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Aggregate Firm Behavior Under Uncertainty, Sentiments, and Aggregate Income

Belirsizlik Altında Toplam Firma Davranışı, Güven ve Toplam Gelir

Serçin Şahin[1]

Abstract

Firms hold buffer stocks such as capital stocks, inventories, liquid assets, and retained earnings to absorb the effects of uncertainties they face. However, the existence of such buffers affects both the performance of all the firms in the economy and the aggregate income. In this study, a stock-flow consistent system dynamics model is built to analyze these effects. Dynamic equilibrium solutions present that the presence of uncertainty decreases both aggregate firm profitability and aggregate income. Furthermore, the effects of a change in the sentiment of entrepreneurs and firm managers on the aggregate variables if the levels of buffer stocks were affected by this sentiment in the presence of uncertainty is analyzed. Simulation results show that a change in the sentiment index causes the aggregate income to change in the same direction.

Keywords: Uncertainty, Sentiments, Stock-Flow Consistent Modelling, System Dynamics.

Öz

Firmalar karşılaştıkları belirsizliğin olumsuz etkilerini bertaraf edebilmek için sabit sermaye, ürün envanterleri, likit varlıklar ve dağıtılmamış karlar gibi çeşitli tampon stoklar tutarlar. Ancak bu tamponların mevcudiyetinin hem ekonomideki tüm firmaların performansı hem de toplam gelir üzerinde etkileri vardır. Bu çalışmada, bu etkileri analiz edebilmek için stok-akım tutarlı bir sistem dinamiği modeli kurulmuştur. Modelin dinamik denge çözümleri belirsizliğin toplam firma karlılığını ve toplam geliri düşürdüğünü ortaya koymaktadır. Öte yandan, belirsizlik altında girişimcilerin ve firma yöneticilerinin güvenlerinin bu tampon stokların düzeyini etkilemesi halinde, bu güvendeki bir değişimin ekonomi üzerindeki etkilerinin ne olacağı da araştırılmıştır. Simülasyon sonuçları güven endeksindeki bir değişimin, toplam gelirde aynı yönlü bir değişime yol açacağını göstermiştir.

Anahtar Kelimeler: Belirsizlik, Güven, Stok-Akım Tutarlı Modelleme, Sistem Dinamiği.

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Introduction

In 1921, both Frank Knight in his Risk, Uncertainty, and Profit and Keynes in his A Treatise on Probability distinguished the concepts of risk and uncertainty. Knight referred to random events that can and cannot be represented with a probability distribution and used the term insurable risk for the first and uninsurable uncertainty for the latter (Dimand, 2021). According to him, this distinction is essential because uncertainty brings profit opportunities that would not exist in situations to which probability distributions can be assigned (Rakow, 2010). Although Keynes refers to the same phenomena as calculable and incalculable risk in his Treatise, he uses risk and uncertainty terms in his General Theory (1936) (Dimand, 2021). Keynes (1936) argues that it is not possible to represent future outcomes with a probability distribution because an exhaustive list of possible outcomes cannot be known, "black swans in the sense of Taleb (2010) are always possible" (Dimand, 2021). More recently, this distinction corresponds to the ergodic and non-ergodic processes in Post-Keynesians (Dunn, 2000). Davidson (1996) argues that even if economic agents' information about past and current events is perfect, this will not constitute a sufficient basis to form a probability distribution on the future events in non-ergodic processes.

In the presence of uncertainty, sentiments play an important role in decisions of economic agents. Because of the unknowability of the future, Keynes (1936) suggests that rational calculation can only in part justify the decisions and actions of economic agents (Marchionatti, 1999). Instead of objective calculations and optimization, economic agents form their expectations with extrapolation, and then, they complement them with what he calls animal spirits (Geiger, 2016). Animal spirits help solving the problem of decision-making under uncertainty, and they are particularly involved in long-term decisions (Franke, 2012). Pigou (1927) argued that investments are volatile because the expectation formation process of entrepreneurs is affected by their optimism and pessimism, namely, sentiments (Geiger, 2016). Schumpeter (1934) agrees that due to the absence of complete information regarding future, entrepreneurs have to rely on their sentiments along with calculations while making investment decisions (Marchionatti, 1999). Post-Keynesians even argue that animal spirits are economic agents' 'rational' response to fundamental uncertainty (Marchionatti, 1999).

As firms operate in a complex environment, uncertainty is present in all stages of the production process. Minsky and Kaufman (2008) argue that investors arrange their asset and liability structures to protect themselves against unfavorable events. Indeed, firms use buffering mechanisms to absorb the effects of uncertainties that might disrupt the production process. These buffers might take different forms towards the type of uncertainty they are built against. Firms hold capacity buffers against uncertainties such as machine breakdowns, discontinuities in capacity adjustment, or variability in the amount and composition of demand (Caputo, 1996, Caves et al., 1979). Firms hold raw material, semi-finished goods, and finished goods in inventories proportional to their sales (Tinbergen and Polak, 1950). Raw materials are needed for production, and the inability to procure them from suppliers or the market might cause a disruption in the production process. Semifinished products inventories are needed to prevent unforeseen factors from creating bottlenecks in the production process (Caputo, 1996). Finished goods inventories held against demand instability and the inflexibility of the production process (Whitin, 1952; Caves et al., 1979). Firms also hold liquid assets as a buffer stock against unexpected declines in cash flow, particularly when they have fixed commitments such as loan payments (Caves et al., 1979; Demir and Ersan, 2017; Doan et al., 2020; Baum et al., 2005). Apart from buffers on the asset side, firms hold retained earnings on the liability side to keep the company floating and make regular dividend payments in case of unexpected declines in profits (Cyert et al., 1996).

Some studies suggest that uncertainty is associated with a deterioration in firm performance. For example, using the economic uncertainty index developed by Ozturk and Sheng (2018), Doan et al. (2020) found that economic uncertainty has a negative effect on the return on equity (ROE) and return on assets (ROA) of small- and medium-sized enterprises in both developing and developed countries. Other studies used the economic policy uncertainty index developed by Baker et al. (2016). Among them, Iqbal et al. (2019) analyzed the effects of economic policy uncertainty on the performance of US-listed non-financial firms and found that uncertainty negatively affects ROE, ROA, and net profit margin. Garcia-Gomez et al. (2021) present similar results for US tourism firms. Feng et al. (2021) found that economic policy uncertainty negatively affects firm investment, employment, and revenues in China. The effects of buffers on firm performance are also analyzed in the literature. Using panel data analysis, Kovach et al. (2015) found that excess capacity and excess inventory reduce ROA of publicly-traded firms in the US. Doan et al. (2005) argue that holding more cash stock against uncertainty reduces firm performance as the proportion of firm resources used in profitable operations would decrease.

