Financial Shocks or Productivity Slowdown: Contrasting the Great Recession and Recovery in the United States and United Kingdom

Kieran Larkin

This article contrasts the experiences of the United States and United Kingdom during and after the Great Recession to understand the role of financial shocks in the magnitude of the crises and length of the recoveries. It starts from the common consensus that the Great Recession first and foremost was a financial crisis. It shows that relative to the United States, the Great Recession in the United Kingdom was more closely associated with a decline in productivity. Motivated by the similar behavior of financial variables at a business cycle frequency, it contrasts the behavior of the U.S. and U.K. economies through the lens of a simple real business cycle model augmented with financial shocks. A credit channel that operates on firm hiring decisions captures the magnitude of the output decline in both the United States and United Kingdom but exaggerates the response of the hours margin for the United Kindgom. The conclusion is that the financial channel supported in the U.S. data seems less appropriate for understanding the U.K. experience. (JEL E24, E32, E44, G01, G32)

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1 INTRODUCTION

The Great Recession renewed academic interest in the role of financial factors in the determination of real macroeconomic quantities. The magnitude of the decline in output, fall in house prices, and failure in financial markets led economists to place greater emphasis on financial institutions, debt, and financial variables within macroeconomic thinking (Reinhart and Rogoff, 2009; Brunnermeier, 2009; and Guerrieri and Uhlig, 2016). The synchronized nature of the decline across developed economies has reasonably been interpreted as suggesting a common cause, principally a large negative financial shock.

This article studies the behavior of the United States and United Kingdom economies during the Great Recession and subsequent slow recovery to study whether

Kieran Larkin is an assistant professor at the Institute for International Economic Studies, Stockholm University, Stockholm, SE-106 91, Sweden.
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(i) differences and similarities in the responses of macroeconomic aggregates can reveal the underlying drivers of the decline and recovery,
(ii) financial shocks were the most important factor in the U.S. and U.K. experiences during and after the Great Recession, and
(iii) financial markets transmit shocks to the real economy in the same way in both countries.

The main finding is that the financial channel has greater explanatory power for the U.S. than the U.K. economy in precipitating the Great Recession. This is perhaps surprising given the prevailing consensus of a financial market origin of the crisis and the strong similarities in the unconditional moments of aggregates at a business cycle frequency in the two countries. Despite having private business sectors that exhibit similar financing dynamics and U.K. households being more indebted than their U.S. counterparts, through the lens of a simple model, financial shocks seem to have been more important for understanding the U.S. economy than the U.K. economy during the Great Recession.

First, in the United Kingdom, changes in productivity account for the majority of macroeconomic movements during the Great Recession. Second, while financial shocks help explain the precipitous decline in output in the United Kingdom in 2008, they also generate counterfactually high volatility in the U.K. labor market. Third, financial conditions took longer to return to normality in the United Kingdom than in the United States. During this period, financial factors appear more relevant in the U.K. setting.

In this analysis, we first apply the classic business cycle accounting (BCA) framework of Chari, Kehoe, and McGrattan (2007) to the U.K. data. The idea of this approach is to understand the key drivers of business cycles in terms of "wedges" in the equilibrium conditions. This is useful, as it can aid model selection. Our analysis shows that a productivity decline was the primary determinant of the fall in output in the United Kingdom during the Great Recession. This contrasts with the finding for the United States, where the data suggest a sizable role for labor market frictions (Brinca et al., 2016). In the United Kingdom, the labor "wedge" mainly plays a roles in very short-run fluctuations in labor. Given this divergence, we assess the ability of a simple real business cycle (RBC) dynamic stochastic general equilibrium model augmented with financial shocks proposed by Jermann and Quadrini (2012) to explain the behavior of macroeconomic and financial variables in the U.S. and U.K. economies. In this model, financial shocks chiefly operate on the labor wedge, by constraining firms in their labor choice. Financial conditions are substantially more volatile in the United Kingdom than in the United States, though this is primarily due to a stronger feedback mechanism from productivity to financial conditions in the U.K. data. In both cases, financial shocks amplify the decline in gross domestic product (GDP) during the Great Recession, but elucidating evidence as to the relevance of this channel is revealed by the labor market. In the U.S. case, financial shocks also improve the model's predictions for hours worked, mirroring the importance of the labor wedge for understanding the Great Recession. In the U.K. case, financial shocks cause too large a response of hours worked, calling into question the validity of the mechanism and financial shocks for understanding the episode.

From 2010 onward following the recession, financial variables returned to normal more quickly in the United States than in the United Kingdom. During this period the downward pressure generated by financial frictions helps explain the prolonged negative response of hours in the United Kingdom. By contrast, in the United States, hours in the data are below where they are predicted to be given the financial shocks observed. More recently, the United Kingdom has seen an hours boom, but through the lens of the model this would imply a loosening of financial constraints not supported by the data.

This article is related to a broad literature that has sought to incorporate financial variables or a financial sector into macroeconomic models. The seminal contribution to this field was the Bernanke, Gertler, and Gilchrist (1999) financial accelerator model. Other notable contributions include Gertler, Kiyotaki, and Queralto (2012) and Gertler and Kiyotaki (2015). The key difference between the financial accelerator models and the Jermann and Quadrini (2012) set up is that the latter incorporates financial shocks as an important source of disturbances in themselves. The specification employed here owes a significant inspiration to the endogenous credit constraints literature, for example, Kiyotaki and Moore (1997). Christiano, Motto, and Rostagno (2010) have analyzed financial frictions in large-scale New Keynesian dynamic stochastic general equilibrium models, finding financial frictions were important for the empirical properties of such models. Recent work has stressed the importance of firm heterogeneity in the transmission of financial shocks. This heterogeneity can affect the representation of a credit crunch in terms of aggregates wedges (Buera and Moll, 2015) or generate a new precautionary channel, which may have been important in the U.K. experience (Melcangi, 2016).

2 COMPARISON OF U.S. AND U.K. FLUCTUATIONS

2.1 Business Cycles

To set the scene for the subsequent analysis, we begin by comparing fluctuations in the U.S. and U.K. economies and the behavior of the housing and financial markets. The main takeaway is that there are substantial similarities in the behavior of aggregate variables between the U.S. and U.K. economies, as previously documented by Blackburn and Ravn (1992). However, we do see divergence in the dynamics of financial variables. Table 1 presents a subset of the standard business cycle statistics.[1] We see that at a business cycle frequency, fluctuations in the U.S. and U.K. economies look very similar. The standard deviation of output in both the United States and United Kingdom is around 1.5. In both countries, consumption is less volatile than output, while investment is more volatile and somewhat more so in the United States than in the United Kingdom. Both variables are highly correlated with output and of a similar magnitude. In the labor market, we see greater, albeit still moderate, divergence. In the United States, private hours are more volatile than output and strongly correlated. In the United Kingdom, hours are less volatile than output. While there is still a strong positive correlation between output and hours in the United Kingdom, the relationship is weaker than that observed in the United States.

Table 1

Business Cycle Statistics

		Relative standard deviation $\sigma(x)/\sigma(Y)$			Correlation with Y $\rho(x,Y)$		
	$\sigma(Y)$	C	I	Hours	C	I	Hours
U.S.	1.52	0.81	4.44	1.27	0.79	0.86	0.89
U.K.	1.51	0.96	2.71	0.92	0.79	0.78	0.75

NOTE: All variables are detrended with an HP (Hodrick-Prescott) filter, with smoothing parameter 1,600. Output (Y), consumption (C), and investment (I) are for 1950 to 2019. Hours are for 1971 to 2019. Hours are private sector hours.

2.2 Housing Markets

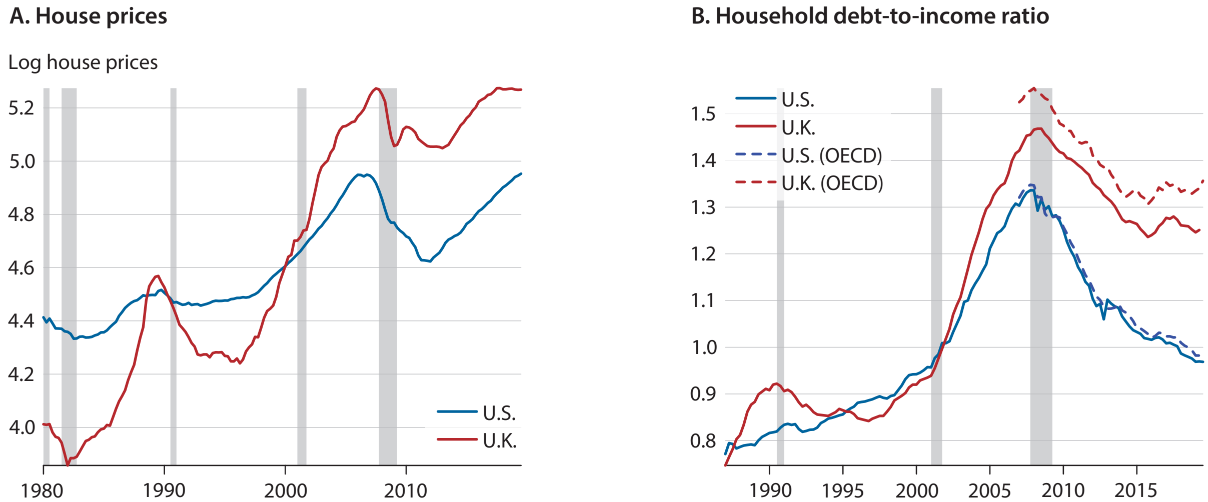
Next we consider the behavior of the housing market, particularly in the run up to the Great Recession. While this article focuses on the role of financial frictions in firm decisions, the importance of housing and household debt for understanding the macroeconomy has been increasingly recognized since the crisis (for a review, see Piazzesi and Schneider, 2016). Figure 1 presents a comparison of house prices and household debt in the United States and United Kingdom. Panel A shows the log of house prices, normalized to coincide in 2000. A number of features are apparent. First, we notice that, in general, house prices appear to be more cyclical in the United Kingdom. Second, we see that in the run up to the Great Recession, house prices increased by more in the United Kingdom than in the United States. Between 2000 and 2007, house prices increased by 107 percent in the United Kingdom versus 46 percent in the United States, likely reflecting tighter supply constraints in the United Kingdom. Third, we notice that the bust was more severe in the United States, with prices falling by 28 percent in the United States from peak to trough relative to by 12 percent in the United Kingdom.

