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Organizational Dynamics and Aggregate Fluctuations: The Role of Financial Relationships

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Organizational Dynamics and Aggregate Fluctuations: The Role of Financial Relationships*

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Abstract

This paper constructs a dynamic stochastic general equilibrium model in which labor reallocations between production and organizational tasks generate endogenous TFP movements and also amplify and propagate the effects of exogenous shocks on macroeconomic activity. Organizational tasks in our model enhances financial relationships between firms and lenders, which lowers the credit spread. We calibrate and estimate the model using Japanese data and conduct a quantitative analysis. Our results suggest that the labor reallocation channel considered in this paper contributes greatly to the observed movements in the measured TFP, and serves as a quantitatively important amplification and propagation mechanism in aggregate fluctuations.

JEL Classifications: E13; E32

Keywords: Labor Reallocations; Financial Relationship; Organizational Capital; TFP; Aggregate Fluctuations

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1 Introduction

Securing finance during hard times is an important task for firms. This activity is costly for the firm in the sense that resources allocated to this activity cannot be utilized for production. This paper constructs a dynamic stochastic general equilibrium model in which the labor reallocation between production and organizational tasks operate as an additional amplification and propagation mechanism through which exogenous shocks to productivity, investment-specific technology, financial relationships between the firm and lender, and household preference weights on consumption and leisure affect macroeconomic activity. We calibrate and estimate the model using Japanese data and conduct a quantitative analysis. Our results suggest that the labor reallocation serves as an important mechanism to amplify the effects of exogenous shocks on aggregate fluctuations through endogenous movements in the measured TFP.

In Japan, loans from financial institutions are an important measure of firm finance. In 2009, the total amount of outstanding loans on firms were 4.8 times the amount of firm equity and 8.7 times the amount of outstanding corporate bonds. There is evidence that the loan market gets tight during recessions, however, the credit spread is not necessarily countercyclical. In order to account for this observation, we assume that firms accumulate organizational capital which enhances the financial relationships with their lenders. During times when lending rates tend to rise, firms reallocate labor from regular production tasks to organizational tasks in order to rebuild financial relationships with lenders. As a result, the increase in the credit spread is mitigated and production declines due to labor reallocations from production to organizational tasks. Unfortunately, data on the labor allocated to organizational tasks does not exist so we cannot directly assess this labor reallocation channel. Therefore, we simulate the model calibrated to the Japanese economy in order to infer the role of labor reallocation.

Models of organizational capital go back at least to Prescott and Visscher (1980) and Atkeson and Kehoe (2005). Our paper is closely related to Ohanian (2001), which argues that changes in organizational capital are an important source of movements in firms' productivity. He argues that about two-thirds of the TFP decline in the U.S. during the Great Depression is due to this mechanism, and suggests that it is related to the breakdowns in the relationships between firms and their suppliers. In such environments firms have to shift time away from regular production to establish new relationships, and the measured productivity falls endogenously[1]. Our model is different in that we emphasize the importance of the relationships between firms and their lenders. In our model, measured TFP falls when firms reallocate labor from production activity to an activity that is directed to rebuild their financial relationships with lenders.

Another strand of literature that is related to our study includes van Rens (2004) and Koenders and Rogerson (2005) that consider models with reallocations of labor within a firm across two activities, regular production and building organizational capital. These studies try to explain the fact that employment growth was slow during the recoveries from recessions in the early 2000s (so called jobless recoveries). Their explanation is that firms simply shifted labor from organizational tasks to production during the recovery phase of the business cycle, and increased production without additional hiring. Hall (2000) also proposes a model of organizational capital based on the idea that when adverse shocks cause job destructions, the economy substitutes between regular production and the formation of new organizational capital.

While we focus on labor reallocations within firms, several papers consider reallocations of production resources across firms and analyze its implications for aggregate productivity and business cycles. Restuccia and Rogerson (2008) present a model in which aggregate productivity falls when production resources are not allocated efficiently across establishments. Hsieh and Klenow (2009) argue that such mechanism is important in explaining the TFP differences between the U.S. and developing countries such as China and India. Eisfeldt and Rampini (2006, 2008) present a model in which reallocations of existing capital across firms generate endogenous movements in aggregate productivity. They argue that during recessions the agency costs increase and costs of capital reallocations become large, which prevents potentially productive reallocations, leading to a lower aggregate productivity.

Our model assumes that firms borrow in order to finance working capital. Christiano and Eichenbaum (1992) and Barth and Ramey (2001) study the role of working capital. They show that the existence of working capital helps to explain the effects of monetary shocks on real activity. In our model, the interest rate spread between the bank's lending rate and the household's deposit rate is endogenous as in

[1]Bernanke and Parkinson (1991) take up other explanations for a procyclicality in the labor productivity, such as labor hoarding and increasing returns.

Bernanke, Gertler, and Gilchrist (1999). In addition to their theory of endogenous credit spreads based on asymmetric information between lenders and borrowers in financial contracts, we assume that the level of credit spread is decreasing in organizational capital which is interpreted as representing the financial relationship between firms and their lenders. Our model also takes into account the possibility of exogenous disruptions in such financial relationships by including a shock to the organizational capital.

The paper proceeds as follows. Section 2 presents business cycle facts of the Japanese economy. Section 3 describes the full structure of the model. Section 4 calibrates and estimates the model using Japanese data, discusses the basic properties of the model with impulse responses to shocks, and analyzes the contributions of each shock through stochastic simulations. Section 5 concludes the paper.

2 Data

Figure 1 presents Japanese credit market data - the Bank of Japan Tankan Survey data on the loan market tightness and the credit spread along with linearly - detrended per capita real GDP. The Tankan Survey data is a diffusion index computed as the number of establishments that perceive that the loan market is tight minus those that perceive that the market is accessible. The credit spread is defined as the difference between the bank lending rate on a 3 month loan and the short term interest rate on a certificate of deposit. We chose the certificate of deposit rate rather than the demand deposit rate to compute the credit spread because the market for demand deposits in Japan was tightly regulated until the mid 1990s. It turns out that the spread is negative throughout the 1980s even when we use the interest rate on certificate of deposits, most likely because the certificate of deposit market was not well developed during this period. Therefore, we focus on the period after 1990 in the quantitative analysis.

The Tankan Survey data clearly shows that the loan market gets tight during economic downturns. The correlation between the Tankan index and output is -0.34. The correlation between the credit spread and output is less intuitive: the credit spread is negatively correlated with output during specific periods but the the overall correlation is weakly positive. For instance, the fall of the premium in 1987 coincides with the beginning of the boom known as the bubble economy. The rise in the premium during 1991 coincides with the end of the bubble economy. The fall in the premium in 1995 coincides with the temporary recovery of the output. The rise in the premium in 2008 also coincides with the sudden drop in output. However, the overall correlation between output and the credit spread is 0.28. Therefore, the degree of credit market tightness in survey data do not necessarily coincide with the rise in the credit premium. We suspect that changes in the firm's organizational capital is contributing to this observation. That is, firm's may try to avoid the credit premium to rise by reallocating resources from regular production activity to non-production activity in order to secure finance.

Figure 2 shows the fluctuations of key Japanese macroeconomic variables, output, consumption, investment, and labor. Consumption includes private consumption expenditure on nondurables and services, and government purchases. Investment includes gross domestic capital formation, household expenditure on durables, and the trade balance. Labor is defined as the total hours worked. All variables are divided by the adult population. Output, consumption and investment are linearly detrended by the average growth rate of output. Consumption, labor and investment and labor are all highly correlated with output. In the quantitative section we use these macroeconomic data in order to calibrate and estimate the model.

3 Model

3.1 Household

The representative household is willing to maximize its lifetime utility which depends on consumption and leisure:

$$U = E_t \sum_{t=0}^{\infty} \beta^t u(C_t, 1 - N_t^s),$$

where C is consumption and $1 - N^s$ is the fraction of aggregate time allocated to leisure, where period preferences are given by

$$u(C_t, 1 - N_t) = \psi_t \log C_t + (1 - \psi_t) \log(1 - N_t^s),$$

where ψ_t stands for variable preference weights.

Thus, the budget constraint is

$$C_t + D_{t+1}^s = W_t N_t^s + R_{t-1} D_t^s + \pi_t + \pi_t^f, \tag{1}$$

where C_t is consumption, D_{t+1}^s is the holdings of a non-state contingent bond which matures in the next period, R_{t-1} is the current return on the bond issued in the previous period, W_t is the real wage, N_t^s is the labor supply, and π_t and π_t^f are profits from the firm and financial intermediary, which are transferred to households in lump-sum fashion. The household takes the real wage and the interest rate on the bond as given, and chooses consumption, saving, and total labor supply.

The household equilibrium conditions are as follows. The first-order condition for labor supply is

$$\frac{1-\psi_t}{\psi_t} \frac{C_t}{1-N_t^s} = W_t. \tag{2}$$

This condition states that the marginal rate of substitution of leisure to consumption is equal to the relative price of leisure, i.e. the real wage. The intertemporal first order condition is

$$\frac{\psi_t}{C_t} = \beta R_t E_t \left[\frac{\psi_{t+1}}{C_{t+1}} \right]. \tag{3}$$

This condition states that the marginal rate of substitution of future consumption to current consumption is equal to the relative price of future consumption, i.e. the inverse of the real interest rate.

