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Mathias Klein and Christopher Krause[1]

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

Abstract

In this study, the relation between consumer credit and real economic activity during the Great Moderation is studied in a dynamic stochastic general equilibrium model. 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 seek to minimize the difference between investors' and their own consumption level. Qualitatively, an income redistribution from labor to capital leads to consumer credit dynamics that are in line with the data. As a validation exercise, we simulate a three-shock version of the model and find that our theoretical set-up is able to reproduce important business cycle correlations.

JEL Classification: E21, E32, E44

Keywords: Income redistribution; consumer credit; relative consumption motive; business cycles

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1 Introduction

This paper seeks to explain the relation between consumer credit and real economic activity during the Great Moderation. For this purpose, we propose a dynamic stochastic general equilibrium model that is able to replicate the business cycle dynamics related to consumer credit as a source of household debt. Our work is motivated by two facts. First, the sharp rise in consumer credit over the last decades, and second, the distinct cyclical properties of the various types of household debt.[1] Both of these observations are illustrated in more detail now.

In the US economy, consumer credit increased substantially over the last decades. For the period of the Great Moderation[2], consumer credit is the second largest private liability and averages 24% of total household debt. Figure 1 displays the evolution of consumer credit in the US economy. Specifically, the left panel illustrates the absolute magnitude in the US, whereas the right panel shows consumer credit relative to labor income. In absolute terms, consumer credit grows over the whole period and starts to accelerate from the mid-1990s onwards. As a fraction of labor income, consumer credit fluctuates around a relatively constant mean from 1982 to the mid-1990s and increases strongly in the second half of the sample. Overall, the ratio of consumer credit to labor income grows from 20% in 1982 to 33% in 2008.

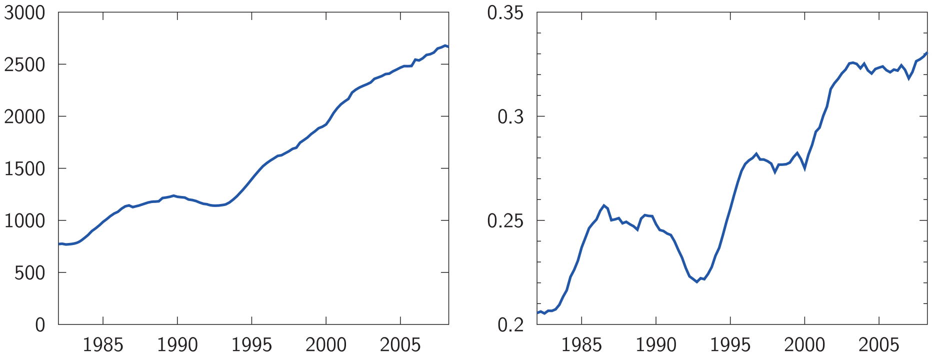
Given this significant private debt accumulation, there is a growing interest in the interrelation between household liabilities and aggregate activity in the short-run. While most of the theoretical literature concentrates on the dynamics of housing debt, the behavior of consumer credit over the business cycle is widely ignored. This would be justified if both series behave the same in the short-run. However, the motivation for this paper is the fact that the business cycle dynamics of consumer credit are different to those of mortgages. The upper part of Table 1 reports business cycle correlations for both consumer credit and housing debt for the Great Moderation. In particular, US data show a positive correlation of both types of household debt with consumption and hours worked from the beginning of the 1980s to the financial crisis in 2008. While both debt series show the exact same correlation with consumption, the correlation between credit and hours worked is about four times as large as the mortgages-hours correlation. Another crucial difference is the relation to real wages. Whereas the correlation coefficient between consumer credit and real wages is -0.32, home mortgages show a positive correlation with wages. The correlation coefficient between both debt types is 0.20, implying that the two

[1]In general, household debt can be categorized into two groups, collateralized debt and non-collateralized debt. In the US economy, home mortgages is the largest collateralized liability, whereas consumer credit accounts for the largest share of non-collateralized debt.

[2]Following Iacoviello and Pavan (2013), and Andrés et al. (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).

Figure 1: Consumer credit.

(a) Consumer credit (in billion US-$) (b) Consumer credit to labor income



Note: Consumer credit and labor income have been deflated using the price index of personal consumption expenditures. For data definitions and sources see Appendix.

series display only a weak positive co-movement in the short-run.[3] These observations suggest that there exist not only quantitative but also qualitative differences between the movements of consumer credit and housing debt over the business cycle. We take this different dynamic behavior as primary motivation to analyze and solely concentrate on consumer credit as a form of non-collateralized debt in the following.

To explain the relation between consumer credit and real economic activity, we propose a business cycle model based on Kumhof and Rancière (2010) and Kumhof et al. (2013) (KRW, henceforth). In their study, KRW show how permanent changes in the income distribution lead to higher household indebtedness which finally makes the outburst of a financial crises more likely. Similar to KRW, our 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. We extend their framework by two components, (i) a mechanism through which a redistribution from labor towards capital takes place, and (ii) a mechanism through which workers value their own level of consumption relative to the investors' level of consumption.[4] We discuss both of these ingredients in more detail now.

The redistribution is modeled as an exogenous shock that magnifies the wedge between the marginal product of labor and the wage rate.[5] In isolation, the redistribution causes

[3]The relation of both types of household debt with output and investment is almost acyclical.

[4]In the theoretical literature, short-run dynamics of housing debt are mainly explained by time-varying loan-to-value ratios in the households borrowing constraint (Iacoviello, 2008; Iacoviello and Pavan, 2013). However, since consumer credit is non-collateralized, this explanation does not seem applicable.

[5]Given this definition, the redistribution shock is equivalent to a price markup shock or labor wedge on the firm side (Chari et al., 2007).

