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Essays on Fiscal Policies in Open Economies

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Essays on Fiscal Policies in Open Economies

A Dissertation Presented for the

Doctor of Philosophy

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Ahiteme Nicodeme Houndonougbo

August 2014

To my mother Veronique, my wife Foumike, and my daughters Ashley and Ivy.

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Abstract

Investigating various fiscal policy issues in the context of an open economy, this dissertation consists of three essays.

The first essay addresses the question of the volatility of foreign aid and its impact on resource-constrained developing economies. A small open-economy business cycle model is developed that accounts for the effect of external shocks specific to developing economies. The model produces business cycle patterns consistent with the data and key stylized facts. The model is calibrated to reflect the structural empirical regularities of an aid-dependent developing country. The parameters of the exogenous stochastic shocks are estimated using Bayesian methods and 50 years of data for Cote d'Ivoire. The results suggest that foreign aid's unpredictability helps explain business cycles' volatility in developing countries.

In the second essay, a dynamic stochastic general equilibrium model (DSGE) is used to analyze the effects of fiscal stimuli, such as investment tax credits (ITC) and wage subsidies, in a small open economy. Various cost-equivalent fiscal schemes are considered in response to an economic downturn. The baseline open-economy model's results are also contrasted with a closed economy case to highlight the role the current account plays during recession and recovery episodes. The results suggest that wage subsidies have faster but shorter effects on production and employment while ITCs have slower but longer lasting impacts. The persistence of fiscal shocks appears to play a significant role in the initial response of investment.

The third essay provides empirical evidence to address a question heavily debated among lawmakers yet hardly ever investigated in the empirical literature: Does increasing taxes on the rich hurt or help employment growth? Proponents of tax hikes on the rich reject the idea that such taxes, which some refer to as "millionaire" taxes, have any negative impact on jobs. Critics, on the other hand, believe taxing the rich, whom they consider "job creators," hurts the economy by hampering job creation. Using newly constructed time series based on the IRS Statistics of Income, this study finds strong and statistically significant positive effects in the short run and some evidence of negative effects in the long run.

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Chapter 1

Foreign Aid Volatility and Real Business Cycles in a Developing Open Economy

1.1 Introduction

It is widely recognized that the volatility of business cycles in developing economies is significantly higher than in industrialized countries. Aggregate fluctuations in output fell considerably in the United States and other OECD countries during the post-World War II period, while the fluctuations remained high for developing countries. As Rand and Tarp (2002) show, the nature and characteristics of business cycles in the developing world differ significantly from developed countries. The empirical literature also documents the huge welfare and growth costs associated with highly volatile business cycles. Pallage and Robe (2003) provide a good discussion on the welfare cost of business cycles in developing countries (See also Gomes and do Nascimento (2004)). Two common explanations for the excessive fluctuations in developing economies are their inability to implement effective stabilizing policies and their exposure to external shocks in a way that developed countries do not experience.

Many developing economies, especially the most resource-constrained, are heavily dependent on external sources of income such as foreign aid. According to The World Bank, aid represents, on average, approximately 13 percent of GNI for low-income countries.[1] Empirical evidence shows that foreign aid is extremely volatile. Using data for 63 countries from 1969 to 1995, Pallage and Robe (2001) estimate aid flows to be twice as volatile as the output of recipient economies. Bulir and Hamann (2003) found that aid is significantly more volatile than fiscal revenues for 72 aid recipient countries between 1975 and 1997.

Empirical studies have also documented the consequences of high volatility in aid flows. Numerous previous works have analyzed the implications of volatile foreign aid without specifically addressing the effects on the business cycles of recipient countries (Agénor and Aizenman (2010), Arellano et al. (2009), Hudson and Mosley (2008a,b), Lensink and Morrissey (2000) and Raddatz (2007)). Given the substantial welfare and growth consequences associated with highly volatile business cycles, it is important to investigate whether foreign aid exacerbates short-run aggregate fluctuations in recipient countries. This question has critical policy implications. To design effective macroeconomic stabilization policies, it is crucial to understand the specific driving forces of short-run fluctuations in developing economies and how those economies respond to exogenous shocks. The role of foreign aid is particularly relevant because the goal of aid is to reduce poverty and promote economic growth. This study contributes to the literature by clarifying the implications of volatile foreign aid for the business cycles of a developing open economy.

Conceptually, procyclical aid will add to the volatility of business cycles while countercyclical aid acts as a stabilizing mechanism. There has been considerable debate in the literature on this cyclicality issue, but no consensus has been reached. Pallage and Robe (2001) find evidence that foreign aid is strongly procyclical for African countries, in particular, and somewhat procyclical for other developing countries in their sample. However, Rand and Tarp (2002) find that, when optimal filters are applied, there is no statistically significant evidence of procyclical aid disbursement. Instead, they find evidence of countercyclical aid in 10 of the 15 countries in their sample. Similarly, Chauvet and Guillaumont (2009), using trade cycles instead of output, find that the procyclical nature of aid is weak.

Surprisingly, little theoretical work has been conducted with regard to aid volatility and the effect on

[1] Average of Net Official Development Assistance (ODA) as a percentage of Gross National Income (GNI) for the 34 low income countries as classified by The World Bank.

the business cycles of developing countries. Most aid literature is empirical.[2] Agénor and Aizenman (2010), Chatterjee and Turnovsky (2005) and Dalgaard (2008) are rare exceptions. However, these studies are based on deterministic frameworks and are not suitable to study economic fluctuations, which are stochastic by nature. This essay contributes to the literature by reconciling two lines of research: foreign aid volatility and small open-economy real business cycles (RBC).

Despite its remarkable success, the standard small open-economy RBC model performs poorly when applied to the data of developing economies.[3] As Schmitt-Grohe and Uribe (2003) note, the small open-economy RBC model predicts the trade balance-to-output ratio (TBY) to be positively correlated with output and predicts consumption to be smoother than output. However, most low and middle-income economies are characterized by countercyclical trade balance and highly volatile consumption. The relevant literature offers two theories to explain this poor performance. The traditional argument is derived from institutional theories. Supporters of this theory argue that developing countries are characterized by a plurality of distortions and market failures that make standard neoclassical models an inadequate framework to analyze those economies. Some of the distortions cited include weak institutions, widespread corruption, and low property rights enforcement. Recent research departs from this mainstream view and asserts that an explicit account of distortions is not necessary to obtain a good fit of the RBC model with the data. Aguiar and Gopinath (2007) show that the RBC model for a small open economy is consistent with an emerging market economy when productivity shocks have a nonstationary component. They acknowledge the presence of distortions but argue that those distortions can be modeled as nonstationary productivity shocks. However, using long samples from Argentina and Mexico, García-cicco et al. (2010) find that the RBC model, driven by stationary and nonstationary productivity shocks, does not adequately explain the observed business cycles. By augmenting the nonstationary shock model with preference shocks and accounting for international financial frictions, they find that the augmented model does a better job mimicking the data for Argentina.

[2]Pallage and Robe (2001), one of the most cited papers on aid volatility, admit that their work may be subject to the criticism of "measurement without theory".

[3]Williamson (1996) provides reviews and discussions on the RBC approach. Mendoza (1991) extends the method to the case of the small open economy with remarkable success. Applied to the Canadian economy, the model replicates many of the stylized facts typical to a small open economy.

In this study, a model of small open-economy business cycles is developed that successfully replicates the data for a developing country. Unlike Aguiar and Gopinath (2007), nonstationary shocks are not assumed a priori. This study's approach also differs from García-cicco et al. (2010) in that preference shocks are not assumed. To make the model consistent with the reality of developing economies, two sources of exogenous shocks that typically affect those countries are accounted for. Foreign aid is modeled as a stochastic transfer from abroad. This specification of foreign aid is not new to the literature. Arellano et al. (2009) similarly treat aid inflows as a stochastic foreign transfer in their two-sector tradable-nontradable model.[4] Following García-cicco et al. (2010), international financial frictions in the form of stochastic interest rate premium shocks are included. Second, the role of the public sector is introduced in the form of investment in public capital, which is financed by a combination of domestic tax revenue and foreign aid. It is well documented that public capital plays a crucial role in resource-constrained developing countries (see, for example, Agénor (2010), Devarajan et al. (1998) and Chatterjee and Turnovsky (2005)). To my knowledge, this study is the first to account for both foreign aid and public investment in a small open-economy business cycle model.

The predictions of the model confirm the finding by García-cicco et al. (2010) that nonstationary shocks do not play a significant role in the business cycles of developing economies. The model produces business cycle patterns that are qualitatively consistent with the data of Cote d'Ivoire and the key stylized facts that standard RBC models fail to capture. Specifically, the excess volatility of consumption versus output is successfully replicated. The model is calibrated to reflect the structural empirical regularities of Cote d'Ivoire, a typical foreign aid dependent developing country. The parameters of the exogenous stochastic shocks are estimated using Bayesian methods and 50 years of data for Cote d'Ivoire. The results indicate that foreign aid adds significantly to the volatility of business cycles in aid-dependent countries. Findings also include evidence that directing more aid resources to public investment instead of household transfers potentially reduces the volatility

[4] As discussed earlier, the exogenous nature of foreign aid is still matter for debate in the empirical literature (Pallage and Robe (2001), Rand and Tarp (2002) and Chauvet and Guillaumont (2009)). It is arguable that a single figure for aid (aggregate aid) is not endogenous to the recipient economy. As Mavrotas and Ouattara (2006) note, aid is heterogeneous and each of its components is differently related to the recipient economy. For example, it makes sense to think of emergency or relief aid as countercyclical while investment-tied aid is possibly procyclical.

of consumption.

The remainder of the essay is organized as follows. Section 2 presents the theoretical developing open-economy business cycle model with foreign aid and international financial frictions. Section 3 presents the calibration of the model and the results of the Bayesian estimations. Section 4 evaluates how well the model performs in terms of replicating the observed business cycles and predicting the response of the economy to exogenous shocks. Section 5 is the conclusion.

1.2 The Model

The economy features a continuum of infinitely-lived identical households. The representative household maximizes its lifetime expected utility from consumption C and leisure:

$$E\sum_{t=0}^{\infty}\beta^t U(C_t, L_t) \tag{1.1}$$

where L stands for labor hours and β is a constant subjective discount factor.

As in standard small open-economy RBC models, domestic residents can borrow from the rest of the world to smooth consumption. The stock of debt at time t, denoted D_t, is subject to the interest rate R_t. The world interest rate R^* is exogenously determined abroad. As a small open economy, residents can borrow as much as they want without affecting the world interest rate. However, a risk premium is assessed based on the aggregate level of indebtedness of the economy. The interest rate R_t is given by:

$$R_t = R^* + p\left(\frac{D_t}{Y_t}\right)$$

where $p\left({}^{D_t}/_{Y_t}\right)$ is the country-specific risk premium. The premium $p(.)$ is a strictly increasing function of indebtedness, as measured by the ratio of stock of foreign debt to output ${}^{D_t}/_{Y_t}$. Schmitt-Grohe and Uribe (2003) showed that using a debt-elastic interest rate premium is one of many ways to ensure stationarity in the small open-economy model with results that are consistent across methods.[5]

[5]Other methods to ensure stationarity include using an Uzawa type preference (endogenous discount factor),

The risk-premium here does not just serve the purpose of ensuring stationarity, as in standard models. The risk premium parameter is calibrated to reflect the actual economy, as discussed in section 3. More importantly, foreign debt shocks are included, as in García-cicco et al. (2010).[6] Blankenau et al. (2001) show that international interest rate shocks can explain up to one-third of the fluctuations in output and more than half of the fluctuations in net exports and net foreign assets. These shocks are not unique to developing economies. What is unique, however, is the magnitude of their consequences on those economies. Many of the financial and economic crises that hit developing countries over the last couples of decades either originated from or were aggravated by sky-rocketing interest rate premiums (Calvo (1998) and Calvo and Mendoza (2000)). A popular example of this is the 1994 Mexican "Tequila" crisis that spread across Latin-American countries and other unrelated emerging markets worldwide.

The country interest rate premium takes the following form:

$$p\left(\frac{D_t}{Y_t}\right) = \psi\left(e^{\frac{D_t}{Y_t}} - 1\right) + \iota_t$$

where ι_t represents the shock to the risk premium and is given by the following AR(1) process:

$$\iota_t = \rho_\iota \iota_{t-1} + \varepsilon_{\iota t}; \qquad \varepsilon_{\iota t} \sim NIID(0, \sigma_\iota^2) \tag{1.2}$$

In sum, the debt-elastic interest rate with premium shocks takes the following form:

$$R_t = R^* + \psi\left(e^{\frac{D_t}{Y_t}} - 1\right) + \iota_t \tag{1.3}$$

Equation 1.3 shows that the premium is nil in expectation for an economy with no external debt. A debt free economy is subject to the world rate and the random component of the potential premium. In addition to the ability to borrow, domestic residents receive international transfers in the form of foreign aid, A_t, which follows the AR(1) process:

introducing portfolio adjustment costs and assuming complete asset markets. In this study, the debt-elastic interest rate approach is used because it realistically reflects the interest rate challenges facing emerging countries.

[6] These innovations constitute a notable departure from the standard RBC model, as noted by García-cicco et al. (2010). The terms "foreign debt shocks" and "interest rate premium shocks" are used interchangeably to denote international financial frictions.

$$\ln\left(A_t/A\right)=\rho_a \ln\left(A_{t-1}/A\right)+\varepsilon_{at}; \qquad \varepsilon_{at}\sim NIID(0,\sigma_a^2) \tag{1.4}$$

where A is the long-run level of foreign aid. As mentioned in the introduction, whether foreign aid is truly exogenous to the recipient economy is a question that is not settled in the literature (Agénor and Aizenman (2010), Chauvet and Guillaumont (2009), Pallage and Robe (2001) and Rand and Tarp (2002)). Aspects such as conditional aid, social insurance aid and aid as a reward for good governance are, among others, candidate justifications for endogenous aid processes (Paul (2006) presents a survey on the topic). However, there is limited empirical evidence in support of the cyclical nature of aid with respect to the recipient economy. In contrast, the high volatility of foreign aid compared to domestic output and fiscal revenue is well documented (Agénor and Aizenman (2010) present a summary). In this study, aid is modeled as an exogenous process to abstract from the discussion on its possible cyclicality and only focus on its proven volatility. Arellano et al. (2009) follow a similar approach and treat aid inflows as a stochastic foreign transfer in their two-sector tradable-nontradable model.

The standard stochastic production technology is augmented with public capital H_t. For each period t, the economy produces a single output Y_t using labor L_t and the stocks of public capital H_{t-1} and private capital K_{t-1} available at the beginning of period t. Hence:

$$Y_t = Z_t F\left(H_{t-1}, K_{t-1}, L_t\right) \tag{1.5}$$

where Z_t is the random technology variable, following the AR(1) process:

$$\ln Z_t = \rho_z \ln Z_{t-1} + \varepsilon_{zt}; \qquad \varepsilon_{zt}\sim NIID(0,\sigma_z^2) \tag{1.6}$$

The stocks of private and public capital evolve according to the standard laws of motion described in equations 1.7 and 1.8, where I_t and J_t are private and public investments and δ and ζ are the depreciation rates.

$$K_t = (1-\delta)K_{t-1} + I_t \tag{1.7}$$

$$H_t = (1-\zeta)H_{t-1} + J_t \tag{1.8}$$

The government provides public capital through a combination of tax revenue and foreign aid. The government budget constraint is given by

$$\tau_t Y_t + \pi A_t = J_t + \Phi_2\left(H_t - H_{t-1}\right) \tag{1.9}$$

where τ_t is the tax rate, $\pi \epsilon\, [0,1]$ is the fraction of aid allocated to public investment and $\Phi_2(.)$ is a convex capital adjustment cost function, with $\Phi_2(0) = 0$ and $\Phi_2'(.) > 0$. The tax rate is assumed to be constant and exogenously set by the government:

$$\tau_t = \tau \tag{1.10}$$

The remaining portion of aid, $(1-\pi)$, enters the household's budget constraint as a transfer, as shown in equation 1.11.

$$D_t = \left(1 + R_{t-1}\right) D_{t-1} + C_t + I_t + \Phi_1\left(K_t - K_{t-1}\right) - \left(1 - \tau_t\right) Y_t - \left(1 - \pi\right) A_t \tag{1.11}$$

where I_t is private investment and $\Phi_1(.)$ represents private capital adjustment costs with similar properties as $\Phi_2(.)$.

The representative household maximizes its lifetime expected utility (1.1) subject to equations 1.2 to 1.11 and a no-Ponzi game condition of the form:

$$\lim_{v \to \infty} \frac{D_{t+v}}{\prod_{u=1}^{v}\left(1 + R_u\right)} \leq 0$$

Let λ_t denote the Lagrange multiplier associated with the household's budget constraint (equation 1.11). The first-order conditions (FOCs) of this maximization problem are equations 1.2 to 1.11

holding with equality, and

$$U_C\left(C_t, L_t\right) = \lambda_t \tag{1.12}$$

$$U_L\left(C_t, L_t\right) = -\lambda_t\left(1-\tau_t\right) Z_t F_L\left(H_{t-1}, K_{t-1}, L_t\right) \tag{1.13}$$

$$\lambda_t = \beta(1+R_t) E_t \lambda_{t+1} \tag{1.14}$$

$$\lambda_t\left[1+\Phi_1'\left(K_t-K_{t-1}\right)\right] = \beta E_t \lambda_{t+1}\left[(1-\delta)+E_t \Phi_1'\left(K_{t+1}-K_t\right)+\left(1-\tau_t\right) Z_{t+1} F_K\left(H_{t-1}, K_{t-1}, L_t\right)\right] \tag{1.15}$$

The FOCs 1.12 to 1.15 are standard. Combining equations 1.12 and 1.13 yields the labor market equilibrium condition, which implies that real wages must equal the effective marginal product of labor (MPL):

$$-\frac{U_L}{U_c} = \left(1-\tau_t\right) Z_t F_L(H_{t-1}, K_{t-1}, L_t)$$

Equations 1.14 and 1.15 are Euler equations, similar to those found in standard small open-economy RBC models. However, they now embed the interest rate premium shocks ι_t and serve as a transmission mechanism to propagate those shocks into the economy.

A dynamic competitive equilibrium is characterized by a set of processes, $\{D_t, R_t, K_{t+1}, H_{t+1}, C_t, L_t, Y_t, I_t, J_t, \lambda_t, \tau_t, Z_t, A_t, \iota_t\}$, which satisfies equations 1.2 to 1.15, the initial conditions and the no-Ponzi game constraint. As a non-linear stochastic model, there is no analytical solution for the transitional dynamics. The model is log-linearized around its unique stationary state. Numerical simulations are used to approximate the law of motion of each variable in the vicinity of the steady state given the state of economy, $\{D_{t-1}, K_{t-1}, H_{t-1}, R_{t-1}\}$ and the exogenous stochastic processes $\{Z_t, A_t, \iota_t\}$.

1.3 Calibration and Estimation Methods

This study uses functional forms that are common in small open-economy RBC models and relies on a combination of calibration and Bayesian estimation to determine the values of the parameters. Preferences are represented by a GHH-type utility function following Greenwood et al. (1988):

$$U(C,L) = \frac{\left(C - \theta\omega^{-1}L^{\omega}\right)^{1-\gamma} - 1}{1-\gamma}$$

where γ is the coefficient of relative risk aversion and θ and ω are the parameters for the intertemporal elasticity of substitution in labor supply.

The cost functions take the following forms: $\Phi_j(x) = {}^1\!/_2\phi_j x^2$ with $\phi_j > 0$ and $j = 1, 2$.

The study assumes a Cobb-Douglas production function with constant returns to scale in public capital, private capital and labor:

$$F(H,K,L) = H^{\kappa}K^{\alpha}L^{1-\alpha-\kappa}$$

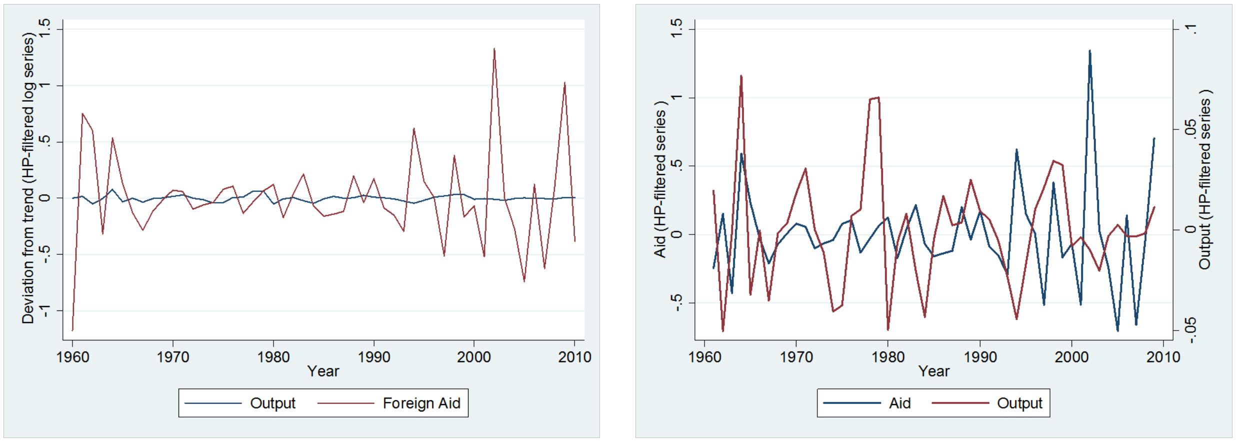
where $\alpha, \kappa > 0$ and $\alpha + \kappa < 1$.

The goal of the calibration exercise is to set the "deep" parameters such that the steady state generated by the model is roughly consistent with the structural empirical facts of the developing economy being studied.

This studies identifies developing countries that are foreign aid-dependent and for which long macroeconomic time series are available. Cote d'Ivoire is one of the few candidate countries that satisfied both criteria.[7] The time series considered are annual observations from 1960 to 2010. The data are from the World Bank's World Development Indicators (WDI) database. Appendix A1 provides further details on the observed series used. Figure 1.1 shows the volatility of foreign aid

[7] Cote d'Ivoire is a former French colony in West Africa on the Gulf of Guinea. Unlike many neighboring countries, it has experienced a long period of political stability following its independence from France in 1960. Cote d'Ivoire is chosen for a few reasons: (1) about 50 years of time series are available for the variables of interest; (2) there are several previous studies on Cote d'Ivoire in the foreign aid literature (e.g., Mavrotas and Ouattara (2006) and Arellano et al. (2009)) and (3) the Ivorian business cycle pattern is fairly similar to Argentina's (with a severe output collapse in the 1980s), and Argentina has been extensively studied in emerging economy RBC papers, providing reference results (Kydland and Zarazaga (2002), Aguiar and Gopinath (2007) and García-cicco et al. (2010)).

compared to output for the past 50 years. Comparing the standard deviations over the period, foreign aid is almost four times more volatile than output.



(a) Panel A

(b) Panel B (Scaled)

Figure 1.1: Volatility of Aid and Output in Cote d'Ivoire

Notes: All series are HP-filtered with the parameter lambda equal 6.25.

Figure 1.2 illustrates the domestic output trend for this timeframe. Cote d'Ivoire experienced two decades of successful economic growth following its independence in 1960. However, during this timeframe, the country also incurred high foreign debt. The drop in commodity prices in the early 1980s combined with the second energy crisis in the late 1970s sent the country into a severe economic depression that lasted more than a decade. The Ivorian economy showed signs of a promising recovery during the 1990s but then experienced another severe economic downturn due to political troubles in 1999 and the beginning of a civil war in 2002.

The period from 1960 to 1980 is assumed to be representative of the long-run balanced growth path to calibrate the model. Kydland and Zarazaga (2002) adopted a similar approach for their calibration, using data for Argentina. The parameter values from the calibration exercise are summarized in Table 1.1. The value of the parameter ψ is set to mimic the average trade balance-to-output ratio of Cote d'Ivoire during this period. On average, the trade balance is positive and approximately 6 percent of GDP. The parameter ϱ corresponds to the Ivorian public investment share of GDP, which is approximately 12 percent. The private and public capital depreciation rates δ and ζ are set to 7 percent and 5 percent, respectively, yielding a private investment share of approximately

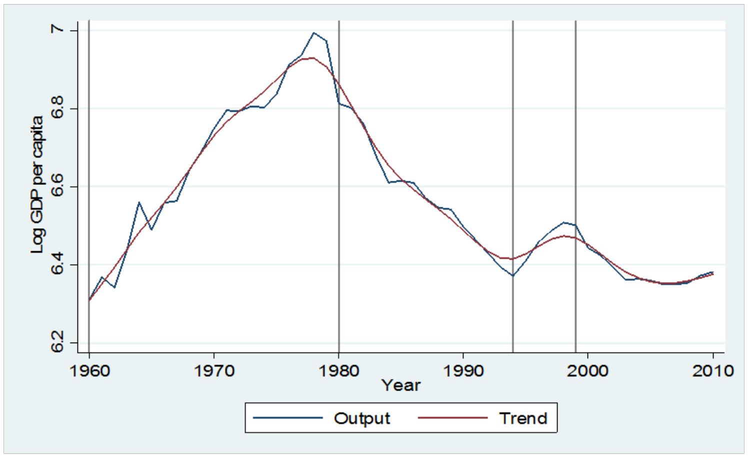


Figure 1.2: Output and its Trend in Cote d'Ivoire from 1960 to 2010
Notes: Trend obtained using an HP filter with lambda=6.25.

11 percent of GDP, which is roughly in line with the average value observed in Cote d'Ivoire. The parameters for the intertemporal elasticity of substitution in labor supply ω and θ are set such that in the steady state households allocate 36 percent of their time to labor.

This study faces the same difficulty as previous studies in regard to assigning values to factor income shares, as there is no reliable data for developing countries. Commonly used values in related literature are adopted; α and κ are set at 0.3 and 0.12, respectively. There is also no reliable data for π, which is set low enough to account for the fact that only a small portion of aid is effectively spent on productive investment. Government expenditure on services and goods, other than capital goods, is treated as a simple transfer to the household. Finally, the discount factor β is set such that the annual real interest rate is approximately 11 percent in the steady state. Assuming that the world interest rate is 4 percent, the implied country risk premium is approximately 7 percent, which is high but realistic for a developing country. García-cicco et al. (2010) set the discount factor for Argentina such that the average annual interest rate is 8.5 percent.

