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The Credit Spread and U.S. Business Cycles

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The Credit Spread and U.S. Business Cycles*

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Abstract

In this paper, we construct a dynamic stochastic general equilibrium model in order to investigate the impact of credit spread shocks on the U.S. business cycle. We find that the shocks to the investment specific technology and the preference weights on consumption and leisure are the main sources of output fluctuation. Shocks to the credit spread and productivity are the main source of the fluctuation in the investment to output ratio. Credit spread shocks also had a significant impact on the output during the recent financial crisis.

JEL Classification: E13, E32
Keywords: Credit Spread, Business Cycles, Investment Specific Technology

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1 Introduction

In this paper, we construct a dynamic stochastic general equilibrium model in order to investigate the impact of credit spread shocks on the U.S. business cycle. We find that exogenous shocks to the credit spread are major sources of the fluctuation in the investment to output ratio and also reduced output during the recent financial crisis.

Several studies investigate the role of credit rate spreads on the U.S. business cycle. Gilchrist, Yankov and Zakrajsek (2009) studies the information content of corporate credit spread for macroeconomic activity. They construct a credit spread portfolio from senior unsecured corporate debt traded in the secondary market over the 1990-2008 period and issued by about 900 U.S. non financial corporates. Their factor-augmented vector auto-regression shows that an unanticipated worsening of business credit conditions, which are identified through the corporate bond spread, predicts substantial and long-lasting declines in economic activity. They argue that disturbances in the credit market explain a substantial fraction of the volatility in the U.S. economic activity during 1990-2010.

We consider fluctuations in the credit spread as exogenous shocks and investigate their quantitative impacts on the U.S. economy. We also consider shocks to government expenditure, total factor productivity, investment specific technology and preference weights on consumption and leisure and compare their quantitative importance. We find that investment specific technology shocks and preference shocks are the main sources of output fluctuation. On the other hand, credit spread and productivity shocks are the main sources of the fluctuation in the investment rate. In addition, credit spread shocks had a significant negative impact on output during the recent financial crisis.

The remainder of the paper is organized as follows. In section 2, we present the quarterly business cycle features of the U.S. economy. In section 3, we describe the dynamic stochastic general equilibrium model we use to account for these features. In section 4, we explain the quantitative method we adopt and present the quantitative results. Section 5 concludes the paper.

2 The U.S. Business Cycle and Credit Spreads

Figure 1a shows the quarterly fluctuations of linearly detrended key macroeconomic variables in the U.S. over the 1980-2010 period. Output is defined as GDP plus the flow service generated from household durable goods stock. Consumption is defined as expenditures on non-durable goods and services plus the flow service from durable goods stock and government capital stock. Investment is defined as the sum of gross capital formation and expenditures on durable goods. Labor stands for total hours worked defined as the number of employed times hours worked per worker. We normalize the hours worked per worker as a fraction of 14 hours per day which we assume to be the maximum possible daily working hours. The detailed method for data construction is described in Otsu (2010). Consumption, labor and investment are all procyclical[1]. Investment is much more volatile than output, while consumption and labor are as volatile as output[2].

Since the credit spread represents the borrowing cost of the firm, we conjecture that this variable is an important determinant of investment and output fluctuations. Figure 1b presents fluctuations of the investment rate and the credit spread along the business cycle. The investment rate is defined as the ratio of investment to output. This variable is highly procyclical, which is obvious given the previous observations of investment and output. The credit spread is defined as the difference between the Baa corporate bond rate and the 3-month treasury bill rate. The data of the interest rate is obtained from the Federal Reserve Economic Data published by the Federal Reserve Bank of St. Louis. The credit spread is countercyclical, especially during the past decade, which is consistent with the observations of Gilchrist et al (2009) and Gerba, Caglar and Chadha (2011)[3]. This implies that the

[1]The correlation coefficients between output and consumption, investment and labor over the 1980-2010 period are 0.96, 0.96, and 0.82 respectively.

[2]The standard deviations of consumption, investment and labor relative to that of output are 1.07, 3.83, and 1.02 respectively. The fact that consumption is more volatile than output goes against the concept of consumption smoothing and the observation of standard real business cycle literature such as Cooley and Prescott (1995). This fact depends on the detrending measure; we use a common linear trend for both consumption and output while standard real business cycle literature uses HP filtered data. After HP filtering our data, the relative volatility of consumption to output is 0.63, which indeed implies household consumption smoothing in reaction to high frequency income shocks.

[3]The correlation coefficient of output and the credit spread is -0.27 over the entire period and -0.69 after 2000. Gerba et al (2011) confirm that this feature is robust across

main driver of credit spreads was shocks to the supply of credit rather than shocks to the demand for credit. In the following section, we develop a simple model that can quantify this effect.

3 Model

The model consists of a representative household, firm, financial intermediary and government. The household purchases risk free assets from the financial intermediary. The financial intermediary invests in government bonds and lending to the firm. The firm borrows from the financial intermediary in order to purchase capital goods.

3.1 Household

The household maximizes its discounted lifetime utility which depends on consumption, leisure and preference shocks:

$$\max E_t \sum_t \beta^t u(c_t, l_t, \Psi_t).$$

For simplicity we define the periodical preference function as

$$u(c_t, l_t, \Psi_t) = \Psi_t \log c_t + (1 - \Psi_t) \log(1 - l_t)$$

where c is consumption, l is normalized labor input, and Ψ_t is the variable preference weight on consumption relative to leisure, $1 - l$.

The household faces the following budget constraint

$$w_t l_t + a_t + \pi_t + \pi_t^f = c_t + \frac{\Gamma a_{t+1}}{R_t} + \tau_t. \tag{1}$$

That is, it uses the labor income $w_t l_t$, return on the non-state-contingent asset a_t, dividend income π_t and π_t^f, in order to purchase consumption goods and non-state-contingent assets that mature next period with a discount rate of R_t and to pay lump-sum taxes τ_t. All variables are detrended by population growth and labor augmenting technology growth where Γ adjusts for this growth trend which we assume as constant.

various measures of credit spreads.

3.2 Firm

The firm maximizes the discounted present value of profits π_t

$$\max E_t \sum_t \prod_t \frac{1}{R_{t-1}} \pi_t.$$

The profits are defined as output y_t and discounted corporate debt d_{t+1} minus labor, investment and borrowing cost:

$$\pi_t = y_t - w_t l_t - x_t + \frac{\Gamma d_{t+1}}{R_t^L} - d_t, \tag{2}$$

where R_t^L is the discount rate of the corporate debt the firm faces.

Output is defined by a Cobb-Douglas production function

$$y_t = z_t k_t^{\theta} l_t^{1-\theta} \tag{3}$$

where z_t is total factor productivity and k_t is the capital stock which accumulates according to the capital law of motion

$$\Gamma k_{t+1} = \phi_t x_t + (1-\delta) k_t. \tag{4}$$

The investment specific technology shock ϕ_t represents the efficiency in accumulating capital stock as in Greenwood, Hercowitz and Huffman (1988).