3.2 Financial Intermediary

In each period, the financial intermediary collects deposits D_{t+1}^s from the household at the rate of R_t and lends funds D_{t+1}^d to the firm at the rate of R_t^k in order to maximize the present value discounted profits:

$$F = E_0 \sum_{t=0}^{\infty} \left[\left(\prod_{t=0}^{\infty} \frac{1}{R_{t-1}} \right) \pi_t^f \right].$$

Future profits are discounted at the deposit rate because the firm is owned by the household and the intertemporal discount rate that the household faces is the deposit rate.

The period profit of the financial intermediary is

$$\pi_t^f = \left(R_{t-1}^k D_t^d - D_{t+1}^d\right) - \left(R_{t-1} D_t^s - D_{t+1}^s\right) - \Phi\left(\frac{D_{t+1}^d}{K_{t+1}}, \frac{D_{t+1}^d}{H_{t+1}}\right) D_{t+1}^d, \qquad (4)$$

where $\Phi(\bullet)$ represents the cost to monitor the solvency of the firm, K_{t+1} is firm's capital stock, and H_{t+1} is firm's organizational capital.

We assume that the monitoring cost is an increasing function of the firm's debt to physical capital ratio $\frac{D_{t+1}^d}{K_{t+1}}$ and the debt to organizational capital ratio $\frac{D_{t+1}^d}{H_{t+1}}$. The debt to physical capital ratio is an indication of the firm's solvency. Therefore, the higher the debt to physical capital ratio, the higher the monitoring cost[2]. We also assume that the financial intermediary requires effort on the firm's side in the form of organizational capital H_{t+1} for the approval of loans. The greater the organizational capital relative to debt, the lower the monitoring cost on the financial intermediary side, ceteris paribus. For simplicity, we assume the following functional form for the monitoring cost:

$$\Phi(H_{t+1}, K_{t+1}, D_{t+1}^d) = \left(\frac{\gamma D_{t+1}^d}{H_{t+1}^{\omega} K_{t+1}^{1-\omega}}\right)^{\phi} - 1.$$

where γ, ϕ, and ω are positive parameters.

The amount of lending is constrained by the amount of deposits the financial intermediary collects from the household:

$$D_{t+1}^s \geq D_{t+1}^d.$$

The financial intermediary's optimality condition with respect to D_{t+1}^d is

$$\frac{R_t^k}{R_t} = (1+\phi)\left(\frac{\gamma D_{t+1}^d}{H_{t+1}^{\omega} K_{t+1}^{1-\omega}}\right)^{\phi} \equiv p_t, \qquad (5)$$

where $p_t \equiv \frac{R_t^k}{R_t}$ is defined as the credit spread. In terms of D_{t+1}^s, in our model, there is no incentive for the financial intermediary to borrow more than it lends. Thus,

$$D_{t+1}^s = D_{t+1}^d.$$

[2] A similar mechanism is present in the financial accelerator model of Bernanke, Gertler and Gilchrist (1999).

3.3 Firms

In each period, the firm takes the interest rates R_t and R_t^k and the real wage W_t as given and chooses the amount of borrowing D_{t+1}^d, investment I_t, total labor demand N_t^d as well as its allocation between the production activity $N_{p,t}$ and the organizational activity related to financial contracts $N_{f,t}$ in order to maximize the present value discounted profits:

$$V = E_0 \sum_{t=0}^{\infty} \left[\left(\prod_{t=0}^{\infty} \frac{1}{R_{t-1}} \right) \pi_t \right], \tag{6}$$

where π_t is the periodical profits in period t.

We assume that the firms borrow in the beginning of the period in order to pay for the wage bill to the workers and pay back in the end of the period. Therefore, the period profit is

$$\pi_t = Y_t - W_t N_t^d - I_t + D_{t+1}^d - R_{t-1}^k D_t^d, \tag{7}$$

where R_t^k is the borrowing rate faced by the firm and Y_t is the goods produced in period t. We also assume that the firm must borrow funds from the financial intermediary in order to finance the operation cost, which is described by the following working capital constraint:

$$D_{t+1}^d \geq W_t N_t^d + I_t. \tag{8}$$

The production function is

$$Y_t = z_t K_t^{\theta} N_{p,t}^{1-\theta}, \tag{9}$$

where z_t is productivity, $N_{p,t}$ is the amount of labor employed in the production activity, and K_t is the physical capital stock. The physical capital stock is owned by the firm and is accumulated according to the following law of motion:

$$K_{t+1} = K_t(1 - \delta_K) + \eta_t I_t, \tag{10}$$

where δ_K is the depreciation rate of physical capital and η_t is the investment-specific technology as in Greenwood, Hercowitz and Krusell (2000).

Total labor N_t^d consists of the labor employed in production activity $N_{p,t}$ and the labor employed in the accumulation of organizational capital $N_{f,t}$:

$$N_t^d = N_{p,t} + N_{f,t}, \tag{11}$$

The organizational capital can be thought of as a firm-specific knowledge that enhances the financial relationship between the firm and the financial intermediary. The organizational capital is accumulated according to the following law of motion:

$$H_{t+1} = H_t(1-\delta_H) + N_{f,t} + \log(\mu_t), \tag{12}$$

where δ_H is the depreciation rate of organizational capital, $N_{f,t}$ is the flow of labor inputs related to organizational capital, and μ_t is a disturbance to the organizational capital which we call the financial disturbance. The firm knows that their actions will affect the credit spread according to (5) and internalizes this feedback effect when it chooses the allocation of labor between two tasks.

The firm maximizes (6) subject to (7), (8), (9), (10), (11), (12), and (5). The first order condition for N_p is

$$(1-\theta)\frac{Y_t}{N_{p,t}} = (1+\phi)p_t W_t.$$

This condition states that in equilibrium the benefit from an additional N_p, the marginal product of labor, must be equal to the cost of acquiring it, i.e. the wage including the borrowing cost.

The first order condition for N_f is

$$(1+\phi)p_t W_t = \phi\omega p_t \frac{D_{t+1}^d}{H_{t+1}} + \frac{1}{R_t} E_t\left[(1+\phi)p_{t+1}W_{t+1}\left(1-\delta_H\right)\right].$$

This condition states that the benefit from an additional N_f, the reduction in the borrowing cost and the resale value of the additional organizational capital, must be equal to the cost of acquiring it, i.e. the wage including the borrowing cost.

The first order condition for capital stock K is

$$\frac{(1+\phi)p_t}{\eta_t} = \phi(1-\omega)p_t\frac{D_{t+1}^d}{K_{t+1}} + \frac{1}{R_t}E_t\left[\theta\frac{Y_{t+1}}{K_{t+1}} + \frac{(1+\phi)p_{t+1}}{\eta_{t+1}}\left(1-\delta_K\right)\right].$$

This condition states that the benefit from an additional investment, the reduction in the premium cost, the marginal product of future capital, and the resale value of it, must be equal to the cost of acquiring it, i.e. the relative price of investment $1/\eta$ including the borrowing cost.

Finally, there is no incentive for the firm to borrow more than the operation cost so (8) should hold with equality.

3.4 Shocks

There are four exogenous variables in the economy; productivity z_t, preference weights ψ_t, investment-specific technology η_t, and financial disturbance μ_t. We assume that the logs of these exogenous variables follow a first order vector autoregessive stochastic process

$$\widetilde{s}_t = P\widetilde{s}_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, V), \tag{13}$$

where $s_t = \{z_t, \psi_t, \eta_t, \mu_t\}$, $\widetilde{s}_t$ denotes the log deviations in s_t from the steady state values, and $\varepsilon_t = \{\varepsilon_{Z,t}, \varepsilon_{\psi,t}, \varepsilon_{\eta,t}, \varepsilon_{\mu,t}\}$.

3.5 Productivity and Measured TFP

In this economy, *productivity* is exogenous and is defined as the value added divided by factor inputs directly dedicated to the production activity:

$$z_t = \frac{Y_t}{K_t^\theta N_{p,t}^{1-\theta}}.$$

On the other hand, the measured total factor productivity (TFP) is endogenous and is defined as the value added divided by total factor inputs including the labor allocated to organizational tasks:

$$TFP_t = \frac{Y_t}{K_t^\theta N_t^{1-\theta}}.$$

The ratio of the two simply boils down to a function of labor inputs:

$$\frac{TFP_t}{z_t} = \left(\frac{N_{p,t}}{N_{p,t} + N_{f,t}}\right)^{1-\theta}. \tag{14}$$

Therefore, in this model, the difference between productivity and measured TFP arises due to the endogenous movements in labor allocated to accumulate organizational capital. For instance, when an adverse shock occurs to the organizational capital, it would be optimal for firms to reallocate labor from production activity to organizational capital accumulation in order to contain the increase in credit spreads. This reallocation lowers measured TFP, even when there is no change in productivity.

3.6 Competitive Equilibrium

The competitive equilibrium is a set of quantities and prices such that

1. Given $\{W_t, R_t, \psi_t, D_t\}$, the household optimizes over $\{C_t, N_t, D_{t+1}\}$.
2. Given $\{W_t, R_t, R_t^k, \eta_t, \mu_t, z_t, K_t\}$, the firm optimizes over $\{N_t, N_{p,t}, N_{f,t}, I_t, K_{t+1}, H_{t+1}, D_{t+1}\}$.
3. Given $\{R_t, R_t^k, D_t\}$, the financial intermediary optimizes over $\{D_{t+1}\}$.
4. Markets clear:

$$\begin{aligned} N_t^s &= N_t^d = N_t \\ D_t^s &= D_t^d = D_t. \end{aligned}$$

5. The resource constraint holds:

$$Y_t = C_t + I_t + (p_t - 1)D_{t+1}.$$

6. Shocks follow the stochastic process (13).

4 Quantitative Analysis

4.1 Calibration

In order to solve the model quantitatively, we need to specify the parameter values. The parameter values and steady state values of key variables used for the quantitative analysis are listed in Table 1.

