

# A Schumpeterian Analysis of Deficit-Financed Dividend Tax Cuts

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## Abstract

I propose a Schumpeterian analysis of the effects of a deficit-financed cut of the tax rate on distributed dividends. I develop a very tractable model that allows me to study analytically transition dynamics and welfare, and complement the qualitative results with a quantitative assessment of the Job Growth and Taxpayer Relief Reconciliation Act (JGTRRA) of 2003. I find that the JGTRRA produces *lower* steady-state growth despite the fact that the economy's saving and employment ratios *rise*. Most importantly, it produces a welfare *loss*. The mechanism that delivers these results is that the tax rate on distributed dividends distorts the returns to investing in the growth of existing product lines and in the development of new product lines. The quantitative exercise suggests that the JGTRRA will reduce welfare by 19.34% of annual consumption per capita, a substantial effect driven by the fact that the steady-state growth rate falls from 2% to 1.08%.

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# 1 Introduction

The dividend tax cut enacted in 2003 with the Job Growth and Taxpayer Relief Reconciliation Act (JGTRRA) has generated a heated public debate and prompted a new wave of research in public and corporate finance. Supporters argue that the Act has reduced the corporate cost of capital and thus raised investment, growth and employment. Critics focus on its distributional implications and on the budget deficits that it has generated, given the government's failure to reduce public spending.

As a large-scale experiment in fiscal policy, the JGTRRA provides a unique research opportunity for modern growth economics since one of the central ideas — perhaps *the* central idea — driving the field is precisely that policy matters. The theory of endogenous innovation, in particular, has produced novel analytical insights that appear well-suited to make a significant contribution to a debate spurred by a drastic change in the taxation of corporate-source income, and heavily loaded on both sides with arguments that rely on notions of entrepreneurship, corporate behavior, and their effects on innovation, job creation and growth.

In this paper, I propose a Schumpeterian analysis of the effects of a deficit-financed cut of the tax rate on distributed dividends. I develop a very tractable model that allows me to study analytically transition dynamics and welfare in response to changes in tax policy. I then calibrate the model and carry out a quantitative exercise that allows me to assess the magnitude of the effects. I find that the policy produces *lower* steady-state growth despite the fact that the economy's saving and employment ratios *rise*. Most importantly, the policy produces a welfare *loss*.

The apparently contradictory behavior of saving and growth, and the pivotal role of product variety in determining the sign of the welfare effect, is a quite natural implication of the latest vintage of Schumpeterian models that sterilize the scale effect through a process of product proliferation that fragments the aggregate market into submarkets whose size does not increase with the size of the workforce.<sup>1</sup> This approach allows one to introduce pop-

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<sup>1</sup>First-generation endogenous growth models feature a positive relation between aggregate market size and growth that results in a positive relation, not supported by the data, between the scale of aggregate economic activity and the growth rate of income per capita. Several contributions proposed solutions based on product proliferation: Peretto (1998, 1999), Dinopoulos and Thompson (1998), Young (1998), and Howitt (1999). See Aghion and Howitt (1998, 2006), Dinopoulos and Thompson (1999), Jones (1999), Peretto and Smulders (2002) for reviews of the various approaches and of the early empirical evidence. This version of Schumpeterian theory has recently received considerable empirical support in Ha and Howitt (2006), Laincz and Peretto (2006), Sedgley (2006), Ulku (2007) and,

ulation growth and elastic labor supply without generating counterfactual behavior of the growth rate. It also implies that fundamentals and policy variables that work through the size of the aggregate market have no growth effects, whereas fundamentals and policy variables that reallocate resources between vertical (quality/productivity) and horizontal (variety) innovation do have long-run growth effects.

The mechanism that delivers my results, then, is that taxes on corporate-source income — in particular distributed dividends — distort the returns to investing in the growth of existing product lines and in the development of new product lines, and thus reallocate resources across activities that have different long-run growth opportunity. The feature that drives this difference in growth opportunity is a fixed operating cost per product line that draws a sharp distinction between the two dimensions of technology space. Specifically, steady-state growth driven by product variety expansion cannot occur independently of population growth because the fixed cost per product line implies that at any point in time the size of the workforce constrains the feasible number of product lines. In the vertical dimension, in contrast, steady-state growth is feasible because improving product quality does not require the replication of fixed costs.<sup>2</sup>

Given the model’s tractability, I first provide analytical results on the growth and welfare effects of dividend tax cuts. I then undertake a quantitative analysis to assess the magnitude of these effects in a specification of the policy change that replicates the JGTRRA. The first exercise develops insight on the model’s mechanics that helps substantially in the interpretation of the quantitative results.

In the qualitative analysis I posit that the government uses lump-sum taxes to balance the budget, holds constant the fraction of GDP allocated to (unproductive) public expenditures, and reduces the tax rate on the dividend income earned by households. The results apply to the case of public debt since Ricardian equivalence holds so that what matters to agents is the present value of the tax liability, not the timing of taxation. The economy’s response to the tax cut is as follows.

- The saving ratio jumps up and then converges from above to a permanently higher value.
- The employment ratio jumps up and then converges from above to a permanently higher value.

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especially, Madsen (2008).

<sup>2</sup>See Peretto and Connolly (2007) for a detailed discussion of this property in endogenous growth models.

- The higher investment sustained by the higher saving and employment ratios does not necessarily translate into an acceleration of income per capita growth because the financial market reallocates resources from quality growth to variety expansion. Growth accelerates if the latter produces sufficiently high aggregate productivity gains through specialization that compensate the slowdown of quality growth. This reallocation, moreover, is in the direction of the low long-run growth opportunity activity so that growth accelerates, if at all, only temporarily and the economy converges to a steady state with lower growth.
- The higher saving and employment ratios have a cost in terms of foregone consumption and leisure. Similarly, the lower steady-state growth has a cost. If the contribution of product variety to aggregate output is small, the expansion of the mass of firms induced by the tax cut does not offset these costs and welfare falls. If the contribution is sufficiently large, instead, welfare rises.

Why does the dividend tax cut trigger such a reallocation of investment effort? The answer is that the lower tax on dividends implies that firms can deliver to stockholders (savers) their reservation after-tax rate of return with a *lower* pre-tax rate of return. The question, then, becomes how the market generates such lower pre-tax return. The answer turns around two key relations. One is the relation between the cash flow of the firm and the pre-tax return it generates, which reflects the fact that since R&D is a fixed, sunk cost there are increasing returns internal to the firm. The other is the relation between cash flow and growth of the firm, which stems from the no-arbitrage requirement that the returns to quality growth and variety expansion be equal. The intuition behind this relation is simply that the return to the creation of a new product line — with the associated creation of a new firm bearing its own fixed operating cost — is more sensitive to market size than the improvement of quality within an existing product line, which does not require the replication of fixed operating costs. The joint operation of these relations yields that, in equilibrium, delivering a lower pre-tax return implies *slower* quality growth.

In the quantitative analysis I posit that the government reduces the tax rate on the dividend income earned by households from 35% to 15% and the tax rate on capital gains from 20% to 15% and finances the revenue shortfall with debt. This replicates the provisions of the JGTRRA and its *de facto* implementation in 2003. I find that the model's transition lasts about 30 years. The saving ratio rises on impact from 0.167 to 0.33 and then

falls gradually to 0.202; the employment ratio rises from 0.33 to 0.388 and then falls gradually to 0.338; the growth rate of income per capita drops on impact from 0.02 to 0.012 and then falls further to 0.0108. Overall, the JGTRRA produces a welfare loss of 19.34% of annual consumption per capita. To check robustness, I do some sensitivity analysis with respect to important parameters of the model. I also compute the welfare change for a hypothetical, extreme version of the JGTRRA that totally eliminates taxation of dividends and capital gains and find that it would produce a welfare loss of 24.03% of annual consumption per capita. These results obtain in the baseline version of the model where social returns to product variety are zero.

Things do not change much when I allow for positive social returns to product variety. A mild degree is sufficient for the JGTRRA to deliver an initial growth acceleration but no matter how strong social returns to product variety the sign of the welfare change remains negative. Specifically, with elasticity of aggregate output with respect to product variety equal to just 10% of the elasticity with respect to labor, the initial contribution of faster variety expansion cancels out with the slowdown of quality growth so that the overall growth rate of income per capita does not jump on impact; for values of the product variety elasticity larger than 10% of the labor elasticity, the model produces an initial, temporary acceleration of income per capita growth. For example, if the product variety elasticity is 50% of the labor elasticity the growth rate jumps initially from 2% to 2.25%. At 16.94% of annual consumption, the welfare effect is smaller in magnitude but still dominated by the fall of long-run growth and the rise of the long-run employment and saving ratios.

This paper contributes to the recent literature on the tax policy implications of Schumpeterian growth models. The insight that tax instruments can be sorted in two classes according to whether they have or do not have growth effects is developed contemporaneously and independently in Zeng and Zhang (2002) and Peretto (2003). One limitation of those studies is that they consider steady states only and thereby ignore welfare. Peretto (2007a, 2007b) extends the analysis to include transitional dynamics and thus allow for the calculation of the welfare effects of changes in the structure of taxation. Peretto (2007b), in particular, focuses on corporate taxes and develops some of the main ingredients used in the analysis undertaken here. That analysis, however, focuses on revenue-neutral changes in the structure of taxation (in a model with no lump-sum taxes or government debt), a feature that produces interesting insights about *hypothetical* reforms of the tax code but limits its relevance for the JGTRRA. (Moreover it is only qual-

itative, with no attempt at calibration.) The main innovation of this paper is that I allow the government to finance the dividend tax cut with debt. Consequently, the analysis applies directly and explicitly to the JGTRRA, an *actual*, real-world experiment in fiscal policy.

I organize the paper as follows. Section 2 sets up the model. Section 3 characterizes equilibrium dynamics and the steady state. Section 4 carries out the qualitative analysis of cuts in the dividend tax rate. Section 5 calibrates the model and studies its quantitative implications. Section 6 concludes.

## 2 The model

The economy is closed. To keep things as simple as possible, there is no physical capital.<sup>3</sup> In particular, I construct a model where the household's portfolio contains securities (shares) issued by firms and backed up by intangible assets accumulated through R&D. Thus, the dividend income earned by households stems from vertical (quality) and horizontal (variety) product differentiation.

### 2.1 Final producers

A competitive representative firm produces a final good  $Y$  that can be consumed, used to produce intermediate goods, invested in R&D that rises the quality of existing intermediate goods, or invested in the creation of new intermediate goods. The final good is the numeraire and I set  $P_Y \equiv 1$ . The production technology is

$$Y = \int_0^N X_i^\theta (Z_i^\alpha Z^{1-\alpha} L_i)^{1-\theta} di, \quad 0 < \theta, \alpha < 1, \quad (1)$$

where  $N$  is the mass of non-durable intermediate goods. These goods are vertically differentiated according to quality: the productivity of  $L_i$  workers using  $X_i$  units of good  $i$  depends on the good's quality,  $Z_i$  and on average

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<sup>3</sup>More precisely, there is no capital in the usual neoclassical sense of a homogenous, durable, intermediate good accumulated through foregone consumption. Instead, there are differentiated, non-durable, intermediate goods produced through foregone consumption. One can think of these goods as capital, albeit with 100% instantaneous depreciation. In accordance with the principles of optimal taxation I posit no taxes on purchases or sales of intermediate goods. Introducing the traditional notion of physical capital in this structure complicates the analysis without changing the basic results.

quality  $Z = \int_0^N \frac{1}{N} Z_j dj$ .<sup>4</sup> This formulation posits zero social returns to variety because they play no essential role in the characterization of the decentralized equilibrium dynamics. I relax this simplifying assumption in Section 4 where I analyze the growth and welfare effects of the JGTRRA.

The first-order conditions for the profit maximization problem of the final producer yield that each intermediate producer faces the demand curve

$$X_i = \left( \frac{\theta}{P_i} \right)^{\frac{1}{1-\theta}} Z_i^\alpha Z^{1-\alpha} L_i, \quad (2)$$

where  $P_i$  is the price of good  $i$ . Let  $W$  denote the wage rate and  $L = \int_0^N L_i di$  denote aggregate employment. The first-order conditions then yield that the final producer pays total compensation

$$\int_0^N P_i X_i di = \theta Y \quad \text{and} \quad WL = (1 - \theta) Y$$

to intermediate producers and labor, respectively.

## 2.2 The corporate sector

The typical intermediate firm operates a technology that requires one unit of final output per unit of intermediate good and a fixed operating cost  $\phi Z$ . The firm can increase quality according to the technology

$$\dot{Z}_i = R_i, \quad (3)$$

where  $R_i$  is R&D investment in units of final output.

To construct the firm's objective function, I adapt the formulation in Turnovsky (1995, Ch. 8 and 11) of a dynamic macro model that incorporates the "New View" in corporate finance and public economics according

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<sup>4</sup>This specification, borrowed from Peretto (2007b), modifies the augmented Schumpeterian model without scale effects developed by Aghion and Howitt (1998) to make it better suited to my purposes and yet leave the core mechanism essentially unchanged. The first is quality spillovers across goods, i.e.,  $\alpha < 1$ . This allows me to work with symmetric equilibria that feature creative accumulation, whereby all incumbent firms do R&D, as opposed to creative destruction, whereby outsiders do R&D to replace the current incumbent. (I discuss reasons why the creative accumulation model is better suited to study the role of corporate taxation policy in Peretto 2007b.) The second modification is that quality enters with exponent  $1 - \theta$ , instead of 1, because my intermediate producers face a unitary marginal cost of production in units of the final good, instead of a marginal cost in units of (physical) capital proportional to their quality level. Both approaches imply that quality enters the reduced-form version of (1) as labor augmenting technical change. Not surprisingly, they produce identical results.

to which firms finance investment internally and distribute the residual income as dividends.<sup>5</sup> Specifically, the firm's gross cash flow (revenues minus production costs) is

$$\Pi_i = X_i (P_i - 1) - \phi Z. \quad (4)$$

I assume that R&D is *not* expensable.<sup>6</sup> The firm then pays total taxes  $t_{\Pi}\Pi_i$ , where  $t_{\Pi}$  is the corporate income tax rate. It follows that

$$D_i = (1 - t_{\Pi}) \Pi_i - R_i \quad (5)$$

is the after-tax dividend distributed to the firm's stockholders.