Evidence of similar dynamics can be seen in the behavior of household indebtedness. Panel B shows the evolution of the household debt-to-income ratio.[2] Both countries saw big increases in this ratio prior to the Great Recession. The rise in indebtedness was greater in the United Kingdom, peaking at 1.47 times disposable income in the United Kingdom relative to 1.35 times disposable income in the United States. An alternative Organisation for Economic Co-operation and Development (OECD) measure has the United Kingdom peaking at an even higher value.[3] Given that the majority of household debt is mortgages and house prices increased by more in the United Kingdom, this greater rise in indebtedness is consistent with patterns in the U.K. housing market. During the recession, households in both countries reduced their debt positions, with a larger decline in the debt-to-income ratio in the United States. By 2019, households in the United States held roughly as much debt as the disposable income they received, while households in the United Kingdom had a debt-to-income ratio not far off that seen at the peak of the boom in the United States.

In summary, both the United States and the United Kingdom experienced significant housing booms prior to the Great Recession. Given the relative increases in house prices and

Figure 1

Housing Market Comparison



NOTE: Gray bars indicate U.S. recession dates as determined by the National Bureau of Economic Research. Recession dates for the United Kingdom differ slightly; for example, there was no technical recession in the United Kingdom in the early 2000s.

SOURCE: House prices are from the OECD. The U.S. Household debt-to-income ratio is constructed as household debt from the Federal Reserve Financial Accounts divided by disposable personal income from the Bureau of Economic Analysis. The U.K. household debt-to-income ratio in reported in the United Kingdom's Economic Accounts.

increases in indebtedness, in 2007 the United Kingdom rather than the United States arguably looked more vulnerable to a financial shock constraining credit to households. However, the scale of the housing bust turned out to be greater in the United States.

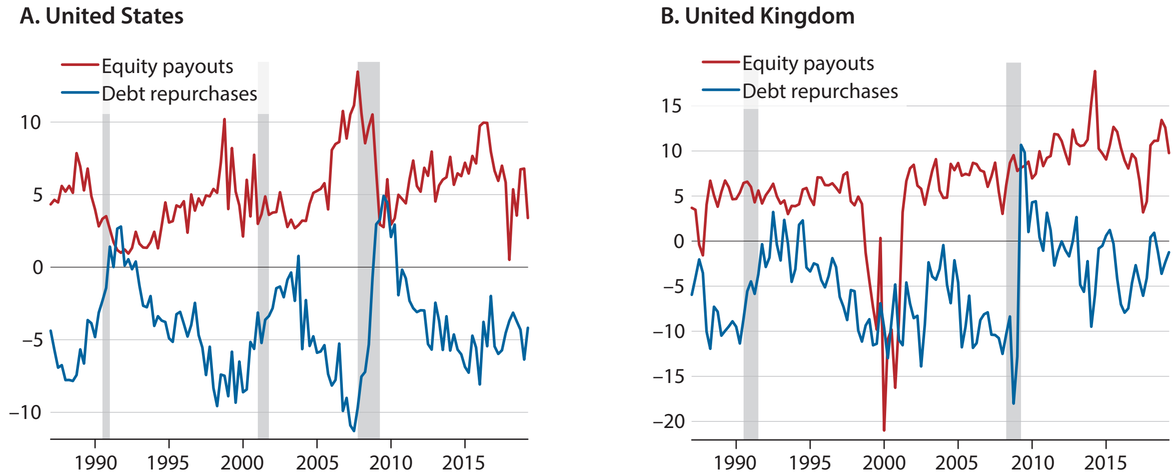
2.3 Financial Markets

One important piece of evidence for understanding the role of financial shocks is to understand the properties of financial variables, particularly those relevant to firm financing. The behavior of financial variables in the United States and United Kingdom appears fairly similar, although the use of equity is less cyclical in the United Kingdom. Following Jermann and Quadrini (2012), we study the behavior of two variables: equity payouts and debt repurchases. Equity payouts refer to the distributed income of firms (which includes dividend payments) minus equity issues (net of share buybacks). The variable captures the net payments made to business owners. Debt repurchases are the reduction in outstanding debt. Both are normalized by GDP.[4]

Figure 2 plots these two variable. The average values of the financial variables are similar in the U.S. and U.K. data. For the U.S. case during the period 1987-2019, the mean values of equity payouts and debt repurchases were 3.9 percent and –4.8 percent, respectively. For the United Kingdom the values were 6.0 and –5.0, respectively. There appears to be a stronger upward trend in equity payouts in the U.K. data.

Figure 2

Comovement of Credit Variables



NOTE: Gray bars indicate U.S. recession dates as determined by the National Bureau of Economic Research. Recession dates for the United Kingdom differ slightly; for example, there was no technical recession in the United Kingdom in the early 2000s.

SOURCE: U.S. data are from the Federal Reserve Flow of Funds and Bureau of Economic Affairs. U.K. data are from the Office of National Statistics. See the appendix for data definitions and constructions.

Table 2

Business Cycle Properties of Financial Variables

	U.S.	U.K.	U.K.*
Mean EquPay/GDP	3.78	6.01	8.27
Mean DebtRep/GDP	–4.78	–4.95	–3.51
SD EquPay/GDP	1.33	3.14	2.20
SD DebtRep/GDP	2.15	2.88	2.24
Corr(EquPay/GDP,GDP)	0.56	–0.11	0.28
Corr(DebtRep/GDP,GDP)	–0.84	–0.59	–0.68
Corr(EquPay/GDP,DebtRep/GDP)	–0.73	0.02	–0.47

NOTE: EquPay, equity payouts. DebtRep, debt repurchases. SD, standard deviation. Corr, correlation. A Baxter and King (1999) band-pass filter which preserves cycles of 1.5 to 8 years is applied to all series. U.K.* refers to an alternative specification of the equity payouts and debt repurchases series where the assets holdings of private firms are deducted from the liabilities.

The stylized facts from the U.S. data are that

(i) equity payouts are negatively correlated with debt repurchases and
(ii) equity payouts are procyclical, while debt repurchases are countercyclical.

One reasonable interpretation of these patterns is the substitutability of financing forms. Recessions are periods where firms restructure their financial position, substituting debt for equity.[5] The properties of the financial variables are also shown in Table 2, which reports the standard deviations of the detrended equity payouts and debt repurchases variables and their correlations with GDP. In the U.K. data, debt repurchases exhibit similar properties to those in the U.S. data. Debt repurchases are countercyclical, increasing during or following recessions (Figure 2). This can be seen in the 1990-92 recession and more dramatically during the Great Recession. The equity payouts variable does not follow the pattern observed in the U.S. data, however. For the most part, the series appears to be acyclical; but there was a significant decline in the variable during the period 1999-2001, which was also a period of growth in the U.K. economy.[6] An alternative specification of the U.K. financial variables is also presented in Table 2, which additionally deducts firm's asset holdings of equity and debt. Under this definition, the U.K. variables more closely resemble the U.S. economy, although the negative correlation between debt repurchases and equity payouts is still not as strong.

Two explanations are offered for the divergence from the U.S. cyclical pattern. First, equivalent movements in the equity payouts variable may be dwarfed by the activity in 1999-2001, so the alternative series better captures the actual financing position of companies. Alternatively, it could reflect a structural difference in the development of the U.S. and U.K. financial markets, with the average firm less able to increase equity financing when debt is more restricted. A priori this would imply greater importance of financial shocks that effect access to debt in the United Kingdom.

3 A BUSINESS CYCLE ACCOUNTING APPROACH TO THE U.K. GREAT RECESSION

To understand the drivers of the Great Recession, we start by applying the Chari, Kehoe, and McGrattan (2007) BCA methodology to the U.K. data. A similar analysis for the U.S. Great Recession can be found in Brinca et al. (2016). The basic idea of this approach is to decompose and attribute movements in the data to changes in wedges that appear in the equilibrium conditions of a representative economy.

3.1 A Benchmark Prototype Economy

The foundation of the BCA approach is that many detailed models of the economy with frictions can be reinterpreted as a simple economy with four time-varying wedges. The authors call this representation their prototype economy. These wedges can be measured using the data and equilibrium conditions and then fed back into the model to ascertain the amount of movement in output that can be attributed to each wedge. The insight is to fit a generic model to the data and consider what types of wedges explain the empirical series observed. It can then be shown that these wedges can be mapped into a variety of more-carefully microfounded frictions in specific models.