In this model, the firm will resort to costly borrowing from the financial intermediary due to a balance sheet constraint

$$\Gamma k_{t+1} = \frac{\Gamma d_{t+1}}{R_t^L}. \tag{5}$$

The credit spread plays a key role in our model through this balance sheet constraint (5). Consider μ_t as the Lagrangian multiplier for this constraint in the firm's maximization problem, which represents the tightness of the balance sheet. For convenience, define $\eta_t = 1 + \mu_t$. Then the first order condition for corporate debt is

$$\Gamma \eta_t = \frac{R_t^L}{R_t}. \tag{6}$$

For simplicity, we assume η_t as exogenous. A high credit spread shock η_t reflects a tight borrowing condition, which limits corporate borrowing and thus investment[4]. Although we do not model the source of the shocks to η_t, we consider these as shocks to the supply of credit. For instance, shocks to the financial intermediary's balance sheet or shocks to the monitoring cost for lenders could be possible candidates.

3.3 Financial Intermediary

The risk-neutral financial intermediary maximizes the present value of its profits π_t^f

$$\max E_t \sum_t \prod_t \frac{1}{R_{t-1}} \pi_t^f$$

The profits are defined as

$$\pi_t^f = \frac{\Gamma a_{t+1}}{R_t} - \frac{\Gamma b_{t+1}}{R_t} - \frac{\Gamma d_{t+1}}{R_t^L} - (a_t - b_t) + d_t. \tag{7}$$

The financial intermediary earns profits on average as long as $R^L > R$. For simplicity, we assume that all earned profits by the financial intermediary is rebated to the household. A positive credit spread $\frac{R^L}{R}$ implies that the financial intermediary is incorporating the firm default risk in their profit maximization problem. For simplicity, we do not model firm default in the equilibrium. Nonetheless, we believe that assuming default in the equilibrium will not affect the main results.

3.4 Government

The government budget constraint

$$g_t = \tau_t + \frac{\Gamma b_{t+1}}{R_t} - b_t \tag{8}$$

states that additional government spending is paid either by lump-sum taxes from the household, or by additional issuance of government bonds b_{t+1}.

Combining the government budget constraint (8) with the household budget constraint (1), firm's profit (2) and the financial intermediary's profit (7), we get the resource constraint

$$y_t = c_t + x_t + g_t. \tag{9}$$

[4]For instance Bernanke, Gertler and Gilchrist (1999) introduce the financial accelerator effect of endogenous credit spreads based on a costly state verification feature of financial contracts.

3.5 Equilibrium

The equilibrium is a set of quantities and prices such that (i) the household optimizes, (ii) the firm optimizes (iii) the financial intermediary optimizes (iv) the government budget constraint (8) holds (v) the resource constraint (9) holds: and (vi) the exogenous state variables follow an AR1 process

$$\widetilde{s_t} = P\widetilde{s_{t-1}} + \varepsilon_t, \varepsilon_t \sim N(0, V) \tag{10}$$

where $s_t = \{\eta_t, g_t, z_t, \phi_t, \Psi_t\}$, $\varepsilon_t = \{\varepsilon_{\eta t}, \varepsilon_{gt}, \varepsilon_{zt}, \varepsilon_{\phi t}, \varepsilon_{\Psi t}\}$, and $\widetilde{s_t} = \ln s_t - \ln s$.

The set of equilibrium conditions are; the labor first order condition

$$\frac{1-\Psi_t}{\Psi_t}\frac{c_t}{1-l_t} = (1-\theta)\frac{y_t}{l_t}, \tag{11}$$

the household asset Euler equation

$$\frac{\Psi_t}{c_t}\frac{1}{R_t} = \widehat{\beta} E_t\left[\frac{\Psi_{t+1}}{c_{t+1}}\right], \tag{12}$$

where $\widehat{\beta} = \frac{\beta}{\Gamma}$, the capital Euler equation

$$\Gamma\left(\eta_t - 1 + \frac{1}{\phi_t}\right) = \frac{1}{R_t}E_t\left[\theta\frac{y_{t+1}}{k_{t+1}} + \frac{1}{\phi_{t+1}}(1-\delta)\right], \tag{13}$$

the production function (3), the capital law of motion (4), the credit spread (6) and the resource constraint (9).

4 Quantitative Analysis

4.1 Calibration

Structural parameters are calibrated to match the U.S. data over the 1980-2010 period. The calibrated parameter values are listed in Table 1 along with the data targets.

Table 1. Parameter Values

Calibration		Data	
θ	0.3711	Γ	1.0069
δ	0.0101	R^L/R	1.0101
Ψ	0.2027	y/k	0.0764
η	0.0032	l	0.2010
R	1.0080	c/y	0.6354
R^L	1.0182	x/y	0.2231
$\widehat{\beta}$	0.9920		

The income share of capital θ is defined as the capital income divided by output. The imputed service flow from durable goods is added to the reported capital income. Output is also adjusted for the imputed service flows as discussed above. We use the quarterly average output growth rate as the growth trend Γ. The capital depreciation rate is calibrated from the capital law of motion equation

$$\delta = 1 - \Gamma + \phi \frac{x}{y}\frac{y}{k},$$

given the investment-output ratio and output-capital ratio where we assume that the investment specific technology ϕ is equal to unity in the steady state. The average preference weight Ψ is calibrated from the household intratemporal first order condition

$$\frac{1-\Psi}{\Psi} = (1-\theta)\frac{y}{c}\frac{1-l}{l},$$

given the consumption-output ratio and labor. The steady state credit spread shock η is computed from the credit spread equation

$$\eta = \frac{1}{\Gamma}\frac{R^L}{R},$$

given the steady state credit spread. The steady state risk free interest rate is calibrated from the capital Euler equation

$$R = \frac{\theta \frac{y}{k} + \frac{1-\delta}{\phi}}{\Gamma\left(\frac{1}{\phi} + \eta - 1\right)}.$$

The subjective discount rate $\widehat{\beta}$ is calibrated from the household asset Euler equation

$$\widehat{\beta} = \frac{1}{R}.$$

4.2 Estimation of the Stochastic Process

The stochastic process of the exogenous state variables is estimated by the maximum likelihood method using the Dynare software introduced in Adjemian, Bastani, Juillard, Mihoubi, Perendia, Ratto, and Villemot (2011). We use the data of output, consumption, labor, investment and credit spread as observable variables in order to estimate the lag matrix P and the variance covariance matrix V in the stochastic process (10). The estimation results are listed in Table 2.

The main reason why we conduct a maximum likelihood estimation is because some exogenous state variables are latent variables[5]. For instance, investment specific technology ϕ_t is computed from the capital Euler equation (4) where the right hand side variables are not observable because of the expectation operator. Capital stock is a latent variable as well since the capital law of motion (4) depends on the latent variable ϕ_t. This means that productivity is also a latent variable since it is computed as a residual from the production function (3). Hence, we use the maximum likelihood method to estimate the stochastic process. For simplicity, we assume that the lag matrix P and the variance covariance matrix V are diagonal.

The estimated values are as follows.

$$
\begin{aligned}
P &= \left|\begin{array}{ccccc} 0.454 & 0 & 0 & 0 & 0 \\ 0 & 0.980 & 0 & 0 & 0 \\ 0 & 0 & 0.998 & 0 & 0 \\ 0 & 0 & 0 & 0.992 & 0 \\ 0 & 0 & 0 & 0 & 0.987 \end{array}\right| \\
V &= \left|\begin{array}{ccccc} 0.007 & 0 & 0 & 0 & 0 \\ 0 & 0.412 & 0 & 0 & 0 \\ 0 & 0 & 0.110 & 0 & 0 \\ 0 & 0 & 0 & 0.032 & 0 \\ 0 & 0 & 0 & 0 & 0.026 \end{array}\right| \times 0.001.
\end{aligned}
$$

4.3 Impulse Responses

In order to understand the channels through which each shocks operate, it is useful to assess the impulse responses of the key endogenous variables to

[5] We use the maximum likelihood estimation code built in the dynare program.

shocks. In figures 2a-e we present the impulse responses of output, consumption, investment, and labor to a one percent increase in credit spread, government, productivity, investment specific technology and preference shocks.