Table 1.1: Calibration

α	β	δ	κ	π	ψ	θ	ϱ	ω	ζ
0.3	0.9	0.07	0.12	0.1	0.05	1.6	0.12	1.75	0.05

The parameters of the exogenous stochastic processes that propagate shocks in the economy using are estimated using Bayesian methods and observed Ivorian data.[8] Specifically, the AR(1) coefficients ρ_z, ρ_a, and ρ_ι and the standard deviations σ_z, σ_a, and σ_ι are estimated. The time series data used include domestic output, foreign aid, and trade balance-to-output ratio from 1960 to 2010. The priors on the AR(1) coefficients are drawn from beta distributions with a 95 percent probability interval that ranges from 0.46 to 0.95. The priors on the standard deviations of the exogenous shocks are drawn from inverse-gamma distributions such that the 95 percent probability intervals have a lower bound near zero and a large upper bound. For more details on the priors, see appendix A2.

1.4 Results and Discussion

1.4.1 Estimation results

Table 1.2 summarizes the posterior distributions of the estimated parameters.[9] The results show that the exogenous processes are persistent. Foreign aid shocks are slightly more persistent than productivity shocks, with a mean half-life of approximately 6 years versus 5 years for productivity shocks. Interest rate premium shocks are extremely persistent, with an estimated coefficient that suggests a process close to a random walk. The estimated standard deviation of foreign aid shocks is almost five times larger than that of productivity shocks and about three times larger than that of foreign debt shocks. The estimates suggest that the model attributes a significant share of business cycle fluctuations to foreign aid shocks. This result is confirmed by the variance decomposition exercise shown in Table 1.3. Foreign aid shocks have the highest impact on the volatility of consumption and public investment. As expected, foreign debt shocks have the highest impact on the volatility of private investment and trade balance. Positive premium shocks force the economy to cut back on deficits. Given the preference for consumption smoothing, deficit cuts severely affect investment.

[8] Estimations were carried out using the software Dynare version 4.2 (Griffoli (2011), Adjemian et al. (2011).)
[9] See Appendix A3 for plots of the probability density functions (PDF) of the posteriors

Table 1.2: Estimation Results: Posterior distributions

Parameter	Mean	95% Conf. Interval		Half-life (Mean)
ρ_z	0.88	0.80	0.96	5
ρ_a	0.89	0.86	0.92	6
ρ_ι	0.99	0.99	0.99	69
σ_z	0.15	0.12	0.18	
σ_a	0.72	0.59	0.85	
σ_ι	0.24	0.20	0.29	

Notes: Estimations are based on five independent runs of Markov Chain Monte Carlo (MCMC) Metropolis-Hasting simulations with 100,000 draws each, from which the first halves were discarded. Plots of the posteriors distributions are shown in Appendix A3. Brooks and Gelman 1989 statistics are shown in Appendix A4. The half-life estimates are computed as $\ln 0.5/\ln \rho_x$ *where* $x = z, a, \iota$.

Table 1.3: Variance Decomposition

Variable	Productivity shock	Foreign aid shock	Interest rate premium shock
Output	43.76	49.15	7.09
Consumption	9.43	88.28	2.3
Investment	23.79	51.06	25.15
Public Investment	11.35	86.81	1.84
Trade balance-to-output	5.91	84.17	9.92

1.4.2 Business cycles properties

As discussed in the introduction, one of the key shortcomings of the standard small open-economy RBC model is its inability to properly replicate the autocorrelation of the trade balance-to-output ratio when applied to developing economies. The standard RBC models and the models with non-stationary shocks theorized by Aguiar and Gopinath (2007) predict a coefficient of autocorrelation that is close to unity and flat over time. This suggests that the TBY ratio follows a process close to a random walk. In the observed data, however, it is clear that the autocorrelation coefficient is less than one for the first order and quickly declines to zero by the fourth lag. For example, for Cote d'Ivoire, the actual first order autocorrelation is 0.67. the model generates predictions that are fairly close to the data, both in terms of magnitude and trend (see Figure 1.3).

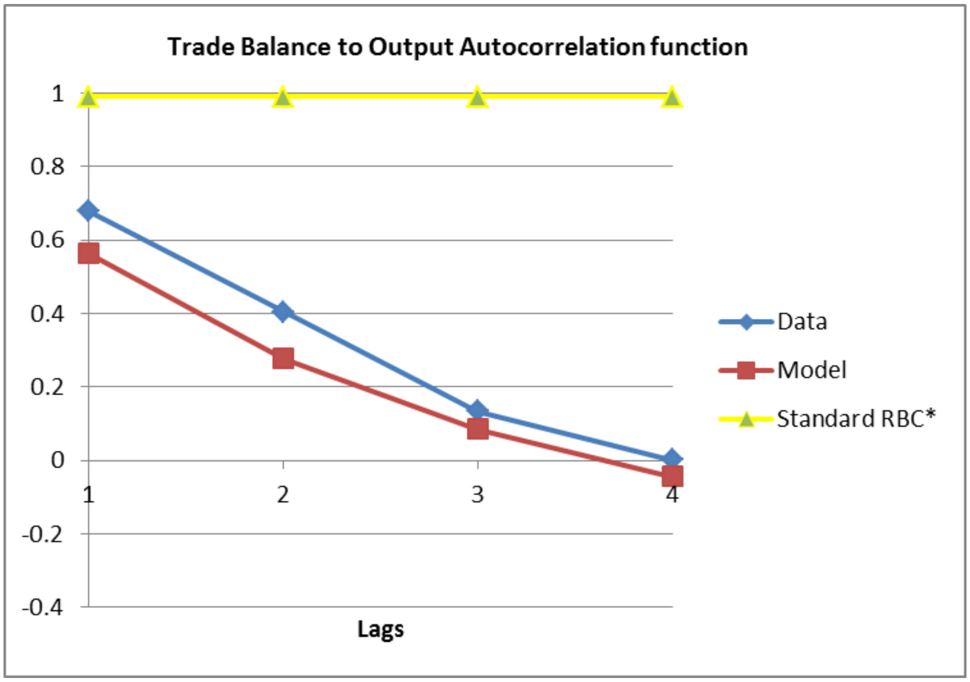


Figure 1.3: Autocorrelation Function of the Trade Balance-to-Output Ratio

Notes: Just as in the data, the model predicts an autocorrelation coefficient close to 0.6 at the first order. The coefficient then declines quickly to zero by the fourth lag. Observations are annual.

* The predicted function for the standard small open economy RBC are borrowed from García-cicco et al. (2010)

One of the main reasons this study's model replicates the behavior of this ratio so well is that it accounts for realistic foreign debt interest rate premiums. In the standard model, the TBY ratio inherits most of its behavior from the near random walk consumption process because of the household preference for smooth consumption. In a model with realistic premiums, the household can still borrow from abroad to smooth consumption, but it must take into account the consequences associated with running consistently high deficits. Trade deficits translate into foreign debt accumulation, which increases interest rate premiums and forces the economy to cut back on the deficit. This issue is further discussed in the second half of this section as the effects of interest rate premium shocks are analyzed.

Perhaps the most critical test for any RBC model is whether it replicates the empirical second moments of the main aggregate variables of the economy. One of the key stylized facts of developing economies' business cycles is that consumption is substantially more volatile than output. Table 1.4 (Panel A) shows the relative standard deviations of consumption and investment with respect to output. The model accurately predicts that both consumption and investment are more volatile than output; however, the volatility of investment is not as high as in the data.

Table 1.4: Data Versus Model Second moments

(a) Standard Deviations (Relative to Output)

	Data*	Model
Output	1	1
Consumption	1.13	1.21
Investment	3.4	1.24

(b) Correlation with Output

	Data*	Model
TBY ratio	-0.05	-0.02
Consumption	0.67	0.64
Investment	0.14	0.16

** The empirical second moments are calculated from Ivorian data for the period from 1960 to 2010.*

Panel B of Table 1.4 shows the correlation with output. All of the correlation results are consistent with the general stylized facts and the data for the Ivorian economy. The model correctly predicts both consumption and investment to be procyclical, with theoretical correlation coefficients of 0.63 and 0.09, respectively, compared to the coefficients of 0.67 and 0.14 in the data. The negative sign of the model correlation of the TBY ratio suggests a countercyclical behavior, as does the data.

To get an idea of the importance of the two foreign shocks for the results, the following test is conducted. The foreign aid and foreign debt shocks are alternately (then simultaneously) removed, and the results are compared to the full model. The structural parameters and steady state are kept identical for all four models. Table 1.5 summarizes the results. In terms of volatility (Panel A), the reduced model with only productivity shocks has the worst results. It predicts both consumption and investment to be less volatile than output. The model with foreign aid and productivity shocks has the closest result to the full model. In terms of correlation with output, the model without foreign aid shocks fails to replicate the countercyclical behavior of the trade balance-to-output ratio. Overall, the full model has the best performance, followed by the model with productivity and foreign aid shocks. These results provide further evidence that volatile foreign aid and international financial frictions add to the volatility of business cycles in low-income countries.

1.4.3 Response to stochastic shocks

This subsection analyzes the response of the economy to stochastic shocks as predicted by the model. Figure 1.4 shows the responses to a productivity shock. As expected, a positive productivity shock

Table 1.5: Reduced Models Versus Full Model and Data

(a) Standard Deviations (Relative to Output)

	Data	Model			
		Full model	Productivity and aid shocks	Productivity and debt shocks	Productivity only
Output	1	1	1	1	1
Consumption	1.13	1.21	1.23	0.58	0.57
Investment	3.4	1.24	1.16	1.08	0.84

(b) Correlation with Output

	Data	Model			
		Full model	Productivity and aid shocks	Productivity and debt shocks	Productivity only
TBY ratio	-0.05	-0.02	-0.04	0.05	-0.06
Consumption	0.67	0.64	0.63	0.96	0.99
Investment	0.14	0.16	0.2	0.3	0.51

leads to an increase in output, consumption, labor and both types of investment in the current period. Because the shock is persistent, agents expect higher income for multiple periods ahead.[10] They borrow against their future income to smooth consumption, which causes the trade balance to depreciate significantly in the current period. To this point, the story is similar to the predictions of the standard small open-economy RBC model, and it is consistent with the countercyclical nature of the trade balance-to-output ratio. However, unlike the standard model, agents face an upward sloping supply of foreign debt. Increased trade deficits translate to an increased foreign debt level, which, in turn, causes the interest rate to spike. Agents react by adjusting their expenditure level to cut back on the deficit and increase saving for a couple of periods after the shock, as illustrated by the trade balance-to-output ratio impulse response function (Figure 1.4, Bottom-Center panel). The savings (or lower deficit) effect, combined with the increased level of output, improve the creditworthiness of the economy, as measured by its debt-output ratio, thus yielding lower interest rates going forward (Figure 1.4, Middle-Left panel). This reaction of the trade-balance effectively illustrates the mechanism through which the model is able to accurately replicate the autocorrelation

[10] Recall the results from the Bayesian estimation in Section 3. The half-life is estimated to be 5 periods.

function of the TBY ratio. Conversely, standard models predict a flat and near random walk process, as discussed above.

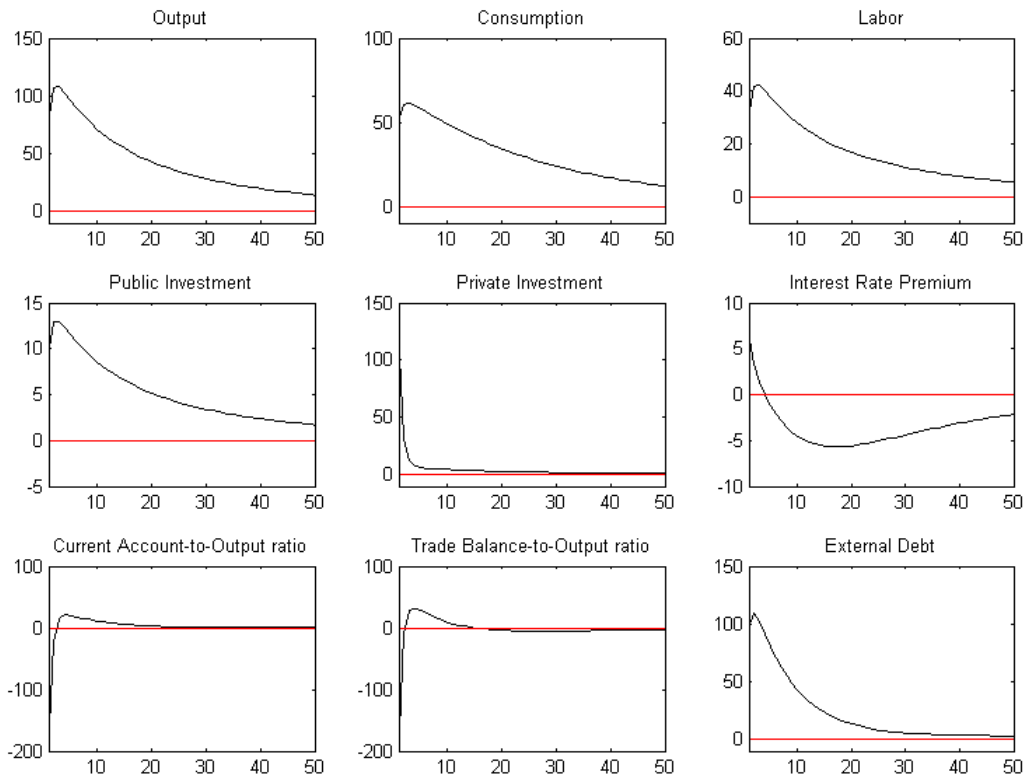


Figure 1.4: Response to Productivity Shock

Notes: The different panels show the impulse response functions following one positive standard deviation productivity shock. All responses are deviations from steady state values and are normalized as percentage of the initial shock. The horizontal axes are number of periods after the shock.

Figure 1.5 shows responses to a foreign aid shock. The initial responses are similar to what the model predicts for the productivity shock: output, consumption, labor and both types investments are all positively affected in the current period. Because foreign aid is persistent, the household borrows against its expected higher future income to smooth consumption. The trade balance naturally deteriorates as a result (Figure 1.5, Bottom-Center panel). However, unlike with productivity shocks, the deterioration of the trade balance here does not necessarily translate into net foreign debt accumulation. As a transfer from abroad, foreign aid has a positive impact on the current account and helps lower the debt level and, consequently, the interest rate premium (Figure 1.5, Middle-Right and Bottom-Right panels).[11]

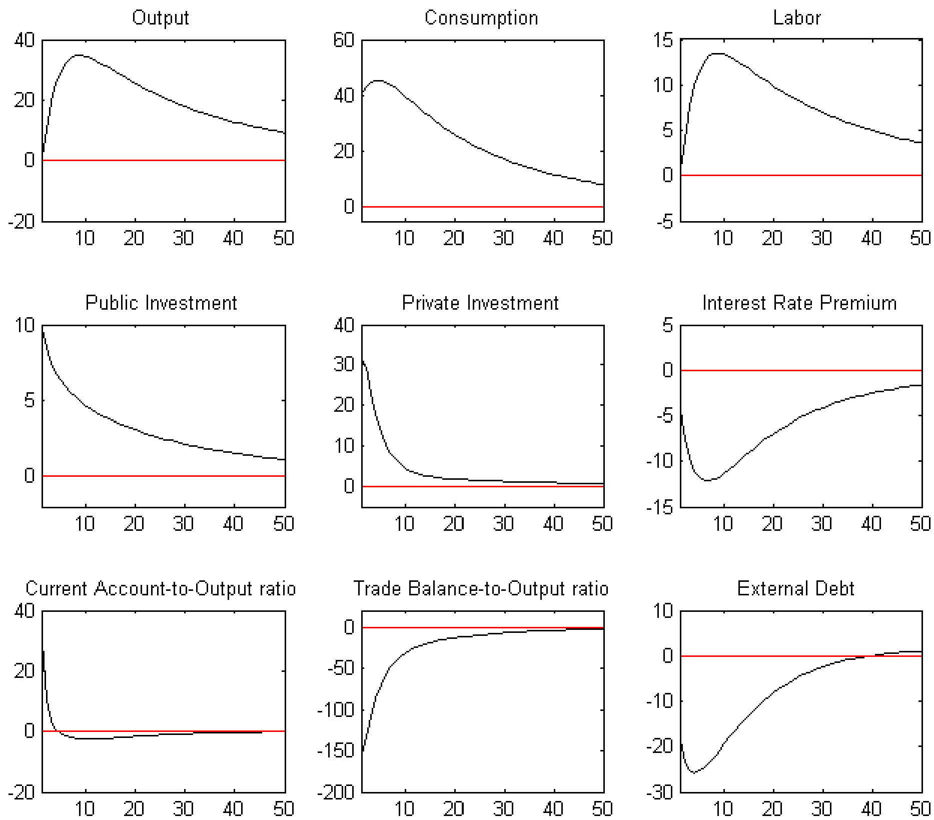


Figure 1.5: Response to Aid Shock

Notes: The different panels show the impulse response functions following one positive standard deviation productivity shock. All responses are deviations from steady state values and are normalized as percentage of the initial shock. The horizontal axes are number of periods after the shock.

Figure 1.6 shows how the economy reacts to an unexpected interest rate premium spike. As expected, output, labor, consumption and investments fall. More notably, the model accurately predicts some of the typical empirical regularities of a "sudden stop" phenomenon, as defined by Calvo (1998).[12]

[11] Here, the increase in foreign aid offsets the effects of the trade balance deficit, as in the national account identity: $\Delta NFA = CA = TB + NT$, where the acronyms stand for Net foreign asset, Current account, Trade balance, and Net transfer, in that order.

[12] The term "sudden stop" was coined by Calvo (1998) to characterize a set of stylized facts associated with financial crises in emerging markets. The key factor for "sudden stops" is the large reversal of the current account deficit as

The skyrocketing risk premium (Figure 1.6, Middle-Right panel) translates into an abrupt loss of access to international capital markets, forcing the economy to save. The result is a sharp and large reversal of the current account deficit as illustrated by the impulse response functions of the current account, trade balance, and external debt (Figure 1.6, bottom panels). At the same time, output and investment collapse as is typical during "sudden stop" episodes (Calvo (1998)).

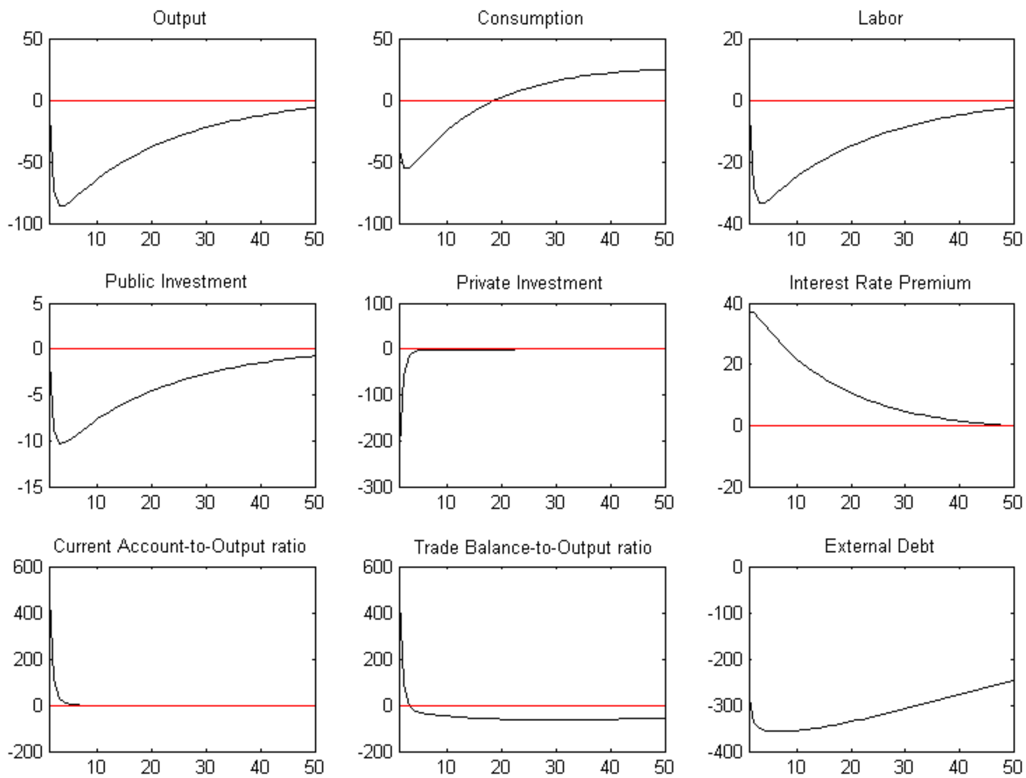


Figure 1.6: Response to Interest Rate Premium Shock

Notes: The different panels show the impulse response functions following one positive standard deviation productivity shock. All responses are deviations from steady state values and are normalized as percentage of the initial shock. The horizontal axes are number of periods after the shock.

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the country loses its ability to borrow internationally.

1.4.4 Implications of aid allocation

Departing from the calibrated economy, this subsection investigates how business cycles are impacted when more aid resources are assigned to public investment instead of household transfers. Different values are assigned to the parameter π, which is the share of aid assigned to public investment. The total level of foreign aid remains unchanged, and all other parameters hold their original values. Table 1.6 shows that the volatility of consumption is significantly reduced when more aid is assigned to public investment. The standard deviation of output barely changes when the allocation of aid resources is changed. Even when most of the aid resources go to public investment (e.g., when $\pi = 0.9$), the volatility of output remains close to its baseline value. As expected, public investment becomes more volatile.

Table 1.6: Standard Deviations (Using Different Aid Allocations)

	pi=0.1 (baseline)	pi=0.5	pi=0.9
Output	0.43	0.42	0.40
Consumption	0.52	0.36	0.24
Private investment	0.46	0.39	0.36
Public Investment	0.10	0.46	0.82

Similarly, Figure 1.7 shows that the response of consumption to a stochastic foreign aid shock is significantly less pronounced when more aid is directed to public investment. In the case where most of the foreign aid resources go to public investment, a positive shock to foreign aid causes consumption to increase by less than 20 percent of the standard deviation of foreign aid at the peak. This is compared to a peak response of over 40 percent in the baseline case where most aid is transferred to households. The response of private investment also follows the same pattern. When π is increased, output responds only slightly less. As expected, public investment responds sharply to any shock to foreign aid. Also noteworthy is the reaction of the current account (and consequently debt), which switches from positive to negative impact as more aid is directed to public investment. The reason for this is that the trade balance deficit is even higher due to the sharp increase in public investment. The additional external resources in the form of foreign aid do not completely offset the deterioration of the trade balance deficit as in the baseline case. As a result, more debt is accumulated, and the interest rate premium fails to fall, as described above.

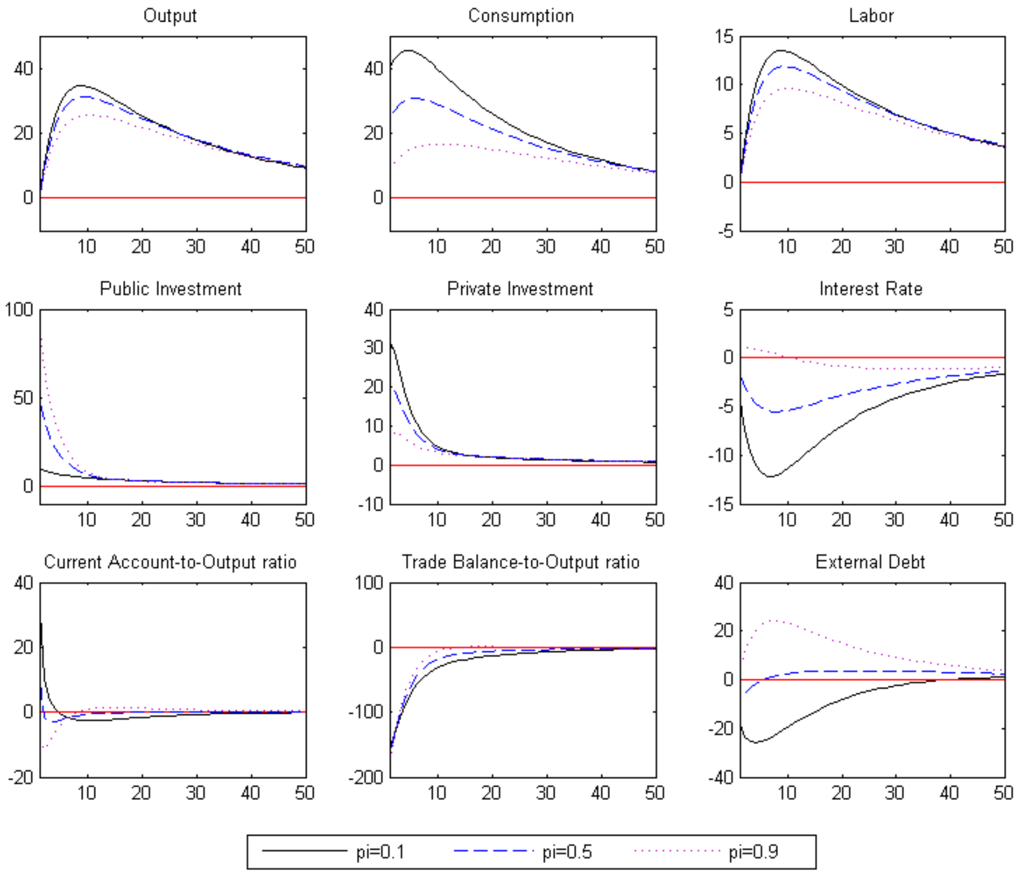


Figure 1.7: Response to Aid Shock Under Different Aid Allocation Scenarios

Notes: The different panels show the impulse response functions following one positive standard deviation shock to foreign aid, under different assumptions for the share of aid (pi) allocated to public investment. All responses are deviations from steady state values and are normalized as percentage of the initial shock. The horizontal axes are number of periods after the shock.

In terms of policy implications, these results suggest that directing more aid towards public investment could significantly reduce the welfare cost associated with volatile consumption. This approach also aligns with the bigger goal of development aid, i.e., helping recipient countries grow their economy and ultimately become less dependent on foreign assistance. Naturally, certain types of aid, such as emergency relief, cannot be included in this discussion because of their temporary nature. Volatile aid could also pose a different set of problems when primarily directed to public investment. Potential issues include half-complete projects and failure to properly maintain existing infrastructures. That said, the welfare improvement from more stable consumption and the long-term goal of building an independent and growing economy are compelling arguments to allocate a larger share of foreign aid towards public investment.

