Fiscal Policy and Growth in a Model with Adjustment Costs to Investment*

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June 2014

AREA 4 - MACROECONOMIA, ECONOMIA MONETÁRIA E FINANÇAS

Abstract

This article presents a neoclassical growth model with adjustment costs to investment and a variety of different fiscal policies. The goal is to analyze how fiscal policies can influence investment decision, capital accumulation and productivity. The model is calibrated using Brazilian data and a set of experiments is performed to investigate the effect of different taxations. We find that tax on private bonds return has the most significant effect on capital level and productivity. This finding comes from the fact that, in equilibrium, an increase in taxation on bonds return decreases the present value of dividends and firm's value throughout real interest rate.

Keywords: Investment, Adjustment Cost, Fiscal Policy.

Resumo

Este artigo apresenta um modelo de crescimento neoclássico com custo de ajustamento ao investimento e uma variedade de diferentes políticas fiscais. O objetivo é analisar como políticas fiscais podem influenciar decisão de investimento, acumulação de capital e produtividade. O modelo é calibrado usando dados brasileiros e um conjunto de experimentos é feito para investigar o efeito de diferentes tributações. Nós concluimos que imposto sobre o retorno de títulos prrivados tem o efeito mais significativo para o nível de capital e produtividade. Este achado vem do fato de que, em equilíbrio, um aumento na tributação do retorno dos títulos diminui o valor presente dos dividendos e o valor da firma através da taxa de juros real.

Palavras-Chave: Investimento, Custo de Ajustamento, Política Fiscal.

JEL Classification: E22; E62

*We owe many thanks to Marcelo S. Bego and Adalto B. Gonçalves for valuable comments.
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"We contend that for a nation to tax itself into prosperity is like a man standing in a bucket and trying to lift himself up by the handle."

– Winston L. S. Churchill.

1 Introduction

The investment represents an essential element in the dynamics of any economy, whether in the short or long term, especially for being one of the main components in the determination of output, employment and income.

Casagrande (2002) considers that the investment sets, at the aggregate level, the economics performance. Moreover, it is also a source of capital accumulation and, therefore, the major determinant of the capability of the economy in the long run. Consists, according to the author, on an unstable component of aggregate demand and responsible for variations in income and employment.

Assumed its importance, there are a number of studies aimed to define the determinants of investment. Analyzing the determinants of private investment in Brazil in the period 1970-1995, Melo and Rodrigues Júnior (1999) found positive effects of aggregate demand on investment, negative relationship between private and public investment in the short-term, positive influence of the availability of demand credit and unfavorable impact of economic instability on investment from the private sector. Ribeiro and Teixeira (2001) add the negative effect of large currency devaluations on private investment.

In order to assess the effects of fiscal policy on investment, based on a panel of OECD countries, Alesina et al. (1999) found a significant negative effect of public spending on private investment. This effect was more evident for the salary component of the public sector, indicating the relevance of the public spending pressure on private investment.

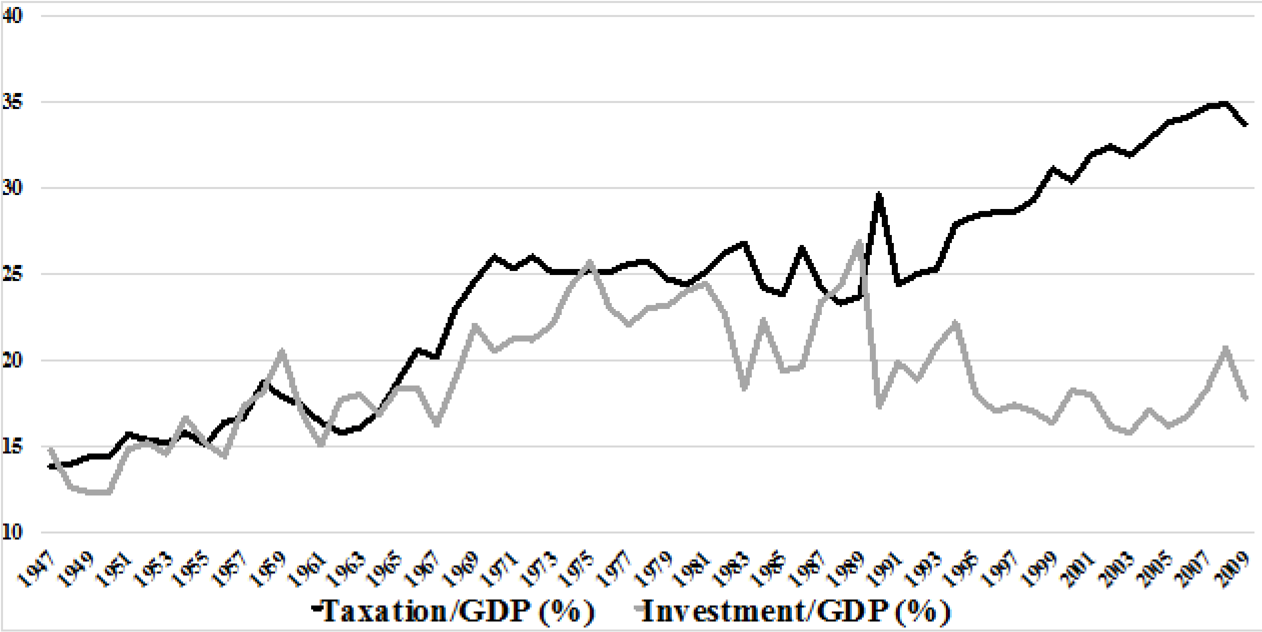
Another important factor relative to investment is the tax burden, keeping an inverse relationship between them. When analyzing in particular the Brazilian economy for the 2000s, Giambiagi (2006), Pastore and Pinotti (2006) and Veloso (2006) show that the increasing tax burden discourages private investment, which tends to reduce the potential growth of country. As an alternative to the resumption of investment, these authors indicate a significant reduction in public spending and in the tax burden of the economy.