This study aims to investigate the effect of uncertainty on aggregate firm performance through buffer stock decisions. In particular, answers to two questions were sought. The first one is how the presence of uncertainty affects the aggregate firm balance sheet if firms hold buffer stocks in their assets and liabilities. The second one is how a change in the sentiments of entrepreneurs and firm managers affects firms' aggregate performance and aggregate income if the levels of buffers are functions of sentiments. To answer these questions, a stock-flow consistent system dynamics model is built, in which the level of excess capital stock, excess inventories, liquid assets, and retained assets held by business firms are

a function of the sentiment index. Then, the model is solved for both the presence of uncertainty and perfect information cases and the results are compared to see the effect of uncertainty. Finally, the model is simulated to observe the effects of an exogenous change in the sentiment index on aggregate variables.

The outline of the study is as follows: After this brief introduction, some brief information on the methodologies used in the paper is given. Section 2 presents the model. Section 3 presents the results and discussion. In the conclusion section, the findings of the study are summarized.

1. Methodology

In this study, a stock-flow consistent system dynamics model is built. In Stock-Flow Consistent (SFC) framework, each agent in an economy is represented with a balance sheet. Fund and goods flows between agents are recorded in accordance with accounting principles so that "everything comes from somewhere and goes to somewhere" (Godley and Lavoie, 2006). Then the model is simulated to understand the holistic behavior of the economy.

Similarly, System Dynamics (SD) is a methodology that tries to understand complex adaptive systems as a whole. In order to understand their dynamic behaviors, SD focuses on the structure of the systems, which consists of nonlinear causal feedback relationships (Sterman, 2000). Components of the systems can be either stocks or flows. Stocks can influence their own flows, which gives rise to feedback loops. Feedback loops can be either positive or negative. While positive loops amplify the effects of shock and work toward growing or destabilizing the system, negative loops work towards balancing the system or resist against change. The existence of time delays in the system gives rise to rich behavior such as overshooting and oscillations.

The SFC framework and SD methodology can complement each other and can be used to simulate the dynamic behavior of economic systems involving nonlinear relationships and significant time delays.

2. Model

There are three groups of agents in the model: households (h), firms (f), and banks (b). In order to focus on the dynamics resulting from firm behavior, the behaviors of households and banks are simplified. Furthermore, the price mechanism is excluded from the model and normalized the aggregate price level to 1.

The dynamic hypothesis is given in Figure 1.[2] The balance sheet and transaction matrices of the economy are given in Tables 1 and 2, respectively.[3]

2.1. Firms

Firms produce a homogenous good, demanded by households for consumption (C) and firms for investment (I). The aggregate demand (AD) is equal to the sum of consumption and investment (Equation 1).

$$\mathrm{AD} = \mathrm{C} + \mathrm{I} \tag{1}$$

Firms base their production decisions on their perceived average aggregate demand ($\overline{\mathrm{AD}}$), which adjusts to actual aggregate demand with a partial adjustment process over a period of T (Equation 2).

$$\frac{\mathrm{d}}{\mathrm{dt}}\overline{\mathrm{AD}} = \frac{1}{\mathrm{T}}(\mathrm{AD} - \overline{\mathrm{AD}}) \tag{2}$$

Firms observe the growth rate of the perceived average aggregate demand (g) over the past T periods (Equation 3). The expected growth rate of the perceived average aggregate demand ($\overline{\mathrm{g}}$) is equal to the perceived average growth rate of the perceived average aggregate demand, which is updated with a partial adjustment process (Equations 4 and 5).

[2] In the figure, arrows between variables indicate a causal relationship. Plus and minus signs indicate the direction of causality. Double bars on the arrows indicate the existence of delays in the corresponding relationship.

[3] Variables in the model can be either stock or flow, which are denoted with a boldface font and a regular font, respectively. Regarding stocks, sectors that hold them as an asset on their balance sheet are denoted with a subscript and sectors that hold them as a liability with a superscript. As for the flows, sectors for which the flow causes an increase in assets or a decrease in liabilities (use of funds) are denoted with a subscript; and sectors for which the flow causes an increase in liabilities or a decrease in assets (source of funds) with a superscript.

