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Income Redistribution, Consumer Credit, and Keeping up with the Riches

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Income redistribution, consumer credit, and keeping up with the Riches*

Mathias Klein   Christopher Krause

July 23, 2019

Abstract

In this study, we set up a DSGE model with upward looking consumption comparison and show that consumption externalities are an important driver of consumer credit dynamics. Our model economy is populated by two different household types. Investors, who hold the economy's capital stock, own the firms and supply credit, and workers, who supply labor and demand credit to finance consumption. Furthermore, workers condition their consumption choice on the investors' level of consumption. We estimate the model and find a significant keeping up-mechanism by matching business cycle statistics. In reproducing credit moments, our proposed model significantly outperforms a model version in which we abstract from consumption externalities.

JEL Codes: E21, E32, E44

Keywords: Income redistribution, consumer credit, relative consumption motive, business cycles.

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1 Introduction

This study investigates the relevance of consumption externalities between different income groups for replicating consumer credit dynamics over the business cycle. For this purpose, we propose a dynamic stochastic general equilibrium (DSGE) model with upward looking consumption comparison that successfully reproduces credit movements during the Great Moderation. We estimate deep model parameters and thereby contribute to the literature as we show that consumption externalities are a significant determinant of short-run credit fluctuations.

Recent empirical studies show that consumption externalities significantly affect individuals' consumption decisions. Bertrand and Morse (2016) find empirical support for so-called "trickle-down consumption", meaning that rising income and consumption at the top of the income distribution induces households in the lower parts of the distribution to consume a larger share of their income. Focusing on the period between the early 1980s and 2008, the authors present evidence for a negative relationship between income inequality and the savings rate of middle-income households. Carr and Jayadev (2015) show that rising indebtedness of U.S. households is directly related to high levels of income inequality. The authors conclude that relative income concerns explain a significant part of the strong increase in household debt for the period 1999-2009. Using data from the German Socio-Economic Panel, Drechsel-Grau and Schmid (2014) demonstrate that upward looking comparison is a significant determinant of individuals' consumption decisions.

Regarding the interrelation between consumption externalities and private debt dynamics, there is yet no conclusive evidence. Bertrand and Morse (2016) provide indirect evidence that non-rich households rely on easier credit access to finance their desired keeping up with richer co-residents. Moreover, they find a positive relationship between the number of personal bankruptcy filings and top income levels. Georgarakos et al. (2014) show that a higher average income increases the tendency to borrow of households with incomes below average. Contrary, Coibion et al. (2014) find that low-income households in high-inequality regions accumulate less debt than similar households in low-inequality regions. However, their findings are mainly driven by mortgages, whereas for our variable of interest, consumer credit, the authors only find mixed results. Against this background, we investigate this relationship within a structural model and show that relative consumption concerns are an essential driver of aggregate credit dynamics.

Understanding how unsecured consumer credit fluctuates over the business cycle is of central importance because of several reasons. First, consumer credit is an im-

Table 1: Credit-related moments in the U.S. (1982q1-2008q2)

	$\rho(x_t, D_t)$	σ_x/σ_D
Output	0.1523	0.4568
Consumption	0.1658	0.2783
Investment	0.0852	1.7524
Hours worked	0.3603	0.5080
Real wage	−0.3207	0.3994

Note: $\rho(x_t, D_t)$ is the cross-correlation of variable x with credit, σ_x/σ_D is the std. deviation of variable x relative to the std. deviation of credit.
Consumer credit has been deflated using the price index of personal consumption expenditures. All variables are logged and HP-filtered (smoothing parameter of 1600) to obtain cyclical components. For data definitions and sources see Appendix A.

portant source of personal finance. For our period of interest, the Great Moderation[1], credit averages 23% of aggregate personal consumption in the United States, indicating that more than one fifth of households' private expenditures were financed by relying on consumer credit.[2] Second, short-run credit movements in the U.S. are characterized by a highly volatile behavior. As Table 1 reports, credit is more than twice (three times) as volatile as output (consumption). Third, and most importantly, business cycle correlations with other main aggregate variables contradict standard theory in which credit represents an instrument to smooth consumption in bad times. Table 1 shows positive co-movements between credit and output and consumption, respectively. In contrast to these empirical observations, one would expect countercyclical correlations when credit is primarily used to smooth consumption.

Our proposed model economy is populated by two types of households. *Investors*, who hold the economy's entire capital stock, own firms and supply credit, and *workers*, who supply labor and demand credit to finance their desired level of consumption. Moreover, we include a mechanism through which workers value their own level of consumption relative to the investors' level of consumption. We refer to this mechanism as *keeping up with the Riches*.[3] This extension allows us to capture the "trickle-

[1]Following Bertrand and Morse (2016) and Iacoviello and Pavan (2013), among others, we date the Great Moderation as the time span between the early 1980s (here 1982q1) and the outburst of the financial crisis (2008q2). We choose the Great Moderation as the underlying time span, because this period is characterized by a significant widening of income disparities and several innovations in financial markets which ultimately made credit access for households easier. Notably, all our qualitative findings are robust when extending the sample by the Great Recession.

[2]Our consumer credit measure includes revolving and non-revolving credit. Revolving credit primarily consists of outstanding credit card balances and accounts for roughly one third of aggregate consumer credit. Non-revolving credit includes auto loans as well as consumer installment loans. For a detailed analysis of consumer credit moments across categories and sample periods, we refer the interested reader to Fieldhouse et al. (2016).

[3]This term is inspired by the literature on *keeping up with the Joneses*. While studies which incorporate this mechanism model relative consumption concerns in relation to the average consumer (e.g. Galí, 1994), in our setup poorer households (workers) aim to keep up with richer ones (investors).

down-consumption" channel of Bertrand and Morse (2016), where the income-poor try to catch up with the income-rich. In the baseline model, fluctuations are driven by four stochastic innovations, namely a neutral technology, investment specific technology, price markup, and wage markup shock. In standard DSGE models, botch technology shocks are main drivers of fluctuations in real variables (Justiniano et al., 2010; Smets and Wouters, 2003). Although in general markup shocks play a minor role in driving output dynamics, we stress their importance in driving credit movements. In particular, in our model setup both innovations shift resources between investors and workers, which in combination with consumption externalities amplifies the credit changes compared to a framework that abstracts from these externalities.

We estimate deep parameters of the four-shock model by a simulated methods of moments (SMM) approach. The parameter measuring the degree of workers' desire to keep up with their richer fellows is estimated to be positive and statistically significant. This leads to the conclusion that keeping up with the Riches is a central driver of credit dynamics over the business cycle. The models' implied credit moments successfully account for the (targeted) credit statistics as reported in Table 1. Notably, we also find that the estimated model replicates conventional output-related statistics that are not targeted in the estimation. We interpret this result as a further justification of our proposed model.

We perform several robustness checks. First, we show that our model without consumption externalities is not able to generate the observed credit dynamics. A lagged consumption externality, however, which induces a catching up-behavior instead of keeping up, matches the targeted moments, but slightly inferior to our baseline specification. Moreover, when accounting for a structural break in the data, we show that (1) our specification successfully accounts for this fact and that (2) although the strength of the motive has decreased over time, consumption externalities play a crucial role in explaining credit dynamics before and after this break.

When taking a closer look at the dynamics of the estimated model versions, we find that the price markup shock and the investment specific technology shock produce credit correlations that are qualitatively in line with the empirical ones as reported in Table 1. However, this is only true when we include the consumption externality in the workers' utility function. When we abstract from the relative consumption motive, we find that the model dynamics to both shocks no more correspond to the empirical counterparts. Notably, replicating the positive correlations between credit, output, and consumption does rely on the keeping up-mechanism. While recent literature finds that the price markup shock is of minor importance for output dynamics (Justiniano et al., 2010), our results indicate that innovations to the price markup, combined with consumption externalities, are essential in replicating short-run credit movements. Concerning the neutral technology shock and the wage markup shock, we find that the model responses do not replicate the empirical credit correlations but the inclusion of these two shocks helps to improve the quantitative performance of the model in terms of credit-related and output-related moments.

Our paper is related to the extensive quantitative literature on consumer credit and bankruptcy, initiated by Chatterjee et al. (2007) and Livshits et al. (2007).[4] In particular, our study is related to Nakajima and Ríos-Rull (2014) who use a quantitative business cycle model with incomplete markets and the option to default on debt to explain the procyclicality of consumer credit, the countercyclicality of bankruptcy filings and the high volatility of both. The key ingredient is countercyclical earnings risk, implying that the variance of individual labor productivity is higher during recessions. This countercyclicality leads to higher risk premia on loans during recessions and thus, to a decrease in consumer debt. Fieldhouse et al. (2016) use a lifecycle model with incomplete insurance markets and a similar bankruptcy mechanism to explain the business cycle properties of consumer credit and bankruptcies. The authors find that only the addition of so-called intermediation shocks, i.e. exogenous countercyclical shocks to the cost of funds for lenders, can generate procyclical borrowing and countercyclical bankruptcy filings. The mechanism behind this finding is that the intermediation shock increases the risk-free interest rate during recessions, simultaneously the cost of a loan, and thus, leads to a decrease in borrowing.

We propose a different mechanism, which is based on recent microeconometric evidence (Bertrand and Morse, 2016), to account for consumer credit dynamics. However, we regard these different mechanisms as complementary, rather than competing or mutually exclusive explanations for consumer credit fluctuations.

The rest of the paper is organized as follows. Section 2 presents the baseline model. In Section 3, we introduce functional forms and show a set of theoretical results that connect the strength of the keeping up-mechanism to a set of deep model parameters. Section 4 describes the calibration and estimation strategy as well as our numerical results. In Section 5, we provide a detailed analysis of the implied model dynamics. In Section 6, we conduct two important robustness tests. First, we show that our baseline results are not affected by introducing a lagged consumption externality. Second, we split the sample and show that, although the degree of upward looking comparisons has decreased over time, it is still a significant factor of credit dynamics. Finally, Section 7 concludes.

[4] See Livshits (2015) for an excellent overview.

2 The model economy

In this section, we construct our baseline model that allows consumption externalities to influence the choices of households and that assesses its role within the business cycle. The economy is populated by a continuum of firms producing differentiated intermediate goods, a representative final good firm and a representative labor bundler. There are two types of households, investors and workers, who are distinguished by their source of income as well as their access to capital and asset markets. Finally, a financial intermediary issues deposits to investors and loans to workers.

2.1 Final good firms

In this perfectly competitive sector, a representative firm produces final consumption good Y_t, combining a continuum of intermediate goods $Y_t(l), l \in [0,1]$, using the constant returns to scale technology

$$Y_t = \left[\int_0^1 Y_t(l)^{\frac{1}{\mu_t}} dl\right]^{\mu_t}, \tag{1}$$

with $\mu_t > 1$. The time-varying price markup μ_t is a function of the elasticity of substitution between intermediate goods and follows an exogenous stochastic process around its steady state value $\bar{\mu}$ given by

$$\log \mu_t = (1-\rho_\mu) \log \bar{\mu} + \rho_\mu \log \mu_{t-1} + \varepsilon_{\mu,t}, \tag{2}$$

where $\varepsilon_{\mu,t} \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma_\mu^2)$, and $|\rho_\mu| < 1$. The firm chooses intermediate inputs to maximize profits subject to (1), which yields the demand function for intermediate good $Y_t(l)$,

$$Y_t(l) = Y_t \left(\frac{P_t(l)}{P_t}\right)^{\frac{\mu_t}{1-\mu_t}}, \tag{3}$$

and subsequently the price index of the final good,

$$P_t = \left[\int_0^1 P_t(l)^{\frac{1}{1-\mu_t}} dl\right]^{1-\mu_t}. \tag{4}$$

2.2 Intermediate goods firms

Each intermediate good is produced by a monopolistically competitive firm according to a production function given by

$$Y_t(l) = z_t F(K_{t-1}(l), N_t(l)), \tag{5}$$

where we assume that F is strictly increasing, twice differentiable in both arguments, exhibits constant returns to scale, and satisfies the Inada conditions. $K_{t-1}(l)$ and $N_t(l)$ denote the quantities of capital and labor services utilized to produce intermediate good $Y_t(l)$. z_t is the technology level common across all firms. We assume that z_t follows an exogenous stochastic process around its steady state value $\bar{z}$,

$$\log z_t = (1-\rho_z)\log \bar{z} + \rho_z \log z_{t-1} + \varepsilon_{z,t}, \tag{6}$$

where $\varepsilon_{z,t} \overset{i.i.d.}{\sim} \mathcal{N}(0,\sigma_z^2)$, and $|\rho_z| < 1$. Intermediate goods firms maximize profits, defined by

$$\Pi_t(l) = Y_t(l) - R_t K_{t-1}(l) - W_t N_t(l), \tag{7}$$

subject to the demand function (3) and to cost minimization, where R_t is the rental rate of physical capital and W_t is the aggregate wage rate. We assume symmetry such that firms charge the same prices and choose the same production inputs. Prices are perfectly flexible, which yields marginal costs that are equal to $1/\mu_t$. Thus, the aggregate wage rate can be expressed as a function of the marginal product of labor MPL_t and μ_t,

$$W_t = \frac{MPL_t}{\mu_t}. \tag{8}$$

The aggregate rental rate of physical capital equals

$$R_t = \frac{MPK_t}{\mu_t}, \tag{9}$$

where MPK_t is the marginal product of capital.

Following Chari et al. (2007), among others, μ_t can also be interpreted as the labor wedge on the firm side, as it drives a wedge between the wage rate and the marginal product of labor.

In the following sections, it will become apparent that the price markup shock shifts income from the poor to the rich households. Thus, we refer to (2) as a *redistribution shock*.[5]

2.3 Employment agency

As in Erceg et al. (2000), we assume that each working household j is a monopolistic supplier of a differentiated labor service $N_{w,t}(j)$. A representative labor bundler,

[5]Throughout the paper, we use the two terms *redistribution shock* and *price markup shock* interchangeably.

termed as *employment agency*, combines the intermediate labor services into a homogeneous labor input $N_{w,t}$ using the constant returns to scale technology

$$N_{w,t} = \left[\int_0^1 N_{w,t}(j)^{\frac{1}{\nu_t}} dj \right]^{\nu_t}, \tag{10}$$

with $\nu_t > 1$. The time-varying wage markup ν_t is a function of the elasticity of substitution between labor types and follows an exogenous stochastic process around its steady state value $\bar{\nu}$,

$$\log \nu_t = (1 - \rho_\nu) \log \bar{\nu} + \rho_\nu \log \nu_{t-1} + \varepsilon_{\nu,t}, \tag{11}$$

where $\varepsilon_{\nu,t} \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma_\nu^2)$, and $|\rho_\nu| < 1$. The labor bundler operates in a perfectly competitive market and minimizes the cost of a given amount of aggregate labor $N_{w,t}$, taking each household's wage rate $W_t(j)$ as given, leading to the labor demand function

$$N_{w,t}(j) = N_{w,t} \left(\frac{W_t(j)}{W_t} \right)^{\frac{\nu_t}{1-\nu_t}}, \tag{12}$$

where W_t is the aggregate wage index. By substituting (12) into (10), we obtain the following expression for the latter,

$$W_t = \left[\int_0^1 W_t(j)^{\frac{1}{1-\nu_t}} dj \right]^{1-\nu_t}. \tag{13}$$

2.4 Households

Our model economy is populated by a continuum of infinitely lived households, indexed on the unit interval. A fraction χ of households is born as *investors* (subscript i), holds the entire stock of physical capital and owns firms. The remaining fraction $1 - \chi$ is born as *workers* (subscript w), makes up the entire labor force and does not have access to capital or stock markets. However, workers can get a credit from financial intermediaries, which helps them to finance their desired level of consumption.