1.5 Conclusions

A model of small open-economy business cycles is built with features that reflect developing economies. Foreign aid is accounted for as an exogenous source of income. The model successfully replicates the key stylized facts of developing economy business cycles. Specifically, consumption is predicted to be more volatile than output. Furthermore, unlike standard small open-economy RBC models, this study's model accurately replicates the autocorrelation function of the trade balance-to-output ratio as observed in the data. The results are in line with the findings by García-cicco et al. (2010) that nonstationary shocks do not play a significant role in the business cycles of developing economies. The model is calibrated and the parameters of the stochastic shocks are estimated using Bayesian methods and 50 years of data for Cote d'Ivoire. The results suggest that foreign aid plays a significant role in the volatility of business cycles in resource-constrained developing countries. Additionally, directing more aid resources toward public investment as opposed to transferring it to households can reduce the volatility of consumption. More generally, this study's results imply that more attention needs to be given to international capital flows when analyzing aggregate fluctuations in those types of economies.

Although the focus of this study is foreign aid, other sources of foreign capital, such as remittances, could be modeled similarly under the same framework. Acosta et al. (2009), for example, show that an increase in remittance flow has significant macroeconomic effects in emerging economies (See also Giuliano and Ruiz-Arranz (2009)). Finally, the model presented in this essay is intended as a general framework that can be used to analyze various policy issues in developing economies. In addition to fiscal policy, possible extensions include the two-sector tradable versus nontradable version to analyze trade policy. Such an extension will also help address issues related to the volatility of the terms-of-trade and the consequences associated with large world price swings.

Chapter 2

The Macroeconomic Effects of Investment Tax Credits, Capital Income Tax Cuts and Wage Subsidies in Open Economies

2.1 Introduction

Among other things, two important lessons learned from the recent global financial crises are that economies are more than ever financially integrated with the rest of the world and fiscal policies can play a significant role in stabilization policies, especially when monetary policies are constrained by the zero lower bound.[1] In a world with almost perfect capital mobility, the domestic economy is no longer fully constrained by its own resources. In this context, understanding the dynamic effects of fiscal policy changes is crucial for both emerging and developed economies. These policies are widely used around the world either to sustain economic growth or to improve ongoing fiscal imbalances. However, during economic downturns, the main goal is often to stabilize the economy

[1] A situation where traditional monetary policy instruments are ineffective due to short-term nominal interest rates being near zero.

by increasing employment, investment, and domestic output.

This essay's objective is to examine and compare the dynamic effects of alternative fiscal policies in the specific context of a small open economy facing a recession. The essay focuses on three policies in particular: investment tax credits, capital income tax cuts and wage subsidies. Although their end goal is similar, the transmission channels differ. With an ITC in place, a government reimburses a fraction of a firm's spending on new capital goods. Reimbursement takes the form of a credit deductible from the firm's overall tax bill. ITCs and capital income tax cuts are direct incentives to invest because they either reduce the cost of capital or improve its return. Higher capital in turn increases the marginal product of labor, hence higher labor demand and higher wages. In the end, the economy produces more output. Similarly, a wage subsidy is a direct incentive to hire.[2] It reduces the effective labor cost and induces the profit maximizing firm to increase employment. Higher labor in turn increases the marginal product of capital and the economy experiences higher capital accumulation and generates more output.

From the policymaker's perspective, it can be challenging to identify the appropriate fiscal response to a an economic downturn. All the benefits and costs associated with each policy must be accounted for in order to compare them and to formulate better policy prescriptions for fiscal authorities. In addition, the dynamic effects of the policy change on government revenue must be accounted for such that comparisons only involve policies with have equivalent costs. This essay addresses this concern.

Despite their recurrence in formulating fiscal stimulus policy in recent history, few theoretical attempts have been made to analyze and contrast their effects on the economy. In a Congressional Research Service report, Hungerford and Gravelle (2010) analyze recent fiscal proposals to use business tax incentives for spurring economic activity. They deplore the lack of studies estimating the impact of investment incentives on employment. Heijdra (2007) also notes that the analysis of fiscal policy in open-economy models has received little attention compared with monetary policy.

Much of the scarce literature on business fiscal incentives uses either a closed economy framework or

[2]Wage subsidies can take many forms. They can be incremental - meaning they only affect new-hiring - or non-incremental. They can target specific groups of workers or be available for all. They can come in the form of a payroll tax break or a government subsidy of specific hiring-related expenses like health insurance.

a deterministic model (e.g. Assibey-Yeboah and Mohsin (2011), Brock and Turnovsky (1981), Broer and Heijdra (2001), Fehr (1996), Gomme (2002), Gordon (1986)), Judd (1987), Karayalcin (1995), and Turnovsky (1982).) Given the increased capital mobility in modern economies, the impacts of investment incentives derived in closed economy models are unlikely to apply to most economies today. Also, investment and employment incentives are often part of a larger effort to stimulate the economy during or after a recession and they tend to be temporary and unpredictable.[3] As such, using a deterministic framework to analyze their effects is problematic given that business cycles are stochastic by nature.

None of the aforementioned studies consider the more realistic combination of open economy and real business cycles. This study attempts to fill that gap. A dynamic stochastic general equilibrium model (DSGE) is used to analyze and contrast the effects of investment and employment incentives in a small open economy. Schmitt-Grohe and Uribe (2003) provide a detailed presentation of the small open-economy real business cycle framework. This study considers various policy rules and works out the economy's transitional dynamics for each case. Included are short-lived versus highly persistent shocks for each of the fiscal policies under consideration. Also, to highlight the importance of international capital flows in how the economy responds to various stimuli, the results of the baseline open economy model are contrasted with those of a closed economy version.

To the best of our knowledge, this study is the first to use a stochastic open-economy framework to contrast the effects of investment and employment fiscal incentives. This study also departs from the standard way fiscal shocks and transitional dynamics are analyzed. In most studies, impulse response functions are used to show the economy's reaction and the transitional path following a fiscal shock occurring while the economy is in the steady state. However, investment and employment incentives often come as a response to a previous shock (i.e., recession) from which the economy is still suffering or recovering. Furthermore, recent works in the public policy literature

[3] In the U.S., an ITC of 7 percent on equipment purchases was introduced in 1962, suspended in 1966, restored in 1968, and repealed in 1969. The ITC was again reintroduced in 1976 and revoked in 1986 by Reagan's tax reform act. The New Jobs Tax Credit (NJTC) of 1977 was introduced to promote employment after the 1973-1975 recession. It was in effect through 1978. More recent examples of employment stimuli include the Bush tax cuts of 2001 and 2003 as well as the extension of the Bush payroll tax cut in the Tax Relief Unemployment Insurance and Job Creation Act of 2010. Also, the American Recovery and Reinvestment Act (ARRA) passed in 2009 to boost the economy in the wake of the 2008-2009 recession featured a number of tax incentives for businesses.

have brought attention to the fact that fiscal multipliers may depend on economic conditions (e.g. Auerbach and Gorodnichenko (2012), Karras (2014), Owyang et al. (2013), Ramey and Zubairy (2014), and Sims and Wolff (2013).) Therefore, alternatives scenarios are considered in which the fiscal shock occurs, not in the steady state, but following an adverse productivity shock.

The results suggest that wage subsidies have faster but shorter effects on production and employment while ITCs have slower but longer lasting impacts. Thus, the goals and timing of fiscal responses to a recession are critical. The positive initial response of investment to an ITC increase or a capital income tax break is much stronger in an open economy than in a closed economy. Consumption behaves differently. In a closed economy, consumption tends to fall when an investment fiscal incentive is provided. In contrast, all three fiscal incentives boost consumption in an open economy. This study also finds that all three fiscal policies positively affect government revenue through their dynamic impacts on labor and capital income taxation. However, consistently with the finding by Judd (1987), only ITC policies are self-financing (revenue multiplier greater than one.) Finally, the persistence of fiscal shocks appears to play a significant role in the initial response of investment. The initial response of investment to an ITC shock is stronger when the shock is weakly persistent (*invest-while-it-lasts* effect.) In contrast, the initial response of investment to a wage subsidy shock is stronger when the shock is highly persistent (*invest-if-it-will-last* effect.)

The rest of the essay is organized as follows. The theoretical framework is presented in section 2, and the model's calibration in section 3. Section 4 discusses the results, and section 5 is the conclusion.

2.2 The Model

This section constructs a DSGE model of a small open economy to accommodate various fiscal instruments. This model serves as a baseline, which is modified later to obtain a closed-economy counterpart. The economy features an infinitely-lived representative household, a representative firm, and a government that conducts fiscal policies. The household derives utility from leisure $(1 - L_t)$ and the consumption of the single non-durable good the firm produces. The household maximizes the present value of her lifetime utility:

$$\max E \sum_{t=0}^{\infty} \beta^t U\left(C_t, L_t\right) \tag{2.1}$$

where C_t is aggregate consumption and L_t is aggregate labor supply. The household receives labor income $W_t L_t$ and income from capital $S_t K_t$, where W_t is wage rate, S_t is rental rate of capital, and K_t is aggregate capital. She may also borrow from the rest of the world. The effective borrowing rate (interest rate) r_t has two components: the world interest rate r^* and a country-specific risk premium p. In a small open economy, agents take the world interest rate as exogenously given. The risk premium depends on the economy's aggregate debt level $\tilde{D}_t$. Hence,

$$r_t = r^* + p\left(\tilde{D}_t\right) \tag{2.2}$$

The function $p(.)$ is assumed to be strictly increasing. Since this is a representative economy, the household's debt D_t is identical to the economy's aggregate debt level $\tilde{D}_t$.

The household is subject to various government taxes. The government collects taxes on both factors of production and redistributes the proceeds to the household in the form of a lump-sum transfer T_t and, when applicable, an investment tax credit $\mu_t I_t$, where μ_t is the rate of investment tax credit and I_t is investment. Denoting τ_L the tax rate on labor income and τ_K the tax rate on capital income, the overall budget constraint for the household is given by:

$$D_t = \left(1 + r_{t-1}\right) D_{t-1} + C_t + \left(1 - \mu_t\right) I_t + \Phi\left(K_t - K_{t-1}\right) - \left(1 - \tau_{Lt}\right) W_t L_t - \left(1 - \tau_{Kt}\right) S_t K_{t-1} - T_t \tag{2.3}$$

where $\Phi(.)$ is a convex capital adjustment cost function. For convenience, $\Phi(0) = \Phi'(0) = 0$ is assumed. With the rate of depreciation δ, the stock of capital evolves according to the process:

$$K_t = \left(1 - \delta\right) K_{t-1} + I_t \tag{2.4}$$

The household's objective is to maximize (2.1) subject to the constraints in equations 2.21 and 2.4, and to the following no-Ponzi game constraint:

$$\lim_{j\to\infty} E_t\left(\frac{D_{t+j}}{\prod_{s=1}^{j}\left(1+r_s\right)}\right)\leq 0 \tag{2.5}$$

The following optimal conditions are obtained from the household maximization problem:

$$U_C\left(C_t,L_t\right)=\lambda_t \tag{2.6}$$

$$U_L\left(C_t,L_t\right)=-\lambda_t\left(1-\tau_{Lt}\right)W_t \tag{2.7}$$

$$\lambda_t=\beta(1+r_t)E_t\lambda_{t+1} \tag{2.8}$$

$$\lambda_t\left[(1-\mu_t)+\Phi'\left(K_t-K_{t-1}\right)\right]=\beta E_t\lambda_{t+1}\left[\left(1-\mu_{t+1}\right)(1-\delta)+\Phi'\left(K_{t+1}-K_t\right)+\left(1-\tau_{Kt+1}\right)S_{t+1}\right] \tag{2.9}$$

where λ_t is the Lagrange multiplier associated with her budget constraint or the shadow price of wealth. These optimal conditions have standard interpretations in terms of marginal costs and benefits. Precisely, the first two conditions dictate the optimal demand for consumption and the optimal labor supply of the household while the last two capture the optimal financial decisions involving borrowing (foreign loans) and investing in domestic capital.

Output is produced by the representative firm according to the following standard neoclassical production function in which the stochastic productivity shocks are represented by Z_t.

$$Y_t=Z_tF\left(K_{t-1},L_t\right) \tag{2.10}$$

Total factor productivity follows the following AR(1) process:

$$\ln Z_t=\rho_Z\ln Z_{t-1}+\varepsilon_{Zt};\qquad \varepsilon_{Zt}\sim NIID(0,\sigma_Z^2) \tag{2.11}$$

The optimal demands for labor and capital are determined by their respective marginal products and real costs. Hence, the following two optimality conditions must hold:

$$W_t = Z_t F_L\left(K_{t-1}, L_t\right) \tag{2.12}$$

$$S_t = Z_t F_K\left(K_{t-1}, L_t\right) \tag{2.13}$$

The government has a balanced-budget constraint for each period, given by:

$$T_t + \mu_t I_t = \tau_{Lt} W_t L_t + \tau_{Kt} S_t K_{t-1} \tag{2.14}$$

When no business fiscal incentive is in place, all of the tax revenue is redistributed to the household in the form of lump-sum transfers T_t. Alternatively, the government uses part of the revenue collected to finance its active fiscal policies. Specifically, the government has three general instruments to conduct active fiscal policy: investment tax credits, wage subsidies, and capital income tax cuts. The payroll tax rate τ_{Lt} has a core component $\bar{\tau}_L$, which is constant, and a wage subsidy component η_{Lt}. Similarly, the tax rate on capital income τ_{Kt} has a core component $\bar{\tau}_K$, which is constant, and a tax cut component η_{Kt}.[4]

$$\tau_{Lt} = \bar{\tau}_L - \eta_{Lt} \tag{2.15}$$

$$\tau_{Kt} = \bar{\tau}_K - \eta_{Kt} \tag{2.16}$$

To make policy rules flexible in the model, a broad functional form is assumed for the three fiscal incentives. Investment tax credit follows the AR(1) process given by equation 2.17, where $\bar{\mu}$ is the long-run average rate and $\varepsilon_{\mu t}$ captures stochastic shocks to the ITC rate. By default, $\bar{\mu} = 0$, which means the government does not provide investment tax credits during normal times (i.e. in steady

[4] In this setup, the wage subsidy is effectively a payroll tax cut. In addition, no distinction is made between the employer and worker portion of the payroll tax. For example, a wage subsidy of 2 percent simply reduces the total payroll tax rate by 2 percentage points. This is similar to the payroll tax treatment of self-employed taxpayers in the U.S..

state). A change in $\bar{\mu}$ is a permanent shock, while a change in $\varepsilon_{\mu t}$ is a temporary shock.[5]

$$\mu_t = (1 - \rho_\mu)\,\bar{\mu} + \rho_\mu \mu_{t-1} + \varepsilon_{\mu t}; \qquad \varepsilon_{\mu t} \sim NIID(0, \sigma_\mu^2) \tag{2.17}$$

Similarly,

$$\eta_{Lt} = (1 - \rho_L)\,\bar{\eta}_L + \rho_L \eta_{Lt-1} + \varepsilon_{Lt}; \qquad \varepsilon_{Lt} \sim NIID(0, \sigma_L^2) \tag{2.18}$$

$$\eta_{Kt} = (1 - \rho_K)\,\bar{\eta}_K + \rho_K \eta_{Kt-1} + \varepsilon_{Kt}; \qquad \varepsilon_{Kt} \sim NIID(0, \sigma_K^2) \tag{2.19}$$

In this setup, a wage subsidy policy is given by: $(\bar{\eta}_L, \epsilon_L)$, where a change in $\bar{\eta}_L$ captures a permanent shock, and a change in ϵ_L is due to an unanticipated temporary shock. Similarly, the investment tax credit policy is given by $(\bar{\mu}, \epsilon_\mu)$ and the capital income tax break policy is given by: $(\bar{\eta}_K, \epsilon_K)$. Though this setup is very general, the essay focuses exclusively on the temporary policy changes.

Of particular interest to open economies are the trade balance and current account balances. Trade balance TB_t equals income minus total domestic spending, including consumption expenditure, investment, and capital adjustment costs:

$$TB_t = Y_t - C_t - I_t - \Phi\left(K_t - K_{t-1}\right) \tag{2.20}$$

The current account balance CA_t captures the change in the foreign debt position of the economy: $-(D_t - D_{t-1})$. The absolute levels of these two variables convey little meaningful information. Thus, the focus is on their ratios to output (i.e. trade balance-to-output ratio $TBY_t = \frac{TB_t}{Y_t}$ and current account balance-to-output ratio $CAY_t = \frac{CA_t}{Y_t}$.)

The Closed Economy Since one of this study's objectives is to compare the effects of various fiscal policies in an open economy with those in a closed economy, the model economy should produce closed economy results under certain conditions. Under financial autarky, there is no international flow of goods and services across countries. Households and firms are completely constrained by national resources. For simplicity, the domestic government is assumed to maintain a balanced

[5] For the ITC to be an effective incentive to invest, the implicit assumption is made that tax credits are refundable. Non-refundable credits are not an effective incentive when the firm's total tax bill is less than the credits it is owed.

budget all the time and there is no outstanding government debt. The household's disposable income is either consumed or invested. The representative household's budget constraint is thus:

$$C_t + (1 - \mu_t) I_t + \Phi (K_t - K_{t-1}) = (1 - \tau_{Lt}) W_t L_t + (1 - \tau_{Kt}) S_t K_{t-1} + T_t. \qquad (2.21)$$

The closed-economy model is implemented as a special case of the open-economy model in which the trade balance and foreign debt are constrained to be zero in each period. The optimization problem remains the same except equation (2.3) is replaced with equation (2.21). It should be noted that in the closed economy the real interest rate is determined by the domestic financial market through the effective marginal product of capital.

2.3 Parametrization and Calibration

For this study, commonly used functional forms in the RBC literature are adopted. Preferences are represented by a GHH-type utility function as follows:

$$U (C_t, L_t) = \frac{\left(C_t - \omega^{-1} L_t^{\omega}\right)^{1-\gamma} - 1}{1 - \gamma}$$

where ω is a positive parameter representing the intertemporal elasticity of substitution in labor supply, and $\gamma > 0$ is the coefficient of relative risk aversion. The production function is assumed to follow a Cobb-Douglas technology with constant returns to scale:

$$F (K_t, L_t) = K_t^{\alpha} L_t^{1-\alpha}$$

where $1 > \alpha > 0$ is the capital share of output. A standard quadratic cost function is used for the capital adjustment cost:

$$\Phi (x) = {}^1\!/_2 \phi x^2; \qquad \phi > 0$$

Finally, the interest rate risk premium is represented by:

$$p(D_t) = \psi \left(e^{D_t - \bar{D}} - 1 \right)$$

where $\psi > 0$ is a scale parameter that captures the country-specific risk premium. There is no set value for all the open economies as the value depends on the country's creditworthiness. In the traditional open-economy macroeconomics literature, the assumption of perfect capital mobility implies this parameter to be equal to zero. Similarly, an extremely high value makes it technically prohibitive for the open economy to borrow internationally -a state of financial autarky. This parameter, as a result, could serve as a proxy variable for identifying whether a model open economy is financially developed (low parameter value) like Canada and the UK, or less developed (relatively high parameter value) like Greece, Turkey, or Bangladesh.

The steady state (long-run equilibrium) is solved for using the functional forms above, and values are assigned to the parameters such that the model economy approximately reflects the long-run structure of a typical small open economy such as Canada. Canada is used for two reasons: (1) parameter values are widely available for Canada, and (2) extensive RBC literature featuring the Canadian economy can be useful in cross checking business cycles patterns the model generates.

This study primarily follows Mendoza (1991) and Schmitt-Grohe and Uribe (2003) for the commonly used parameter values, as summarized in Table 2.1. Three notable exceptions are the discount factor β, the rate of depreciation of physical capital δ, and the persistence of productivity shocks ρ_z. Unlike Mendoza (1991) and Schmitt-Grohe and Uribe (2003), who use annual frequency, this study's model economy is calibrated to a quarterly frequency. This higher frequency was chosen based on the goal of analyzing the economy's short-term dynamics following adoption of a given fiscal stimulus. These three parameters' values are adjusted to reflect the higher frequency.

Table 2.1: Calibration

α	β	δ	γ	ω	ϕ	ψ	σ_z
0.32	0.9901	0.025	2	1.455	0.028	0.0001	0.01

In the steady state, $D_t = \bar{D}$ and as a result, the country specific risk premium is nil. From one of the Euler equations, the value of β can easily be calibrated for a quarterly real-world interest rate of 1 percent (approximately 4 percent annually). Based on the Canadian debt-output ratio during the period 1991-2012, the steady-state debt-output ratio of the model economy is assumed to be 0.60. This number is consistently assumed for all the calibration exercises except when open-economy results are compared with those of a closed economy. To have meaningful comparisons, the two types of economy need to have identical steady states, given that the closed-economy model has no external debt. For this purpose, the steady-state level of foreign debt is assumed to be zero when comparing open and closed economies.

Tax parameters

Next, the fiscal parameters are set. In the steady state, the government budget constraint in equation 2.14 becomes:

$$T + \mu I = \tau_L WL + \tau_K SK \tag{2.22}$$

$$T + \bar{\mu} I = (\bar{\tau}_L - \bar{\eta}_L) WL + (\bar{\tau}_K - \bar{\eta}_K) SK \tag{2.23}$$

When the economy is on its long-run full employment path, it is assumed there is no fiscal incentive. That is, $\bar{\mu} = 0$, $\bar{\eta}_L = 0$ and $\bar{\eta}_K = 0$.

Normalizing in terms of output yields:

$$\frac{T}{Y} = \bar{\tau}_L \frac{WL}{Y} + \bar{\tau}_K \frac{SK}{Y} \tag{2.24}$$

where $\frac{T}{Y} = \theta$ is the economy's overall tax burden, and $\frac{WL}{Y}$ and $\frac{SK}{Y}$ are the labor and capital income shares, respectively. The above equation can be rewritten as:

$$(1 - \alpha) \bar{\tau}_L + \alpha \bar{\tau}_K = \theta \tag{2.25}$$

As discussed earlier, α is assigned a value commonly used in the RBC literature for the Canadian economy. For the long-run tax rate on labor income, $\bar{\tau}_L$, the measure of tax wedge that the OECD calculates for Canada is used.[6] The long-run overall tax burden in the economy is also obtained from the OECD statistics. Excluding taxes on goods and services, the average tax burden for Canada from 1965 to 2011 is 23.2 percent.[7] Finally, equation 2.25 can be used to obtain the long-run tax rate on capital income, $\bar{\tau}_K$.

$$\bar{\tau}_K = \frac{\theta - (1-\alpha)\,\bar{\tau}_L}{\alpha} \tag{2.26}$$

In sum, the following values are obtained: $\theta = 0.232$, $\alpha = 0.32$, $\bar{\tau}_L = 0.31$ and $\bar{\tau}_K = 0.066$.[8]

Magnitude of the fiscal shocks

Equivalent shocks are given across the different fiscal policy schemes. Each fiscal response is such that the tax expenditure's present value (how much the policy costs the taxpayer) is the same. Assuming the fiscal shock is given at time $t = p$, the tax expenditures are determined as follows:

- ITC: $PolicyCost_{ITC} = \sum_{t=0}^{\infty} \beta^t \mu_t I_t$, where $\mu_t = 0$ for $t < p$, and $\mu_t = (1-\rho_\mu)\,\bar{\mu}_t + \rho_\mu \mu_{t-1} + \epsilon_{\mu t}$ for $t \geq p$.
- WS policy cost: $PolicyCost_{WS} = \sum_{t=0}^{\infty} \beta^t \eta_{Lt} W_t L_t$, where $\eta_{Lt} = 0$ for $t < p$ and $\eta_{Lt} = (1-\rho_L)\,\bar{\eta}_{Lt} + \rho_L \eta_{Lt-1} + \epsilon_{Lt}$ for $t \geq p$.
- CI policy cost: $PolicyCost_{CI} = \sum_{t=0}^{\infty} \beta^t \eta_{Kt} S_t K_t$, where $\eta_{Kt} = 0$ for $t < p$ and $\eta_{Kt} = (1-\rho_K)\,\bar{\eta}_{Kt} + \rho_K \eta_{Kt-1} + \epsilon_{Kt}$ for $t \geq p$.

The total tax expenditure is set equal to a fixed percentage of output (5 percent in the benchmark case). Five percent was chosen for no particular reason other than it is a reasonable size given recent fiscal stimulus packages.[9] The American Recovery and Reinvestment Act of 2009 (ARRA)

[6] The OECD defines the total tax wedge as the combined central and sub-central government income tax plus employee and employer social security contribution taxes, as a percentage of labor costs defined as gross wage earnings plus employer social security contributions. (OECD (2007))

[7] Including taxes on goods and services, the tax burden is 32.7 percent. However, in this study, taxes on goods and services are excluded because they are not captured in the model as tax revenue, which includes labor and capital income taxes. Taxes on goods and services are implicitly deduced such that in the long-run equilibrium, government transfers to the households T, equal total revenue.

[8] A second alternative can be used to calibrate directly the tax rates on labor and capital incomes. Instead of using the economy's overall tax burden, the factor- specific tax burdensθ_L and θ_K can be used (with $\theta_L = \frac{\bar{\tau}_L WL}{Y}$ and $\theta_K = \frac{\bar{\tau}_K SK}{Y}$.) That is, $\bar{\tau}_L = \frac{\theta_L}{1-\alpha}$ and $\bar{\tau}_K = \frac{\theta_K}{\alpha}$.

[9] It is important to stress that 5 percent of GDP is the policy's lifetime cost. The immediate cost at the time of implementation depends on several factors, including the shock's magnitude and the policy's persistence. For

was approximately 800 billion dollars, t about 5 percent of the U.S.'s GDP. It is worth noting, however, that the ARRA of 2009 combined many other instruments beside tax incentives. Fiscal incentives accounted for roughly a third of the stimulus package.

2.4 Results and Discussion

2.4.1 Response to Isolated Fiscal Shocks

Isolated equivalent one-period shocks are given to ITC, wage subsidy, and capital income tax break. The results are shown 2.1. Contrary to the findings by Turnovsky and Sen (1990), this study finds that temporary shocks only affect the economy in the short-run. Ultimately, all the variables (including output, employment, capital stock, and consumption) revert to their original long-run equilibrium.

A wage subsidy policy has the fastest effect on output. In response to a wage subsidy that costs 5 percent of output in terms of tax expenditure, output increases by 1.7 percent in the first quarter (Figure 2.1 Panel A). The response to a cost equivalent ITC shock is much slower. The effects on output start kicking in slowly in the second quarter with a 1.2 percent increase. However, the wage subsidy's effects are not as long lasting compared to those of the ITC. Following the ITC shock, the positive impact on output increases steadily to peak at 3.2 percent after 7 quarters, then declines slowly. Output stays 1 percent higher than its steady-state level twenty-four quarters after the initial ITC shock. With a wage subsidy policy, the positive impact on output falls below 1 percent within four quarters following the shock.