Table 1: Business cycle correlations (1982q1-2008q2)

	Consumer credit		Housing debt	
Consumption	0.32	(0.10)	0.32	(0.10)
Hours worked	0.36	(0.09)	0.09	(0.07)
Real wage	−0.32	(0.09)	0.30	(0.08)
Consumer credit	-		0.20	(0.30)
	Profits			
Real wage	−0.38	(0.11)		
Labor share	−0.47	(0.14)		
Labor income	−0.14	(0.04)		

Note: Consumer credit, housing debt, profits and labor income have 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. Standard errors in parentheses are based on the Newey and West (1994) estimator with a Bartlett kernel and bandwidth given by $\lfloor 4(T/100)^{2/9} \rfloor$. For data definitions and sources see Appendix.

a decline in wages and an increase in profits, which lead to a rise in the investors' income, and consequently, to a higher consumption level of investors. On the other hand, the decreasing wage rate causes workers' income and consumption to drop, while credit demand increases. Therefore, a standard business cycle model, in which optimal consumption decisions are mainly driven by smoothing incentives, does not generate a positive co-movement between consumption expenditures and consumer credit, as observed in the data. To overcome this shortcoming, we include a relative consumption motive that we refer to as *keeping up with the Riches*. This mechanism forces workers to minimize the difference between investors' and their own consumption level so that workers increase labor supply and borrow from investors when the redistribution shock hits the economy. As a result of incorporating the relative consumption motive, the redistribution produces positive correlations between consumption, labor and consumer credit, while there is a negative co-movement between wages and credit. All these model responses are in line with the empirical observations reported in the upper part of Table 1.

Including such a redistribution is motivated by the observation that real wages and the labor share are negatively correlated with corporate profits over the considered period of time. As the lower part of Table 1 reveals, the respective correlation coefficients are -0.38 and -0.47. Moreover, the data show a negative correlation between profits and labor income. In our model, this is captured by the redistribution shock, which directly generates these negative co-movements.

The relative consumption motive in the utility function of the working households is backed by recent empirical work. In particular, Heffetz (2011) studies the importance of conspicuous consumption between different income groups. He finds that among the whole income distribution, income elasticities can mainly be explained by status consumption motives of individuals. In addition, Bertrand and Morse (2013) find empirical evidence 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. Similar, Alvarez-Cuadrado and El-Attar (2012) show that interpersonal comparison is an important factor for the declining saving rates of the bottom half of the income distribution observable for the last three decades. 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. In addition, while we focus on the period of the Great Moderation, Coibion et al. (2014) use data just ranging from 2001-2012. Therefore, we do not see their findings as a contradiction to our analysis.

In our theoretical set-up, income redistribution in favor of investors leads workers to increase consumption expenditures to minimize differences in consumption levels. Such a mechanism is also considered in the models by Al-Hussami and Remesal (2012), Alvarez-Cuadrado and El-Attar (2012), and Kim and Ryoo (2013).[6]

There are some recent papers focusing on the relation between household debt and economic activity. In a model consisting of two agents, KRW study the effects of increasing inequality on household debt and the potential outburst of a crisis in the long-run. Iacoviello (2008) constructs a heterogeneous agents set-up that is able to mimic the long-run evolution of income inequality and household debt as well as the cyclical behavior of debt. Campbell and Hercowitz (2005) propose a borrower-saver model that can replicate the observed falling volatility of main aggregate variables such as output, consumption and hours worked as well as household debt starting with the beginning of the Great Moderation. By setting up an overlapping generations model, Iacoviello and Pavan (2013) study the effects of higher individual income risk and lower downpayments on mortgage debt. In a two household economy, Ravenna and Vincent (2014) show how differential productivity shocks affect income inequality and household debt. However, none of these studies focus on the business cycle correlations of consumer credit or deliver an explanation for the relationship between credit and aggregate economic activity.

The rest of the paper is organized as follows. Section 2 presents the model. In Section 3, the calibration strategy is described. Section 4 discusses qualitative results, shown by impulse responses of the structural shocks in our model. In particular, we examine

[6] Al-Hussami and Remesal (2012) study the connection between income inequality and current account imbalances, whereas Alvarez-Cuadrado and El-Attar (2012) explain changes in individual and aggregate saving rates by an increase in inequality. Kim and Ryoo (2013) use the relative consumption motive to match long-run dynamics of debt accumulation and consumption.

the effects of the redistribution shock as well as the responses of a technology and a wage markup shock, both central components in state-of-the-art business cycle models. We show that the redistribution shock is able to replicate the business cycle dynamics concerning consumer credit, while the two other shocks fail to reproduce the positive co-movement between consumer credit and consumption. In Section 5, we simulate the fully fledged model for the Great Moderation and compare the simulated correlations with their empirical counterparts. It turns out that the model is also able to reproduce important business cycle correlations quantitatively. Finally, Section 6 concludes.

2 The model economy

This section outlines our baseline model, which consists of two types of households, a continuum of firms producing intermediate goods, a representative final good firm, and a representative labor bundler.

2.1 Households

The model economy is populated by a continuum of infinitely lived households, indexed on the unit interval. Following KRW, a fraction χ of households, termed as *investors* (subscript i), holds the entire stock of physical capital and owns firms, while the remaining fraction, $1-\chi$, termed as *workers* (subscript w), makes up the entire labor force. Moreover, investors issue credit to workers. In contrast to KRW, we abstract from any default on consumer credit. For our period of interest, the Great Moderation, delinquency rates on consumer credit in the US move around a stable mean and does not start to accelerate until the Great Recession. Similar to small open economy models, we need a mechanism in our model that rules out random walk components in the equilibrium dynamics.[7] Therefore, we integrate wealth in the utility function of investors (WIU).[8] Furthermore, the respective shares of households are fixed.

2.1.1 Investors

Investors maximize their lifetime utility function

$$E_0 \sum_{t=0}^{\infty} \beta_i^t U_i(C_{i,t}, D_{i,t}), \tag{1}$$

where β_i is the specific discount factor of investors, and U_i is the period utility function. As KRW, we assume that investors derive utility from consumption, $C_{i,t}$, and financial

[7] Schmitt-Grohé and Uribe (2003) compare different modeling strategies that induce stationarity within small open economy models.

[8] In Section 3.4, we show that our model produces similar results when including a quadratic debt adjustment cost for workers instead of WIU.

wealth, $D_{i,t}$. The latter assumption is extensively discussed in Carroll (2000) who argues that the savings behavior of top-earners within the US economy cannot be explained by models, in which the only purpose of wealth accumulation is financing future consumption. Instead, the author suggests to integrate financial assets into utility functions.