2.4.1 Investors

The preferences of investors are given by their expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta_i^t U_i(C_{i,t}), \tag{14}$$

where $\beta_i \in (0, 1)$ is the specific discount factor of investors, $U_i(\cdot)$ is the period utility function, and E_0 is the expectations operator with respect to information in period 0.

Since investors do not supply labor, we assume that the level of consumption is the only argument of the investors' utility function.

Definition 1 (Investors' utility function). *We impose the following assumptions on the investors' utility function U_i.*

(i) $\frac{\partial U_i}{\partial C_i} > 0, \frac{\partial^2 U_i}{(\partial C_i)^2} < 0,$

(ii) $\lim_{C_i \to \infty} \frac{\partial U_i}{\partial C_i} = 0, \lim_{C_i \searrow 0} \frac{\partial U_i}{\partial C_i} = \infty.$

Assumption (i) states that the utility function is strictly increasing, twice differentiable and strictly concave in the investors' level of consumption. Assumption (ii) ensures that the Inada conditions hold.

Investors can hold two different assets. They are the sole owner of the capital stock, which is rented to intermediate goods firms at rate R_t, and they have a riskless savings account at the financial intermediary. For each unit of savings, the investor gets an interest of i^d. The investors' budget constraint is then given by

$$C_{i,t} + I_{i,t} + Q_t^d D_{i,t} \leq D_{i,t-1} + R_t K_{i,t-1} + \frac{\Pi_t}{\chi}, \tag{15}$$

where $I_{i,t}$ denotes investment, $D_{i,t} \in \mathbb{R}_+$ are deposits, $Q_t^d := 1/(1 + i_{t-1}^d) \in (0, 1)$, with i_t^b being the interest received, and Π_t/χ is the individual share of profits from ownership of firms. The law of motion for physical capital is

$$K_{i,t} = (1 - \delta)K_{i,t-1} + \zeta_t I_{i,t}, \tag{16}$$

where δ is the depreciation rate. ζ_t denotes a shock to the relative price of investment in terms of the consumption good. We assume that the shock follows an AR(1)-process around its steady state value $\bar{\zeta}$,

$$\log \zeta_t = (1 - \rho_\zeta) \log \bar{\zeta} + \rho_\zeta \log \zeta_{t-1} + \varepsilon_{\zeta,t}, \tag{17}$$

where $\varepsilon_{\zeta,t} \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma_\zeta^2)$, and $|\rho_\zeta| < 1$. The investors' optimization problem is then given by the objective function (14) which is maximized subject to (15) and (16) so that the first order conditions are given by

$$\Lambda_{i,t} = U_i'(C_{i,t}), \tag{18}$$

$$\Lambda_{i,t} = \beta_i E_t \zeta_t \Lambda_{i,t+1} \left(R_{t+1} + \frac{1 - \delta}{\zeta_{t+1}} \right), \tag{19}$$

$$\Lambda_{i,t} Q_t^d = \beta_i E_t \Lambda_{i,t+1}, \tag{20}$$

where $U_i'(\cdot)$ denotes the first derivative of the utility function with respect to the argument in brackets, and $\Lambda_{i,t}$ denotes the Lagrange multiplier associated with (15). Finally, the transversality conditions that rule out infinite wealth accumulation, given by

$$\lim_{j\to\infty} E_t \beta^j \Lambda_{i,t+j} K_{i,t+j} = 0, \tag{21}$$

$$\lim_{j\to\infty} E_t \beta^j \Lambda_{i,t+j} Q^d_{t+j} D_{i,t+j} = 0, \tag{22}$$

are required to hold.

2.4.2 Workers

The preferences of worker j are given by his expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta_w^t U_w \left(C_{w,t}(j), X_t(j), N_{w,t}(j) \right), \tag{23}$$

where $\beta_w \in (0,1)$ is the specific discount factor of workers, $U_w(\cdot)$ is the period utility function, $C_{w,t}(j)$ is the workers' consumption level and $X_t(j)$ is a consumption externality that is strictly positive and that workers take as given. In each period, workers are endowed with one unit of time that is allocated between leisure $L_{w,t}(j)$ and individual labor services $N_{w,t}(j)$.

Definition 2 (Worker's utility function). *We impose the following assumptions on the workers' utility function U_w.*

(i) $\dfrac{\partial U_w}{\partial C_w} > 0$, $\dfrac{\partial^2 U_w}{(\partial C_w)^2} < 0$, $\dfrac{\partial U_w}{\partial N_w} < 0$, $\dfrac{\partial^2 U_w}{(\partial N_w)^2} < 0$,

(ii) $\dfrac{\partial^2 U_w}{(\partial C_w)^2}\dfrac{\partial^2 U_w}{(\partial N_w)^2} - \left(\dfrac{\partial^2 U_w}{\partial C_w \partial N_w}\right)^2 > 0$,

(iii) $\lim_{C_w\to\infty} \dfrac{\partial U_w}{\partial C_w} = 0$, $\lim_{C_w\searrow 0} \dfrac{\partial U_w}{\partial C_w} = \infty$,

(iv) $\dfrac{\partial U_w}{\partial X} < 0 \vee \dfrac{\partial U_w}{\partial X} > 0$,

(v) $\dfrac{\partial MRS_w}{\partial X} > 0 \vee \dfrac{\partial MRS_w}{\partial X} < 0$, *where* $MRS_w := -\dfrac{\partial U_w/\partial L_w}{\partial U_w/\partial C_w}$.

Assumptions (i), (ii), and (iii) refer to the standard properties of utility functions, namely that they are twice differentiable, strictly increasing in consumption, strictly decreasing in labor, strictly concave in these two variables and that Inada conditions are satisfied.

The key issue here is the role of the consumption externality in (iv) and (v).[6] Assumption (v) specifies the effect of X in terms of the marginal rate of substitution (MRS) between leisure and consumption. We say that preferences exhibit *keeping up with the Riches*, if the MRS is increasing in X (first argument of (v)). This implies that a rise in the consumption externality may raise the worker's marginal utility of consumption relative to leisure, leading the worker to work more hours if prices are fixed. Preferences that feature the opposite effect are termed *running away from the Riches* (second argument of (v)).[7] Note that assumption (iv) is necessary for (v) but not vice versa.

Including this consumption externality mechanism is motivated by recent microeconometric studies, which find that upward looking comparison significantly affect individuals consumption decisions (Bertrand and Morse, 2016; Carr and Jayadev, 2015; Drechsel-Grau and Schmid, 2014).

Workers face the following budget constraint,

$$C_{w,t}(j) + D_{w,t-1}(j) \leq W_t(j)N_{w,t}(j) + Q_t^b D_{w,t}(j) - \frac{\phi}{2}(D_{w,t}(j) - \bar{D}_w)^2, \tag{24}$$

where $D_{w,t}(j) \in \mathbb{R}_+$ denotes received credit at price $Q_t^b := 1/(1+i_{t-1}^b) \in (0,1)$, with i_t^b being the interest paid, and $W_t(j)$ is the individual wage rate of household j. The last term of (24) represents a quadratic cost of choosing a quantity of credit different from the steady state value $\bar{D}_w$. This assumption can be thought of as a kind of transaction cost and is needed to rule out random walk components in the equilibrium dynamics of credit.[8] To rule out Ponzi schemes, we impose

$$\lim_{j\to\infty} E_t \prod_{s=0}^{j} Q_{t+s}^b D_{w,t+j} \leq 0. \tag{25}$$

The optimization problem of working household j is then given by the objective function (23) subject to (24), (25) and the demand for the household's differentiated labor input (12). We assume symmetric working households such that all workers set the same wage, supply the same amount of labor, and choose the same amount of consumption and credit. As for the final good price, we assume that wages are perfectly flexible.

[6]Following Dupor and Liu (2003), preferences exhibit *jealousy* if the worker derives disutility from an increase in the externality (first argument of (iv)), and *admiration* if the opposite is true (second argument of (iv)).

[7]For specific preferences that are additively separable in (C_w, X) and L_w, assumption (v) is equivalent to $[\partial^2 U_w/(\partial C_w \partial X)]/[\partial U_w/\partial C_w] \gtrless 0$, as used by Galí (1994), but in general this is not the case.

[8]Similar to our problem, Schmitt-Grohé and Uribe (2003) compare different modeling strategies that induce stationarity within small open economy models.

Letting $\Lambda_{w,t}$ be the workers' Lagrange multiplier on their budget constraint, the symmetric optimal choices for consumption, labor supply, and credit demand are then ultimately determined by

$$\Lambda_{w,t} = U'_w(C_{w,t}), \tag{26}$$

$$\Lambda_{w,t} W_t = -U'_w(N_{w,t})\nu_t, \tag{27}$$

$$\Lambda_{w,t}\left[Q^b_t - \phi\left(D_{w,t} - \bar{D}_w\right)\right] = \beta_w E_t \Lambda_{w,t+1}, \tag{28}$$

where $U'_w(\cdot)$ denotes the first derivative of the utility function with respect to the argument in brackets.

From (27), it is apparent that the wage rate is a function of the marginal rate of substitution between leisure and consumption, MRS_t, and the wage markup ν_t,

$$W_t = \nu_t MRS_t. \tag{29}$$

In close analogy to the price markup, ν_t can be interpreted as the labor wedge on the household side. In a perfectly competitive economy, μ_t and ν_t would be one such that wages equal the marginal product of labor on the one hand, and the marginal rate of substitution on the other.

2.5 Financial Intermediaries

There is a representative financial intermediary that issues one-period deposits to investors and one-period loans to workers. We follow Cúrdia and Woodford (2010) by assuming that this type of intermediation is costly.[9] In particular, we assume that the following condition describes the financing of the intermediary,

$$D_t = B_t + \Psi(B_t), \tag{30}$$

where D_t are aggregate deposits, B_t are aggregate loans, and $\Psi(\cdot)$ are intermediation costs.[10] Equation (30) states that deposits at period t have to cover loans at period t, including the costs of intermediation. The intermediary then maximizes profits, given by

$$\max_{D_t, B_t}(1 - Q^b_t)B_t - (1 - Q^d_t)D_t, \tag{31}$$

[9] These costs include e.g. operating costs, but are also supposed to capture default risk.

[10] Following Cúrdia and Woodford (2010), we assume that $\Psi(\cdot)$ is positive and twice differentiable for $B > 0$, with $\Psi(0) = 0$, $\partial\Psi/\partial B > 0$, and $\partial^2\Psi/(\partial B)^2 > 0$.

subject to (30). Perfect competition then yields the following first order condition

$$(1 - Q_t^b) - (1 - Q_t^d)\frac{\partial \Psi(B_t)}{\partial B_t} = 1 - Q_t^d, \tag{32}$$

implying that the gains from one additional unit of loans are equal to the cost of one additional unit of deposits. We use this optimality condition to define a spread ϖ between the interest rates in the following way,

$$1 - Q_t^b = (1 - Q_t^d)(1 + \varpi_t), \tag{33}$$

where $\varpi_t := \partial \Psi(B_t)/\partial B_t$. It follows from the properties of Ψ that ϖ_t is strictly larger than zero and increasing in the amount of aggregate loans for $B_t > 0$, and subsequently, that the borrowing interest rate has to be strictly larger than the interest rate on deposits.

2.6 Aggregation and market clearing

Aggregates are defined as the weighted average of the respective variables for each household type. Hence, we get

$$C_t = \chi C_{i,t} + (1 - \chi) C_{w,t}, \tag{34}$$
$$I_t = \chi I_{i,t}. \tag{35}$$

The markets for capital and labor clear when

$$K_t = \chi K_{i,t}, \tag{36}$$
$$N_t = (1 - \chi) N_{w,t}, \tag{37}$$

at their respective prices R_t and W_t, deposit and credit market clearing require that

$$D_t = \chi D_{i,t} \tag{38}$$
$$B_t = (1 - \chi) D_{w,t}, \tag{39}$$

at prices Q_t^d and Q_t^b, while the aggregate resource constraint is given by

$$Y_t = C_t + I_t + (1 - \chi)\frac{\phi}{2}(D_{w,t} - \bar{D}_w)^2 + \Psi(B_t). \tag{40}$$

2.7 Equilibrium

In this section, we define the equilibrium for the economy described above.

Definition 3 (Competitive equilibrium). *Given the exogenous realizations of* $\{\zeta_t,\ \mu_t,\ z_t,\ \nu_t\}_{t=0}^{\infty}$*, a competitive rational expectations equilibrium is a stochastic set of sequences*

$$\{C_t, C_{i,t}, C_{w,t}, D_{i,t}, D_{w,t}, I_t, I_{i,t}, K_t, K_{i,t}, \Lambda_{i,t}, \Lambda_{w,t}, N_t, N_{w,t}, \Pi_t, Q_t^b, Q_t^d, R_t, W_t, Y_t, D_t, B_t\}_{t=0}^{\infty}$$

satisfying

1. *the investors' first order conditions* (18)-(20)*, with binding budget constraint* (15) *and transversality conditions* (21) *and* (22)*,*
2. *the workers' first order conditions* (26)-(28)*, with binding budget constraint* (24) *and binding no-Ponzi condition* (25)*,*
3. *factor prices* (8) *and* (9)*, capital accumulation* (16)*, profits definition* (7) *and production technology* (5)*,*
4. *the financial intermediaries' first order condition* (32) *as well as condition* (30)*,*
5. *the aggregation identities* (34) *and* (35)*, and*
6. *the market clearing condition for capital* (36)*, labor* (37)*, deposits* (38) *and loans* (39)*.*

The model is solved by a log-linear approximation around its deterministic steady state.

3 Theoretical results

The next subsection presents our choice of functional forms for the production technology and the utility functions, as well as some qualitative results that connect the strength of the keeping up-mechanism with two model parameters.

3.1 Functional forms

The investors' period utility function is given by

$$U_i(C_i) = \log C_i, \tag{41}$$

while the workers' period utility function is assumed to be

$$U_w(C_w, X, N_w) = \frac{(C_w X^{-b})^{1-\sigma} - 1}{1-\sigma} - \frac{\gamma N_w^{1+\eta}}{1+\eta}, \tag{42}$$

where b indicates the strength of the consumption externality, σ is a risk aversion parameter, γ is a scaling parameter, and η denotes the inverse Frisch elasticity of labor supply. This specification implies that $MRS_t = \gamma N_{w,t}^{\eta} / \Lambda_{w,t}$. We assume that X is defined as

$$X_t := \frac{C_{i,t}}{C_{w,t}}, \tag{43}$$

such that workers value the contemporaneous consumption level of investors relative to their own.[11] The sign of b then ultimately determines if preferences exhibit jealousy or admiration. If b is positive, U_w implies jealousy, while for negative values, the conditions for admiration are met.