Next, I define the *after-tax* rate of return to equity as

$$r = (1 - t_D) \frac{D_i}{V_i} + (1 - t_V) \frac{\dot{V}_i}{V_i}, \quad (6)$$

where  $V_i$  is the price of firm  $i$ 's shares,  $t_D$  is the tax on distributed dividends and  $t_V$  is the tax on capital gains. In equilibrium  $r$  must equal the rate of return to saving obtained from the individual's maximization problem (see below) and thus is the same across firms. Integrating forward, this equation yields the after-tax value of the firm

$$V_i(t) = \int_t^{\infty} e^{-\frac{\bar{r}(t,s)}{1-t_V}(s-t)} \frac{1-t_D}{1-t_V} [(1-t_{\Pi}) \Pi_i(s) - R_i(s)] ds,$$

where  $\bar{r}(t, s) \equiv \frac{1}{s-t} \int_t^s r(v) dv$  is the average interest rate (return to saving) between  $t$  and  $s$ .

The firm chooses the time path of its product's price and R&D in order to maximize the objective function above subject to (2), (3) and (4). The firm takes average quality,  $Z$ , in (2) and (4) as given. The characterization of the firm's decision is straightforward and in symmetric equilibrium<sup>7</sup> yields

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<sup>5</sup>There is an alternative "Old View" that holds that corporations finance investment by issuing new shares. I work out the results under the New View since there are theoretical and empirical reasons to think that it is more relevant. (I discussed these reasons in detail in Peretto (2007b).) In an Appendix available on request, I sketch the model under the Old View and show that the mechanism driving growth remains the same.

<sup>6</sup>This assumption is not realistic since many countries (e.g., the U.S.) grant full expensibility of R&D costs. However, it does not affect the main results while it simplifies many of the expressions in the paper and allows me to draw a sharp distinction between taxation of corporate profits and distributed dividends. See Peretto (2007b) for a detailed analysis of what happens under partially or fully expensible R&D in a model of this class.

<sup>7</sup>See Peretto (1998, 1999) for a discussion of the conditions under which it is reasonable to work with symmetric equilibria in models of this class. These conditions essentially

the rate of return to quality innovation (see the Appendix for the derivation)

$$r = (1 - t_V)(1 - t_{\Pi}) \alpha \left( \frac{\Pi}{Z} + \phi \right). \quad (7)$$

Observe that this return does not depend on the tax on dividend income. The reason is that the firm treats dividends as a residual and thus taxation of the dividend income received by the stockholder does not affect its internal production/investment decisions.

I now characterize the birth of new firms. Setting up a firm at time  $t$  requires  $\beta Z$  units of final output, where  $\beta > 1$ .<sup>8</sup> Because of this sunk cost, the new firm cannot supply an existing good in Bertrand competition with the incumbent monopolist, but must introduce a new good that expands product variety. Notice that for simplicity I assume that new firms enter at the average quality level. To fix terminology, I shall refer to the introduction of new products that expand the variety of intermediate goods and are brought to market by new firms as “entry”.

New firms finance entry by issuing equity. Entry is positive if the value of the firm is equal to its after-tax setup cost, i.e., if the free-entry condition  $V_i = \beta Z$  holds. The post-entry profit that accrues to an entrant is given by the expression derived for the typical incumbent. Hence, the value of the firm satisfies the arbitrage condition (6). Taking logs and time derivatives of the free-entry condition, substituting into (6) and imposing symmetry yields

$$r = \frac{(1 - t_D)}{\beta} \left[ (1 - t_{\Pi}) \frac{\Pi}{Z} - \frac{R}{Z} \right] + (1 - t_V) \frac{\dot{Z}}{Z}. \quad (8)$$

Observe that this rate of return decreases with  $t_D$ .

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reduce to the two requirements that: (a) the firm-specific return to quality innovation is decreasing in  $Z_i$  (see the Appendix); (b) entrants enter at the average level of quality  $Z$  (see below). The first implies that if one holds constant the mass of firms and starts the model from an asymmetric distribution of firm sizes, then the model converges to a symmetric distribution. The second requirement simply ensures that entrants do not perturb such symmetric distribution.

<sup>8</sup>The R&D technology (3) says that achieving quality level  $Z$  within an existing product line has a cumulative cost of  $Z$ . If we assume that entrepreneurs have access to the same technology in the creation of a new firm, then it is natural to write the cost of creating a new product line with initial quality level  $Z$  as  $Z$ . However, entrepreneurs have to pay additional setup costs that incumbents have already paid. If these costs are also proportional to  $Z$ , then it is natural to write the total entry cost as  $\beta Z$ ,  $\beta > 1$ .

### 2.3 Households

The economy is populated by a representative household whose (identical) members supply labor services and purchase financial assets (corporate equity) in competitive labor and asset markets. Each member is endowed with one unit of time. The household has preferences

$$U(t) = \int_t^\infty e^{-(\rho-\lambda)(s-t)} \log u(s) ds, \quad \rho > \lambda \geq 0, \quad \gamma > 0,$$

where

$$\log u(s) = \log \frac{C(s)}{e^{\lambda s}} + \gamma \log(1 - l(s)).$$

$\rho$  is the individual discount rate. Initial population is normalized to one so that at time  $t$  population size is  $e^{\lambda t}$ , where  $\lambda$  is the rate of population growth. Instantaneous utility is defined over consumption per capita  $Ce^{-\lambda t}$  and leisure  $1 - l$ , where  $C$  is aggregate consumption and  $l$  is the fraction of time allocated to work.  $\gamma$  measures preference for leisure.

The household faces the flow budget constraint (I impose symmetry across firms to keep the notation simple):

$$\dot{s}NV + s\dot{N}V = \left[ (1 - t_D)D - t_V\dot{V} \right] sN + (1 - t_L)Wle^{\lambda t} - (1 + t_C)C - T,$$

where  $s$  and  $\dot{s}$  are, respectively, the level and change of equity holding in each firm,  $N$  is the mass of firms,  $D$  is the dividend per share distributed by each firm,  $\dot{V}$  is the appreciation of each firm's equity. The government taxes labor income at rate  $t_L$ , dividends at rate  $t_D$ , capital gains at rate  $t_V$ , and consumption at rate  $t_C$ . It also levies lump-sum taxes  $T$ .

The optimal plan for this setup is well known. The household saves and supplies labor according to:

$$\rho - \lambda + \frac{\dot{C}}{C} = r = (1 - t_D) \frac{D}{V} + (1 - t_V) \frac{\dot{V}}{V}; \quad (9)$$

$$L = le^{\lambda t} = e^{\lambda t} - \frac{(1 + t_C)\gamma C}{(1 - t_L)W}. \quad (10)$$

The Euler equation (9) defines the after-tax, reservation rate of return to saving that enters the evaluation of corporate equity discussed above.

## 2.4 The Government

I derive the results for the case of lump-sum taxation and no public debt because the notation is simpler. Specifically, the government consumes final goods and satisfies the budget constraint<sup>9</sup>

$$G = t_L WL + t_C C + t_{\Pi} \Pi N + t_D DN + t_V \dot{V} N + T.$$

I characterize fiscal policy as

$$G = gY, \quad g < 1.$$

The public spending ratio  $g$  and the tax rates  $t_L$ ,  $t_C$ ,  $t_{\Pi}$ ,  $t_D$ , and  $t_V$  are fixed. The endogenous instrument is  $T$ . In the Appendix I show that the economy with public debt generates the same equilibrium dynamics as the economy with no debt because Ricardian equivalence holds. Hence, the results derived below describe the case of a deficit-financed dividend tax cut where the government pays back the debt in the future.

## 3 The economy's dynamics

In this section I first show how the interaction of incumbents and entrants (quality and variety innovators) in the assets market determines the relation between growth and the return to stockholding. I then turn to the rest of the economy and impose equilibrium of the assets, labor and output markets to determine dynamics. Finally, I characterize the steady state.

### 3.1 Equilibrium of the corporate sector

Define the growth rate of quality  $z \equiv \hat{Z} = \frac{R}{Z}$ . (A hat on top of a variable denotes a proportional growth rate.) No-arbitrage between quality growth and variety expansion requires that their rates of return be equal. Using (7) and (8) this condition yields

$$z \equiv \frac{R}{Z} = (1 - t_{\Pi}) \frac{\alpha \phi - \left( \frac{1-t_D}{1-t_V} \frac{1}{\beta} - \alpha \right) \frac{\Pi}{Z}}{1 - \frac{1-t_D}{1-t_V} \frac{1}{\beta}}. \quad (11)$$

Figure 1 illustrates. The flat line is equation (7), which says that the return to quality is independent of quality growth because the R&D technology (3)

<sup>9</sup>To simplify this expression, I impose symmetry across firms and the normalization that each firm's stock of shares is  $s \equiv 1$ .

features constant returns to scale. The upward sloping line is equation (8), which says that the return to entry (variety expansion) depends positively on quality growth.

As one can see from the diagram, an interior equilibrium with both types of R&D exists and is stable if the entry locus (8) cuts the quality locus (7) from below.<sup>10</sup> There are two conditions for this situation to occur.<sup>11</sup> The first is the intercept condition

$$\frac{1-t_D}{\beta} \frac{\Pi}{Z} < \alpha(1-t_V) \left( \frac{\Pi}{Z} + \phi \right) \Rightarrow \alpha\phi > \left( \frac{1-t_D}{1-t_V} \frac{1}{\beta} - \alpha \right) \frac{\Pi}{Z}; \quad (12)$$

the second is the slope condition

$$1-t_V - \frac{1-t_D}{\beta} > 0 \Rightarrow \beta > \frac{1-t_D}{1-t_V}. \quad (13)$$

In the remainder of the analysis I impose that the slope condition holds. This is not restrictive since  $\beta > 1$  and in the data  $t_D > t_V$ .

Equations (7) and (11) characterize the instantaneous equilibrium of the corporate sector given the quality-adjusted cash flow,  $\frac{\Pi}{Z}$ , which at any point in time is determined by the macroeconomic conditions of the economy. The model admits two types of interior equilibrium:

- for  $\beta > \frac{1-t_D}{1-t_V} > \beta\alpha$  quality growth is decreasing in  $\frac{\Pi}{Z}$ ;
- for  $\beta > \beta\alpha > \frac{1-t_D}{1-t_V}$  quality growth is increasing in  $\frac{\Pi}{Z}$ .

The first equilibrium might surprise the reader since the literature has typically produced models with zero fixed operating costs that necessarily predict a positive relation between the growth and profitability of a product line. Once firms bear these costs, however, the return to variety can be more sensitive to the quality-adjusted cash flow than the return to quality, in which case an increase in the quality-adjusted cash flow reallocates

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<sup>10</sup>The equilibrium is stable in the sense that a deviation with, say, higher  $z$  yields that the return to entry becomes higher than the return to quality growth. The financial market then reallocates resources from quality growth to variety expansion, thereby reducing the rate of quality growth and restoring equilibrium.

<sup>11</sup>The model's equilibrium is well-defined also in the case in which these conditions fail, but it has the unappealing feature that either only variety expansion or only quality growth takes place. I omit these corner solutions because they add no insight.

resources from investment in existing products to investment in new products.<sup>12</sup> To fix terminology, I refer to the first case as the low- $\beta\alpha$  regime and the second as the high- $\beta\alpha$  regime. Notice how, regardless of the regime, holding constant  $\frac{\Pi}{Z}$  a decrease in  $t_D$  *always* lowers  $z$ . The reason is that dividend taxation does not distort the return to internal investment, see equation (7), while it distorts the return to entry, see equation (8).

### 3.2 General equilibrium

I now construct the general equilibrium of the economy. I define the private consumption ratio  $c \equiv \frac{C}{Y}$  and the number of firms per capita  $n \equiv Ne^{-\lambda t}$ . Rewrite the labor supply equation (10) as

$$l(c) = \frac{1}{1 + \Gamma c}, \quad \Gamma \equiv \frac{(1 + t_C)\gamma}{(1 - t_L)(1 - \theta)}. \quad (14)$$

The labor market is competitive and clears instantaneously so that  $l(c)$  is the equilibrium employment ratio.

Next, observe that the fact that the final producer pays total compensation  $\theta Y$  to intermediate producers yields  $NX = \theta^2 Y$ . Imposing symmetry in the production function (1) and using this relation allows me to write

$$Y = \Omega l(c) e^{\lambda t} Z, \quad \Omega \equiv \theta^{\frac{2\theta}{1-\theta}}. \quad (15)$$

Accordingly, I can write

$$\frac{\Pi}{Z} = \frac{1 - \theta}{\theta} \frac{X}{Z} - \phi = \theta(1 - \theta) \frac{\Omega l(c)}{n} - \phi. \quad (16)$$

This equation shows how, given the mass of firms per capita  $n$ , equilibrium of the labor market determines the firm's quality-adjusted cash flow.