Wage subsidies also have the fastest impact on consumption and employment (Figure 2.1 Panels B and C). Also, their peak impacts on consumption and labor are much higher than those of ITC. The wage subsidy policy increases consumption and employment by 1.6 percent and 2.5 percent, respectively, in the initial period; then the impacts fall quickly to less than 0.5 percent after three years. Conversely, the ITC's impacts increase steadily to 1.5 percent for consumption and 2.2

example, an ITC policy that amounts to 5 percent of GDP for its lifetime and that has a persistence coefficient of 0.82 (i.e. half-life of 3.5 quarters) will cost 1.3 percent of GDP in the first period, 0.9 percent in the second period, and significantly less thereafter. A similar wage subsidy policy will cost 0.9 percent of GDP in the first period and 0.8 percent in the second period.

percent for employment eight quarters after the policy shock, and both impacts stay above 0.5 percent for more than five years.

Capital income tax break has the weakest impact on the economy in general and on output in particular. Its impact on output is less than 0.3 percent at its peak. The weak impact of this form of fiscal incentive can be explained by the fact that it is applied to existing capital stock and no additional spending is required of the firm to take advantage of the tax break. Also, given capital adjustment costs, capital income tax cuts need to be substantial and highly persistent to generate significant response.

As expected, the ITC policy shock has significantly higher impacts on investment than the wage subsidy policy (Figure 2.1 Panel D). The ITC policy increases investment by almost 80 percent in the initial period, compared to less than 6 percent for the wage subsidy policy and about 10 percent for the capital income tax break policy. However, the ITC shock's impacts on investment are not as long lasting as on output, labor, or consumption. With investment, the ITC's impacts fall quickly and even become negative after two years. This investment behavior is discussed in more detail when the role played by the shocks' persistence is analyzed.

ITC has a strongly negative impact on the current account initially as agents borrow from the rest of the world to take advantage of the domestic investment incentive. However, after a few quarters, as the policy ends, the current account becomes positive. This result can be explained by the fact that part of the observed increase in investment is due to a change of timing of planned investment spending as opposed to new investment. Compared to ITCs, wage subsidies and capital income tax breaks have negligible impacts on the trade balance to output ratio.

Overall, the ITC policy generates the highest increase in the household's welfare as measured by her lifetime utility's present value. The wage subsidy policy follows, and the capital income tax cut policy comes last.[10]

[10] It is noteworthy that capital adjustment costs play an important role in the investment's response, especially to ITC and capital income tax break policies. The commonly used value is assumed for the adjustment cost parameter (ϕ=0.028). At the margin, increasing this parameter's value negatively affects the incentive to invest when a pro-investment policy is implemented.

Multiplying effects and policy returns

Of interest to policymakers is each policy's impact on government revenues. A tax revenue multiplier is obtained for each policy by dividing the change in tax revenue due to the policy by the cost of the policy. Different time horizons are considered, including 1 to 5 years and lifetime multipliers. Table 2.2 shows the multipliers for the three policies. Each policy costs 1 percent of steady-state output in terms of tax expenditure. Multipliers are reported for each of the two sources of tax revenue (labor income and capital income taxes.) The total revenue multiplier for the ITC policy (Table 2.2 column 4) is greater than 1 for time horizons beyond one year. This result is consistent with the finding by Judd (1987) that ITC policies are self-financing through their impact on capital and labor income taxation. Furthermore, the results in Table 2.2 suggest that most of the positive effect of the ITC policy on government revenue is through labor income taxation, which accounts for 90 percent of the lifetime multiplier.

Wage subsidies and capital income tax cuts also have a positive impact on government revenue, but the corresponding multipliers are less than 1, which indicates that these two policies are not self-financing. Over their lifetime, they generate additional tax revenues equivalent to 69 percent and 32 percent of their costs, respectively.

Table 2.2: Revenue Multipliers by Policy

	Investment Tax Credit			Wage Subsidy			Capital Income Tax Cuts		
Change in tax revenue	Labor only	Capital only	Total	Labor only	Capital only	Total	Labor only	Capital only	Total
After 1 year	0.28	0.05	0.34	0.23	0.02	0.26	0.03	0.01	0.03
After 3 years	1.42	0.16	1.58	0.44	0.05	0.49	0.14	0.02	0.16
After 5 years	2.11	0.22	2.34	0.51	0.05	0.57	0.21	0.02	0.24
Lifetime	2.82	0.29	3.11	0.62	0.06	0.69	0.29	0.03	0.32

Notes. Government revenue comes from two sources: labor income tax $\bar{\tau}_L W_t L_t$ and capital income tax $\bar{\tau}_K S_t K_t$. The multipliers are obtained by dividing the additional tax revenue generated by the policy (compared to steady-state revenue) by the cost of the policy. All costs and revenues are discounted using the discount factor β. The lifetime horizon is approximated with 100 quarters.

For each policy, returns are computed for the main macroeconomic aggregates to determine which policies have the biggest "bang for the buck". The policy returns are obtained by relating the gains from the policy to its cost. For instance, the ITC policy's return in terms of output is obtained by dividing the cumulative deviations of output from its steady-state value by the ITC policy cost.[11] The results are shown in Table 2.3. The ITC policy consistently has the highest lifetime returns in terms of output, consumption, employment, and investment. The wage subsidy policy comes second except for the returns in terms of investment.[12]

Table 2.3: Policy Returns

(a) Output

	Investment Tax Credit	Wage Subsidy	Capital Income Tax Cuts
After 1 year	1.35	1.12	0.14
After 3 years	6.80	2.11	0.69
After 5 years	10.12	2.47	1.03
Lifetime	13.51	2.99	1.37

(b) Consumption

	Investment Tax Credit	Wage Subsidy	Capital Income Tax Cuts
After 1 year	0.51	0.78	0.05
After 3 years	2.44	1.42	0.25
After 5 years	3.72	1.66	0.38
Lifetime	6.23	2.26	0.63

(c) Employment

	Investment Tax Credit	Wage Subsidy	Capital Income Tax Cuts
After 1 year	0.34	0.58	0.03
After 3 years	1.70	1.01	0.17
After 5 years	2.53	1.13	0.26
Lifetime	3.38	1.27	0.34

(d) Investment

	Investment Tax Credit	Wage Subsidy	Capital Income Tax Cuts
After 1 year	10.41	0.64	1.06
After 3 years	11.29	0.74	1.15
After 5 years	8.83	0.63	0.90
Lifetime	6.84	0.61	0.70

Notes. The returns are obtained by dividing the cumulative present value of the deviations of output, consumption, employment and investment from their steady-state values by the present value of the policy cost. The lifetime horizon is approximated with 100 quarters. The lifetime returns in terms of investment are lower than short-term returns because investment falls below steady-state after its initial jump (See Figure 2.1 Panel D.)

Persistence of the Fiscal Shocks

Noteworthy is how the fiscal shocks' persistence affects the results. Fiscal shocks of equal magnitude (one standard deviation) are applied. However, three levels of persistence are considered: the benchmark case with $\rho = 0.82$ (3 quarters half-life), the low-persistence case with $\rho = 0.5$ (1 quarter half-life) and the high-persistence case with $\rho = 0.95$ (13 quarters half-life). The results are shown

[11] All gains and costs are in present value terms.

[12] Multipliers and returns were also calculated for the case where the fiscal policies are pursued as a response to a negative productivity shocks. No significant changes are noted in the results.

in Figure 2.2.

When the ITC shock is weakly persistent, the initial response of investment tends to be much higher compared to when it is highly persistent. This response could be explained by an *invest-while-it-lasts* type effect. That is, agents try to quickly take advantage of the ITC by changing their capital expenditure timing when the chances of having those tax credits in the near future are low (little persistence). With an ephemeral ITC policy, investment significantly increases when the policy begins, immediately followed by a drop below steady state. Output responds positively; and, unlike investment, it stays above steady state during the entire adjustment process, regardless of persistence. However, the peak response of output is much higher when the ITC shock is persistent because more capital is being built when the policy is long lasting.[13]

Regardless of persistence, the capital stock eventually returns to its initial value. No permanent effect is recorded in any case. This result is in contrast with the findings by Turnovsky and Sen (1990) that both temporary and permanent ITCs have similar initial effects on capital accumulation. Even without a truly permanent ITC policy, agents tend to factor in the fiscal incentive's availability going forward. When the incentive is more likely to last, the initial response is much weaker than when it is perceived as limited-time opportunity.

With wage subsidy shocks of equal magnitude but different persistence, the key variables' initial responses are similar, except for investment. Contrary to an ITC, a wage subsidy generates a strong reaction of investment only when the policy is persistent (Figure 2.2 Panel D). Given capital adjustment costs, a short-lived policy does not give firms enough incentives to add extra capacity in order to take advantage of lower labor costs. Furthermore, labor cannot be accumulated for future use as is the case with capital. Hence, an *invest-if-it-will-last* effect is observed with wage subsidies, as opposed to *invest-while-it-lasts* effect with ITCs. That is, a strong initial investment response results when the wage subsidy policy is long-lasting. Comparing the peak responses, the high-persistent wage subsidy boosts investment almost eight times more than a low-persistence subsidy

[13]The extreme case where policies have zero persistence is also experimented with. For example, an ITC costing 1 percent of GDP is given in a single period and agents can only take advantage of it based only on new capital purchased in that period. The main results previously discussed stand. Wage subsidies generate the fastest responses while ITC generates the longer-lasting impacts. Capital income tax cuts yield the weakest responses. Because of the lack of persistence, wage subsidies fail to generate a meaningful boost in investment.

of equivalent magnitude.

2.4.2 Fiscal Policies as Response to a Negative Productivity Shock

Next, the effectiveness of different business incentives and their combination as countercyclical fiscal policy tools are compared. Instead of giving the policy shock in steady state, an economic downturn is first simulated that results from an adverse productivity shock. A negative 1 percent productivity shock is given, causing output to fall by approximately 2 percent below its steady state in the quarter when the shock is given. Then the behavior of the economy under five different policies is compared, one of which is passive and the other four active. The four active fiscal policies are equivalent in terms of how much they cost the taxpayer. For each policy, the rate of tax-credits, tax cuts, or subsidies are determined, such that the policy's present value cost equals 2 percent of the steady-state output. These rates are calculated using the formula described in the calibration section. The five policies are as follows:

Policy 1 - **Do-Nothing**: Under the Do-Nothing policy, no fiscal incentive is given to boost economic activity.

Policy 2 - **ITC**: The government responds to the recession by providing a temporary ITC to boost investment. The ITC rate is determined such that the cost is 2 percent of output. In the calibrated economy, this cost is achieved with an ITC rate of 1.6 percent in the first quarter the policy is implemented. That is, for every dollar spent as new capital expenditure, firms get a credit of 1.6 cent on their tax bill. The ITC rate decays progressively to zero according to the ITC shock's persistence. The benchmark persistence coefficient is set to 0.82, which is the same as productivity shock's persistence for the Canadian economy.

Policy 3 - **Wage Subsidy**: The government responds with a wage subsidy to lift employment. The size of the wage subsidy is such that the cost is equivalent to 2 percent of output, translating into a labor income tax break of 0.6 percentage points in the first period the policy is implemented. The tax break then dies over time according to the fiscal shock's persistence.

Policy 4 - **Capital Income Tax Break**: Under this policy, the government lowers the tax rate on capital income in an attempt to boost investment and employment. The cost-equivalent capital income tax break is 1.2 percentage points.

Policy 5 - **Mix ITC/Wage Subsidy**: This is a cost-equivalent 50/50 mix of an ITC and a wage subsidy. That is, the government responds to the recession with a fiscal package that consists of an ITC and a wage subsidy of similar cost (1 percent of output each). The ITC rate is 0.8 percent, and the labor income tax is cut 0.2 percentage points. The mixed-policy's cost is equivalent to that of other policies.

For now, all fiscal responses are assumed to be implemented in the quarter following the negative productivity shock. In the next subsection, the fiscal response's impacts on the results is considered.

Figure 2.3 shows each variable's behavior when the negative shock occurs and when the fiscal policy is implemented. In the quarter when the economy is hit by a negative 1 percent productivity shock, the output, employment, and consumption fall by 1.9 percent, 1.3 percent, and 0.9 percent, respectively.[14]

Under the passive policy ("Do-Nothing"), the economy progressively recovers at its own pace and ultimately returns to its original steady state. The pace of this automatic recovery depends mostly on the productivity shock's persistence. In the model economy, output takes ten quarters to return to within 0.5 percent of its original steady-state level without any fiscal stimulus.

Under the ITC policy, investment jumps by 32 percent in the period when the policy is put in place. However, the impact on output, employment, and consumption lags due to the capital accumulation process. Output takes three quarters to reach (and surpass) its pre-recession level. Similarly, the deviation of employment and consumption from their respective steady-state levels become positive two periods after the beginning of the ITC policy. The economy continues to expand above its long-run equilibrium and reaches a peak eight periods after the policy starts, with output at 0.9 percent above steady state. The capital stock also grows to reach a peak of 2 percent above its long-run value. After that initial phase of accelerated investment, the economy starts to settle down and converges back to its long-run value as the temporary ITC incentive decays. During this correction period, investment falls considerably and remains below its long-run value for several years. Although the ITC incentive only lasts a few periods, it takes much longer for output to settle

[14] To put these figures in perspective, a 1.3 percent decline in employment means approximately 200,000 jobs lost in the Canadian economy (or 1.8 million jobs lost in the U.S. economy) in a single quarter.

down.

When a wage subsidy policy is implemented, the economic impact is felt almost immediately as output, employment, and consumption jump in the same period the employment incentive is given. Unlike with the ITC policy, the wage subsidy's effects die down much faster. Expectedly, the wage subsidy policy has the strongest initial impact on employment.

A capital income tax break of equivalent cost fails to pull the economy out of the hole. The recovery paths of output, employment and consumption are just slightly better than under the "do-nothing" policy. Investment is the only variable that tends to be affected by this policy, but the effect is subdued and fails to provide a meaningful lift to capital stock and output.

As expected, the mixed-policy (wage subsidy/ITC) yields results that fall between what the individual policies generate. The recovery is faster than with the ITC alone, and the impact on the economy is longer lasting than with only the wage subsidy. Also noteworthy is that the trade balance deteriorates significantly when an ITC is implemented. It then becomes positive a few quarters later as the investment falls below long-run equilibrium and the capital stock adjusts. This non-monotonic behavior of the trade balance is consistent with previous findings in the literature (Assibey-Yeboah and Mohsin (2011), Turnovsky and Sen (1990))

Importance of the fiscal response's timing

In the baseline scenarios, the fiscal response comes just one quarter after the recession hits. In the real world, beside automatic stabilizers, such a prompt response is unlikely. Going through different steps leading to fiscal stimulus takes time. First, policymakers learn that the economy is going through a recession due to an adverse shock. This information comes with a lag, given the timing of measurement and the release of economic indicators. Then, policymakers evaluate possible policy responses and go through an often long political process to get a stimulus plan approved. Next comes the implementation phase, which can also be slow depending on the policy.

The delays in fiscal policy response are taken into account. As mentioned above, even without a fiscal stimulus (Do-Nothing policy), the economy tends to recover automatically after an adverse shock, though this automatic recovery may be slow. With an ITC or wage subsidy in place, the economy bounces back more rapidly. When the policy response comes several quarters after the adverse productivity shock, the economy may already be close to full recovery. Figure 2.4 and 2.5 show the paths of the economy with fiscal responses that occur 3 and 5 quarters after an adverse shock of low persistence. Late fiscal responses tend to generate unplanned expansions and accentuate volatility rather than accelerate recovery. Particularly when a fiscal response comes 5 quarters after the adverse shock, the recovery gain for employment is close to nothing, compared to that of the passive "Do-Nothing" policy.

2.4.3 Open versus closed economy

The economy's responses to fiscal incentives in an open versus closed economy are compared. The two model economies are calibrated such that the steady states are identical. In the long-equilibrium, the stock of foreign debt in the open economy is zero. The trade balance and current account are also set equal to zero in the open-economy steady state to be consistent with the absence of borrowing opportunity in a closed economy.

As shown in Figure 2.6, an ITC policy generates a much stronger response of investment in an open economy. A five percent ITC causes investment to nearly double in an open economy, compared to just a 12 percent gain in a closed economy. This result can be explained by the current account's behavior. In an open economy, agents can take full advantage of the ITC incentive by borrowing from the rest of the world to finance investment. There is a significant flow of foreign capital into the economy to invest and benefit from the temporary incentive. As a result, the current account deteriorates deeply when the ITC policy starts. An ITC of one percent causes a current account deficit of nearly 6 percent of output in the initial period. The trade deficit shrinks in the subsequent periods as the economy expands due to the extra capital accumulated. Also, as the ITC policy tapers, the investment level readjusts as capital flows out.

Conversely, no borrowing opportunity exists in a closed economy. To take advantage of the investment incentive, agents must sacrifice consumption, thus explaining why consumption falls immediately when the ITC shock occurs. However, because agents value smooth consumption, there is little room for investment to grow considerably given the budget constraint. An ITC of one percent causes consumption to fall by only 0.3 percent below its steady state as investment increases by 1.02 percent. Investment's timid response to the ITC policy under a closed economy translates into a weak impact on the economy in terms of employment and production. The ITC incentive only slightly affects output and labor in a closed economy.[15]

Figure 2.7 shows that the responses a wage subsidy policy generates in a closed economy are similar to those it generates in an open economy, except for investment. A wage subsidy policy essentially changes the relative factor price (the wage rental ratio) by making labor relatively cheaper compared to capital. The change in the wage rental ratio has two types of effects: substitution and output effects. Both effects are positive for employment. For investment, the substitution effect is negative, while the output effect is positive. The firm substitutes capital for labor because the latter is relatively cheaper due to the wage subsidy. At the same time, the increase in output requires more capital. Unlike capital, labor is not mobile. Therefore, the payroll fiscal incentive has the same effects on employment in closed and open economies. In a closed economy, however, domestic savings can only be used to finance investment, whereas in an open economy, domestic savings can also be used to buy foreign assets. These distinctions explain why a slightly higher investment response is observed in a closed economy, while a current account surplus combined with a lower investment increase is observed in an open economy.

2.5 Conclusions

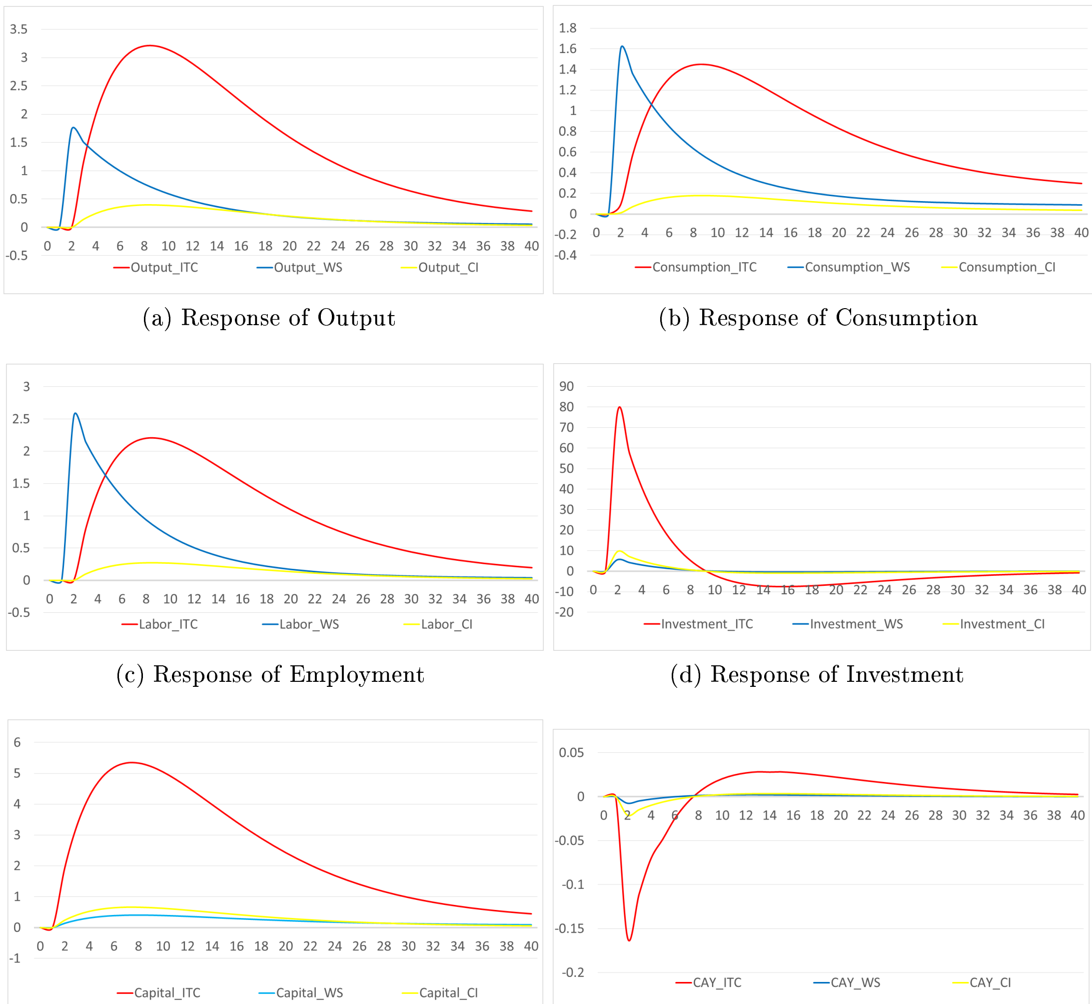
A comprehensive dynamic general equilibrium framework is built to analyze and compare the macroeconomic effects of various business fiscal incentives in the context of an open economy. The model features various fiscal policy instruments, such as investment tax credits, wage subsidies, and

[15]Results similar to the closed-economy results are obtained in the open-economy model by setting the risk premium parameter ψ high enough.

capital income tax breaks. The alternative fiscal incentives are set such that they are cost equivalent in terms of tax expenditure. Episodes of economic downturn following an adverse productivity shock are simulated, and various cost-equivalent fiscal policy responses are considered.

Wage subsidies tend to have faster impacts on output, but these effects are relatively short. Investment tax credits, on the other hand, tend to have slower but longer lasting impacts. These results suggest that the fiscal responses' goals and timing are crucial in deciding what policy is appropriate. This study also finds that all the fiscal policies considered have positive impacts on government revenue, but the ITC policy is the only one that is self-financing (mostly through its impact on labor income taxation.) Finally, the fiscal shocks' persistence appears to play an important role in the initial investment response.

This framework can be extended to analyze the effects of anticipated shocks as well as those of truly permanent shocks.



(a) Response of Output

(b) Response of Consumption

(c) Response of Employment

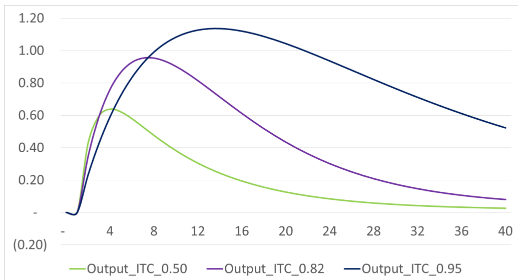
(d) Response of Investment

(e) Response of Capital

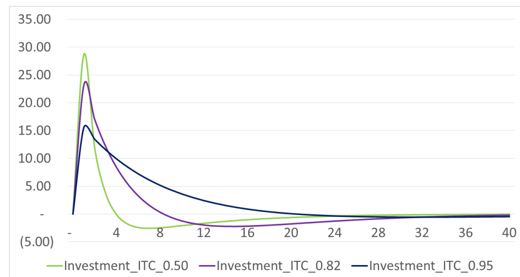
(f) Response of Current Account-to-Output Ratio

Figure 2.1: Comparison of the Key Variables' Responses to Each Fiscal Policy Shock

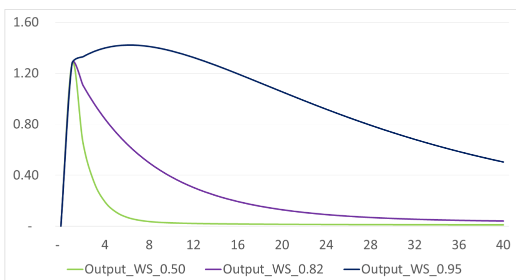
Notes. Responses are to equivalent fiscal policy shocks costing 5 percent of output in terms of cumulative present value of tax expenditure. Vertical axes are percentage deviations from the long run equilibrium. Horizontal axes are quarters. All shocks are given in the first quarter.



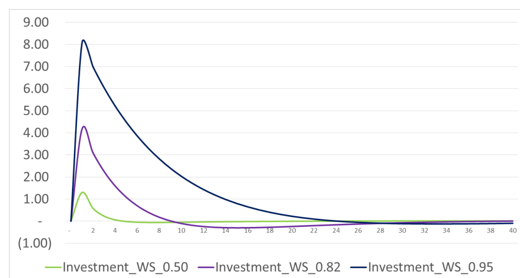
(a) Response of Output to ITC



(b) Response of Investment to ITC



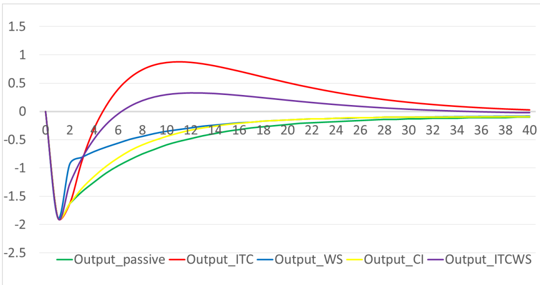
(c) Response of Output to Wage Subsidy



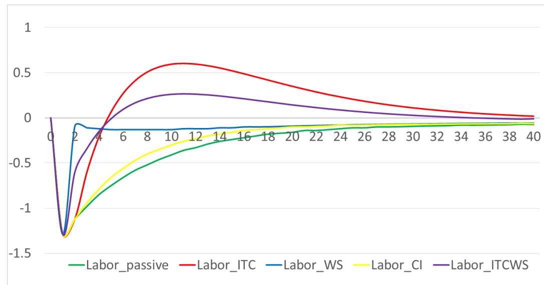
(d) Response of Investment to Wage Subsidy

Figure 2.2: Responses to Fiscal Policy Shocks of Different Persistence

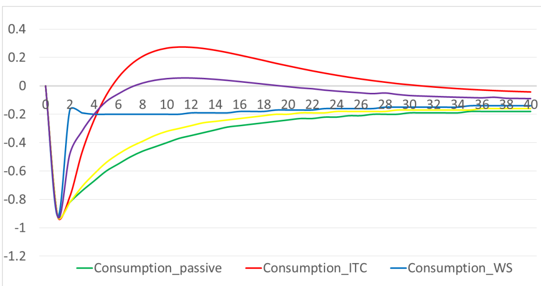
Notes. Responses are to one standard deviation ITC or wage subsidy shocks of various persistence. The persistence values are indicated in subscript. Vertical axes are percentage deviations from the long run equilibrium. Horizontal axes are quarters. All shocks are given in the first quarter.