In the following, we exclude the case of $\sigma = 1$. Assuming a logarithmic form for the first part of the workers' utility function would imply that the marginal rate of substitution between consumption and leisure is independent of the consumption externality. This is a violation of condition (v) in Definition 2 and therefore, we assume that $\sigma > 0$ and $\sigma \neq 1$.

The magnitude of σ and the sign of b are of crucial importance whether working households aim to keep up with the investors or if they are running away. This relationship can be expressed by $\text{sgn}(\partial U_w / \partial X) = \text{sgn}(b(1-\sigma))$. In particular, there are the four different cases $\{b > 0, \sigma > 1\}$, $\{b < 0, \sigma \in (0,1)\}$, $\{b > 0, \sigma \in (0,1)\}$, and $\{b < 0, \sigma > 1\}$. While the first two cases imply that workers wish to keep up, the latter imply running away. As our estimations below indicate, only the first case is relevant.

Intermediate good firms produce according to the Cobb-Douglas production function

$$Y_t = z_t K_{t-1}^{\alpha} N_t^{1-\alpha}, \tag{44}$$

where $\alpha \in [0,1]$ measures the output elasticity of capital. This specification implies that $MPL_t = (1-\alpha) Y_t / N_t$ and $MPK_t = \alpha Y_t / K_{t-1}$.

We follow Cúrdia and Woodford (2010) and set the functional form for intermediation costs as

$$\Psi(B_t) = \psi B_t^{\kappa}, \tag{45}$$

where ψ is a positive constant and κ can be interpreted as the elasticity of loans.

[11]Similar specifications of relative consumption motives are used by Airaudo and Bossi (2017) and Alvarez-Cuadrado and Japaridze (2017). They study how consumption externalities affect the impact of monetary policy and financial deregulation, respectively. In a latter section, we show that our results are robust when modeling the externality based on lagged consumption levels.

3.2 A first set of results

The following two results clarify the role of b and σ on shaping the behavior of working households and consequently, their role for the cyclical properties of our economy. We first present the workers' specific consumption Euler equation which relates the consumption growth of investors and changes in the credit price to their own consumption growth. Afterwards, we analytically derive the response of the workers' consumption to a marginal increase in the investors' consumption level. The result is of particular importance to our quantitative analysis in the following, as we are then be able to compare our result to related empirical findings of Bertrand and Morse (2016).

Proposition 1. *Suppose that the consumption externality is given by* (43) *and abstracting from debt adjustment costs, the workers' log-linearized Euler equation is given by*

$$\widehat{C}_{w,t+1} - \widehat{C}_{w,t} = -\frac{1}{\sigma + b(\sigma-1)}\widehat{Q}^b_t + \frac{b(\sigma-1)}{\sigma + b(\sigma-1)}\left(\widehat{C}_{i,t+1} - \widehat{C}_{i,t}\right), \tag{46}$$

where a circumflex indicates log-deviations from the respective steady state value.

This proposition shows that the workers' intertemporal consumption choice is determined by two channels, consumption smoothing and the keeping up-motive. Since workers do not have access to capital markets, they are not able to transfer their income between periods so that the only option to smooth consumption is via credit. A high σ therefore implies that fluctuations in the price of credit have less influence on the consumption decision and the respective household prefers a smooth consumption profile. The strength of consumption smoothing in our setting is jointly determined by σ and b. In this sense, a positive b amplifies the consumption smoothing motive of workers, as long as $\sigma > 1$.

On the other hand, σ also affects the strength of the keeping up-motive, as can be seen in the second term on the right-hand side of (46). A positive b then implies that the keeping up-motive is increasing in σ. If b is equal to zero, the keeping up-channel is shut down and consumption smoothing is only determined by σ.

The following proposition characterizes the influence of b on the worker's consumption decision when there is an increase in the investor's consumption level.

Proposition 2. *Suppose that $\sigma > 1$. Given an exogenous one-time change in investor's consumption $d\widehat{C}_{i,t}$, the worker's consumption response is given by*

$$d\widehat{C}_{w,t} = \xi_0 d\widehat{C}_{i,t}, \tag{47}$$

where $\xi_0 := \dfrac{\frac{b(\sigma-1)}{\eta}\left(\bar{W}\bar{N}_w + \frac{(\bar{Q}^b)^2}{\phi}\right)}{\frac{(\sigma+b(\sigma-1))}{\eta}\left(\bar{W}\bar{N}_w + \frac{(\bar{Q}^b)^2}{\phi}\right) + \bar{C}_w}$, *and* $|\xi_0| \in (0,1)$.

Proof. See Appendix. □

This proposition states that the (partial equilibrium) response of workers is determined by b and σ, besides a few positive steady state values and the labor supply elasticity. Unsurprisingly, the response is zero if b is equal to zero. This expression is of particular importance in our numerical analysis below, as we use it to compare this value to the values found in Bertrand and Morse (2016).

4 Parametrization

We use an SMM approach to estimate a subset of the structural parameters of the model. Of particular importance are the parameters that determine the impact of the relative consumption motive, namely b and σ. The characteristics of the neutral technology shock and the redistribution shock are estimated by ordinary least squares. The parameters that are not estimated are calibrated in a standard fashion.

4.1 Calibrated parameters

Table 2 reports the calibrated parameter values, where an upper bar denotes the steady state value of the respective variable. One model period corresponds to one quarter.

The discount factor of investors is set to 0.995 to match an annual steady state real interest rate of 2 percent. Workers have a discount factor of 0.994 to match a steady state credit-to-labor income ratio of 27%, which is the average for the Great Moderation. We choose an inverse Frisch elasticity η of 1, which is in the range of values suggested by Hall (2009). We normalize the steady state level of labor supply to 0.33 and set γ accordingly.

To ensure comparability to the empirical study of Bertrand and Morse (2016), the share of investors (rich households) in the overall population χ is set to 20 percent.[12] α equals 0.33, implying a steady-state capital share of income of about 26 percent. The depreciation rate of capital δ equals 0.025, which corresponds to an annual depreciation rate on capital equal to 10 percent.

The intermediation cost function includes two parameters. For ϕ, we choose a value of 2.629 to generate a steady state credit spread of 2% (annualized). The loan elasticity κ is set to 5 as in Cúrdia and Woodford (2010).

We assign a value of 1.25 to the steady state price markup to match an investors' income share of 48 percent.[13] For the steady state wage markup, we follow Schmitt-Grohé and Uribe (2011) and choose 1.1, which is in the interval of typically used values in the literature. The steady state levels $\bar{z}$ and $\bar{\zeta}$ are normalized to 1.

[12]The same ratio of workers-to-capital owners is chosen by Lansing and Markiewicz (2018).

[13]This value is taken from the Current Population Survey (CPS) for the years from 1982 to 2007.

Table 2: Model calibration

	Parameter	Value	Target
Preferences			
Investors' discount factor	β_i	0.995	Annual real interest rate of 2%
Workers' discount factor	β_w	0.994	Credit-to-labor income of 27%
Inverse Frisch elasticity	η	1.000	Hall (2009)
Disutility of labor	γ	5817.827	SS labor supply of 0.33
Fraction of investors	χ	0.200	Bertrand and Morse (2016)
Technology			
Capital share	α	0.330	Capital share of income of 26%
Depreciation rate	δ	0.025	Annual depreciation of 10%
Credit friction			
Intermed. cost constant	ψ	2.629	SS credit spread of 2%
Loan elasticity	κ	5.000	Cúrdia and Woodford (2010)
Steady state			
Price markup	$\bar{\nu}$	1.250	48% income share of investors
Wage markup	$\bar{\mu}$	1.100	Schmitt-Grohé and Uribe (2011)
Labor	$\bar{N}$	0.330	Normalization
Neutral technology	$\bar{z}$	1.000	Normalization
Inv. spec. Technology	$\bar{\zeta}$	1.000	Normalization

4.2 OLS estimation

In line with the construction of the empirical moments reported in Table 1, the sample for the OLS estimation covers the period 1982q1 to 2008q2. With the exception of the TFP series, all data series mentioned in the following are obtained from the FRED database.[14]

TFP data are taken from Fernald (2012). This quarterly series on aggregate technology controls for aggregation effects, varying utilization of capital and labor, nonconstant returns, and imperfect competition. The variable is detrended before estimation by a one-sided HP-filter, as suggested by Stock and Watson (1999), with a smoothing value of 1600. The estimated AR-coefficient and standard deviation are 0.837 and 0.008 respectively. These estimates are similar to the findings of Bullard and Singh (2012) who use the standard (unadjusted) Solow residual to calculate the shock characteristics.

[14]See Appendix A for a detailed description of the data.

For constructing a time series of the price markup, we follow Galí et al. (2007) and use the following equation,

$$\mu_t = MPL_t - w_t, \tag{48}$$

where the marginal product of labor MPL_t equals $\log[(1-\alpha)y_t/n_t]$. y_t/n_t is measured as the real output per hour worked of all persons in the nonfarm business sector, and w_t is the log of real compensation per hour in this sector. Again, all series are detrended by the one-sided HP-filter. The estimates of the AR-coefficient and the standard deviation are 0.777 and 0.006 respectively, and thus, similar to those of Galí et al. (2007) and Karabarbounis (2014). The upper part of Table 3 summarizes the parameter values estimated by OLS.

4.3 SMM estimation

According to (29), the wage markup ν_t is defined as the product of the real wage rate W_t and the marginal rate of substitution MRS_t. Given the specific utility function of working households,

$$MRS_t = \frac{\gamma N_{w,t}^{\eta}}{\Lambda_{w,t}}, \quad \text{where } \Lambda_{w,t} = C_{w,t}^{-\sigma} X_t^{b(\sigma-1)}. \tag{49}$$

Calculating a wage markup series would require data on C_i and C_w, and an appropriate value for b, the parameter measuring the strength of the relative consumption motive. However, since there is no such data available, to the best of our knowledge, and there is little guidance in the literature about values for b, we use the SMM estimator to overcome this data problem.[15] The objective of SMM is to find a parameter vector that minimizes the weighted distance between simulated model moments and their empirical counterparts.

Let $\widehat{\Omega}$ be a $k \times 1$ vector of empirical moments computed from the data and let $\Omega(\theta)$ be the $k \times 1$ vector of simulated moments computed from artificial data. The corresponding time series are generated from simulating the model given a draw of random shocks and the $p \times 1$ vector $\theta \in \Theta$, with $\Theta \subseteq \mathbb{R}^p$. The length of the simulated series is τT, where T is the number of observations in the real data set and $\tau \geq 1$ is an integer. Then, the SMM estimator is given by

$$\widetilde{\theta}_{SMM} = \underset{\theta \in \Theta}{\arg\min} \left[\widehat{\Omega} - \Omega(\theta)\right]' \Upsilon^{-1} \left[\widehat{\Omega} - \Omega(\theta)\right], \tag{50}$$

[15] The SMM approach was proposed by McFadden (1989) and extended by Lee and Ingram (1991), among others.

where Υ is a $k \times k$ positive-definite weighting matrix.

Specifically, $\widehat{\Omega}$ contains the consumer credit moments as shown in Table 1. $\widetilde{\theta}_{SMM}$ contains the estimates for b, σ, ϕ, ρ_ζ, σ_ζ, ρ_ν, and σ_ν. For the weighting matrix, we follow Ruge-Murcia (2013) and choose a matrix with diagonal elements equal to the optimal weighting matrix while all off-diagonal elements are equal to zero.[16] Hence, we only put weight on moments that are observed in the data and force the estimation to consider only economically meaningful moments (see Cochrane, 2005, chap. 11). Additionally, we follow Born and Pfeifer (2014) and incorporate prior information about the parameters to estimate. In particular, we choose prior means $\bar{\theta}$ for each parameter in θ and expand $[\widehat{\Omega} - \Omega(\theta)]$ by $(\widetilde{\theta}_{SMM} - \bar{\theta})$, the deviation of the estimated parameter from the respective prior mean. We expand Υ by attaching small penalty terms to the diagonal, which raise the objective function when deviating from the prior mean. The penalties are of negligible magnitude compared to the other elements in Υ but impose soft bounds on the parameters.[17] We choose this procedure to rule out local minima in implausible regions of the state space which is often the case when estimating DSGE models.[18] Since we want to be agnostic about the strength of the relative consumption motive b, we choose a prior mean of 0 so that deviations from zero are only tolerated if they imply significant improvements in the targeted moments.

To rule out dependence on one particular draw of shocks, we draw several sets of shocks and choose the parameter set that minimizes the mean of all objective functions. We use the following algorithm to estimate θ.

Algorithm 1 (Construction of objective function to be minimized). *We start with a guess for $\widetilde{\theta}_{SMM}$. Then:*

1. *Draw 50 sets of shocks, each consisting of $(\tau T + 1500) \times 4$ values.*

2. *For each set of shocks: solve the model, simulate time series, discard the first 1500 periods, compute moments, compute objective function.*

3. *Take the mean of all 50 objective function values and minimize this.*

We set τ to 10, implying that the artificial time series are ten times larger than the original sample size. Ruge-Murcia (2013) shows that this is a useful choice for handling the trade-off between accuracy and computational cost.

[16] Ruge-Murcia (2013) shows that this choice produces consistent parameter estimates, while standard errors are just slightly higher than those generated with the optimal weighting matrix. The optimal weighting matrix is given by the inverse of the variance-covariance matrix associated with the sample moments. We compute this matrix with the VARHAC-estimator with automatic lag selection by the Bayesian information criterion (see Den Haan and Levin, 1997).

[17] Born and Pfeifer (2014) show that this procedure can be interpreted as using a truncated normal distribution.

[18] Also known as the "dilemma of absurd parameter estimates", see An and Schorfheide (2007).

Table 3: Estimated parameter values

	Parameter	Prior	Value	SD
OLS estimation				
AR(1)-coefficient technology shock	ρ_z		0.8368	(0.0554)
Standard deviation technology shock	σ_z		0.0084	(0.0031)
AR(1)-coefficient redistribution shock	ρ_μ		0.7769	(0.0629)
Standard deviation redistribution shock	σ_μ		0.0063	(0.0024)
	Parameter	Prior	Value	SD
Relative consumption motive	b	0.0000	2.9198	(0.1708)
Risk aversion parameter	σ	2.0000	4.1754	(0.1658)
Debt adjustment cost parameter	ϕ	0.0000	0.9961	(0.0072)
AR-coefficient inv. spec. technology shock	ρ_ζ	0.5000	0.9181	(0.0029)
Standard deviation investment shock	σ_ζ	0.0050	0.0102	(0.0001)
AR-coefficient wage markup shock	ρ_ν	0.5000	0.6080	(0.0373)
Standard deviation wage markup shock	σ_ν	0.0050	0.0281	(0.0009)

Following Ruge-Murcia (2013), we compute the standard errors of $\widetilde{\theta}_{SMM}$ from an estimate of its asymptotic covariance matrix as

$$(1+1/\tau)(J'\Upsilon J)^{-1}J'\Upsilon JSJ(J'\Upsilon J)^{-1}, \tag{51}$$

where J is the Jacobian matrix and S is the full variance-covariance matrix of the empirical moments.