The prototype economy is a standard stochastic growth model. Let s_t be a vector denoting one of finitely many events. Let $s^t = (s_0, \ldots, s_t)$ be the history of events up to period t, calling each history a state. The probability of each state in period 0 is $\pi_t(s^t)$, with s_0 given. The economy has four stochastic variables, which are all functions of the random state variable, s^t: the efficiency wedge, $A_t(s^t)$; labor wedge, $1-\tau_{nt}(s^t)$; investment wedge, $1/[1+\tau_{it}(s^t)]$; and government consumption wedge, $g_t(s^t)$. Consumers maximize expected utility, where the arguments are per capita consumption, c_t, and per capita labor, n_t:

$$\sum_{t=0}^{\infty}\sum_{s^t}\beta^t \pi_t\left(s^t\right)U\left(c_t\left(s^t\right),n_t\left(s^t\right)\right)N_t,$$

$$c_t+\left[1+\tau_{it}\left(s^t\right)\right]i_t\left(s^t\right)=\left[1-\tau_{nt}\left(s^t\right)\right]w_t\left(s^t\right)n\left(s^t\right)+r_t\left(s^t\right)k_t\left(s^{t-1}\right)+T_t\left(s^t\right).$$

The law of motion for capital is $(1+\gamma_n)k_{t+1}(s^t) = (1-\delta)k_t(s^{t-1}) + i_t(s^t)$, with $k_t(s^{t-1})$ per capita capital stock and $i_t(s^t)$ per capita investment. The other variables are the wage, $w_t(s^t)$; rental rate on capital, $r_t(s^t)$; discount factor, β; depreciation rate, δ; population, N_t; population growth rate, $(1+\gamma_n)$; and per capita lump-sum transfers/taxes, T_t.

The production function is $A_t(s^t)F(k_t(s^{t-1}),(1+\gamma)^t n_t(s^t))$, where $(1+\gamma)$ is the rate of labor augmenting technical progress. Firms maximize profits, setting factor prices equal to their marginal product. The equilibrium of the prototype economy is summarized by the following equations: the resource constraint, production function, intratemporal condition on labor, and intertemporal Euler equation, respectively:

$$\begin{gathered}
c_t\left(s^t\right)+i_t\left(s^t\right)+g_t\left(s^t\right)=y_t\left(s^t\right),\\
y_t\left(s^t\right)=A_t\left(s^t\right)F(k_t\left(s^{t-1}\right),\left((1+\gamma)^t n_t\left(s^t\right)\right),\\
-\frac{U_{nt}\left(s^t\right)}{U_{ct}\left(s^t\right)}=\left[1-\tau_{nt}\left(s^t\right)\right]A_t\left(s^t\right)(1+\gamma)^t F_{nt}\left(s^t\right),\\
U_{ct}\left(s^t\right)\left[1+\tau_{it}\left(s^t\right)\right]=\beta\sum_{s^{t+1}}\pi_t\left(s^{t+1}\mid s^t\right)U_{ct+1}\left(s^{t+1}\right)\\
\times\left\{A_{t+1}\left(s^{t+1}\right)F_{kt+1}\left(s^{t+1}\right)+(1-\delta)\left[1+\tau_{it+1}\left(s^{t+1}\right)\right]\right\}.
\end{gathered}$$

By design, the efficiency wedge resembles a standard technology/productivity parameter. The labor wedge takes the form of a tax on labor, distorting the consumer's preference for setting the marginal rate of substitution between consumption and leisure equal to the marginal product of labor. The investment wedge looks like a tax on investment, distorting the intertemporal Euler equation.

3.2 The Business Cycle Accounting Methodology

The next step is to apply the BCA methodology to the U.K. data. A brief description of the steps taken follows (for the full treatment, see Chari, Kehoe, and McGrattan, 2007):

(i) The prototype model is log-linerized and the decision rules, $y(s_t,k_t)$, $i(s_t,k_t)$, and $n(s_t,k_t)$, are calculated.

(ii) Each wedge is set equal to the value of a component of the state, so $s^t = (A_t,\tau_{nt},\tau_{it},g_t) = (s_{At},s_{nt},s_{it},s_{gt})$ and the state is assumed to follow the Markov process: $s_{t+1} = P_0 + Ps_t + \varepsilon_{t+1}$, where ε_{t+1} is independent and identically distributed over time and distributed normally, mean zero, with the covariance matrix $\mathbf{V} = \mathbf{QQ'}$.

(iii) Maximum likelihood is used to compute the underlying parameters: $\bar{\mathbf{s}}$, $\mathbf{P}$, and $\mathbf{Q}$.

(iv) To analyse the effect of the wedges, the economy is run with agents optimizing subject to their decision rules. However, only one wedge (or a combination of wedges) is allowed to fluctuate; the rest are held at a steady-state value.[7]

3.3 Applying Business Cycle Accounting to the U.K. Great Recession

The findings from the BCA exercise are now presented. For this analysis, U.K. quarterly data for the period 1973:Q2-2012:Q1 are used. The model was calibrated with the discount factor $\beta = 0.9825$, utility of leisure $\alpha = 1.8834$, capital share $\theta = 0.3600$, and depreciation rate $\delta = 0.0250$. The growth rates of the population γ_n and productivity γ were set to 0.0044 and 0.0238, respectively. Equivalent figures for the U.S. economy may be found in Brinca et al. (2016). Figure 3 shows U.K. output alongside the efficiency wedge, A_t; labor wedge, $1-\tau_{nt}$; and investment wedge, $1/[1+\tau_{it}]$. The wedges alone do not tell us their impact on macroeconomic variables but do provide insight into the magnitudes of their distortion. The efficiency wedge and labor wedge show the greatest distortion during this period. In contrast, the investment wedge declines, recovers a little, and then stays at a fairly constant level, at around 99 percent of its steady-state value, for the full period. This pattern does not coincide with the Bernanke, Gerler, and Gilchrist (1999) style financial accelerator models, which affect the economy via an investment wedge.

Figure 4 shows the dynamics predicted by the model for the United Kindgom for output, labor, and investment when only the efficiency wedge, labor wedge, or investment wedge is allowed to fluctuate.[8] The actual data for the period are also shown. The model with the efficiency wedge is able to explain most of the movement in output over the period. The model with the labor wedge shows a minor decline in output, between 2009 and 2010, but it is insufficient to match the data. For example, in 2010, the predicted decline in output for the model with the efficiency wedge is 6.5 percent; for the model with the labor wedge, it is 2.3 percent. In the data, the recorded decline is 8.3 percent. By 2012, the predicted decline in output of the model with the efficiency wedge is 10.7 percent, capturing 90.7 percent of the decline in the data (11.8 percent); by this point, the labor wedge model has almost returned to trend. The one feature of the data that the labor wedge does capture is the mild improvement in output that takes place between 2010:Q2 and 2010:Q4.

Figure 3

Business Cycle Accounting Wedges in the United Kingdom

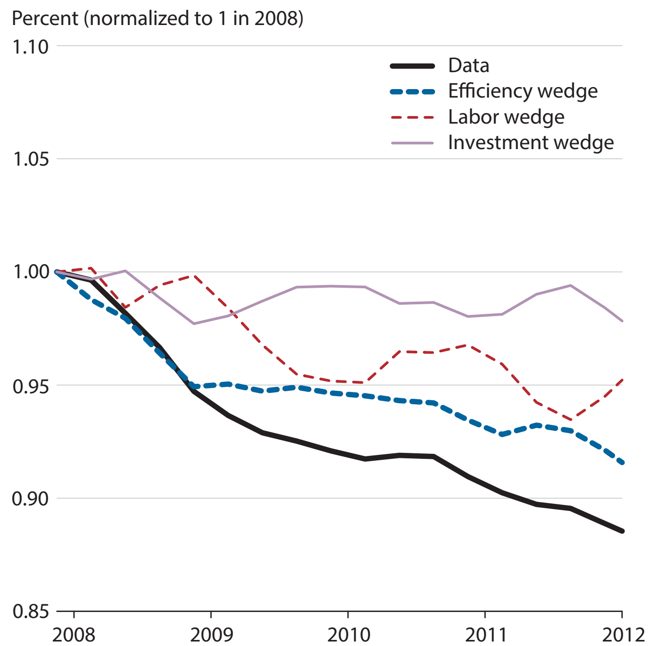
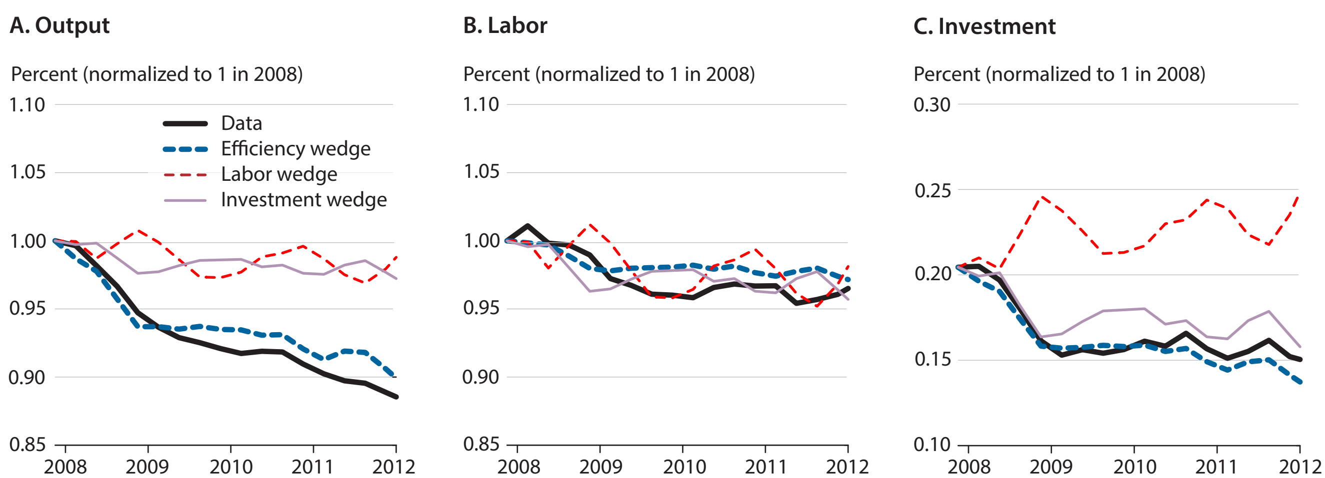


Figure 4

Contribution of Business Cycle Wedges to U.K. Great Recession



As might be expected, the model with the labor wedge does a better job of predicting the decline in labor. It approximates both the magnitude of the decline and subsequently captures the recovery and set-back dynamics between 2010 and 2011. In 2010, the labor wedge model predicts a 3.6 percent decline in labor, whereas the data implies a 4.2 percent reduction. Finally, turning to investment, the model with the efficiency wedge replicates the data well, closely tracking the sharp initial contraction. The model with the labor wedge poorly predicts the behavior of investment, consistently predicting an increase rather than decrease relative to trend.