In our framework, wealth appears in the form of credit issued to workers, $D_{i,t}$. We assume an additive log-utility structure, which leads to the functional form

$$U_i(C_i, D_i) = \log(C_i) + \varphi_d \log(D_i), \tag{2}$$

where $\varphi_d > 0$ is the utility weight on outstanding debt to workers. The investors' budget constraint is given by

$$C_{i,t} + I_{i,t} + Q_t D_{i,t} \leq D_{i,t-1} + R_t K_{i,t-1} + \frac{\Pi_t}{\chi}, \tag{3}$$

where $I_{i,t}$ denotes investment, Q_t is the time t price of a credit that yields one unit of output in $t+1$, R_t is the rental rate of capital, and Π_t/χ is the individual share of profits from ownership of firms. The law of motion for physical capital is

$$K_{i,t} = (1-\delta)K_{i,t-1} + I_{i,t}, \tag{4}$$

where δ is the depreciation rate. Investors maximize (1) subject to (3) and (4) so that the first order conditions are given by

$$\Lambda_{i,t} = \frac{1}{C_{i,t}}, \tag{5}$$

$$\Lambda_{i,t} = \beta_i E_t \Lambda_{i,t+1}(R_{t+1} + 1 - \delta), \tag{6}$$

$$\Lambda_{i,t} Q_t = \frac{\varphi_d}{D_{i,t}} + \beta_i E_t \Lambda_{i,t+1}. \tag{7}$$

Here, $\Lambda_{i,t}$ denotes the Lagrange multiplier associated with (3). The no-Ponzi-game constraint is given by

$$\lim_{j\to\infty} E_t \frac{D_{i,t+j}}{\prod_{s=0}^{j} \frac{1}{Q_{t+s}}} \leq 0. \tag{8}$$

2.1.2 Workers

Each working household j maximizes the utility function

$$E_0 \sum_{t=0}^{\infty} \beta_w^t U_w \left(C_{w,t}, C_{i,t}, N_{w,t}(j)\right), \tag{9}$$

where β_w is the specific discount factor of workers. Here, we assume that this subset of households derives utility from their own level of consumption, $C_{w,t}$, but disutility from individual working effort, $N_{w,t}(j)$, and the investors' level of consumption, $C_{i,t}$. Including this consumption externality mechanism is backed by microeconometric studies, which find that relative income and consumption differences significantly affect subjective well-being.[9] Additionally, Bertrand and Morse (2013) show that increasing consumption expenditures in the upper part of the income distribution, induce households in the lower tiers to consume a larger share of their income.

Formally, the workers' period utility is given by

$$U_w(C_w, C_i, N_w(j)) = \log\left(C_w - b\frac{C_i}{C_w}\right) - \frac{\gamma N_w(j)^{1+\eta}}{1+\eta}, \tag{10}$$

where γ is a scaling parameter, and η is the inverse Frisch elasticity. Adapting the specification of Dupor and Liu (2003), we model b as a "jealousy" parameter (i.e. $b \geq 0$), implying that an increase in the investors' consumption level leads to a decrease in the workers' utility level.[10]

Workers face the following budget constraint,

$$C_{w,t} + D_{w,t-1} \leq W_t(j)N_{w,t}(j) + Q_t D_{w,t}, \tag{11}$$

where $D_{w,t}$ denotes received credit at price Q_t, and $W_t(j)$ is the individual wage rate of household j. Letting $\Lambda_{w,t}$ be the workers' Lagrange multiplier on their budget constraint, the optimal choices for consumption and credit demand are determined by

$$\Lambda_{w,t} = \frac{1 + b\frac{C_{i,t}}{(C_{w,t})^2}}{C_{w,t} - b\frac{C_{i,t}}{C_{w,t}}}, \tag{12}$$

$$\Lambda_{w,t} Q_t = \beta_w E_t \Lambda_{w,t+1}. \tag{13}$$

2.2 Final good firms

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

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{1}{\mu_t}} di\right]^{\mu_t}, \tag{14}$$

[9] See e.g. McBride (2001), Blanchflower and Oswald (2004), or Luttmer (2005).

[10] Similar specifications of relative consumption motives are used by Alvarez-Cuadrado and El-Attar (2012) and Al-Hussami and Remesal (2012) who study the effect of rising inequality on individual saving rates and current account imbalances, respectively.

with $\mu_t > 1$. The elasticity μ_t follows an exogenous stochastic process around its steady state value $\bar{\mu}$ given by

$$\log \mu_t = (1 - \rho_\mu) \log \bar{\mu} + \rho_\mu \log \mu_{t-1} + \varepsilon_{\mu,t}, \tag{15}$$

where $\varepsilon_{\mu,t} \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma_\mu^2)$, and $0 < \rho_\mu < 1$. The firm chooses intermediate inputs to maximize profits subject to (14), which yields the demand function for intermediate good i,

$$Y_t(i) = Y_t \left(\frac{P_t(i)}{P_t} \right)^{\frac{\mu_t}{1-\mu_t}}, \tag{16}$$

and subsequently the price index of the final good,

$$P_t = \left[\int_0^1 P_t(i)^{\frac{1}{1-\mu_t}} di \right]^{1-\mu_t}. \tag{17}$$

2.3 Intermediate good firms

Each intermediate good is produced by a monopolistically competitive firm according to the Cobb-Douglas production function

$$Y_t(i) = z_t K_t(i)^\alpha N_t(i)^{1-\alpha}, \tag{18}$$

where $\alpha \in [0, 1]$ measures the capital income share. $K_t(i)$ and $N_t(i)$ denote the quantity of capital and labor services utilized to produce intermediate good i. z_t is the technology level common across all firms and follows an exogenous stochastic process around its steady state value $\bar{z}$,

$$\log z_t = (1 - \rho_z) \log \bar{z} + \rho_z \log z_{t-1} + \varepsilon_{z,t}, \tag{19}$$

where $\varepsilon_{z,t} \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma_z^2)$, and $0 < \rho_z < 1$.

Intermediate good firms maximize profits subject to the demand function (16) and to cost minimization. We assume identical firms and that prices are perfectly flexible so that marginal cost is 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,

$$W_t = \frac{MPL_t}{\mu_t}, \tag{20}$$

where $MPL_t = (1 - \alpha) Y_t / N_t$, and the rental rate of capital is a function of the marginal product of capital and μ_t. In the context of monopolistic competition, μ_t is also known as the price markup.

Since workers make up the entire labor force, a positive shock to the price markup shifts income from workers to investors. Thus, we refer to (15) as a *redistribution shock*.[11] 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.