The results of the SMM estimation are shown in the lower part of Table 3. For b, we obtain a value of 2.92 that is estimated to be significantly different from zero, indicating a strong presence of the relative consumption motive. For σ, we estimate a value of 4.18. To get a better interpretation of these values, we make use of Proposition 2, which quantifies the (partial equilibrium) reaction of workers' consumption to an increase in investors' consumption. Inserting the values of b and σ as well as the estimate of the debt adjustment cost parameter ϕ into ξ_0 gives a coefficient of 0.6416. This implies that a 1 percent increase in investors' consumption leads to an increase of about 0.64 percent in workers' consumption. This elasticity is in the upper range of estimates provided by Bertrand and Morse (2016), which implies that our estimated model is able to replicate microeconometric evidence on the strength of the keeping up-motive.

The investment specific technology shock is estimated to have a relatively high degree of persistence, whereas the wage markup shock displays a relatively low degree of persistence. Moreover, the standard deviations of both shocks, σ_ζ and σ_ν, are in line

Table 4: Data and simulated model moments

	$\rho(x_t, D_t)$		σ_x/σ_D		$\rho(x_t, Y_t)$		σ_x/σ_Y	
	Data	Model	Data	Model	Data	Model	Data	Model
Output	0.1523	0.1246	0.4568	0.3364	-	-	-	-
Consumption	0.1658	0.1548	0.2783	0.3046	0.8020	0.7468	0.6092	0.9059
Investment	0.0852	0.0227	1.7524	1.0194	0.9061	0.7086	3.8359	3.0321
Hours worked	0.3603	0.4112	0.5080	0.5619	0.8144	0.6797	1.1120	1.6717
Real wage	−0.3207	−0.5422	0.3994	0.4977	0.0023	−0.2883	0.8743	1.4819

Note: $\rho(x_t, D_t)$ is the cross-correlation of variable x with credit, σ_x/σ_D is the std. deviation of variable x relative to the std. deviation of credit, $\rho(x_t, Y_t)$ is the cross-correlation of variable x with output, σ_x/σ_Y is the std. deviation of variable x relative to the std. deviation of output.
Consumer credit has been deflated using the price index of personal consumption expenditures. All variables are logged and HP-filtered (smoothing parameter of 1600) to obtain cyclical components. For data definitions and sources see Appendix.

Table 5: Estimated parameter values for both specifications

	Parameter	$b = \hat{b}$	$b = 0$
Relative consumption motive	b	2.9122	-
Risk aversion parameter	σ	4.1682	8.1658
Debt adjustment cost parameter	ϕ	0.9962	1.0349
AR-coefficient investment specific technology shock	ρ_ζ	0.9179	0.7376
Standard deviation investment shock	σ_ζ	0.0103	0.0137
AR-coefficient wage markup shock	ρ_ν	0.6043	0.4976
Standard deviation wage markup shock	σ_ν	0.0282	0.0076

with values found by related studies.[19] The estimated debt adjustment cost parameter ϕ takes a value of 0.996.

Columns 2-5 of Table 4 report the credit moments obtained from the data and from the model simulations. All these model moments are close to the empirical ones with only minor discrepancies. As in the data, the model dynamics imply positive correlations between credit and consumption, output and hours worked, respectively, whereas the real wage and consumer credit are negatively correlated. Investment does not show a contemporaneous correlation with credit. Also in line with their empirical counterparts, the estimated model implies that output, consumption, hours worked, and the real wage are less volatile than consumer credit, whereas investment displays a higher relative volatility. Thus, the rather negligible differences suggest that our calibration/estimation exercise provides a set of reasonable parameter values and, furthermore, supports the inclusion of the *keeping up with the Riches* mechanism into the proposed theoretical setup.

[19]See, e.g., Galí et al. (2007) and Iacoviello (2015).

Columns 6-9 of Table 4 show the correlations between output and the remaining four aggregate variables as well as the standard deviations of these aggregates relative to the standard deviation of output. Note that these statistics are not included in the moment-matching approach so that we can interpret these results as the model's ability to replicate important conventional business cycle relations.

Simulating the model leads to a strong procyclical behavior of investment and hours worked with correlation coefficients close to the empirical moments. Moreover, the model produces a strong positive co-movement between output and consumption as observed in the data. The implied relative standard deviations of these variables also show a similar magnitude as their empirical counterparts. The only two moments that are qualitatively off are those related to the wage rate. However, recent research has revealed significant changes in the co-movements of most labor market variables since the beginning of the Great Moderation (e.g. Andrés et al., 2013; Galí and Gambetti, 2009). Reproducing the acyclical behavior of real wages documented in Table 4 therefore poses a challenge for most macroeconomic models. Nevertheless, the differences between the two sets of moments are only small-sized so that we interpret the results of this quantitative exercise as a validation of our proposed model and the underlying calibration/estimation strategy.

4.4 Estimation without b

In the following, we demonstrate that our proposed model that includes the relative consumption motive outperforms the model in which the relative consumption motive is excluded. In doing so, we repeat our model estimation but set $b = 0$ so that we abstract from any consumption externalities. Table 5 shows the estimated parameters of this exercise and compares them to our baseline estimation which includes the relative consumption motive. It turns out that some parameters for the model with $b = 0$ alter drastically compared to the baseline case. In particular, σ is estimated to be significantly larger than in our baseline case. This is not surprising as the baseline estimation suggests a strong consumption smoothing channel, as specified in Proposition 1. To achieve a similar strength of the channel in absence of b, σ has to be considerably higher than in the baseline.

The model in which $b = 0$ performs worse in replicating the credit moments compared to our proposed setup. As Table 6 shows, the model that excludes upward looking consumption comparison does neither reproduce the positive correlation between credit and output nor the positive correlation between investment and credit. Instead, both correlations are negative, although only slightly. Moreover, when $b = 0$, the positive correlation between consumption and credit is considerably smaller. Furthermore, both the positive correlation between credit and hours worked and the negative cor-

Table 6: Data and simulated model moments for both specifications

	$\rho(x_t, D_t)$			σ_x/σ_D		
	Data	$b = \hat{b}$	$b = 0$	Data	$b = \hat{b}$	$b = 0$
Output	0.1523	0.1255	−0.0320	0.4568	0.3362	0.2743
Consumption	0.1658	0.1537	0.0743	0.2783	0.3044	0.2348
Investment	0.0852	0.0228	−0.0643	1.7524	1.0199	1.5863
Hours worked	0.3603	0.4104	0.6418	0.5080	0.5620	0.5008
Real wage	−0.3207	−0.5406	−0.7265	0.3994	0.4973	0.6804
	$\rho(x_t, Y_t)$			σ_x/σ_Y		
	Data	$b = \hat{b}$	$b = 0$	Data	$b = \hat{b}$	$b = 0$
Consumption	0.8020	0.7296	−0.1286	0.6092	0.9406	0.8567
Investment	0.9061	0.6796	0.8538	3.8359	3.1115	5.7848
Hours worked	0.8144	0.6369	0.0245	1.1120	1.6474	1.8296
Real wage	0.0023	−0.2274	0.1160	0.8743	1.5292	2.4864

Note: $\rho(x_t, D_t)$ is the cross-correlation of variable x with credit, σ_x/σ_D is the std. deviation of variable x relative to the std. deviation of credit.

relation between credit and the wage rate are considerably larger than in the data. In addition, the model that abstracts from the consumption externality induces a negative correlation between output and consumption, which stands in sharp contrast to the data. This counterintuitive relation is a result of the high estimated risk aversion that decouples aggregate consumption from the business cycle. We show below that two of the four shocks are specifically responsible for this result as they imply a negative relation between output and consumption when $b = 0$.

To conclude, we see the worse credit correlations and overall output moments implied by the model that does not include the relative consumption motive as a further justification of our proposed model mechanism. Including the keeping up-parameter significantly improves the model's ability to match the data.

4.5 Estimation without σ

When we exclude instead σ from the estimation procedure and set it to a more conventional value of 2, the results are quite similar to the baseline. Table 7 reports the corresponding parameter estimates and the simulated model moments of this exercise. b is now estimated to be 4.52 as it has to compensate for the lower value of σ. However, this increase in b helps to generate the targeted model moments reasonably close to empirical ones. The same is true for the moments that were not targeted in the estimation procedure. If we exclude b from the estimation as well and set it to 0 instead, the model is not able to generate four of the five targeted correlations. In particular, we get a negative correlation between credit and output and consumption,

Table 7: Estimated parameters, data and simulated moments for $\sigma = 2$

	Parameter	$b = \hat{b}$	$b = 0$
Relative consumption motive	b	4.5245	-
Debt adjustment cost parameter	ϕ	1.0481	0.6073
AR-coefficient investment specific technology shock	ρ_ζ	0.8381	0.7629
Standard deviation investment shock	σ_ζ	0.0096	0.0133
AR-coefficient wage markup shock	ρ_ν	0.5776	0.4969
Standard deviation wage markup shock	σ_ν	0.0213	0.0003

	$\rho(x_t, D_t)$			σ_x/σ_D		
	Data	$b = \hat{b}$	$b = 0$	Data	$b = \hat{b}$	$b = 0$
Output	0.1523	0.0965	−0.4260	0.4568	0.3326	0.3097
Consumption	0.1658	0.1686	−0.0970	0.2783	0.3009	0.2923
Investment	0.0852	−0.0328	−0.3610	1.7524	1.1276	1.3852
Hours worked	0.3603	0.5002	0.3954	0.5080	0.5165	0.1627
Real wage	−0.3207	−0.5938	−0.6552	0.3994	0.5519	0.4875
	$\rho(x_t, Y_t)$			σ_x/σ_Y		
	Data	$b = \hat{b}$	$b = 0$	Data	$b = \hat{b}$	$b = 0$
Consumption	0.8020	0.6675	0.3898	0.6092	0.9054	0.9440
Investment	0.9061	0.7088	0.7249	3.8359	3.3924	4.4757
Hours worked	0.8144	0.4980	−0.3719	1.1120	1.5557	0.5257
Real wage	0.0023	−0.0729	0.6958	0.8743	1.6629	1.5756

Note: $\rho(x_t, D_t)$ is the cross-correlation of variable x with credit, σ_x/σ_D is the std. deviation of variable x relative to the std. deviation of credit.

respectively, which stands in sharp contrast to the empirically observed moments. In summary, while fixing σ prior to the estimation still leads to reasonably well model moments, this is not true when fixing b as well. Once again, these results highlight the importance of consumption externalities for understanding credit dynamics.

5 Model dynamics

In the previous section, we have shown that our proposed four-shock model successfully replicates the empirical credit moments. Now, we investigate the model dynamics induced by each of the four shocks separately. Table 8 presents the credit moments obtained from simulating our model where dynamics are driven by just one of the four shocks. Afterwards, we present impulse responses for the two different model estimations, the unrestricted baseline estimation and the restricted estimation with $b = 0$ from Section 4.4, to highlight the impact of the keeping up-mechanism.

Table 8: Simulated model moments - shock analysis

Variable	All Shocks		Price Markup		Investment Specific		Neutral Technology		Wage markup	
	$b=\hat{b}$	$b=0$	$b=\hat{b}$	$b=0$	$b=\hat{b}$	$b=0$	$b=\hat{b}$	$b=0$	$b=\hat{b}$	$b=0$
					Correlation with Credit					
Output	0.1255	−0.0298	0.9784	0.9875	0.9349	−0.6056	−0.6681	−0.7330	−0.5530	−0.5984
Consumption	0.1537	0.0745	0.7243	−0.6853	0.8845	0.8232	−0.9564	−0.9478	−0.9779	−0.9801
Investment	0.0228	−0.0645	0.9783	0.9781	−0.1130	−0.7574	−0.4884	−0.5623	−0.4329	−0.4804
Hours worked	0.4104	0.6406	0.9741	0.9700	0.9374	−0.4615	0.9575	0.9645	−0.5108	−0.5626
Wage rate	−0.5406	−0.7249	−0.8911	−0.8888	−0.9422	0.2140	−0.9080	−0.9150	0.4244	0.4894
					Relative Standard Deviation w.r.t. Credit					
Output	0.3362	0.2738	0.3838	0.2784	0.7448	0.1972	0.2362	0.3035	0.2222	0.2563
Consumption	0.3044	0.2345	0.0880	0.0511	1.0275	0.4803	0.0952	0.1433	0.0493	0.0600
Investment	1.0199	1.5842	1.5134	1.4041	0.5031	2.5672	0.8087	0.9427	0.8967	1.0192
Hours worked	0.5620	0.5004	0.5728	0.4186	1.1218	0.3226	0.6708	0.6715	0.3348	0.3864
Wage rate	0.4973	0.6787	0.6461	0.6383	0.3770	0.1378	0.8812	0.9510	0.1134	0.1308
					Correlation with Credit					
Cons. Ineq.	0.6319	0.6152	0.9516	0.9532	0.9000	0.8600	0.9199	0.9038	0.9535	0.9582
Inc. Ineq.	0.1384	−0.0226	0.9748	0.9806	0.9307	−0.7744	−0.6658	−0.7322	−0.5500	−0.5957
Borr. Int. Rate	−0.2575	−0.4065	0.1107	−0.7933	−0.8814	−0.8670	−0.4906	−0.6019	0.1791	0.3128
					Correlation with Output					
Cons. Ineq.	0.5819	−0.2330	0.9942	0.9836	0.9961	−0.9230	−0.9041	−0.9491	−0.7776	−0.7992
Inc. Ineq.	0.9989	0.9937	0.9995	0.9992	0.9999	0.9625	1.0000	1.0000	1.0000	1.0000
Borr. Int. Rate	−0.5996	0.3108	−0.0737	−0.8505	−0.9917	0.9205	0.9733	0.9790	0.7197	0.5715

5.1 Moment analysis

The upper part of Table 8 reports the correlations between credit and the respective macroeconomic aggregate for each shock separately. We find for the unrestricted model that the price markup and the investment specific technology shock lead to a positive co-movement between credit and output as well as between credit and consumption. The remaining two shocks produce negative correlations between credit and output and credit and consumption irrespective of the inclusion of keeping up-behavior. In contrast to the unrestricted estimation, the price markup shock leads to a strong negative correlation between credit and consumption for the model that abstracts from consumption externalities. Moreover, the investment specific technology shock produces a negative correlation between credit and output and credit and investment, while the former correlation is positive when estimating b. In this case, the neutral technology, price markup, and investment specific technology shock also induce a positive correlation between credit and hours worked and a negative co-movement between credit and wages, perfectly in line with the data. Clear differences between the responses of both model estimations can be observed for the price markup and the investment specific shock. As we will explain in more detail in the next subsections, the price markup and the investment specific technology shock are of major importance in reproducing procyclical credit dynamics.

Turning to the relative standard deviations, we see for the unrestricted estimation that both markup shocks and the neutral technology shock lead to output, consumption and hours dynamics that are less volatile than the respective credit dynamics. The investment specific technology shock, on the other hand, produces consumption and hours series that are more volatile than credit, while investment exhibits less volatility. The latter is also true for the neutral technology and the wage markup shock in the unrestricted parametrization. In contrast, only the price markup shock induces investment responses that are more volatile than the credit ones. All four shocks produce wage series that are less volatile than the simulated credit series.