Although the magnitude of the decline in labor is also captured well by the model with the investment wedge, closer inspection reveals that for many of the minor fluctuations it moves in the wrong direction. Interestingly, the model with the investment wedge does not do a particularly good job of predicting the movement of investment. In 2010, investment is 21.2 percent below its trend, while the model with an investment wedge has declined by 11.9 percent, explaining only 56.1 percent of the actual decline.

In summary, the behavior of the key macroeconomic variables—output, labor, and capital—in the U.K. Great Recession can be mostly attributed to the movements of a time-varying efficiency wedge. One interpretation is that this wedge is a standard productivity parameter. A labor wedge adds additional explanatory power, particularly to the movement of labor, but compared with the efficiency wedge, its contribution is modest. This contrasts with the U.S. experience. While the Markov process for the wedges has similar attributes in the United Kingdom and the United States (compare Table A1 to Chari, Kehoe, and McGrattan, 2007), undertaking a BCA exercise for the U.S. Great Recession uncovers a substantial role for the labor wedge: It accounts for 46 percent of the movement in output during the period.

Considering the U.K. economy in the longer run, the efficiency wedge is still critical to understanding movements in output, but the labor and investment wedges also take on greater importance. Indeed, the labor wedge has been found to play a dominant role in the 1982 recession in the United Kingdom (Kersting, 2008; Brinca et al., 2016). The general form of the prototype economy means that the primitive shocks hitting the model should not necessarily be identified as productivity shocks.[9] The presence of heterogeneity in the economy may also obscure the underlying sources of frictions. Indeed, Buera and Moll (2015) show that in the presence of heterogeneity in the financial goods market, credit shocks can be interpreted as an efficiency wedge.

4 A MODEL WITH FINANCIAL FRICTIONS AND FINANCIAL SHOCKS

This section sets out a simple RBC model with financial frictions and financial shocks à la Jermann and Quadrini (2012), which can be used to compare the U.S. and U.K. economies during the Great Recession. In this setting, firms have access to two forms of finance: equity and debt, following the empirical evidence presented above. A firm's preferred form of financing is debt, but its ability to issue debt is subject to financial frictions. This friction ultimately distorts the firm's labor supply decision, as wages must be paid in advance. Financial shocks are changes in the magnitude of this financing friction.

As will be discussed in the results (Section 6.3), despite the inclusion of additional financial variables, the Jermann and Quadrini (2012) model can still be mapped into a BCA framework as set out above in terms of four key wedges. As this model features a financing friction that distorts the household's intratemporal labor decision, it offers the perfect setting to consider the role of financial shocks in the U.S. and U.K. experiences of the Great Recession. As presented in Section 3, a key difference between the U.S. and U.K. Great Recession experiences was the importance of the labor wedge.

4.1 Firms Sector

4.1.1 Production. A continuum of firms, on the [0,1] interval, are characterized by the Cobb-Douglas production function $F(z_t, k_t, n_t) = z_t k_t^{\theta} n_t^{1-\theta}$, where z_t is the stochastic productivity variable, k_t is the capital input, and n_t is the labor input. Capital is determined in the previous period. The law of motion for capital is $k_{t+1} = (1-\delta)k_t + i_t$, where i_t is investment and δ is the period depreciation rate. The model has two sources of aggregate uncertainty—the productivity variable, z_t, and a financial variable, ξ_t. Firms finance their activity with debt, b_t, and equity, d_t. Debt is preferred to equity due to a tax wedge on the gross interest rate faced by firms. For a given interest rate, r_t, the firm's after-tax gross rate of interest on debt is $R_t = 1 + r_t(1-\tau)$. Given its financing options, the firm's budget constraint can be written as

$$b_t + w_t n_t + k_{t+1} + d_t = (1-\delta)k_t + F(z_t, k_t, n_t) + \frac{b_{t+1}}{R_t},$$

where w_t is the wage paid to labor.

4.1.2 Firm Enforcement Constraint. Firms also make use of an intra-period loan, l_t, which finances working capital. In particular, the intra-period loan is used to finance the disparity between beginning-of-the-period payments and revenues generated during the period. The model's timing is as follows: A firm begins each period with its intertemporal liabilities, b_t. It chooses labor, n_t; investment, i_t; equity payouts, d_t; and next period's intertemporal liabilities, b_{t+1}. These payments need to be made before production is completed and therefore must be financed by the intra-period loan, l_t. The intra-period loan equals $l_t = w_t n_t + i_t + d_t + b_t - b_{t+1}/R_t$. Substituting the definition of the intra-period loan into the firm's budget constraint shows us that the intra-period loan is equal to production: $l_t = F(z_t, k_t, n_t)$.

Firm borrowing, both intratemporally and intertemporally, is subject to a constraint. The constraint takes the form of a limited enforceability debt contract, based on the possibility of default. Firms are able to default after production, prior to the repayment of the intra-period loan. It is assumed that the revenues from the period's production can be diverted by the firm and cannot be recovered by the lender. The in-period liabilities at the moment of default are $l_t + b_{t+1}/(1+r_t)$; the firm's assets are next period's capital, k_{t+1}. It is assumed that when contracting the intra-period loan, the value of the firm's capital stock in default is uncertain.[10] To model this uncertainty, with probability ξ_t the lender recovers the full value of the firm's net assets $k_{t+1} - b_{t+1}/(1+r_t)$, and with probability $1-\xi_t$ the lender recovers no value from the firm's net assets. In expectation the value of default is $\xi_t(k_{t+1} - b_{t+1}/(1 + r_t)) + (1 - \xi_t) \cdot 0$, which gives the enforcement constraint:

$$\xi_t\left(k_{t+1} - \frac{b_{t+1}}{(1+r_t)}\right) \geqslant l_t. \tag{1}$$

The enforcement constraint (1) is the key friction in the model and introduces a role for financial shocks. The value of the firm's assets that can be recouped by the lender of the intra-period loan is net of the firm's next-period intertemporal debt. Intertemporal debt and the intra-period loan both make the enforcement constraint tighter, although intratemporal debt more so. In contrast, a larger capital stock eases the constraint, as the lender has more assets to call upon in default.

The probability of recovering the full value of the remaining assets in default, ξ_t, is taken as our financial variable and is assumed to follow a stochastic process. Higher realizations of ξ_t loosen the constraint, allowing for greater debt issuance. Lower realizations imply a tightening of lending conditions. Given its role in determining the firm financing decision, the shocks that hit ξ_t are interpreted as financial shocks. As a further friction, we restrict the degree to which the firm can alter its financial structure by constraining equity payouts with an adjustment cost. The model assumes that the actual cost to the firm of making equity payouts of d_t is $\varphi(d_t) = d_t + \kappa(d_t - \bar{d})^2$. In this formulation, $\bar{d}$ is steady-state equity payouts, while $\kappa > 0$.[11]

4.1.3 The Firm Problem and First-Order Conditions. The firm problem is summarized by the following Bellman equation, where the states are the period capital stock, k_t, and intertemporal debt, b_t; the aggregate states, $\mathbf{s}_t$, are the productivity variable, z_t, and financial variable, ξ_t; and primes are used to denote next period's variables:

$$V(\mathbf{s};k,b) = \max_{d,n,k',b'} \left\{ d + \boldsymbol{E}m'V(\mathbf{s}';k',b') \right\}$$

subject to

$$(1-\delta)k + F(z,k,n) - wn + \frac{b'}{R} = b + \varphi(d) + k'$$

$$\xi\left(k' - \frac{b'}{(1+r)}\right) \geqslant F(z,k,n).$$

The current value of the firm—including this period's dividend—is given by the function $V(\mathbf{s};k,b)$, where future earnings are discounted by the stochastic discount factor, m'.[12] Prices are wages, w; the interest rate, r; and the gross interest rate faced by the firm, R. Prices are determined in general equilibrium and are taken by the firm as given. Letting the Lagrange multiplier on the enforcement constraint be μ, the first-order conditions for the firm are

$$F_n(z,k,n) = w \cdot \left(\frac{1}{1-\mu\varphi_d(d)}\right) \tag{2}$$

$$\boldsymbol{E}m' \cdot \left(\frac{\varphi_d(d)}{\varphi_d(d')}\right)\left[1-\delta+\left(1-\mu'\varphi_d(d')\right)F_k(z',k',n')\right] + \xi\mu\varphi_d(d) = 1 \tag{3}$$

$$R\boldsymbol{E}m' \cdot \left(\frac{\varphi_d(d)}{\varphi_d(d')}\right) + \xi\mu\varphi_d(d)\left(\frac{R}{1+r}\right) = 1. \tag{4}$$

These first-order conditions provide the optimality condition for labor demand (2); the intertemporal condition governing demand for capital (3); and the intertemporal condition governing debt (4), which links the financial variable and the tightness of the enforcement constraint. The most important of these conditions is the labor demand equation. The firm does not set the marginal product of labor equal to the wage rate, because of the wedge $1/[1 - \mu\varphi(d)]$.[13] Further, the size of the wedge depends on the Lagrange multiplier and the deviation of equity payouts from the steady state. Labor demand is decreasing in both of these arguments, providing a key mechanism by which financial shocks are transmitted to real macroeconomic quantities.