2.4 Employment agencies

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, termed as *employment agency*, combines the intermediate labor services into a homogenous labor input, $N_{w,t}$, using the technology

$$N_{w,t} = \left[\int_0^1 N_{w,t}(j)^{\frac{1}{\nu_t}} dj \right]^{\nu_t}, \tag{21}$$

with $\nu_t > 1$. The elasticity ν_t follows an exogenous stochastic process around its steady state value $\bar{\nu}$,

$$\log \nu_t = (1 - \rho_\nu) \log \bar{\nu} + \rho_\nu \log \nu_{t-1} + \varepsilon_{\nu,t} \tag{22}$$

where $\varepsilon_{\nu,t} \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma_\nu^2)$, and $0 < \rho_\nu < 1$. The labor bundler operates in a perfectly competitive market such that profit maximization given (21) leads to the labor demand function

$$N_{w,t}(j) = N_{w,t} \left(\frac{W_t(j)}{W_t} \right)^{\frac{\nu_t}{1-\nu_t}}, \tag{23}$$

where W_t is the aggregate wage rate. By substituting (23) into (21), we obtain the following expression for the latter,

$$W_t = \left[\int_0^1 W_t(j)^{\frac{1}{1-\nu_t}} dj \right]^{1-\nu_t}. \tag{24}$$

We assume symmetric working households and, as for the final good price, that wages are perfectly flexible. Thus, the wage rate is defined as a function of the marginal rate of substitution, MRS_t, and the wage markup, ν_t,

$$W_t = \nu_t MRS_t, \tag{25}$$

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

where $MRS_t = \gamma N_{w,t}^{\eta}/\Lambda_{w,t}$. 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 Aggregation and market clearing

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

$$C_t = \chi C_{i,t} + (1-\chi) C_{w,t}, \tag{26}$$

$$K_t = \chi K_{i,t}, \tag{27}$$

$$I_t = \chi I_{i,t}, \tag{28}$$

$$N_t = (1-\chi) N_{w,t}. \tag{29}$$

Credit market clearing requires that

$$(1-\chi) D_{w,t} = \chi D_{i,t}, \tag{30}$$

while the aggregate resource constraint is given by

$$Y_t = C_t + I_t. \tag{31}$$

A competitive rational expectations equilibrium is a stochastic set of sequences $\{C_t,\, C_{i,t},\, C_{w,t},\, D_{i,t},\, D_{w,t},\, I_t,\, I_{i,t},\, K_t,\, K_{i,t},\, \Lambda_{i,t},\, \Lambda_{w,t},\, N_t,\, N_{w,t},\, \Pi_t,\, Q_t,\, R_t,\, W_t,\, Y_t\}_{t=0}^{\infty}$ satisfying the households' and firms' first-order conditions, as well as aggregation identities, market clearing conditions, and no-Ponzi-game constraints, given the exogenous realizations of $\{\mu_t,\, z_t,\, \nu_t\}_{t=0}^{\infty}$. The model is solved by a log-linear approximation around its deterministic steady state.

3 Calibration

Table 2 shows the parameter values of the models' baseline calibration, where an upper bar denotes the steady state value of the respective variable. The simulated data of the model are at a quarterly frequency. The depreciation rate of capital, δ, equals 2.5%, which corresponds to an annual depreciation rate on capital equal to 10 percent. The discount factor of workers β_w is set to 0.995. In the steady state, the workers' discount factor, β_w, is equal to the consumer credit price $\bar{Q}$. Due to WIU, β_i has to be lower than β_w. This

Table 2: Model calibration

	Parameter	Value
Preferences		
Discount factor, investors	β_i	0.99
Discount factor, workers	β_w	0.995
Inverse Frisch elasticity	η	1
Relative consumption motive	b	$\{0, 0.05, 0.1\}$
Capitalist spirit	φ^d	0.0055
Fraction of investors	χ	0.05
Technology		
Capital share	α	0.27
Capital depreciation rate	δ	0.025
Steady state		
Labor	$\bar{N}$	0.33
Credit-to-labor income	$\bar{D}_w/(\bar{W}\bar{N}_w)$	0.27
Price markup	$\bar{\mu}$	1.1
Wage markup	$\bar{\nu}$	1.1
Technology	$\bar{z}$	1

becomes clear when looking at the steady state conditions for credit supply by investors and credit demand by workers,

$$\beta_i = \bar{Q} - \frac{\varphi^d \bar{C}_i}{\bar{D}_i} \qquad \text{and} \qquad \beta_w = \bar{Q}.$$

Given positive steady state values for investors' consumption $\bar{C}_i$ and credit supply $\bar{D}_i$, WIU ($\varphi^d > 0$) requires $\beta_w > \beta_i$. Although investors discount the future more heavily than workers, investors are net savers, while workers are net borrowers in our set-up. This is in contrast to other models where more impatient households borrow from the patient in equilibrium (e.g. Campbell and Hercowitz, 2005; Iacoviello, 2008; Iacoviello and Pavan, 2013). In the baseline calibration, β_i is set to 0.99 so that the difference between both discount factors is rather small. In a latter robustness check, we show that our qualitative results still hold when workers face a quadratic debt adjustment cost (DAC) such that we can equate β_w and β_i.

Following KRW, the share of investors in the overall population, χ, is set to 5%. We normalize the steady state level of labor to 0.33 and set the inverse Frisch elasticity, η, to 1, which is in the range of values suggested by Hall (2009). The capital share parameter, α, equals 0.27. We set $\bar{\mu}$ and $\bar{\nu}$ to 1.1 so that steady state markups in the product and labor market are 10%, which is in the range of values typically used in the literature. The technology level $\bar{z}$ is normalized to 1.

The real interest rate on capital is calculated via the Euler equation of investors, which yields $\bar{R} = 0.035$. In equilibrium, marginal cost equals the inverse of the price markup. The steady state values for the rental rate of capital and marginal cost are used to calculate the steady state wage rate, which leads, subsequently, to the steady state level of capital. After obtaining the levels of both input factors, we are able to calculate the steady state output level. The resulting steady state investment-to-GDP ratio equals 17%, which is roughly in line with US data.

Because the price markup is larger than unity, profits are positive in equilibrium. By assuming a steady state consumer credit-to-labor income ratio for workers, $\bar{D}_w/(\bar{W}\bar{N}_w)$, of 27%, which is the average for the Great Moderation, and using the two budget constraints, we determine the consumption levels of both agents. The investors' consumption level is then used to obtain the respective shadow price of consumption $\bar{\lambda}_w$. With the use of all these steady state values, the utility weight on financial wealth φ^d can be calculated.