We can use our model simulation also to gain some insights into how relative income and consumption fluctuate over the business cycle. For this purpose, we construct a series for consumption and income inequality, respectively.[20] As the third part of Table 8 reports, consumption and income inequality are positively correlated with credit, implying that an increase in inequality is accompanied by a rise in credit. This holds true irrespective of estimating b or setting $b = 0$. Nevertheless, the correlation between consumption inequality and credit is slightly stronger when we estimate b. This finding is supported by the evidence of Bertrand and Morse (2016) and Georgarakos et al. (2014) who find that growing inequality is positively associated with an increase in consumer credit. Overall, we find that the both markup shocks produce the strongest correlation between consumption inequality and credit, irrespective of b.

Consumption and income inequality are both positively correlated with output when estimating b, implying a widening (narrowing) of income and consumption differences in a boom (recession). While all shocks generate more or less a perfect correlation between output and income inequality, the procyclicality of consumption inequality is driven by shocks to price markup and investment. When setting $b = 0$ consumption inequality is countercyclical, whereas income inequality shows a strong procyclical pattern, as all shocks generate this result.[21]

We also investigate how the borrowing interest rate behaves in both model versions. Irrespective of estimating b or setting $b = 0$, the interest rate is negatively correlated with credit, implying lower (higher) credit costs when credit markets become loose (tight). Turning to the correlation with output, we find for the unrestricted estimation that the borrowing interest rate behaves countercyclical such that the credit price goes up (down) when output is high (low).[22] This negative correlation is mainly

[20]Consumption inequality is defined as the ratio between investors' consumption and workers' consumption. Income inequality is defined as the ratio between investors' income (the sum of profits, income from physical capital and income from deposits) and workers' income (labor income).

[21]The cyclical behavior of income inequality is still an open question in the literature. While some studies find that income inequality moves countercyclical (Heathcote et al., 2010), others detect a procyclical behavior especially during the Great Moderation during which inequality increased significantly (Galbraith, 2009; Morin, 2019). Moreover, note that our inequality measures are based on just two representative households and should therefore not be directly compared to commonly used inequality measures that take the whole income (consumption) distribution into account.

[22]This is in line with the mechanism in Nakajima and Ríos-Rull (2014) who only consider neutral technology shocks but also countercyclical wage risk.

driven by dynamics due to the investment specific shock. Contrary, when restricting b, we find a procyclical borrowing interest rate mainly due to both technology shocks.

To get a better understanding for the respective responses, in the following, we will discuss in more detail impulse responses for each of the four shocks.

5.2 Price markup shock

Figure 1 presents the model responses to a price markup shock. The shock leads to a falling wage rate while not affecting the marginal product of labor. A similar effect can be observed for the rental rate of capital. Due to lower marginal cost, profits rise so that investors obtain a higher income, and increase their consumption level and investment. If the relative consumption motive is present (solid lines), working households respond by increasing their consumption level as well. They derive the additionally required income through two sources. First, workers raise their labor supply and second, they enhance their demand for credit so that the drop in labor income, defined as the product of the real wage and hours worked, is almost fully compensated. The increase in credit is enhanced by a falling borrowing interest rate. As investment and hours worked rise, aggregate output also goes up when the price markup shock hits the economy.

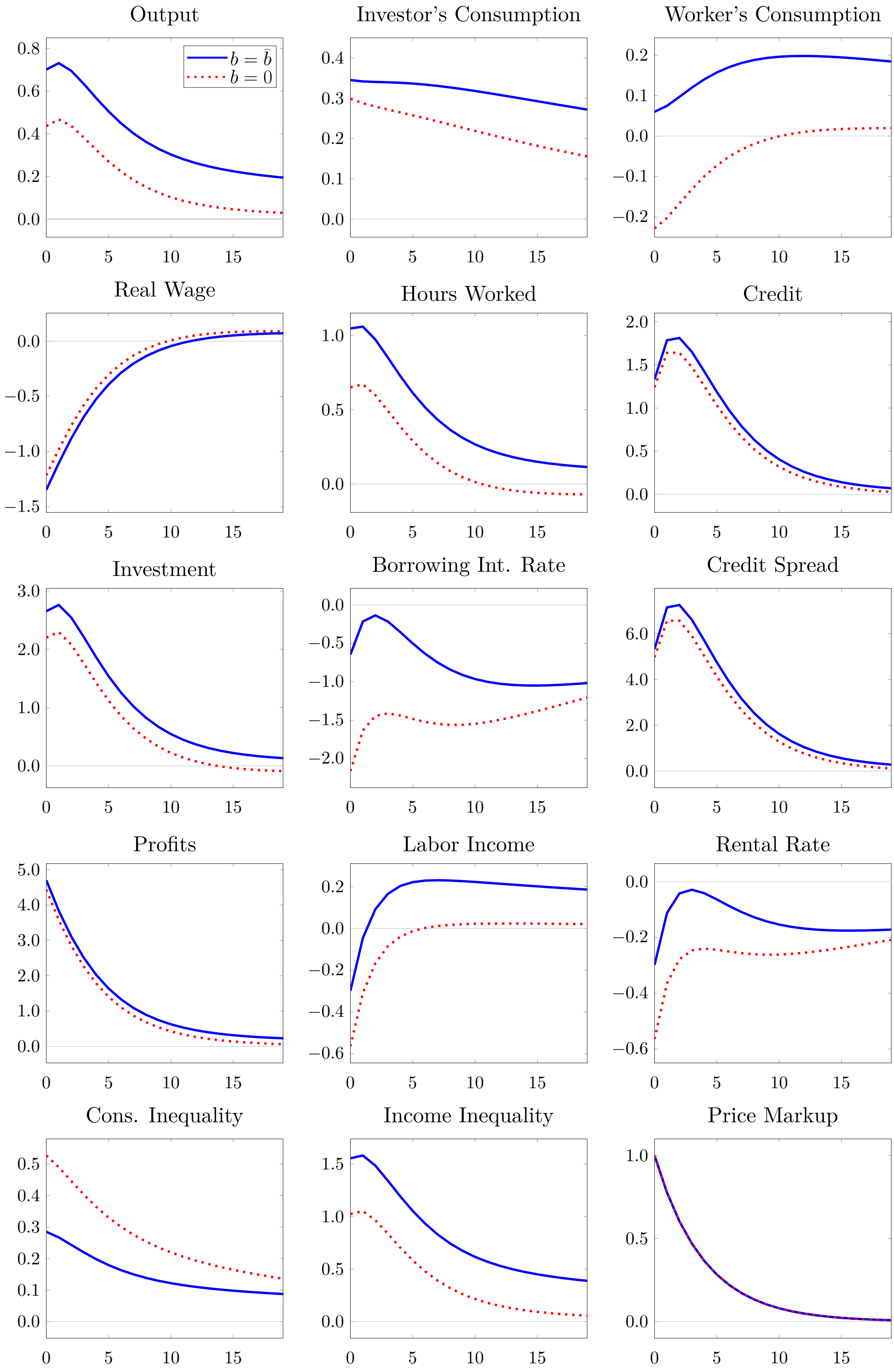
The outcome changes if we abstract from the relative consumption motive (dashed lines). Now, the workers' choice of consumption does not hinge on the investors anymore. In this case, workers increase their labor supply by a smaller amount and reduce their consumption expenditures. As a result, the drop in labor income is more pronounced and output goes up to a lesser extent.

Consumption inequality rises in both scenarios but significantly less when the relative consumption motive is present. Income inequality is also strongly increasing after a price markup shock, caused by large profits on the investors' side while labor income drops on impact and rises only moderately over time.

5.3 Investment specific technology shock

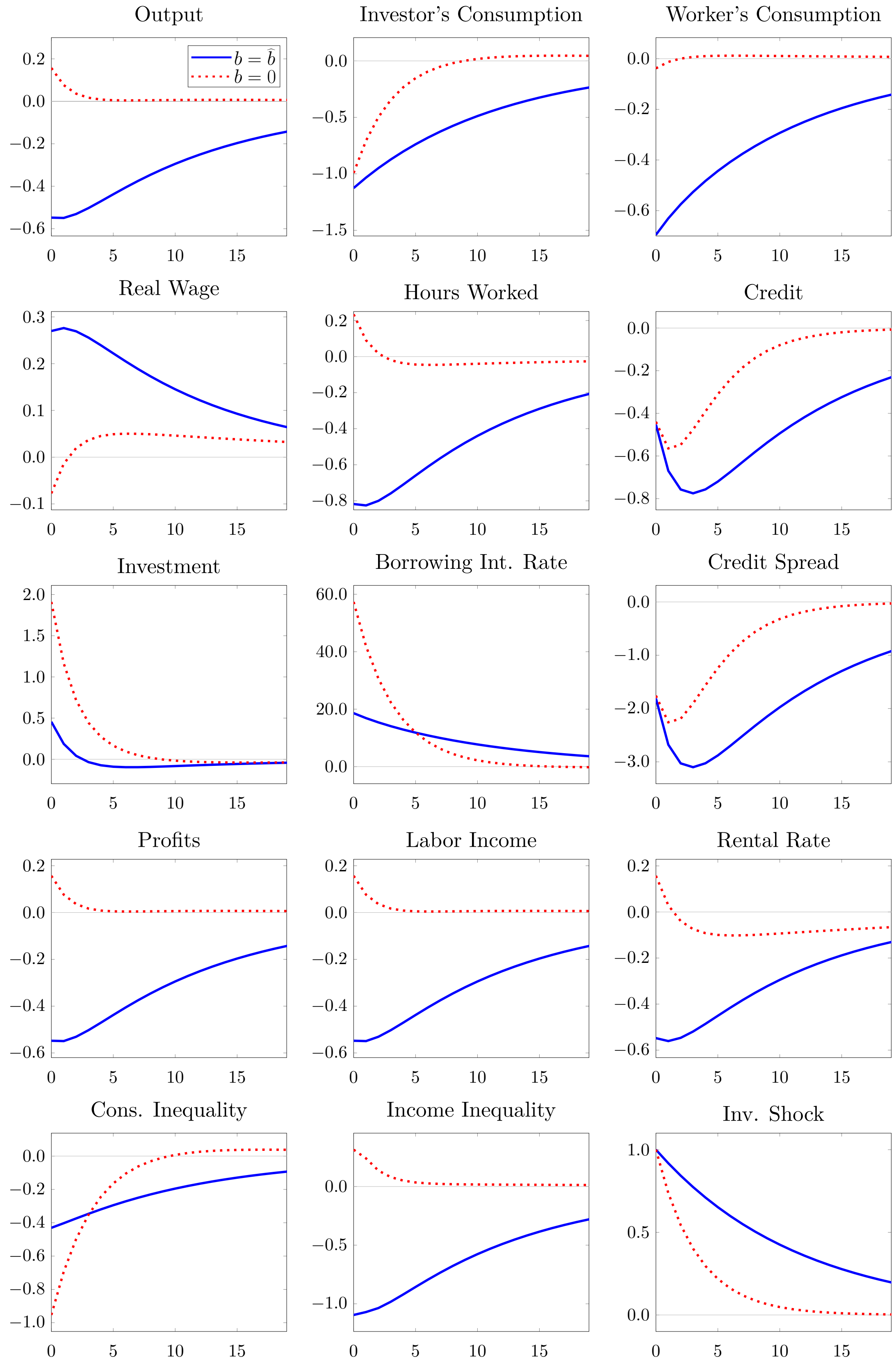
Figure 2 presents the model responses to an investment specific technology shock. In the unrestricted model (solid lines), investors shift their expenditures from consumption to investment on impact, as the shock makes saving in capital more profitable. Since workers imitate the consumption behavior of investors, they also decrease their consumption expenditures. This results in a reduced supply of hours worked and a falling demand for credit. As credit falls, the interest rate goes up, although not as much as the interest rate on deposits, so that the credit spread decreases ultimately. The strong decrease in labor supply leads then to a fall in aggregate output and profits, resulting in a significant decrease of investors' income and their personal expenditures.

Figure 1: Impulse responses to price markup shock



Note: Responses are measured in percentage deviations from steady state. Horizontal axes measure time in quarters.

Figure 2: Impulse responses to investment specific technology shock



Note: Responses are measured in percentage deviations from steady state. Horizontal axes measure time in quarters.

The negative responses of most aggregate variables is supported by empirical evidence showing that investment-specific technology shocks have contractionary effects (Basu et al., 2013).

The results change significantly when the consumption externality is switched off (dashed lines). Working households now increase their labor supply and reduce their credit demand by a smaller amount so that the reduction in consumption expenditures is only marginal. Similarly, the investors' consumption level drops less pronounced, also due to an increase in profits. Consequently, the rise in investment is more persistent and as both input factors increase also output goes up when the relative consumption motive is absent.

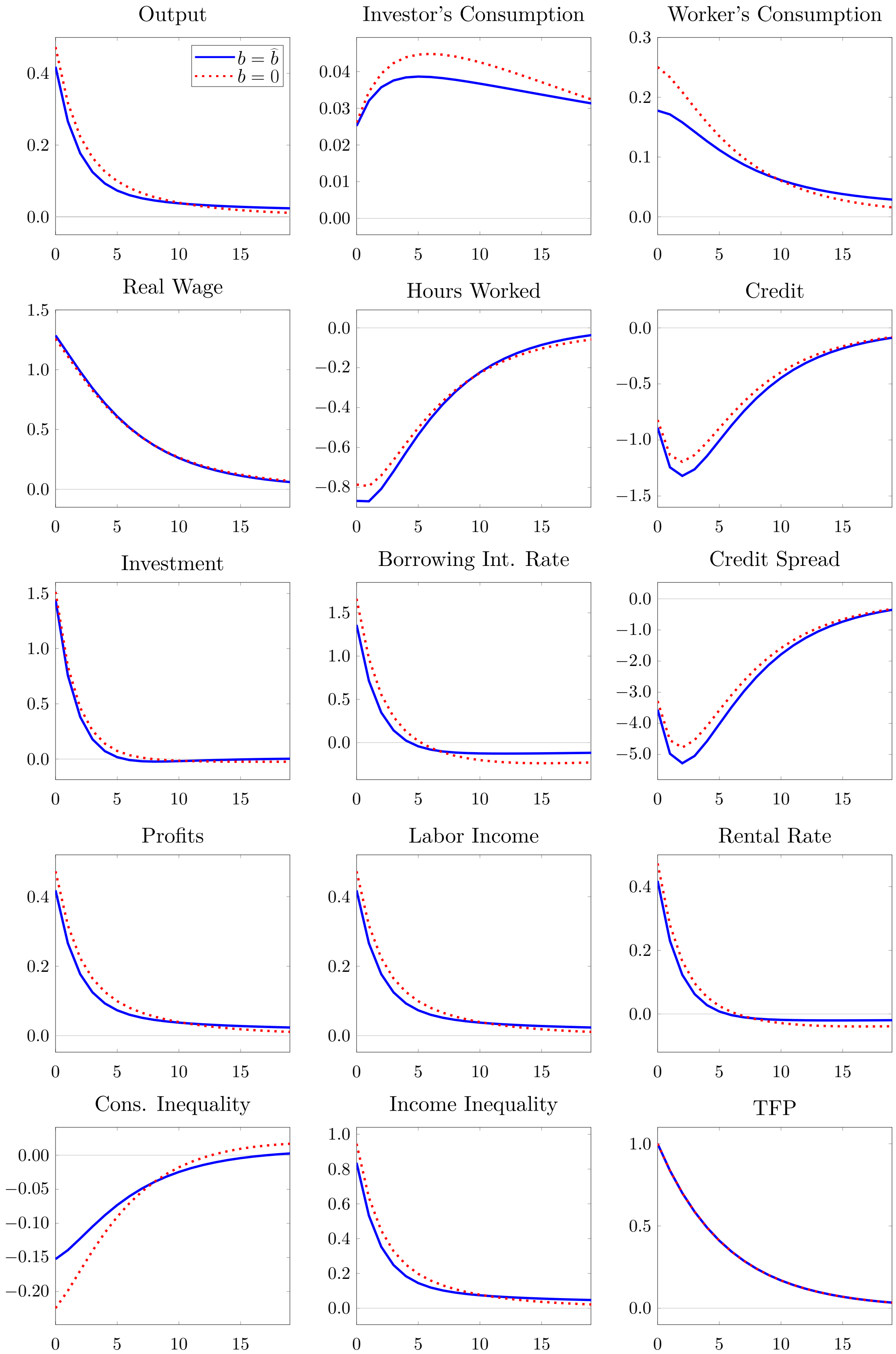
Consumption inequality drops strongly as investors decrease their consumption expenditures relatively more than workers in both scenarios. Income inequality, on the other hand, decreases when the relative consumption motive is present and rises otherwise. In the former case, investors experience a decline in profits and capital income as the rental rate drops sharply. Since both types lose in terms of income but the investors relatively more, income inequality decreases. In the other case, the opposite is true. Both types' income increases but investors gain relatively more so that inequality in income increases slightly.

