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Financial Conditions and Slow Recoveries

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Abstract

We argue that financial frictions and financial shocks can be an important factor behind the slow recoveries from the three most recent recessions. To illustrate this point, we augment a parsimonious RBC model with a collateral constraint whose tightness is randomly disturbed by a shock that prescribes the general financial condition in the economy. We present evidence that such financial shock has become more persistent since the mid 1980s. We show that this can be an important contributor to the recent slow recoveries, and that a main mechanism in shaping the behaviors of employment and investment/capital stock during the recoveries may have to do with just-in-time-uses of labor and capital services in the face of tight credit conditions. To assess the importance of such financial shock relative to other shocks in contributing to the slow recoveries, we enrich a New Keynesian model, which features various structural shocks and frictions widely considered in the literature, with the financial frictions and financial shocks studied in our parsimonious model. Our structural estimates of this comprehensive model indicate that financial shocks can play a dominant role in accounting for the slow recoveries.

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1 Introduction

Recoveries from the three most recent recessions are slow, compared to the recoveries from other post-World War II recessions in the United States. This is illustrated in Figure 1, which plots the gross rates of output and employment growth from the NBER-dated trough in each of the past three (1991, 2001, and 2009) recessions and of the typical postwar recession prior to 1985 (taken to be the average of the recessions between 1967 and 1985) in the three years following the trough. As is evident from the figure, the three post-1985 recoveries are much slower and more sluggish than the pre-1985 recovery, and the contrast is even more striking for employment (lower panel) than for output (upper panel).

Figure 2 highlights such contrast between pre-1985 and post-1985 recoveries by displaying side-by-side across each subsample the average cumulative growth rate of output and of employment four (upper panel) and eight (lower panel) quarters into a recovery. As can be seen from the figure, the average output growth rate accumulated over four quarters following a trough is less than 3% in the post-1985 period, compared to more than 7% in the pre-1985 era (about 6% versus more than 13% at an eight-quarter horizon); when we look at the average cumulative employment growth rate from the trough, we see an even more stark reduction across the two subsample periods: from about 3% earlier to being slightly negative now at a four-quarter horizon (from around 6% earlier to less than 1% now at an eight-quarter horizon).

It is worth noting that, in order to make a sensible comparison across recoveries from different business cycles, in both Figures 1 and 2, the data for each business cycle are indexed to the beginning of the recovery, that is, the trough. Indexing in this manner is useful not only because it may help isolate the comparison from the impact of potential long term factors, but also because the value of each indexed data point intuitively corresponds to the gross rate of growth in the underlying variable from the end of the relevant recession.

The phenomenon of a slow recovery has attracted much attention in recent years. Koenders and Rogerson (2005) relate the 1991 and 2001 slow recoveries to employment overhang and inefficiency in worker-job match accumulated during the long expansions preceding those recessions and resultant need for organizational restructuring during the recessions (see, also, Berger 2012). Groshen and Potter (2003) argue that the slow recovery from the 2001 recession might be caused by sectoral shift that occurred during the recession (see, also, Jaimovich and Siu 2012 for a similar argument that emphasizes the role of occupational shift occurring in the recession).[1] A just-in-time-use-of-labor hypothesis (e.g., Schreft and Singh 2003; Hodgson, Schreft and Singh 2005) emphasizes the increased reliance of firms on adjustments along the intensive margin (versus the extensive margin) of labor inputs as a potential cause of the reduced speed of recoveries from the 1991 and 2001 recessions in employment growth rate. A recent empirical study (i.e., Panovska 2014) finds evidence in favor of this hypothesis and suggests that changes in the relative importance of business-cycle shocks might have played a role in the increased importance of variations along the intensive margin of labor services.

The importance of various business-cycle shocks in accounting for the slower recoveries observed after 1985 is investigated by Gali, Smets and Wouters (2012) using a structural model, from which the intensive margin of labor adjustment is entirely abstracted away. Their main finding is that, for the recent three cyclical recoveries, the low growth rates of employment can be attributed entirely to the low growth rates of output, which are caused by relatively adverse shocks experienced during the recoveries. Of the eight shocks that they consider, investment-specific technology, risk premium, wage markup, and monetary policy shocks are shown to be the main factors behind the slow recoveries since 1985.