Figure 2a shows the impulse response to a 1 percent increase the credit spread η. An increase in the credit premium increases the cost of investment so investment will fall. The reduction of the relative price of consumption to investment creates a positive income effect on the consumer. Both consumption and leisure increases which leads to a fall in labor and output[6].

Figure 2b show the impulse responses to a 1 percent increase the government expenditure g. The increase in government expenditure reduces the household's disposable income and hence creates a negative income effect. This leads to a reduction in consumption and leisure. The reduction in leisure causes an increase in labor and output. One counter-intuitive result is that investment rises in response to an increase in government expenditure. This result depends on the persistence of the government expenditure shock. Labor supply rises more and remains high in response to an increase in government expenditure when the persistence is higher due to a stronger income effect. The rise in future labor supply increases the expected marginal product of capital, which encourages investment. With the estimated persistence, 0.98, this effect dominates the crowding out effect. With a slightly lower persistence parameter such as 0.95, the crowding out effect dominates so that investment falls in response to government expenditure.

Figure 2c shows the impulse response to a 1 percent increase in productivity z. The impulses show that this shock clearly boosts most of variables, as found in a standard Real Business Cycle literature. Productivity directly increases output. In addition, it stimulates labor demand due to the increase in the marginal product of labor. Consumption increases due to the increase in income and the substitution from leisure to consumption. Investment increases as households prefer to smooth consumption over time by saving part of the increased income.

Figure 2d shows the impulse response to a 1 percent increase in the investment-specific technology ϕ. This shock reduces the effective price of investment goods relative to consumption goods which leads to an increase in investment. The increase in the relative price of consumption goods cre-

[6]It turns out that the lending rate does not respond much to the credit spread shock. This implies that the deposit rate absorbs all of its impact. Note that the inverse of the deposit rate is the discount factor of the firm's future profits. Therefore, a drop in the deposit rate increases the effective cost of investment.

ates a negative income effect on the consumer which leads to a decrease in consumption and leisure. This leads to a rise in labor and output.

Figure 2e shows the impulse response to a 1 percent increase in preference weight Ψ. This shock increases the households subjective value of consumption relative to leisure. Therefore consumption and labor both increases. Output increases as a result of the increases in labor. Investment increases as households prefer to smooth consumption over time by saving part of the increased income.

4.4 Simulation

Once all of the parameter values are specified, we can compute the shocks and use them for simulation. The simulation method follows the business cycle accounting procedure of Chari, Kehoe and McGrattan (2007). First, we solve for the linear decision rules using the Dynare program. Then we use the linear decision rules and data of the observable variables output, consumption, investment, labor and credit spreads in order to compute the shocks to the exogenous variables. Finally, we plug the shocks into the model and investigate the quantitative impacts of each shock on the endogenous variables.

Figure 3 shows the fluctuation of the computed exogenous state variables and output. Investment specific technology moves together quite closely with output. Surprisingly, productivity is less correlated with output than investment specific technology. The main reason why our productivity series is less correlated with output than in studies such as Chari, Kehoe and McGrattan (2007) is because our capital stock series is affected by the investment specific technology shocks that is not present in their model[7]. The government expenditure is much more volatile than other exogenous variables[8]. The credit spread is much less volatile than other exogenous variables and is countercyclical as discussed in the previous section. The key question is, how much do these shocks affect the endogenous variables.

Figure 4a shows the results of plugging each series of shocks one by one

[7]Capital stock is treated as a latent variable in both models. In our model, a procyclical investment specific technology shock will cause a procyclical fluctuation in capital stock. This reduces the procyclicality of the measured productivity shocks.

[8]The main reason of this is because we included trade balance in government expenditure following Chari, Kehoe and McGrattan (2007). It turns out that this variable is not imporant in accounting for the U.S. business cycles so we will not make further adjustment.

into the decision rule of output. The fluctuation of output is mainly accounted for by the fluctuation of preference and investment specific technology shocks. Credit spread shocks also account for part of the fluctuations in output especially during the recent financial crisis. Productivity and government expenditure shocks are less important in accounting for the fluctuation in output.

Our results that distortions in the labor market are important in accounting for the U.S. business cycles are consistent with the result of Chari et al (2007). Preference shocks in our model are observationally equivalent to the labor market distortions in their model that are computed from the intratemporal first order condition[9]. On the other hand, our results that investment specific technology shocks are important seems inconsistent with their results that distortions in the investment market have little impact on the U.S. business cycles. This is not the case. Both investment specific technology shocks in our model and investment market distortions in their model are computed from the capital Euler equation. However, the former also affects the capital law of motion (4) while the later does not. When a positive investment specific technology shock hits the economy, this increases future capital stock given the observed level of investment. Therefore, it directly affects future output, which is a channel not present in Chari et al (2007). In addition, the affect of investment specific technology shocks on capital stock dramatically reduces the importance of productivity shocks.

Figure 4b shows the simulation results for the investment rate. Our results show that productivity and credit spread shocks are important in accounting for the fluctuation in the investment rate. Since the investment rate is analogous to the national savings rate in a closed economy, our result that productivity is important in accounting for the fluctuation in the U.S. investment rate is consistent with the results of Chen, Imrohoroglu and Imrohoroglu (2006)[10]. Credit spread is especially important in accounting for

[9]Preference shocks also appear in the household intertemporal first order condition. In order to be completely observationally equivalent, the preference shocks must be permanent.

[10]Literture on savings rates usually define national savings rate as the net investment to net national product ratio

$$\frac{x_t - \delta k_t}{y_t - \delta k_t},$$

rather than the investment to output ratio. We reach to a similar result regardless of this difference in savings and investment rates.

the investment collapse during the recent financial crisis.

5 Conclusion

In this paper, we constructed a dynamic stochastic general equilibrium model with credit spread, government expenditure, productivity, investment specific technology and preference,shocks in order to quantitatively account for the U.S. business cycle fluctuations through 1980-2010. We find that fluctuations in preference and investment specific technology shocks are important in accounting for the fluctuations output while credit spread and productivity shocks are important in accounting for the fluctuations in the investment rate. Credit spread shocks also play a significant role in the output decline during the recent financial crisis.

There are several remaining issues that we have not discussed in this paper. Investment specific technology shocks can also be modelled in a two sector modelled with consumption and investment goods producers. Productivity in the investment sector should operate in a similar fashion as the investment specific technology in our model. The robustness of our results should be checked across these different settings such as Justiniano, Primiceri and Tambalotti (2011). In addition, studies such as Fisher (2006) identify the fluctuations of investment specific technology using the data of the relative price of investment goods to consumption goods. While investment specific technology is treated as a latent variable in our model, ideally we would like to compare its computed level to its empirical counterpart. Furthermore, by assuming exogenous credit spread, we are ignoring the feedback channel of the shocks through endogenous reactions of the financial market. We can alternatively introduce financial shocks in a model with endogenous credit spreads as in Bernanke, Gertler and Gilchrist (1999). We believe that this will not change the main result of the paper. Since these issues are beyond the scope of this paper, they are left for future research.