Table 1. Parameter values and steady states

θ	0.362
δ_K	0.0225
δ_H	0.1
β	0.996
ϕ	0.1
ψ	0.268
ω	0.524
γ	1.520

The values of capital income share θ and physical capital depreciation rate δ_K are from Hayashi and Prescott (2002)[3]. There is less information on the value of the organizational capital depreciation rate δ_H. We follow the assumption of Corrado, Hulten and Sichel (2009) on the depreciate rate of firm specific intangible resources[4]. The spread elasticity parameter ϕ is chosen so that the likelihood is maximized when we conduct the structural estimation. The values of the subjective discount rate β, steady state preference weight ψ, spread weight on organizational capital ω, and level parameter in the spread γ are set to match the data average of investment to output ratio $\frac{I}{Y} = 0.317$, total labor $N = 0.25$, deposit rate $R = 1.0037$, and lending rate $R^k = 1.0068$. For simplicity, we normalize the steady state values of exogenous variables as $z = \eta = \mu = 1$.

[3]The value of θ is computed as the ratio of capital income to total income. The value of δ_K is computed as the ratio of capital depreciation to the value of capital stock. Hayashi and Prescott (2002) calibrate the these parameters using the annual data over the 1985-1989 period. Extending the period does not make much difference.

[4]Corrado, Hulten and Sichel (2009) assume that the firm specific intangible resources are the average of R&D and brand equity depreciation. In their paper, firm specific resources are used for production whereas we assume that it is used for financial contracts.

4.2 Impulse Responses

In this section, we describe the model's impulse responses to shocks to the economy. For simplicity, we assume that the stochastic lag matrix is diagonal[5]:

$$\widetilde{s}_t = \begin{pmatrix} 0.9 & 0 & 0 & 0 \\ 0 & 0.9 & 0 & 0 \\ 0 & 0 & 0.9 & 0 \\ 0 & 0 & 0 & 0.9 \end{pmatrix} \widetilde{s}_{t-1} + \varepsilon_t.$$

The impulse response functions are computed by solving a linearized set of equilibrium conditions derived from the model. Figures 3a-3d plot the impulse responses of the economy to a 1% increase in each exogenous variable. We subdivided the responses into four panels; stock variables, macro variables, labor variables and financial variables.

Figure 3a plots the impulse response of the economy to a 1% positive investment-specific technology shock $\varepsilon_{\eta,t}$. This shock immediately affects consumption and investment as investment becomes inexpensive relative to consumption. Therefore, the macro variables panel shows that investment rises and consumption falls on impact. The drop in consumption creates a negative income effect on the household which raises labor supply. The financial variables panel shows that debt will increase due to the increase in demand for investment and labor. This causes the credit spread to increase. The labor variables panel shows that both types of labor increase. Productive labor increases in order to satisfy the increase in demand for investment. Financial labor increases as well in order to counteract the increase in the spread. The stock variables panel shows that organizational capital, physical capital and debt all increase. The measured TFP falls due to the increase in financial labor despite the increase in output.

Figure 3b plots the impulse response of the economy to a 1% positive financial shock $\varepsilon_{\mu,t}$. This shock immediately reduces the demand for financial labor. The labor variables panel shows that financial labor drops dramatically while productive labor increases in order to maintain the parity of the return to labor across the two labor activities. Total labor decreases as the decrease in financial labor is large. The

[5] This assumption is merely made for clear exposure of the impulse responses. We will relax this assumption in the following simulation section where we estimate the entire stochastic process.

macro variables panel shows that output increases due to the increase in productive labor despite the decrease in total labor. Investment increases as the demand for physical capital rises. The financial variables panel shows that debt falls due to the drop in total labor despite the increase in investment. The drop in debt shrinks the spread. The stock variables panel shows that physical capital increases and debt decreases. The feedback through the spread function creates a negative demand on organizational capital so that it decreases in spite of the original positive shock. Measured TFP rises as a result of the decrease in financial labor.

Figure 3c plots the impulse response of the economy to a 1% positive preference shock $\varepsilon_{\psi,t}$. This shock immediately affects consumption and labor. The macro variables panel shows that consumption and labor both increase since consumption becomes more valuable relative to leisure. The labor variables panel shows that both productive and financial labor increase. The increase in productive labor leads to an increase in output. The financial variables panel shows that the increase in labor leads to an increase in debt and thus the spread. This discourages investment. The stock variables panel shows that organizational capital and debt increase while physical capital slightly decreases. Measured TFP falls due to the increase in financial labor despite the increase in output.

Figure 3d plots the impulse response of the economy to a 1% positive productivity shock $\varepsilon_{z,t}$. Productivity directly increases output. Furthermore, the macro variables panel shows that labor and investment increases as the firm increases inputs while productivity is relatively high. The financial variables panel shows that the increase in debt due to the increase in inputs leads to an increase in the spread. The labor variables panel shows that not only productive labor but also financial labor increases. This is because the firm counteracts the increase in the spread by investing in organizational capital[6]. The stock variables panel shows that organizational capital, physical capital and debt all increase. Measured TFP increases by less than 1% despite the 1% increase in productivity since financial labor increases.

[6] The increase in the demand for financial labor drives the wage up. This in turn depresses the demand for productive labor. Therefore, the reaction of productive labor depends on the increase in marginal product of productive labor and the increase of the wage due to the rise in financial labor. The latter depends on the spread elasticity parameter ϕ. It turns out that with higher elasticity, such as $\phi = 0.3$, the productive labor will decrease in response to an increase in productivity.

4.3 Estimation

In order to conduct a quantitative analysis on the impact of each shocks on the economy, we have to obtain the values of the stochastic process parameters. The stochastic process is structurally estimated with the Dynare Bayesian estimation program using the data of output, total labor supply, investment and the credit spread because the exogenous variables are not directly observable. We set the orthogonal persistence matrix used in the impulse response exercise and an orthogonal variance covariance matrix with a one percent standard deviation for each shock as the initial guess. We assume that the shocks are contemporaneously uncorrelated so that the variance matrix is diagonal[7]. The estimated values for the stochastic process are as follows.

$$P = \begin{bmatrix} 0.85 & 0.18 & 0.03 & 0.12 \\ -0.26 & 0.62 & 0.08 & 0.12 \\ -0.28 & -0.18 & 1.05 & 0.11 \\ -0.17 & -0.22 & 0.05 & 1.07 \end{bmatrix}, V = \begin{bmatrix} 0.003^2 & 0 & 0 & 0 \\ 0 & 0.005^2 & 0 & 0 \\ 0 & 0 & 0.009^2 & 0 \\ 0 & 0 & 0 & 0.007^2 \end{bmatrix}$$

Once we estimate the stochastic process, we can solve the model for linear decision rules as in the impulse response section. The shocks are recovered using the linear decision rules and the data of observable variables, following Chari, Kehoe and McGrattan (2007). The linear decision rules computed by Dynare are

$$\begin{aligned} \widetilde{x}_t &= A\widetilde{x}_{t-1} + B\varepsilon_t \\ \widetilde{v}_t &= C\widetilde{x}_{t-1} + D\varepsilon_t \end{aligned}$$

where x_t is a vector of state variables consisting of H_t, K_t and s_t while v_t is a vector of the observable variables respectively. First we assume that the state variables are initially at the steady state level so that $\widetilde{x}_0 = 0$ and $\varepsilon_1 = D^{-1}\widetilde{v}_1$. Given the computed value of ε_1 we can compute $\widetilde{x}_1 = B\varepsilon_1$. Then we can compute $\varepsilon_2 = D^{-1}\widetilde{v}_2 - D^{-1}C\widetilde{x}_1$. Given the computed values of ε_2 and $\widetilde{x}_1$ we can compute $\widetilde{x}_2 = A\widetilde{x}_1 + B\varepsilon_2$ and so on so forth until we back out the full series of ε_t.

The computed exogenous variables $\widetilde{s}_t$ are plotted along with output in Figure 4. The downward trend in preference weights closely matches that of output. We conjecture that the main contributor to this trend is the shifts in Japanese demo-

[7] This assumption does not affect the quantitative results as the model is simulated using a linearized mothod.

graphics. For instance, the increase in retired adults due to population aging over the two decades will show up as an increase in the preference on leisure. Alternatively, Braun, Ikeda and Joines (2009) show that the shrinking family size due to the falling birth rate can affect the labor decision. In their model, the head of the household determines the consumption and leisure level of the entire family. All family members consume goods while only the head of the household works in the labor market. Thus, the less dependants in the family, the higher the weight on leisure for the family as a whole.

4.4 Simulation

In order to assess the impact of each shock on the economy, we conduct counterfactual simulations feeding each shock one-by-one into the model. Table 2 presents the mean squared error of the simulated series adjusted for the data variance. That is,

$$MSE = \frac{\sum_{t=1}^{T} \left(v_t^{sim} - v_t^{data} \right)^2 / T}{\sigma^2_{v^{data}}},$$

where v_t^{sim} and v_t^{data} denotes the simulated series and the corresponding data for the selected variable. Table 3 reports the contribution index which is defined as

$$INDEX = corr(v_t^{sim}, v_t^{data}) \frac{\sigma_{v^{sim}}}{\sigma_{v^{data}}} = \frac{\sigma_{v^{sim} v^{data}}}{\sigma^2_{v^{data}}}.$$

Notice that the index for a variable will add up to one because feeding all shocks into the model will perfectly reproduce the data. Therefore, the index for each shock represents the contribution of the shock to the fluctuation of each variable.