In another recent study, Jermann and Quadrini (2012) introduce a new type of business-cycle shocks into a structural framework with financial frictions in which firms' ability to borrow is restrained by an enforcement constraint. These "financial shocks" (labeled as such as they randomly disturb the value of firms' collateral and thus firms' ability to borrow) are shown to be a main driver of the three most recent recessions. The study fixes the capital utilization rate and considers only total hours worked but not employment. The lack of any mechanism to capture tradeoffs between extensive and intensive margins of capital and labor may have contributed to their model's inability to generate persistence in output and labor. Also, for the purpose of motivating the present paper, the study by Jermann and Quadrini focuses on how adverse financial shocks may have contributed to the downturns in 1990-1991, 2001, and 2008-2009, but is salient about the potential implications of these shocks for the subsequent recoveries in output and employment.

[1]For related or alternative hypotheses see, among others, Ma (2003), Schweitzer (2003), Aaronsan, Rissman and Sullivan (2004), Van Rens (2004), Gomme (2005), Di Tella and MacCulloch (2005), Andolfatto and MacDonald (2006), Engemann and Owyang (2007), Faberman (2008), Shimer (2010), Bachmann (2011), Garin, Pries and Sims (2011), and Willems and Wijnbergen (2012).

This paper studies such implications. Since the issue addressed here is why the post-1985 recoveries are slower than the pre-1985 recoveries, it is essential that we examine both episodes rather than just the more recent one that is the focus of Jermann and Quadrini (2012). Financial frictions and financial shocks are similarly introduced as in there, except that working capital loan is here modeled in a somewhat more conventional way, in that wage bills and purchases of investment goods must be paid at the beginning of each period, before production takes place and revenues are realized, whereas dividend and bond payments can be settled at the end of the period, after the realization of revenues. We find that the financial shocks have become more persistent since 1985,[2] and this is an important contributor to the slower recoveries during the post-1985 period. When we model working capital loan in the same way as in Jermann and Quadrini (2012), in that not only payments to workers and for purchases of investment goods but also payments to stockholders and bondholders must be made before production takes place and revenues are realized, our results are quantitatively less striking, though qualitatively similar. Similar results are also obtained when we use the Chicago Fed's National Financial Conditions Index to proxy the financial variable in our model.

It is easy to see the intuition for why a more persistent adverse financial shock originated in a recession can drag the subsequent recovery triggered by a positive productivity shock: since greater persistence of the financial shock implies that credit conditions are more likely to remain tight in the early phase of the recovery, firms are more likely to continuously face difficulties in obtaining loans and thus be limited in their ability to increase labor and capital inputs to expand production; as a result, the economy may recover more slowly.

To get in line our model's predictions with the data on employment, and on investment and capital stock, substitutions between adjustments along the two margins of labor and of capital inputs are also important: to cope with the positive productivity shock in the face of a binding borrowing constraint, firms may rely more on increasing the utilization rate of capital and hours worked per employee in the early stage of the recovery, but less on growing

[2] Such a turning point may not come as a total surprise given the widespread financial innovations and deregulations since the 1980s, which have dramatically complicated the financial architecture, turning it into a somewhat shadow and opaque system with many loose links, and which have also made it harder for monetary policy (which itself has undergone a dramatic transformation in adapting to the changing financial world) to improve financial conditions during recessions and even recoveries. It is natural to take a longer time for an adverse financial shock to dissipate in such a more complex financial system. Corroborating evidence is also presented by Loutskina and Strahan (2009), Knotek and Terry (2009), and Hatzius, Hooper, Mishkin, Schoenholtz and Watson (2010).

employment and capital investment. The result is slow recovery in employment growth rate accompanied by delayed investment and capital shortage in the early phase of the recovery. Whereas the substitution between the two margins of labor inputs echoes the just-in-time-use-of-labor hypothesis of Schreft and Singh (2003), Hodgson, Schreft and Singh (2005), and Panovska (2014), the substitution between the two margins of capital inputs finds its empirical support as is illustrated by Figure 3 that plots the cyclical components of capital utilization rate, investment, and capital stock for the US economy.[3]

As is seen from Figure 3, capital utilization rate usually increases as soon as a recovery begins, but investment can rebound with a delay while capital shortage can persist for an extended period into the recovery, and such contrast is especially stark during the slower recoveries experienced in recent times when financial conditions are persistently tight.[4]

We use a parsimonious model with only financial and productivity shocks to get a sense about the quantitative importance of the financial shock and the relative contribution of the tradeoff mechanism for the two margins of labor and capital inputs. The time series for the shocks are here constructed following the same methodology used in the two-shock model of Jermann and Quadrini (2012) that however fixes the intensive margins of both labor and capital inputs. Since the shock series so constructed are independent of whether or not other shocks are also included in the model, their macroeconomic effects will not be overstated just because those other shocks are abstracted away from the model. Using such constructed series, we simulate the model, and its variant where the intensive margins of labor and capital inputs are fixed. The simulation results confirm our intuition above. The series of output and employment generated from our benchmark model track their empirical counterparts closely for the entire sample period. Moreover, the benchmark model tracks closely the empirically observed reduction, from the pre-1985 era to the post-1985 period, in the speed of recovery from a business-cycle trough in output and employment growth. Yet, when we shut down the intensive margins of labor and capital inputs, the employment

[3]From now on we will focus on cyclical components obtained by passing actual and simulated data through the Hodrick-Prescott filter with a smoothing parameter of 16000.