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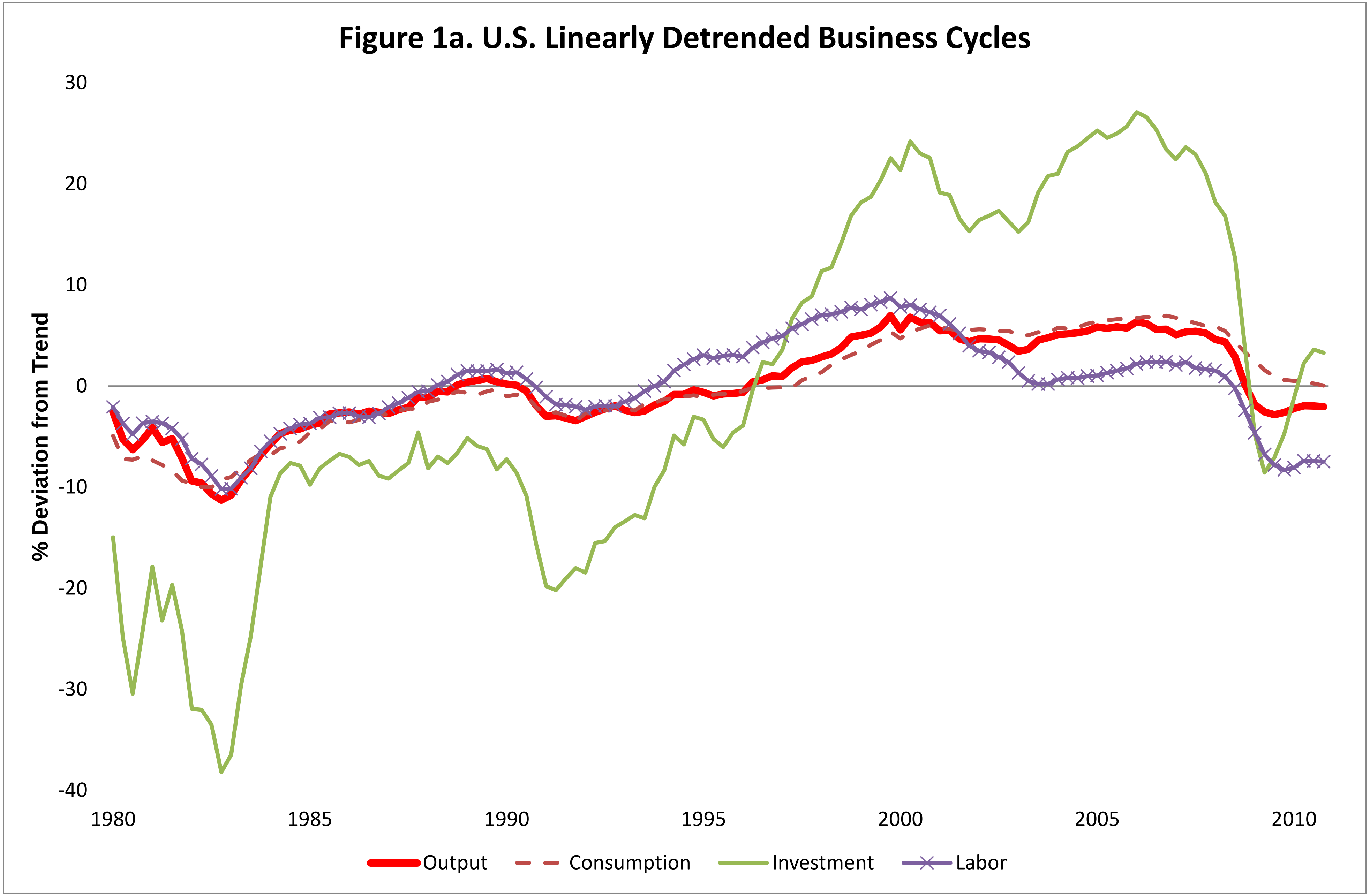


Figure 1a. U.S. Linearly Detrended Business Cycles
30
20
10
0
-10
-20
-30
-40
% Deviation from Trend
1980
1985
1990
1995
2000
2005
2010
Output
Consumption
Investment
Labor