Equations (14)-(15) characterize the supply side of the output market. Equilibrium requires

$$Y = G + C + N(X + \phi Z + R) + \beta Z \dot{N}.$$

Recall that  $NX = \theta^2 Y$  and  $G = gY$ . Using the employment relation (14), the reduced-form production function (15), the definition of  $n$ , and dividing

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<sup>12</sup>Fixed operating costs are necessary, not sufficient to generate this equilibrium. Most of the papers referenced in footnote 1 that look at transitional dynamics posit zero fixed operating costs and thus could not uncover the negative relation between cash flow and quality growth. Notice, in fact, that  $\phi = 0$  implies that one must restrict the right hand side of (12) to be positive for an equilibrium with  $z > 0$  to exist.

through by  $Y$ , I obtain

$$(1 - \theta^2 - g - c) \frac{\Omega}{n(1 + \Gamma c)} = \phi + z + \beta(\lambda + \hat{n}). \quad (17)$$

Notice that  $c + g$  is the overall (private plus public) consumption ratio so that  $1 - c - g$  is the economy's saving ratio.

Equilibrium of the assets market requires that the rate of return to saving be equal to the rate of return to investment generated by firms. The definition of  $c$ , the Euler equation (9), the employment relation (14) and the reduced-form production function (15) allow me to write this condition as

$$r - z = \rho + \frac{1}{1 + \Gamma c} \hat{c}. \quad (18)$$

Observe now that (7), (11) and (16) yield that (17)-(18) define a system of two differential equations in  $c$  and  $n$  only. The following proposition and the phase diagram in Figure 2 characterize the resulting dynamics.

**Proposition 1** *There exists a unique perfect-foresight general equilibrium. Given initial condition  $n_0$ , the economy jumps on the saddle path and converges to the steady state  $(n^*, c^*)$ .*

**Proof.** See the Appendix. ■

The model's remarkably simple transition allows me to derive the welfare implications of dividend tax cuts in a straightforward manner. Before doing that, however, it is useful to characterize the steady state.

### 3.3 The steady state

I construct the equilibrium of the assets market as the intersection of the relation

$$r = \rho + z, \quad (19)$$

describing the reservation interest rate of savers, with the relation

$$r = (1 - t_D) \frac{D}{V} + (1 - t_V) \frac{\dot{V}}{V},$$

which describes the rate of return to stocks delivered by firms. The insight driving this paper emerges clearly from how one can use the relations derived above to rewrite this equation in  $(z, r)$  space.

I begin by using the definition of pre-tax dividend (5) and the free-entry condition  $V = \beta Z$  to write

$$\frac{D}{V} = \frac{D}{\beta Z} = \frac{1}{\beta} \left[ (1 - t_{\Pi}) \frac{\Pi}{Z} - z \right].$$

I then solve (11) for  $\frac{\Pi}{Z}$  and substitute the result in this expression to obtain

$$\frac{D}{V} = \frac{\alpha \phi (1 - t_{\Pi}) - (1 - \alpha) z}{\frac{1 - t_D}{1 - t_V} - \alpha \beta}.$$

Finally, I write

$$r = (1 - t_D) \frac{\alpha \phi (1 - t_{\Pi}) - (1 - \alpha) z}{\frac{1 - t_D}{1 - t_V} - \alpha \beta} + (1 - t_V) z. \quad (20)$$

This locus describes the return to investment in quality and variety innovation produced by the no-arbitrage condition that the rates of return to the two activities be equal.

The model's solution turns out to be remarkably simple since (9) and (20) yield the closed-form expressions:<sup>13</sup>

$$z^* = \frac{\alpha \phi (1 - t_{\Pi}) (1 - t_D) - \rho \left( \frac{1 - t_D}{1 - t_V} - \alpha \beta \right)}{(1 - \alpha) (1 - t_D) + t_V \left( \frac{1 - t_D}{1 - t_V} - \alpha \beta \right)}; \quad (21)$$

$$r^* = \alpha \frac{\phi (1 - t_{\Pi}) (1 - t_D) + \rho (1 - t_V) \left( \beta - \frac{1 - t_D}{1 - t_V} \right)}{(1 - \alpha) (1 - t_D) + t_V \left( \frac{1 - t_D}{1 - t_V} - \alpha \beta \right)}. \quad (22)$$

Rather than differentiating these expressions, however, it is more insightful to investigate the properties of the equilibrium by looking at how the investment locus shifts with the tax rates. The proposition below summarizes the results, Figure 3 illustrates.

**Proposition 2** *There are two steady-state equilibrium configurations:*

- for  $\beta > \frac{1 - t_D}{1 - t_V} > \beta \alpha$  the return to investment is downward sloping in  $z$ , shifts up with  $t_D$ , and shifts down with  $t_{\Pi}$ ,  $t_V$ ;
- for  $\beta > \beta \alpha > \frac{1 - t_D}{1 - t_V}$  the return to investment is upward sloping in  $z$ , shifts down with  $t_D$ ,  $t_V$ , and shifts up with  $t_{\Pi}$ .

<sup>13</sup>Existence conditions are discussed in the proof of Proposition 1.

*In both cases, an increase in  $t_D$  raises  $z^*$  and  $r^*$  while an increase in  $t_{\Pi}$  lowers them. The effects of  $t_V$ , in contrast, depend on which case applies: in the former an increase in  $t_V$  raises  $z^*$  and  $r^*$ , in the latter it lowers them.*

**Proof.** See the appendix. ■

Recall that the analysis of no-arbitrage in the previous section shows that in the low- $\beta\alpha$  regime instantaneous quality growth is decreasing in the quality-adjusted cash flow while in the high- $\beta\alpha$  regime it is increasing. The proposition just stated says that this difference has no role in determining the sign of the steady-state effects of dividend taxation.

Why does taxation of dividends raise steady-state growth? As the proof of the proposition shows, the partial derivatives of the return to investment with respect to  $z$  and  $t_D$  always have opposite sign. Consequently, the locus shifts up with  $t_D$  when it is downward sloping and intersects the saving locus from above, while it shifts down with  $t_D$  when it is upward sloping and intersects the saving locus from below. This is no accident, of course. The reason is that in using (11), the construction of the investment locus (20) incorporates the relation between quality growth and the quality-adjusted cash flow that results from the partial equilibrium analysis of no-arbitrage in Figure 1. That diagram shows that a higher  $t_D$  does not affect the return to quality while it shifts down the return to entry. To restore equilibrium, resources flow from variety expansion to quality growth. The key then is that accounting for the endogeneity of  $\frac{\Pi}{Z}$  in steady-state general equilibrium does not change this outcome. The reason is that in the low- $\beta\alpha$  regime the return to entry is more sensitive to the cash flow than the return to quality while the reverse is true in the high- $\beta\alpha$  regime. It thus follows that in (20) the partial derivatives of  $r$  with respect to  $z$  and  $t_D$  always have opposite sign. It is straightforward to see that similar reasoning explains the effects of taxation of corporate profits.

The rate of return generated by the firm is related to its scale of activity since that is the variable that underpins the firm's cash flow. To see this, I now use (7) and (16) to solve for employment per firm:

$$\left(\frac{l}{n}\right)^* = \left(\frac{L}{N}\right)^* = \frac{r^*}{\Omega\theta(1-\theta)(1-t_V)(1-t_{\Pi})\alpha}. \quad (23)$$

Since  $r^*$  is increasing in  $t_D$  and decreasing in  $t_{\Pi}$  and  $t_V$ , this measure of firm size is increasing in  $t_D$  while  $t_{\Pi}$  and  $t_V$  have an ambiguous effect. Notice also that firm size is independent of  $t_C$  and  $t_L$ . Next, I use the free-entry

condition  $V = \beta Z$ , (15) and (23) to compute the wealth (to GDP) ratio

$$\left(\frac{NV}{Y}\right)^* = \frac{\beta}{\Omega} \left(\frac{n}{l}\right)^* = \frac{\beta\theta(1-\theta)(1-t_V)(1-t_\Pi)\alpha}{r^*}. \quad (24)$$

Very intuitively this equation says that for a given interest rate the ratio is decreasing in  $t_\Pi$  and  $t_V$ . If these direct effects dominate the indirect effects through the interest rate, then the ratio is decreasing in  $t_\Pi$  and  $t_V$ . Since the interest rate is the only channel through which  $t_D$  enters this expression, the ratio is decreasing in  $t_D$  because the interest rate is increasing in  $t_D$ .

Next, I substitute (14), (19) and (23) into (17) to calculate

$$c^* = 1 - \theta^2 - g - \theta(1-\theta)(1-t_V)(1-t_\Pi)\alpha \frac{\beta\lambda + \phi + z^*}{\rho + z^*}, \quad (25)$$

which says that  $c^*$  is increasing in  $z^*$ , and thereby increasing in  $t_D$ , if  $\beta\lambda + \phi > \rho$ . This yields the sensible result that taxation of dividends raises consumption, that is, *reduces* the overall saving ratio  $1 - c^* - g$ .

To solve for the labor market equilibrium, I now use (14) to obtain

$$l^* = \frac{1}{1 + \Gamma c^*}, \quad \Gamma \equiv \frac{(1 + t_C)\gamma}{(1 - t_L)(1 - \theta)}$$

which is decreasing in  $t_D$ , since  $c^*$  is increasing in  $t_D$ , and in  $t_L$  and  $t_C$ . Finally, I can rewrite (23) as

$$n^* = \theta(1-\theta)(1-t_V)(1-t_\Pi)\alpha \frac{\Omega l^*}{r^*}. \quad (26)$$

With a little bit of tedious algebra, I can show that this expression is decreasing in  $t_D$ . I can also show that  $n^*$  is decreasing in  $t_\Pi$ ,  $t_V$ ,  $t_L$ ,  $t_C$  and increasing in  $g$ . With these comparative statics results in hand, I am now ready to undertake the main experiment of the paper.

## 4 A dividend tax cut: Analytical results

In the analysis below, I posit  $\beta\lambda + \phi > \rho$  to study the effects of the tax cut under conditions that yield the reasonable result that lower taxation of dividends raises the saving ratio  $1 - g - c^*$ . I offer three remarks in support of this choice. First, this response is precisely what most economists would expect. Second, the prediction that the dividend tax cut would raise saving, investment and growth has been offered as one of the strongest arguments in favor of the policy. Third, it always holds in the calibrated model.

I organize this section in two parts. The first deals with the basic model with zero social returns to product variety. The second relaxes this simplifying assumption and shows that introducing positive social returns to product variety yields dynamics consistent with those of the basic model. Working out the two cases separately makes transparent the conditions under which social returns to product variety change the sign of the welfare effect of the tax cut.

#### 4.1 The basic model

Figure 2 illustrates the transition in  $(n, c)$  space. The following proposition establishes a central result of the paper.

**Proposition 3** *Assume  $\beta\lambda + \phi > \rho$ , which ensures that the relation between taxation of dividends and the economy's steady-state consumption ratio  $c^* + g$  is positive. Then, if the economy is in the low- $\beta\alpha$  regime,  $\beta > \frac{1-t_D}{1-t_V} > \beta\alpha$ , a reduction of the tax rate on dividends financed with an increase in lump-sum taxes or public debt is necessarily welfare reducing; if, instead, the economy is in the high- $\beta\alpha$  regime,  $\beta > \beta\alpha > \frac{1-t_D}{1-t_V}$ , a reduction of the tax rate on dividends financed with an increase in lump-sum taxes or public debt is not necessarily welfare reducing.*

**Proof.** Let 0 be the arbitrary date when the government cuts  $t_D$ . Refer to the phase diagram in Figure 2. The consumption ratio  $c$  jumps down and raises thereafter to the value  $c^{**} < c^*$ . Accordingly, the employment ratio  $l$  jumps up and falls thereafter to the value  $l^{**} > l^*$ . The initial jump up in  $l$  produces an initial jump up in the quality-adjusted cash flow  $\frac{\Pi}{Z}$ . According to equation (11), in the low- $\beta\alpha$  regime this change, together with the direct effect of the lower  $t_D$  which is always negative, produces a *fall* in quality growth  $z$ . The economy thereafter experiences a rising rate of quality growth that converges to the value  $z^{**} < z^*$ . To see welfare, use (15) to write output per capita,  $y \equiv Y e^{-\lambda t}$ , as

$$\log y(t) = \log \Omega l(t) + \int_0^t z(s) ds + \log Z(0).$$

Without loss of generality I normalize  $Z(0) \equiv 1$ . Using this expression and the definition of  $c$ , I then write flow utility as

$$\begin{aligned} \log u(t) &= \log y(t) + \log c(t) + \gamma \log(1 - l(t)) \\ &= \log \Omega + \int_0^t z(s) ds + \log(l(t) c(t)) + \gamma \log(1 - l(t)). \end{aligned}$$

Flow utility features a tension between work and leisure. However, equation (14) allows me to calculate (I suppress time arguments to simplify the notation):

$$\begin{aligned} \log(lc) + \gamma \log(1-l) &= \log \frac{c}{1+\Gamma c} + \gamma \log \frac{\Gamma c}{1+\Gamma c} \\ &= (1+\gamma) \log \frac{c}{1+\Gamma c} + \gamma \log \Gamma, \end{aligned}$$

which is increasing in  $c$ . The welfare effect of the tax cut then is

$$\Delta \equiv U_0 - U^* = \int_0^\infty e^{-(\rho-\lambda)t} \log \frac{u(t)}{u^*} dt,$$

where  $U^*$  is welfare at  $(n^*, c^*)$  and the change in flow utility along this transition is

$$\log \frac{u(t)}{u^*} = (1+\gamma) \log \frac{\frac{c(t)}{1+\Gamma c(t)}}{\frac{c^*}{1+\Gamma c^*}} + \int_0^t [z(s) - z^*] ds.$$

The first term is negative because  $c(t) \leq c^{**} < c^*$ . This reflects the loss of utility due to the lower consumption ratio. The second term is also negative because  $z(t) \leq z^{**} < z^*$ . Therefore, the welfare change is surely negative because the economy experiences a slowdown in quality growth as well as a loss of consumption. In the high- $\beta\alpha$  regime things differ only in that the initial jump in the quality-adjusted cash flow due to the expansion of aggregate market size produces a jump up in quality growth that could offset the direct effect of the lower  $t_D$ , and thereby produce a growth acceleration. If this acceleration is strong enough, and the welfare functional puts sufficient weight on the early part of the transition, then we can have an overall welfare increase despite the lower steady-state growth rate. This initial acceleration must offset also the negative effect on flow utility of the lower consumption ratio (which includes lower leisure). ■

This result deserves a few comments. The model incorporates the traditional effect that people need to work harder to pay for the anticipated increase in lump-sum taxes. In addition, it incorporates the Schumpeterian quality/variety trade-off investigated in the recent literature. Accordingly, the effect of the tax cut depends on two margins. The first compares how much the economy loses from slower quality growth with how much it gains from the increase in product variety. The second compares how much the economy loses from the lower consumption and leisure with how much it

gains from the increase in product variety. With zero social returns to variety, the mass of firms per capita matters only because given aggregate variables it determines firm-level variables and thus drives the dynamics of the interest rate and growth. It does not, however, contribute directly to productivity. The next subsection relaxes this assumption.