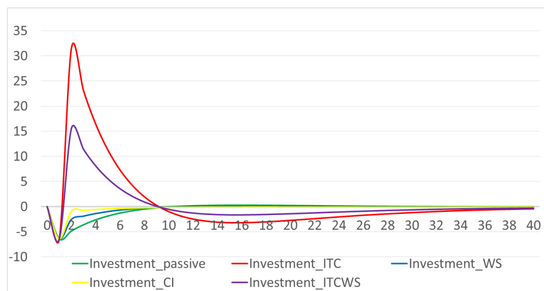
(a) Response of Output



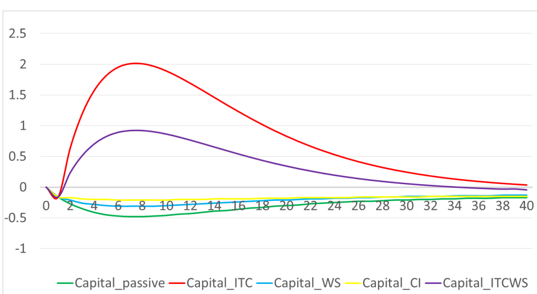
(b) Response of Employment



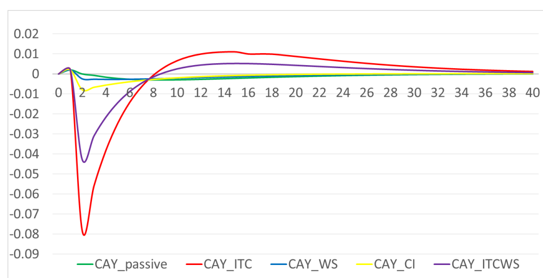
(c) Response of Consumption



(d) Response of Investment



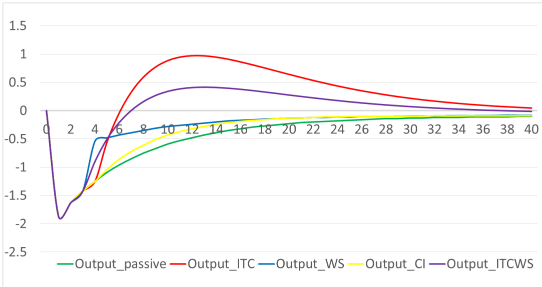
(e) Response of Capital



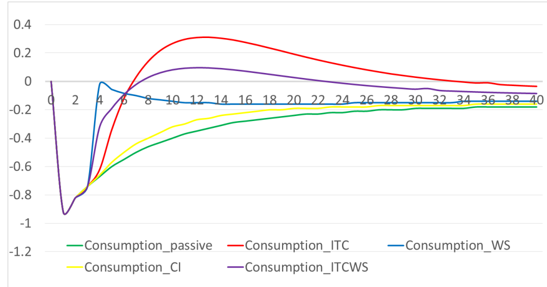
(f) Response of Current Account-to-Output Ratio

Figure 2.3: Fiscal Policies Following an Adverse Productivity Shock

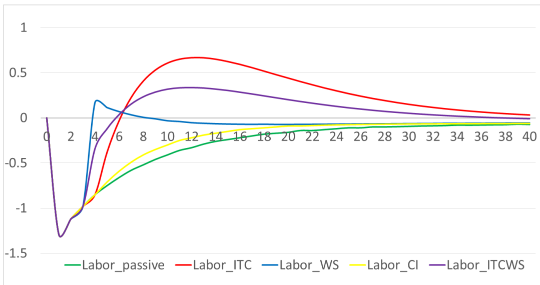
Notes. A negative one standard deviation productivity shock is given in period 1, which causes output to fall by nearly 2 percent. Fiscal shocks are given in period 2. Five policies are considered: “Do-Nothing”, investment tax credits (ITC), wage subsidies (WS), capital income tax cuts (CI), and mix investment tax credits and wage subsidies (ITCWS). The fiscal shocks are such that all policies (except “Do-Nothing”) have the same present value cost (2 percent of steady-state output.)



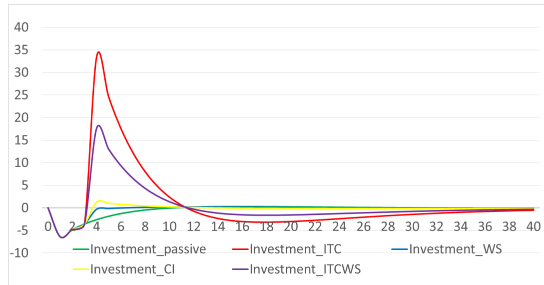
(a) Output



(b) Consumption



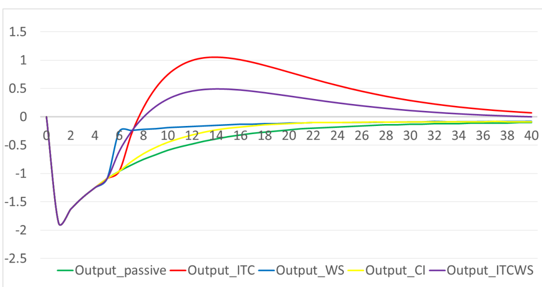
(c) Employment



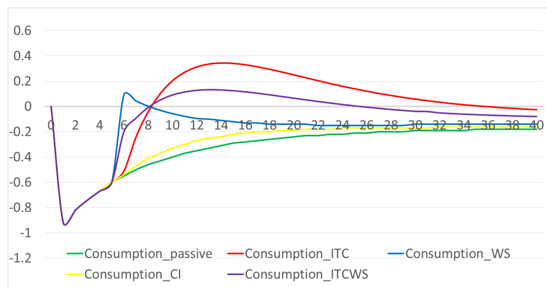
(d) Investment

Figure 2.4: When the Fiscal Response Occurs Three Periods After the Negative Shock

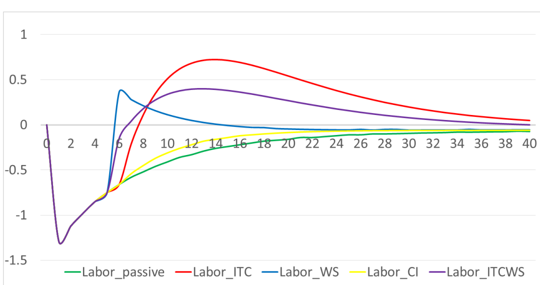
Notes. See notes Figure 2.3. The fiscal shocks are given three quarters after the adverse productivity shock.



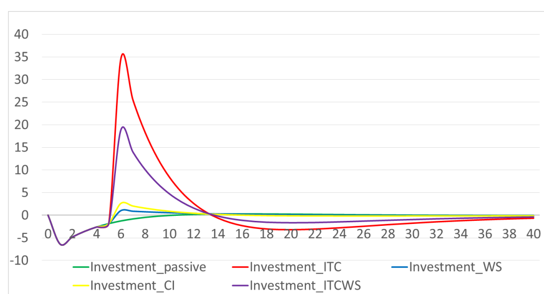
(a) Output



(b) Consumption



(c) Labor



(d) Investment

Figure 2.5: When the Fiscal Response Occurs Five Periods After the Negative shock

Notes. See notes Figure 2.3. The fiscal shocks are given five quarters after the adverse productivity shock.

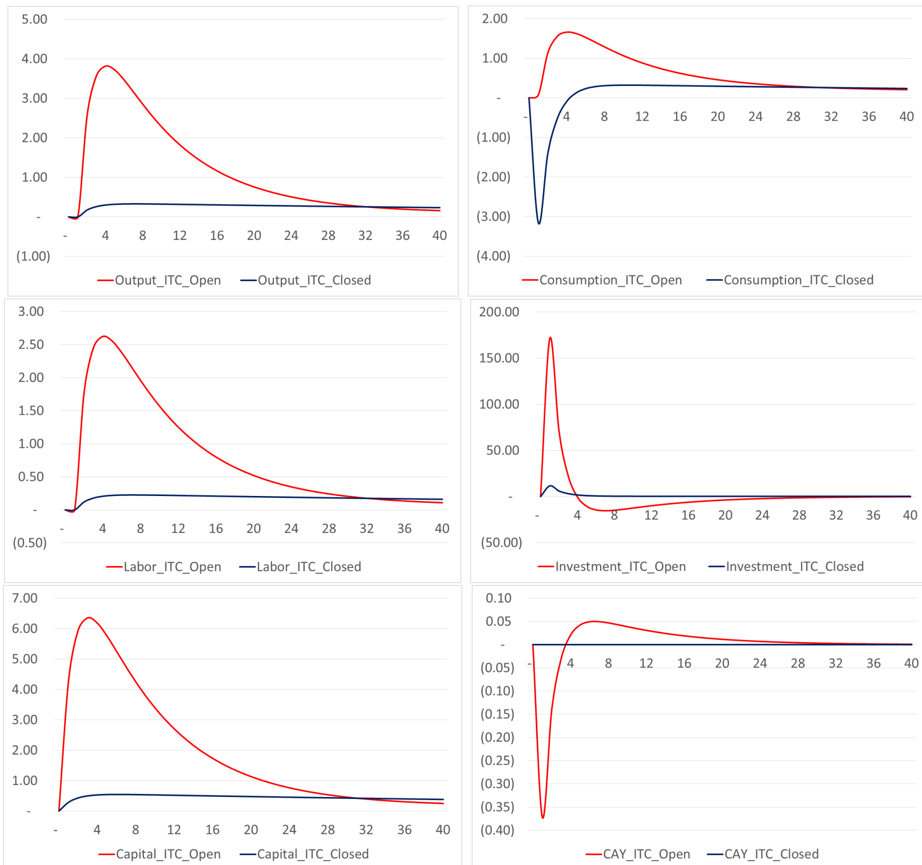


Figure 2.6: Open Versus Closed Economy: ITC

Notes. The two model economies (open and closed) are calibrated such that they have identical steady state (zero trade balance and no outstanding debt in the open economy). The responses follow a positive ITC shock given in period 1. The policy costs 5 percent of steady-state output in present value.

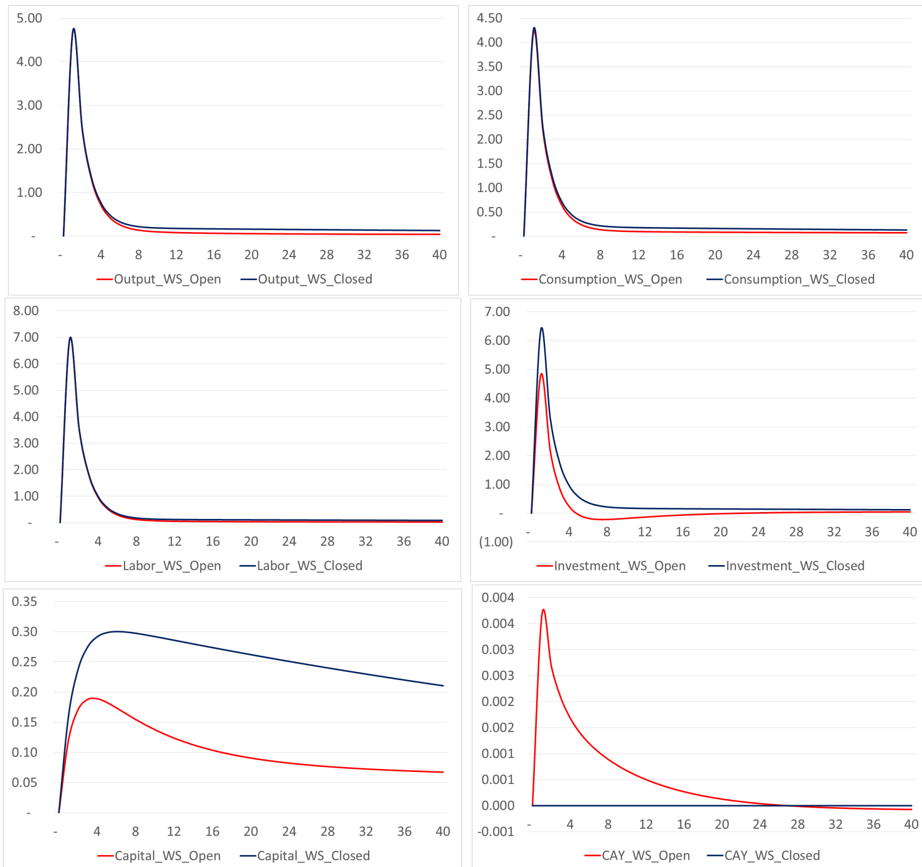


Figure 2.7: Open Versus Closed Economy: Wage Subsidy

Notes. The two model economies (open and closed) are calibrated such that they have identical steady state (zero trade balance and no outstanding debt in the open economy). The responses follow a positive wage subsidy shock given in period 1. The policy costs 5 percent of steady-state output in present value.

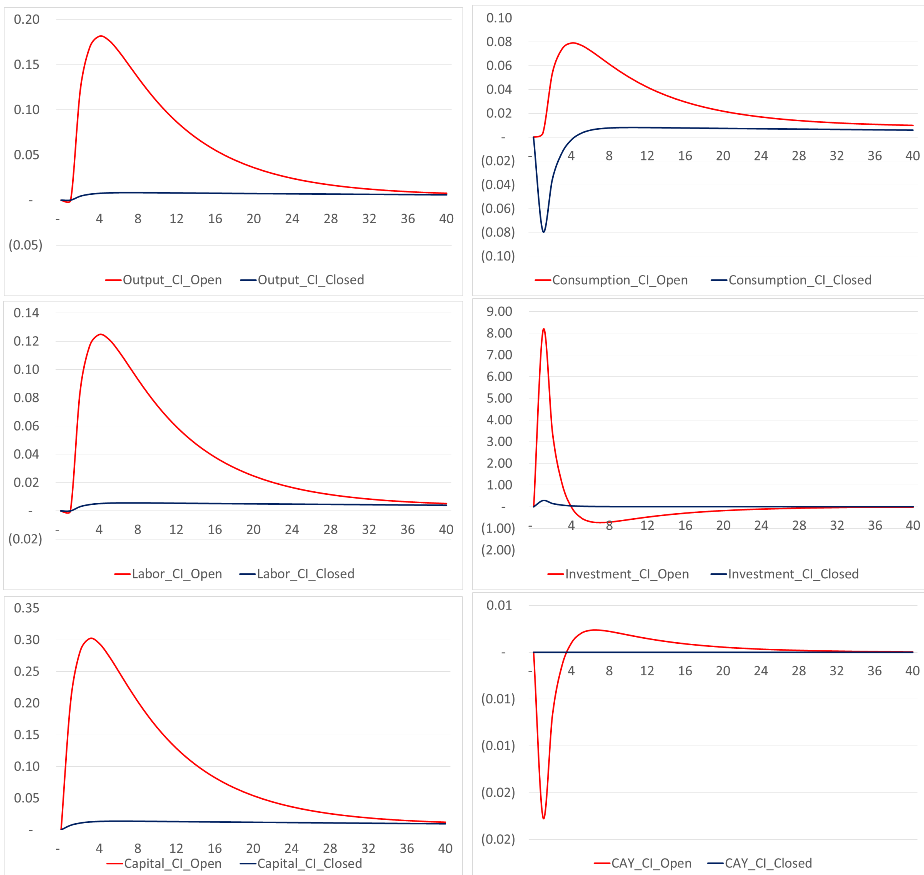


Figure 2.8: Open Versus Closed Economy: Capital Income Tax Break

Notes. The two model economies (open and closed) are calibrated such that they have identical steady state (zero trade balance and no outstanding debt in the open economy). The responses follow a positive capital income tax cut given in period 1. The policy costs 5 percent of steady-state output in present value.

Chapter 3

Millionaires or Job Creators: What Really Happens to Employment When You Stick it to the Rich?

3.1 Introduction

The question of raising taxes on individuals at the top of the income distribution continues to generate passionate debates among economists and lawmakers. This debate is particularly heated in the U.S., where the growing income concentration since the 1970s has become a major issue (see for example Atkinson et al. (2011), Autor et al. (2008), Bakija et al. (2012), Mankiw (2013), Piketty and Saez (2003), and Stiglitz (2012).) The Occupy movement that began in New York City in 2011 and quickly spread to many major cities around the world is a good illustration of current economic divides. Lately, the stunning success of the bestselling book "Capital in the Twenty-first Century" by Piketty (2014) brought even more attention to the issue. The extreme popularity of Piketty's book is also the unnecessary yet irrefutable proof that inequality concerns and the redistributive aspect of tax systems are now more than ever a topic of interest beyond academic circles.

The rich are often a prime target when more tax revenue is needed.[1] However, one key area where

[1] California Propositions 63 (2004) and 82 (2006) are good examples (Lee (2011).)

disagreements emerge is the economy-wide consequences of such tax changes. The purpose of this essay is to answer with empirical evidence this simple question: Does imposing higher taxes on the rich help or hurt job creation? The question has important political implications, and opinions on the matter are highly polarized. Proponents of tax hikes on the rich reject the idea that such tax increases, which some call the "millionaire tax," negatively affect jobs. Detractors, on the other hand, believe that increasing taxes on the wealthy, which they consider "job creators," harms the economy by hampering job creation, or worse, by destroying existing jobs.

Surprisingly, this important question has received little attention in the empirical tax literature. Much of the existing literature addresses two related issues. Part of the literature focuses on the rich by examining how tax changes affecting them influence outcomes like their taxable income, labor supply, or interstate migration. Goolsbee (2000), for instance, uses detailed compensation data on corporate executives to evaluate their taxable income's responsiveness to the increased marginal tax rates in 1993. He finds a significant decline in taxable income among executives at the top of the income distribution in the short run, but very little responsiveness in the long run. Goolsbee concludes that the observed decline is more of a short-run shift in compensation timing rather than a permanent change in taxable income. Slemrod (2000) presents an excellent review of the literature regarding the behavioral responses of the affluent when they are taxed more heavily. (See also Piketty et al. (2014) and Saez et al. (2012)). This work differs from these studies as it is interested in the economy-wide consequences of taxing the rich.

Another line of the fiscal policy literature examines the impact of general tax hikes (or tax cuts) on aggregate employment or, more generally, the macroeconomic effects of tax changes. Most economists agree that, in general, tax increases have negative effects on gross domestic product (GDP) via multiplying effects. However, there is little agreement on the tax multiplier's magnitude. The endogenous nature of fiscal policy changes creates a challenge in empirically isolating tax changes' true impact on economic activity. Two prominent papers recently addressed this issue using new approaches. Romer and Romer (2010) construct a new measure of exogenous tax changes based on analyses of narrative records, such as presidential speeches and congressional reports. They separate all legislated tax changes that occurred in the postwar period into endogenous and exogenous categories. Using their new measure of exogenous tax changes, they find that the negative effects of tax increase on economic activity are much larger than those obtained using broader measures. Barro and Redlick (2011) estimate the macroeconomic effects of government purchases and taxes using Ramey (2009)'s defense news variable and a newly constructed measure of average marginal tax rate (AMTR). They find significantly negative effects of tax increases on GDP, with an estimated tax multiplier around -1.1. Other researchers that have investigated this issue include Alm and Rogers (2010), Auten et al. (2008), and Böhringer et al. (2005). These studies are related to this one in the sense that they investigate economy-wide impacts of tax changes. However, the focus of this study is on tax increases for the well-to-do only, holding the economy's overall tax pressure constant.

Perhaps the closest work to this study is that of Zidar (2013). Using Romer and Romer (2010)'s narrative-based exogenous tax changes, Zidar constructs a measure that distinguishes which income groups received those tax changes. He finds that the negative relationship between tax changes and economic growth is mostly driven by lower-income groups. Specifically, tax cuts that benefit the bottom 90 percent have large positive effects on growth, while tax cuts that go to the top 10 percent have small and statistically insignificant effects. This study differs from Zidar (2013) in many regards. One key difference is the focus on tax changes affecting the very top of the income distribution. Based on the 2011 IRS statistics of income, the top 10 percent income class (used by Zidar) included households with an adjusted gross income of $133,000 or more. By most definitions, this group includes much of the middle class. In this study, the top 1 percent is used as the baseline. This study also considers alternative thresholds, such as 0.1 percent, 0.5 percent, and 5 percent. In addition, unlike Zidar (2013) who partly relies on compositional differences in income groups across states for identification, this study exploits variation in relative federal tax burden by income group across time. Zidar justifies his approach as follows: "If tax cuts for high income earners generate substantial economic activity, then states with a large share of high income taxpayers should grow faster following a tax cut for high income earners." This assertion can be problematic given the nearly perfect capital mobility across U.S. states, and the fact that much of the economic activity generated in a given state can be linked to high-income earners residing in a different state.

This essay contributes to the literature by providing rare empirical evidence on the causal relationship between the relative tax burden of the rich and aggregate employment growth. Both short-run and long-run effects are investigated. A new time series on relative tax burden is constructed by income groups based on the IRS statistics of income. The empirical framework builds on Barro and Redlick (2011) and Romer and Romer (2010). This study also adds to the larger discussion on rising income inequality by shedding some light on the macroeconomic consequences of purely redistributive tax policies.

The results show that an increase in the relative share of tax paid by the rich has strong and statistically significant positive effects on net job creation in the short run. In the preferred specification, a 1 percentage point increase in the share of tax paid by the top percentile of taxpayers is associated with an increase of quarterly payroll employment growth by 0.05 percentage points (or 22,500 additional jobs added per month.) Findings also include evidence of negative effects in the long run, though the cumulative net impact (both short and long runs) is positive. The main results hold to a number of robustness checks, including restricting the sample to a period of exclusively exogenous tax changes, based on the narrative record analysis in Romer and Romer (2010). The results are also consistent across alternative specifications and estimation methods, including unrestricted and Bayesian VARs.

Although the transmission mechanisms' structural identification is beyond the scope of this study, possible explanations for the results are provided. According to basic textbook Keynesian theory, increasing taxes in general has a negative impact on aggregate output through the negative multiplying effect. However, the tax multiplier's magnitude is increasing in the marginal propensity to consume. For example, a purely redistributive policy change (no change in revenue) that increases the tax burden on the rich and lowers everyone else's would have a negative effect on the one hand due to the tax hike on the rich, and a positive effect on the other hand due to the tax break for everyone else. Because the rich have a lower marginal propensity to consume, the positive effect outweighs the negative. Therefore, a revenue neutral redistributive tax policy would have a positive net effect within a simple Keynesian framework. This analysis also holds if the tax hike on the rich is used to finance government spending. In theory, the positive government spending multiplying effect outweighs a tax increase's negative multiplying effect. This relationship is particularly true when the tax increase is only for the rich, given their lower marginal propensity to consume.

While the short-run impact seems obvious, at least within a Keynesian framework, whether the benefits persist in the long run is a different story. Increasing the tax burden on the rich could harm job creation in the long-run through the investment channel. This effect is related to the claim that the rich are the "job creators," possessing the resources to invest both in physical capital and innovative ventures. Taxing them more heavily arguably reduces that incentive at the margin. As argued in Mankiw (2013), society should not be concerned about a fraction of the population aspiring to become super rich, as long as the process is socially productive. For instance, game-changing innovators like Steve Jobs are to be encouraged.

This study abstracts from the theoretical transmission mechanisms and focuses on the empirical evidence of the causal relationship between taxing the rich and employment growth. The remainder of the essay is structured as follows. Section 2 discusses methodological issues and identification strategies. Section 3 presents the newly constructed time series on relative tax burden by income group and briefly discusses the rest of the data. Section 4 presents the results. Section 5 is the conclusion.

3.2 Methodological Issues

Addressing the overall employment impact of a tax hike on the rich can be challenging in terms of identification and data availability. While showing a correlation between employment growth and an increase in the tax burden on the rich may be straightforward, establishing a causal relationship requires more care. In this section, the identification issues faced and the strategies used to overcome those issues are addressed.

Consider the following simple equation:

$$y_t = \alpha + \beta \Delta T_t + \varepsilon_t \tag{3.1}$$

where $y_t = \frac{Y_t - Y_{t-1}}{Y_{t-1}}$ is a measure of employment growth, T_t is a measure of the relative tax burden on the rich, and ε_t represents all the other factors, both observed and unobserved, that affect the growth of employment. Changes in some of those factors cause the relative tax burden on the rich to change as well. One issue that comes to mind when estimating macroeconomic tax effects is the endogenous relationship between fiscal policy changes and economic activity. Policymakers may react to economic fluctuations and make fiscal changes for stabilization purposes. To the extent that those tax changes equally affect all income levels, the measure of tax burden on the rich should be expected to be exogenous after controlling for the economy's overall tax pressure. However, through the political process generating fiscal policy changes, the well-to-do could possibly end up with a change in their tax burden that differs from that of the remaining taxpayers. Estimating equation 3.1 would lead to a biased estimate of β under these conditions.

