2010).

Finally, our treatment of capital gains taxes simplifies the computational burden significantly but is arguably unrealistic. Capital gains in practice are taxed only when realized and this allows individuals to time the realization of capital gains in their favor. It is often suggested, see for example Gourio and Miao (2008) or Sinn (1991), that this could be crudely modelled as an accrual tax at a lower rate. To the extent this is true, our main result of a fall in the capital stock and in welfare should survive such an extension since this would reduce the effects of capital gains taxes. One could also explicitly model realization-based capital gains taxes along the lines of Gavin et. al. (2007), but at a higher computational cost.

Finally, the work of Gourio and Miao (2010) has shown that firm heterogeneity could be important in analyzing a dividend tax reform. Given that their results in terms of capital accumulation are opposite to ours, it would be very interesting to combine firm heterogeneity and household heterogeneity in order to assess which effect dominates and the extent to which there are interactions between the two. However, it is not clear whether this is feasible with the current state of knowledge in models of heterogeneity.

APPENDIX

Appendix A: The Relationship between the Stock Price and the Capital Stock

Using the definition of the risk-free return, together with the stock Euler condition (4), we can write the stock price at time t as:

$$p_t\left(1+r_{t+1}\right)=\left[\left(1-\tau_d\right)d_{t+1}+p_{t+1}-\tau_g\left(p_{t+1}-p_t\right)\right]$$

Solving for the current stock price p_t yields

$$p_t=\frac{1}{1+\frac{r_{t+1}}{1-\tau_g}}\left(\frac{1-\tau_d}{1-\tau_g}d_{t+1}+p_{t+1}\right)$$

and repeated forward substitution, along with a no-bubble condition, yields the price dividend mapping (6). The capital Euler condition (9) can be manipulated to write capital as a function of dividends as follows:

$$\begin{aligned}1 &= \frac{1}{1+\frac{r_{t+1}}{1-\tau_g}}\left(1-\delta+AF_K\left(K_{t+1},L_{t+1}\right)\right)\Rightarrow\\ K_{t+1} &= \frac{1}{1+\frac{r_{t+1}}{1-\tau_g}}\left(\left(1-\delta\right)K_{t+1}+AF_K\left(K_{t+1},L_{t+1}\right)K_{t+1}\right)\end{aligned}$$

Using the constant returns to scale assumption, we can write:

$$K_{t+1}=\frac{1}{1+\frac{r_{t+1}}{1-\tau_g}}\left(\left(1-\delta\right)K_{t+1}+AF\left(K_{t+1},L_{t+1}\right)-w_{t+1}L_{t+1}\right)$$

and replacing the right hand side from the firm's financing constraint, we obtain:

$$K_{t+1}=\frac{1}{1+\frac{r_{t+1}}{1-\tau_g}}\left(d_{t+1}+K_{t+2}\right)$$

Repeated forward substitution (with the use of the transversality condition) leads to the following expression:

$$K_{t+1}=\sum_{j=1}^{\infty}\left(\prod_{i=0}^{j-1}\frac{1}{1+\frac{r_{t+1+i}}{1-\tau_g}}\right)d_{t+j} \tag{13}$$

Comparing (13) to (6) gives the relationship between capital and stock price in equation (10).

Appendix B: Numerical Algorithm

B.1 Computing the Stationary Competitive Equilibrium

We use a generalized policy function iteration which relies on the first-order conditions (mainly the Euler equation) of the model. Further, we approximate all the relevant policy and value functions with linear interpolation over a finite but endogenous grid on assets. To solve the individual problem with policy iterations, we proceed as follows. Given the aggregate capital K, the stock price p, dividends d, the wage rate w and a tax vector (τ_d, τ_g, τ_l), we let h be the vector consisting of the individual policy functions of interest, i.e., $h = [c, s']$. Let T be a non-linear operator such that $T[h;\ d, K, p, w, \tau_l]$ satisfies the individual optimality conditions given taxes. To approximate the fixed point, we follow the steps below.

Step 1: Guess an initial vector $[h^0; p^0, \tau_l^0]$, where $h^0 = [c^0, s'^0]$. Using p^0 we can calculate d^0, w^0 and K^0.

Step 2: For each iteration $n \geq 1$, use the previous guess h^{n-1} and $[d^{n-1}, K^{n-1}, w^{n-1}, \tau_l^{n-1}, p^{n-1}]$ to compute the new vector h^n that satisfies the individual equilibrium conditions.