4.2 Household Sector

Whereas the firm sector is non-standard, the household sector in the model is close to the textbook RBC representation. There is a continuum of households on the unit interval, which maximize expected lifetime utility:

$$\boldsymbol{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t, n_t)$$

with consumption, c_t; labor, n_t; and discount factor, β. Households cannot hold capital, but instead are shareholders in firms and hold non-state contingent bonds issued by the firm sector. The household budget constraint is

$$w_t n_t + b_t + s_t(d_t + p_t) = \frac{b_{t+1}}{1+r_t} + s_{t+1} p_t + c_t + T_t.$$

Most arguments in the household budget constraint are familiar from the firm side. The additional elements are the equity share holding, s_t; the market price of shares, p_t; and lump sum taxes, T_t.[14] The resulting first-order conditions for the household problem are

$$w_t U_c(c_t, n_t) + U_n(c_t, n_t) = 0 \tag{5}$$

$$U_c(c_t, n_t) - \beta(1+r_t)\boldsymbol{E_t} U_c(c_{t+1}, n_{t+1}) = 0 \tag{6}$$

$$U_c(c_t, n_t) p_t - \beta \boldsymbol{E_t}(d_{t+1} + p_{t+1}) U_c(c_{t+1}, n_{t+1}) = 0. \tag{7}$$

From the household's intratemporal labor supply decision (5), it is clear that changes in financial conditions will feed back via wages to hours supplied. The two intertemporal conditions (6) and (7) provide a no-arbitrage condition for the returns on debt and equity. From the household problem, we derive the stochastic discount factor for the firm problem, setting $m_{t+j} = \beta^j U_c(c_{t+j}, n_{t+j})/U_c(c_t, n_t)$.

5 CALIBRATION

A number of the model's parameters are standard in the business cycle literature. The discount factor (β) is set to 0.983, and the utility function form is $U(c,n) = \ln(c) + \alpha \cdot \ln(1 - n)$, with the weight of leisure (α) set so that steady-state hours are 0.300. Depreciation is set to $\delta = 0.025$, and the steady state of the productivity variable to $z = 1$. The capital share in the Cobb-Douglas production function is set to $\theta = 0.360$ in the United States and to a slightly higher value in the United Kingdom ($\theta = 0.379$) following evidence in Karabarbounis and Neiman (2014). For reasonable values, these parameters are not that important for the model's quantitative performance. The tax wedge, which specifies the advantage of debt financing over equity, is set to $\tau = 0.342$ in the United States and $\tau = 0.286$ in the United Kingdom, based on OECD averages of the headline corporate income tax rate for the period 1987-2019. This variable determines when the enforcement constraint binds and the steady-state values of ξ and μ. Compared with the U.S. parameterization, the U.K. model requires τ to be set 5.5 percentage points lower, implying a smaller wedge between debt and equity.

The steady-state value of the financial parameter, ξ, was chosen so that the steady-state ratio of end-of-period debt to GDP is equal to the empirical average. For the United Kingdom, the debt-to-GDP ratio is higher than for the United States, $b^e/y = 3.510$ versus 3.340.[15] The combination of the tax rate, capital share, and debt levels offset each other so that the enforcement constraint ends up with a similar value in both the United States and United Kingdom, 0.164 and 0.161, respectively. Finally, a value for the equity cost parameter (κ) is required. The parameter is chosen so that the standard deviation of equity payouts generated by the model matches the standard deviation of the empirical series. Relative to the U.S. specification, a higher value of κ is required for the United Kingdom, implying a greater punishment for deviating from long-run equity payouts. As the target moment, the standard deviation of equity payouts is higher in the United Kingdom. The difference in calibration is due to the underlying volatility of the measured stochastic process (see Section 5.1). Full details of the calibration are provided in Table 3, and the targeted moments are provided in Table 4.

5.1 Calibration of the Stochastic Processes

To uncover the parameters of the stochastic process, data are used to generate a log-linearized series for the productivity variable and financial variable. The productivity variable is constructed using the standard Solow residual approach:

$$\hat{z}_t = \hat{y}_t - \theta \hat{k}_t - (1-\theta)\hat{n}_t .$$

The financial variable is obtained with a similar methodology from the enforcement constraint, recalling the assumption that the enforcement constraint always binds. Log-linerizing equation (2), after substituting in output, $y_t = l_t$, results in

$$\hat{\xi}_t = \phi_k \hat{k}_{t+1} + \phi_b \hat{b}^e_{t+1} + \hat{y}_t .$$

From this equation, $\hat{\xi}_t$ can be determined using data on the end-of-period capital stock, $\hat{k}_{t+1}$; end-of-period debt stock, $\hat{b}^e_{t+1}$; and business GDP, $\hat{y}_t$. The coefficients are $\phi_k = \bar{\xi} \cdot \bar{k} / \bar{y}$ and

Table 3

Calibration of U.S. and U.K. Models

	U.S.	U.K.
External calibrations		
Discount factor (β)	0.9825	0.9825
Utility of leisure (a)	1.8835	1.8566
Capital share (θ)	0.3600	0.3790
Depreciation (δ)	0.0250	0.0250
Tax wedge (τ)	0.3415	0.2861
Internal calibrations		
Enforcement parameter (ξ)	0.1636	0.1606
Payout cost (κ)	0.0901	0.2648
Calibrations from data process		
SD of productivity shock (σ_z)	0.0045	0.0047
SD of financial shock (σ_ξ)	0.0083	0.0102
Markov process for stochastic variables ($\mathbf{A}$)	$\begin{bmatrix} 0.986 & 0.001 \\ -0.028 & 0.983 \end{bmatrix}$	$\begin{bmatrix} 1.041 & -0.026 \\ 0.159 & 0.942 \end{bmatrix}$

NOTE: SD, standard deviation.

Table 4

Targeted Moments

	U.S.	U.K.
Debt-to-GDP ratio $\left(\frac{b^e}{y}\right)$	3.34	3.51
SD of EquPay/GDP ($\sigma(EquPay)$)	2.29	2.40

NOTE: SD, standard deviation. EquPay, equity payouts.

$\phi_b = \bar{\xi} \cdot \overline{b^e} / \bar{y}$ and set to the country-relevant values. Once the productivity and financial variable series have been constructed, the following VAR can be estimated on data over the period 1987:Q1-2019:Q2:

$$\begin{pmatrix} \hat{z}_{t+1} \\ \hat{\xi}_{t+1} \end{pmatrix} = \mathbf{A} \begin{pmatrix} \hat{z}_t \\ \hat{\xi}_t \end{pmatrix} + \begin{pmatrix} \epsilon_{z,\, t+1} \\ \epsilon_{\xi,\, t+1} \end{pmatrix}.$$

The VAR gives the stochastic process of the model and also allows one to calculate the standard deviations of the shocks; the estimated parameters are given in Table 3. Compared with the U.S. estimates, larger cross effects between the stochastic variables are observed in the U.K. data. In particular, the effect of the lag of the productivity variable on the financial variable is substantial.[16] This effect turns out to be an important driving features of the U.K. simulations and leads to more closely correlated productivity and financial cycles and larger volatility of the financial conditions.

6 QUANTITATIVE FINDINGS

To analyze the quantitative fit of the model, the initial values of $\hat{z}_{1987:Q1}$ and $\hat{\xi}_{1987:Q1}$ are used as the starting point for the two stochastic series. The innovations from the VAR are fed into the model, and the policy functions from the log-linearized system are used to calculate the responses of the model's macroeconomic variables. Figure 5 compares the behavior of the stochastic variables in the United States and United Kingdom: the productivity and financial shocks as well as the implied Lagrange multiplier.[17] The series for productivity follow each other fairly closely, although the 1990-91 recession and late-2000 boom are more pronounced in the U.K. case. The behavior of the financial variable is also similar in the U.K. case, but the volatility is substantially higher, with a large contraction in the early 1990s. In both countries there is evidence of a significant financial shock in 2007-08.