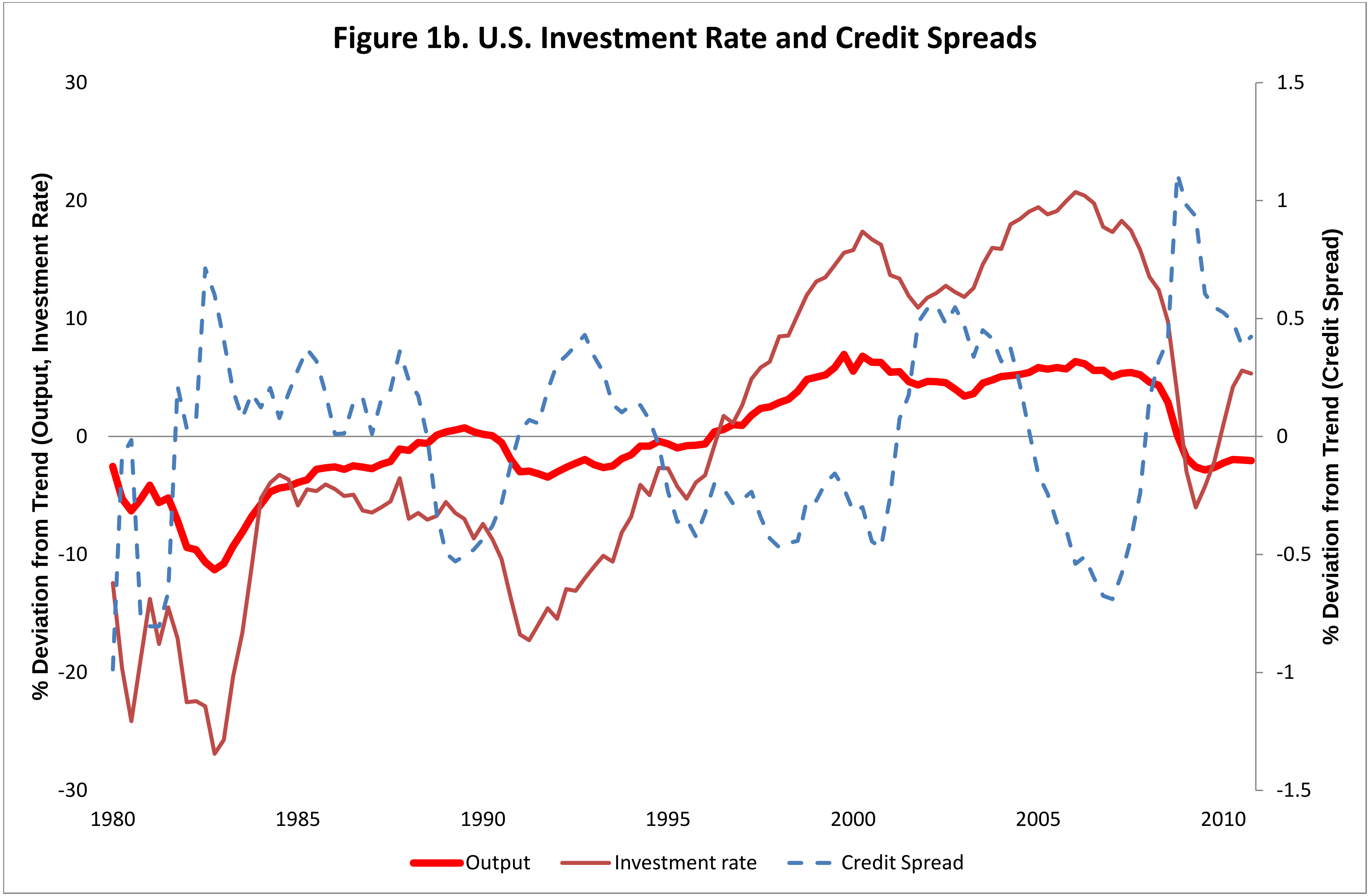
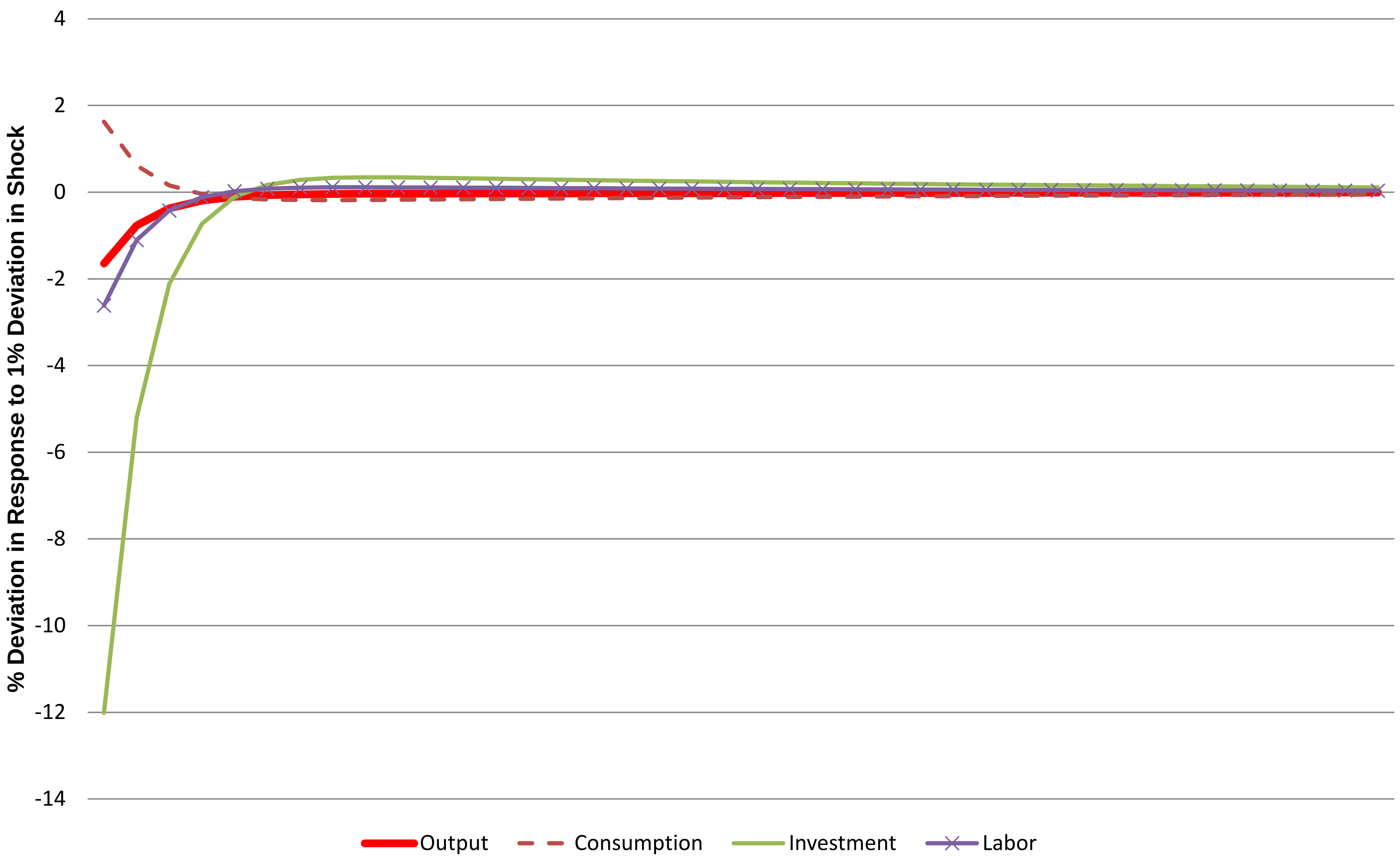


Figure 1b. U.S. Investment Rate and Credit Spreads
% Deviation from Trend (Output, Investment Rate)
% Deviation from Trend (Credit Spread)
30
20
10
0
-10
-20
-30
1.5
1
0.5
0
-0.5
-1
-1.5
1980
1985
1990
1995
2000
2005
2010
Output
Investment rate
Credit Spread