Table 2. Mean Squared Error

	Inv. Tech	Financial	Preference	Productivity
Output	0.81	1.43	0.18	1.29
Investment	0.85	1.56	0.41	1.52
Labor	0.90	1.32	0.12	0.80
Spread	0.82	1.90	2.40	1.76
TFP	0.79	1.95	0.75	3.11

Table 3. Contribution Index

	Inv. Tech	Financial	Preference	Productivity
Output	0.16	−0.06	0.93	−0.03
Investment	0.15	0.11	0.81	−0.07
Labor	0.06	−0.10	0.90	0.14
Spread	0.14	0.43	−0.45	0.87
TFP	0.29	0.13	0.62	−0.04

For output, investment, labor and measured TFP, the simulation results with preference shocks $\varepsilon_{\psi,t}$ have the smallest mean squared error and the largest contribution index. Therefore, throughout the entire period, preference shocks played the most important role among the 4 shocks. However, in terms of the spread, preference shocks does the worst job. For the spread, investment-specific technology shocks $\varepsilon_{\eta,t}$ have the lowest mean squared error, while productivity shocks $\varepsilon_{z,t}$ have a much higher contribution. This is due to the large volatility of the simulated output in response to productivity shocks.

Figures 5a and 5b plots the simulation results for further analysis. Figure 5a presents the effects of each shock on output. Clearly, preference shocks have the most important influence on the decline in output throughout the entire period. One important reason why preference shocks are important in accounting for output is because it can account for the decline in labor. Investment-specific technology shocks contributes to the slump after 2000. Financial shocks are important during the recent recession, and also contributed to the fall in output in the early 1990s (immediately after the bubble burst) as well as in the late 1990s (the period of financial crisis in Japan). Productivity shocks had negative impact on output during early 1990s. The overall contribution of productivity shocks is smaller compared to the preference and financial shocks, however.

Figure 5b presents the effects of each shock on investment, labor, the credit spread, and the measured TFP. In terms of investment, preference shocks in the early 1990s, investment-specific technology shocks during the early 2000s and financial shocks during the late 1990s and during the recent recession are important respectively. Preference shocks are important in accounting for the decline in labor throughout the entire period. Regarding the measured TFP, investment-specific technology shocks are important during the late 1990s to early 2000s while financial disturbances are important during the recent recession. The simulation with preference shocks are highly correlated with the data throughout the entire period. Therefore, investment-specific technology shocks, financial shocks, and preference shocks are affecting output through the endogenous TFP channel caused by the reallocation of labor.

Figure 6 decomposes the fluctuation of TFP into the portion coming from productivity shocks and the portion coming from labor reallocation as shown in (14). This figure shows that the measured TFP can be volatile with a fairly constant series of exogenous productivity. The labor reallocation channel accounts for most of the fluctuation in measured TFP in our model.

5 Conclusion

In this paper, we constructed and estimated a dynamic stochastic general equilibrium model that emphasizes labor reallocations between production and organization tasks. Organizational tasks in our model is related to the accumulation of organizational capital that enhances financial relationships between firms and financial intermediaries. The labor reallocations generate endogenous movements in measured TFP, and serve as an additional force that amplifies and propagates the effects of exogenous shocks on aggregate fluctuations. Quantitative analysis of the Japanese economy shows that the estimated preference shocks are important in accounting for the output fluctuations throughout the entire period due to the impact on labor input; investment-specific technology shocks are important in accounting for the recession in the early 2000s; and financial shocks are important in accounting for the recession in 2009 most notably as well as recessions in the period immediately after the bubble burst and the period of financial crisis in Japan. Our main finding is that the labor reallocation channel considered in this paper contributes greatly to the observed movements in measured TFP, and once we take into account this channel, the contribution of purely exogenous productivity shocks is reduced, while the contributions of the remaining shocks—especially the preference shocks—are increased. In other words, the labor reallocation channel works to amplify and propagate the effects of exogenous shocks to the economy, such as productivity shocks, investment-specific technology shocks, financial shocks, and preference shocks, through the endogenous movements in the measured TFP.

There are several issues not addressed in this paper. First, in our model we do not consider retained earnings as a source of firm financing. Although we believe that incorporating self financing will not overturn any of our main results, this might reduce the quantitative importance of the labor reallocation channel. Next, the monitoring cost function is not derived from first principles. It would be insightful to solve for financial contracts that explicitly incorporate the need of organizational capital. Finally, it would be interesting to compute the contributions of demographic trends on the shifts in preference weights. While these related issues are important, we believe they are out of the scope of this paper and leave them for future research.

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A Sensitivity Analysis

In this section, we provide sensitivity analysis results. First we simulate the model with different levels of ϕ. We also detrend the results in section 4.4 by the HP filter. The sensitivity analysis results for output is summarized in Table A1. We report the variance adjusted mean squared error and contribution index as in section 4.4.

Table A1. Sensitivity Analysis (Output)

		Inv. Tech.	Financial	Preference	Productivity
$\phi = 0.1$	MSE	0.81	1.43	0.18	1.29
	Cont.	0.16	−0.06	0.93	−0.03
$\phi = 0.2$	MSE	0.69	1.20	0.07	1.58
	Cont.	0.25	0.03	0.94	−0.22
$\phi = 0.3$	MSE	0.69	1.15	0.05	1.86
	Cont.	0.25	0.08	1.00	−0.33
HP Filtered	MSE	1.04	1.67	0.59	1.75
	Cont.	0.05	0.27	0.73	−0.04

The sensitivity analysis shows that the main results are not sensitive to the parameter value ϕ. Preference shocks are the main contributor to output fluctuation. Increasing the elasticity parameter ϕ reduces the importance of productivity shocks and increases that of other shocks.

Detrending the results allows us to focus on the high frequency fluctuations of the economy. The results in section 4.4 show that preference shocks account for the decline in output mainly though its depressing effects on labor. We find that removing the medium term HP trend, we still find preference shocks the most important source of output fluctuation. Figure A1 plots the HP filtered results. As in the benchmark results, financial shocks are important in accounting for the output drops in the late 1990s and late 2000s while preference shocks account for output fluctuation throughout the entire period. Understanding the nature of high frequency fluctuation in preference weights is left for future research.

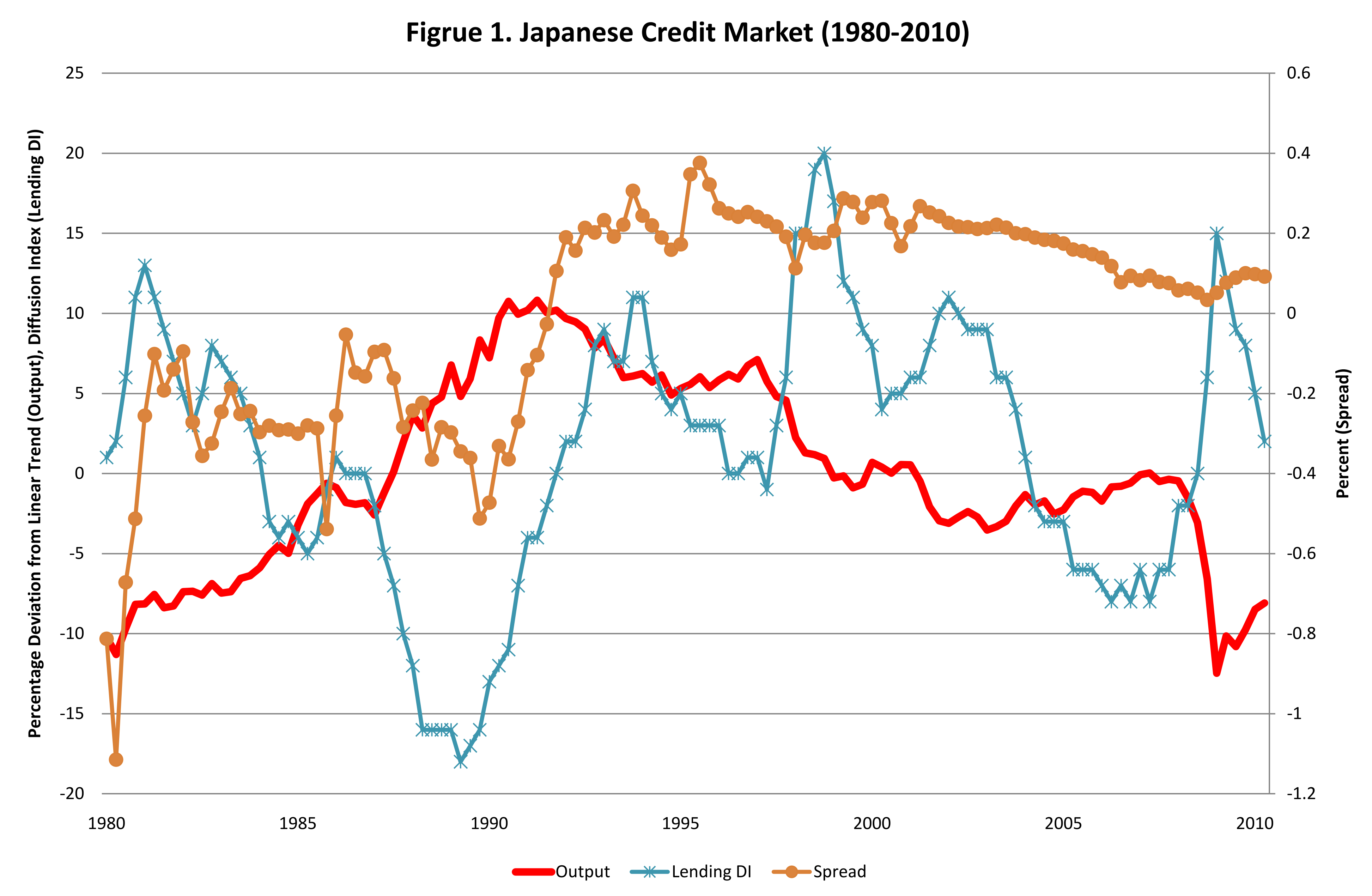

Figrue 1. Japanese Credit Market (1980-2010)
Percentage Deviation from Linear Trend (Output), Diffusion Index (Lending DI)
Percent (Spread)
25
20
15
10
5
0
-5
-10
-15
-20
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
1980
1985
1990
1995
2000
2005
2010
Output
Lending DI
Spread