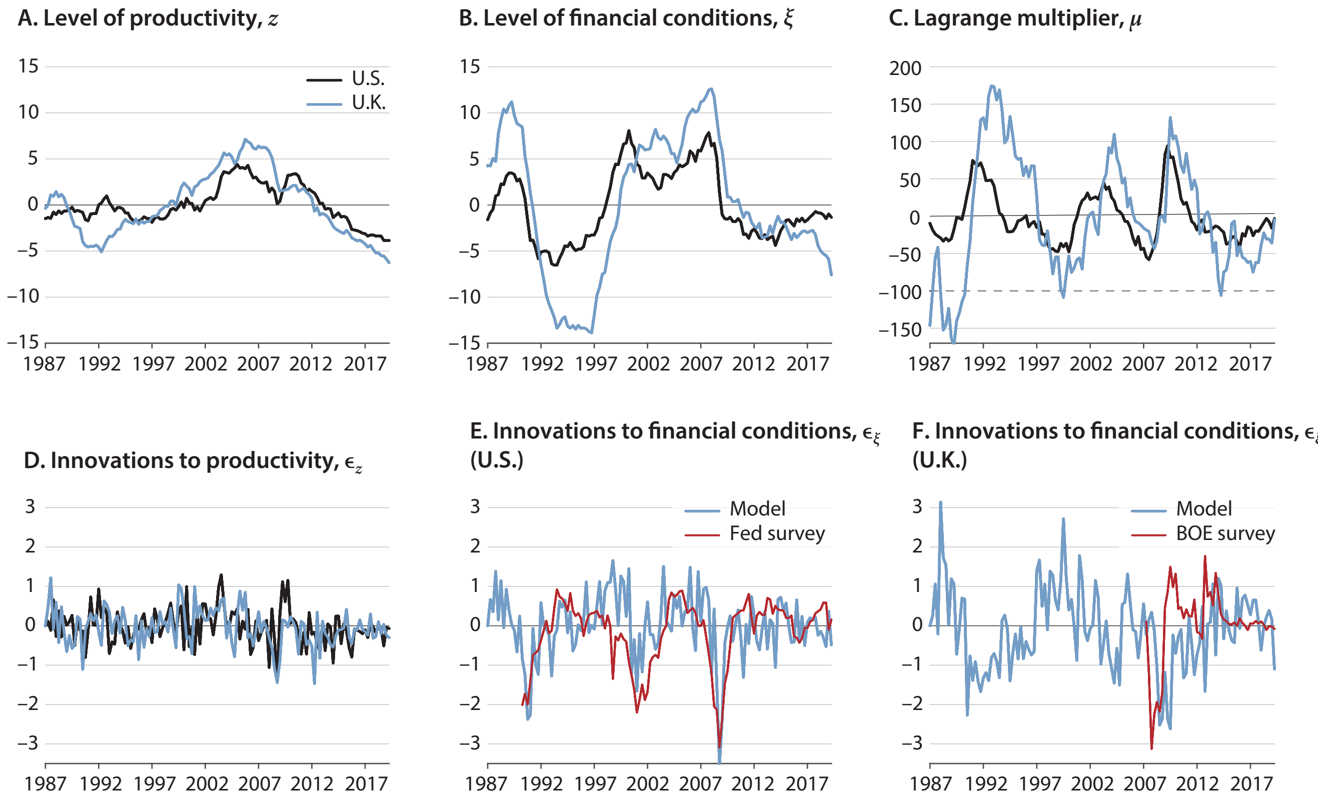
In the lower panels of Figure 5, the innovations to the stochastic variables are shown: the productivity, ϵ_z, and financial, ϵ_ξ, shocks. Between 2008:Q3 and 2009:Q1, we see large negative realizations in both shock variables. The financial shocks appear to possess relevant information on credit conditions. To show this we also present a rescaled variable summarizing the availability of credit from the Federal Reserve and the Bank of England, respectively.[18] The two variables chart a similar path of changing credit conditions to the innovations to financial conditions and notably collapse during the Great Recession. One difference between the U.S. and U.K. economies is that the estimated financial innovations are more frequently negative in the post-2010 period in the United Kingdom, implying a continued deterioration in credit availability.

6.1 U.S. Great Recession and Recovery

Figure 6 presents results of the key macroeconomic and financial quantities for the U.S. economy. The model is simulated with only the productivity shocks (holding the financial variable at its steady-state level), only the financial shocks (holding productivity at its steady-state

Figure 5

Comparing the U.S. and U.K. Stochastic Processes



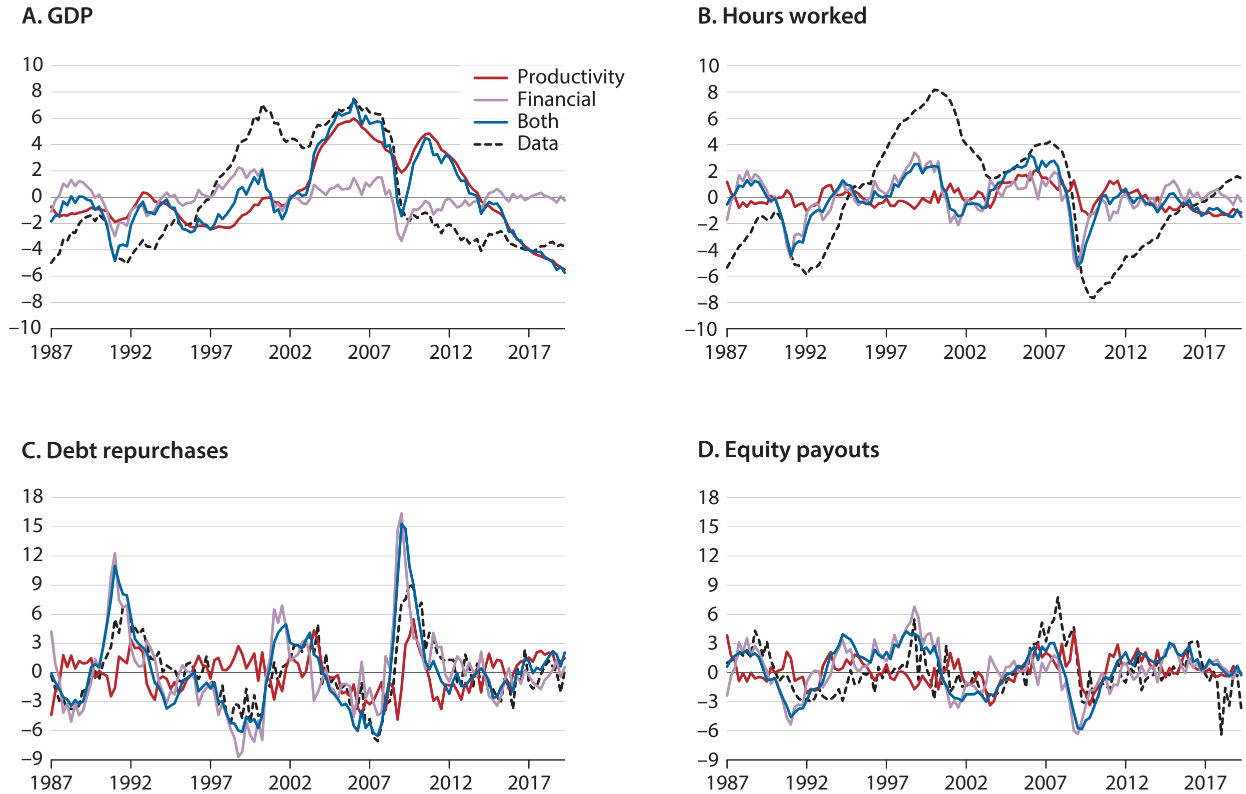
NOTE: Fed survey, Federal Reserve Senior Loan Officer Opinion Survey on Bank Lending Practices. BOE survey, Bank of England Credit Conditions Survey.

level), and the full baseline specification with both shocks. The true path of the data are also shown. The model provides a reasonable fit to the U.S. data. The productivity shock is key to generating the boom prior to the Great Recession but in general fails to move hours worked sufficiently. The addition of financial shocks, by increasing the labor wedge, generates a larger decline in hours worked during the Great Recession, which enables the model to generate a much closer fit to the magnitude of the decline in output than is generated with productivity shocks alone. Indeed, the presence of financial shocks improves the fit of hours worked across the whole specification. Despite this, the labor wedge implied by the financial series does not generate the persistence in the decline in output seen in the data after 2009, as financial conditions do not deteriorate further. This emphasizes that it is changes in rather than the level of financial conditions that matter for the model's dynamics. As a result, GDP rebounds too quickly. Financial conditions are unable to account for the slow recovery in the U.S. economy.

The lower panel presents the response of the financial variables. Here we see the model is able to accurately capture the dynamics of debt repurchases and equity payouts. As in the data,

Figure 6

U.S. Model with Productivity and Financial Shocks



during the Great Recession, firms substituted debt for equity in the face of tighter lending conditions. The model with only productivity shocks is less able to match these dynamics. Post 2012, in the face of smaller disturbances to financial conditions, firms kept their financing decisions fairly constant.