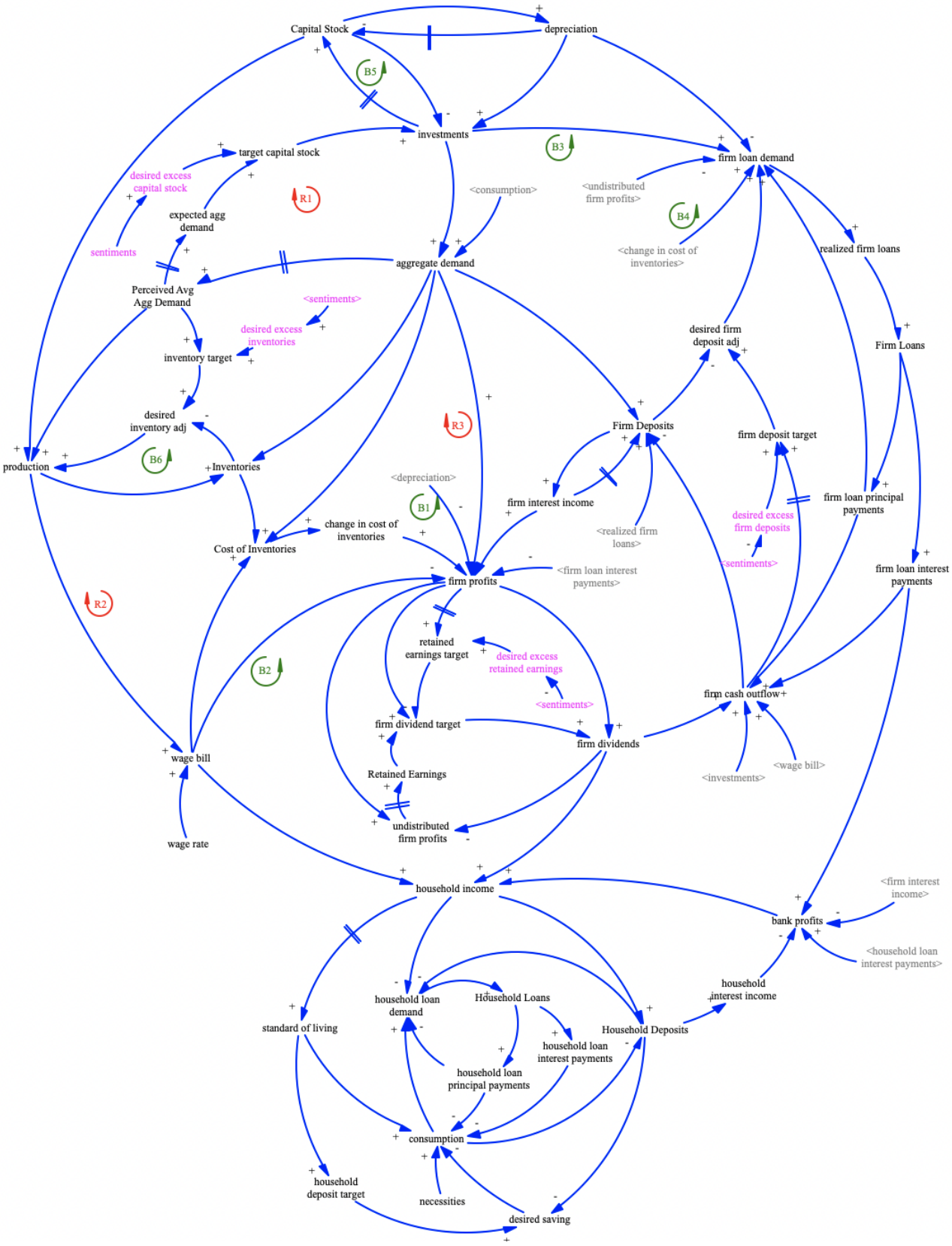


Figure 1. The Dynamic Hypothesis

Table 1. The Balance Sheet of the Economy

	Households	Firms	Banks	Σ
Capital		$+\boldsymbol{K}$		$+\boldsymbol{K}$
Inventories		$+\boldsymbol{IN}$		$+\boldsymbol{IN}$
Bank Deposits	$+\boldsymbol{DP_h}$	$+\boldsymbol{DP_f}$	$-\boldsymbol{DP^b}$	0
Loans	$-\boldsymbol{LN^h}$	$-\boldsymbol{LN^f}$	$+\boldsymbol{LN_b}$	0
Equities	$+\boldsymbol{EQ^h}$	$-\boldsymbol{EQ^f}$	$-\boldsymbol{EQ^b}$	$-\boldsymbol{K}-\boldsymbol{IN}$
Σ	0	0	0	0

Table 2. The Transaction Matrix of the Economy

	Households	Firms		Banks	Σ
		Current	Capital		
Consumption	$-C$	$+C$			0
Investment		$+I$	$-I$		0
Amortization		$-\delta\boldsymbol{K}$	$+\delta\boldsymbol{K}$		0
Wages	$+WB$	$-WB$			0
Dividends	$+DV_h$	$-DV^f$		$-DV^b$	0
Undistributed Profits		$-UP^f$	$+UP^f$		0
INTEREST ON:					
Bank Deposits	$+r^{dp}\boldsymbol{DP_h}$	$+r^{dp}\boldsymbol{DP_f}$		$-r^{dp}\boldsymbol{DP^b}$	0
Loans	$-r^{ln}\boldsymbol{LN^h}$	$-r^{ln}\boldsymbol{LN^f}$		$+r^{ln}\boldsymbol{LN_b}$	0
CHANGE IN STOCKS OF:					
Bank Deposits	$-\frac{d}{dt}\boldsymbol{DP_h}$		$-\frac{d}{dt}\boldsymbol{DP_f}$	$+\frac{d}{dt}\boldsymbol{DP^b}$	0
Loans	$+\frac{d}{dt}\boldsymbol{LN^h}$		$+\frac{d}{dt}\boldsymbol{LN^f}$	$-\frac{d}{dt}\boldsymbol{LN_b}$	0
Inventories		$+\frac{d}{dt}\boldsymbol{IN}$	$-\frac{d}{dt}\boldsymbol{IN}$		0
Equities	$-\frac{d}{dt}\boldsymbol{EQ_h}$		$+\frac{d}{dt}\boldsymbol{EQ^f}$	$+\frac{d}{dt}\boldsymbol{EQ^b}$	0
Σ	0	0	0	0	0

$$\mathrm{g} = \frac{\mathrm{AD}}{\overline{\mathrm{AD}}} - 1 \tag{3}$$

$$\frac{\mathrm{d}}{\mathrm{dt}}\bar{\mathrm{g}} = \frac{1}{\mathrm{T}}(\mathrm{g} - \bar{\mathrm{g}}) \tag{4}$$

$$\mathrm{E}[\overline{\mathrm{AD}}] = (1 + \bar{\mathrm{g}})\overline{\mathrm{AD}} \tag{5}$$

Since production takes time, firms target holding a multiple of the perceived average aggregate demand in inventories (Equation 6).

$$\widehat{\mathbf{m}} = (1 + \iota)\overline{\mathrm{AD}} \tag{6}$$

Here, ι is the excess inventory target coefficient, which indicates how much excess inventories firms want to hold as a buffer due to the inability to predict the aggregate demand with precision in the presence of uncertainty. Since firms would be willing to hold more inventories when they are more optimistic about the future of aggregate demand, this coefficient is a positive function of the sentiment index (SI) (Equation 7). The sentiment index measures the optimism of entrepreneurs and firm managers about the future of the economy and is assumed to take values between 0 and 2, with a normal value of 1.

$$\iota = \bar{\iota}(\mathrm{SI})^{\gamma} \tag{7}$$

Here, $\bar{\iota} > 0$ is the normal level of excess inventory target coefficient when sentiment index equals 1, and $\gamma > 0$ is the sensitivity parameter. Firms desire to reach their inventory target over a period of T. Therefore, firms' desired production ($\widetilde{\mathrm{PD}}$) equals the perceived average aggregate demand plus the inventory adjustment (Equation 8).

$$\widetilde{\mathrm{PD}} = \overline{\mathrm{AD}} + \frac{1}{\mathrm{T}}(\hat{\boldsymbol{\imath}}\hat{\mathbf{n}} - \mathbf{in}) \tag{8}$$

Firms use capital (K) and labor (L) as inputs in the production process. These inputs are assumed to be complementary so that the aggregate production technology can be represented with a Leontief production function (Equation 9).

$$\mathrm{f[PD]} = \min[\alpha\mathbf{K}, \beta\mathrm{L}] \tag{9}$$

Here, α is the productivity of capital and β is the productivity of labor. The labor supply is assumed to be infinitely elastic at the current wage rate, w, which is exogenous to the model. Then, firms hire labor just enough to produce the planned production, and wage bill (WB) is the total amount paid to the labor hired (Equations 10 and 11).

$$\mathrm{L} = \frac{\widetilde{\mathrm{PD}}}{\beta} \tag{10}$$

$$\mathrm{WB} = \mathrm{wL} \tag{11}$$

However, firms cannot change the amount of capital they have immediately; it is fixed for the current period. Therefore, the amount of capital determines the firms' production capacity (Equation 12).

$$\mathrm{PD} = \min\left[\frac{\mathbf{K}}{\alpha}, \widetilde{\mathrm{PD}}\right] \tag{12}$$

The change in inventories is equal to the difference between the aggregate demand and production level (Equation 13).

$$\frac{\mathrm{d}}{\mathrm{dt}}\mathbf{in} = \mathrm{PD} - \mathrm{AD} \tag{13}$$

Inventories are recorded with their costs on the balance sheet (Godley and Lavoie, 2006). The change in the cost of inventories is equal to the wage bill paid for production in the current period and the cost of goods sold (Equation 14).

$$\frac{\mathrm{d}}{\mathrm{dt}}\mathbf{IN} = \mathrm{wPD} - \frac{\mathbf{IN}}{\mathbf{in}}\mathrm{AD} \tag{14}$$

Firms target holding enough capital to meet the expected aggregate demand; therefore, they invest in capital. Due to uncertainty in aggregate demand, firms hold an excess amount of capital, the value of which is a function of the sentiment index (Equations 15 and 16).

$$\hat{\mathbf{K}} = \frac{(1+\epsilon)}{\alpha}\mathrm{E}[\overline{\mathrm{AD}}] \tag{15}$$

$$\epsilon = \bar{\epsilon}(\mathrm{SI})^{\gamma} \tag{16}$$

Here, ϵ is the excess capital coefficient; $\bar{\epsilon} > 0$ is the normal level of excess capital coefficient when the sentiment index is equal to 1, and γ is the sensitivity parameter.