5.4 Neutral technology shock

Figure 3 shows the effects of a positive neutral technology shock to the model economy. For $b = \hat{b}$, an increase in z_t causes output to go up immediately. As a result of the rise in productivity, the marginal products of labor and capital increase, leading to a higher wage rate and interest rate on capital. Both types of agents increase their respective consumption levels, although the rise is more pronounced for working households. As workers aim to keep up with investors, they reduce hours worked and credit demand substantially which leads to a higher interest rate but a lower credit spread. However, workers' total labor income increases as the rise in the wage rate is more pronounced than the fall in hours worked. Real profits increase by a similar magnitude compared to output.

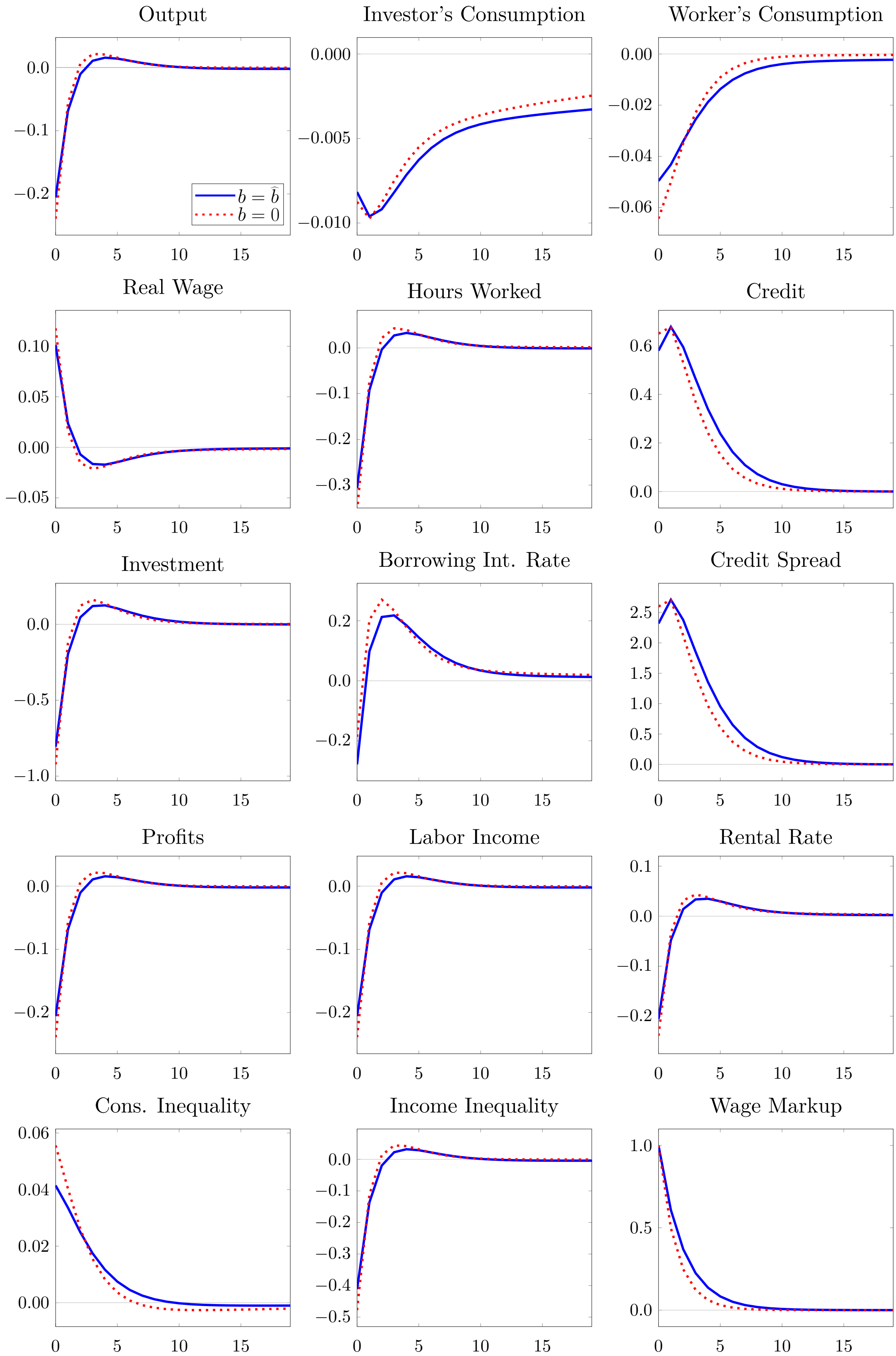
If we abstract from the relative consumption motive, the results are quantitatively different but do not change qualitatively. Profits and, therefore, investors' income and consumption increase by a larger amount compared to the case of $b = \hat{b}$. Since workers do not internalize the investors' consumption level, they also consume more compared to the unrestricted estimation. Consequently, workers reduce labor supply by a smaller amount so that their labor income increases stronger. Profits of investors as well as investment rise by a larger amount. To sum up, the introduction of the relative consumption motive dampens the expansionary effects of a neutral technology shock.

Figure 3: Impulse responses to neutral technology shock



Note: Responses are measured in percentage deviations from steady state. Horizontal axes measure time in quarters.

Figure 4: Impulse responses to wage markup shock



Note: Responses are measured in percentage deviations from steady state. Horizontal axes measure time in quarters.

Consumption inequality decreases as workers increase their consumption expenditures relatively more. On the other hand, income inequality rises sharply through higher profits and higher capital income.

5.5 Wage markup shock

In Figure 4, the effects of a positive wage markup shock are presented. For $b = \hat{b}$, the shock leads to a boost in the wage rate, whereas the marginal product of labor remains unchanged. Due to cost minimization, the demand for labor falls and output decreases immediately. This leads to lower profits and investors reducing their consumption level slightly. On the workers side, the reduction in labor demand is so strong that, although wages rise, workers' labor income declines. The compensation of this income loss and their desire to keep up with the investors forces workers to demand a higher amount of credit to mitigate the drop in consumption leading to a higher credit price and a lower spread.

Consumption inequality rises as workers cut their consumption expenditures relatively more than investors, while income inequality decreases as investors face not only a drop in profits but also a drop in capital income.

When $b = 0$, the results show only quantitative differences. Overall, the responses display only marginal differences to the estimation with $b = \hat{b}$.

6 Robustness

In this section, we show that our results are robust when modifying the externality such that it is based on lagged relative consumption. More specifically, we investigate a catching up-behavior instead of keeping up. In a second robustness exercise, we split the sample and study whether the degree of upward looking comparison has changed over time.[23]

[23] The appendix includes additional robustness exercises. In particular, we investigate the sensitivity of our results with respect to the choice of the inverse Frisch elasticity η. Additionally, we allow for different specifications of the externality X_t.

6.1 Catching up with the Riches

First, we adjust the reference point of workers in equation (23). Instead of assuming that X enters contemporaneously, workers' utility depends here on past relative consumption.[24] Thus, the workers' utility function becomes

$$U(C_{w,t}, X_{t-1}, N_{w,t}) = \frac{(C_{w,t}X_{t-1}^{-b})^{1-\sigma} - 1}{1-\sigma} - \frac{\gamma N_{w,t}^{1+\eta}}{1+\eta}, \quad \text{with } X_{t-1} := \frac{C_{i,t-1}}{C_{w,t-1}}, \tag{52}$$

where b again determines the strength of the relative consumption motive. The focus on past relative consumption might be justified by the fact that agents need time to observe and realize other agents' consumption decisions, and to adjust their own consumption expenditures. We run the same procedure as with our baseline specification, namely estimate the vector of parameters $\theta^* = \{b, \sigma, \phi, \rho_\zeta, \sigma_\zeta, \rho_\nu, \sigma_\nu\}$ by SMM. The upper part of Table 9 reports the estimated parameters for this specification.

We find that the parameter governing the catching up-preferences is positive and significant, but somewhat smaller as for the keeping up-preferences. Moreover, the risk aversion parameter σ slightly increases. The remaining parameters are similar to the baseline estimates.

The lower part of Table 9 reports the simulated moments in comparison to their empirical counterparts. We find an overall good fit with this preference specification as all of the targeted moments are in line with the data. In terms of the non-targeted moments in columns 6-9, we detect a slightly different pattern compared to our baseline case. The model with catching up-preferences is able to replicate the acyclicality of the real wage. This comes at the cost of a relatively lower procyclicality of consumption, investment and hours worked, and a much more volatile real wage series such that wages are more than twice a volatile as in the data.

The intuition behind these results is the following. Consider the workers' (log-linearized) Euler equation abstracting from debt adjustment costs, given by

$$\widehat{C}_{w,t+1} - \frac{(b(1-\sigma)+\sigma)}{\sigma}\widehat{C}_{w,t} + \frac{b(1-\sigma)}{\sigma}\widehat{C}_{w,t-1} = -\frac{1}{\sigma}\widehat{Q}_t + \frac{b(\sigma-1)}{\sigma}\left(\widehat{C}_{i,t} - \widehat{C}_{i,t-1}\right).$$

As compared to Proposition 1, catching up-preferences introduce an additional lagged consumption term to the workers' Euler equation. This is an additional internal habit channel that simplifies consumption smoothing so that a lower b is necessary to get the targeted moments.

The acyclicality of the real wage, on the other hand, is related to the estimated shock parameters of both the investment specific technology shock and the wage markup shock. Both shocks induce a negative correlation between output and the real wage,

[24] In analogy to Abel (1990), we call this *catching up with the Riches*.

Table 9: Estimated parameter values with catching up preferences

	Parameter	Value	SD
Relative consumption motive	b	0.8914	(0.0418)
Risk aversion parameter	σ	4.6662	(0.0532)
Debt adjustment cost parameter	ϕ	1.0948	(0.0187)
AR-coefficient inv. specific technology shock	ρ_ζ	0.8460	(0.0301)
Standard deviation investment shock	σ_ζ	0.0098	(0.0005)
AR-coefficient wage markup shock	ρ_ν	0.6384	(0.1901)
Standard deviation wage markup shock	σ_ν	0.0193	(0.0033)

	$\rho(x_t, D_t)$		σ_x/σ_D		$\rho(x_t, Y_t)$		σ_x/σ_Y	
	Data	Model	Data	Model	Data	Model	Data	Model
Output	0.1523	0.0847	0.4568	0.3041	-	-	-	-
Consumption	0.1658	0.1465	0.2783	0.2955	0.8020	0.5083	0.6092	0.9729
Investment	0.0852	-0.0301	1.7524	1.2405	0.9061	0.6846	3.8359	4.0820
Hours worked	0.3603	0.4951	0.5080	0.5007	0.8144	0.3116	1.1120	1.6494
Real wage	-0.3207	-0.5250	0.3994	0.6024	0.0023	0.0172	0.8743	1.9853

Note: $\rho(x_t, D_t)$ is the cross-correlation of variable x with credit, σ_x/σ_D is the std. deviation of variable x relative to the std. deviation of credit, $\rho(x_t, Y_t)$ is the cross-correlation of variable x with output, σ_x/σ_Y is the std. deviation of variable x relative to the std. deviation of output.
Consumer credit has been deflated using the price index of personal consumption expenditures. All variables are logged and HP-filtered (smoothing parameter of 1600) to obtain cyclical components. For data definitions and sources see Appendix.

and since both have a smaller estimated standard deviation, this leads to a less negative correlation.

When comparing keeping up to catching up, we conclude that the latter are slightly inferior when it comes to matching second moments as the keeping up-preferences match six of ten targets better and five of eight non-targeted moments.

6.2 Split-sample estimation

As a final check, we test whether our findings are robust when splitting the sample. As shown by Fieldhouse et al. (2016) the cyclical behavior of credit has shifted during the early 1990s. As Table 10 reports, we indeed find a change in the cyclicality of consumer credit. In particular, we split the full sample into one pre-1990 and one post-1990 sample and find that credit is strongly procyclical in the first part of the sample, whereas it turns mainly acyclical thereafter. This result might suggest that also the strength of the keeping up-mechanism has changed over time.

To investigate this issue, we estimate our model parameters for both subsamples. As expected, the size of the relative consumption motive is much stronger in the pre-1990 sample than in the post-1990 sample. The parameter is estimated to be more than twice as large in the first subsample. However, also in the second subsample, we find a

Table 10: Estimated parameters and simulated moments for both subsamples

	Parameter	Full	Pre-1990	Post-1990
Relative consumption motive	b	2.9122	3.9235	1.7841
Risk aversion parameter	σ	4.1682	5.0694	3.1387
Debt adjustment cost parameter	ϕ	0.9962	1.0718	0.8497
AR-coefficient inv. specific technology shock	ρ_ζ	0.9179	0.6317	0.9589
Standard deviation investment shock	σ_ζ	0.0103	0.0072	0.0116
AR-coefficient wage markup shock	ρ_ν	0.6043	0.1641	0.4150
Standard deviation wage markup shock	σ_ν	0.0282	0.0133	0.0236

	Pre-1990				Post-1990			
	$\rho(x_t, D_t)$		σ_x/σ_D		$\rho(x_t, D_t)$		σ_x/σ_D	
	Data	Model	Data	Model	Data	Model	Data	Model
Output	0.3527	0.3755	0.4578	0.2983	0.0081	−0.0593	0.4599	0.3426
Consumption	0.4758	0.4385	0.2118	0.2197	0.0136	0.0162	0.3084	0.3292
Investment	0.2815	0.1443	2.0085	1.1565	−0.0809	−0.1025	1.6207	1.0985
Hours worked	0.4485	0.7032	0.4691	0.5657	0.2944	0.2991	0.5325	0.5244
Real wage	0.1653	−0.6718	0.3599	0.5917	−0.5527	−0.5428	0.4290	0.4912

	Pre-1990				Post-1990			
	$\rho(x_t, Y_t)$		σ_x/σ_Y		$\rho(x_t, Y_t)$		σ_x/σ_Y	
	Data	Model	Data	Model	Data	Model	Data	Model
Consumption	0.6915	0.5252	0.4625	0.7368	0.8516	0.7095	0.6706	0.9606
Investment	0.9116	0.8188	4.3870	3.8777	0.9088	0.6630	3.5239	3.2110
Hours worked	0.8468	0.5163	1.0246	1.8974	0.7950	0.6216	1.1578	1.5327
Real wage	−0.4901	−0.2849	0.7860	1.9846	0.2278	−0.1345	0.9327	1.4376

Note: $\rho(x_t, D_t)$ is the cross-correlation of variable x with credit, σ_x/σ_D is the std. deviation of variable x relative to the std. deviation of credit. $\rho(x_t, Y_t)$ is the cross-correlation of variable x with output, σ_x/σ_Y is the std. deviation of variable x relative to the std. deviation of output.

positive value for b, which indicates that relative consumption concerns are still an important determinant of credit dynamics in the more recent part of the sample. For both subsamples, the model produces credit dynamics that show only minor discrepancies compared to the empirical ones. Moreover, the non-targeted output moments match the observed ones fairly closely pre- and post-1990. Overall, we conclude that, while the strength of the relative consumption motive has decreased over time, our estimation on the more recent past still strongly speaks in favor of consumption externalities.