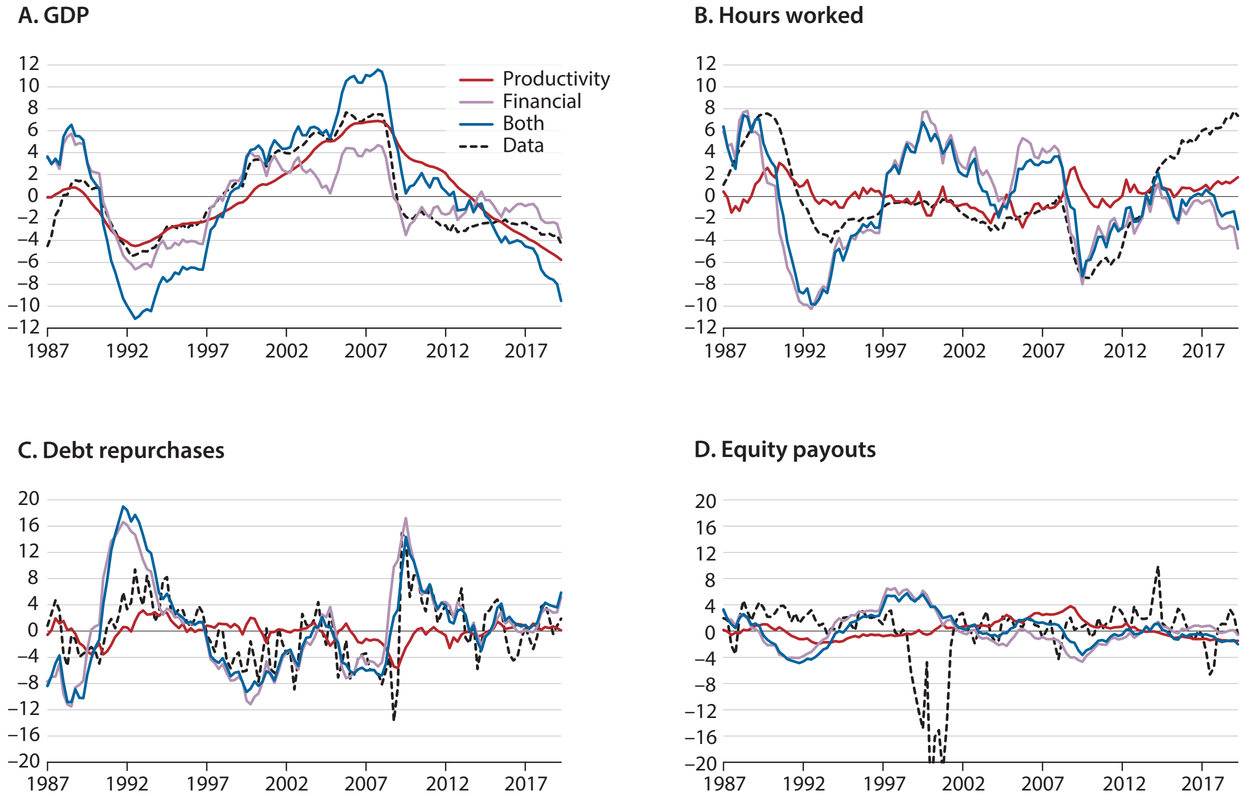
6.2 U.K. Great Recession and Recovery

Figure 7 presents the same exercise for the U.K. economy. The combined shocks in the U.K. case do a better job of matching the output data than they do for the U.S. case. In particular, the U.K. productivity series provides a better fit during both the 1990s recession and mid-2000s boom than the U.S. series. Similar to the U.S. case, the productivity shocks alone are not able to generate the decline in output seen during the Great Recession, but with the addition of the financial shocks, the model captures the sharp decline during this period. Indeed, the combined shocks probably generate too-large a contraction from 2007 onward.[19]

In the U.S. calibration, the predictions of the model subjected to financial shocks improved the model's fit to the data due to the superior representation of the fluctuations in hours worked, but this is less clear in the U.K. calibration. While financial shocks do add more volatility to

Figure 7

U.K. Model with Productivity and Financial Shocks



the hours-worked series, the model does not provide a good fit. It generates too large a reduction in hours worked in the early 1990s, and the decline predicted for the Great Recession is significantly in excess of that observed in the data. This does present a puzzle. The model's ability to improve the match of the dynamics of the output series is highly dependent on the movement of hours worked. If the financial frictions "get GDP right," but achieve this by overestimating the reduction in hours worked, this suggests the movement in the labor wedge generated in the U.K. data by financial shocks is counterfactually large. This prediction calls into question the relevance of this channel for understanding the Great Recession in the United Kingdom.

The U.K. model does a better job of fitting the delayed recovery than the U.S. model does, with both financial shocks and productivity shocks providing a reasonable account of the output dynamics. One of the reasons for this is that the financial variables take longer to recover in the U.K. case than in the U.S. case, generating a series of small negative financial shocks between 2010 and 2012. The further financial shocks delay the recovery in hours in the U.K. model, matching the slow recovery seen in the data. However, this comes at the cost of missing the boom in hours worked post 2012, due to the very same mechanism. A declining labor wedge, driven by improving financial conditions, would be required to match this feature. This is not observed in the financial series estimated in the U.K. data. Further, all else equal, a declining wedge would come at the cost of a worse fit to the sluggish output growth observed in the post-recession period by generating a new boom.

The model's predictions for the financial series are now considered. The addition of financial shocks enables the model to capture the dynamics of debt repurchases post 1997 and during the Great Recession, but quantitatively it predicts too much debt repurchasing during the 1990s recession. Unsurprisingly, the equity payouts series is poorly replicated by the model, as it predicts a procyclical pattern not evident in the data. When recalibrated and compared with the alternative U.K. debt repurchases and equity payouts series, the fit with equity payouts is improved, but the debt repurchases series is now too volatile (see Figure A1).

A measure of best fit of the model is the sum of squared deviations of the predicted model series from the data for the U.S. and U.K. economies, when feeding in the productivity shocks, financial shocks, or both (Table A2). In the U.S. case for GDP, hours, and debt repurchases, the addition of the financial shocks improves the model fit relative to a model with only one of the shock series. In the U.K. case, the model with only productivity shocks fits the data best. Surprisingly, the model with only productivity shocks is also a superior fit for both financial variables (debt repurchases and equity payouts).

6.3 Business Cycle Accounting Meets Financial Frictions

The relative success and failure of the RBC model with financial shocks to explain the U.S. and U.K. data mirrors the findings of the BCA exercise. Indeed, the Jermann and Quadrini (2012) model can be mapped directly into the BCA framework despite the inclusion of additional financial variables.

The main mechanism by which firm financing decisions impact real variables in the model is the labor wedge. It can be easily shown that $\mu_t \varphi_d(d_t) = \tau_{nt}$, and thus the labor wedge's size is determined by the tightness of the enforcement constraint and deviations from long-run equity payouts. It can additionally be shown that the financing frictions appear in the investment wedge through tomorrow's Lagrange multiplier on the financial constraint, μ_{t+1}, and changes in the relative marginal cost of dividend issuance this period and next. One could further extend the BCA framework in the spirit of Sustek (2011), who incorporates asset market and monetary policy wedges to apply the BCA framework to monetary models. Indeed, an additional asset market wedge shows up in the intratemporal debt condition, equation (4). Data on the financial variables, either debt repurchases or equity payouts, could be used to pin down fluctuations in the asset market wedge. However, in terms of the analysis, this would alter the behavior of only the investment wedge, rather than the labor wedge. It is the latter that is the key channel for differentiating between the experiences of the U.S. and U.K. economies.

In the United States, where a large role has been found for the labor wedge during the Great Recession, the financial contraction improved the model fit to aggregate dynamics. In the United Kingdom, while financial shocks improved the fit of the decline in output during the Great Recession, the implied hours movements were too large, calling into question the importance of this channel. The model appears to be overly sensitive to this transmission mechanism when calibrated to the U.K. productivity and financial shock processes. Related reasoning would also seem to cast doubt on a housing-specific financial channel in the United Kingdom. It has been shown that the construction sector of the U.S. housing market is highly interconnected with other sectors of the economy (Boldrin et al., 2012). These linkage can transmit demand shocks to employment responses in other sectors, manifesting as a large labor wedge. In the United Kingdom, one explanation could be that the construction sector is less integrated, otherwise these linkages would generate too large a response in the labor market, as seen in the financial channel analysis above. Further, while households in the United Kingdom were more indebted than their U.S. counterparts, thus potentially more vulnerable to a credit squeeze, the decline in house prices was actually less severe in the United Kingdom, possibly suggesting a smaller financial shock (see Section 2.2).

Finally, from the earlier analysis we concluded that frictions that affect the investment margin are of minor importance in explaining U.K. output movements, which would rule out an alternative financial accelerator channel as proposed by Bernanke, Gertler, and Gilchrist (1999), mirroring the original findings of Chari, Kehoe, and McGrattan (2007) for the United States. If financial frictions are of first-order importance for understanding the U.K. experience in the Great Recession, it appears they must manifest in the efficiency wedge, perhaps due to firm heterogeneity as highlighted by Buera and Moll (2015). This differs from the explanation for the United States.

7 CONCLUSION

This article has analyzed the role of financial shocks in understanding the Great Recession and recovery in the United States and United Kingdom. The addition of financial shocks certainly helps explain the depth of the decline in output between 2007 and 2009 in both countries. However, despite the apparent similarities between the two recessessions, it seems difficult to attribute both to the same cause: financial shocks that constrain firm hiring decisions. The key mechanism by which the simple model transmits financial shocks to the economy—the introduction of a labor wedge—seems more applicable to the U.S. data than the U.K. data. The volatility of hours worked in the United Kingdom is not consistent with this channel. Instead, much of the dynamics of the macroeconomic quantities, even during the recent recession, can still be accounted for by movements in a simple efficiency wedge or productivity variable. This may be due to differences in the housing or financial market structures. While the dynamics of debt repurchases are similar in the United Kingdom and the United States, equity payouts are acyclical in the United Kingdom, whereas they are strongly countercyclical in the United States. For policymakers this would seem to suggest that efforts during the crisis to alleviate the tightening of credit and offset financial shocks may have had more potency in the United States relative to in the United Kingdom. In the United Kingdom, other policy tools such as fiscal policy may have been more appropriate, although a full analysis of the optimal policy response is beyond the scope of this article. Further, given the greater indebtedness of U.K. households in 2007 and similar behavior of debt repurchases in the United States and United Kingdom, it is not necessarily clear policymakers could have diagnosed this difference a priori. Thus, a more general policy finding is to emphasize the need to monitor the magnitude of various channels during a crisis, even when the causes appear to be strongly related across countries.