## 4.2 The economy with social returns to product variety

I rewrite the production function in (1) as<sup>14</sup>

$$Y = n^\nu \int_0^N X_i^\theta (Z_i^\alpha Z^{1-\alpha} L_i)^{1-\theta} di, \quad 0 < \theta, \alpha < 1, \nu > 0.$$

Proceeding as in the previous analysis, this expression yields

$$Y = n^\eta \Omega L Z, \quad \eta \equiv \frac{\nu}{1-\theta}. \quad (27)$$

These social increasing returns to product variety are external to all agents so that their behavior does not change with respect to the characterization above. The only important difference is that the instantaneous reservation interest rate of savers now is

$$r = \rho + z + \frac{1}{1 + \Gamma c} \hat{c} + \eta \hat{n},$$

where the last term captures the contribution of product variety growth to total factor productivity growth. The presence of this term complicates the algebra without altering the basic mechanism.

The expression for the cash flow now reads

$$\frac{\Pi}{Z} = \theta (1 - \theta) \frac{\Omega l(c)}{n^{1-\eta}} - \phi.$$

The restriction  $\eta < 1$  implies that positive social returns to product variety do not overturn the market share effect so that the quality-adjusted cash flow remains decreasing in  $n$ . This ensures that the basic forces at work in the model, and therefore the characterization of the equilibrium dynamics, remain qualitatively unchanged. Notice that  $\eta < 1$  requires  $\nu < 1 - \theta$ , that is, an elasticity of output with respect to product variety that is less than the elasticity of output with respect to labor.

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<sup>14</sup>See Aghion and Howitt (1998, pp. 407-408, in particular footnote 6) for arguments that justify introducing social returns to variety in this fashion. See also Peretto (2007a, 2007b) for further discussion of social returns to variety in models of this class.

The following proposition shows that the results from Proposition 1 above apply virtually unchanged to this case. I use the subscript  $\nu$  to denote the steady-state values for the case  $\nu > 0$ .

**Proposition 4** *Assume  $\nu < 1 - \theta$  so that  $\eta < 1$ . Then, there exists a unique perfect-foresight general equilibrium. Given initial condition  $n_0$ , the economy jumps on the saddle path and converges to the steady state:*

$$\begin{aligned} c_\nu^* &= c^*; \\ n_\nu^* &= (n^*)^{\frac{1}{1-\eta}}. \end{aligned}$$

**Proof.** See the Appendix. ■

Observe that the solution for  $c_\nu^*$  (and therefore for  $l_\nu^*$ ) is given by the same expression as in the case  $\nu = 0$ . Also, recall that the characterization of the assets market equilibrium in steady state is independent of  $\frac{\Pi}{Z}$ . Therefore, the terms  $n^{1-\eta}$  and  $\eta\hat{n}$  in the expressions above do not affect the solutions for the steady-state growth and interest rates, which in this case as well are  $z^*$  and  $r^*$  in (21)-(22). Thus, aside from the modifications of the transition dynamics just studied, the only difference due to positive social returns to product variety is that they deliver a *smaller* mass of firms per capita (because  $n^* < 1$ ) without changing any other feature of the steady state.

An important way in which social returns to product variety change the model's implications for the dividend tax cut is the aforementioned contribution of product variety growth to total factor productivity growth. Equation (27) and the resources constraint (17) yield

$$\begin{aligned} \hat{y} &= z + \eta\hat{n} \\ &= z + \left[ \frac{\eta}{\beta} (1 - g - c - \theta^2) \frac{\Omega l}{n} - \beta\lambda - \phi - z \right] \\ &= \left( 1 - \frac{\eta}{\beta} \right) z + \frac{\eta}{\beta} \left[ (1 - g - c - \theta^2) \frac{\Omega l}{n} - \beta\lambda - \phi \right], \end{aligned}$$

where (11) and (16) yield

$$z = (1 - t_\Pi) \frac{\alpha\phi - \left( \frac{1-t_D}{1-t_V} \frac{1}{\beta} - \alpha \right) \left[ \theta(1-\theta) \frac{\Omega l}{n} - \phi \right]}{1 - \frac{1-t_D}{1-t_V} \frac{1}{\beta}}.$$

When the tax cut is implemented  $n$  does not jump while  $l$  jumps up. Consequently, the term in brackets jumps up. The previous analysis has shown

that  $z$  jumps up with  $l$  in the high- $\beta\alpha$  regime and jumps down in the low- $\beta\alpha$  regime. Recall also that the direct effect of a reduction of  $t_D$  is negative regardless of which regime applies. Hence, an important aspect of allowing for social returns to product variety is that it introduces an additional force that, at least temporarily, works against the negative direct effect of the dividend tax cut and can yield an acceleration of income per capita growth for a broader range of parameters values. Given that variety expansion is not an engine of long-run growth, however, the economy exhibits at best an inverted- $\surd$  time profile of productivity growth, whereas the initial acceleration is followed by a permanent slowdown with respect to the initial steady state. As for the case of zero social returns to product variety discussed in Proposition 3, the possibility of an initial growth acceleration makes the theoretical welfare effect ambiguous.

To check the welfare implications, observe that flow utility now is

$$\log u(t) = (1 + \gamma) \log \frac{c(t)}{1 + \Gamma c(t)} + \eta \log n(t) + \int_0^t z(s) ds. \quad (28)$$

The new element here is the productivity gain due to product variety,  $n$ , that increases in response to a dividend tax cut. The result in Proposition 3 generalizes as follows. (I drop the subscript  $\nu$  since I no longer need to differentiate the steady-state values below from those that apply in the case  $\nu = 0$ .)

**Proposition 5** *Under the assumptions of Propositions 2-4, consider an economy in the low- $\beta\alpha$  regime,  $\beta > \frac{1-t_D}{1-t_V} > \beta\alpha$ . A sufficient condition for a reduction of the tax rate on dividends financed with an increase in lump-sum taxes (or an increase in public debt) to be welfare reducing is that the initial (pre-shock) steady state satisfies*

$$l^* > \frac{1}{1 + \frac{1+\gamma}{\eta}}.$$

**Proof.** See the Appendix. ■

I wish to stress that the proposition establishes a *sufficient* condition for the tax cut to be welfare reducing. Interestingly, this condition concerns exclusively the labor market. The reason is that the proof splits the role of the increase of product variety in two components that reflect two trade-offs. The first inequality compares how much utility the economy loses from slower quality growth with how much it gains from the increase in product

variety. This comparison says that the loss dominates the gain regardless of specific parameter values. The second inequality compares how much utility from consumption and leisure is lost in exchange for the gain due to product variety. An important feature of this comparison is that the channel linking the gain from variety to the loss from consumption is the employment ratio because the economy needs to raise employment to support a larger mass of firms. The parameter  $\Gamma$ , which regulates the response of labor supply to changes in the consumption ratio, tells us how much consumption the economy needs to give up to sustain the increase in product variety generated by the tax cut.

How strict is the second condition? Since  $\eta < 1$  this inequality holds if

$$l^* > \frac{1}{2 + \gamma}.$$

For the period 1960-2000, the total U.S. labor input — the average hours worked per person times the employment ratio — has ranged between 0.3 and 0.36 with a mean value of 0.33.<sup>15</sup> The U.S. economy thus satisfies the sufficient condition in the proposition if

$$\gamma > \frac{1}{0.33} - 2 = 1.03.$$

The business-cycle literature typically works  $\gamma = 2.2$ . In the quantitative analysis below, I obtain the value  $\gamma = 1.439$  from the employment equation (14) and data on the consumption ratio and the tax rates. Since either case satisfies the inequality, we conclude that qualitatively what matters for the sign of the welfare effect of the policy under investigation in the economy with  $\nu > 0$  is whether the economy is in the low- or high- $\beta\alpha$  regime, exactly the conclusion reached in the case  $\nu = 0$ .

## 5 The JGTRRA: Quantitative analysis

The qualitative analysis above shows that we need to know whether we are in the low or high- $\beta\alpha$  regime. If the economy is in the low- $\beta\alpha$  regime the welfare effect of the dividend tax cut is negative regardless of the degree of

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<sup>15</sup>If one interprets  $l$  more narrowly as the fraction of the individual time endowment allocated to work, which is what a literal reading of the model suggests, the data says that the fraction is clearly larger than 0.33. Similarly, one can reinterpret the model as specifying  $l$  as the fraction of the working age population that is employed and this number too is (much!) larger than 0.33.

social returns to product variety. If, instead, the economy is in the high- $\beta\alpha$  regime the welfare effect is not necessarily negative. The purpose of the quantitative work discussed in this subsection is to provide additional information on the model's transition and evaluate the welfare change due to the JGTRRA under a wide range of values of the entry cost.

The estimation of entry costs is still in its infancy. We have drastically different results according to how one thinks about these costs. Djankov et al. (2002) provide estimates of regulatory entry costs. Strictly speaking these exclude the technological component that is at the heart of this paper — recall that I think of  $\beta$  as the cost of developing a new product and its manufacturing process with productivity level  $Z$  plus any additional cost that entrants must pay to start operations. If these extra costs are proportional to  $Z$ , we can write  $\beta = 1 + \kappa$ , where 1 is the cost of achieving productivity level  $Z$  starting from scratch and  $\kappa$  is the additional cost due to regulations and other barriers to entry. Djankov et al. (2002) estimate that in the U.S. economy these costs are about 0.0169 of GDP per capita. We can translate this into an estimate of  $\kappa$  as follows. Since we posit the cost as proportional to  $Z$ , we can calculate

$$\kappa Z = 0.0169 \cdot Y e^{-\lambda t} \Rightarrow \kappa = 0.0169 \cdot \frac{Y e^{-\lambda t}}{Z} = 0.0169 \cdot \Omega \cdot l^* = 0.002,$$

which yields  $\beta = 1.002$ . An alternative approach is to estimate  $\beta$  from stock market and employment information (see the Appendix for details). Using (24), we have

$$\beta = \Omega \cdot \left(\frac{NV}{Y}\right)^* \cdot \left(\frac{L}{N}\right)^* = 6.55.$$

Given this range of variation, and how important the entry cost is for welfare, it is wise to check the results' robustness over a wide range of values of  $\beta$ .

I calibrate the model as follows; the details are in the Appendix.

Table 1. Fiscal variables

$g$	$t_{\Pi}$	$t_D$	$t_V$	$t_L$	$t_C$
0.143	0.335	0.35	0.2	0.256	0.05

Table 2. Steady state

$c^*$	$l^*$	$r^*$	$z^*$
0.69	0.33	0.04	0.02

Table 3. Parameters

$\rho$	$\gamma$	$\theta$	$\alpha$	$\phi$	$\beta$
0.02	1.439	0.31	0.163	0.068	6.55

It is worth emphasizing that I use equations (14), (22) and (25) to compute  $\gamma$ ,  $\alpha$ ,  $\phi$  from the data concerning the fiscal variables and the steady state values of the endogenous variables. Consequently, I have degrees of freedom only over  $\theta$ ,  $\rho$ ,  $\beta$ . The first two are rather conventional parameters. In particular,  $\theta$  plays the role of the traditional capital share and I set its value accordingly. As discussed,  $\beta$  requires particular care. I also set the degree of social return to variety equal to zero, i.e.,  $\nu = 0$ , in the baseline case. I then do sensitivity analysis over the range  $\nu \in (0, 1 - \theta)$ .

Figure 5 shows the economy’s response to the JGTRRA in the baseline case. The dynamics are well behaved and the transition lasts about 30 years. The consumption ratio  $c$  falls on impact from 0.69 to 0.52 and then rises gradually to 0.655. This dynamics yields that the economy’s overall saving ratio  $1 - c - g$  rises on impact from 0.167 to 0.33 and then falls gradually to 0.202. The employment ratio  $l$  rises from 0.33 to 0.388 and then falls to 0.338. The growth rate of income per capita  $z$  drops on impact from 0.02 to 0.012 and then falls further to 0.0108. The last result is interesting. The economy thus calibrated is in the high- $\beta\alpha$  regime, where the initial rise of the quality-adjusted profit  $\frac{\Pi}{Z}$  should produce a jump up in  $z$ . Yet, it does not because the direct effect of the change in tax rates, in particular the negative effect of the cut in the tax rate on dividends, dominates in equation (11).