The workers' shadow price of consumption depends on the parameter b, which measures the strength of the relative consumption motive in their utility function. Given our specific calibration strategy, the set of values for b has an upper bound of 0.101, ensuring that standard assumptions for the utility function, i.e. $\partial U_w/\partial C_w > 0, \partial^2 U_w/(\partial C_w)^2 < 0$, are satisfied. In what follows, we examine how sensitive the model reacts to a set of three different choices for b, $\{0, 0.05, 0.1\}$, when the economy is hit by the structural shocks. Finally, after choosing b, the parameter γ is calibrated via the steady state labor supply condition.

4 Qualitative results

In Section 1, we show that for the period of the Great Moderation consumer credit exhibits

a) a positive correlation with consumption,

b) a positive correlation with hours worked,

c) a negative correlation with real wages.

In this section, we use our proposed model to study the effects of a technology shock, a wage markup shock and a redistribution shock, and assess their ability to reproduce these empirical relationships.

As mentioned above, the two markup shocks are closely related to the labor wedge, which is responsible for substantial unexplained cyclical fluctuations.[12] By including these

[12] See Hall (1997), Galí et al. (2007), Chari et al. (2007), Shimer (2009), Karabarbounis (2014).

shocks, we stress the importance of the labor wedge not only for labor market outcomes but also for the behavior of consumer credit over the past three decades.

For comparability purposes, we set the AR(1) coefficients of all three shocks, ρ_z, ρ_ν, ρ_μ, to 0.9 to induce a high degree of persistence and normalize the respective shock variances to 1. We present model responses for three different b values, $\{0, 0.05, 0.1\}$, to highlight the impact of the workers' relative consumption motive.

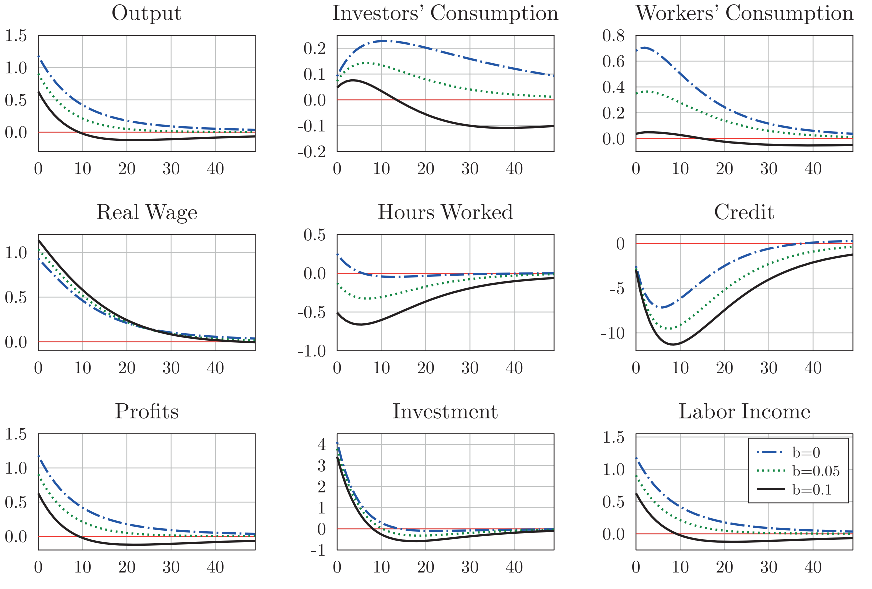
In an additional robustness analysis, we investigate the responses to the redistribution shock when including DAC instead of WIU.

4.1 Technology shock

Figure 2 shows the effects of a positive technology shock to the model economy. We first discuss the results for $b = 0$ (dash-dotted lines). An increase in z_t causes output to go up immediately. As a result of the output rise, the marginal products of labor and capital increase, leading to a higher wage rate and interest rate on capital. Investors invest more and workers increase their labor supply. Consequently, labor income increases more strongly than the wage rate. Real profits increase by a similar magnitude as output. A higher labor income leads to a falling demand for credit by workers. As both household groups receive higher incomes than in the steady state, investors as well as workers increase their consumption levels significantly. If the relative consumption motive is switched off, an exogenous productivity increase leads to a negative correlation between consumer credit and wages, as observable in the data. However, the shock is not able to reproduce the positive co-movement of consumer credit, labor, and consumption.

For the cases that $b > 0$, the results are slightly different. For $b = 0.05$ (dotted lines), profits and, therefore, investors' income and consumption increase by a smaller amount compared to $b = 0$. Since workers now seek to minimize the difference between both consumption levels, they also consume less than for $b = 0$. Consequently, workers increase leisure by reducing labor supply and, in addition, reduce credit demand even further. Although labor supply drops, labor income is still larger than in the steady state, as the absolute increase in the wage rate is stronger than the labor decrease. As a result, workers obtain a higher income. Given the negative response in labor, output increases by less than unity. All these effects are amplified, as b increases further. If $b = 0.1$ (solid lines), both consumption levels increase just slightly, whereas hours worked and consumer credit decline more sharply. To summarize, if the relative consumption motive is present, the technology shock is able to reproduce the negative correlation between consumer credit and wages, and leads to a positive co-movement between credit and labor. Nevertheless, the model generates a negative relation between consumer credit and consumption, which is in contrast to the data.

Figure 2: Impulse responses to a one standard deviation technology shock.