Figure 2a. Impulse Response: Credit Spread Shock



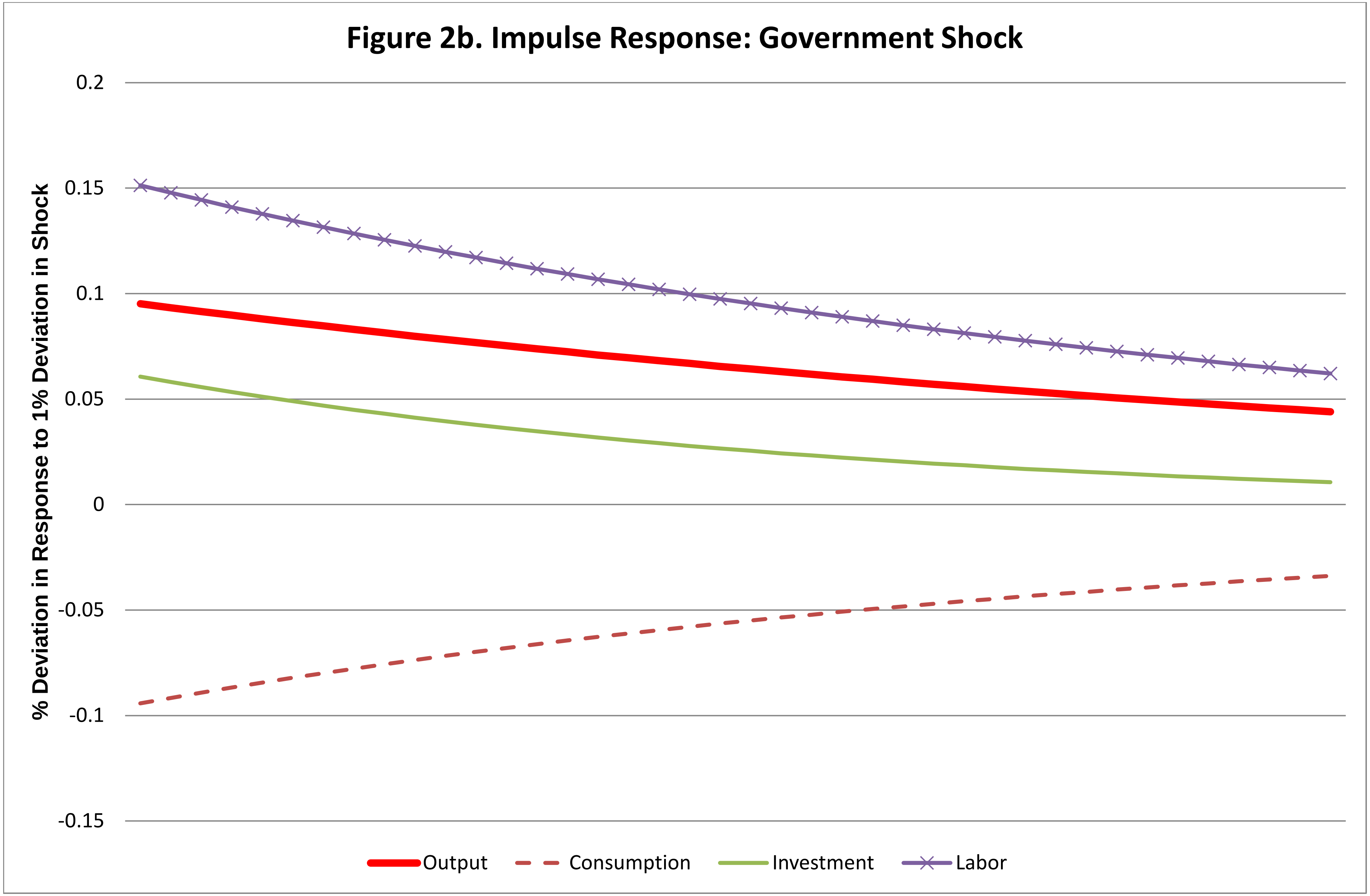


Figure 2b. Impulse Response: Government Shock
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
% Deviation in Response to 1% Deviation in Shock
Output
Consumption
Investment
Labor

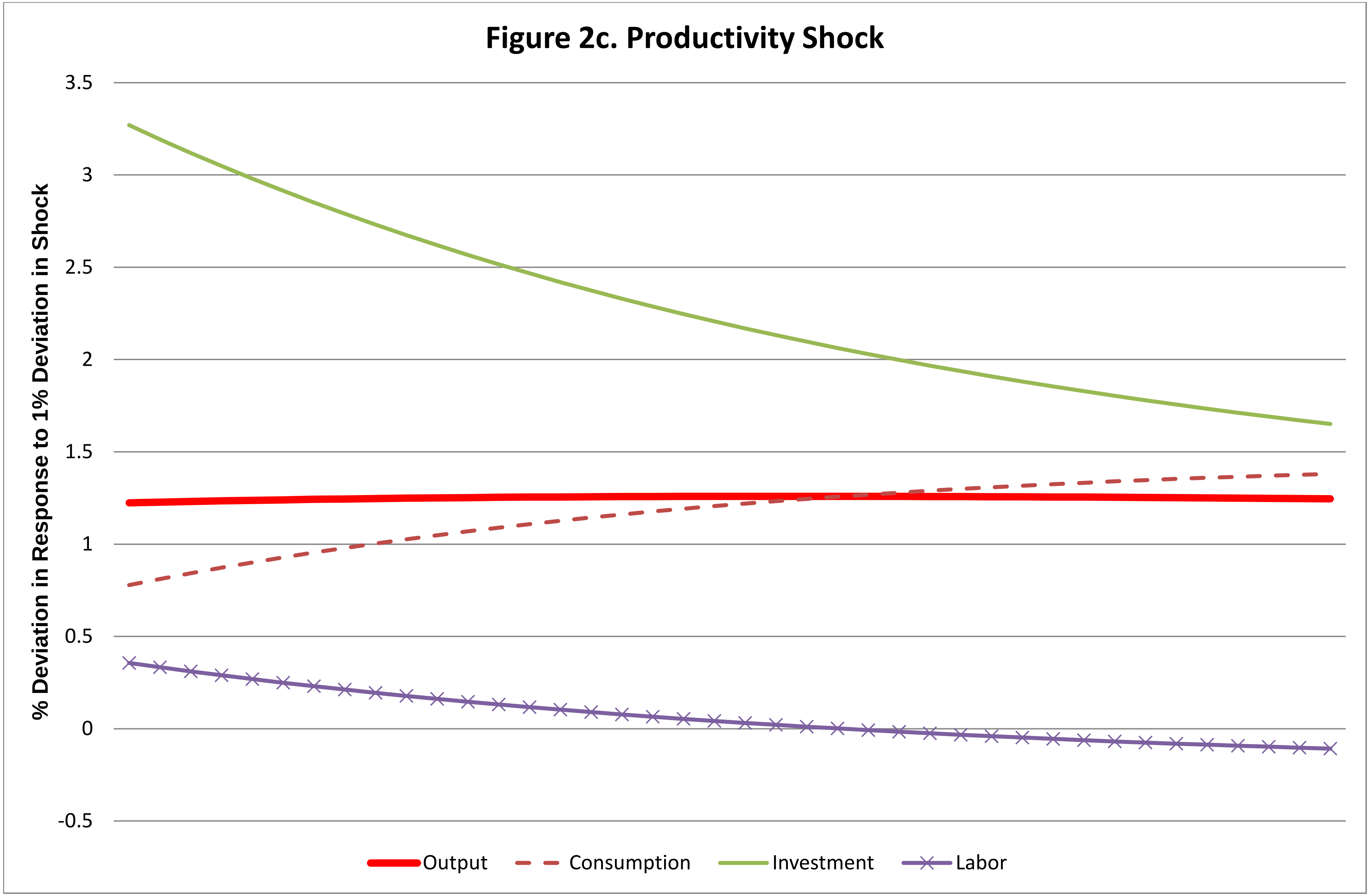


Figure 2c. Productivity Shock
% Deviation in Response to 1% Deviation in Shock
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
Output
Consumption
Investment
Labor