The overall result is that welfare falls. In calculations not reported for brevity, I have experimented with several values of  $\beta$ . The following table summarizes the welfare effect of the policy for a few values of  $\beta$  and three values of  $\gamma$  that stand out:  $\gamma = 0$  because it corresponds to inelastic labor supply;  $\gamma = 1.439$  because it is what I “estimate” from the data using the model;  $\gamma = 2.2$  because it is common in the literature. The welfare effect is in % of annual consumption per capita; a positive value means a welfare loss, a negative value means a welfare gain. (This reflects the usual convention that we have a welfare loss when we need to raise consumption to make the policy acceptable to agents.) The baseline case is in boldface.

Table 4. Welfare cost

$\beta/\gamma$	0	<b>1.439</b>	2.2
2	23.54	25.90	26.23
3	19.80	22.02	22.34
<b>6.55</b>	17.29	<b>19.34</b>	19.64
10	16.74	18.75	19.05

An important aspect of this analysis is that when  $\beta$  changes the whole triplet  $(\beta, \phi, \alpha)$  changes, since  $\phi$ ,  $\alpha$  are “estimated” from equations (22) and

(25) conditional on the value of  $\beta$ . The following table shows the relation among these parameters.

Table 5. The triplet  $(\beta, \phi, \alpha)$

$\beta$	$\phi$	$\alpha$	$\beta\alpha$
1.002	-0.0023	0.9013	0.9031
1.02	-0.0021	0.8882	0.9059
1.1815	0	0.7859	0.9285
1.2	0.0002	0.7757	0.9308
2	0.0104	0.4962	0.9924
3	0.0231	0.3421	1.0263
4	0.0358	0.2611	1.0444
5	0.0485	0.2111	1.0555
<b>6.55</b>	<b>0.0682</b>	<b>0.1627</b>	1.0657
8	0.0866	0.1340	1.0720
9	0.0993	0.1195	1.0755
10	0.1120	0.1078	1.0780

As one can see, very low values of  $\beta$  produce nonsensical results for  $\phi$ . The reason is that when  $\beta$  is too low the existence conditions for an interior equilibrium fail and the model cannot produce the steady-state vector  $(c^*, l^*, r^*, z^*)$  in Table 2 unless  $\phi$  and  $\alpha$  adjust, and the adjustment, of course, does not need to make economic sense. Experimenting with several values of  $\beta$  I found that 2 is the lower bound below which we cannot go without destroying the key properties of the model. (Specifically, this means violating the conditions discussed in Section 3.1 and Propositions 1-2.) Notice also how multiplying the  $\beta$  column by the  $\alpha$  column in the table always yields numbers larger than  $\frac{1-t_D}{1-t_V} = .8125$ . In other words, to fit the steady-state vector  $(c^*, l^*, r^*, z^*)$  in Table 2 the model must always be in the high- $\beta\alpha$  regime. This rules out the low- $\beta\alpha$  regime wherein, as we have seen, the welfare effect of a dividend tax cut is necessarily negative.

One might be interested in the “pure” comparative dynamics effect of a change in  $\beta$ . One then might proceed as follows. Select  $\beta = 6.55$  as the baseline case; “estimate”  $\phi$ ,  $\alpha$ ; change  $\beta$  without re-estimating  $\phi$ ,  $\alpha$ . The following table shows the welfare results. I report only values  $\beta \geq 4.5$  because, given that I am not re-estimating  $\phi$  and  $\alpha$ , for  $\beta < 4.5$  the existence

condition for an interior equilibrium fails and the model breaks down.

Table 6. “Pure” effect of  $\beta$

$\beta$	Welfare cost %
4.5	15.78
5	16.54
6	18.26
<b>6.55</b>	<b>19.34</b>
7	20.31
8	22.77
9	25.73
10	29.32

According to this analysis the welfare cost rises rapidly with  $\beta$ , whereas in Table 4 it decreases with  $\beta$ . To understand the difference, recall that here each row is associated to a different vector of steady-state values characterizing the economy before the change in tax rates and that except for the baseline case the steady-state vector does not fit the data. The numbers in Table 4 do not suffer from this problem because by construction each row is associated to the steady-state vector  $(c^*, l^*, r^*, z^*)$  in Table 2, which is data.

I now turn to the more interesting extension that allows for social returns to product variety. Recall that we are always in the high- $\beta\alpha$  regime that potentially allows for an initial growth acceleration. It is remarkable how even a mild degree of social returns to product variety is sufficient to deliver an initial growth acceleration but no matter how strong social returns to product variety the welfare effect remains negative. Figure 6 shows the dynamics for  $\eta \equiv \frac{\nu}{1-\theta} = 0.1$ . This value means that the elasticity of output with respect to product variety in the reduced-form aggregate production function (27) is  $\nu = 10\% \times (1 - \theta)$ , where  $1 - \theta$  is the elasticity with respect to labor. The initial fall of quality growth due to the tax cut cancels out with the initial acceleration of variety growth and the rate of growth of income per capita does not jump. Figure 7 shows that pushing the value of  $\eta$  up to 0.5 produces a substantial growth acceleration, from 2% to 2.25% on impact, that disappears in about 10 years. (Also, the transition becomes longer than 30 years.) Figure 8 summarizes the welfare effects. The solid line represents the case in which  $t_D$  and  $t_V$  drop to 15%, the dashed line the case in which  $t_D$  and  $t_V$  drop to 0%. In both cases the magnitude of the loss decreases with  $\eta$ . The reason is that an economy with larger  $\eta$  experiences a larger increase in the steady-state mass of firms per capita; see Proposition 4 and observe that the percentage change in  $n_\nu^*$  due to the tax

cut is  $\frac{1}{1-\eta}$  times the percentage change in  $n^*$ . This larger increase in product variety compensates more the adverse effects due to the slower steady-state growth rate and higher saving and employment ratios. Interestingly, if  $\eta$  is sufficiently large the complete elimination of taxes on dividends and capital gains yields a welfare gain.

## 6 Conclusion

In this paper, I have proposed a Schumpeterian investigation of the growth and welfare effects of a deficit-financed cut of the tax rate on dividends. To my own surprise, I found that under broad and plausible conditions the tax cut reduces long-run growth.

On reflection, this result rests on a straightforward intuition: the lower dividend income tax requires firms to reduce the pre-tax dividend-price ratio and/or the after-tax capital gain components of the return that they deliver to the stockholder in order to match his reservation after-tax rate of return. This, in turn, requires that firms reduce the growth rate of future earnings by investing less in quality growth. Crucially, firms are willing to reduce the growth rate of quality within each product line when overall product variety rises. This is because demand becomes less concentrated and firms exploit less effectively the cost-spreading effect associated to (exogenous) fixed operating costs and (endogenous) fixed R&D costs.

The increase in product variety embodies the model's key insight that lower taxation of dividends reallocates resources from quality growth to product proliferation. But product proliferation is the activity with low long-run growth opportunity. The reason is that fixed operating costs imply that the number of products is constrained by the size of the workforce, so that in the horizontal dimension of technology space steady-state growth independent of (exogenous) population growth is not possible. In the vertical dimension, in contrast, steady-state growth is feasible because improving product quality does not require the replication of fixed costs.

This mechanism has interesting implications for welfare. The effect of the tax cut depends on two margins. The first compares how much the economy loses from slower quality growth with how much it gains from the increase in product variety. The second margin compares how much the economy loses from the lower consumption and leisure with how much it gains from the increase in product variety. An important feature of this comparison is that the channel linking the gain from variety to the loss from consumption is the employment ratio because the economy needs to raise employment to

support a larger mass of firms. The parameters that regulate the response of labor supply to changes in the consumption ratio, then, tells us how much consumption the economy needs to give up to sustain the increase in product variety generated by the tax cut.

This analysis is particularly relevant to the current debate on the Job Growth and Taxpayer Relief reconciliation Act of 2003 (JGTRRA). One argument in support of the Act, based on conventional economic wisdom, is that the reduction of the tax rate on distributed dividends and capital gains reduces the corporate cost of capital and thereby increases saving and investment. This paper's analysis suggests that things are not so straightforward in an environment where market structure matters. The growth effects of such interventions depend on how they affect the financial market's allocation of funds between the vertical (quality) and horizontal (variety) dimensions of technological advance. The welfare effects depend on the relative contribution of the two dimensions to aggregate output. An implication of this trade-off is that the JGTRRA will deliver a welfare loss of 19.34% of annual consumption per capita if social returns to variety are zero. If social returns to variety are positive the magnitude of the loss is smaller. For example, with elasticity of aggregate output with respect to product variety equal to 10% of the labor elasticity the welfare loss is 16.94% of annual consumption.

## 7 Appendix

### 7.1 Derivation of the return to quality

The usual method of obtaining first-order conditions is to write the Hamiltonian for the optimal control problem of the firm. This derivation highlights the intuition. The firm undertakes R&D up to the point where the shadow value of the innovation,  $q_i$ , is equal to its cost,

$$\frac{1 - t_D}{1 - t_V} = q_i \Leftrightarrow R_i > 0. \quad (29)$$

Since the innovation is implemented in-house, its benefits are determined by the marginal after-tax profit it generates. Thus, the return to the innovation must satisfy the arbitrage condition

$$\frac{r}{1 - t_V} = \frac{1 - t_D}{1 - t_V} (1 - t_\Pi) \frac{\partial \Pi_i}{\partial Z_i} \frac{1}{q_i} + \frac{\dot{q}_i}{q_i}. \quad (30)$$

To calculate the marginal profit, observe that the firm's problem is separable in the price and investment decisions. Facing the isoelastic demand (2) and

a marginal cost of production equal to one, the firm sets  $P_i = \frac{1}{\theta}$ . The firm's cash flow then is

$$\Pi_i = \frac{1-\theta}{\theta} \theta^{\frac{2}{1-\theta}} L_i Z_i^\alpha Z^{1-\alpha} - \phi Z$$

and has the convenient property that

$$\frac{\partial \Pi_i}{\partial Z_i} = \alpha \frac{\Pi_i + \phi Z}{Z_i}.$$

Substituting into (30) and imposing symmetry yields (7).

## 7.2 The economy with public debt

I now show that the economy with lump-sum taxes yields the same equilibrium path as the economy with public debt. The household budget constraint reads

$$\dot{B} + s\dot{N}V + s\dot{N}V = rB + \left[ (1-t_D)D - t_V\dot{V} \right] sN + (1-t_L)Wle^{\lambda t} - (1+t_C)C,$$

where  $B$  is the stock of government bonds and the remaining notation is unchanged. For simplicity I assume no taxation of the interest income from government bonds. This setup is standard and yields the same first-order conditions as the case of lump-sum taxes, with the only addition that indifference between stocks and bonds requires that they pay the same after-tax rate of return. This is just another way of saying that equilibrium of the assets market requires no-arbitrage.

The introduction of public debt, therefore, does not change the equilibrium behavior of the household and corporate sectors of the economy. The budget constraint for the government is

$$G + rB = t_L WL + t_C C + t_\Pi N (\Pi - R) + t_D D sN + t_V \dot{V} sN + \dot{B}.$$

Now recall the normalization  $s \equiv 1$ , the definition of pre-tax dividends  $D = (1-t_\Pi)(\Pi - R)$ , and substitute the household's constraint into the government's constraint to obtain

$$G + \dot{N}V = N(\Pi - R) + WL - C.$$

Recalling the free-entry condition  $V = \beta Z$ , the definition of cash flow,  $\Pi = (P-1)X - \phi Z$ , and that the representative final producer remunerates its factors of production according to  $WL = (1-\theta)Y$  and  $NPX = \theta Y$ , this becomes

$$Y = G + C + N(X + \phi Z + R) + \beta Z \dot{N},$$

which is the resource constraint used in the text. It follows that replacing lump-sum taxation with public debt leaves the dynamical system unchanged. In other words, Ricardian equivalence holds.