The identifying assumption is made that tax changes occurring one or more years earlier are not determined by the economy's current state.[2] Thus, the following alternative equation is considered:

$$y_t = \alpha + \sum_{j=1}^{J} \beta_j \Delta T_{t-j} + \delta_1 U_{t-1} + \delta_2 TP_{t-1} + \varepsilon_t \tag{3.2}$$

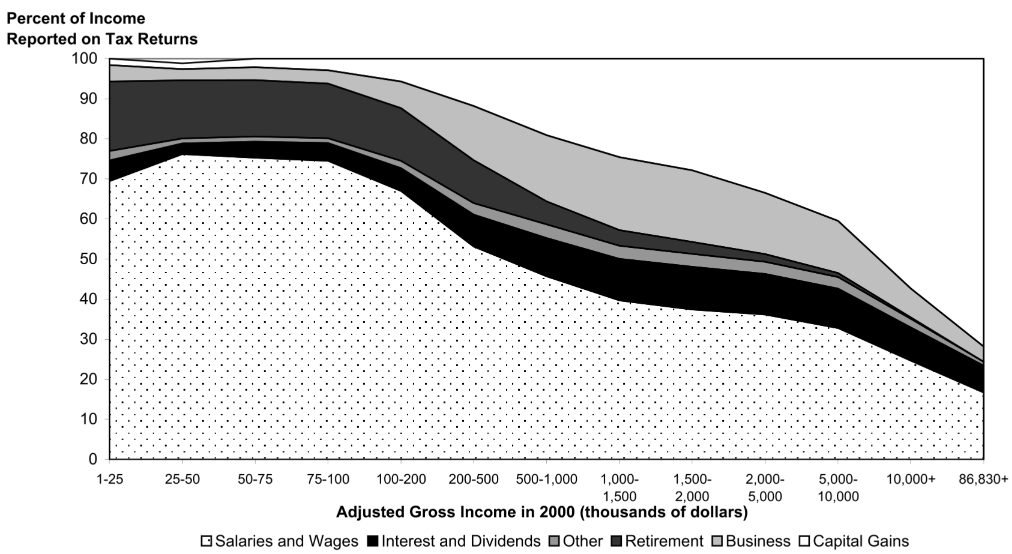
where U_{t-1} is a lagged business cycle indicator (the unemployment rate for example) and TP_{t-1} is a measure of the overall tax pressure in the economy. To account for the amount of slack in the economy, To account for the amount of slack in the economy, U_{t-1} is added. As argued in Barro and Redlick (2011) and in Romer and Romer (2010), omitted variables that are orthogonal to the tax variable when a lagged business cycle indicator is added are not a source of bias for the fiscal effects. This control is particularly important here since this study is not fully modeling employment growth. Rather, it is merely interested in the sign of the partial effects (if any) on employment growth resulting from a tax increase on the rich.

Another potential endogeneity concern is the possibility of heterogeneous income growth during

[2] Under certain circumstances, the contemporaneous tax variable could be treated as exogenous as well, as described in Blanchard and Perotti (2002). With quarterly data, for example, it is hard to imagine that policymakers can (1) learn about a problem in the economy; (2) design a policy to correct the problem; and (3) implement that policy, all within the same period. Even with annual data, this contemporaneous reaction is still problematic, although not impossible.

certain expansions or recessions. For example, for a particular episode of economic boom, the rich could see their income grow faster than that of the remaining. Consequently, their relative share of tax burden would increase due to the economic expansion, not the other way around. Using lagged tax variables partially addresses this issue. However, without specifically modeling aggregate employment growth's dynamics, there is still a risk of capturing correlation as causation in equation 3.2.

To address this issue, the heterogeneity in income composition across income groups is exploited. A simple examination of Figure 3.1 reveals that taxpayers on the right tail of the income distribution receive predominantly capital income (capital gains, interests, and dividends). On the other hand, labor income (salaries and wages) represents the bulk of the low- to middle-income classes' revenue.



Footnotes:
1. Interest and Dividends includes both taxable and non-taxable interest and all dividends.
2. Other income is the total of state tax refunds, alimony, non-capital asset property, estate and trust, unemployment, foreign earned exclusion, other, gambling, and rent and royalty income.
3. Retirement income includes both the taxable and nontaxable portions of IRA distributions, Social Security benefits, and pensions and annuities (as reported on tax returns).
4. Business income is defined as Schedule C, S-corp , partnership, and farm income.
5. Capital gains income is the combination of capital gains distributions reported on the 1040 and net taxable gains on capital assets reported on Schedule D.
6. The final AGI category is the 400 returns with the highest AGI. The definition of income here is slightly different than for the other income classes. All information is for taxable income as a percent of AGI. Retirement income is not included.
Source: Table 1.400, IRS, Statistics of Income, Individual Income Tax Returns 2000, Publication 1304 (Rev. 0402003). Table 1, IRS, Statistics of Income Bulletin, Spring 2003, Publication 1136 (Revised 6-03).

Figure 3.1: Composition of Income by AGI Class in 2000

Figure source: Tax Policy Center

To rule out reverse causation, the assumption is made that an episode of economic expansion causing the relative tax burden of the rich to increase due to their relative income growth is captured by the differential of growth in capital versus labor income. The variable RIG (relative income growth) in equation 3.3 is a measure of the difference between the growth rate of capital income and that of labor income for all taxpayers.

$$y_t = \alpha + \sum_{j=1}^{J} \beta_j \Delta T_{t-j} + \delta_1 U_{t-1} + \delta_2 TP_{t-1} + \delta_3 RIG_{t-1} + \varepsilon_t \tag{3.3}$$

The regression analysis is complemented with a reduced-form VAR(p) specified as follows:

$$\begin{aligned} y_t =& v_1 + \sum_{p=1}^{P} a_{1p} y_{t-p} + \sum_{p=1}^{P} b_{1p} \Delta T_{t-p} + \varepsilon_{1t} \\ \Delta T_t =& v_2 + \sum_{p=1}^{P} a_{2p} y_{t-p} + \sum_{p=1}^{P} b_{2p} \Delta T_{t-p} + \varepsilon_{2t} \end{aligned} \tag{3.4}$$

The testable assumption is made that the errors in system 3.4 are not contemporaneously correlated. More generally, innovations in the employment equation are assumed to be independent from those in the tax equation.

The VAR approach complements the analysis in three ways. First, including many lags of the dependent variables establishes a more general specification of employment growth's dynamics without necessarily modeling its determinants. The second advantage is the possibility of analyzing longer-run employment effects of tax hikes on the rich, using orthogonalized impulse response functions. Finally, the VAR approach can help disentangle some of the mechanisms through which a tax hike on the rich may affect employment. Various components of GDP (e.g. consumption, investment) are alternatively added as a third dependent variable to the reduced-form VAR as shown in the system of equations 3.5:

$$\begin{aligned} y_t =& v_1 + \sum_{p=1}^{P} a_{1p} y_{t-p} + \sum_{p=1}^{P} b_{1p} \Delta T_{t-p} + \sum_{p=1}^{P} c_{1p} C_{t-p} + \varepsilon_{1t} \\ \Delta T_t =& v_2 + \sum_{p=1}^{P} a_{2p} y_{t-p} + \sum_{p=1}^{P} b_{2p} \Delta T_{t-p} + \sum_{p=1}^{P} c_{2p} C_{t-p} + \varepsilon_{2t} \\ C_t =& v_3 + \sum_{p=1}^{P} a_{3p} y_{t-p} + \sum_{p=1}^{P} b_{3p} \Delta T_{t-p} + \sum_{p=1}^{P} c_{3p} C_{t-p} + \varepsilon_{3t} \end{aligned} \tag{3.5}$$

3.3 Data

Tax Data

A time series is constructed on relative federal individual income tax burden by income group, using data from the Statistics of Income (SOI), published annually by the Internal Revenue Service (IRS) and available from 1913.

The preferred explanatory variable is the share of tax liability that falls on the rich, with the definition of *rich* based purely on income. By default, taxpayers in the top percentile of the pre-tax income distribution (the so-called "1 percent") are considered rich. Alternative thresholds, such as 0.1, 0.5, 5, 10 or 20 percent, are considered throughout the analysis.[3]

To obtain a given income group's share of tax liability, the tax liability of that group is divided by all taxpayers' total tax liability for the year. Henceforth, this variable is referred to as *taxshare*. Using the share of tax liability has many advantages over other commonly used measures, such as marginal tax rate or average marginal tax rate.

First, *taxshare* captures all federal individual income taxes, regardless of the income source. Given the U.S. tax system's complexity (itemized deductions, AMT, various credits, and loopholes), determining a specific tax rate that truly reflects individual taxpayers' tax burden can be challenging. This challenge is particularly true regarding the most affluent taxpayers because they are generally better equipped to take advantage of all legal opportunities to minimize their tax liabilities. In 2013 for instance, more than half of the combined benefits of the top 10 federal tax expenditures went to the top quintile, according to CBO estimates (CBO (2013).) The top one percent received 17 percent of those benefits. By using the share of liabilities, this difficulty can be circumvented because this measure is the actual relative burden that falls on the wealthy after accounting for all possible tax treatments. For example, many lawmakers advocate closing tax loopholes that tend to favor the rich. Closing those loopholes will not be captured by marginal rates but will be clearly

[3] As discussed in Slemrod (2000), there are some caveats in using annual income as the metric to define rich. For example, a household that receives a one-time high income in a given year may be misleadingly classified as rich. Slemrod (2000) also discusses alternative affluence indicators, such as wealth, lifetime consumption, and lifetime income. In this study, annual income is used because it is the only measure for which data is available by group for multiple years.

reflected in the share of tax burden falling on the rich because they are the largest beneficiaries. Without being specific about what deductions or tax expenditures are being eliminated, changes in the tax system resulting in effectively shifting relative burden from the masses to the well-to-do and vice versa can be captured.

Second, *taxshare* is to some extent robust to changes in income affecting the entire distribution spectrum. When everybody in the economy gets richer (at the same pace), the "one percent" group does not change. This matters for identification. For example, consider a non-tax-related unobserved shock that boosts economic activity (employment and income). Such a shock causes everyone's taxes to increase at the same time because of higher tax brackets. This affects the average effective tax rate and the average marginal tax rate by income group, rendering those variables endogenous. However, such a shock would not affect the tax share by percentile because as everyone's income and taxes increase, the income distribution remains the same, as does each percentile's share of tax liability. The only case in which the tax share by percentile (say, for the rich) would be affected without a change in fiscal policy is if the income of the rich grows at a different pace than that of the remaining population. In that case, the relative growth control variable should capture that effect, leaving the *taxshare* variable exogenous.[4]

A somewhat less desirable alternative measure of the tax pressure on the rich is their effective average income tax rate. Henceforth, this variable is referred to as *averagetaxrate* or *ATR*. To obtain this measure, the income group's tax liability is divided by the corresponding total income. For example, the effective average tax rate for the top quintile is the ratio of the aggregated tax liability of taxpayers in the top quintile to the aggregated income reported by those taxpayers. As discussed earlier, this variable is more prone to endogeneity than *taxshare*.

Employment and Economic Activity Data

The main dependent variable of this study is the growth rate of seasonally adjusted payroll employment. Up-to-date monthly payroll employment data are readily available from the Bureau of Labor Statistics (BLS) starting in 1939. The unemployment rate and other labor force statistics

[4]As discussed earlier, the heterogeneity in income composition is exploited across income groups for this control. (See identification section.)

are also collected from the BLS. The data on gross domestic product (GDP) and its components are collected from the Bureau of Economic Analysis (BEA). The 2009 chained measures for GDP and its components are used in this study. Finally, the income composition data used to compute the variable RIG are from the SOIs.

Frequency and Range of Data

The tax variables are observed annually (federal returns) while most of the economic activity variables are available at least quarterly. Two sets of regressions based on each frequency are run. Each frequency has its advantages. The annual data eliminates having to deal with seasonality issues in macroeconomic variables (Romer and Romer (2010)). With quarterly data, the variation in employment can be better captured. Even though the tax liability variables are observed annually (when returns are filed), thinking of them as constant throughout the fiscal year makes sense. First, all tax laws applicable for a given year (including rates, brackets, and deductions) are typically known at the beginning of the year or long before. In addition, taxpayers are assumed to have a reasonable idea of their annual income for the current year. As such, they are aware of their annual tax burden throughout the year. Therefore, the tax burden variables are considered constant within years, and the annual observations are replicated in all four quarters of the year.

The sample covers the period from 1947Q1 to 2011Q4. Although annual data exist back to 1939 for most economic activity variables, including payroll employment, the tax distribution data for the World War II period is problematic. For some years between 1939 and 1945, close to half of the returns were not allocated to any income group (classified as "not distributed" in the SOIs). In addition, important changes, including requirements to file, occurred between 1939 and 1947. The number of returns reported in the SOIs went from 7 million in 1939 to close to 50 million by 1945. Since only the filed returns are observed, significant changes in requirements to file can affect the distribution and the definition of *rich* and, therefore, render comparison across time problematic.

Summary statistics of the key variables are in Table 3.1.

Table 3.1: Summary Statistics

	N	Mean	St. Dev.	Min	Max
Payroll growth	268	.4298507	.6678301	-1.7	2.9
Share Top 1pct	260	24.73231	6.643535	15.6	39
Average Tax Rate Top 1pct	260	28.81385	3.515212	22.3	36.5
Average Tax Rate All	260	13.18769	1.179033	9	15.8
GDP growth	267	.7992509	.9758356	-2.6	4
U-Rate	264	5.825379	1.66368	2.6	10.7
RIG	244	2.406496	13.10341	-37.30811	33.157

Notes. The data are quarterly from 1947Q1 to 2011Q4. *RIG* is the relative income growth of capital versus labor income.

3.4 Results

3.4.1 General Results

Equation 3.3 is estimated using quarterly data. At first, only one lag of the independent variable of interest, *taxsharetop1pct*, is considered; this variable measures the share of tax liability falling on the top 1 percent of the population. The results are reported in Table 3.2. For all four columns, the dependent variable is the quarterly growth rate of seasonally adjusted payroll employment. The estimated coefficients on the lagged tax burden variable (*taxsharetop1pct*) are positive and statistically significant in all four specifications. In the equation with all controls (column 4), the estimated coefficient is 0.050 (s.e.=0.023). That is, a 1 percentage point increase in the share of federal individual income tax liability falling on the rich is associated with an increase of 0.05 percentage point in quarterly payroll employment growth (or 0.2 percentage point annually). To put this result in perspective, an annual growth of 0.2 percent means 22,500 additional jobs per month, assuming 135 million current nonfarm payroll employment jobs in the U.S. economy.

The lagged unemployment rate is included to account for unobservables that are correlated with the business cycle. The growth rate of GDP is also added as a control variable. Since employment-growth behavior is not being explicitly modeled, adding GDP growth allows capturing the effects of most determinants of the dependent variable that are orthogonal to the tax variable. In principle, omitting those orthogonal variables should not bias the estimates. However, it helps improve the overall explanatory power of the model, especially given the limited time-series sample size.[5] As expected, the estimated coefficient on GDP growth is positive and statistically significant, meaning, *ceteris paribus,* GDP growth is associated with job growth.

The economy's overall tax pressure is controlled by using the average tax rate for all taxpayers (total tax collected divided by total income for all taxpayers in a given year). The purpose of this control is to partial out the general effects of tax hikes affecting everyone. With this control, the coefficient on *taxshare* reveals what happens when the relative tax burden on the rich is increased while holding the economy's overall tax pressure constant. That tax policy change is purely redistributive. Finally, the differential in capital versus labor income growth (RIG) is controlled for. This control helps rule out increases in the tax share of the rich due to income growth less wealthy taxpayers do not experience. The estimated coefficients for these two controls are mostly insignificant.

Next, the equation in column 4 of Table 3.2 is re-estimated using alternative thresholds to define rich. Alternatively, the richest 0.1, 0.5, 1, and 5 percent taxpayers are considered. The results are shown in 3.3. Column 3 of Table 3.3 uses the baseline definition (1 percent) and serves as a benchmark. The results generally hold across thresholds, except for the top 0.5 percent and to some extent the top 0.1 percent.[6]

The effects on employment growth of increasing other income groups' *taxshare* is considered. To that end, the same equation is estimated using the five quintiles as well as the bottom 50 percent income groups. The results are shown in 3.4. Increasing the top quintile's tax share appears to have a positive statistically significant effect on employment. This effect is consistent with the previous results using narrower definitions of rich. The estimated coefficient of 0.067 (s.e.=0.025) is 34 percent higher than that of the baseline regression (top 1 percent). Interestingly, increasing the fourth quintile's *taxshare* has a strong negative and statistically significant effect on employment growth. The estimated coefficient on the fourth quintile's *taxshare* is -0.088 (s.e.=0.026).

To understand this result's implications, it is important to determine which taxpayers fall into this income class. In 2011, the latest year in this study's sample, the fourth quintile includes households

[5]The adjusted R^2 largely increases from less than 0.05 to more 0.50 once GDP growth is added.

[6]One possible explanation for inconsistent results above the top 1 percent threshold is the level of detail in income classification in the IRS reports. For example, the top income class in the 2011 Statistics of Income (SOI) is $1 million or more, including 290,000 households (0.2 percent of taxpayers.)

Table 3.2: Effects of Increasing Tax Share of The Top 1 percent on Payroll Employment Growth

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.
Lagged Taxshare Top 1%	0.0874***	0.0630***	0.0657***	0.0497**
	(0.0266)	(0.0165)	(0.0156)	(0.0231)
Lagged Unemployment Rate		-0.0516***	-0.0389**	-0.0509**
		(0.0161)	(0.0170)	(0.0205)
GDP Growth		0.488***	0.494***	0.497***
		(0.0373)	(0.0365)	(0.0366)
Lagged Average Tax Rate All			0.101*	0.0721
			(0.0516)	(0.0567)
Lagged RIG				0.00472
				(0.00296)
Constant	0.423***	0.332***	0.254**	0.299**
	(0.0417)	(0.100)	(0.107)	(0.122)
Observations	256	256	256	244
Adjusted R^2	0.049	0.549	0.560	0.570

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes. Data are quarterly from 1947Q1 to 2011Q4. The dependent variable is the quarterly growth rate of nonfarm payroll employment. Four-period seasonal difference and one year lag are used for variables that are only observed yearly (federal income tax variables). *Average Tax Rate All* is total tax collected divided by total income for all taxpayers in a given year. RIG (relative income growth) is the differential in capital versus labor income growth. Capital income includes capital gains, dividends, and interests. Labor income includes salary and wages.

with adjusted gross income (AGI) between $45,000 and $85,000, meaning much of the middle class fall into the fourth quintile. Therefore, the results suggest that increasing the middle class's relative tax burden significantly harms job growth. Statistically significant effects are not found for lower income groups.

3.4.2 Short Versus Long Run Effects

To capture the effects of tax increase in both the short and long runs, equation 3.3 including multiple lags of the *taxshare* variable is estimated. The results are shown in 3.5. In columns 1 and 2, 16 quarterly lags are included. The contemporaneous variable is also included in column 1. Although none of the estimated coefficients is individually significant, they are jointly significant by groups of 3 or 4 consecutive lags. These results are not surprising given the tax variable's frequency. As noted earlier, the tax variables are only observed annually, but the true values are assumed constant throughout the year. Thus, quarterly tax variables are obtained by replicating the yearly observations to all four quarters of the year. By construction, two consecutive quarterly lags are identical for three out of four quarters. Consequently, adding consecutive quarterly lags does not add much additional information to the model but does dilute the tax variables' effects.

To circumvent this issue, including only one lag every four quarters for 4 years is considered.[7] Columns 3 and 4 of Table 3.5 show the results using this approach. Column 4 is the preferred specification because of potential endogeneity issues associated with using contemporaneous tax variables, as discussed in section 2. Positive and statistically significant effects are found for the first- and second- year lags (that is quarterly lags 4 and 8). In addition, negative and statistically significant effects are found for the third and fourth years (quarterly lags 12 and 16). These results suggest that although increasing the relative tax burden of the rich has positive effects on employment growth in the short run, it may hurt job growth in the long run. However, in terms of magnitude, the positive short-run effects appear to slightly dominate the long-run effects. The estimated coefficients for the first- and second-year lags are 0.084 (s.e. = 0.020) and 0.044 (s.e. = 0.015), respectively. The estimated coefficients for the third- and fourth-year lags are -0.039 (s.e. = 0.017) and -0.053 (s.e. = 0.016), respectively. The cumulative effects of all four lags is 0.035 (pvalue$<$0.01). That is approximately 50,000 jobs added quarterly.[8]

3.4.3 Robustness Checks

Using Romer and Romer's Exogenous Tax Change Period

Section 2 discussed potential endogeneity issues due to economic conditions causing tax changes instead of the other way around. To deal with this issue, the assumption was made that tax changes

[7] That is, the coefficients are effectively restricted on all other quarterly lags to zero. This assumption is relaxed later on in the Bayesian VAR analysis using informative priors.

[8] Calculation based on 135 million current jobs in the U.S. economy)

occurring one or more years earlier are not determined by the economy's current state. However, it is conceivable that policymakers forecast changes in economic conditions several periods ahead and initiate tax changes in anticipation. If so, even lagged tax variables may not be completely exogenous. To assess the estimates' robustness to this unlikely but potential issue, Romer and Romer (2010)'s analysis of all federal tax policy changes occurring in the U.S. in the postwar period is used.

Using narrative records such as presidential speeches and congressional reports, Romer and Romer (2010) separate all legislated tax changes that occurred in the postwar period into two broad categories: endogenous and exogenous tax changes . They classify as "endogenous" those tax changes made in response to factors likely to affect economic activity in the near future. Such changes include countercyclical tax policies and those driven by government spending. They classify as "exogenous" those tax changes that are not made to offset other factors causing output growth to deviate from normal. These include long-run growth and deficit-driven tax changes.

A careful examination of the results of Romer and Romer (2010)'s narrative analysis reveals an opportunity to exploit their findings to test the robustness of this study's estimates. Figure 3.2 shows all legislated tax changes in the postwar period classified in the exogenous (Panel A) and endogenous (Panel B) categories. Almost all the tax changes that occurred between 1976 and 2001 appear to fall in the exogenous category.

Henceforth, the period from 1977Q1 to 2000Q4 is referred to as the *Romer and Romer exogenous tax change period*. The model is estimated for that restricted sample. The results are shown in Table 3.6. Regardless of the threshold definition of *rich* considered, strong positive and statistically significant coefficients are found. An increase in the relative tax burden of the rich does positively affect employment growth in the short run. The effects are also larger than those found using the full sample. This finding is consistent with Romer and Romer (2010)'s finding that the effects of exogenous tax increases are much larger than those found using broader measures of tax changes.

As with the full sample, multiple lags are added in attempting to replicate the short- versus long-run analysis. Table 3.7 shows the results. The estimated coefficients for the first- and second-year lags are still positive and strongly significant. Although the estimated coefficients for the long run (third- and fourth-year lags) keep their negative signs, they are not statistically significant. With the limited length of the *Romer and Romer's exogenous tax change period* (23 years), this (lack of) result for the long run is not surprising.

Using Changes in Tax Liability (Instead of *Taxshare*)

Using the share of tax paid by the high income groups as explanatory variable of interest, the results consistently show that an increase in the relative tax burden of the rich is associated with higher job growths. However, it could be the case that what really matters for employment growth is not the tax burden on the rich, but rather, the tax burden on everyone else. In other words, the results could be driven by tax cuts for the middle and low income classes, rather than by tax hikes on the rich. Or it could be a combination of both. Because the *taxshare* variable is a relative measure, it does not differentiate between the two eventualities.

To understand what side really drives the results, a different specification is experimented with. Instead of *taxshare*, the changes in tax liability for the top earners and for everyone else are included in the model. That is, payroll employment growth is regressed on changes in tax liability for the top 1 percent and for the bottom 99 percent (top 5 percent and bottom 95 percent are also considered) along with the usual controls.

The results are shown in Table 3.8. It appears clearly that tax changes for the rich (Top 1 percent and Top 5 percent) are statistically significant, and the signs of the coefficients are consistent with the previous results. The effects of changes for the bottom 99 percent and bottom 95 percent are not statistically significant. This is true whether or not the overall level of taxes constant is held constant (Columns 1 and 3 versus Columns 2 and 4 in Table 3.8). These results suggest that tax changes for the rich indeed matters.

To address concerns over of potential correlation between changes in taxes for the Top 1 percent and the Bottom 99 percent (respectively Top 5 percent and Bottom 95 percent), the two variables are alternatively added to the model. As shown in Table 3.9, the results stand: the effects of tax changes for the rich on employment growth are statistically significant.

Other Robustness Checks

An alternative measure of relative tax burden on the rich is tried using the average tax rate per income class instead of tax share.[9] Table 3.10 shows the results using *ATR* instead of *taxshare*. Similar results as with the baseline are found. That is, an increase in the relative tax burden of the rich has positive effects on employment growth in the short run.

The estimations are also replicated using annual data to address concerns regarding use of yearly-observed tax variables in quarterly estimations. As shown in Table 3.11, the results are generally consistent with the quarterly estimations. Positive short-run effects and negative long-run effects are found. The estimated coefficients on the first and second lags are, respectively, 0.209 (s.e. = 0.097) and 0.207 (s.e. = 0.066), roughly four times the average quarterly coefficients (see Table 3.5).

3.4.4 Results of VAR Analysis

Unrestricted VAR

The vector autoregressive (VAR) approach is used to complement the regression analysis of the short- and long-run effects of increasing taxes on the rich. With the VAR approach, the dynamics of employment growth can be systematically captured by including its own lags. In addition, by using impulse response functions, the impact of tax variable innovations can be better tracked over time and short- and long-run effects can be better distinguished. The VAR Granger (non-)causality test is also performed to investigate possibilities of reverse causation.

The system of equations 3.4 is first estimated as an unrestricted VAR with 16 quarterly lags.[10] The impulse response functions (IRF) are shown in Figure 3.3.[11] Next, the same logic is followed as with the single-equation regressions, and consecutive quarterly lags of the same year are excluded. Specifically, lags 1, 4, 8, 12 and 16 are included. Figure 3.4 shows the IRF for this second specification. The general patterns of the IRFs are the same for the full and reduced models.

[9] The average tax rate is obtained as the ratio of tax liability by adjusted gross income per income class.

[10] Various VAR lag order selection criteria (including AIC, LR and SC) are used to determine the approximate lag length.

[11] The generalized impulses (GIRF) as described in Pesaran and Shin (1998). Because no contemporaneous correlation exists in the VAR residuals (tested), the GIRF results do not differ much from the simple non-orthogonalized IRFs or the Cholesky-orthogonalized IRFs.

The IRF in Panel B (Figure 3.4) shows the response of employment growth to an exogenous change in the tax share of the rich and how that response varies over time.[12] Two interesting results appear. A positive and statistically significant impact appears in the short run (1 to 2.5 years after the shock), and a negative and statistically significant impact appears in the long run (4 years after the shock). The cumulative effects stays positive in both the short and the long run as shown in Panel B of 3.5. These VAR results are consistent with the findings in the single equation regression analysis.

Panel C (Figure 3.4) shows that the *taxshare* variable is not significantly affected by exogenous changes in employment growth. This finding eliminates concerns of potential reverse causation. A Granger (non-)causality test was performed after the VAR and the results shown in Table 3.12 confirm the absence of causation from employment growth to *taxshare*. Conversely, the null hypothesis of absence of causation from *taxshare* to employment growth is rejected at the 1 percent level.