Firms desire to invest in capital ($\tilde{\mathrm{I}}$) to reach the capital target over a period of T, in addition to replacing the depreciated capital (Equation 15).

$$\tilde{\mathrm{I}} = \frac{1}{\mathrm{T}}\left(\hat{\mathbf{K}} - \mathbf{K}\right) + \delta\mathbf{K} \tag{17}$$

Here, $\delta > 0$ is the depreciation rate of capital.

As the price of the product is normalized to 1, firms' revenues from sales are equal to the aggregate demand. In addition to sales revenues, firms receive interest income on their deposits from banks. On the other hand, the cost of products sold

equals the wage bill minus the change in inventories (Godley and Lavoie, 2006). Amortization and interest paid on loans are other costs of the firm. Firms' profit is the difference between their revenues and costs (Equation 18).

$$\pi = \left[\mathrm{AD} + \mathrm{r}^{\ln}\mathbf{DP_f}\right] - \left[\left(\mathrm{WB} - \frac{\mathrm{d}}{\mathrm{dt}}\mathbf{IN}\right) + \delta\mathbf{K} + \mathrm{r}^{\ln}\mathbf{LN^f}\right] \tag{18}$$

Firms want to retain some of their earnings against rainy days. Firms target holding a multiple of their perceived average profits ($\overline{\pi}$), which adjusts to actual profits with a partial adjustment mechanism over a period of T (Equation 19 and 20).

$$\frac{\mathrm{d}}{\mathrm{dt}}\overline{\pi} = \frac{1}{\mathrm{T}}(\pi - \overline{\pi}) \tag{19}$$

$$\widehat{\mathbf{RE}} = \rho\overline{\pi} \tag{20}$$

Here, ρ is the retained earnings target coefficient. Firms would want to hold more retained earnings when their expectations about the future state of the economy deteriorate. Therefore, this coefficient is a negative function of the sentiment index (Equation 21).

$$\rho = \bar{\rho}(\mathrm{SI})^{-\gamma} \tag{21}$$

Here, $\bar{\rho} > 0$ is the normal retained earnings target coefficient when the sentiment index is equal to 1, and γ is the sensitivity parameter. Firms desire to reach this retained earnings target over a period of T. On the other hand, they also want to stabilize the dividends they distribute over time (Lintner, 1958; Dobrovolsky, 1958). Therefore, the desired dividends ($\widehat{\mathrm{DV}}^{\mathrm{f}}$) reach target dividend ($\widehat{\mathrm{DV}}^{\mathrm{f}}$) over a period of T (Equation 22 and 23). If the current level of profits is below the target level of dividend, they can use retained earnings (Çağıran-Tuncer and Ulusoy, 2017). However, realized dividends (DV^{f}) cannot exceed the sum of the actual level of retained earnings and profits (Equation 24).

$$\widehat{\mathrm{DV}}^{\mathrm{f}} = \max\left[\overline{\pi} - \frac{1}{\mathrm{T}_1}\left(\widehat{\mathbf{RE}} - \mathbf{RE}\right), 0\right] \tag{22}$$

$$\frac{\mathrm{d}}{\mathrm{dt}}\widehat{\mathrm{DV}}^{\mathrm{f}} = \frac{1}{\mathrm{T}}\left(\widehat{\mathrm{DV}} - \widehat{\mathrm{DV}}^{\mathrm{f}}\right) \tag{23}$$

$$\mathrm{DV}^{\mathrm{f}} = \min\left[\max(\mathbf{RE} + \pi, 0), \widehat{\mathrm{DV}}^{\mathrm{f}}\right] \tag{24}$$

Then, undistributed profits (UP^{f}), which are also equal to the change in the retained earnings, equal the difference between actual profits and realized dividends (Equation 25).

$$\mathrm{UP}^{\mathrm{f}} = \frac{\mathrm{d}}{\mathrm{dt}}\mathbf{RE} = \pi - \mathrm{DV}^{\mathrm{f}} \tag{25}$$

Furthermore, firms are also required to make principal and interest payments on their outstanding loans (LP^{f}). Therefore, wage bill, dividends, investment, and loan payments constitute their total cash outflow (Equation 26).

$$\mathrm{CO}^{\mathrm{f}} = \mathrm{WB} + \mathrm{DV}^{\mathrm{f}} + \mathrm{LP}^{\mathrm{f}} + \mathrm{I} \tag{26}$$

Due to uncertainties, firms want to hold some cash in their bank deposits. Firms target holding a multiple of their perceived average cash outflow, which adjusts to the actual cash outflow with a partial adjustment mechanism over a period of T (Equations 27 and 28).

$$\frac{\mathrm{d}}{\mathrm{dt}}\overline{\mathrm{CO}}^{\mathrm{f}} = \frac{1}{\mathrm{T}}(\mathrm{CO}^{\mathrm{f}} - \overline{\mathrm{CO}}^{\mathrm{f}}) \tag{27}$$

$$\widehat{\mathbf{DP_f}} = \lambda\overline{\mathrm{CO}}^{\mathrm{f}} \tag{28}$$

Here, λ is the firm deposit target coefficient. Firms would want to hold more in bank deposits when their expectations about the future state of the economy deteriorate. Therefore, λ is a negative function of the sentiment index (Equation 29).

$$\lambda = \bar{\lambda}(\mathrm{SI})^{-\gamma} \tag{29}$$

Here, $\bar{\lambda}$ is the normal firm deposit target coefficient when the sentiment index is equal to 1, and γ is the sensitivity parameter. Firms want to adjust the level of their bank deposits to the target level ($\widehat{\mathrm{DC}}_{\mathrm{f}}$) over a period of T (Equation 30).

$$\widehat{\mathrm{DC}}_{\mathrm{f}} = \frac{1}{\mathrm{T}}\left(\widehat{\mathbf{DP_f}} - \mathbf{DP_f}\right) \tag{30}$$

Firms demand loans from banks (LD^{f}) equal to the difference between cash outflows and cash inflows, in case this difference is positive (Equation 31).

$$\mathrm{LD}^{\mathrm{f}} = \left[\mathrm{I} + \frac{\mathrm{d}}{\mathrm{dt}}\mathbf{IN} + \widetilde{\mathrm{DC}}_{\mathrm{f}} + \varphi\mathrm{LN}^{\mathrm{f}}\right] - \left[\delta\mathbf{K} + \mathrm{UP}^{\mathrm{f}}\right] \tag{31}$$