### 7.3 Proof of Proposition 1

Equations (7), (11) and (16) yield:

$$z = (1 - t_{\Pi}) \frac{\frac{1-t_D}{1-t_V}}{\beta - \frac{1-t_D}{1-t_V}} \phi - (1 - t_{\Pi}) \frac{\left(\frac{1-t_D}{1-t_V} - \alpha\beta\right) \theta (1 - \theta) \Omega l(c)}{\beta - \frac{1-t_D}{1-t_V}} \frac{1}{n};$$

$$r - z = (1 - t_{\Pi}) \left[ (1 - t_V) \alpha + \frac{\frac{1-t_D}{1-t_V} - \alpha\beta}{\beta - \frac{1-t_D}{1-t_V}} \right] \theta (1 - \theta) \frac{\Omega l(c)}{n}$$

$$- (1 - t_{\Pi}) \frac{\frac{1-t_D}{1-t_V}}{\beta - \frac{1-t_D}{1-t_V}} \phi.$$

Equations (14), (17) and (18) then yield the dynamical system:

$$\hat{n} = \frac{\Omega}{\beta} \left[ \frac{\varphi_1 - c}{n(1 + \Gamma c)} - \varphi_2 \right];$$

$$\hat{c} = \frac{\varphi_3}{n} - \varphi_4 (1 + \Gamma c),$$

where I define:

$$\varphi_1 \equiv 1 - g - \theta^2 + (1 - t_{\Pi}) \frac{\left(\frac{1-t_D}{1-t_V} - \alpha\beta\right) \theta (1 - \theta)}{\beta - \frac{1-t_D}{1-t_V}} > 0;$$

$$\varphi_2 \equiv \frac{1}{\Omega} \left[ \beta\lambda + \phi \frac{\beta - t_{\Pi} \frac{1-t_D}{1-t_V}}{\beta - \frac{1-t_D}{1-t_V}} \right] > 0;$$

$$\varphi_3 \equiv (1 - t_{\Pi}) \left[ (1 - t_V) \alpha + \frac{\frac{1-t_D}{1-t_V} - \alpha\beta}{\beta - \frac{1-t_D}{1-t_V}} \right] \theta (1 - \theta) \Omega > 0;$$

$$\varphi_4 \equiv (1 - t_{\Pi}) \frac{\frac{1-t_D}{1-t_V}}{\beta - \frac{1-t_D}{1-t_V}} \phi + \rho > 0.$$

The  $\dot{n} \geq 0$  and  $\dot{c} \geq 0$  loci are, respectively:

$$\varphi_1 - c \geq \varphi_2 (1 + \Gamma c) n \Rightarrow \frac{\varphi_1 - \varphi_2 n}{1 + \varphi_2 \Gamma n} \geq c;$$

$$1 \geq \frac{\varphi_4}{\varphi_3} (1 + \Gamma c) n \Rightarrow \frac{1}{\Gamma} \left( \frac{\varphi_3}{\varphi_4 n} - 1 \right) \geq c,$$

The steady state is:

$$c^* = \varphi_1 - \varphi_2 \frac{\varphi_3}{\varphi_4};$$

$$n^* = \frac{\varphi_3}{\varphi_4 + \Gamma (\varphi_1 \varphi_4 - \varphi_3 \varphi_2)}.$$

The phase diagram is in Figure 2. The existence condition for the steady state is that the  $\dot{c} = 0$  locus cut the horizontal axis to the left of where the  $\dot{n} = 0$  locus does:

$$\frac{\varphi_1}{\varphi_2} > \frac{\varphi_3}{\varphi_4}.$$

Paths above the saddle path eventually yield zero or negative  $n$  and thus cannot be equilibria. Paths below the saddle path eventually yield zero or negative  $c$  and similarly cannot be equilibria.

#### 7.4 Proof of Proposition 2

The sign of the partial derivative of (20) with respect to  $z$  is given by

$$-(1 - t_D) \frac{(1 - \alpha)}{\frac{1-t_D}{1-t_V} - \alpha\beta} + (1 - t_V) = -\alpha(1 - t_V) \frac{1 - \frac{1-t_D}{1-t_V} \frac{1}{\beta}}{\frac{1-t_D}{1-t_V} \frac{1}{\beta} - \alpha},$$

the sign of the partial derivative with respect to  $t_D$  by

$$\alpha\phi(1 - t_{\Pi}) - (1 - \alpha) z^* = [\alpha\phi(1 - t_{\Pi}) t_V + (1 - \alpha) \rho] \left( \frac{1 - t_D}{1 - t_V} - \alpha\beta \right),$$

and the sign of the partial derivative with respect to  $t_{\Pi}$  by

$$-(1 - t_D) \frac{\alpha\phi}{\frac{1-t_D}{1-t_V} - \alpha\beta}.$$

The partial derivative with respect to  $t_V$  is always negative.

#### 7.5 Proof of Proposition 4

I follow the same procedure as in the proof of Proposition 1 to obtain the dynamical system:

$$\hat{n} = \frac{\Omega}{\beta} \left[ \frac{\varphi_1 - c}{n^{1-\eta} (1 + \Gamma c)} - \varphi_2 \right];$$

$$\hat{c} = (1 + \Gamma c) \left[ \frac{\varphi_3}{n^{1-\eta} (1 + \Gamma c)} - \varphi_4 - \eta \hat{n} \right].$$

Using the first equation, the second becomes

$$\hat{c} = (1 + \Gamma c) \left[ \frac{\varphi_3}{n^{1-\eta} (1 + \Gamma c)} - \varphi_4 - \eta \frac{\Omega}{\beta} \frac{\varphi_1 - c}{n^{1-\eta} (1 + \Gamma c)} + \eta \frac{\Omega}{\beta} \varphi_2 \right].$$

For the purposes of this exercise, it is useful to write the  $\hat{n} \geq 0$  and  $\hat{c} \geq 0$  loci, respectively, as follows:

$$n \leq \left[ \frac{\varphi_1 - c}{\varphi_2 (1 + \Gamma c)} \right]^{\frac{1}{1-\eta}};$$

$$n \leq \left[ \frac{\varphi_3 - \eta \frac{\Omega}{\beta} (\varphi_1 - c)}{\left( \varphi_4 - \eta \frac{\Omega}{\beta} \varphi_2 \right) (1 + \Gamma c)} \right]^{\frac{1}{1-\eta}}.$$

The steady state is

$$c_\nu^* = \varphi_1 - \varphi_2 \frac{\varphi_3}{\varphi_4};$$

$$n_\nu^* = \left[ \frac{\varphi_3}{\varphi_4 + \Gamma (\varphi_1 \varphi_4 - \varphi_3 \varphi_2)} \right]^{\frac{1}{1-\eta}}.$$

Figure 4 shows the phase diagram. I have two cases, depending on whether the  $\hat{c} = 0$  locus is decreasing or increasing, although this feature does not affect the dynamics. As for the case  $\eta = 0$ , the existence condition is that the  $\hat{c} = 0$  locus cut the horizontal axis to the left of where the  $\hat{n} = 0$  locus does. Notice that

$$\frac{\varphi_1}{\varphi_2} > \frac{\varphi_3}{\varphi_4} > \frac{\varphi_3 - \eta \frac{\Omega}{\beta} \varphi_1}{\varphi_4 - \eta \frac{\Omega}{\beta} \varphi_2},$$

so that existence of the equilibrium with  $\eta = 0$  implies existence of the equilibrium with  $0 < \eta < 1$ . As before, paths above the saddle path eventually yield zero or negative  $n$  and thus cannot be equilibria. Paths below the saddle path eventually yield zero or negative  $c$  and similarly cannot be equilibria.

## 7.6 Proof of Proposition 5

The transition dynamics in response to the tax cut feature time profiles of  $c$ ,  $l$ , and  $z$  that are qualitatively identical to those discussed in Proposition 2 for the case  $\nu = 0$ : the consumption ratio  $c$  jumps down and raises thereafter,

converging to a value  $c^{**} < c^*$ ; the employment ratio  $l$  jumps up and falls thereafter, converging to a value  $l^{**} > l^*$ ; the growth rate of quality jumps down and rises thereafter converging to a value  $z^{**} < z^*$ . Observe that the gain from product variety is largest at the end of the transition when  $n$  is largest, while the loss from lower consumption and the slowdown of quality growth is smallest at the end of the transition when  $c$  and  $z$  are highest. If I can show that at the end of the transition the gain from variety is smaller than the losses from consumption and quality growth, then I have that the change in utility is surely negative. In other words, if I can show that the policy reduces welfare when the transition has infinite speed, which is when the variety gain has the maximal chance of overturning the consumption and quality growth losses, then the policy surely reduces welfare in the case of the transition with finite speed. Specifically, I want to show that

$$\Delta = \int_0^\infty e^{-(\rho-\lambda)t} \log \frac{u(t)}{u^*} dt < \Delta_\infty = \int_0^\infty e^{-(\rho-\lambda)t} \log \frac{u^{**}}{u^*} dt < 0.$$

Using (28) and integrating, the inequality I seek to establish is

$$\Delta_\infty = \frac{1}{\rho - \lambda} \left[ (1 + \gamma) \log \frac{\frac{c^{**}}{1 + \Gamma c^{**}}}{\frac{c^*}{1 + \Gamma c^*}} + \eta \log \frac{n^{**}}{n^*} + \frac{z^{**} - z^*}{\rho - \lambda} \right] < 0.$$

Given that  $\rho > \lambda$ , I need to show that the expression inside the bracket is positive. Upon reflection, this requires me to show that the expression

$$(1 + \gamma) \log \frac{c}{1 + \Gamma c} + \eta \log n + \frac{z}{\rho - \lambda}$$

is increasing in  $t_D$  in a neighborhood of  $c = c^{**}$ . To accomplish this task, it is useful to recall equation (26), which says that the steady-state mass of firms per capita is

$$n = \frac{\Theta}{r(1 + \Gamma c)}, \quad \Theta \equiv \theta(1 - \theta)(1 - t_V)(1 - t_\Pi) \alpha \Omega.$$

Therefore, I can use  $r = \rho + z$  to rewrite the expression above as

$$(1 + \gamma) \log \frac{c}{1 + \Gamma c} - \eta \log c - \eta \log(\rho + z) + \frac{z}{\rho - \lambda} + \eta \log \Theta.$$

The last term is a constant independent of  $t_D$ . This procedure splits utility in the sum of two components, one due to consumption  $c$  and one due to

quality growth  $z$ . A sufficient condition for the sum to be increasing is that each component be increasing. Therefore, I have the two conditions:

$$\begin{aligned} \left[ \frac{1 + \gamma + \eta}{c(1 + \Gamma c)} - \frac{\eta}{c} \right] \frac{dc}{dt_D} &> 0; \\ \left[ -\frac{\eta}{\rho + z} + \frac{1}{\rho - \lambda} \right] \frac{dz}{dt_D} &> 0. \end{aligned}$$

The characterization of the steady state yields

$$\frac{dc}{dt_D} > 0 \quad \text{and} \quad \frac{dz}{dt_D} > 0.$$

Then, the second inequality is surely satisfied because

$$\frac{\rho + z}{\rho - \lambda} > 1 > \eta.$$

The first inequality holds in a neighborhood of the new steady state if

$$\frac{1 + \gamma}{\eta} > \Gamma c^{**}.$$

Taking into account that  $c^* > c^{**}$ , I can rewrite this condition as

$$\frac{1 + \gamma}{\eta} > \Gamma c^*,$$

which concerns the steady state that the economy starts from instead of that to which it converges after the tax cut. This condition is of course satisfied for  $\eta = 0$ . It is also satisfied for  $\gamma = 0$ , i.e.,  $\Gamma = 0$ , which yields inelastic labor supply. It is useful to use the employment equation (14) to rewrite the inequality as

$$l^* > \frac{1}{1 + \frac{1 + \gamma}{\eta}},$$

which does not require information on tax rates.

## 7.7 Calibration

Table A1. Steady states and fiscal variables

Variable	Description	Value	Source
$c^*$	$\frac{\text{consumption}}{\text{output}}$	0.69	NIPA
$l^*$	$\frac{\text{employment}}{\text{population}}$	0.33	NIPA
$r^*$	interest rate	0.04	NIPA
$z^*$	growth rate	0.02	NIPA
$g$	$\frac{\text{public spending}}{\text{output}}$	0.143	NIPA
$t_{\Pi}$	corporate	0.335	NIPA T1.10, $\frac{\text{line 18}}{\text{line 17}}$
$t_D$	dividend	0.35	JGTRRA
$t_V$	capital gains	0.2	JGTRRA
$t_L$	labor	0.256	Daveri and Tabellini (2002)
$t_C$	consumption	0.05	Mendoza et. al. (1997)

The exact formula for  $t_{\Pi}$  is the following:

$$t_{\Pi} = \frac{\text{taxes on corporate income to government}}{\text{profits with inventory valuation and capital consumption adj.}}$$

The values for  $t_D$ ,  $t_V$  before and after the policy change are the statutory rates reported in the JGTRRA.

Table 2. Calibrated parameters

Parameter	Value	Description	Source
$\theta$	0.31	capital share	NIPA
$\lambda$	0.01	population growth	U.S. census
$\rho$	0.02	discount rate	conventional
$\gamma$	1.439	preference for leisure	eq. (14)
$\beta$	6.55	sunk entry cost	eq. (24)
$\alpha$	0.163	appropriable quality	eqs. (22), (25) given $\beta$
$\phi$	0.068	fixed operating cost	eqs. (22), (25) given $\beta$

The procedure is the following. For  $\gamma$ , I used equation (14) and data on  $c^*$ ,  $l^*$ ,  $t_L$ ,  $t_C$  from Table 1. For  $\beta$ , I used equation (24) and computed  $\frac{NV}{Y}$  = average 1995-2005 ratio of nonfarm nonfinancial corporate business corporate equities liability to adjusted income (source: FED Flow of Fund accounts, L.213, Table: Corporate equities) and  $\frac{L}{N}$  = average employment per firm (source: Laincz and Peretto (2006)).

## References

- [1] Aghion P. and Howitt P., 1998, *Endogenous Growth Theory*, Cambridge, MIT University Press.
- [2] Aghion P. and Howitt P., 2006, Growth with Quality-Improving Innovations: An Integrated Framework, in: *Handbook of Economic Growth*, Edited by P. Aghion and S. Durlauf, North Holland.
- [3] Dinopoulos E. and Thompson P., 1998, Schumpeterian Growth without Scale Effects, *Journal of Economic Growth*, 3, 313-335.
- [4] Dinopoulos E. and Thompson P., 1999, Scale Effects in Schumpeterian Models of Economic Growth, *Journal of Evolutionary Economics*, 9, 157-187.
- [5] Djankov S., La Porta R., Lopez-de-Silanes F., Shleifer A., 2002, The Regulation of Entry, *Quarterly Journal of Economics*, 117, 1-37.
- [6] Howitt P., 1999, Steady Endogenous Growth with Population and R&D Inputs Growing, *Journal of Political Economy*, 107, 715-730.
- [7] Jones C.I., 1999, Growth: With or without Scale Effects? *AEA Papers and Proceedings*, 89, 139-144.
- [8] Laincz C. and Peretto P.F., 2006, Scale Effects in Endogenous Growth Theory: An Error of Aggregation, not Specification, *Journal of Economic Growth*, 11, 263-288.
- [9] Madsen J., 2008, Semi-endogenous versus Schumpeterian Growth Models: Testing the Knowledge Production Function Using International Data, *Journal of Economic Growth*, 13, 1-26.
- [10] Peretto, P.F., 1998, Technological Change and Population Growth, *Journal of Economic Growth*, 3, 283-311.
- [11] Peretto P.F., 1999, Cost Reduction, Entry, and the Interdependence of Market Structure and Economic Growth, *Journal of Monetary Economics*, 43, 173-195.
- [12] Peretto P.F., 2003, Fiscal Policy and Long-Run Growth in R&D-Based Models with Endogenous Market Structure, *Journal of Economic Growth*, 8, 325-347.