Furthermore, when estimating the elasticity of investment relative to Brazilian taxation, Santos and Pires (2009) indicates that an increase of 1% in tax rate is associated with a 1% reduction in private investment.

In this regard, figure 1 shows the ratio of taxation/GDP vis-a-vis investment/GDP, in the 1947-2009 period, according to data from IPEADATA (2014). Corroborating these authors, its empirically observed that the tax burden over Gross Domestic Product (GDP) ratio ranged from 27.9% in 1994 (year marked by economic stabilization promoted by the Plano Real), to 30.4% in 2000 and 33.7% in 2009. During the same period, the investment/GDP ratio registered decrease, indicating 22.2%, 18.3% and 17.8%, respectively.

Therefore, considering the period in Figure 1, the tax burden has grown considerably, relative to the Brazilian GDP, from 1963 to 1970, while the investment/GDP ratio, paradoxically, grew until 1981. Veloso et al. (2008) associates it, mainly, to the lagged effect associated with the restructurings of Program of the Government Economic Action (PAEG), in the administration of President Castello Branco (1964-1967). However, during the second half of the 1980s, Brazil experienced a sharp drop in investment, possibly because of internal political and economic instabilities, confirmed by Luporini and Alves (2010). It is observed from then,

Figure 1: Taxation/GDP and Investment/GDP, in %, for Brazilian economy, 1947 to 2009. Source: IPEADATA (2014).



in general, negative relationship between taxes and investment, supporting research by Santos and Pires (2009). Especially after the 1994 Brazilian economic stabilization, there is a progressive increase in the tax burden, in order to sustain the persistent increase in public spending in the same period, as discussed by Giambiagi (2006), Pastore and Pinotti (2006) and Veloso (2006). This behavior may have inhibited investment, which remained on a downward trend, with change of trajectory only in 2003-2008 as a result of public interventions. Finally, in 2009, in response to the international economic crisis, the Brazilian tax burden recedes in proportion to GDP, however, with investment accompanying such movement.

Thus, the purpose of this article is to analyze how the tax component, mainly taxes over profit and revenue of firms, can affect investment decision, productivity, growth and well being of the Brazilian economy. The paper proceeds as follows. Section 2 presents the model and the calibration strategy, section 3 shows the quantitative results with different government labor market policies. Section 4 provides concluding remarks.

2 Model

In this section, we use the neoclassical growth model to analyze different fiscal policies. We add technological shocks to total factor productivity: $A = A(s)$ where s follows a Markov Chain with transition matrix P. Therefore, in equilibrium, prices will depend on the aggregate state variables: (K, s).

Preferences

There are a measure one of identical infinitely lived agents. Their instantaneous utility function is defined over consumption and leisure. Agents own firms and receive dividends.