7 Conclusion

In this paper, we set up a dynamic stochastic general equilibrium model that mimics the short-run dynamics of consumer credit for the period of the Great Moderation. The model consists of two different household types. Investors, who hold the economy's entire capital stock, own the firms and supply credit, and workers who make up the entire labor force and demand credit to finance their desired level of consumption. In addition, we incorporate a *keeping up with the Riches* mechanism so that workers aim to keep up with the investors' level of consumption.

When estimating deep model parameters, we find a positive significant value for the workers' keeping up-parameter. Qualitatively, an income redistribution from labor to capital and an investment specific technology shock lead to model dynamics that are perfectly in line with the empirical evidence. More precisely, both shocks generate positive correlations of consumer credit with output, consumption, and labor, while there is a negative co-movement between consumer credit and the real wage. In contrast, a neutral technology shock and a wage markup shock are not able to generate the positive correlations between consumer credit, output, and consumption. In reproducing empirical credit moments, the proposed model significantly outperforms a model version in which consumption externalities are not included. Complementary to micro-evidence (Bertrand and Morse, 2016), we have provided macro-evidence on the link between income redistribution, consumption externalities, and credit dynamics.

We think that a potential promising area of future research lies in extending our proposed model by strategic default. In particular, combining incomplete markets and default on unsecured credit as studied by Chatterjee et al. (2007) and Livshits et al. (2007) with relative consumption concerns might provide important insights in terms of business cycle fluctuations and welfare costs that are of great interest for the research community but also for policymakers.

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A Data definitions and sources

Data definitions and sources

Variable	Definition	Source	Series ID
Consumer credit	Level of consumer credit held by households and nonprofit organizations	Board of Governors of the Federal Reserve System	HCCSDODNS
Output	Real output in the nonfarm business sector	U.S. Department of Labor: Bureau of Labor Statistics	OUTNFB
Hours worked	Hours of all persons in the nonfarm business sector	U.S. Department of Labor: Bureau of Labor Statistics	HOANBS
Real wage	Real compensation per hour in the nonfarm business sector	U.S. Department of Labor: Bureau of Labor Statistics	COMPRNFB
Labor productivity	Real output per hour of all persons in the nonfarm business sector	U.S. Department of Labor: Bureau of Labor Statistics	OPHNFB
Consumption	Real personal consumption expenditures	U.S. Department of Commerce: Bureau of Economic Analysis	PCECC96
Investment	Real gross private domestic investment	U.S. Department of Commerce: Bureau of Economic Analysis	GPDIC96
Prices	Chain-type price index of personal consumption expenditures	U.S. Department of Commerce: Bureau of Economic Analysis	PCECTPI
Total factor productivity	Utilization-adjusted total factor productivity	Fernald (2012)	
Delinquency rate	Delinquency rate on consumer loans, all commercial banks	U.S. Department of Commerce: Bureau of Economic Analysis	DRCLACBS
Income share	Share of Aggregate Income Received by Each Fifth and Top 5 Percent of Households, All Races	Current Population Survey (CPS)	

B Proof of Proposition 2

We make use of the workers' three first order conditions (26)-(28) as well as their budget constraint (24) in log-linearized form, given by

$$\widehat{\Lambda}_{w,t} - b(\sigma-1)\widehat{C}_{i,t} + (\sigma + b(\sigma-1))\widehat{C}_{w,t} = 0 \tag{53}$$

$$\widehat{W}_t - \eta \widehat{N}_{w,t} + \widehat{\Lambda}_{w,t} = 0 \tag{54}$$

$$\widehat{\Lambda}_{w,t+1} + \phi \frac{\bar{D}_w}{\bar{Q}^b}\widehat{D}_{w,t} - \widehat{Q}_t^b - \widehat{\Lambda}_{w,t} = 0, \tag{55}$$

$$\bar{W}\bar{N}_w(\widehat{W}_t + \widehat{N}_{w,t}) - \bar{C}_w\widehat{C}_{w,t} - \bar{D}_w\widehat{D}_{w,t-1} + \bar{Q}^b\bar{D}_w\widehat{Q}_t^b + \bar{Q}^b\bar{D}_w\widehat{D}_{w,t} = 0, \tag{56}$$

where a circumflex indicates log-deviations from the respective steady state, and a bar refers to the variable's steady state. We only consider a partial equilibrium effect here, so that changes in the wage rate and the price for credit do not occur. We use (53) to eliminate $\widehat{\Lambda}_w$ and (54) to eliminate $\widehat{N}_w$. Then, we combine (55) and (56) to get rid of $\widehat{D}_w$. The resulting equation is given by

$$\begin{aligned}
&\left(\frac{b(\sigma-1)}{\eta}\left(\bar{W}\bar{N}_w + \frac{(\bar{Q}^b)^2}{\phi}\right)\right)\widehat{C}_{i,t} - \left(\frac{b(\sigma-1)}{\eta}\frac{(\bar{Q}^b)^2}{\phi}\right)\widehat{C}_{i,t+1} \\
&- \left(\frac{\sigma+b(\sigma-1)}{\eta}\left(\bar{W}\bar{N}_w + \frac{(\bar{Q}^b)^2}{\phi}\right) + \bar{C}_w\right)\widehat{C}_{w,t} + \left(\frac{\sigma+b(\sigma-1)}{\eta}\frac{(\bar{Q}^b)^2}{\phi}\right)\widehat{C}_{w,t+1} = 0.
\end{aligned} \tag{57}$$

Rearranging gives

$$\widehat{C}_{w,t} = \xi_0\widehat{C}_{i,t} + \xi_1\widehat{C}_{i,t+1} + \xi_2\widehat{C}_{w,t+1}, \tag{58}$$

where

$$\begin{aligned}
\xi_0 &:= \frac{\frac{b(\sigma-1)}{\eta}\left(\bar{W}\bar{N}_w + \frac{(\bar{Q}^b)^2}{\phi}\right)}{\frac{\sigma+b(\sigma-1)}{\eta}\left(\bar{W}\bar{N}_w + \frac{(\bar{Q}^b)^2}{\phi}\right) + \bar{C}_w}, \quad \xi_1 := -\frac{\frac{b(\sigma-1)}{\eta}\frac{(\bar{Q}^b)^2}{\phi}}{\frac{\sigma+b(\sigma-1)}{\eta}\left(\bar{W}\bar{N}_w + \frac{(\bar{Q}^b)^2}{\phi}\right) + \bar{C}_w}, \\
\text{and } \xi_2 &:= \frac{\frac{\sigma+b(\sigma-1)}{\eta}\frac{(\bar{Q}^b)^2}{\phi}}{\frac{\sigma+b(\sigma-1)}{\eta}\left(\bar{W}\bar{N}_w + \frac{(\bar{Q}^b)^2}{\phi}\right) + \bar{C}_w}.
\end{aligned} \tag{59}$$

Iterating equation (58) recursively forward, after $T-1$ times, we obtain the following expression

$$\widehat{C}_{w,t} = \xi_0\widehat{C}_{i,t} + (\xi_1 + \xi_0\xi_2)\widehat{C}_{i,t+1} + \cdots + \xi_2^{T-1}\widehat{C}_{i,t+T} + \xi_2^T\widehat{C}_{w,t+T}, \tag{60}$$

where T is a large number. With this equation at hand, we consider an exogenous on-time perturbation $d\widehat{C}_{i,0}$ of the investors' consumption level. This implies that it returns to its steady state in period 1 so that all $\widehat{C}_{i,t}$ are zero for $t > 0$. Given that $|\xi_2| < 1$ and letting $T \to \infty$, we obtain equation (47).

C Robustness

C.1 Additional data moments

Tables 11-13 show additional moments related to credit fluctuations. Table 11 presents credit moments for the pre-1990 and the post 1990 sample. While the relative volatility of credit is fairly constant across both subsamples, the correlation with other main aggregates has changed over time. In particular, credit shows a strong correlation with output and consumption in the first part of the sample, whereas the correlation with both variables is almost zero in the later part of the sample. Moreover, pre-1990 credit is positively correlated with wages but the correlation becomes negative in the more recent sample.

Table 12 presents autocorrelations of the main aggregates. Consumer credit shows a high degree of persistence comparable to the one of hours worked. Contrary, wages indicate the lowest degree of persistence. Finally, Table 13 shows cross-correlations with output. Whereas credit is positively correlated with lagged output, it show a negative correlation with future output.

Table 11: Data moments for both subsamples

	Pre-1990		Post-1990	
	$\rho(x_t, D_t)$	σ_x/σ_D	$\rho(x_t, D_t)$	σ_x/σ_D
Output	0.3527	0.4578	0.0081	0.4599
Consumption	0.4758	0.2118	0.0136	0.3084
Investment	0.2815	2.0085	−0.0809	1.6207
Hours worked	0.4485	0.4691	0.2944	0.5325
Real wage	0.1653	0.3599	−0.5527	0.4290

Note: $\rho(x_t, x_{t-k})$ is the cross-correlation of variable x with credit, σ_x/σ_D is the std. deviation of variable x relative to the std. deviation of credit.

Table 12: Autocorrelations

	$\rho(x_t, x_{t-1})$	$\rho(x_t, x_{t-2})$	$\rho(x_t, x_{t-3})$	$\rho(x_t, x_{t-4})$
Consumer credit	0.9489	0.8478	0.6911	0.4890
Output	0.8586	0.6647	0.4220	0.2089
Consumption	0.8317	0.6705	0.5116	0.2862
Investment	0.8469	0.6247	0.3672	0.1090
Hours worked	0.9338	0.8016	0.6030	0.3863
Real wage	0.7699	0.5393	0.3546	0.1982

Note: $\rho(x_t, x_{t-k})$ is the cross-correlation of variable x with the kth lag of itself.

Table 13: Cross-correlation with output

	$\rho(x_t, Y_{t+k})$								
	-4	-3	-2	-1	0	$+1$	$+2$	$+3$	$+4$
Cons. credit	0.4453	0.4335	0.3669	0.2560	0.1178	-0.0335	-0.1517	-0.2144	-0.2333
Output	0.2210	0.4459	0.6926	0.8678	1.0000	0.8566	0.6808	0.4558	0.2665
Consumption	0.3697	0.5048	0.6415	0.7457	0.8007	0.7221	0.5476	0.3433	0.1328
Investment	0.0862	0.3601	0.6382	0.8167	0.8976	0.7676	0.6151	0.4258	0.2847
Hours worked	0.4774	0.6709	0.8097	0.8559	0.8246	0.7018	0.5415	0.3502	0.1669
Real wage	-0.0559	-0.0938	-0.1333	-0.0761	-0.0193	0.0202	0.0065	-0.0050	-0.0199

Note: $\rho(x_t, Y_{t+k})$ is the cross-correlation of variable x with output k periods ahead.

C.2 Frisch elasticity

In this subsection, we investigate the sensitivity of our results with respect to the choice of the inverse Frisch elasticity η. In particular, we set η to higher values, implying less elastic labor supply, which is more in line with micro data, to determine its impact.

Table 14 reports both the estimated parameters (upper part) and the simulated moments (lower part) for each parametrization. Recall that we set $\eta = 1$ in our baseline case. One of the main results is that b and σ are increasing in η. This is not surprising as the labor supply response plays a crucial role in the keeping up-mechanism. It follows that both b and σ have to compensate for the less elastic labor supply to ultimately generate the targeted moments. Debt adjustment costs are also increasing in η. This results from the fact that higher b and σ induce more volatility in credit and thus, ϕ has to rise to lower the fluctuations in credit. Another striking result is that the standard deviation of the wage markup shock is drastically increasing in η. Recall the role of this specific shock in our model. An increase in the wage markup leads to negative credit correlations with consumption, output, investment and hours worked. Since a higher η suppresses the responses of all variables, stronger shocks are needed and therefore, σ_ν almost triples when we make labor supply very inelastic.

The lower part of the table reveals that both sets of moments (targeted and non-targeted) barely change with higher η. This leads to the conclusion that the labor supply elasticity is a important parameter in the sense that our results quantitatively change. But even with very inelastic labor supply the keeping up-mechanism successfully generates the cyclical properties of consumer credit that can be found in the data.

C.3 Alternative keeping-up preferences

Recall that we specified the workers' period utility function as follows,

$$U_{w,t}(C_{w,t}, X_t, N_{w,t}) = \frac{(C_{w,t}X_t^{-b})^{1-\sigma} - 1}{1-\sigma} - \frac{\gamma N_{w,t}^{1+\eta}}{1+\eta},$$

with $X_t := C_{i,t}/C_{w,t}$. In the following, we investigate two alternative specifications for X_t.

Table 14: Estimated parameters, data and simulated moments for different η

	Parameter	$\eta = 1$	$\eta = 3$	$\eta = 5$
Relative consumption motive	b	2.9198	3.4553	3.6561
Risk aversion parameter	σ	4.1754	4.7909	5.0697
Debt adjustment cost parameter	ϕ	0.9961	1.6054	2.1444
AR-coefficient investment specific technology shock	ρ_ζ	0.9181	0.9076	0.8989
Standard deviation investment shock	σ_ζ	0.0102	0.0104	0.0105
AR-coefficient wage markup shock	ρ_ν	0.6080	0.5634	0.5301
Standard deviation wage markup shock	σ_ν	0.0281	0.0511	0.0688

	$\rho(x_t, D_t)$				σ_x/σ_D			
	Data	$\eta = 1$	$\eta = 3$	$\eta = 5$	Data	$\eta = 1$	$\eta = 3$	$\eta = 5$
Output	0.1523	0.1246	0.1171	0.1057	0.4568	0.3364	0.3322	0.3291
Consumption	0.1658	0.1548	0.1489	0.1434	0.2783	0.3046	0.3102	0.3156
Investment	0.0852	0.0227	0.0128	−0.0024	1.7524	1.0194	1.0105	1.0211
Hours worked	0.3603	0.4112	0.4367	0.4674	0.5080	0.5619	0.5390	0.5175
Real wage	−0.3207	−0.5422	−0.5579	−0.5805	0.3994	0.4977	0.5028	0.5115
	$\rho(x_t, Y_t)$				σ_x/σ_Y			
	Data	$\eta = 1$	$\eta = 3$	$\eta = 5$	Data	$\eta = 1$	$\eta = 3$	$\eta = 5$
Consumption	0.8020	0.7468	0.7435	0.7314	0.6092	0.9059	0.9342	0.9594
Investment	0.9061	0.7086	0.6848	0.6633	3.8359	3.0321	3.0435	3.1041
Hours worked	0.8144	0.6797	0.6334	0.5790	1.1120	1.6717	1.6245	1.5749
Real wage	0.0023	−0.2883	−0.2151	−0.1381	0.8743	1.4819	1.5164	1.5573

Note: $\rho(x_t, D_t)$ is the cross-correlation of variable x with credit, σ_x/σ_D is the std. deviation of variable x relative to the std. deviation of credit.