Firms' equity is equal to the sum of a fixed paid-up capital ($\mathbf{PC^f}$) and retained earnings (Equation 32).

$$\mathbf{EQ^f} = \mathbf{PC^f} + \mathbf{RE^f} \tag{32}$$

Firms' leverage (LV) is calculated as the ratio of liabilities to equity (Equation 33).

$$\mathrm{LV} = \frac{\mathbf{LN^f} + \mathbf{EQ^f}}{\mathbf{EQ^f}} \tag{33}$$

Firms' return on equity (ROE) is calculated as the ratio of firm profits to equity (Equation 35).

$$\mathrm{ROE} = \frac{\pi^{\mathrm{f}}}{\mathbf{EQ^f}} \tag{34}$$

Finally, firms' return on assets (ROA), is calculated as the ratio of firm profits to their assets (Equation 34).

$$\mathrm{ROA} = \frac{\pi^{\mathrm{f}}}{\mathbf{K} + \mathbf{IN} + \mathbf{DP_f}} \tag{35}$$

2.2. Households

Households receive wages (WB^{f}) from firms and interest income on their deposits from banks. As they own firms and banks, their profits accrue to households in the form of dividends ($\mathrm{DV}^{\mathrm{f}}, \mathrm{DV}^{\mathrm{b}}$). (Equation 36)

$$\mathrm{Y_h} = \mathrm{WB}^{\mathrm{f}} + \mathrm{DV}^{\mathrm{f}} + \mathrm{DV}^{\mathrm{b}} + \mathrm{r}^{\mathrm{dp}}\mathbf{DP_h} \tag{36}$$

As the government is excluded from the model, there is no tax, and household disposable income equals their income (Equation 37).

$$\mathrm{YD_h} = \mathrm{Y_h} \tag{37}$$

Households' behaviors are based on their standard of living. The standard of living is assumed to be determined by their perceived average disposable income ($\overline{\mathrm{YD}}_{\mathrm{h}}$), which adjusts to their actual disposable income with a partial adjustment mechanism over a period of T (Equation 38).

$$\frac{\mathrm{d}}{\mathrm{dt}}\overline{\mathrm{YD}}_{\mathrm{h}} = \frac{1}{\mathrm{T}}(\mathrm{YD_h} - \overline{\mathrm{YD}}_{\mathrm{h}}) \tag{38}$$

Households target holding a multiple (ϖ) of their standard of living as their wealth (Equation 39). Households are assumed to preserve their wealth only in the form of bank deposits (Equation 40).

$$\widehat{\mathbf{W_h}} = \varpi\overline{\mathrm{YD}}_{\mathrm{h}} \tag{39}$$

$$\widehat{\mathbf{W_h}} = \widehat{\mathbf{DP_h}} \tag{40}$$

Households desire to save ($\tilde{\mathrm{S}}$) out of their disposable income to close the gap between their target and actual levels of bank deposits over a period of T (Equation 41).

$$\tilde{\mathrm{S}} = \frac{1}{\mathrm{T}}\left(\widehat{\mathbf{DP_h}} - \mathbf{DP_h}\right) \tag{41}$$

Households also have to make payments on their loans (LP^{h}). Consumption demand (C) equals the perceived average disposable income remaining after desired saving and loan payments. However, a minimum amount of consumption for survival is assumed to be necessary for households. These are called necessities (CN), and consumption demand cannot be less than this amount (Equation 42).

$$\mathrm{C} = \max\left[(\overline{\mathrm{YD}}_{\mathrm{h}} - \tilde{\mathrm{S}} - \mathrm{LP}^{\mathrm{h}}), \mathrm{CN}\right] \tag{42}$$

Households' total spending (TS^{h}) equals the sum of consumption and loan payments (Equation 43). Realized saving (S) is the difference between household disposable income and total spending (Equation 44).

$$\mathrm{TS}^{\mathrm{h}} = \mathrm{C} + \mathrm{LP}^{\mathrm{h}} \tag{43}$$

$$S = \overline{YD_h} - TS^h \tag{44}$$

Households are assumed to be willing to pay their debt as soon as possible. Hence, if realized saving is positive, households first repay their loans and deposit the remaining amount, if any. If realized saving is negative, households first use their deposits for expenditures. In case their deposits are not sufficient, they demand consumer loans from banks for the remaining amount (Equation 45).

$$LD = \begin{cases} \min\left[S, (1-\varphi)\mathbf{LN^h}\right] & , \text{if } S > 0 \\ \min[(S + \mathbf{DP_h}), 0] & , \text{otherwise} \end{cases} \tag{45}$$

2.3. Banks

Banks issue deposits to households and firms and grants loans to them. Banks are assumed to grant all the loans demanded by households and firms (Equation 46).

$$LR_b = LD_f + LD_h \tag{46}$$

Bank loans are amortized loans. The principal is paid at a fixed rate (φ) of the outstanding loans (Equation 47). Total loan payments due equals the sum of principal payments due and interest payments due (Equations 48 and 49).

$$\widetilde{PP} = \varphi\mathbf{LN} \tag{47}$$

$$\widetilde{IP} = r^{ln}\mathbf{LN} \tag{48}$$

$$\widetilde{LP} = \widetilde{PP} + \widetilde{IP} \tag{49}$$

Here, φ is the loan principal payment rate, and r^{ln} is the loan interest rate. The deposit interest rate is assumed to be exogenous to the model, and banks determine the loan interest rate with a markup over the deposit interest rate (Equation 50).

$$r^{ln} = (1+\mu)r^{dp} \tag{50}$$

Banks collect loan payments and pay interest on deposits. Banks' profits are equal to the difference between loan interest payments and deposit interest payments. As banks are owned by households, they distribute all the profits to households in the form of dividends (Equation 51).

$$DV^b = r^{ln}\left(\mathbf{LN^f} + \mathbf{LN^h}\right) - r^{dp}(\mathbf{DP_f} + \mathbf{DP_h}) \tag{51}$$

3. Dynamic Equilibrium

The dynamic equilibrium is the state in which all stocks and flows in the economy are constant. First, the dynamic equilibrium conditions for the presence of uncertainty case are solved, then the dynamic equilibrium conditions for the perfect information case are derived as a special case of the former.

In what follows, the dynamic equilibrium values of variables are indicated with a single star superscript in the presence of uncertainty case and with a double star superscript in the perfect information case.