They also can trade one-period bonds. Government taxes families on consumption, savings and labor income. The representative agent faces the following problem:

$$v(b, z, K, s) = max_{(c,l,z',b')}\{u(c, 1 - l) + \beta E[v(b', z', K', s')/s]\} \tag{1}$$

subject to

$$(1 + \tau^c)c(K, s) + P^z(K, s)z' + b' = W + (1 - \tau^l)w(K, s)l + T \tag{2}$$

$$c \geq 0; 1 \leq z' \geq 0; 1 \leq l \geq 0; \tag{3}$$

where:

$$W' = (1+r(K, s)(1-\tau^{b'}))b'+(P^z(K', s')+d^z(K', s'))z'-[(1-\tau^{z'})(P^z(K', s')-P^z(K, s))]^+z' \tag{4}$$

with

$$[(1 - \tau^{z'})(P^z(K', s') - P^z(K, s))]^+ = max\{(1 - \tau^{z'})(P^z(K', s') - P^z(K, s)), 0\} \tag{5}$$

Note that there are two types of taxation on household savings. The first one is the taxation on the net return of one-period bonds (τ^b) and the second one is the taxation on capital gain from stocks (τ^z). Equation (5) shows that capital gain taxation is strictly positive only when selling price is higher than purchased price.

Technology

Firms face taxation on dividends and production. They own capital and make investment's decision. For simplicity, we assume that depreciation rate equals 100%. Investment is subject to an adjustment cost that is assumed to be a quadratic function: $J(I)$.

$$V(K, s) = max_{\{d,L,I,K'\}}\{(1 - \tau^d)d + \frac{1}{1 + r(s)}E[V(K', s')/s]\} \tag{6}$$

subject to:

$$d = (1 - \tau^y)A(s)F(K, L) - w(K, s)L - I - J(I) \tag{7}$$

$$K' = I \tag{8}$$

Government

Government has a balanced budget for each period and each state:

$$g'+T' = \tau^{c'}c'+\tau^{l'}w(K', s')l'+r(K', s')\tau^{b'}b'+[\tau^{z'}(P^z(K', s')-P^z(K, s))]^+z+\tau^{d'}d'+\tau^{y'}A(s')F(K', L') \tag{9}$$

2.1 Recursive Competitive Equilibrium

A stationary recursive competitive equilibrium is a set of price functions: $\{r(K, s)$, $P^z(K, s)$, $w(K, s)\}$; household's allocation functions: $\{c(b, z, K, s), l(b, z, K, s), b'(b, z, K, s), z'(b, z, K, s)\}$; firm's allocation functions: $\{d(K, s)$, $L(K, s)$, $I(K, s)$, $K'(K, s)\}$, government fiscal policies: $\{g, T, \tau^c, \tau^l, \tau^b, \tau^z, \tau^d, \tau^y\}$ and value functions: $v(b, z, K, s)$ and $V(K, s)$ such that:

i. $v(b,z,K,s)$ satisfies household's Bellman equation (1) and $c(b,z,K,s)$, $l(b,z,K,s)$, $b'(b,z,K,s)$ and $z'(b,z,K,s)$ are the associated policy functions.

ii. $V(K,s)$ satisfies Bellman equation (6) and $d(K,s)$, $L(K,s)$, $I(K,s)$ and $K'(K,s)$ are the associated policy functions.

iii. Government fiscal policies satisfies (9)

iv. Markets clear:

$$c+g+I = A(s)F(K,L) - J(I) \tag{10}$$

$$l = L \tag{11}$$

$$b = 0 \tag{12}$$

$$z = 1 \tag{13}$$

v. Law of motion for aggregate states (K,s) is induced by the Markov chain and the optimal policy for aggregate capital, $K' = g(K,s)$.

Market clearing conditions (10) shows that aggregate demand equals the net production function out of adjustment costs. Appendix (A) shows the partial equilibrium analysis for representative household and appendix (B) shows the decision for the representative firm.

2.2 Calibration Strategy and Benchmark Economy

In order to study the competitive equilibrium, the model is calibrated to replicate the Brazilian economy in the deterministic long-run economy and a set of experiments is conducted. We feed the model with changes in the government parameters to study how much of the change in investment and production can be accounted for changes in fiscal policy. The algorithm for the numerical solution consists of linearizing all the equations that characterizes the equilibrium using first order Taylor approximation around the deterministic steady state.

The instantaneous utility function used is the additive separable logarithm utility function, therefore, there are just two parameters to calibrate for preferences: β and a [1]. β was calibrated to match Brazilian annual real interest rate of 43.4% [2]. The other parameter, a, was calibrated to match the time Brazilian workers allocate to labor market activities [3].