Bayesian VAR

One natural problem with VAR estimations is the need for large samples because of the high number of coefficients to estimate. For example, in the system 3.4 VAR with two endogenous variables, 16 lags, and at least one exogenous variable (the constant term), $2 * (16 * 2 + 1) = 66$ coefficients must be estimated. With 3 endogenous variables (system 3.5), the number of coefficients to estimate increases to 147. This high number of parameters to estimate is certainly an issue given the limited sample size. One way to deal with this issue is to restrict some of the coefficients to zero by excluding some lags altogether. This step was taken in the select lag unrestricted VAR specification discussed earlier. However, Bayesian VAR provides an alternative that does not require imposing these extreme restrictions. However, Bayesian VAR provides an alternative that does not require imposing these extreme restrictions.

In the Bayesian VAR specification, all the lags are included that would optimally be included if the sample size were not a concern (16 lags in this case). The coefficient-specific prior distributions are then specified to convey additional information about the model. A modified version of the

[12]Panels A and D show the response of each endogenous variable to its own shocks and are not of much interest in this study.

Litterman-Minnesota priors is used.[13] The modification pertains to the treatment of annually observed variables. Because the *taxshare* variable only changes every four quarters, lags 4, 8, 12 and 16 are allowed to have diffuse priors. All other prior variances are calculated based on commonly used hyper-parameters for Minnesota priors. The Bayesian VAR's results are illustrated in 3.6. The general patterns are similar to what are obtained in the unrestricted VAR analysis.[14]

3.5 Conclusions

The impact of increasing taxes on the rich using U.S. time series data from the IRS Statistics of Income has been empirically investigated. Positive and statistically significant short-run effects have been identified. Increasing the relative tax burden on the rich does lead to higher employment growth in the short run and some negative long-run effects. However, the net cumulative effects stay positive in the long run. In trying alternative specification and estimation approaches, the results remain the same. As a robustness check, the sample is restricted to a period of purely exogenous tax changes based on Romer and Romer (2010)'s narrative record analysis. Along with the results holding in the restricted "exogenous" sample, the effects are even stronger. This finding is consistent with that of Romer and Romer (2010): estimated tax effects obtained using their restrictive measure of exogenous tax changes are larger than those found using broader measures of tax changes.

One of the limitations of this study is that the transmission mechanisms of the effects are not structurally identified. This is certainly an area where future work could be done. Explanations for what drives the results are provided. Some of the positive effects observed in the short run are likely driven by redistribution effects via consumption, while investment possibly drives the negative long-run effect. That being said, structurally identifying the specific channels through which tax hikes on the rich affect the economy both short and long term will better clarify the policy implications of this study's findings. A natural extension would be to dissect those channels.

[13] This type of priors essentially adjusts the precision of a given coefficient's prior distribution based on how weak the effects are believed to be. Because longer lags are believed to have weaker effects than shorter lags, the prior's variance decreases with the lag length. For example, the distribution of lag 10's prior will be more concentrated around zero compared to that of lag 1 or 2. Detailed discussions of the Minnesota priors as well as other types of priors are provided in Koop and Korobilis (2010) and Lutkepohl (2007).

[14] A Bayesian VAR is also estimated based purely on Minnesota priors (without special treatment of yearly *taxshare* lags) and the results are very similar.

Table 3.3: Using Alternative Threshold Definitions of Rich

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.
Lagged Taxshare Top 0.1%	0.0508*			
	(0.0303)			
Lagged Taxshare Top 0.5%		0.00945		
		(0.0244)		
Lagged Taxshare Top 1%			0.0497**	
			(0.0231)	
Lagged Taxshare Top 5%				0.0512**
				(0.0219)
Lagged Unemployment Rate	-0.0565**	-0.0478**	-0.0509**	-0.0522**
	(0.0229)	(0.0214)	(0.0205)	(0.0207)
GDP Growth	0.496***	0.497***	0.497***	0.496***
	(0.0367)	(0.0361)	(0.0366)	(0.0363)
Lagged Average Tax Rate All	0.0615	0.0543	0.0721	0.0666
	(0.0550)	(0.0538)	(0.0567)	(0.0555)
Lagged RIG	0.00844***	0.00850***	0.00472	0.00490*
	(0.00216)	(0.00302)	(0.00296)	(0.00273)
Constant	0.330**	0.276**	0.299**	0.305**
	(0.136)	(0.125)	(0.122)	(0.121)
Observations	244	244	244	244
Adjusted R^2	0.566	0.562	0.570	0.572

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes. See notes Table 3.2.

Table 3.4: The Effects of Increasing the Tax Share of Other Income Groups

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.	(5) Empl.	(6) Empl.
Lagged Taxshare Top Quintile	0.0667***					
	(0.0247)					
Lagged Taxshare 4th Quintile		-0.0875***				
		(0.0263)				
Lagged Taxshare 3rd Quintile			0.00309			
			(0.0585)			
Lagged Taxshare 2nd Quintile				-0.0144		
				(0.101)		
Lagged Taxshare Bottom Quintile					0.130	
					(0.491)	
Lagged Taxshare Bottom 50%						-0.0568
						(0.0577)
Lagged Unemployment Rate	-0.0525***	-0.0525***	-0.0470**	-0.0469**	-0.0434*	-0.0490**
	(0.0201)	(0.0191)	(0.0216)	(0.0207)	(0.0245)	(0.0212)
GDP Growth	0.491***	0.485***	0.497***	0.496***	0.509***	0.491***
	(0.0369)	(0.0370)	(0.0366)	(0.0360)	(0.0474)	(0.0370)
Lagged Average Tax Rate All	0.0797	0.0421	0.0486	0.0515	0.139**	0.0606
	(0.0586)	(0.0539)	(0.0559)	(0.0552)	(0.0612)	(0.0582)
Lagged RIG	0.00626***	0.00794***	0.00938***	0.00919***	0.00491*	0.00851***
	(0.00230)	(0.00205)	(0.00245)	(0.00229)	(0.00277)	(0.00225)
Constant	0.298**	0.310***	0.271**	0.270**	0.277*	0.282**
	(0.120)	(0.114)	(0.123)	(0.120)	(0.143)	(0.124)
Observations	244	244	244	244	176	244
Adjusted R^2	0.578	0.584	0.562	0.562	0.561	0.565

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. See notes Table 3.2.

Table 3.5: Short- Versus Long-Run Effects

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.
Taxshare Top 1%	-0.0382		0.0154	
	(0.0316)		(0.0203)	
L Taxshare Top 1%	0.0586	0.0258		
	(0.0463)	(0.0365)		
L2 Taxshare Top 1%	0.0168	0.0168		
	(0.0442)	(0.0439)		
L3 Taxshare Top 1%	0.0135	0.0134		
	(0.0438)	(0.0436)		
L4 Taxshare Top 1%	0.0131	0.0350	0.0847***	0.0838***
	(0.0498)	(0.0467)	(0.0195)	(0.0195)
L5 Taxshare Top 1%	0.0755	0.0584		
	(0.0465)	(0.0442)		
L6 Taxshare Top 1%	-0.0343	-0.0345		
	(0.0399)	(0.0400)		
L7 Taxshare Top 1%	0.00195	0.00173		
	(0.0426)	(0.0427)		
L8 Taxshare Top 1%	0.0248	0.0383	0.0434***	0.0441***
	(0.0483)	(0.0473)	(0.0149)	(0.0145)
L9 Taxshare Top 1%	0.0577	0.0451		
	(0.0484)	(0.0476)		
L10 Taxshare Top 1%	-0.0487	-0.0490		
	(0.0455)	(0.0454)		
L11 Taxshare Top 1%	-0.0145	-0.0146		
	(0.0415)	(0.0415)		
L12 Taxshare Top 1%	0.00201	0.0155	-0.0388**	-0.0391**
	(0.0442)	(0.0435)	(0.0167)	(0.0164)
L13 Taxshare Top 1%	0.000926	-0.0118		
	(0.0454)	(0.0449)		
L14 Taxshare Top 1%	-0.0185	-0.0187		
	(0.0441)	(0.0440)		
L15 Taxshare Top 1%	-0.0527	-0.0528		
	(0.0412)	(0.0412)		
L16 Taxshare Top 1%	-0.00711	-0.00546	-0.0554***	-0.0534***
	(0.0285)	(0.0285)	(0.0160)	(0.0155)
Lagged Unemployment Rate	-0.0657***	-0.0688***	-0.0625***	-0.0591***
	(0.0188)	(0.0185)	(0.0188)	(0.0183)
Lagged RIG	-0.00119	-0.00180	-0.00105	-0.000360
	(0.00256)	(0.00264)	(0.00258)	(0.00261)
Lagged Average Tax Rate All	0.0580	0.0733	0.0609	0.0442
	(0.0463)	(0.0451)	(0.0479)	(0.0438)
GDP growth	0.430***	0.429***	0.445***	0.448***
	(0.0303)	(0.0303)	(0.0324)	(0.0316)
Constant	0.464***	0.483***	0.434***	0.412***
	(0.111)	(0.109)	(0.114)	(0.110)
Observations	232	232	232	232
Adjusted R^2	0.626	0.625	0.616	0.617

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes. See notes Table 3.2.

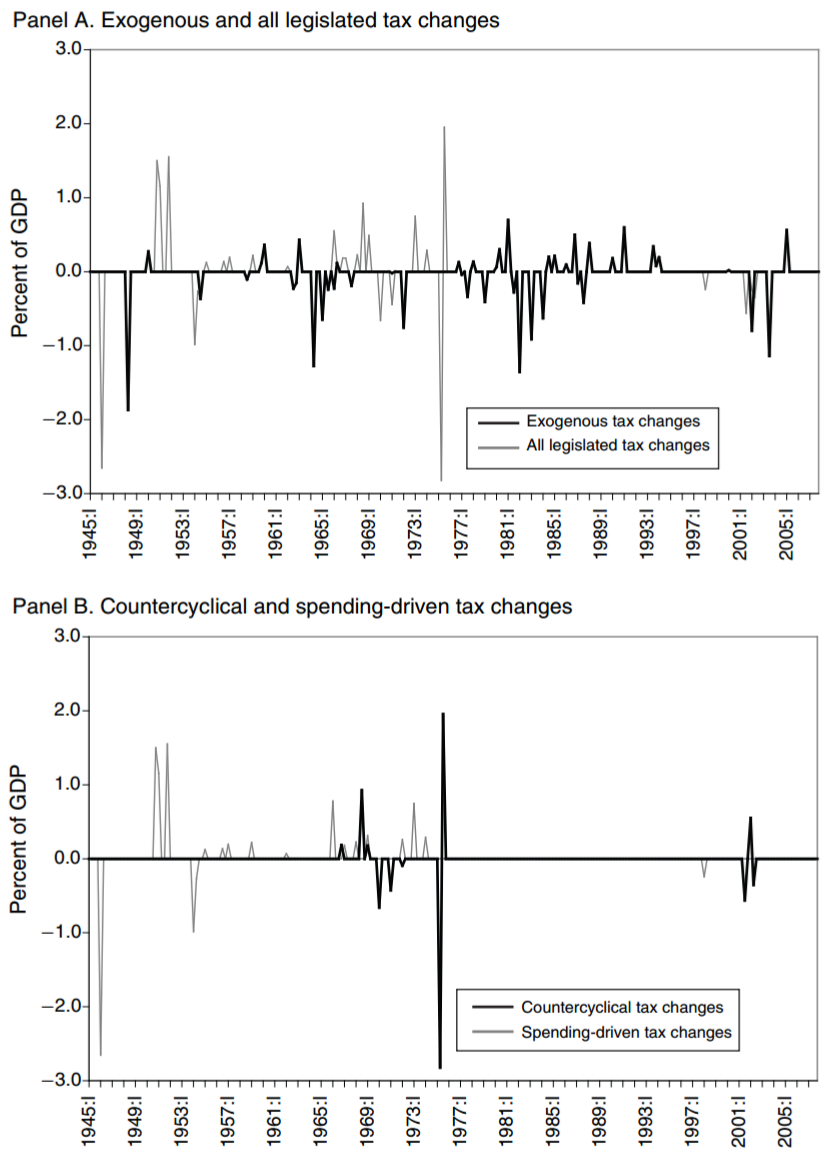


Figure 3.2: Romer and Romer (2010)'s Narrative Analysis of Tax Changes

Source: Romer and Romer (2010)

Notes. Panel A. shows all legislated tax changes from 1945Q1 to 2005Q4. Panel B. shows only tax changes classified as "endogenous" according to Romer and Romer's narrative record analysis. The period from 1977Q1 to 2000Q4 has almost no "endogenous" changes.

Table 3.6: Using Romer and Romer's Exogenous Tax Change Period

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.
Lagged Taxshare Top 0.1%	0.0977***			
	(0.0276)			
Lagged Taxshare Top 0.5%		0.0601***		
		(0.0209)		
Lagged Taxshare Top 1%			0.0868***	
			(0.0235)	
Lagged Taxshare Top 5%				0.0672***
				(0.0225)
Lagged Unemployment Rate	-0.0708***	-0.0400*	-0.0507**	-0.0497**
	(0.0249)	(0.0234)	(0.0222)	(0.0235)
GDP Growth	0.381***	0.380***	0.359***	0.383***
	(0.0378)	(0.0385)	(0.0398)	(0.0375)
Lagged Average Tax Rate All	-0.0646	-0.0158	-0.0316	-0.0202
	(0.0731)	(0.0672)	(0.0694)	(0.0673)
Lagged RIG	-0.00531	-0.00643	-0.00703*	-0.00660
	(0.00401)	(0.00414)	(0.00400)	(0.00406)
Constant	0.657***	0.448***	0.514***	0.491***
	(0.152)	(0.146)	(0.141)	(0.146)
Observations	96	96	96	96
Adjusted R^2	0.543	0.527	0.558	0.529

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes. The sample is restricted to the *Romer and Romer's exogenous tax change period* (from 1977Q1 to 2000Q4.)

Table 3.7: Short Versus Long Run Using Romer and Romer's Exogenous Tax Change Period

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.
Taxshare Top 1%		-0.0201	
		(0.0208)	
L4 Taxshare Top 1%	0.0868***	0.116***	0.117***
	(0.0235)	(0.0244)	(0.0246)
L8 Taxshare Top 1%		0.112***	0.106***
		(0.0289)	(0.0274)
L12 Taxshare Top 1%		-0.0328	-0.0359
		(0.0262)	(0.0261)
L16 Taxshare Top 1%		-0.0307	-0.0388
		(0.0242)	(0.0237)
Lagged Unempl. Rate	-0.0507**	-0.0322	-0.0382
	(0.0222)	(0.0270)	(0.0269)
GDP growth	0.359***	0.306***	0.305***
	(0.0398)	(0.0363)	(0.0361)
Lagged Average Tax Rate All	-0.0316	-0.0396	-0.0306
	(0.0694)	(0.0751)	(0.0718)
Lagged RIG	-0.00703*	-0.00825**	-0.00781*
	(0.00400)	(0.00401)	(0.00407)
Constant	0.514***	0.391*	0.422**
	(0.141)	(0.206)	(0.205)
Observations	96	96	96
Adjusted R^2	0.558	0.668	0.669

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes. The sample is restricted to the *Romer and Romer's exogenous tax change period* (from 1977Q1 to 2000Q4.)

Table 3.8: What Matters: the Rich Paying more or Others Paying Less?

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.
Lagged Tax Change Top 1%	0.0158***	0.0135***		
	(0.00454)	(0.00407)		
Lagged Tax Change Bottom 99%	0.00604	-0.00251		
	(0.00740)	(0.00416)		
Lagged Tax Change Top 5%			0.0220***	0.0165***
			(0.00721)	(0.00575)
Lagged Tax Change Bottom 95%			0.000363	-0.00637
			(0.00612)	(0.00451)
Lagged Unemployment Rate	-0.0461**	-0.0464**	-0.0463**	-0.0465**
	(0.0204)	(0.0204)	(0.0209)	(0.0210)
GDP Growth	0.502***	0.499***	0.506***	0.503***
	(0.0345)	(0.0354)	(0.0339)	(0.0351)
Lagged Average Tax Rate All	-0.130		-0.144	
	(0.113)		(0.114)	
Lagged RIG	0.00337	0.00336	0.00337	0.00380
	(0.00273)	(0.00274)	(0.00280)	(0.00277)
Constant	0.111	0.193	0.106	0.196
	(0.149)	(0.135)	(0.150)	(0.136)
Observations	244	244	244	244
Adjusted R^2	0.587	0.585	0.583	0.580

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes. See notes Table 3.2. The *Tax Change* variable for each income group measures the percentage change in tax liability for that group over a year. The first two columns feature Top 1 percent versus Bottom 99 percent while the last two columns feature Top 5 percent versus Bottom 95 percent. In Columns 1 and 3, the overall average tax rate constant is held constant as in the baseline specification to capture re-distributional effects only. In Columns 2 and 4, the overall average tax rate variable is removed to allow cases where tax hikes for some groups are not necessarily associated with tax cuts for other groups.

Table 3.9: What Matters: the Rich Paying more or Others Paying Less? (Alternative Specification)

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.
Lagged Tax Change Top 1%	0.0157***			
	(0.00444)			
Lagged Tax Change Bottom 99%		0.00573		
		(0.00744)		
Lagged Tax Change Top 5%			0.0220***	
			(0.00727)	
Lagged Tax Change Bottom 95%				0.00273
				(0.00635)
Lagged Unemployment Rate	-0.0489**	-0.0445**	-0.0465**	-0.0456**
	(0.0194)	(0.0221)	(0.0200)	(0.0219)
GDP Growth	0.499***	0.500***	0.506***	0.498***
	(0.0359)	(0.0348)	(0.0345)	(0.0353)
Lagged Average Tax Rate All	-0.0689	-0.00784	-0.140*	0.0225
	(0.0646)	(0.102)	(0.0841)	(0.0935)
Lagged RIG	0.00294	0.00974***	0.00333	0.00960***
	(0.00266)	(0.00227)	(0.00271)	(0.00232)
Constant	0.173	0.213	0.109	0.242*
	(0.115)	(0.151)	(0.127)	(0.145)
Observations	244	244	244	244
Adjusted R^2	0.588	0.563	0.584	0.562

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.10: Using Average Tax Rate Instead of Tax Share

VARIABLES	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.
Lagged Average Tax Rate Top 1%	0.0478	0.0475**	0.0514**	0.108***
	(0.0310)	(0.0213)	(0.0219)	(0.0375)
Lagged Unemployment Rate		-0.0516***	-0.0460**	-0.0570***
		(0.0171)	(0.0194)	(0.0193)
GDP Growth		0.499***	0.493***	0.483***
		(0.0359)	(0.0351)	(0.0367)
Lagged Average Tax Rate All				-0.151*
				(0.0780)
Lagged RIG			0.0103***	0.0126***
			(0.00214)	(0.00240)
Constant	0.436***	0.336***	0.278**	0.356***
	(0.0415)	(0.102)	(0.110)	(0.112)
Observations	256	256	244	244
Adjusted R^2	0.009	0.534	0.576	0.582

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

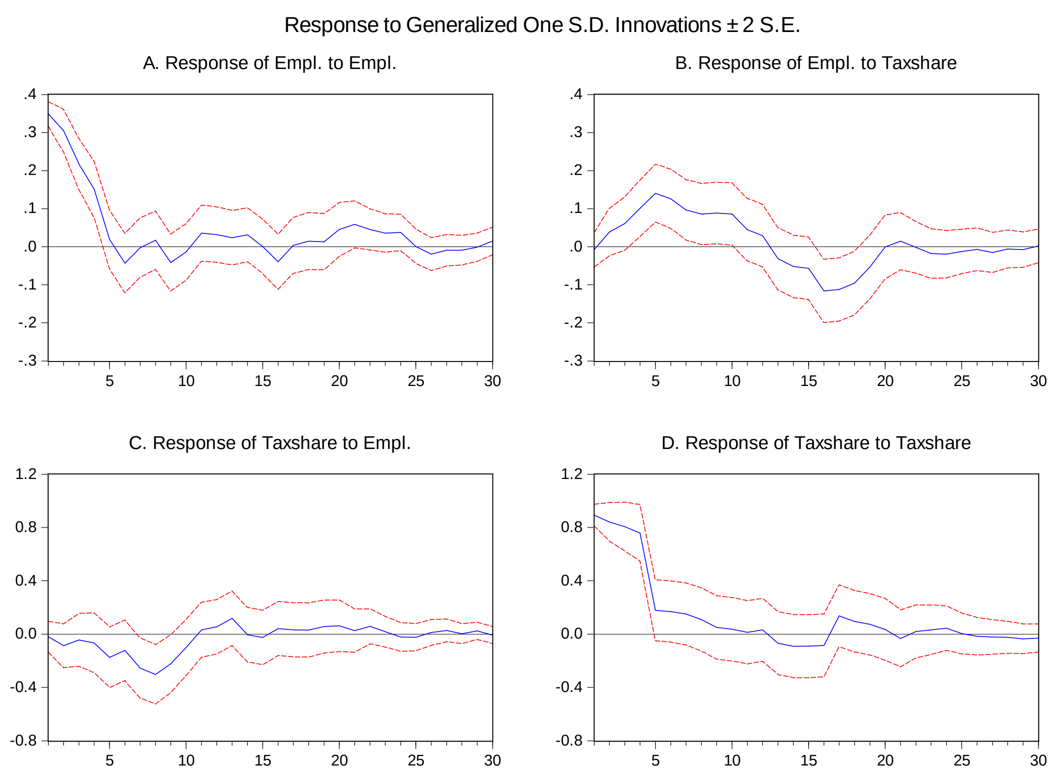


Figure 3.3: Unrestricted VAR, All Lags

Table 3.11: Using Annual Data

VARIABLES	(1) Employment	(2) Employment
L Taxshare Top 1%	0.209**	
	(0.0973)	
L2 Taxshare Top 1%	0.207***	
	(0.0663)	
L3 Taxshare Top 1%	0.00720	
	(0.0578)	
L4 Taxshare Top 1%	-0.196**	
	(0.0764)	
L Taxshare Top 1%		0.184**
		(0.0765)
L2 Taxshare Top 5%		0.186***
		(0.0670)
L3 Taxshare Top 5%		0.0415
		(0.0537)
L4 Taxshare Top 5%		-0.210***
		(0.0768)
Lagged Unemployment Rate	-0.0727	-0.0517
	(0.0786)	(0.0830)
Lagged Average Tax Rate All	0.694***	0.675***
	(0.223)	(0.206)
Lagged RIG	-0.0130	-0.0107
	(0.0105)	(0.00995)
GDP Growth	0.714***	0.748***
	(0.0649)	(0.0528)
Constant	-0.104	-0.342
	(0.514)	(0.492)
Observations	58	58
Adjusted R^2	0.801	0.814

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes. Data are annual from 1947 to 2011)

Table 3.12: VAR Granger Causality Test

VAR Granger Causality/Block Exogeneity Wald Tests
Sample: 1947Q1 2011Q4
Included observations: 240

Dependent variable: Empl.

Excluded	Chi-sq	df	Prob.
Taxshare Top 1%	23.01492	5	0.0003
All	23.01492	5	0.0003

Dependent variable: Taxshare

Excluded	Chi-sq	df	Prob.
Employment growth	2.869308	5	0.7201
All	2.869308	5	0.7201

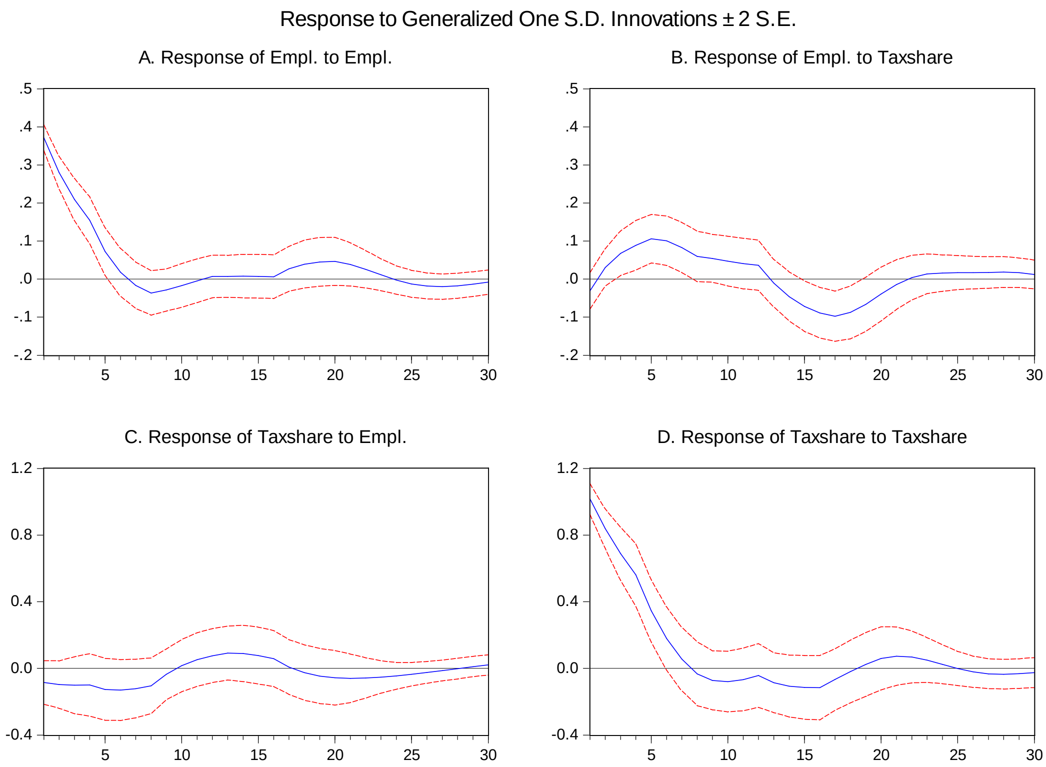
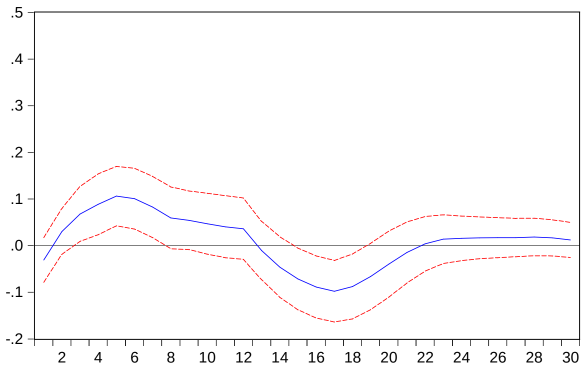
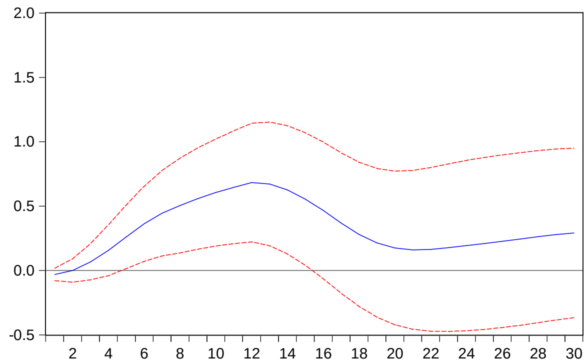


Figure 3.4: Unrestricted VAR, Select Lags



(a) Panel A. Impulse Response



(b) Panel B. Accumulated Response

Figure 3.5: IRF and Accumulated Impulse Response

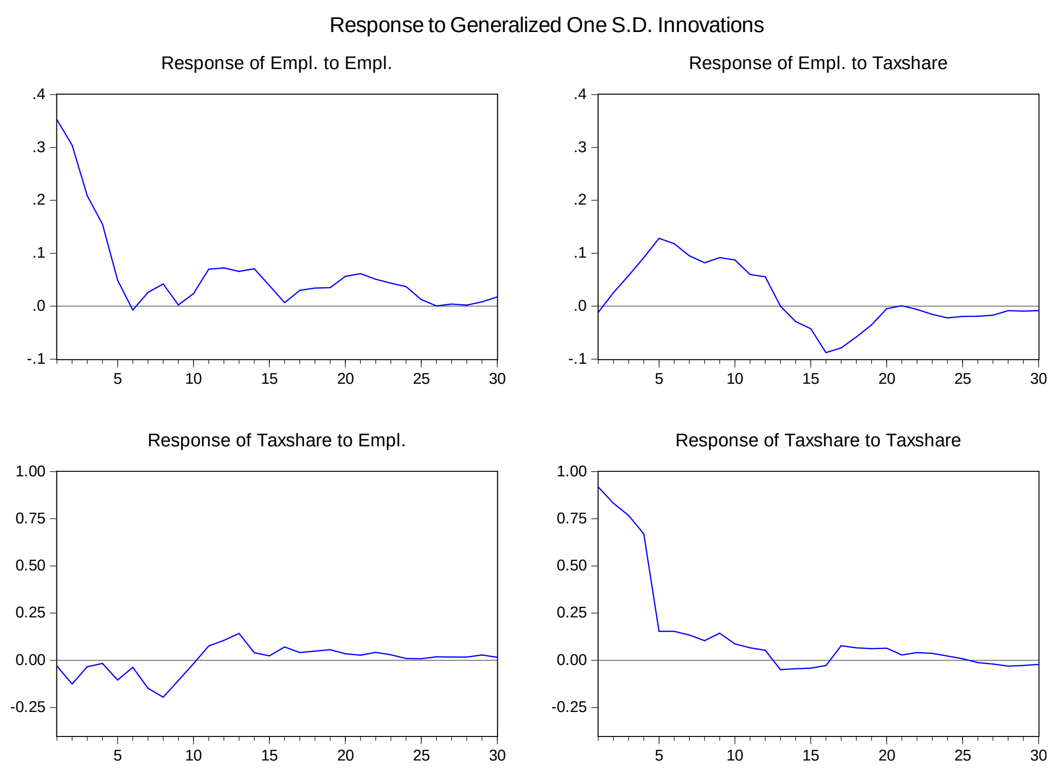


Figure 3.6: Bayesian VAR

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Appendices

A. Chapter 1 appendices

A1. Data

The Ivorian macroeconomic time series are obtained from the World Bank's World Development Indicators (WDI) database. The observations are annual and cover the period from 1960 to 2010. All series except the trade balance-to-output ratio are log-transformations of per capita values.