3.1. The Presence of Uncertainty

First of all, aggregate demand is constant and equal to the perceived average aggregate demand and expected aggregate demand (Equation 52).

$$AD^* = E[AD] = \overline{AD} \tag{52}$$

As inventories are constant, production equals aggregate demand, and inventories are equal to their target (Equations 53, 54, and 55).

$$PD^* = AD^* \tag{53}$$

$$\mathbf{in}^* = (1+\iota)AD^* \tag{54}$$

$$\mathbf{IN}^* = w(1+\iota)AD^* \tag{55}$$

As capital stock is constant and equal to its target, investment is equal to depreciation (Equations 56 and 57).

$$\mathbf{K}^* = \frac{(1+\varepsilon)}{\alpha}AD^* \tag{56}$$

$$I^* = \frac{(1+\varepsilon)\delta}{\alpha} AD^* \tag{57}$$

Household income is constant and equal to their standard of living and consumption. Household deposits are at their target level. As household income is the total of the wage bill, dividends, and interest income (Equation 36), consumption can be written as a function of the wage bill, profits, and deposit interest income. If this is substituted in the aggregate demand equation (Equation 1), firm profits can be written as in Equation 58.

$$\pi^{f*} = \left[\left(1 - \frac{(1+\varepsilon)\delta}{\alpha}\right)\left(1 - \varpi r^{dp}\right) - \frac{w}{\beta}\right] AD^* \tag{58}$$

If Equation 58 is substituted in the aggregate income equation (Equation 1), household income can be written as in Equation 59. Moreover, household deposits are equal to their wealth target (Equation 60), and household loans are equal to zero.

$$Y^* = \overline{YD}^* = \left[1 - \frac{(1+\varepsilon)\delta}{\alpha}\right] AD^* \tag{59}$$

$$\mathbf{DP}^{h*} = \varpi\left[1 - \frac{(1+\varepsilon)\delta}{\alpha}\right] AD^* \tag{60}$$

As the firm loan stock is constant, realized firm loans equal firm loan principal payments (Equation 61).

$$LR^{f*} = \varphi \mathbf{LN}^{f*} \tag{61}$$

Even though bank profit could be equal to any number, for the sake of simplicity, bank profits are assumed to be zero. Furthermore, household loans are equal to zero at the dynamic equilibrium. When these are substituted in the bank profit equation (Equation 51), the dynamic equilibrium level of firm loans can be written as a function of household and firm deposits (Equation 62).

$$\mathbf{LN}^{f*} = \frac{\left(\mathbf{DP}^{f*} + \mathbf{DP}^{h*}\right)}{1+\mu} \tag{62}$$

As bank deposits are equal to their target value in the dynamic equilibrium, when the values of cash outflow items are substituted in Equation 26, firm deposits can be written as in Equation 63.

$$\mathbf{DP}^{f*} = \frac{\rho\left[\alpha(1+\mu) + \varpi\varphi\left(\alpha - \delta(1+\varepsilon)\right)\right]}{\alpha[(1+\mu)(1+\lambda r^{dp}) - \lambda\varphi]} AD^* \tag{63}$$

Finally, firm retained earnings are at their target level (Equation 64).

$$\mathbf{RE}^{f*} = \rho\left[\left(1 - \frac{(1+\varepsilon)\delta}{\alpha}\right)\left(1 - \varpi r^{dp}\right) - \frac{w}{\beta}\right] AD^* \tag{64}$$

3.2. Perfect Information

If there is no uncertainty about the future, firms do not hold any excess capacity and inventories. Furthermore, firm deposits and retained earnings are equal to zero. In our model, this situation corresponds to the case in which parameters ε, ι, λ, ρ are all zero.

$$\mathbf{K}^{**} = \frac{\varepsilon}{\alpha} AD^{**} \tag{65}$$

$$\mathbf{IN}^{**} = wAD^{**} \tag{66}$$

$$\pi^{f**} = \left[\left(1 - \frac{\delta}{\alpha}\right)\left(1 - \varpi r^{dp}\right) - \frac{w}{\beta}\right] AD^{**} \tag{67}$$

$$Y^{**} = \overline{YD}^{**} = \left[1 - \frac{\delta}{\alpha}\right] AD^{**} \tag{68}$$

$$\mathbf{DP}^{h**} = \varpi\left[1 - \frac{\delta}{\alpha}\right] AD^{**} \tag{69}$$

$$\mathbf{LN}^{f**} = \frac{\varpi}{1+\mu}\left[1 - \frac{\delta}{\alpha}\right] AD^{**} \tag{70}$$

4. Results

The model is simulated for different scenarios. In each simulation the time unit is chosen as quarters and the model is simulated for 1000 periods. The aggregate demand is normalized to 1 in both uncertainty and perfect information cases for easier comparison ($\mathrm{AD}^{*} = \mathrm{AD}^{**} = 1$). Other parameters are calibrated with reasonable values, as given in Table 3.

4.1. Comparison of the Perfect Information and the Presence of Uncertainty Cases

The model is simulated for the dynamic equilibriums of uncertainty and perfect information cases. Values of the key variables in both scenarios are given in Table 4.

In both cases, aggregate production equals aggregate demand, which is 1. However, as firms hold more capital in the presence of uncertainty to make the same level of production, depreciation is higher. Even though investments are higher to replace the depreciated capital, profits are lower due to the increase in firm saving in the form of amortization expenses. As a result, aggregate income is lower, which causes lower standard of living, wealth, and consumption levels for households. Therefore, the welfare of households is lower in the presence of uncertainty.

Moreover, the presence of uncertainty lowers firms' performance in terms of the value they generate for their investors comparing to the sources invested. Firms' funding requirements increase with the increased holdings of fixed capital, inventories, and bank deposits. Even though part of the increase in assets are funded through additional bank loans, firm equity also increases in the form of both paid capital and retained earnings. As a result, firm leverage decreases. Furthermore, with the effect of decreased profits and increased assets, return on assets decreases. As the return on equity equals the multiplication of firm leverage and return on assets, firms' aggregate return on equity decreases in the presence of uncertainty.

Table 3. Parameter Values

Parameter	Value
AD^{*}, AD^{**}	1
α	0.25
β	1
ι	1
ε	0.1
ρ	1
λ	4
w	0.75
δ	0.025
φ	0.05
ϖ	8
CN	0.2
r^{dp}	0.005
μ	1
T	6

Table 4. Values of Key Variables in Simulation Runs

Variable	Perfect Information	Uncertainty
PD	1	1
$\boldsymbol{K}$	4	4.4

$\boldsymbol{in}$	1	2
$\boldsymbol{IN}$	0.75	1.5
$\boldsymbol{DP_f}$	0	1.21443
$\boldsymbol{LN^f}$	3.6	4.16722
$\boldsymbol{RE}$	0	0.4176
$\boldsymbol{PC}$	1.15	2.52962
$\boldsymbol{EQ^f}$	1.15	2.94722
I	0.1	0.11
$\delta \boldsymbol{K}$	0.1	0.11
LR_f	0.18	0.208361
PP^f	0.18	0.208361
IP^f	0.036	0.0416722
WB^f	0.75	0.75
DV^f	0.114	0.1044
LV_f	4.13043	2.41395
ROA_f	0.024	0.0146744
ROE_f	0.0991304	0.0354233
DV^b	0	0
Y	0.9	0.89
$\boldsymbol{DP_h}$	7.2	7.12
$\boldsymbol{LN^h}$	0	0

4.2. A Change in the Level of Sentiment Index in the Presence of Uncertainty

In this subsection, the effect of a change in the sentiment index on aggregate income, investment, and leverage in the presence of uncertainty is analyzed. In each scenario, the simulation started at the dynamic equilibrium under uncertainty. Then, at period 100, an exogenous shock was given to the sentiment index. Particularly, the effects of 0.25 and 0.50 drops and rises in the sentiment index on the aggregate variables are observed. The simulation results are shown in Figures 2 and 3. The dynamic equilibrium case is also shown in graphs for easier comparison.