The production function is assumed to be a Cobb-Douglas, hence, there are four parameters to calibrate for technology: the capital share, θ; the parameter for the adjustment cost function, A_I, where $J(I) = A_I I^2$ and two parameters for the technology shock, the persistence parameter, ρ and the variance, σ^2. The capital share and the technology shock parameters were taken from Gomes et al. (2005)[4]. Finally, A_I was calibrated to match Brazilian capital output ratio of 1.75 (Gomes et al. (2005)).

Table 1 shows the last seven remaining parameters to be calibrated regarding to government policies. They were calibrated to match the historical series of public finance: government expenditures, revenue from taxes on consumption, revenue from labor income taxes, revenue

[1] The instantaneous utility function is: $u(c, 1-l) = ln(c_t) + aln(1-l_t)$.

[2] Average annual real interest rate from 1997-2013, source from World Bank database.

[3] According to PNAD (Pesquisa Nacional de Amostra Domiciliar - National Household Survey), h_t is approximately 0.31.

[4] $\theta = 0.45$, $\rho = 0.589$ and $\sigma^2 = (0.0446)^2$.

Government parameters determined jointly	Value	Comments
g	20.35% Y	Total government expenditure
τ_c	5.46% Y	Taxes: ICMS, ISS, IPI
τ_l	1.2% Y	Taxes: IRF and obligatory social security taxes
τ_z	0.10% Y	Taxes: IRPF
τ_b	0.32% Y	Taxes: IRPF
τ_d	4.46% Y	Taxes: IRPJ, CSLL
τ_y	5.35% Y	Taxes: PIS/PASEP, COFINS

Table 1: Government parameters calibrated jointly. Source: IPEADATA

from wealth taxes, revenue from capital gain taxes, revenue from firm's dividends taxes and finally revenue from firm's sales taxes as percentage of Brazilian GDP.

3 Quantitative Results

Adjustment Cost

Figures 2 and 3 show the impulse responses from technological shock in the model without adjustment cost and the model with adjustment cost. The main difference is the speed of adjustment and persistence of the shock. With adjustment cost, the adjustments of investment and capital level are smoother. On the other hand, the adjustments of marginal value of capital (Tobin's q) and the interest rate (RLT) in figures 2a and 3a are faster in the model with adjustment cost to investment. Note that a positive technological shock increases the value of the firm in the short run. Since Tobin's q has increased, investment (and capital level) increases.

Figure 2: Impulse responses from technological shock - Model without adjustment cost.