Step 3: Using h^n and the distribution for the idiosyncratic shock Π, calculate Ψ, the joint (stationary) distribution of assets and income. Next, use Ψ to calculate the aggregate demand for stocks by the firm to get the new stock price p^n.

Step 4: The new tax rate on labor τ_l^n is calculated given Ψ and h^n to satisfy the government's budget constraint.

Step 5: Repeat Steps 2-4 until convergence.

Note that our setting requires the introduction of some notable differences with respect to the standard procedure to solve models with uninsurable income shocks.

B.2 Computing the Transition Between Steady States

When we calculate the transition between steady states we need to adjust the above procedure in the following way. First, for the sake of the exposition assume that convergence to the new steady state takes place in T periods. Then we follow the steps below.

Step 1: Guess a time series for the variables $\left\{h_t^0;\ K_t^0, p_t^0, d_t^0, w_t^0, \tau_{l,t}^0\right\}_{t=1}^T$, together with the time series for the distribution of individuals $\{\Psi_t^0\}_{t=1}^T$. Again, knowing $\{p_t^0\}_{t=1}^T$ we can calculate $\{K_t^0, d_t^0, w_t^0\}_{t=1}^T$. We then initialize the first period with stationary distribution of the first steady state ($\Psi_1^0 = \Psi_{SS1}$ and $p_1^0 = p_{SS1}$) and we assume that at time T we are already in the second steady state ($\Psi_T^0 = \Psi_{SS2}$ and $p_T^0 = p_{SS2}$)).

Step 2: For each iteration $n \geq 1$ and for each time period $1 \leq t \leq T-1$, we use the previous guess for the next period h_{t+1}^{n-1} and $[K_t^{n-1}, p_t^{n-1}, d_t^{n-1}, w_t^{n-1}, p_t^{n-1}, \tau_{l,t}^{n-1}]$ to compute the new vector h_t^n that satisfies the individual equilibrium conditions.

Step 3: Using h^n and Π, we calculate Ψ_{t+1}^n, the joint distribution of assets and income and then use Ψ_{t+1}^n to calculate the demand of stocks and the new price p_t^n. These two variables are compared the initial guesses Ψ_{t+1}^{n-1} and p_t^{n-1} for all $1 \leq t \leq T-1$.

Step 4: The new tax rate on labor for each time period $1 \leq t \leq T-1$ is calculated given Ψ_t^{n-1} and h_t^n to satisfy the government's budget constraint at each period.

Step 5: Repeat Steps 2-4 until convergence for all periods $1 \leq t \leq T-1$.

Appendix C: Welfare Computation and Decomposition

Transition

The economy begins at an initial steady state (at $t = 0$) with a given, constant level of aggregate capital K^{old} and an initial distribution of stocks Ψ^{old}. The change in the tax system induces a sequence of aggregate capital stocks and distributions $\{K_t, \Psi_t\}_{t=0}^{T}$ that eventually converges (at time T) to the new steady state K^{new}, Ψ^{new}. Let $x = (\epsilon, s)$ be a point in the individual state space of the economy. *Given the sequence of aggregates*, the maximized utility (value function) for an individual household with individual state x at time t is denoted by $V_t(x)$. Similarly, denote the corresponding consumption and stock policy functions by $c_t(x)$ and $S_t(x)$ respectively. At steady state the aggregates are constant and the value functions are time independent. We use $V^{old}(x)$ and $V^{new}(x)$ for the steady state value functions before and after the reform[22]. The welfare of an individual household at any point t along the transition is:

$$V_t(x_t) = \sum_{j=0}^{\infty} \beta^j \sum_{x_{t+j}|x_t} \pi(x_{t+j}|x_t) \frac{c_{t+j}(x_{t+j})^{1-\sigma}}{1-\sigma}$$

where $\pi(x_{t+j}|x_t)$ is the probability of state x_{t+j} given x_t. To be more precise, this value can be represented recursively as

$$V_t(\epsilon_t, s_t) = \frac{c_t(\epsilon_t, s_t)^{1-\sigma}}{1-\sigma} + \beta \sum_{\epsilon_{t+1}|\epsilon_t} \Pi(\epsilon_{t+1}|\epsilon_t) V_{t+1}\left(\epsilon_{t+1}, S_t(\epsilon_t, s_t)\right)$$

This representation can be used to compute $V_0(x_0)$ backwards starting at $V_T(x_T) = V^{new}(x_T)$. Clearly, $V_0(x_0)$ represents the welfare of an individual with individual state x_0 in the economy where the reform takes place. The corresponding welfare in case the reform does not happen is simply

$$V^{old}(\epsilon_0, s_0) = \frac{c^{old}(\epsilon_0, s_0)^{1-\sigma}}{1-\sigma} + \beta \sum_{\epsilon_1|\epsilon_0} \Pi(\epsilon_1|\epsilon_0) V^{old}\left(\epsilon_1, S^{old}(\epsilon_0, s_0)\right)$$