An increase in the sentiment index means that firms are more optimistic regarding the future course of the economy, and they are willing to be prepared for a higher level of aggregate demand. The immediate effect of an increase in the sentiment index is the increase in the buffer capital stock and buffer inventories. First off, investments increase to reach the new target level of capital stock, and therefore the aggregate demand increases, reinforcing the increases in investments (R1). Simultaneously, firms increase production using their existing excess capacities to meet the increased investment demand and desired inventory adjustment. The increase in production increases household income through the wage bill, increasing household consumption and, therefore, aggregate demand (R2). Increased aggregate demand increases firms' profits and, therefore, firm dividend payments, reinforcing the increase in household income, consumption, and aggregate demand (R3).

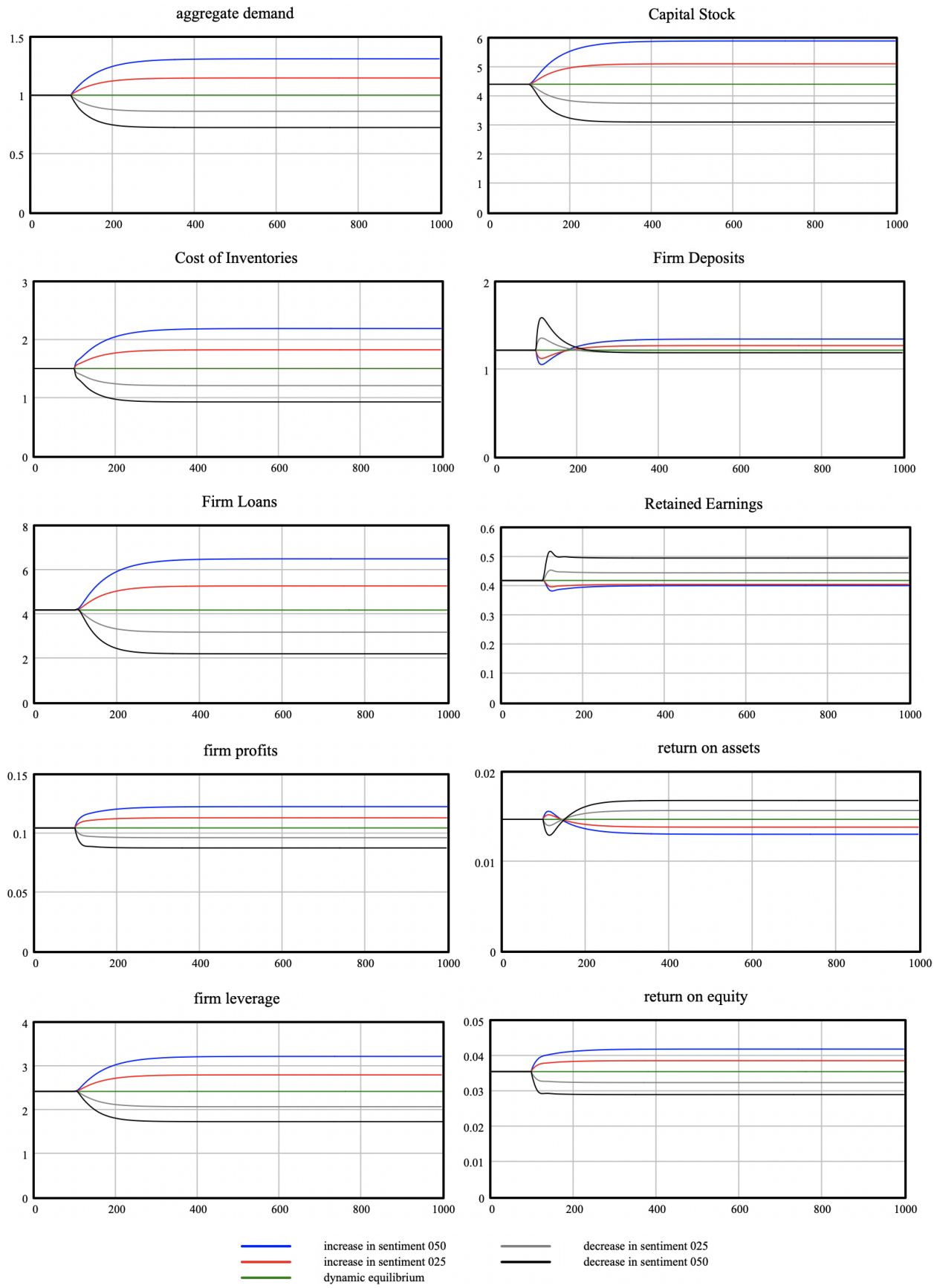


Figure 2. The Effect of a Change in the Sentiment Index on Firm Variables

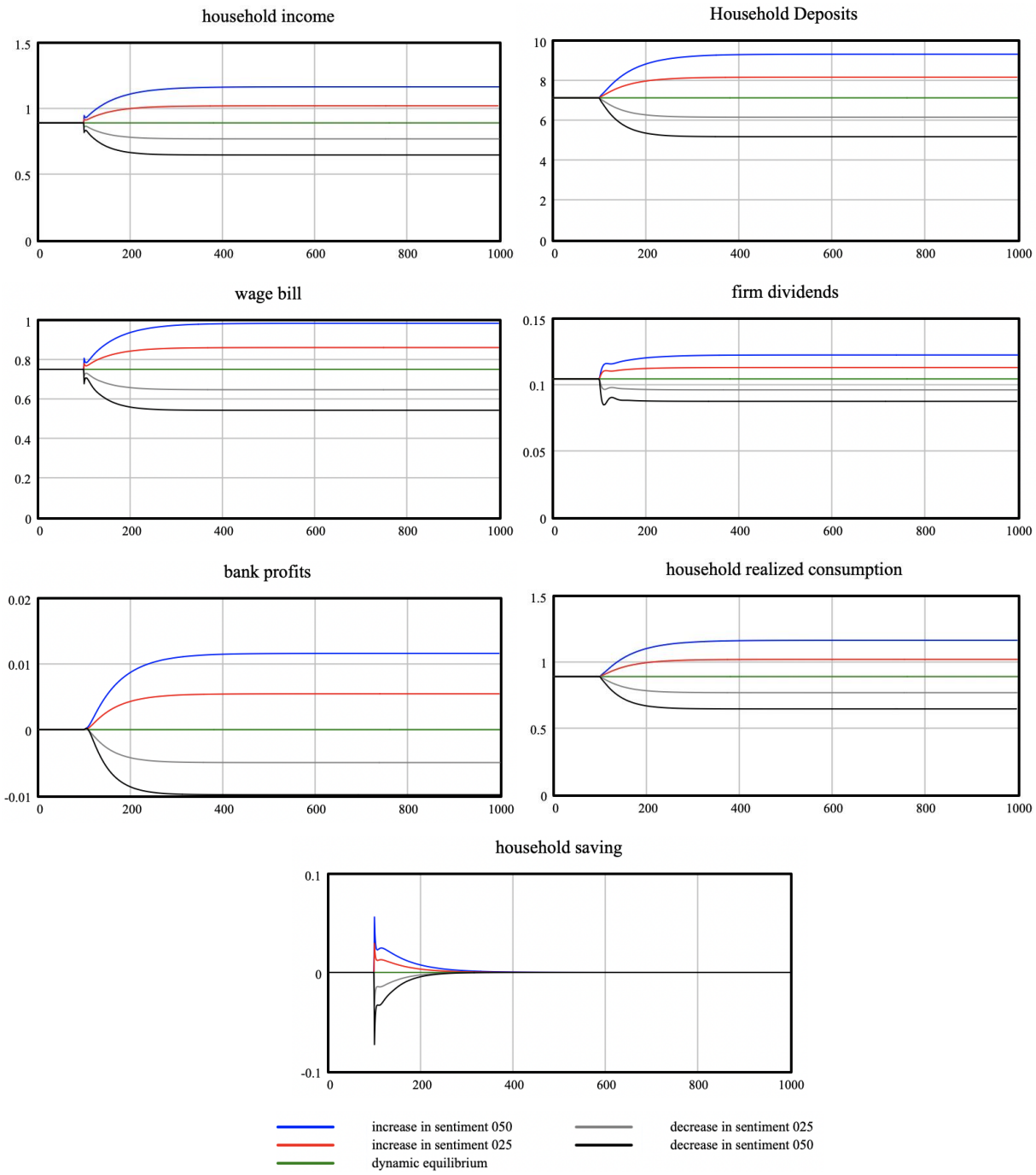


Figure 3. The Effect of a Change in the Sentiment Index on Household Variables

Two other immediate effects of the increase in the sentiment index are the decrease in the target level of firm deposits and the target level of retained earnings. These two changes have opposing effects on firms' cash balance. As a result of the decrease in the target level of firm deposits, some part of the cash outflow can be met from the decrease in firm deposits. On the other hand, the decrease in firm retained earnings target causes an increase in firm dividend payments and a decrease in undistributed profits, which increases cash outflow. Since the latter effect dominates, cash balance deteriorates, and therefore, loan demand increases. Firms' loan stock, hence, firms' loan principal and interest payments due increase accordingly.

Negative feedback loops are working in the background as well. With the increase in capital stock, depreciation increases, which puts negative pressure on firm profits (B1). Supporting this effect, the increased wage bill resulting from the increase in production reduces profits (B2). Finally, the increase in funding requirement with the increased level of investments (B3) and the increased cost of inventories (B4) causes an increase in the firm loan stock, decreasing firm profits with the increase in the firm loan interest payments. As these negative feedback loops gain power with the increases in the capital stock and inventories, firm profits level off. On the other hand, with the capital stock being closer to its target level (B5)

and the inventories being closer to its target level (B6), the increase in production and, therefore, wage bill slows down, which slows down the increase in the aggregate household income. Eventually, the effects of balancing feedback loops neutralize the effects of positive feedback loops, and the aggregate income and aggregate demand stabilize at higher levels than the dynamic equilibrium.

An overshooting behavior is observed in firm deposits and retained earnings. The firm deposit target coefficient decreases with the increase in the sentiment index. Therefore, part of the cash outflow resulting from increased investments and cost of inventories is met from the firm deposits, and firm deposits decrease for a while. However, with the decrease in the retained earnings target and increased profits, firm dividend target increases, and firm dividends are soon adjusted to higher levels. In addition, with the increase in firm investments due to higher capital stock, increase in wage bill due to higher levels of production, and increase in firm loan principal and interest payments due to higher firm loan stock, the cash outflow increases. As the increase in cash outflows dominates over the effect of the decrease in the firm deposit coefficient, the firm deposit target starts to increase once again, until balancing slightly above its dynamic equilibrium level, eventually.