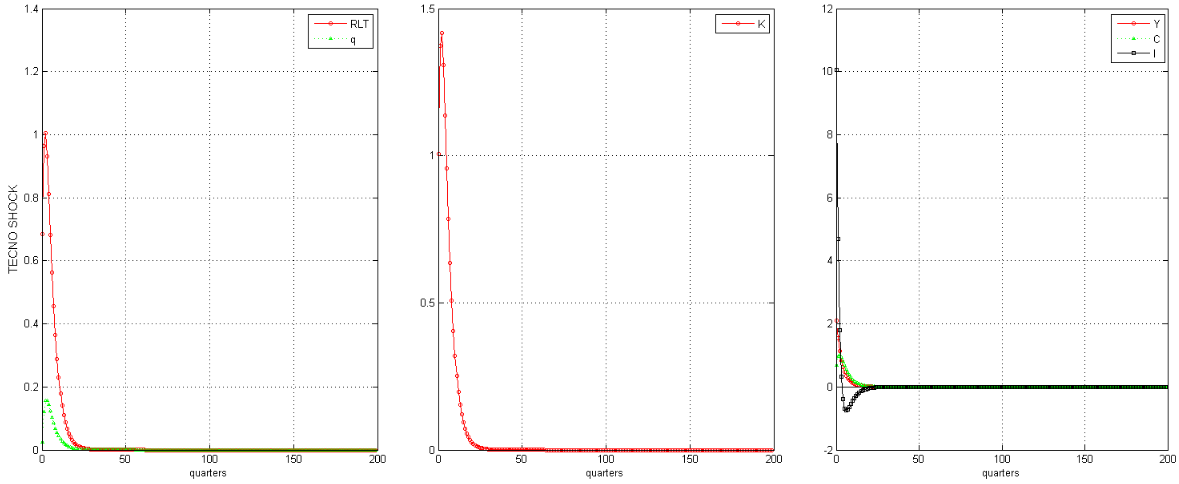
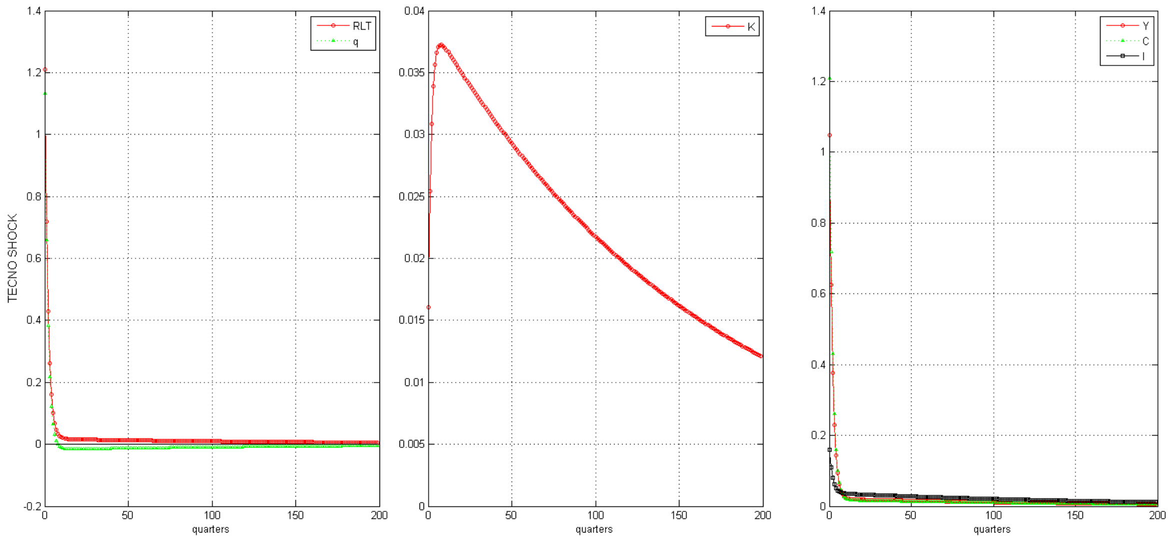


Figure 3: Impulse responses from technological shock - Model with adjustment cost.



Fiscal Policies Implications

With the parameters calibrated, we first analyze the long-run implications of changes in fiscal policy. Because of the nature of government spending, g, an increase in g, ceteris paribus, will only decrease private consumption and have no effect on investment and production. That occurs because, using the government balanced budget (equation 9), an increase in government expenditures increases the lump-sum tax in the same amount implying no distortions in relative prices [5]. Table 2 shows the main long-run results when we increase in 10% and 20% government taxation on firm's production with respect to the benchmark parameters.

Taxation	Output	Change in Consumption as percentage of GDP	Change in Capital as percentage of GDP
Benchmark Case	100	-	-
$1.1\tau_y$	99.15	-1.88%	-2.95%
$1.2\tau_y$	98.33	-3.01%	-5.6%

Table 2: Long-Run results for changes in taxation on production

Table 2 shows that an increase of 10% in the tax on sales, τ_y, decreases capital level in approximately 3% of GDP, which is greater than the effect in U.S. of 2% (Djankov et al. (2010)).

Taxation	Output	Change in Consumption as percentage of GDP	Change in Capital as percentage of GDP
Benchmark Case	100	-	-
$1.1\tau_b$	98.27	-1.97	-5.87%
$1.2\tau_b$	95.48	-3.76	-11.66%

Table 3: Long-Run results for changes in taxation on bonds

Interestingly, the most important tax with respect to capital accumulation is the taxation on private bonds. This comes from the fact that this tax changes the real interest rate in equilibrium and therefore, impacts on consumption decision and, most important, in the present value of dividends, decreasing firm's value. Table 3 shows that an increase of 10% in the tax on bonds, τ_b, decreases capital level in approximately 6% of GDP, which is almost the double of the effect of taxation on sales.

4 Concluding Remarks

This paper shows that changes in fiscal policy, mainly, taxes on firm's sales and in the return of private bonds have important effects on capital and GDP level. Most important, we showed that, in equilibrium, the strongest effect arises from taxation on private bonds. This happens because an increase in taxes on bond's return changes the real interest rate in the long-run equilibrium, decreasing the value of the firm and, therefore, investment decision in the path towards the new

[5] See Alesina et al (2002) for a model with public investment and government wages.

steady state. In the long run, the economy presents a lower level of capital, lower productivity and lower capital output ratio.