Finally, in the post-recession period, financial factors are attributed different importance. Financial variables returned more quickly to normality in the United States; therefore, this channel has limited explanatory power for the slow recovery. In the United Kingdom between 2010 and 2012, negative financial shocks do appear to have played a role in delaying the recovery in hours worked, partially explaining the slow recovery. However, through the lens of the model, the hours booms post 2012 observed in the United Kingdom would imply a significant loosening of financial frictions since the crisis, but this is not supported by the data. ■

APPENDIX

Construction of Equity Payouts and Debt Repurchases Series

- Equity payouts = (Net dividends – Share issues)/Business GDP
- Debt repurchases = –Net increase in credit market instruments/Business GDP
- For the United States, equity payouts and debt repurchases are constructed as in Jermann and Quadrini (2012).
- For the United Kingdom, data are from the Office of National Statistics:
  - Net dividends: Distributed income of corporations (code: ROCH)
  - Share issues: Net acquisition of financial liabilities (code: NEVL)
  - Net increase in credit market instruments: Net acquistions of financial liabilities: Securities other than shares (NETR) + Net acquisitions of financial liabilities: Loans (NEUT)
  - Business GDP: GDP (code: YBHA) – (General government: Final consumption expenditure (code: CPSA)
- Nonseasonally adjusted items are seasonally adjusted and smoothed with a moving average. One observational outlier in share issuance (2000:Q1) is removed and replaced with average-over-average values from three quarters before and three quarters after.

Table A1

Properties of Business Cycle Accounting Wedges

A. Summary statistics

Variable	$\frac{SD(x)}{SD(gdp)}$	Cross correlation with $y(t-k)$, $k=$ –2	–1	0	1	2
Efficiency	0.76	0.58	0.59	0.65	0.31	0.06
Labor	1.57	0.36	0.51	0.62	0.73	0.78
Investment	0.74	0.13	0.06	0.02	–0.26	–0.46
Government consumption	2.00	–0.30	–0.38	–0.32	–0.34	–0.25

B. Cross correlations

Variable X, Z	Cross correlation with $X(t)$, $Z(t-k)$, $k=$ –2	–1	0	1	2
Efficiency, labor	0.28	0.10	–0.11	–0.22	–0.34
Efficiency, investment	0.19	0.42	0.71	0.60	0.51
Efficiency, government consumption	–0.27	–0.26	–0.11	–0.08	0.08
Labor, investment	–0.75	–0.75	–0.74	–0.51	–0.30
Labor, government consumption	–0.16	–0.27	–0.41	–0.44	–0.45
Investment, government consumption	–0.07	0.00	0.13	0.22	0.33

NOTE: *SD*, standard deviation.

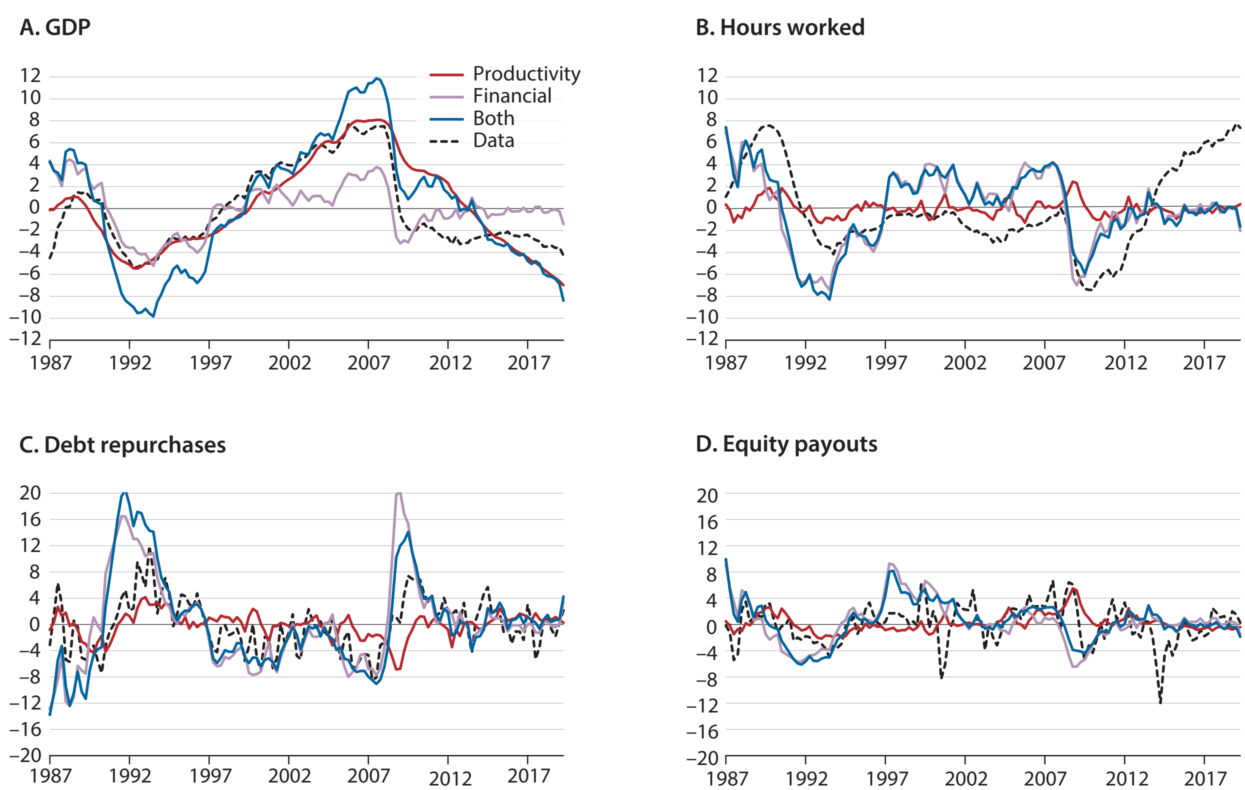
Table A2

Squared Deviations of Model Simulation from the Data

Variable	Shocks	U.S.	U.K.
Output	Productivity	0.15	0.06
	Financial	0.17	0.07
	Both	0.11	0.14
Hours	Productivity	0.22	0.16
	Financial	0.17	0.35
	Both	0.16	0.26
Debt repurchases	Productivity	0.14	0.27
	Financial	0.11	0.39
	Both	0.07	0.34
Equity payouts	Productivity	0.07	0.33
	Financial	0.11	0.51
	Both	0.09	0.49

Figure A1

U.K. Model with Productivity and Financial Shocks: Alternative Debt and Equity Definitions



NOTES

[1] This follows the well-established methodology set out in King and Rebelo, 1999. All data are in logs and measured as deviations from an HP (Hodrick-Prescott) filter trend.

[2] For income, we use household disposable income.

[3] The OECD reports a slightly higher measure of the debt-to-income ratio for the United Kingdom than that reported by the National Accounts. For the United States, the measures coincide almost exactly.

[4] U.S. data are from the Federal Reserve Flow of Funds. U.K. data are from the U.K.'s Economic Accounts, published by the Office for National Statistics. Both refer to the behavior of the private non-financial corporate sector. Full details of the data used are presented in the appendix.

[5] This finding is debated in the finance and macroeconomic literature; see Covas and Haan (2011).

[6] This can be attributed to a ten-fold increase in the flow of share and equity issuance at this time, largely due to significant merger and acquisition activity.

[7] As emphasized by Chari, Kehoe, and McGrattan (2007), while the wedges are held constant, the decision rules still react to the underlying state vector s_t, which does fluctuate—so the expectations of the wedge, or wedges, that fluctuates is identical to the fully specified prototype economy.

[8] Both output and labor are normalized to 1.0 in the base period—the beginning of the recession, 2007:Q4. Investment is divided by the base period level of output. A technological progress trend of 2.38 percent is removed from output, investment, and the government consumption wedge.

[9] For example, Chari, Kehoe, and McGrattan (2007) shows input-financing frictions can also manifest themselves as an efficiency wedge.

[10] Such an assumption could be justified on the basis of costly verification of the true value of a firm's capital; see Shleifer and Vishny (1992).

[11] Such a cost could be associated with the pecuniary transaction costs associated with share repurchases and equity issuance (Altinkilic and Hansen, 2000) or the preference for dividend smoothing (Lintner, 1956).

[12] The firm's equity value is defined as the firm's value divided by its current-period net assets: $V(\mathbf{s};k,b)/(k-b)$.

[13] It can be shown that providing $\tau > 0$, in the steady state, the enforcement constraint binds and $\mu > 0$.

[14] Taxes, which are taken as given, are solely used to finance the tax benefit of debt for firms and is equal to $T_t = B_{t+1}/[1 + r_t(1-\tau)] - B_{t+1}/(1+r_t)$.

[15] Note that end-of-period debt is the relevant data measure, where $b^e = b/(1+r_t)$.

[16] In both countries the VAR still satisfies the stability requirement, with the eigenvalues inside the unit circle.

[17] To solve for the policy functions, the model is log linearized around the steady state, under the assumption of a constantly binding enforcement constraint. Notice the simulation implies that the Lagrange multiplier does not always bind in the U.K. case, although except from at the beginning of the series these deviations are fairly small.

[18] For the United States, the variable is the net percentage of domestic banks tightening standards for large and middle-market firms reported in the Federal Reserve's Senior Loan Officer Opinion Survey on Bank Lending Practices. For the United Kingdom it is the change in the availability of credit to the corporate sector reported in the Bank of England's Credit Conditions Survey.

[19] One subtlety is that the stronger co-movement of the productivity and financial variables in the U.K. calibration means that firms anticipate a tightening of credit conditions when productivity declines, even if the variable is held at the steady state. Thus, the channels are less distinguishable than in the U.S. economy.

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