Figure 2. Japanese Macroeconomic Variables (1980-2010)

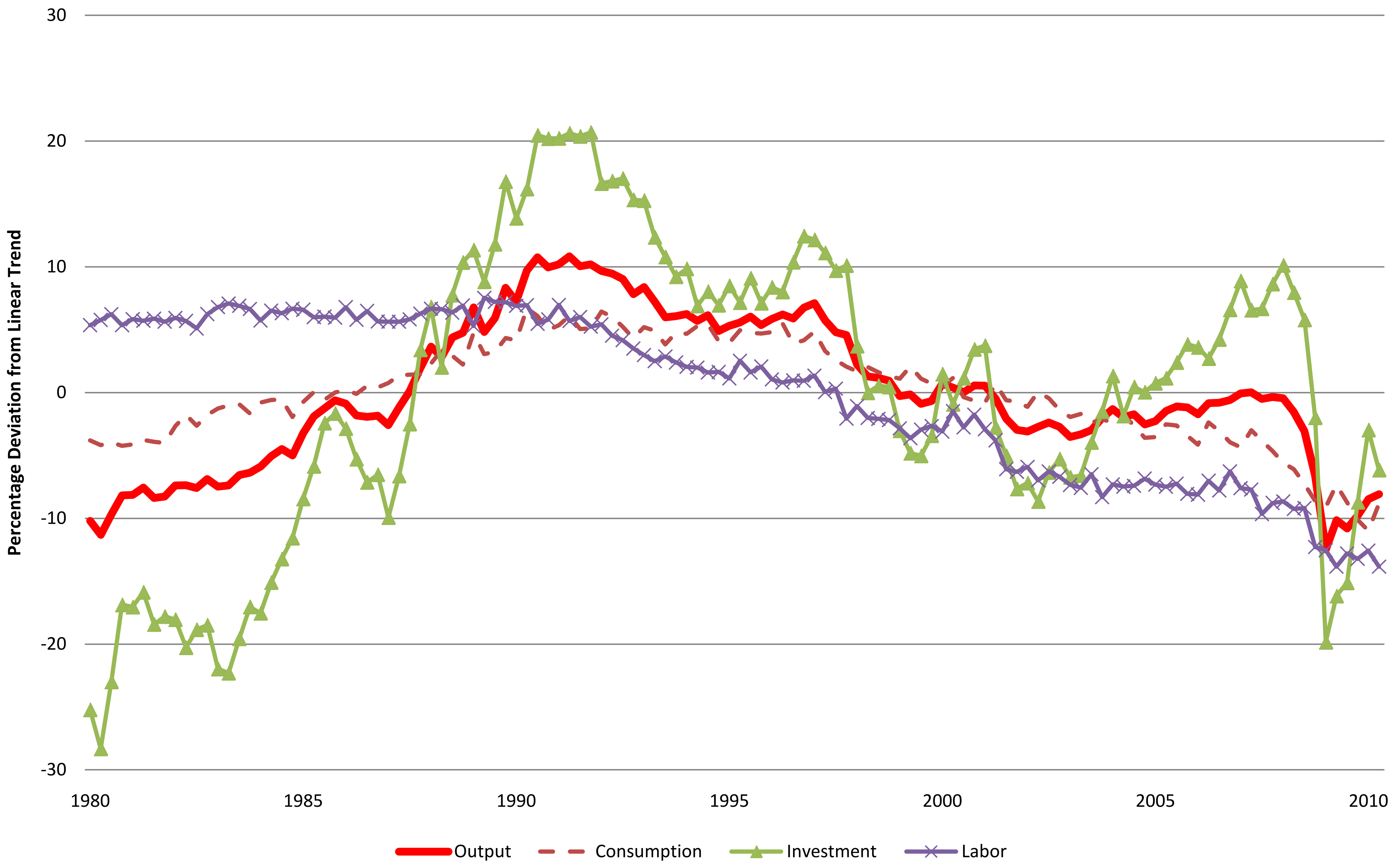


Figure 3a. Impulse Response to a 1% Increase in Investment Specific Technology Shock