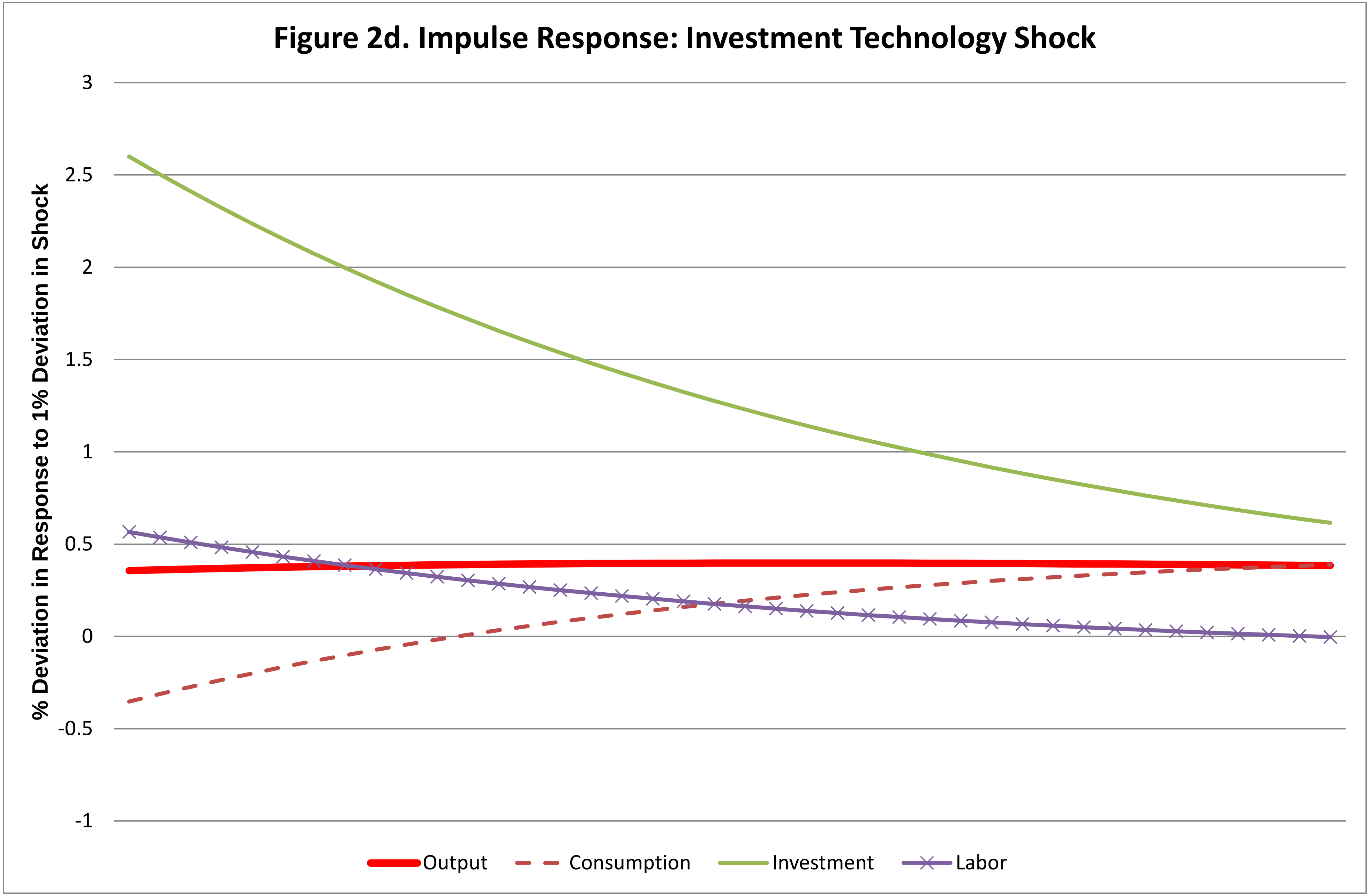


Figure 2d. Impulse Response: Investment Technology Shock
% Deviation in Response to 1% Deviation in Shock
3
2.5
2
1.5
1
0.5
0
-0.5
-1
Output
Consumption
Investment
Labor

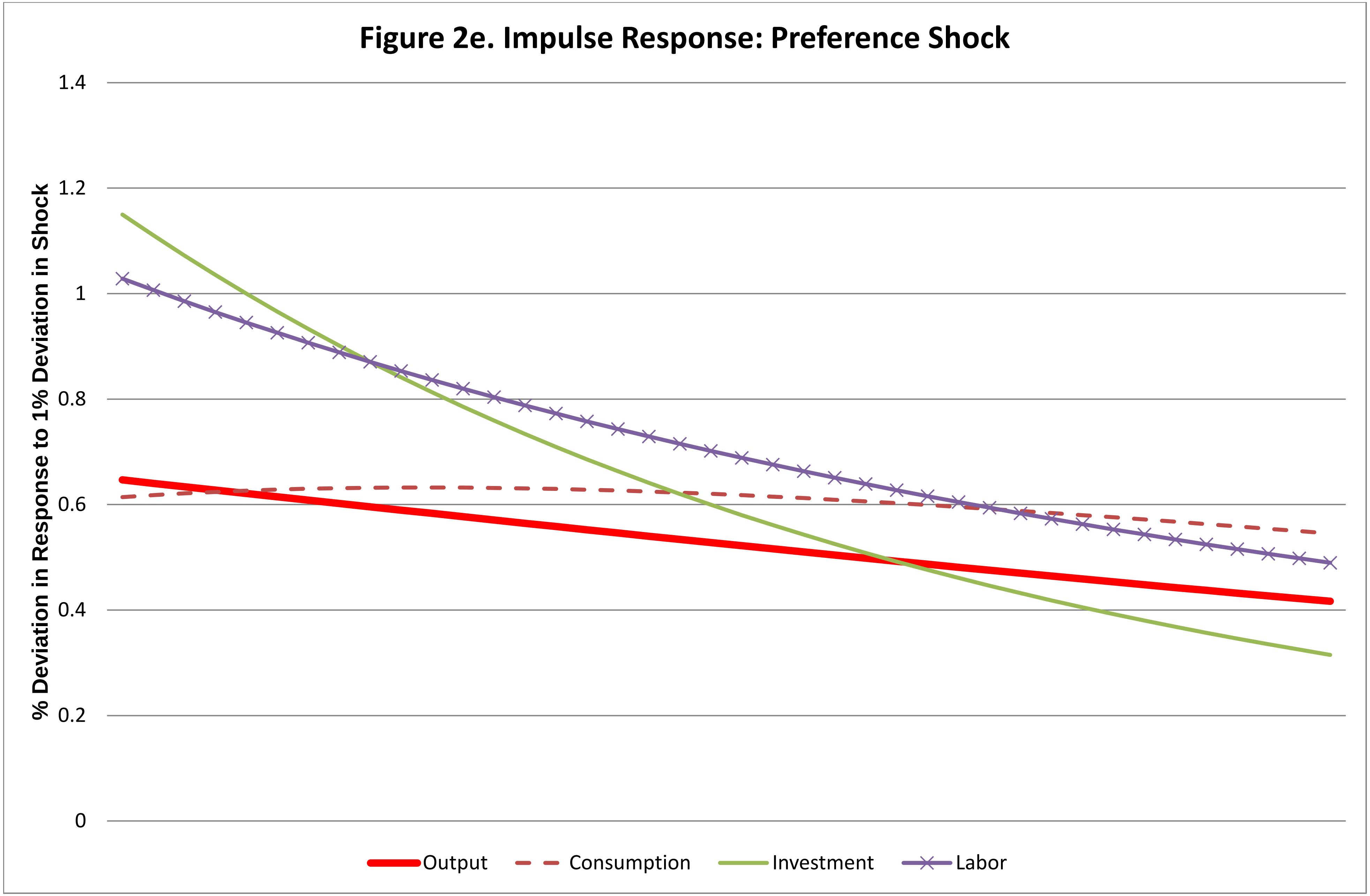


Figure 2e. Impulse Response: Preference Shock
% Deviation in Response to 1% Deviation in Shock
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Output
Consumption
Investment
Labor