These individual welfare levels can be aggregated to yield a (utilitarian) measure of aggregate/average welfare using the initial distribution of households Ψ^{old}

$$\begin{aligned} W^{old} &= \sum_{(\epsilon_0, s_0)} \Psi^{old} V^{old}(\epsilon_0, s_0) \\ W_0^{new} &= \sum_{(\epsilon_0, s_0)} \Psi^{old} V_0(\epsilon_0, s_0) \end{aligned}$$

We use W^{old} and W_0^{new} to compare the welfare with and without the reform. Specifically, we compute the equivalent variation in consumption, λ, defined as the percent increase in

[22] We do the same for the policy functions.

consumption in every date/event of the economy without reform that is required to make the old and the new aggregate welfare equal. Clearly λ satisfies

$$1+\lambda = \left(\frac{W_0^{new}}{W^{old}}\right)^{\frac{1}{1-\sigma}}$$

If $\lambda < 0$, then consumption in the old equilibrium would need to be decreased, indicating that aggregate welfare is lower in the new equilibrium.

To decompose the overall welfare effect into the aggregate and the distributional components we follow the idea in Domeij and Heathcote (2004). For the aggregate component, we consider a hypothetical economy that shares all the features of the pre-reform economy, except that consumption is scaled by the ratio of aggregate consumptions in the pre- and post-reform economies, since we maintain the same consumption distribution after the reform. Let the aggregate consumptions be denoted by C_t^{new} and C^{old} (note the pre-reform economy is in steady state so aggregate consumption would be constant across time). Then we can compute individual welfare at t in that economy as

$$\hat{V}_t(x_t) = \sum_{j=0}^{\infty} \beta^j \left(\frac{C_{t+j}^{new}}{C^{old}}\right)^{1-\sigma} \sum_{x_{t+j}|x_t} \pi(x_{t+j}|x_t) \frac{c^{old}(x_{t+j})^{1-\sigma}}{1-\sigma}$$

As above, this can be computed backwards using

$$\hat{V}_t(\epsilon_t, s_t) = \frac{c^{old}(\epsilon_t, s_t)^{1-\sigma}}{1-\sigma} \left(\frac{C_t^{new}}{C^{old}}\right)^{1-\sigma} + \beta \sum_{\epsilon_{t+1}|\epsilon_t} \Pi(\epsilon_{t+1}|\epsilon_t) \hat{V}_{t+1}\left(\epsilon_{t+1}, S^{old}(\epsilon_t, s_t)\right)$$

and starting at

$$\begin{aligned} \hat{V}_T(\epsilon_T, s_T) &= \left(\frac{C^{new}}{C^{old}}\right)^{1-\sigma} \sum_{j=0}^{\infty} \beta^j \sum_{x_{t+j}|x_t} \pi(x_{t+j}|x_t) \frac{c^{old}(x_{t+j})^{1-\sigma}}{1-\sigma} \\ &= \left(\frac{C^{new}}{C^{old}}\right)^{1-\sigma} V^{old}(\epsilon_T, s_T) \end{aligned}$$

With $\hat{V}_0(\epsilon_0, s_0)$ in hand, the aggregate component of welfare can be computed just like before as a consumption equivalent using the average welfare measure

$$\hat{W}_0 = \sum_{(\epsilon_0, s_0)} \mu(\epsilon_0, s_0) \hat{V}_0(\epsilon_0, s_0)$$

so that

$$1+\hat{\lambda} = \left(\frac{\hat{W}_0}{W^{old}}\right)^{\frac{1}{1-\sigma}}$$

Finally, the distributional component $\tilde{\lambda}$ is defined as a residual

$$\left(1+\hat{\lambda}\right)\left(1+\tilde{\lambda}\right) = (1+\lambda)$$

Steady States

Comparing steady states is more controversial because of the different distributions associated with the different steady states. We compare steady state welfare making some particular assumptions for illustrative purposes. Specifically, we define the overall average consumption equivalent as

$$1+\lambda_{ss}=\left(\frac{W^{new}}{W^{old}}\right)^{\frac{1}{1-\sigma}}$$

i.e. by comparing the average welfare level in the two steady states. We also decompose this into aggregate and distributional components. The aggregate component is computed by assuming that the distribution is the same in the two steady states and only adjusting individual consumptions by the ratio of aggregate consumptions. This leads to an aggregate component $\hat{\lambda}_{ss}$ given by

$$1+\hat{\lambda}_{ss}=\frac{C^{new}}{C^{old}}$$

The distributional component is then defined as a residual just like before.