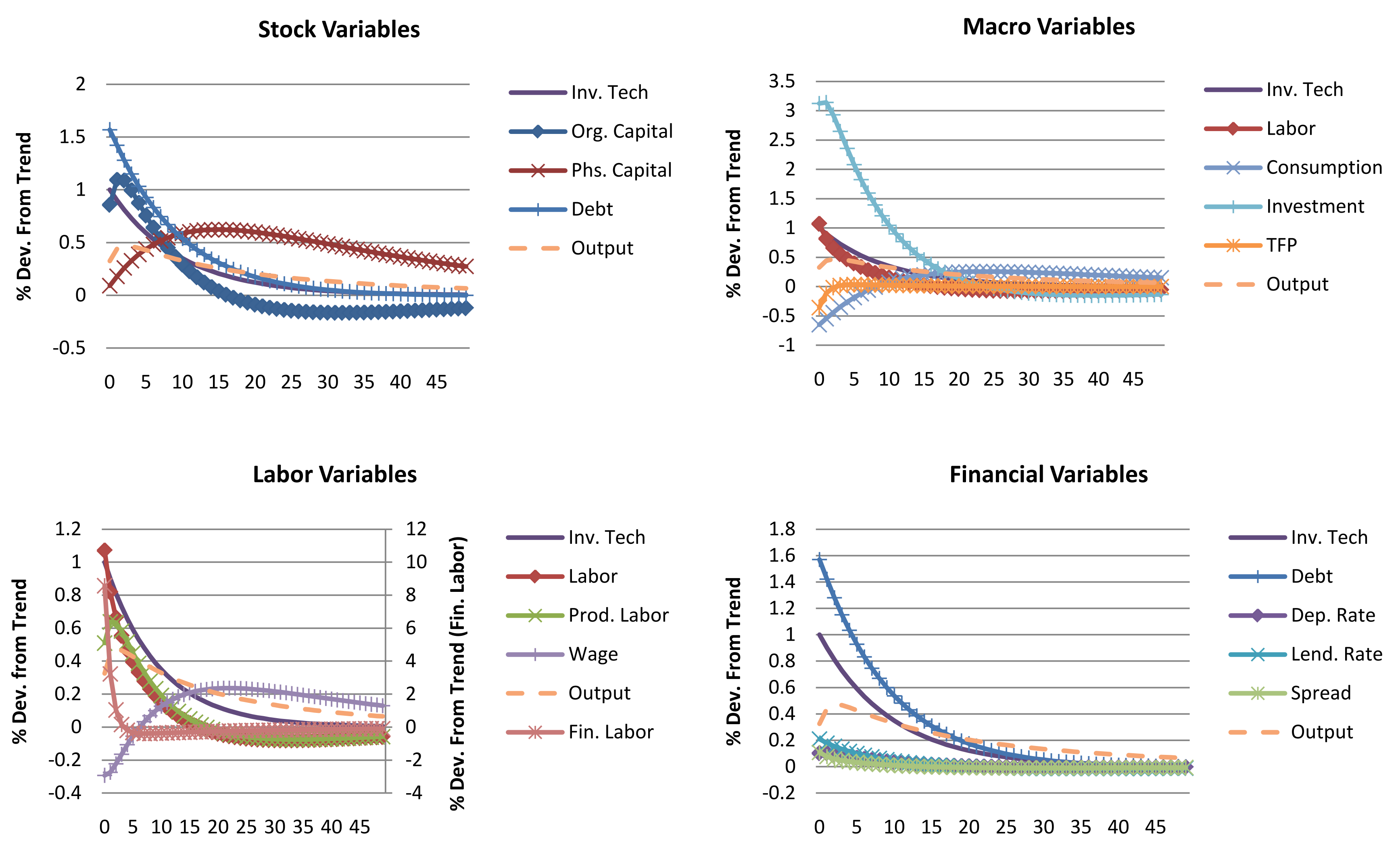


Figure 3b. Impulse Response to a 1% Increase in Financial Shock

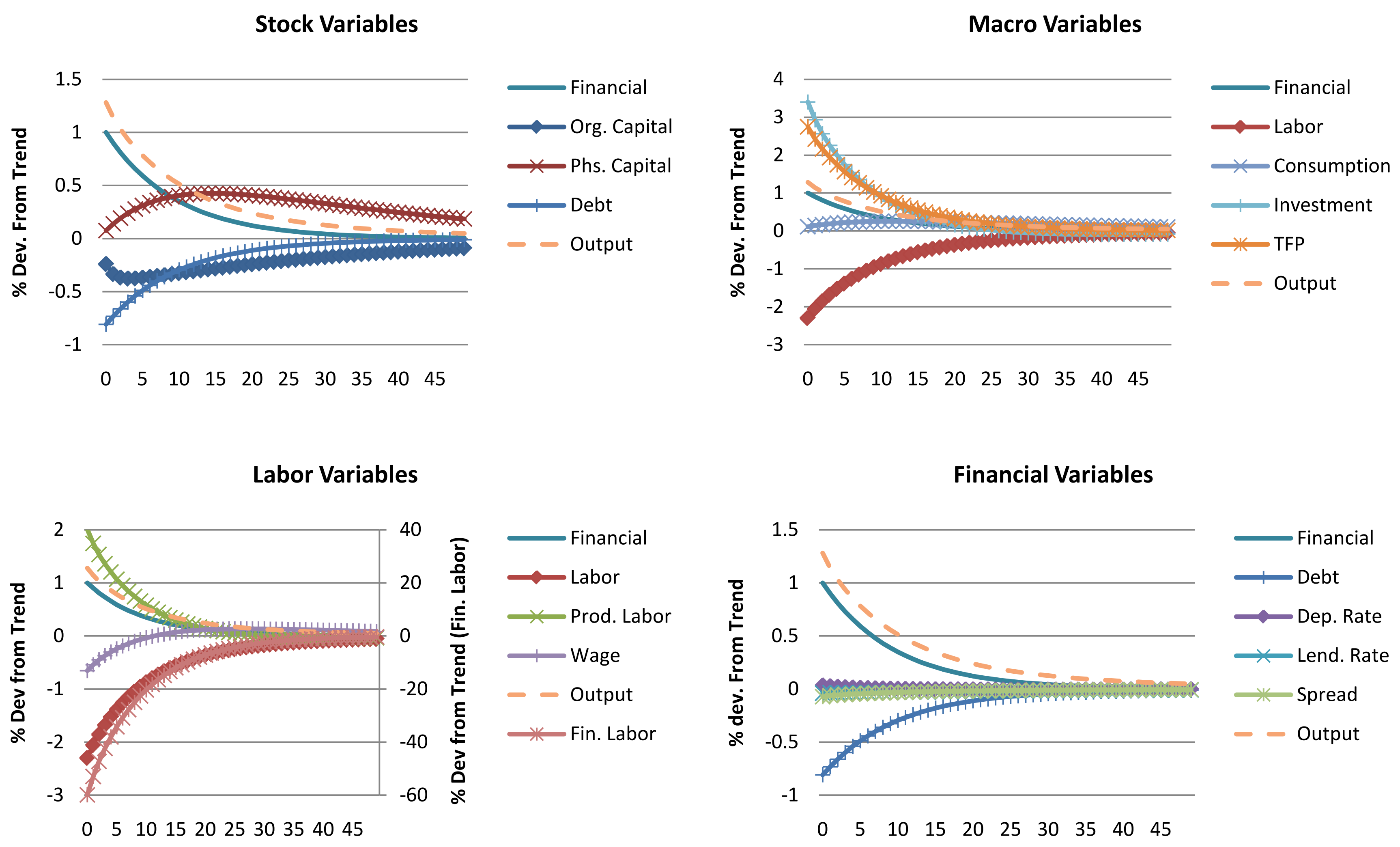


Figure 3c. Impulse Response to a 1% Increase in Preference Shock

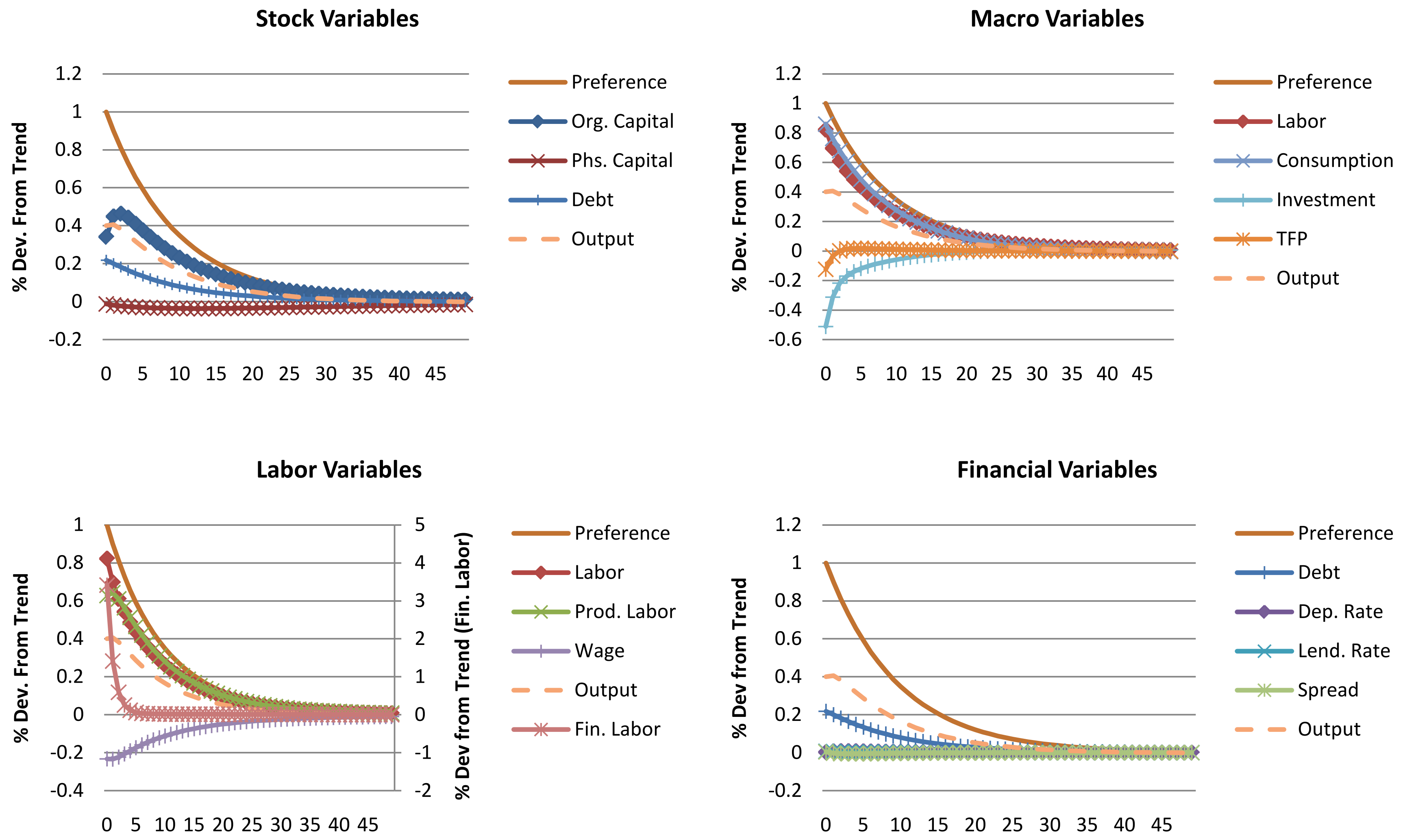


Figure 3d. Impulse Response to a 1% Increase in Productivity Shock