- [13] Peretto P.F., 2007a, Schumpeterian Growth with Productive Public Spending and Distortionary Taxation, *Review of Development Economics*, 11, 699-722.
- [14] Peretto P.F., 2007b, Corporate Taxes, Growth and Welfare in a Schumpeterian Economy, *Journal of Economic Theory*, 137, 353-382.
- [15] Peretto P.F. and Smulders S., 2002, Technological Distance, Growth, and Scale Effects, *The Economic Journal*, 112, 603-624.
- [16] Peretto P.F. and Connolly M., 2007, The Manhattan Metaphor, *Journal of Economic Growth*, 12, 329-350.
- [17] Sedgley N., 2006, A Time Series Test of Innovation-Driven Endogenous Growth, *Economic Inquiry*, 44, 318-332.
- [18] Turnovsky S., 1995, *Methods of Macroeconomics Dynamics*, Cambridge, MIT University Press.
- [19] Ulku H., 2007, R&D, Innovation, and Growth: Evidence from Four Manufacturing Sectors in OECD Countries, *Oxford Economic Papers*, 59, 513-535.
- [20] Young A., 1998, Growth Without Scale Effects, *Journal of Political Economy*, 106, 41-63.
- [21] Zeng J. and Zhang J., 2002, Long-Run Effects of Taxation in a Non-Scale Growth Model with Innovation, *Economics Letters*, 75, 391-403.

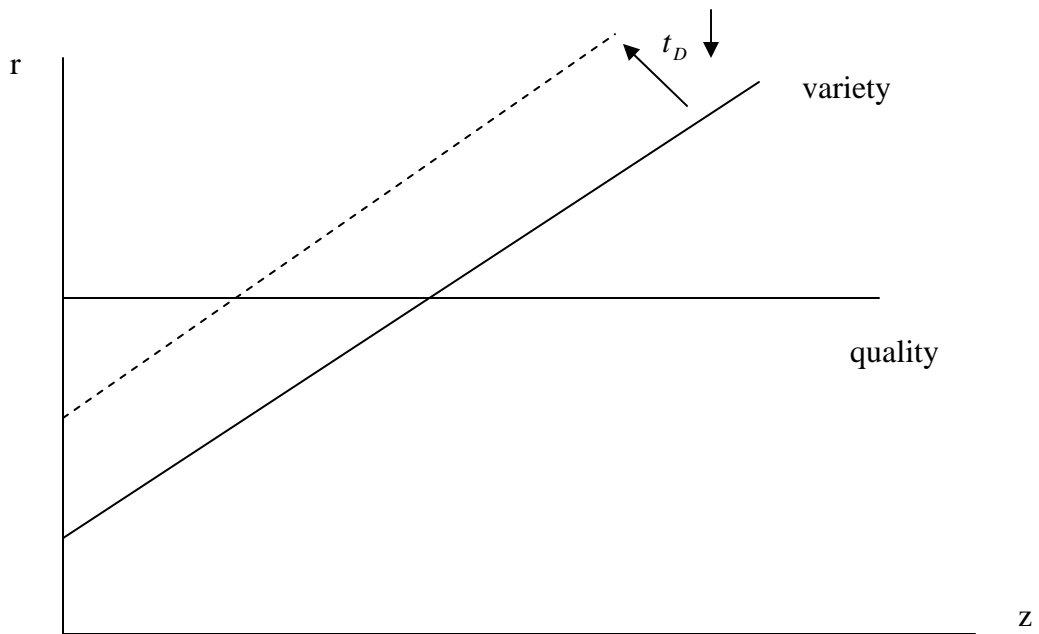


Figure 1: Equilibrium of the Corporate Sector with Effects of the Tax Cut

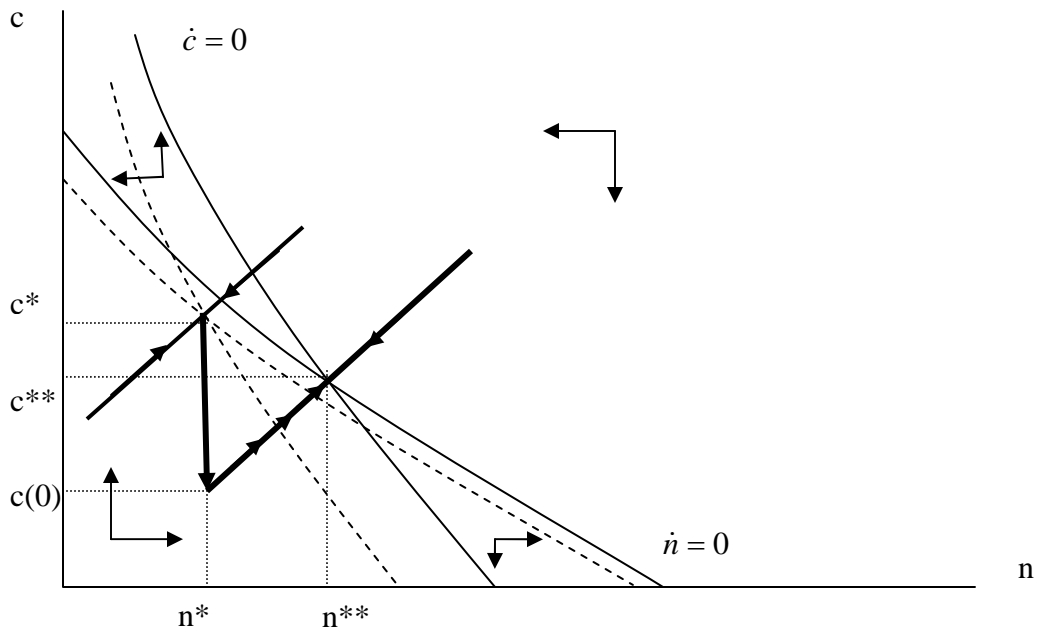


Figure 2: General Equilibrium Dynamics with Effects of the Tax Cut

The dashed lines represent the steady-state loci before the tax cut. The Bold line is the transition path in response to the tax cut. For simplicity the diagram represents only arrows of motion for the dynamics after the tax cut.

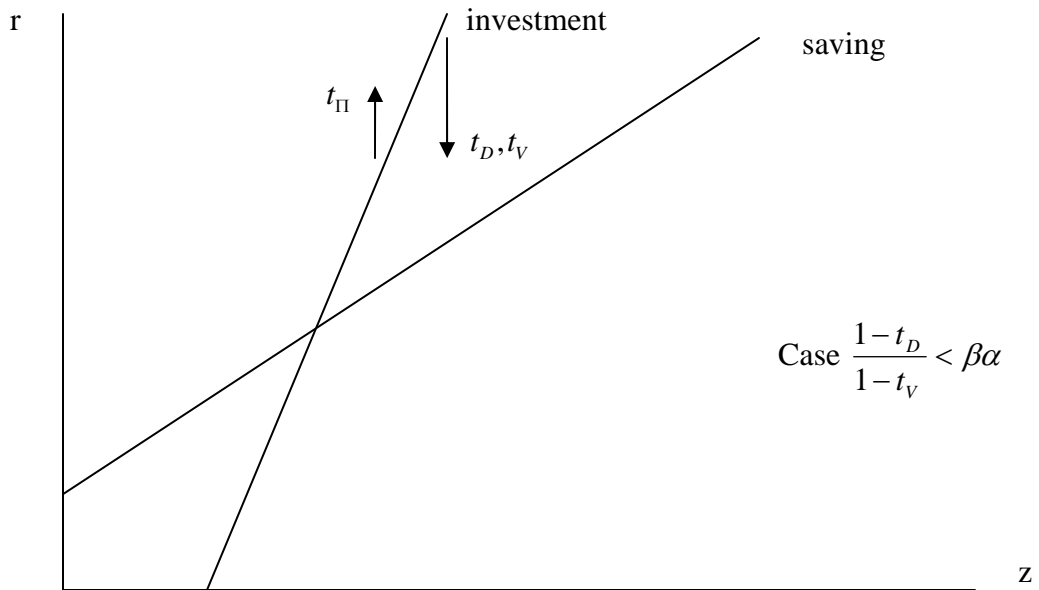
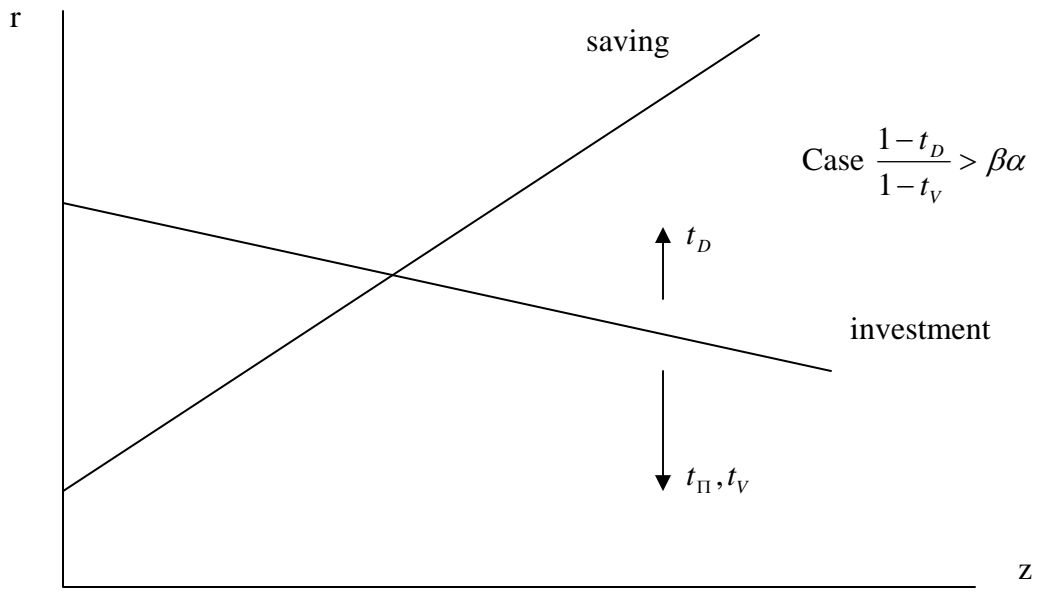


Figure 3: Steady-State Equilibrium of the Assets Market

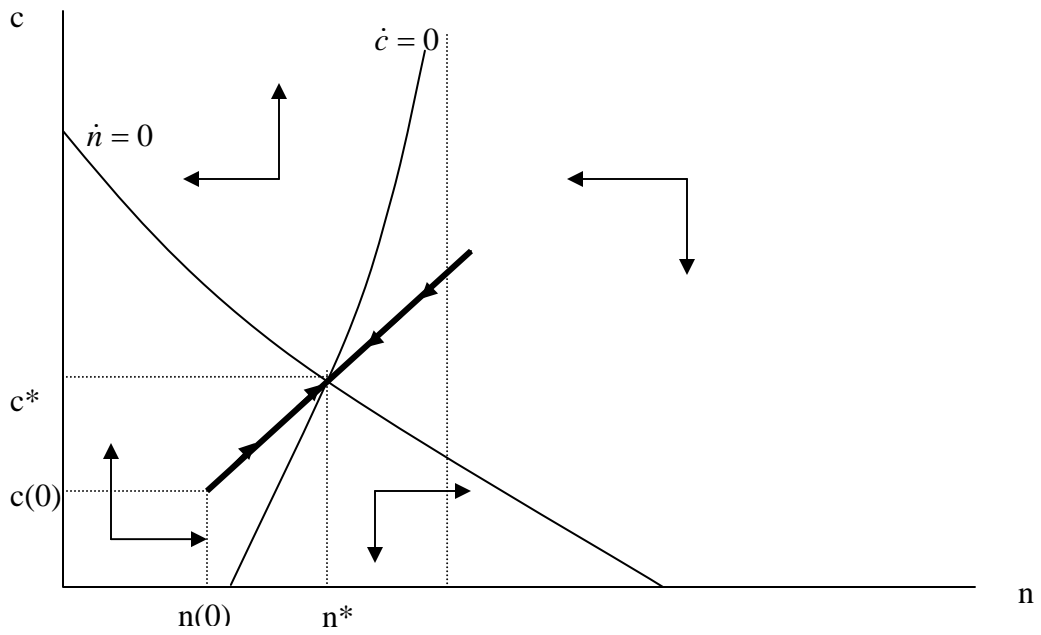
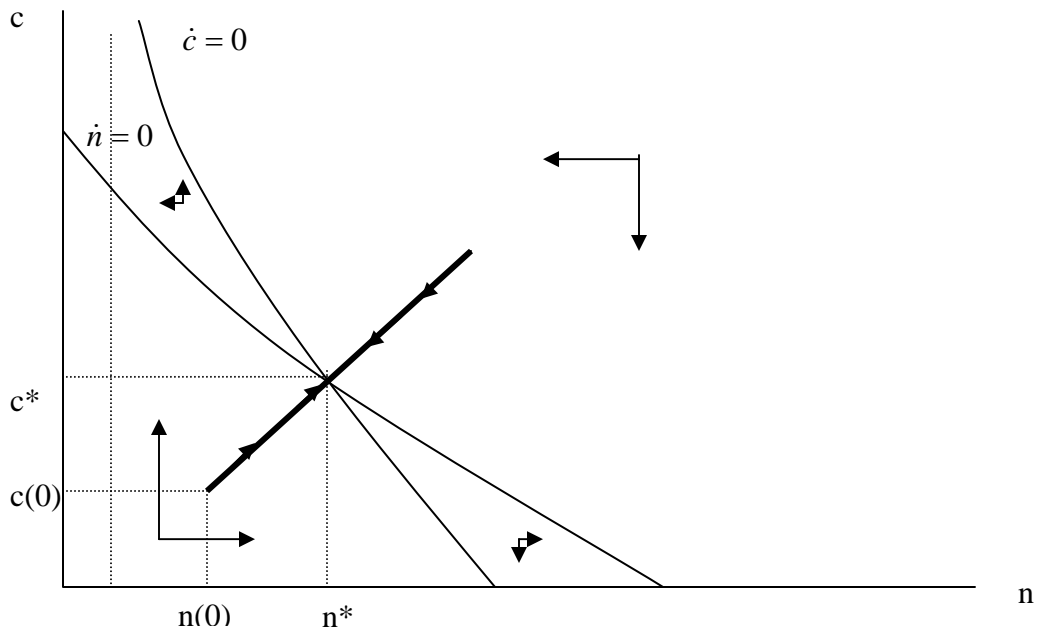