Similar behavior is observed in firms' retained earnings. The retained earnings target coefficient decreases with the increase in the sentiment index. However, with the increased profits but lagging dividends, undistributed profits turn positive, and retained earnings increase for a short period of time. As dividends adjust to the higher levels of the firms' dividends target, undistributed profits turn negative, and retained earnings start to decrease. On the other hand, the level of retained earnings target starts to increase once again with the increase in firm profits. Firm dividends target and dividends decrease accordingly. Undistributed profits turn positive, and retained earnings start to increase once again until leveling off below their dynamic equilibrium level.

The dynamics of firms' return on equity is influenced by firms' leverage and firms' return on assets. While firm equity decreases due to the decrease in firms' retained earnings, firms' total liabilities increases. Therefore, firm leverage increases. On the other hand, firms' return on assets increases at the beginning due to the fact that firm profits increase faster than firm total assets. However, as depreciation expenses increase with the increase in the fixed capital stock and the loan interest payments increase with the increasing firm loan stock, profits increase more slowly than the increase in firm total assets. Therefore, return on assets start to fall until balancing slightly below its dynamic equilibrium level. This means that firms cannot use their assets as efficiently as before. However, due to the dominating effect of firm leverage, almost a smooth increase in firms' return on equity is observed.

When it comes to banks, their profits increase with the increase in firm loan stock and the decrease in firm deposits. As a result of all the aforementioned effects, household income, standard of living, and consumption increase. Therefore, an increase in the sentiment index increases the welfare of households.

As Figures 2 and 3 suggest, the dynamics resulting from a decrease in the sentiment index is the mirror image of that of the increase in the sentiment index.

Conclusion

In order to deal with uncertainty, firms hold different kinds of buffers as their assets and liabilities. In this study, a stock-flow consistent system dynamics model is built to investigate how uncertainty and sentiments affect the aggregate firm performance and aggregate income through buffers firms hold.

The simulation results of our model have shown that the presence of uncertainty decreases aggregate firm efficiency and profitability in the dynamic equilibrium. Namely, in order to make the same level of production, firms use more resources under uncertainty. As a result of the higher fixed capital stock, depreciation is higher, requiring a higher proportion of aggregate production to be allocated to investments to maintain the capital stock. Aggregate profits are lower because of the amortization allowances; therefore, aggregate income, household standard of living, household wealth, and consumption are lower in the dynamic equilibrium under uncertainty. On the other hand, in the presence of uncertainty, an increase (decrease) in the level of the sentiment index causes an increase (decrease) in the aggregate income, leverage, and return on equity. However, the return on assets is lower (higher) in the new equilibrium because of the increases (decreases) in the depreciation expenses and loan interest payments. Therefore, the resource efficiency of firms decreases (increases) in the presence of uncertainty.

These results point out to the fact that the presence of uncertainty causes a reduction in the performance of the economy. While it is impossible to establish a business environment with perfect foresight, policymakers can improve the macroeconomic performance with policy and regulations that make the future course of the economy more foreseeable.

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