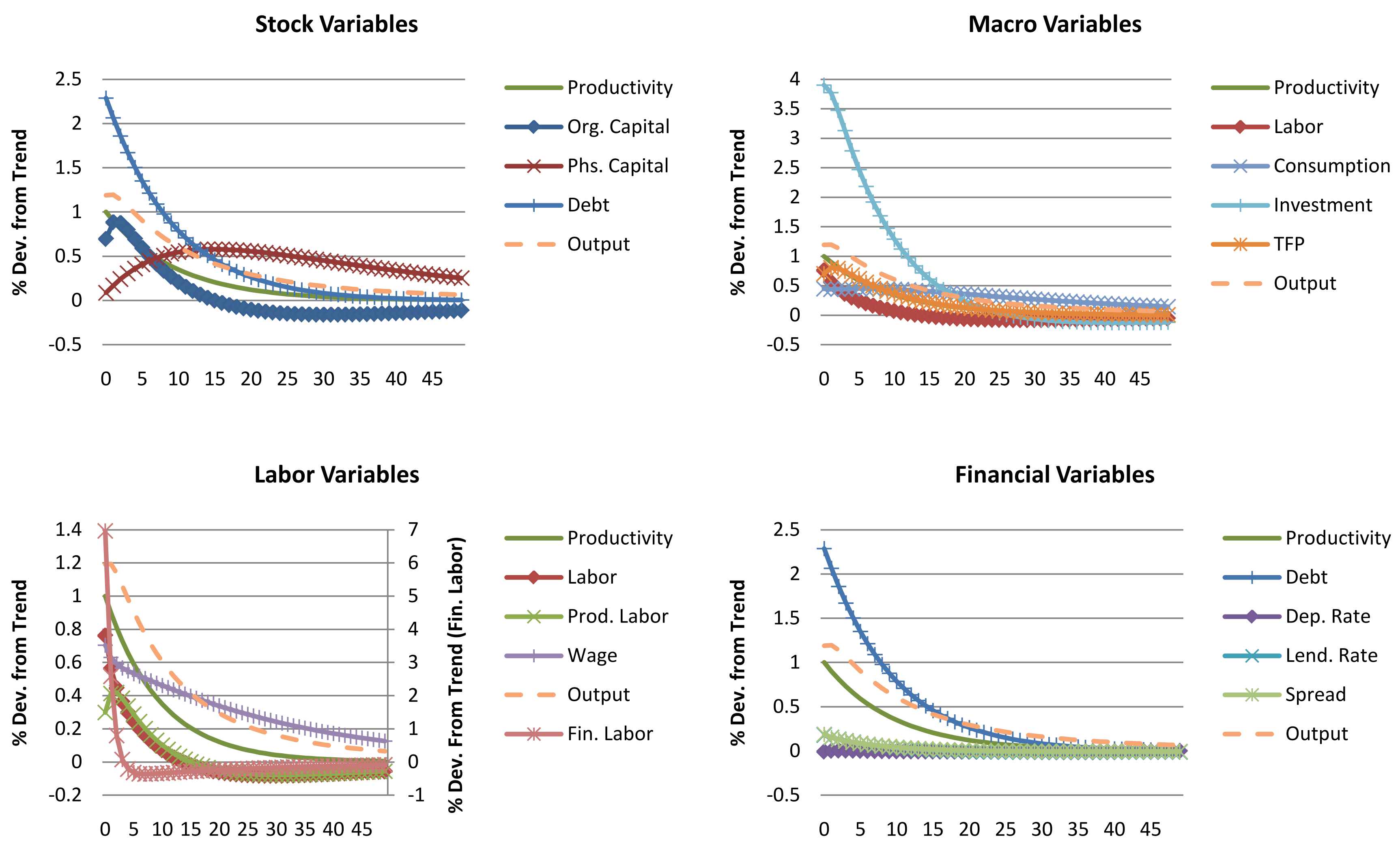


Figure 4. Estimated Exogenous Variables

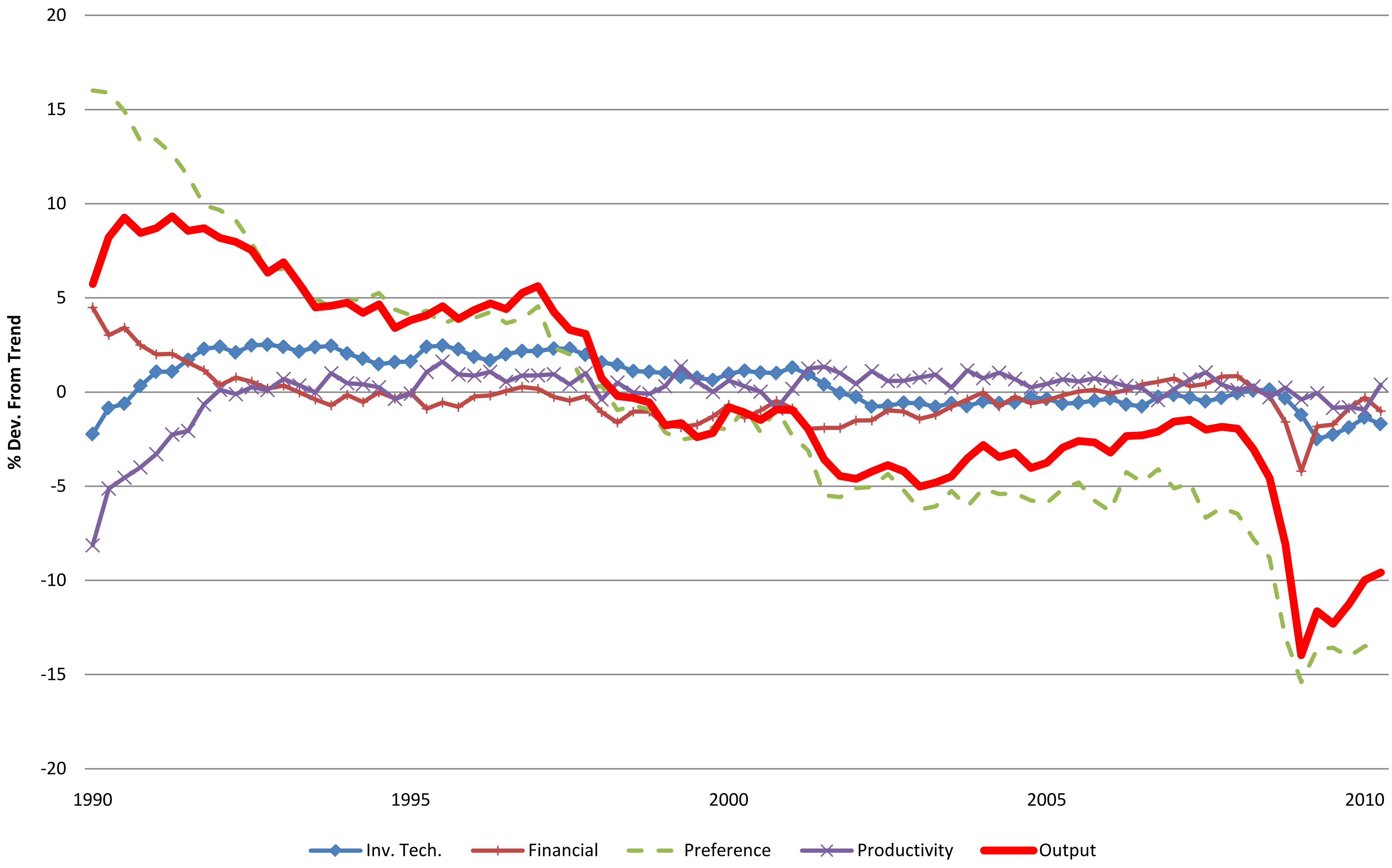


Figure 5a. Simulation Result-Output

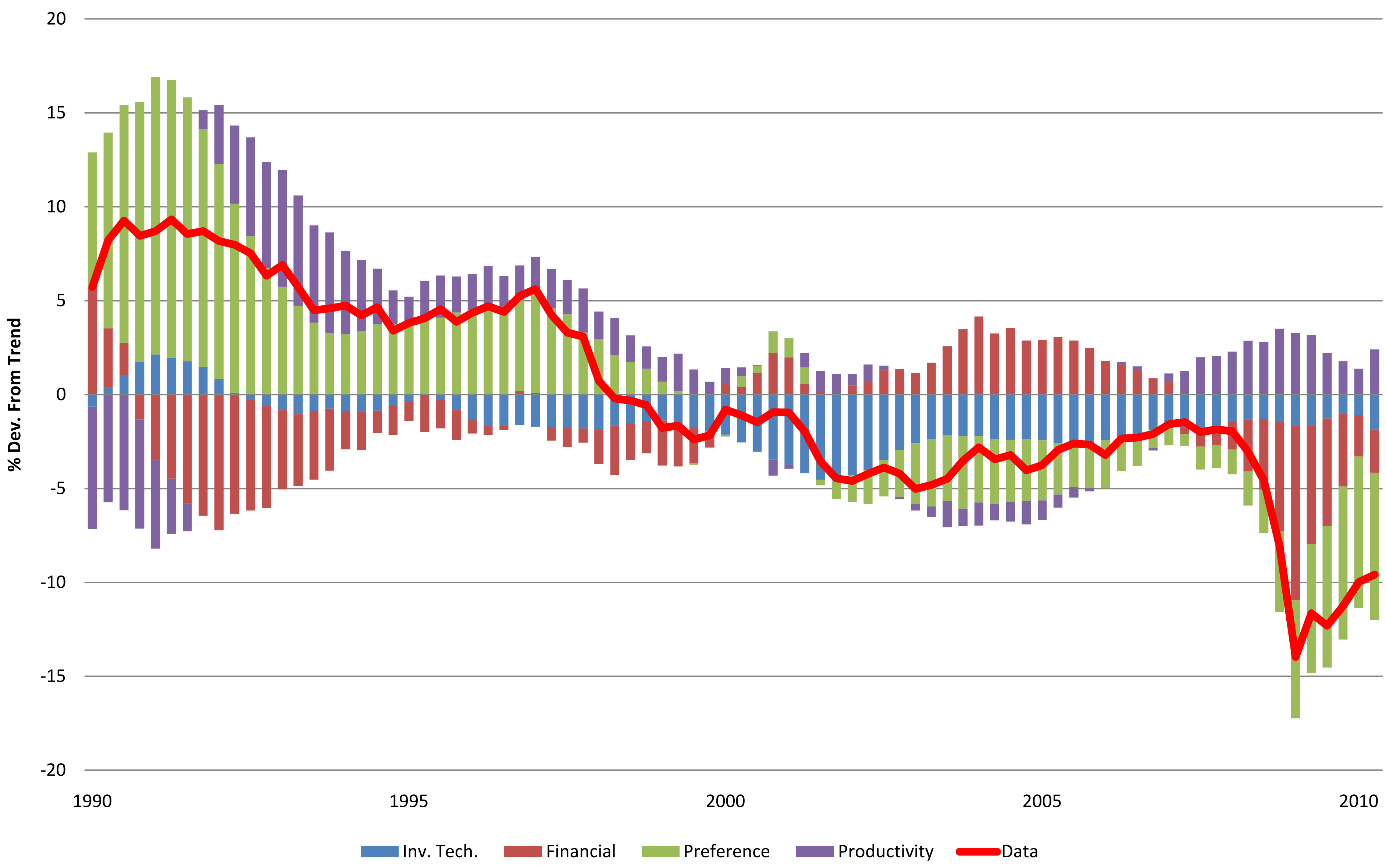
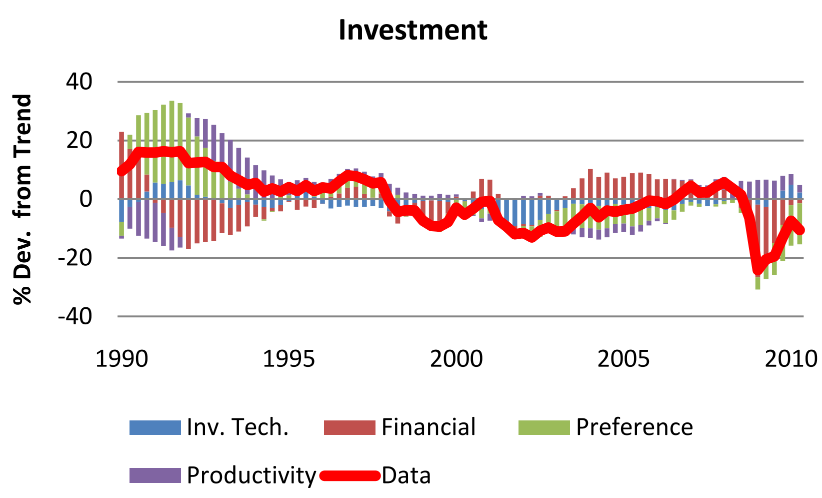
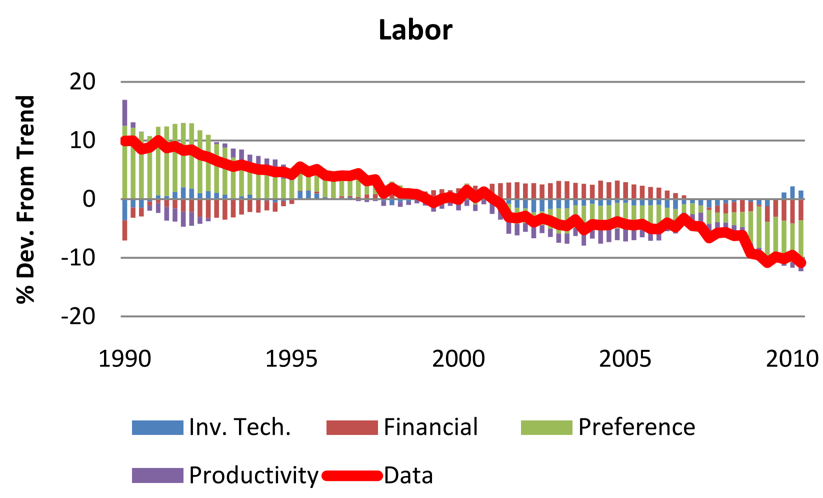