This first draft of the paper just considered the long-run implications of different taxations, therefore, taxes on dividends and capital gains have no effect (see appendix B). Therefore, a natural extension of this paper is to consider short-run effects of government policy shocks. Finally, other possible extension for our model is to consider public investment and government wages in the model in order to analyze how government spending might affect private investment, profit and production.

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A Household's Problem

Let λ be the Lagrangean multiplier. Therefore, the first order conditions for the representative household problem are:

$$\frac{\partial v}{\partial c} = 0 \rightarrow u_1(c, 1-l) = \lambda(1+\tau^c) \tag{14}$$

$$\frac{\partial v}{\partial l} = 0 \rightarrow u_2(c, 1-l) = \lambda(1+\tau^l)w(s) \tag{15}$$

$$\frac{\partial v}{\partial b'} = 0 \rightarrow \beta E[v_b(b', z', s')/s] = \lambda \tag{16}$$

$$\frac{\partial v}{\partial z'} = 0 \rightarrow \beta E[v_z(b', z', s')/s] = \lambda P^z(s) \tag{17}$$

Applying Benveniste and Scheinkman formula to equations (16) and (17) and using equation (14) to substitute for λ:

$$\frac{u_1(c, 1-l)}{u_2(c, 1-l)} = \frac{(1+\tau^c)}{(1+\tau^l)w(s)} \tag{18}$$

$$\frac{u_1(c, 1-l)}{(1+\tau^c)} = \beta E[\frac{u_1(c', 1-l')}{(1+\tau^{c'})}[1+r(s')(1-\tau^{b'})]/s] \tag{19}$$

$$\frac{u_1(c,1-l)}{(1+\tau^c)} = \beta E[\frac{u_1(c',1-l')}{(1+\tau^{c'})}[(P^z(s')+d^z(s'))-(1-\tau^{z'})(P^z(s')-P^z(s))^+]/s] \quad (20)$$

Rearranging equations (19) and (20):

$$\beta E[\frac{u_1(c',1-l')}{u_1(c,1-l)}\frac{(1+\tau^c)}{(1+\tau^{c'})}[1+r(s')(1-\tau^{b'})]/s] = 1 \quad (21)$$

$$\beta E[\frac{u_1(c',1-l')}{u_1(c,1-l)}\frac{(1+\tau^c)}{(1+\tau^{c'})}\frac{[(P^z(s')+d^z(s'))-(1-\tau^{z'})(P^z(s')-P^z(s))^+]}{P^z(s)}/s] = 1 \quad (22)$$

Equation (18) shows that, in the optimum, the ratio of the marginal utilities equals the ratio of the cost between consumption and leisure. Equations (21) and (22) show the well-known general asset pricing formula. For any security, the expected return adjusted by the stochastic discount factor equals one.

B Firm's Problem

The problem of a representative firm is:

$$V(K,s) = max_{\{L,I,K'\}}\{(1-\tau^d)((1-\tau^y)A(s)F(K,L)-w(K,s)L-I-J(I))+\frac{1}{1+r(s)}E[V(K',s')/s]\} \quad (23)$$

subject to:

$$K' = I \quad (24)$$

Let q be the Lagrangean multiplier. Therefore, the first order conditions are:

$$\frac{\partial V}{\partial L} = 0 \rightarrow (1-\tau^d)(1-\tau^y)A(s)F_L(K,L) = w(K,s) \quad (25)$$

$$\frac{\partial V}{\partial K'} = 0 \rightarrow \frac{1}{1+r(s)}E[V_K(K',s')/s] = q \quad (26)$$

$$\frac{\partial V}{\partial I} = 0 \rightarrow (1-\tau^d)[1+J'(I)] = q \quad (27)$$

Note that equation (27) is the famous Tobin's q theory. It shows that firm invests to the point where the market value of capital (q) equals its replacement cost. Using Benveniste and Scheinkman formula in equation (26) and substituting for q using equation (27):

$$\frac{1}{1+r(s)}E[(1-\tau^{d'})(1-\tau^{y'})A(s')F_K(K',L')/s] = (1-\tau^d)[1+J'(I)] \quad (28)$$

With full depreciation and constant taxation, equation (28) can be written as:

$$\frac{1}{1+r(s)}E[(1-\tau^y)A(s')F_K(K',L')/s] = [1+J'(I)] \quad (29)$$

Equation (29) shows that the only tax that matters for firms investment decision is the tax on production as long as the taxation on dividends is constant over time.