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

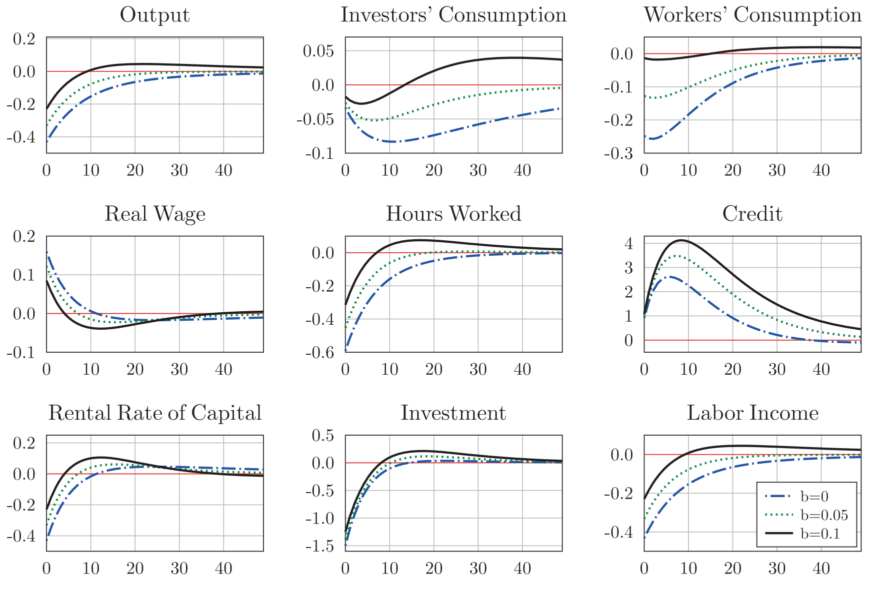
4.2 Wage markup shock

In Figure 3, the effects of a positive wage markup shock are presented. For $b = 0$ (dash-dotted lines), 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. This reduction is so strong that, although wages rise, workers' labor income declines. Consumption smoothing forces workers to demand a higher amount of credit. However, workers' consumption decreases on impact. As the interest rate on capital decreases, investment declines as well. Combined with the falling labor demand, output decreases immediately, which leads to lower profits received by investors. Consequently, investors also reduce their consumption level.

For the cases that $b > 0$, the results change quantitatively but not qualitatively. The downturns in hours worked, labor income and output are less strongly when b becomes larger. Similarly, profits fall by a smaller amount such that investors' consumption level decreases less. In addition, the reduction in workers' consumption is smaller for larger values of b.

In line with the data, the model generates a negative correlation between consumer credit and wages as a response to a wage markup shock. On the other hand, a wage markup shock leads to negative co-movements between consumer credit, consumption and

Figure 3: Impulse responses to a one standard deviation wage markup shock.



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

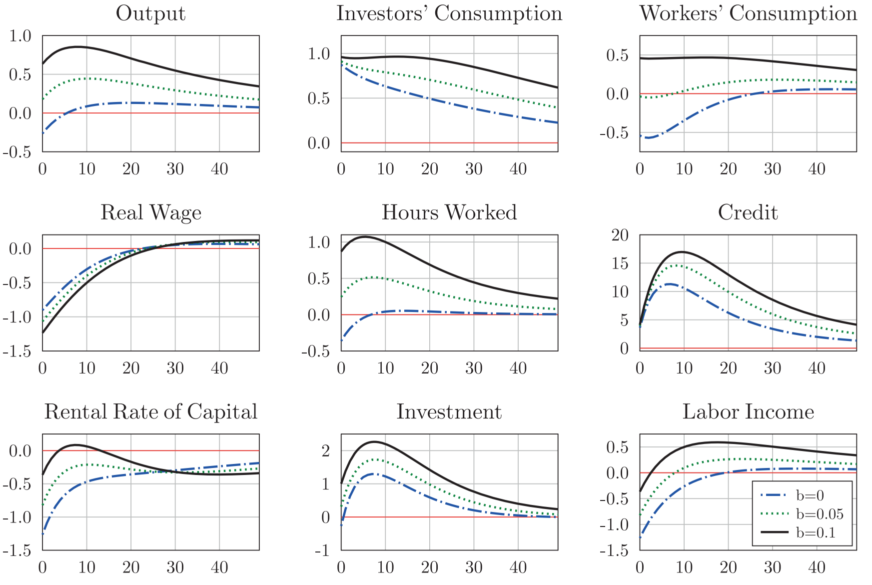
labor, which is not consistent with empirical observations. These results do not depend on the presence of the relative consumption motive in the workers' utility function.

4.3 Redistribution shock

Figure 4 presents the model responses of the redistribution 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 such that investors obtain a higher income and increase their consumption level. In the absence of the relative consumption motive ($b = 0$, dash-dotted lines), workers respond to the falling wage rate by reducing labor supply so that the absolute drop in labor income is stronger than the wage reduction. Workers enhance their demand for credit on impact to smooth consumption. However, as overall income is less than in the steady state, their consumption level is below the steady state as well.

The situation changes if $b > 0$ so that the workers' choice to consume also depends on the level of investors' consumption. Even for very small values of b, workers increase their labor supply although the wage rate is decreasing. As a result, the drop in labor income is dampened but still considerable. While for $b = 0.05$ (dotted lines) output is increasing on impact, the relative consumption motive is not strong enough to produce an increasing

Figure 4: Impulse responses to a one standard deviation redistribution shock.



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

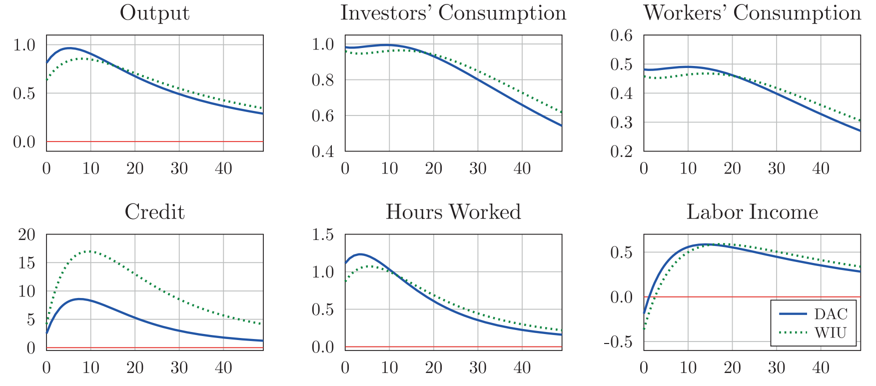
Table 3: Empirical and model correlations with consumer credit (Credit)

	Empirical correlation	Technology shock $b=0$	Technology shock $b>0$	Wage markup shock $b=0$	Wage markup shock $b>0$	Redistribution shock $b=0$	Redistribution shock $b>0$
Credit - Real wage	-	-	-	-	-	-	-
Credit - Hours worked	+	-	+	-	-	-	+
Credit - Consumption	+	-	-	-	-	-	-/+

consumption level of workers. As this incentive gets stronger, the response of labor supply is amplified such that the labor income decline on impact is almost disappearing. Finally, for $b = 0.1$ (solid lines), workers increase their own consumption level.