C.3.1 Absolute consumption externality

First, we consider the case of an absolute consumption externality (AbsCE), i.e. $X_t := C_{i,t}$, which implies that workers' utility is decreasing (increasing) in the investors' consumption for a positive (negative) b. Moreover, this implies that the workers' MRS is increasing (decreasing) in the investors' consumption if b is positive (negative).

To relate such a specification to our baseline case, we assume that the externality is defined as

$$X_t = \frac{C_{i,t}}{(C_{w,t})^\omega}, \quad \text{with } \omega \in [0, 1], \tag{61}$$

where $\omega = 0$ is the case of an absolute externality, $\omega = 1$ is our baseline case, and $\omega \in (0, 1)$ are intermediate cases. Table 15 reports the estimated values of b and σ for different ω values, together with the implied moments by these specifications.

We find that the estimates for b are slightly u-shaped in ω, and that higher higher values for ω are associated with higher estimates for σ, although not in a monotonic relation. Regarding the targeted moments, all specifications generate a positive correlation between consumption and credit. The purely absolute consumption externality ($\omega = 0$), however, is not able to reproduce the positive correlation between output and consumption. In general, higher ω perform better in matching correlations, which is also mostly true for relative standard deviations. Since the higher ω, the closer the specification to our baseline, and therefore, we conclude that an absolute consumption externality is inferior to a relative externality. Intermediate specifications, however, do a good job in matching the targeted moments.

Table 15: Estimated parameters, data and simulated moments for different ω (AbsCE)

	$\omega = 0$	$\omega = 0.2$	$\omega = 0.4$	$\omega = 0.6$	$\omega = 0.8$	$\omega = 1$
b	1.8306	2.4559	2.8711	3.0020	2.9522	2.9122
σ	3.4350	3.1005	3.8274	4.1877	4.1789	4.1682

	$\rho(x_t, D_t)$						
	Data	$\omega = 0$	$\omega = 0.2$	$\omega = 0.4$	$\omega = 0.6$	$\omega = 0.8$	$\omega = 1$
Output	0.1523	−0.0002	0.0789	0.1151	0.1293	0.1275	0.1255
Consumption	0.1658	0.1581	0.1608	0.2263	0.1706	0.1614	0.1537
Investment	0.0852	−0.1261	−0.0308	−0.0172	0.0239	0.0233	0.0228
Hours worked	0.3603	0.7306	0.5304	0.4662	0.4027	0.4068	0.4104
Real wage	−0.3207	−0.6312	−0.6052	−0.5443	−0.5392	−0.5402	−0.5406
	σ_x/σ_D						
	Data	$\omega = 0$	$\omega = 0.2$	$\omega = 0.4$	$\omega = 0.6$	$\omega = 0.8$	$\omega = 1$
Output	0.4568	0.1488	0.3705	0.3655	0.3582	0.3460	0.3362
Consumption	0.2783	0.1350	0.2908	0.2611	0.3035	0.3045	0.3044
Investment	1.7524	0.6293	1.1734	1.2457	1.0137	1.0130	1.0199
Hours worked	0.5080	0.1306	0.4855	0.5614	0.5674	0.5644	0.5620
Real wage	0.3994	0.2099	0.5382	0.5729	0.4764	0.4875	0.4973

C.3.2 Additive consumption externality

Second, we consider the case of an additive consumption externality (AddCE), i.e. $X_t := C_{i,t} - C_{w,t}$, which implies that workers' utility is decreasing (increasing) in the difference between investors' and workers' consumption for a positive (negative) b. Moreover, this also implies that the workers' MRS is increasing (decreasing) in the consumption difference for a positive (negative) b.

As in the previous case, we investigate a flexible form that nests different cases, namely

$$X_t := C_{i,t} - \omega C_{w,t}, \quad \text{with } \omega \in [0, 1], \tag{62}$$

where $\omega = 0$ refers to the case of the absolute consumption externality, while $\omega = 1$ is simply the difference between the investors' and the workers' consumption level. One major difference to the baseline and AbsCE is the domain of the utility function. While it was $\mathbb{R}^2_+ \times [0,1]$ so far, it now shrinks to $\mathcal{S} \times [0,1]$, where $\mathcal{S}$ is defined as

$$\mathcal{S} := \left\{ (C_{w,t}, C_{i,t}) \in \mathbb{R}^2_+ | X_t > 0 \right\} \subset \mathbb{R}^2_+, \tag{63}$$

which is clearly smaller than $\mathbb{R}^2_+$. Table 16 reports the estimated values for b and σ for different ω values, as well as the implied moments of these specifications.

We find that the estimates for b are increasing in ω, while the opposite is true for σ. Moreover, higher ω perform better in terms of matching correlations and relative standard deviations. The case of an unweighted difference in consumption levels performs best in this respect and is comparable to the baseline results. However, since these specifications displayed stability issues during our simulations, we conclude that our baseline choice is superior.

Table 16: Estimated parameters, data and simulated moments for different ω (AddCE)

	$\omega = 0$	$\omega = 0.2$	$\omega = 0.4$	$\omega = 0.6$	$\omega = 0.8$	$\omega = 1$
b	1.8306	1.8095	1.9796	2.0924	2.2314	2.3204
σ	3.4350	3.2735	3.0692	2.8582	2.6520	2.5465

	$\rho(x_t, D_t)$						
	Data	$\omega = 0$	$\omega = 0.2$	$\omega = 0.4$	$\omega = 0.6$	$\omega = 0.8$	$\omega = 1$
Output	0.1523	−0.0002	0.0712	0.0569	0.1143	0.1064	0.1156
Consumption	0.1658	0.1581	0.2211	0.2126	0.1802	−0.0144	0.2129
Investment	0.0852	−0.1261	−0.1027	−0.1042	0.0001	0.1419	−0.0027
Hours worked	0.3603	0.7306	0.7714	0.7619	0.8112	0.8313	0.5089
Real wage	−0.3207	−0.6312	−0.6411	−0.6470	−0.7011	−0.7802	−0.5732

	σ_x / σ_D						
	Data	$\omega = 0$	$\omega = 0.2$	$\omega = 0.4$	$\omega = 0.6$	$\omega = 0.8$	$\omega = 1$
Output	0.4568	0.1488	0.1709	0.1682	0.2236	0.2890	0.3525
Consumption	0.2783	0.1350	0.1586	0.1535	0.1765	0.1705	0.2457
Investment	1.7524	0.6293	0.7064	0.7269	0.8578	1.0251	1.2390
Hours worked	0.5080	0.1306	0.1706	0.1727	0.2629	0.3754	0.5360
Real wage	0.3994	0.2099	0.2580	0.2623	0.3759	0.5152	0.5758

D Log-linearized equations

Investors:

$$\widehat{\Lambda}_{i,t} + \widehat{C}_{i,t} = 0 \tag{64}$$

$$\widehat{\Lambda}_{i,t+1} = \widehat{Q}_t^d + \widehat{\Lambda}_{i,t} \tag{65}$$

$$\widehat{\Lambda}_{i,t+1} + (1 - \beta_i(1-\delta))\widehat{R}_{i,t+1} - \beta_i(1-\delta)\widehat{\zeta}_{i,t+1} = \widehat{\Lambda}_{i,t} - \widehat{\zeta}_{i,t} \tag{66}$$

$$\bar{R}\bar{K}_i(\widehat{R}_t + \widehat{K}_{i,t-1}) + \bar{D}_i\widehat{D}_{i,t-1} + \frac{\bar{\Pi}}{\chi}\widehat{\Pi}_t - \bar{C}_i\widehat{C}_{i,t} - \bar{I}_i\widehat{I}_{i,t} - \bar{Q}^d\bar{D}_i(\widehat{Q}_t^d + \widehat{D}_{i,t}) = 0 \tag{67}$$

Workers:

$$\widehat{\Lambda}_{w,t} + (\sigma + b(\sigma-1))\widehat{C}_{w,t} - (b(\sigma-1))\widehat{C}_{i,t} = 0 \tag{68}$$

$$\widehat{\Lambda}_{w,t} + \widehat{W}_t - \eta\widehat{N}_{w,t} - \widehat{\nu}_t = 0 \tag{69}$$

$$\widehat{\Lambda}_{w,t+1} + \frac{\phi\bar{D}_w}{\bar{Q}^b}\widehat{D}_{w,t} = \widehat{\Lambda}_{w,t} + \widehat{Q}_t^b \tag{70}$$

$$\bar{W}\bar{N}_w(\widehat{W}_t + \widehat{N}_{w,t}) + \bar{Q}^b\bar{D}_w(\widehat{Q}_t^b + \widehat{D}_{w,t}) - \bar{C}_w\widehat{C}_{w,t} - \bar{D}_w\widehat{D}_{w,t-1} = 0 \tag{71}$$

Production:

$$\widehat{Y}_t - \widehat{z}_t - (1-\alpha)\widehat{N}_t - \alpha\widehat{K}_{t-1} = 0 \tag{72}$$

$$\widehat{MC}_t + \widehat{\mu}_t = 0 \tag{73}$$

$$\widehat{MC}_t - (1-\alpha)\widehat{W}_t - \alpha\widehat{R}_t + \widehat{z}_t = 0 \tag{74}$$

$$\widehat{W}_t + \widehat{N}_t - \widehat{R}_t - \widehat{K}_{t-1} = 0 \tag{75}$$

$$\widehat{K}_t - \delta\widehat{I}_t - (1-\delta)\widehat{K}_{t-1} = 0 \tag{76}$$

$$\bar{\Pi}\widehat{\Pi}_t - \bar{Y}\widehat{Y}_t + \bar{R}\bar{K}(\widehat{R}_t + \widehat{K}_{t-1}) + \bar{W}\bar{N}(\widehat{W}_t + \widehat{N}_t) = 0 \tag{77}$$

Intermediaries/Credit market:

$$(\bar{Q}^d + \bar{Q}^d\psi\kappa B^{\kappa-1})\widehat{Q}_t^d - \bar{Q}^b\widehat{Q}_t^b - (1-\bar{Q}^d)(\kappa-1)\psi\kappa\bar{B}^{\kappa-1}\widehat{B}_t = 0 \tag{78}$$

$$\bar{D}D_t - (\bar{B} + \psi\kappa\bar{B}^{\kappa})\widehat{B}_t = 0 \tag{79}$$

$$\widehat{D}_t - \widehat{D}_{i,t} = 0 \tag{80}$$

$$\widehat{B}_t - \widehat{D}_{w,t} = 0 \tag{81}$$

$$\bar{\varpi}\widehat{\varpi}_t + \bar{Q}^b\widehat{Q}_t^b - (\bar{Q}^d\bar{\varpi} + \bar{Q}^d)\widehat{Q}_t^d = 0 \tag{82}$$

Aggregation and market clearing:

$$\widehat{K}_t - \widehat{K}_{i,t} = 0 \tag{83}$$

$$\widehat{N}_t - \widehat{N}_{w,t} = 0 \tag{84}$$

$$\widehat{I}_t - \widehat{I}_{i,t} = 0 \tag{85}$$

$$\widehat{C}_t - \chi \bar{C}_i \widehat{C}_{i,t} - (1-\chi)\bar{C}_w \widehat{C}_{w,t} = 0 \tag{86}$$

Shocks:

$$\widehat{z}_t = \rho_z \widehat{z}_{t-1} + \varepsilon_{z,t} \tag{87}$$

$$\widehat{\mu}_t = \rho_\mu \widehat{\mu}_{t-1} + \varepsilon_{\mu,t} \tag{88}$$

$$\widehat{\nu}_t = \rho_\nu \widehat{\nu}_{t-1} + \varepsilon_{\nu,t} \tag{89}$$

$$\widehat{\zeta}_t = \rho_\zeta \widehat{\zeta}_{t-1} + \varepsilon_{\zeta,t} \tag{90}$$

E Weighting matrix

To compute the weighting matrix W, we make use of the procedure described in Den Haan and Levin (1997). This algorithm generates the optimal weighting matrix based on the VARHAC-estimator. As described in the main text, we only use the diagonal of the resulting matrix. Additionally, we want to incorporate prior knowledge about the parameters we estimate to avoid implausible values. In particular, we choose prior means for each parameter (see Table 3) so that deviations from these means increase the value of the objective function. We also expand W by attaching penalty terms to the diagonal. These penalties determine how much the deviation from a respective mean is punished.

In the case where we only use the diagonal of the optimal W, we observe that the minimization routine chooses σ and b to be extremely high without improving the targeted moments tangibly. We therefore implicitly impose that $\sigma \in (1, 10]$, which is a reasonably generous interval for this parameter.[25] We also impose that b should not be too high because microeconometric studies find a significant but moderate reference consumption behavior. Therefore, we relate the penalty terms corresponding to these two parameters to the highest on the diagonal of W, which is then the lowest on W^{-1}. We choose them to be a tenth of this entry because this ensures that our two assumptions hold and, on the other hand, that the penalties are still significantly smaller than all other entries in the adjusted W^{-1}. These "soft bounds" then imply that deviations from the chosen mean are only tolerated if they imply significant reductions in the objective function value. In the specific case of b, this implies that a positive (or similarly a negative) value is only chosen if this leads to significantly better moments. For the other parameters, we find that there is no need to use any penalty at all. Table 17 summarizes the entries on the diagonal of our W^{-1}.

Table 17: Entries in the inverse weighting matrix

Moment/Parameter	Value
Corr(Output, Credit)	$1.6033e+08$
Corr(Consumption,Credit)	$3.5189e+08$
Corr(Investment, Credit)	$1.8559e+06$
Corr(Hours, Credit)	$5.0493e+07$
Corr(Wage, Credit)	$6.8707e+07$
Std(Output)/Std(Credit)	$1.6195e+08$
Std(Consumption)/Std(Credit)	$7.5977e+07$
Std(Investment)/Std(Credit)	$7.1863e+07$
Std(Hours)/Std(Credit)	$4.9029e+07$
Std(Wage)/Std(Credit)	$3.1813e+07$
Relative consumption motive b	$1.8559e+04$
Inverse substitution elasticity σ	$1.8559e+04$
Debt adjustment cost parameter ϕ	0.0
AR-coefficient inv. specific technology shock ρ_ζ	0.0
Standard deviation investment shock σ_ζ	0.0
AR-coefficient wage markup shock ρ_ν	0.0
Standard deviation wage markup shock σ_ν	0.0

[25] As already stated, we have to rule out the case of $\sigma = 1$ because of the specific functional form of the workers' utility function.