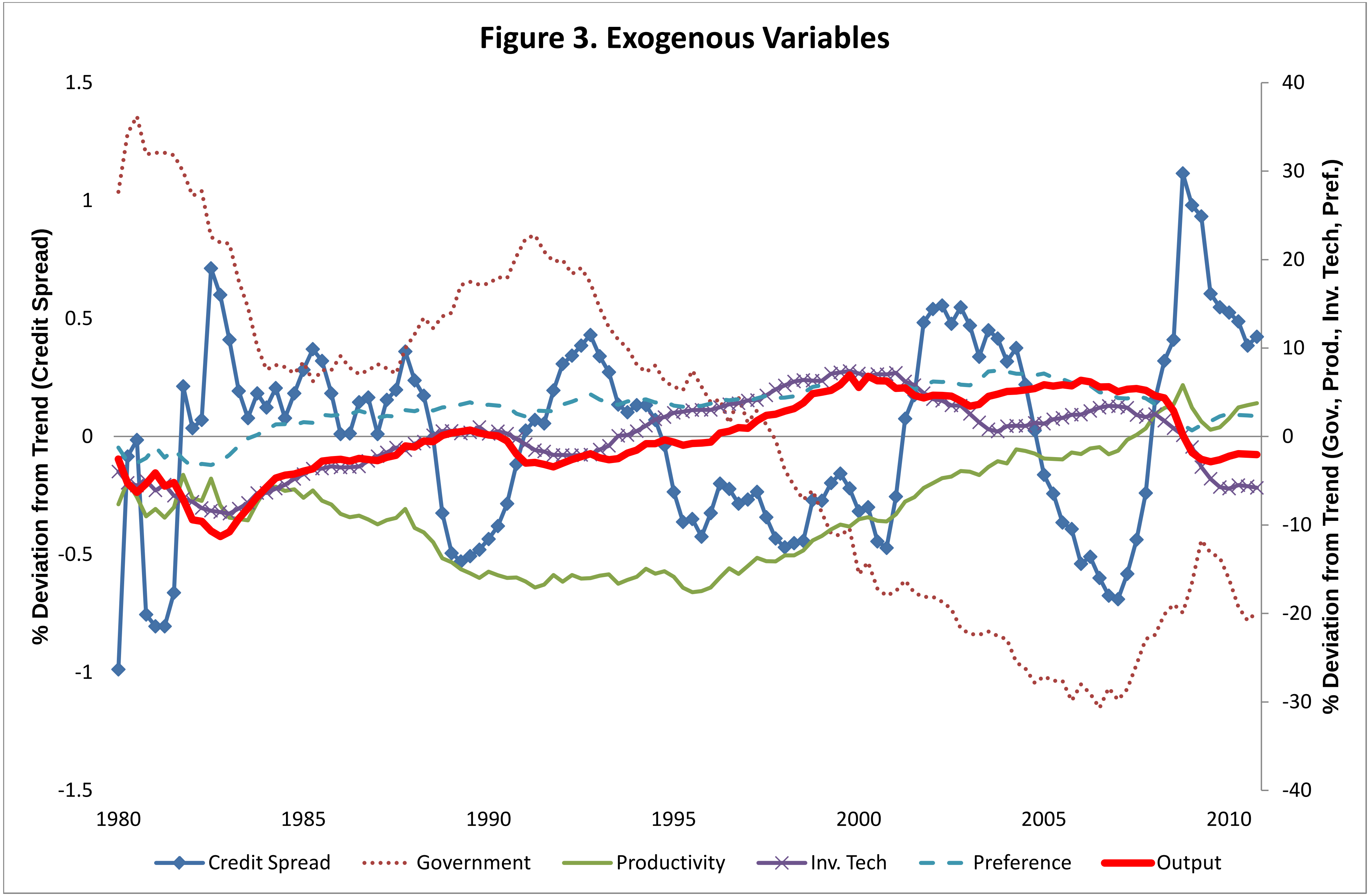


Figure 3. Exogenous Variables
% Deviation from Trend (Credit Spread)
% Deviation from Trend (Gov., Prod., Inv. Tech, Pref.)
1.5
1
0.5
0
-0.5
-1
-1.5
40
30
20
10
0
-10
-20
-30
-40
1980
1985
1990
1995
2000
2005
2010
Credit Spread
Government
Productivity
Inv. Tech
Preference
Output

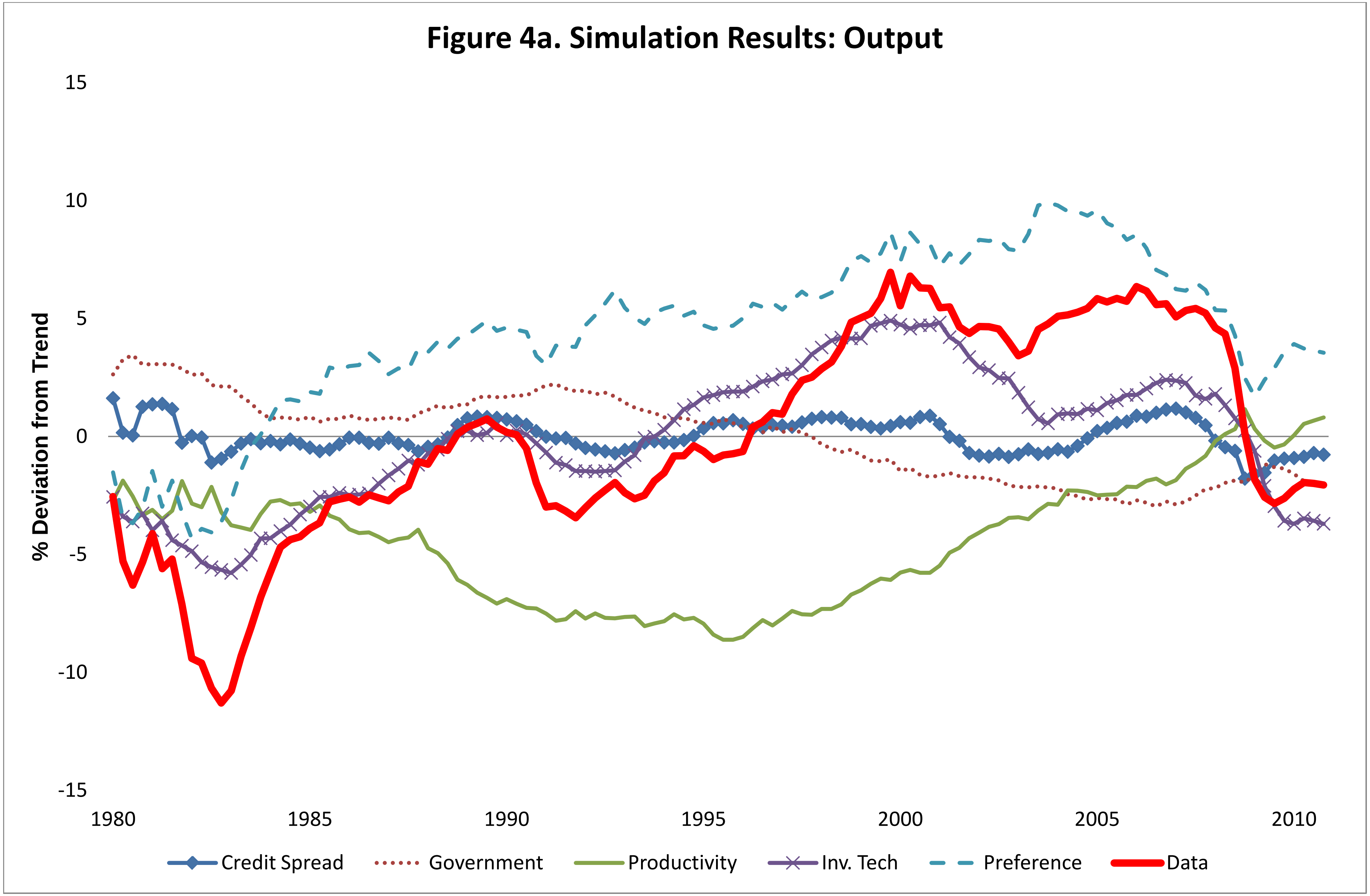


Figure 4a. Simulation Results: Output
15
10
5
0
-5
-10
-15
% Deviation from Trend
1980
1985
1990
1995
2000
2005
2010
Credit Spread
Government
Productivity
Inv. Tech
Preference
Data

Figure 4b. Simulation Results: Investment Rate