If $b = 0$, a redistribution shock produces a negative correlation between consumer credit and wages, and negative co-movements between credit, labor and consumption. For already small positive values of b, we observe a positive relation between credit and labor. Additionally, if b exceeds a certain threshold, redistribution in favor of investors leads to a positive correlation between consumer credit and consumption. Thus, if b becomes large enough, the model responses to a redistribution shock are perfectly in line with the data. Table 3 summarizes the major findings of our impulse response analysis.

Figure 5: Impulse responses to a one standard deviation redistribution shock, comparison between debt adjustment cost (DAC) and wealth in the utility (WIU).



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

4.4 Debt adjustment cost

In our baseline calibration, we integrate WIU to ensure stationarity of the equilibrium dynamics. In the following, we show that this assumption is not crucial for our qualitative findings. Similar to Iacoviello (2008), we incorporate DAC as an alternative modification that removes the random walk property.

In the absence of WIU ($\varphi_d = 0$), the investors' first-order condition for credit changes to

$$\Lambda_{i,t} Q_t = \beta_i E_t \Lambda_{i,t+1}. \tag{32}$$

The investors' optimality conditions for consumption and capital are still the same as in the baseline case. When facing DAC, workers maximize utility subject to the following budget constraint,

$$C_{w,t} + D_{w,t-1} \leq W_t(j) N_{w,t}(j) + Q_t D_{w,t} - \phi(D_{w,t} - \bar{D})^2, \tag{33}$$

where the last term represents a quadratic cost of holding a quantity of credit different from the steady state value $\bar{D}$. While the workers' first-order condition for consumption remains unchanged, the optimal demand for consumer credit now takes the form

$$\Lambda_{w,t} \left[Q_t - 2\phi \left(D_{w,t} - \bar{D} \right) \right] = \beta_w E_t \Lambda_{w,t+1}. \tag{34}$$

All remaining first-order conditions are identically equal to the baseline model. When considering the steady state of equation (33) and (34), it follows that $\beta_i = \beta_w = \bar{Q}$. Whereas incorporating WIU requires $\beta_w > \beta_i$, including DAC implies the same discount factors for both agents.

To solve the model, we set β_i and β_w to 0.99, and the adjustment cost parameter, ϕ, to an arbitrarily small value, here 0.05. The remaining parameter values are equal to the baseline calibration, summarized in Table 2. Figure 5 compares model responses to a redistribution shock when assuming WIU (dotted lines) or DAC (solid lines) for key variables. The relative consumption motive parameter, b, is 0.1 for both model constellations. Once again, the AR(1) coefficient of the shock process is set to 0.9 and we simulate a one standard deviation redistribution shock.

Qualitatively, the models' responses to a redistribution shock are similar, whether WIU or DAC is included. The redistribution from labor to capital leads to an increased consumption level of investors for both modeling strategies. To finance their desired level of consumption, workers demand more credit and supply more labor. However, in the presence of DAC, workers increase their credit demand by less compared to the baseline model because debt accumulation becomes more expensive. In contrast, labor supply rises stronger such that the income reduction is smaller on impact. Since workers supply more labor, output also goes up more strongly compared to the WIU baseline case. Finally, workers also raise their consumption expenditures in the presence of DAC if the economy is hit by a redistribution shock.

Although quantitatively there are some minor differences in the responses to the shock, qualitatively the model dynamics are the same. Both model variants lead to a negative relation between consumer credit and wages if redistribution happens in favor of capital. In addition, and in line with the data, impulse responses of both modeling strategies produce a positive co-movement between consumer credit, consumption, and labor if the economy faces a redistribution shock. Thus, the model responses to a redistribution shock do not rely on the WIU assumption.

5 Quantitative results

So far, we concentrated on qualitative findings. As an additional quantitative exercise, we simulate the model and assess its performance by comparing simulated correlation coefficients with their empirical counterparts for the Great Moderation in the US. In this simulation process, the model is driven by all three shocks: the technology shock, the redistribution shock, and the wage markup shock. Since we only use arbitrary values for the qualitative analysis, we need to specify the respective AR-coefficient and standard deviation of each shock. We estimate the characteristics of the technology shock and the redistribution shock by ordinary least squares (OLS). Due to data limitations, the remaining parameters are estimated with a Simulated Method of Moments (SMM) approach.

5.1 OLS estimation

As observation period, we select the Great Moderation, ranging from 1982q1 to 2008q2. With the exception of the capital stock series (AMECO database of the European Commission), all data series mentioned in the following are obtained from the FRED database.

The technology shock is calculated via the Solow residual,

$$z_t = y_t - (1-\alpha)n_t - \alpha k_t, \tag{35}$$

where y_t is the log of real output in the nonfarm business sector, n_t is the log of hours worked of all persons in the nonfarm business sector, and k_t is the log of net real capital stock of the whole economy (linear interpolation of annual values). All variables are detrended by the HP-filter with a smoothing value of 1600. The capital share of income, α, equals 0.27, as in the model calibration. The calculated Solow residual moves procyclically[13], and the estimated AR-coefficient and standard deviation are 0.7 and 0.008 respectively. These estimates are similar to the findings of Bullard and Singh (2012).

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

$$\mu_t = MPL_t - w_t, \tag{36}$$

where the marginal product of labor, MPL_t, equals $(1-\alpha)y_t/n_t$. y_t/n_t is measured as the log of real output per person 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 HP-filter. In line with the findings of Galí et al. (2007) and Karabarbounis (2014), the obtained shock series shows a weak procyclical behavior.[14] The estimates of the AR-coefficient and the standard deviation are 0.715 and 0.011 respectively, and thus, similar to those of Galí et al. (2007) and Karabarbounis (2014). The upper part of Table 4 summarizes the parameter values estimated by OLS.

[13] The correlation coefficient between the Solow residual and output is 0.52.

[14] The correlation coefficient between the constructed redistribution shock series and output equals 0.27.