Figure 4: General Equilibrium Dynamics with Social Returns to Variety

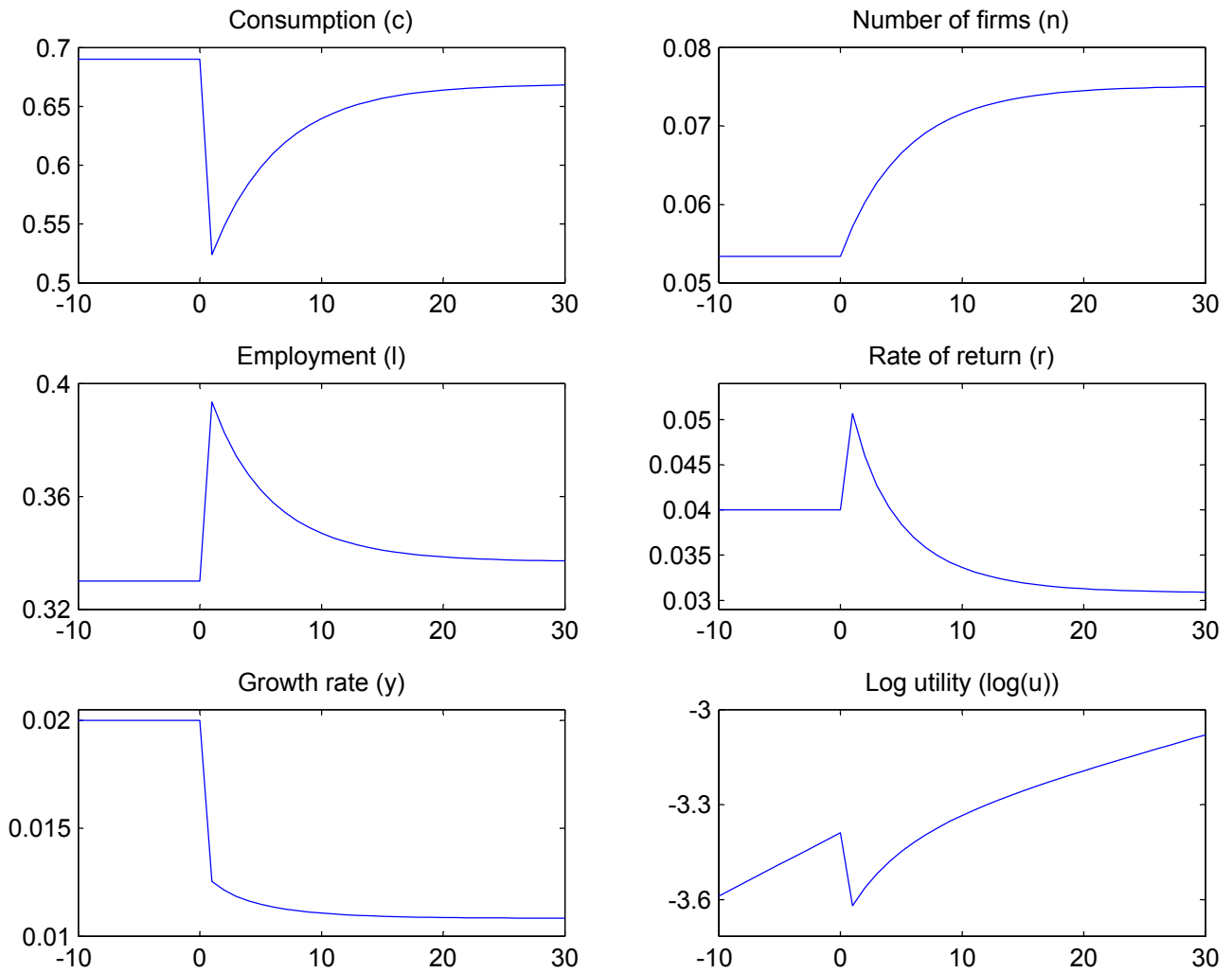


Figure 5. Impulse response function  $\eta = 0$ : dividend and capital gains tax rate reduction

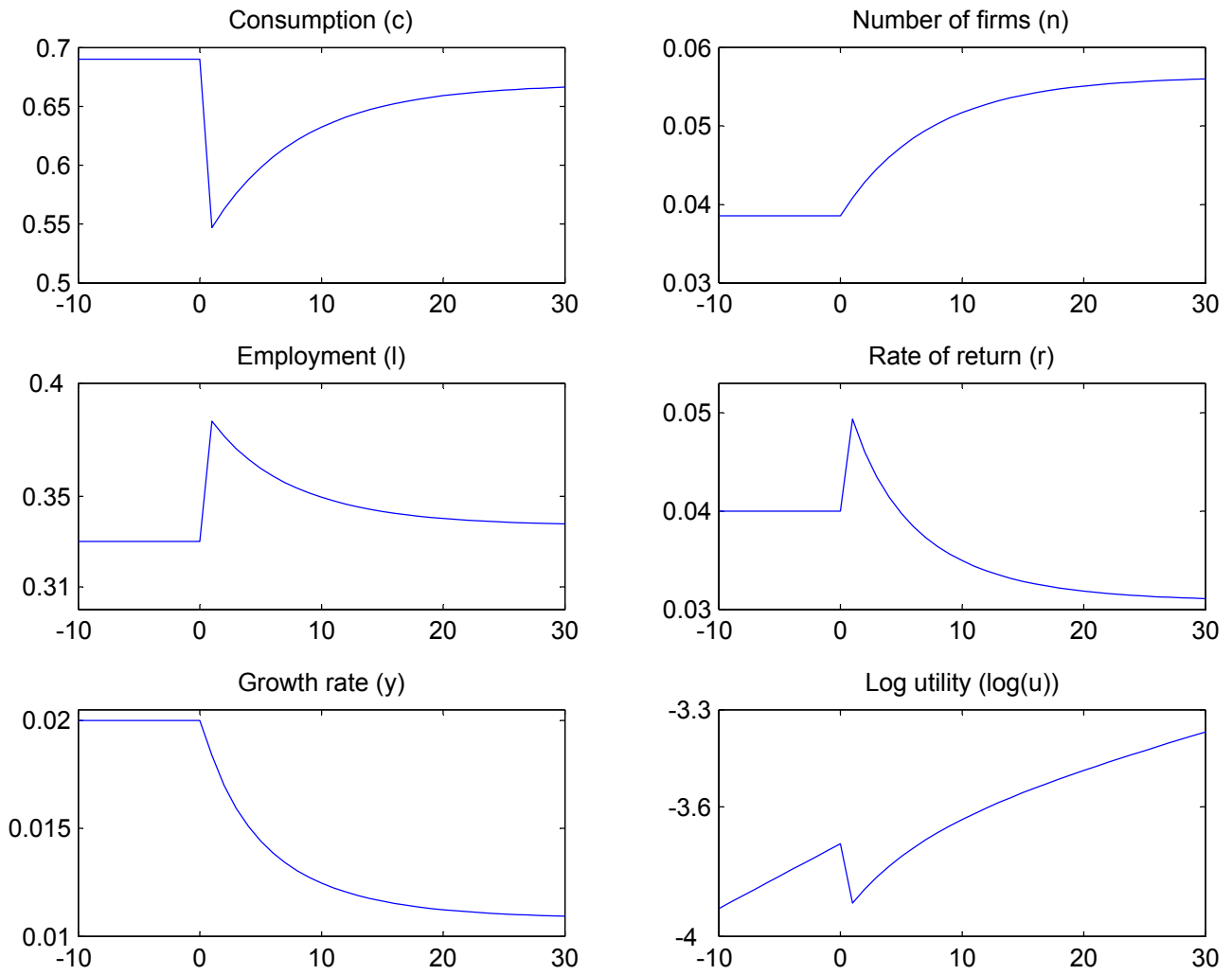


Figure 6. Impulse response function  $\eta = 0.1$ : dividend and capital gains tax rate reduction

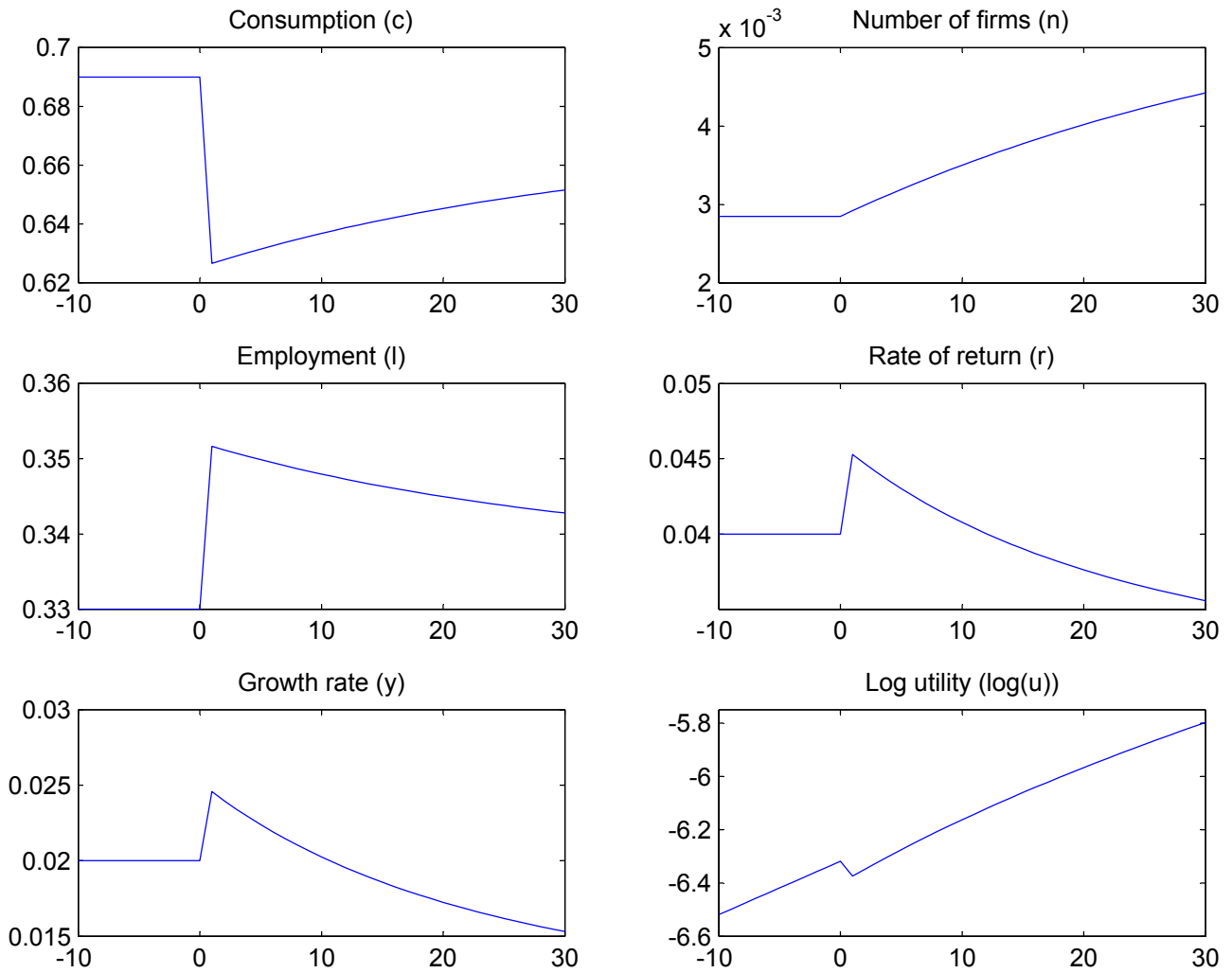


Figure 7. Impulse response function  $\eta = 0.5$ : dividend and capital gains tax rate reduction

Figure 8. Welfare cost/gain for different values of  $\eta$