Output: GDP

Consumption: Final consumption expenditure

Private Investment: Gross fixed capital formation, Private sector

Public Investment: Gross fixed capital formation, Public sector

Foreign Aid: Net official development assistance (ODA) and official aid received

TBY (Trade balance-to-output ratio): External balance on goods and services

Table A.1: Summary statistics

	Obs.	Mean	Std. Dev.	Min	Max
Consumption	49	6.27	0.22	5.9	6.74
Investment	49	4.85	0.65	3.97	6.14
Private Investment	45	4.31	0.68	3.37	5.54
Public Investment	45	3.85	0.78	2.56	5.34
GDP	49	6.57	0.19	6.34	7
Foreign aid	49	3.02	0.74	1.16	4.72
TBY ratio	49	0.06	0.05	-0.07	0.17

A2. Prior specifications

Table A.2: Prior Distributions

Parameter	Dist.	p1	p2	95% prob. Interval	
ρ_z	beta	0.75	0.15	0.46	0.95
ρ_a	beta	0.75	0.15	0.46	0.95
ρ_ι	beta	0.75	0.15	0.46	0.95
σ_z	Inv.-gamma	0.5	4	0.002	10.05
σ_a	Inv.-gamma	0.5	4	0.002	10.05
σ_ι	Inv.-gamma	0.5	4	0.002	10.05

A3. Estimation results: PDFs of priors and posteriors

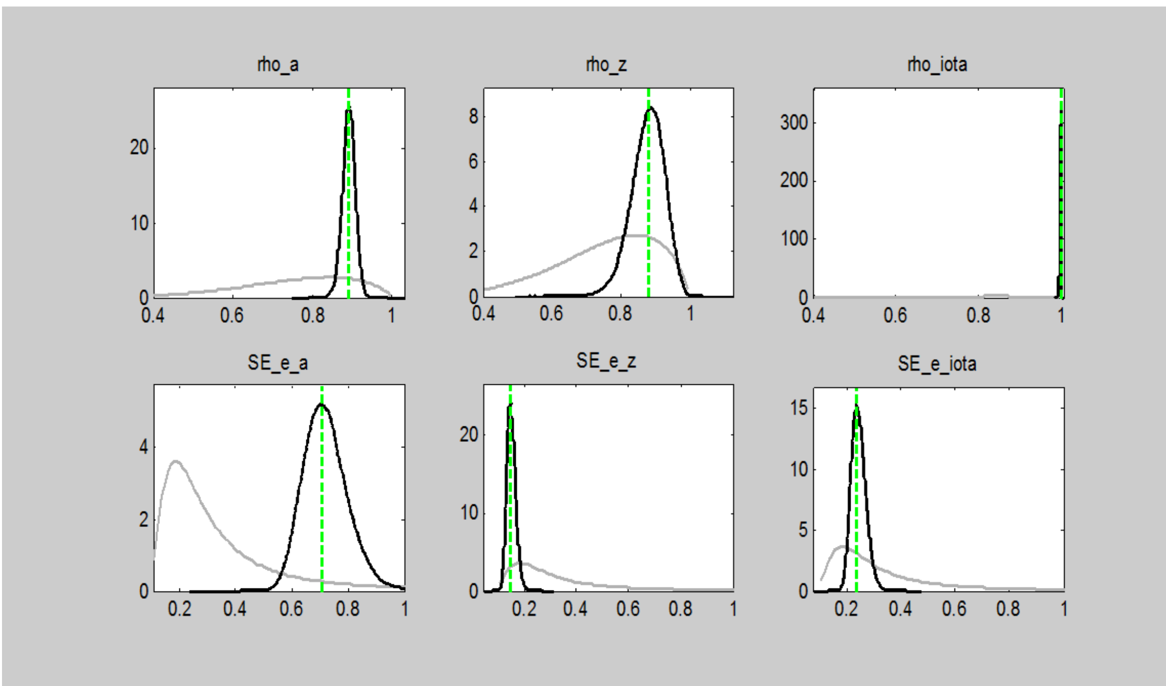
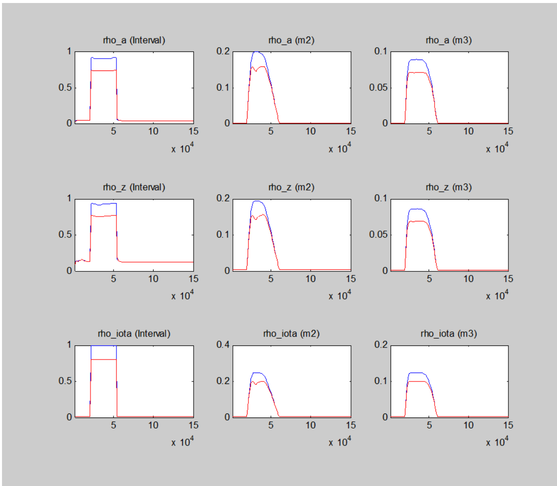


Figure A.1: Estimation Results: Prior and Posterior Distibutions

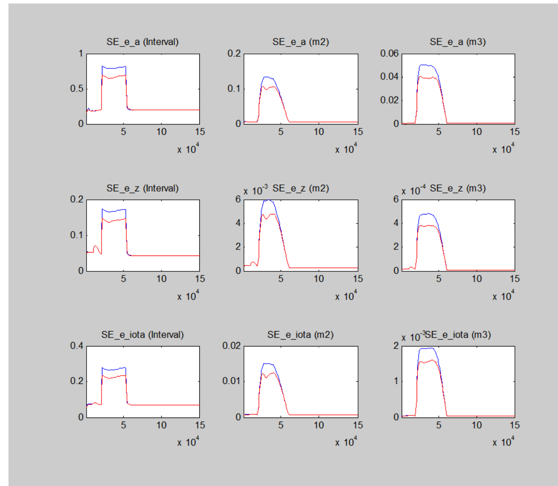
Notes: The different panels show the estimated posterior distributions (in black) for each parameter. The top panels are the AR(1) coefficients. The bottom panels are the standard deviations of the exogenous shocks. The prior distributions (in grey) are reported for reference. The green lines indicates the mode of the posterior distributions calculated numerically. All the posteriors have a normal shape and the numerical (green) mode do coincide with the peak of the posteriors for all the estimates.

Estimations are based on five independent runs of Markov Chain Monte Carlo (MCMC) Metropolis-Hasting simulations with 100,000 draws each, from which the first halves were discarded. The Brooks and Gelman 1989 statistics are shown in Appendix A4 below.

A4. Brooks and Gelman 1989 statistics



(a) Panel A



(b) Panel B

Figure A.2: Brooks and Gelman 1989 Statistics

Notes: Panel A shows the statistics for the AR(1) coefficients and Panel B shows the statistics for the standard deviations of the exogenous shocks. Estimations are based on five independent runs of Markov Chain Monte Carlo (MCMC) Metropolis-Hasting simulations. The red lines are estimates of the variance within chains. The blue lines are estimates of the sum of the variances within and between chains. For each parameter, the red lines are stabilized and the gaps between the two lines are closed, indicating convergence was obtained.

B. Chapter 2 appendices

B1. Solving the household problem

$$\max E \sum_{t=0}^{\infty} \beta^t U\left(C_t, L_t\right)$$

subject to:

$$D_t = \left(1 + R_{t-1}\right) D_{t-1} + C_t + \left(1 - \mu_t\right) I_t + \Phi\left(K_t - K_{t-1}\right) - \left(1 - \tau_{Lt}\right) W_t L_t - \left(1 - \tau_{Kt}\right) S_t K_{t-1} - T_t$$

$$R_t = R^* + p\left(\frac{D_t}{Y_t}\right)$$

$$K_t = \left(1 - \delta\right) K_{t-1} + I_t$$

First order conditions:

$$\mathscr{L} = E \sum_{t=o}^{\infty} \beta^t \left\{U((C_t, L_t) - \lambda_t \left[-D_t + \left(1 + R_{t-1}\right) D_{t-1} + C_t + \left(1 - \mu_t\right) I_t + \Phi\left(K_t - K_{t-1}\right) - \left(1 - \tau_{Lt}\right) W_t L_t - \left(1 - \tau_{Kt}\right) S_t K_{t-1}\right] - T_t\right\}$$

$$\frac{\partial \mathscr{L}}{\partial C_t} = U_C\left(C_t, L_t\right) - \lambda_t = 0$$

$$U_C\left(C_t, L_t\right) = \lambda_t$$

$$\frac{\partial \mathscr{L}}{\partial L_t} = U_L\left(C_t, L_t\right) + \lambda_t\left(1 - \tau_{Lt}\right) W_t = 0$$

$$U_L\left(C_t, L_t\right) = -\lambda_t\left(1 - \tau_{Lt}\right) W_t$$

$$\frac{\partial \mathscr{L}}{\partial D_t} = \beta^t \lambda_t - \beta^{t+1}(1+R_t)E_t\lambda_{t+1} = 0$$

$$\lambda_t = \beta(1+R_t)E_t\lambda_{t+1}$$

$$\frac{\partial \mathscr{L}}{\partial K_t} = -\beta^t \lambda_t \left[(1-\mu_t) + \Phi'\left(K_t - K_{t-1}\right)\right] - E_t\beta^{t+1}\lambda_{t+1}\left[-\left(1-\mu_{t+1}\right)(1-\delta) - \Phi'\left(K_{t+1}-K_t\right) - \left(1-\tau_{Kt+1}\right)S_{t+1}\right] = 0$$

$$\lambda_t \left[(1-\mu_t) + \Phi'\left(K_t - K_{t-1}\right)\right] = \beta E_t\lambda_{t+1}\left[\left(1-\mu_{t+1}\right)(1-\delta) + \Phi'\left(K_{t+1}-K_t\right) + \left(1-\tau_{Kt+1}\right)S_{t+1}\right]$$

B2. Steady state solutions

The Functional forms

$$U(C,L) = \frac{\left(C - \omega^{-1}L^{\omega}\right)^{1-\gamma} - 1}{1-\gamma}$$

$$\Phi(x) = {}^1\!/_2\,\phi x^2; \qquad \phi > 0$$

$$p(D) = \psi\left(e^{D-\bar{D}} - 1\right)$$

$$F(K,L) = K^{\alpha}L^{1-\alpha}$$

Interest Rate R The steady state risk premium is nil.

$$R = R^*$$

Capital to Output ratio $\frac{K}{Y}$ Use the Euler equation from $\frac{\partial \mathscr{L}}{\partial K_t}$ and rearrange to get the capital to output ratio.

$(1-\mu) = \beta\left[(1-\tau_K)ZF_K + (1-\mu)(1-\delta)\right]$

$\frac{Y}{K} = (1-\mu)\frac{\frac{1}{\beta}-(1-\delta)}{\alpha(1-\tau_K)}$

$$\frac{K}{Y} = \frac{\alpha(1-\tau_K)}{(1-\mu)\left[\frac{1}{\beta}-(1-\delta)\right]}$$

Output to Labor ratio $\frac{Y}{L}$ Combine the marginal utility equations (from consumption and labor) and the marginal product of labor equation to get the labor market equilibrium condition. Rearrange to get the output to labor ratio.

$-\frac{U_L}{U_C} = (1-\tau_L)W = (1-\tau_L)ZF_L$

$\frac{Y}{L} = \frac{L^{\omega-1}}{(1-\alpha)(1-\tau_L)}$

Capital to Labor ratio $\frac{K}{L}$ $\frac{K}{L} = \frac{K}{Y}\frac{Y}{L}$

$\frac{K}{L} = \frac{\alpha(1-\tau_K)}{(1-\alpha)(1-\mu)(1-\tau_L)\left[\frac{1}{\beta}-(1-\delta)\right]}L^{\omega-1}$

Labor L Use the output to labor and capital to labor ratios to derive a closed-form solution for steady-state labor.

$Y = ZK^{\alpha}L^{1-\alpha}$

$\frac{Y}{L} = Z\left(\frac{K}{L}\right)^{\alpha}$

$$L = \left[(1-\alpha)(1-\tau_L)Z\left(\frac{\alpha(1-\tau_K)}{(1-\alpha)(1-\mu)(1-\tau_L)\left[\frac{1}{\beta}-(1-\delta)\right]}\right)^{\alpha}\right]^{\frac{1}{(\omega-1)(1-\alpha)}}$$

Other variables

- Output: $Y = \frac{1}{(1-\alpha)(1-\tau_L)}L^{\omega}$
- Capital: $K = \frac{\alpha(1-\tau_K)}{(1-\alpha)(1-\mu)(1-\tau_L)\left[\frac{1}{\beta}-(1-\delta)\right]}L^{\omega}$
- Investment: $I = \delta K$
- Wage: $W = Z(1-\alpha)K^{\alpha}L^{-\alpha}$
- Capital rental rate: $S = Z\alpha K^{\alpha-1}L^{1-\alpha}$
- Lump sum tax: $T = \tau_L WL + \tau_K SK - \mu I$

- Debt: $D = \frac{D}{Y} Y$
- Consumption: $C = (1 - \tau_L) WL + (1 - \tau_K) SK + T - RD - (1 - \mu) I$
- Lambda: $\lambda = \left(C - \omega^{-1} L^{\omega}\right)^{-\gamma}$
- Productivity: $Z = 1$
- Investment subsidy rate: $\mu = \bar{\mu}$
- Trade Balance: $TB = Y - C - I$
- Current Account: $CA = TB - RD$

C. Chapter 3 Appendices

Steps to construct the *taxshare* and *averagetaxrate* series from SOI data The share and average series are constructed using the Statistics of Income's (SOI) individual income tax data from 1913 to 2011. One important note about the SOI data is that current dollar amounts, instead of percentiles, define pre-tax income brackets. Because of issues related to comparing those figures across time (including inflation, existence of trend in income growth, and change in fiscal definition of *income*.), using a dollar definition of rich for a time-series based analysis is problematic. Even after adjusting for inflation, a dollar-based definition of income would still be inconsistent over time. For example, saying all individuals with income over 1 million inflation-adjusted dollars are considered rich would lead to a situation in which a growing group of rich would develop over time because of the national average income's positive trend. Consequently, the tax share of the rich, considering the dollar-based definition, - would inherit a positive trend for no policy-related reason. To obtain a consistent definition of *rich* in this study's time series, the dollar brackets of the SOIs are converted into percentiles. Based on the SOI data there are three steps to obtain the *taxshare* and *averagetaxrate* series.

Step1: For each income group (for example, $10,000 to $25,000), the following information was collected from the annual SOIs: number of returns, pre-tax income (taxable income or Adjusted Gross Income (AGI)), and tax liability.[15] [16]

Step2: The income group distributions (for example $10,000 to $25,000) were converted to the following percentile groups: bottom 50%; all five quintiles; top 10, 5, 1, 0.5, and 0.1 percentiles. Because mapping dollar income groups to percentiles is virtually impossible, interpolation is used between some income groups. Using interpolation may lead to less accurate percentile measures at the bottom of the distribution, given the density of low-income dollar groups.

[15] Data from 1913 to 1949 are from the 1949 SOI, which has historical tables by income group for this period. Similarly, data from 1950 to 1959 are from the 1959 SOI; and data from 1960 to 1969 are from 1969 SOI. From 1970 to 1980, individual SOIs are used. And from 1980 to 2011, SOIs tax liability by income group for 1980 to 2011 is available for download from the IRS's website.

[16] The measure of pre-tax income reported is not the same across all SOIs. Before 1944, the measure reported is taxable income, i.e., gross income minus deductions. Adjusted Gross Income (AGI) is used for 1944 and after.

However, the top-income groups, which are this study's focus, suffer less from this problem.[17] [18]

Step3: The following variables of interest are computed for each year t:

- *taxshare* for percentile group i = Tax liability group i / Total tax liability all taxpayers
- *averagetaxrate* for percentile group i = Tax liability group i / Income group i

[17]For some years, the SOI has a "No positive income" category for which the total income is sometime negative (possibly due to business losses or deductions exceeding income). When distributions are computed, they are treated as zero income instead of negative income to be consistent with other years when these categories are not reported. When applicable, taxes reported for this category are insignificant and discarded. Alternatively, they could be added to the left tail, but the impact on the distributions remains trivial.

[18]For the period from 1950 to 1969, the distribution reported in the SOIs is only for taxable returns. The non-taxable returns are added to the no income category. This addition affects the tax burden distribution's accuracy at the very left tail (bottom quintile) but should not affect the other categories. Again, this study is more concerned with the right tail's accuracy.

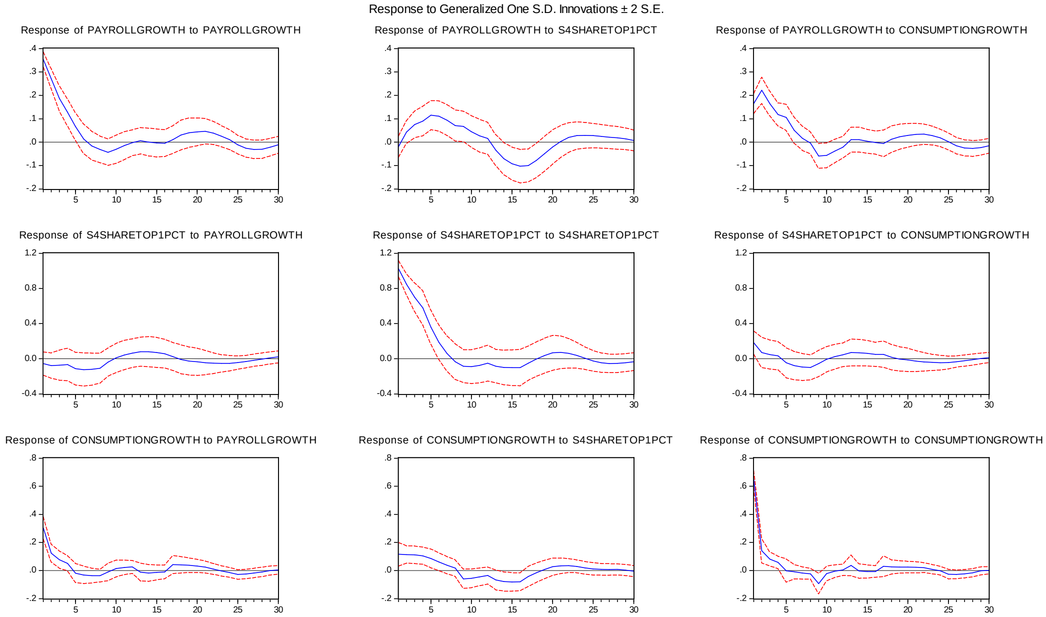
Table C.1: Transmission Mechanisms: Effects on GDP Components

VARIABLES	(1) Empl.	(2) Cons.	(3) Invt.	(4) Invt.	(5) Exports
Lagged taxshare Top 1%	0.0838***	0.0542*	0.339**	0.242	0.276*
	(0.0195)	(0.0293)	(0.161)	(0.158)	(0.141)
L8S4.taxsharetop1pct	0.0441***	-0.0368	-0.136	-0.0701	0.0228
	(0.0145)	(0.0255)	(0.127)	(0.116)	(0.138)
L12S4.taxsharetop1pct	-0.0391**	-0.0899***	-0.514***	-0.353***	-0.188
	(0.0164)	(0.0248)	(0.124)	(0.122)	(0.171)
L16S4.taxsharetop1pct	-0.0534***	0.0123	-0.0365	-0.0585	-0.0859
	(0.0155)	(0.0271)	(0.135)	(0.122)	(0.140)
Lagged Unemployment Rate	-0.0591***	-0.000174	0.375**	0.376**	-0.0398
	(0.0183)	(0.0286)	(0.172)	(0.170)	(0.179)
GDP Growth	0.448***				
	(0.0316)				
Lagged Average Tax Rate All	0.0442				
	(0.0438)				
Lagged RIG	-0.000360				
	(0.00261)				
consumptiongrowth				1.788***	
				(0.381)	
Constant	0.412***	0.844***	-1.165	-2.674***	1.683
	(0.110)	(0.181)	(1.002)	(1.026)	(1.207)
Observations	232	244	244	244	244
Adjusted R^2	0.617	0.048	0.080	0.167	0.004

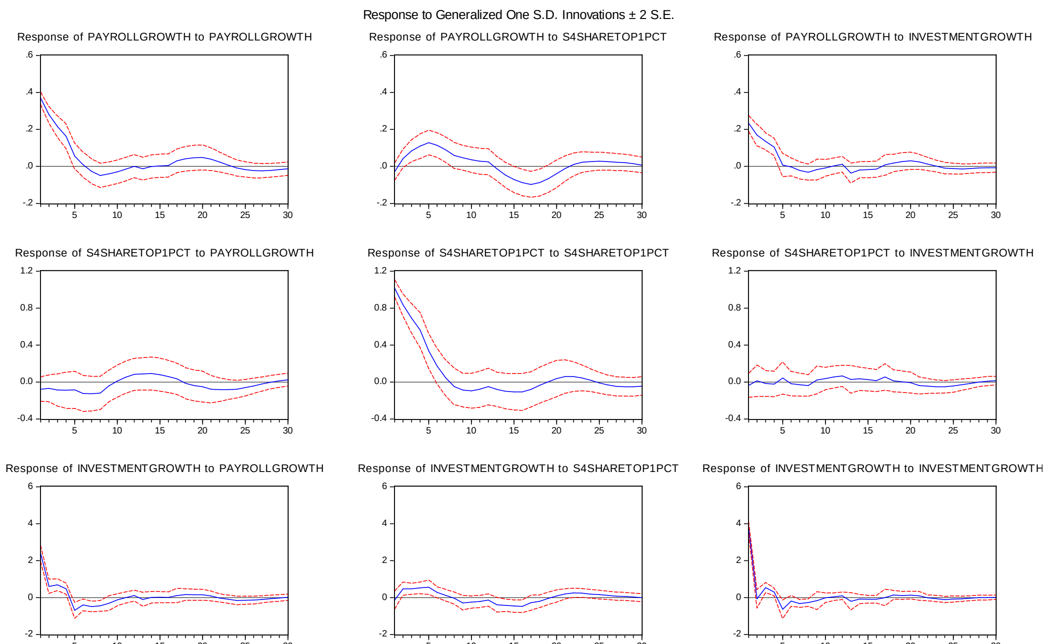
Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes. Data are quarterly from 1947Q1 to 2011Q4.



(a) With Consumption



(b) With Investment

Figure C.1: Three Variable VAR

Vita

Ahiteme Nicodeme Houndonougbo was born and grew up in Cote d'Ivoire. After graduating from high-school in 2000, he moved to Benin, where his parents are originally from. He completed his undergraduate studies in Finance and Economics at the National University of Benin and spent four years working for Ecobank, a pan-African banking group. Ahiteme obtained a masters in Finance from the Catholic University of Lille in 2006. In 2008, he returned to graduate school at Columbia University's School of International and Public Affairs. After graduating from Columbia University with a masters in economic policy management in 2009, he joined the Department of Economics at the University of Tennessee in Knoxville, where he obtained his PhD in Economics in 2014. Ahiteme's research focuses on development and fiscal policy issues, particularly in the context of small open economies. In August 2014, he will be joining the Department of Business and Social Entrepreneurship at Rollins College in Winter Park, Florida, where he has accepted a position as Assistant Professor of Economics.