5.2 SMM estimation

According to (25), 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 workers,

$$MRS_t = \frac{\gamma N_{w,t}^{\eta}}{\Lambda_{w,t}}, \quad \text{where} \quad \Lambda_{w,t} = \frac{1 + b\frac{C_{i,t}}{(C_{w,t})^2}}{C_{w,t} - b\frac{C_{i,t}}{C_{w,t}}}, \tag{37}$$

to calculate a wage markup series, we would need data on $C_{i,t}$ and $C_{w,t}$, 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, originally proposed by McFadden (1989) and Lee and Ingram (1991), to overcome the data problem. 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 have length τT and are generated from simulating the model given a draw of random shocks and the $p \times 1$ vector $\theta \in \Theta$, with $\Theta \subseteq \mathbb{R}^p$. Then, the SMM estimator is given by

$$\widetilde{\theta}_{SMM} = \underset{\theta \in \Theta}{\arg\min} \left[\widehat{\Omega} - \Omega(\theta)\right]' W^{-1} \left[\widehat{\Omega} - \Omega(\theta)\right], \tag{38}$$

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

Specifically, $\widehat{\Omega}$ contains the correlation coefficients of consumer credit with output, consumption, investment, hours worked, wage rate, and labor productivity, as shown in the first column of Table 5. $\widetilde{\theta}_{SMM}$ contains the estimates for b, ρ_ν, and σ_ν. For the weighting matrix, we follow Ruge-Murcia (2013) and Born and Pfeifer (2014), and choose a matrix with diagonal elements equal to the optimal weighting matrix while all off-diagonal elements are equal to zero.[15] 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).

All parameters are set as in the baseline calibration (see Table 2), except for those of $\widetilde{\theta}_{SMM}$. As mentioned above, the set of possible values for b has an upper bound at 0.101 to ensure that standard assumptions for the utility function are satisfied. The parameter measuring the persistence of the wage markup shock, ρ_ν, has to be smaller than 1 to

[15]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.

prevent unit root or explosive behavior of the shock. 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.

Table 4: Parameter values model simulation

	Parameter	Mean	Median	SD
	Parameter		Value	
OLS estimation				
AR(1)-coefficient technology shock	ρ_z		0.700	
Standard deviation technology shock	σ_z		0.008	
AR(1)-coefficient redistribution shock	ρ_μ		0.715	
Standard deviation redistribution shock	σ_μ		0.011	
	Parameter	Mean	Median	SD
SMM estimation				
Relative consumption motive	b	0.100	0.101	0.003
AR(1)-coefficient wage markup shock	ρ_ν	0.899	0.960	0.141
Standard deviation wage markup shock	σ_ν	0.060	0.048	0.039

Note: Mean is the average of the estimated parameter values, Median and SD are the median and standard deviation of the empirical parameter distribution. These statistics are based on 500 replications.

The results of the SMM estimation are shown in the lower part of Table 4. For b, we obtain an average value of 0.1 and a median of 0.101, indicating that in most simulations the imposed upper bound is reached. The AR-coefficient for the wage markup shock displays a high degree of persistence with a median of 0.96 and a somewhat smaller average. Both shock characteristics, ρ_ν and σ_ν, are close to the values of Galí et al. (2007), although it should be noted that they use a different utility function when calculating the wage markup series.

Table 5 reports the correlation coefficients obtained from the data and from the model simulation. The first two columns contain the relation of consumer credit to main aggregate variables. All these model moments are very close to those in the data with only minor discrepancies. The model coefficients for output and investment are slightly smaller than in the data, while the model-produced negative co-movement between consumer credit and real wage is slightly stronger than in the data. However, these 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.

Column 3 and 4 reveal the correlations between output and the remaining five measures. Note that the coefficients of column 3 were not included in the moment-matching approach. Thus, we interpret these results as the model's ability to important conventional business cycle relations.

Table 5: Data and simulated model correlations

	Consumer credit		Output	
	Data	Model	Data	Model
Output	0.15	0.10	-	-
Consumption	0.32	0.32	0.78	0.42
Investment	0.09	0.05	0.91	0.99
Hours worked	0.36	0.40	0.81	0.75
Real wage	−0.32	−0.50	0.00	0.23
Labor productivity	−0.41	−0.42	0.46	0.32

Note: Concerning data correlations, 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.

Simulating the model leads to a strong procyclical behavior of investment and hours worked with coefficients close to the empirical moments. The model is also able to produce positive co-movements between output and consumption, and output and labor productivity, although the empirical correlations are somewhat higher than their simulated counterparts. While the wage rate is completely acyclical in the data, the two series are weakly correlated in the model simulation. However, 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 strategy.

6 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 seek to minimize the difference between investors' and their own consumption level.

By inducing an income redistribution from labor to capital, the model generates dynamics that are in line with empirical evidence. More precisely, this redistribution leads to a positive correlation of consumer credit with consumption and labor, while there is a negative co-movement between consumer credit and the real wage. In contrast, both a technology shock and a wage markup shock are not able to generate the positive correlation between consumer credit and consumption. In an additional quantitative exercise, we estimate key parameters of the model and compare the simulated correlations with their empirical counterparts for the Great Moderation. By doing so, we obtain correlation coefficients between output and other main aggregate variables that are similar to the data correlations. We interpret this result as a validation of our theoretical set-up.

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Appendix: Data definitions and sources

Variable	Definition	Source	Series ID (FRED database)
Consumer credit	Level of consumer credit held by households and nonprofit organizations	Board of Governors of the Federal Reserve System	HCCSDODNS
Housing debt	Level of mortgages held by households and nonprofit organizations	Board of Governors of the Federal Reserve System	HHMSDODNS
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 person in the nonfarm business sector	U.S. Department of Labor: Bureau of Labor Statistics	PRS85006163
Consumption	Real personal consumption expenditures for nondurable goods	U.S. Department of Commerce: Bureau of Economic Analysis	DNDGRA3Q086SBEA
Investment	Real gross private domestic investment	U.S. Department of Commerce: Bureau of Economic Analysis	GPDIC96
Profits	Corporate profits after tax	U.S. Department of Commerce: Bureau of Economic Analysis	CP
Labor income	Compensation of employees	U.S. Department of Commerce: Bureau of Economic Analysis	W209RC1Q027SBEA
Labor share	Labor share in the nonfarm business sector	U.S. Department of Labor: Bureau of Labor Statistics	PRS85006173
Capital	Net real capital stock of the total economy at 2005 prices (linear interpolation of annual values)	AMECO database of the European Commission	
Prices	Chain-type price index of personal consumption expenditures	U.S. Department of Commerce: Bureau of Economic Analysis	PCECTPI