References

[1] Á. Ábrahám, E. Cárceles-Poveda (2010), Endogenous Trading Constraints with Incomplete Asset Markets, Journal of Economic Theory, 145, 974-1004.

[2] D. R. Aiyagari (1995), Optimal Capital Income Taxation with Incomplete Markets, Borrowing Constraints and Constant Discounting , J. Political Economy 103(6), 1158-75.

[3] D. R. Aiyagari (1994), Uninsured Idiosyncratic Risk and Aggregate Saving , Quarterly Journal of Economics 109(3), 659-684.

[4] Auerbach A. J. and K. A. Hassett (2005), The 2003 Dividend Tax Cuts and the Value of the Firm: An Event Study, NBER Working Paper 11449.

[5] A. Castaneda, J. Diaz Gimenez, J. V. Rios-Rull (2003), Accounting for earnings and wealth inequality, J. Political Economy 111(4), 818-857.

[6] C. Chamley (1986), Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives, Econometrica 54(3), 607-622.

[7] T. Cooley, E. Prescott, Frontiers of Business Cycle Research (1995), Princeton University Press.

[8] E. Carceles-Poveda, D. Coen Pirani (2009), Shareholders Unanimity with Incomplete Markets, International Economic Review 50.

[9] E. Carceles-Poveda, D. Coen Pirani (2010), Owning Capital or Being Shareholders: An Equivalence Result with Incomplete Markets, Review of Economic Dynamics 13(3).

[10] H. Cole, L. Ohanian (1999) The Great Depression in the US from a Neoclassical Perspective, Federal Reserve Bank of Minneapolis Quarterly Review 23 (Winter), 2-24.

[11] J. Davila, J.H. Hong, P. Krusell, J. V. Rios-Rull (2007), Constrained Efficiency in the Neoclassical Growth Model with Uninsurable Idiosyncratic Shocks, Unpublished Manuscript, CERMSEM, University of Pennsylvania and Princeton University.

[12] A. Diaz, J. Pijoan-Mas, J. V. Rios-Rull (2003), Habit Formation: Implications for the Wealth Distribution, J. Monetary Economics 50(6), 1257-1291.

[13] D. Domeij, J. Heathcote (2004), On the Distributional Effects of Reducing Capital Taxes, International Economic Review, 45(2), 523-554.

[14] Feenberg, D. and E. Coutts (1993). An Introduction to the Taxsim Model. Journal of Policy Analysis and Management, Vol 12, No 1, Winter 1993.

[15] Gordon, R and M. Dietz (2006), Dividends and Taxes, NBER Working Paper 12292.

[16] F. Gourio, J. Miao, Dynamic Effects of Permanent and Temporary Dividend Tax Policies on Corporate Investment and Financial Policies, Working Paper, Boston University, (2008)

[17] F. Gourio, J. Miao (2010), Firm Heterogeneity and the Long Run Effects of Dividend Tax Reform, American Economic Journal: Macroeconomics 2(1), 131-168.

[18] W. Gavin, F. Kydland, M. Pakko (2007), Monetary Policy, Taxes, and the Business Cycle, Journal of Monetary Economics, 1587-1611.

[19] E. McGrattan (2009), Capital Taxation during the US Great Depression, Working Paper 670, Federal Reserve Bank of Minneapolis.

[20] McGrattan, E. R. and E. C. Prescott (2005), Taxes, Regulations and the Value of U.S. Corporations, Federal Reseve Bank of Minneapolis, Research Department Staff Report 309.

[21] E. Mendoza, A. Razin, L. Tesar (1994), Effective Tax Rates in Macroeconomics. Cross Country Estimates of Tax Rates on Factor Income and Consumption, J. Monet. Econ. 34, 297-323.

[22] Poterba, J. M. and L. H. Summers (1983), Dividend Taxes, Corporate Investment, and 'Q', Journal of Public Economics, 22, 135-167.

[23] Santoro, M. and C. Wei (2009a), Taxation, Investment and Asset Pricing, mimeo.

[24] Santoro, M. and C. Wei (2009b), A Note on the Impact of Progressive Dividend Taxation on Investment Decisions, mimeo.

[25] Sinn, H.W. (1991), Taxation and the Cost of Capital: the Old View, the New View and Another View, NBER Working Paper 3501