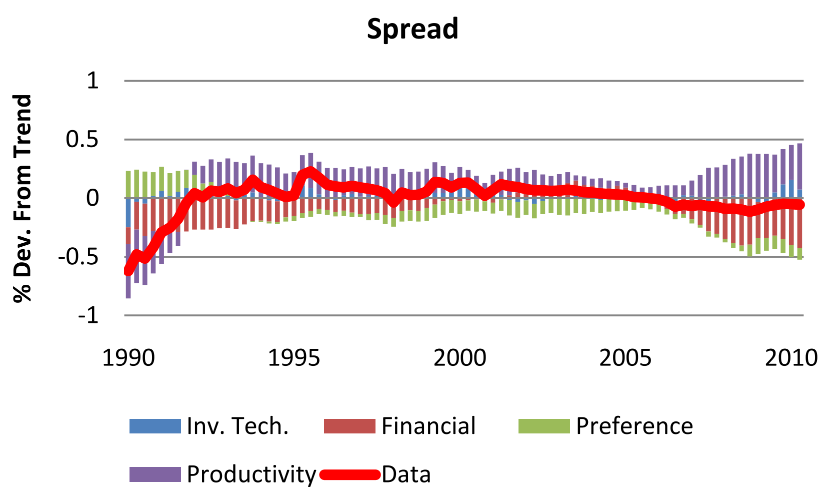


Figure 5b. Simulation Results Continued







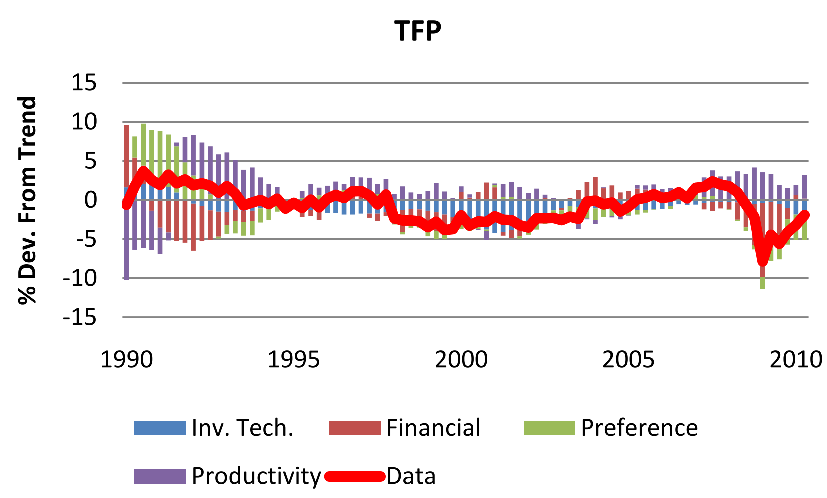


Figure 6. Decomposition of Measured TFP

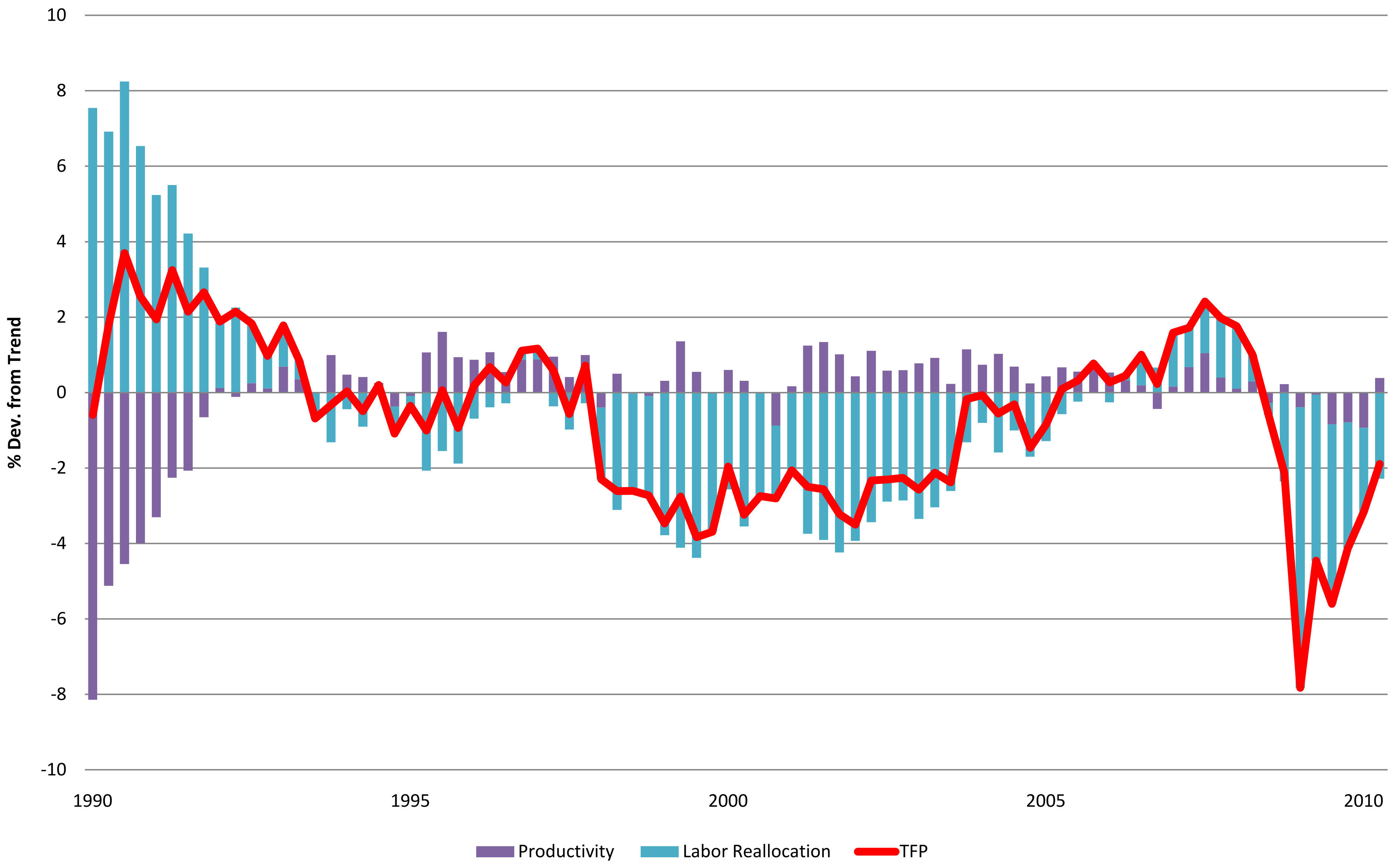


Figure A1. Simulation Result- Output Decomposition (HP Filtered)