[4]The substitution between the two margins of capital inputs and its implication for capital shortage during a recovery have long been noted in the literature (e.g., Gertler and Hubbard 1989; Gertler and Gilchrist 1994; Kashyap et al. 1994). Several studies actually link such capital shortage to the persistently high long-term unemployment rate in Europe (e.g., Benassy 1999; Braumann 1997; Acemoglu 2001). When situated in this strand of the literature, a contribution of this paper is to demonstrate a transmission mechanism through which persistently tight financial conditions can intensify such substitution to cause severe capital shortage and slow recovery in employment and output growth from a recession.

growth rate following the trough of a recession elevates to a level dramatically beyond data observable, for both the pre-1985 era and the post-1985 episode. That said, a significant difference between pre-1985 and post-1985 employment growth rates continues to show up even in this case, reconfirming the importance of the increased persistence in the financial shock for explaining the empirically observed reduction across the two subsample periods in the speed of recovery from a recession trough.

The main findings are also supported by our counter-factual analyses. When we divide the constructed series into two sub-series, one for the pre-1985 era and the other for the post-1985 episode, and use them to estimate two bivariate VAR processes respectively, we uncover statistically significant evidence that the financial shock has been more persistent after 1985 than it was before 1985. When we re-simulate the model, first using the VAR system estimated from the pre-1985 sub-series, and then using the VAR system estimated from the post-1985 sub-series, as the stochastic driving processes, we find that recovery from a recession indeed is much slower in the latter case than in the former one. This is true even when we set the standard deviations for the innovation terms in the shock processes to be the same across the two subsamples, adopt the Jermann and Quadrini (2012) form of borrowing constraint, or use the Chicago Fed's National Financial Conditions Index to proxy the financial variable in our model.

Taken together, we consider these results as providing strong evidence to suggest that not only the three recent episodes of considerable financial distress, namely, the S&L crisis in the late 1980s to the early 1990s, the dot-com bubble burst in the early 2000s, and especially most recently the more severe financial crisis that started in the mortgage markets in the late 2000s, contributed significantly to the downturns in 1990-1991, 2001, and 2008-2009, as demonstrated by Jermann and Quadrini (2012), but their adverse effects continued into the subsequent recoveries posting a major drag on the rebounds of employment and output growth from the troughs.

In light of the findings by Gali, Smets and Wouters (2012), it is also fitting to assess the importance of financial shocks relative to other shocks in contributing to the recent slow recoveries. To this end, we enrich their model, which is based on Gali, Smets and Wouters (2011) that features eight structural shocks and various frictions widely considered in the literature, with the financial frictions and financial shocks studied in this paper. Similar to their structural estimation approach, our richer model is also estimated with Bayesian maximum likelihood methods. Our decomposition results suggest that financial shocks are a dominant contributor to the recent slow recoveries, and this is so regardless of whether our model is estimated based on the whole sample or on the two subsamples separately.

2 A Parsimonious Model

We incorporate financial frictions and financial shocks into the framework of Burnside and Eichenbaum (1996), which is a variant of Hansen (1985), augmented to incorporate both variable capital-utilization rate and varying hours worked per employee. One feature of this model is that units of effective labor input co-move positively with capital utilization because the two are complementary to each other in production. Financial frictions and financial shocks are introduced in a way similar to that in Jermann and Quadrini (2012), except that working capital loan is here modeled in a somewhat more conventional way, in that wage bills and purchases of investment goods must be paid at the beginning of each period, before production takes place and revenues are realized, whereas dividend and bond payments can be settled at the end of the period, after the realization of revenues.

The economy is populated by a continuum of households along with a continuum of firms, both of a unit measure. A representative household consists of a large number of infinitely-lived individuals, each endowed with T hours of time in any given period. To go to work, an individual incurs a fixed cost, in terms of ζ hours of time. The date-t instantaneous utility of such a working individual is given by $\ln(c_t) + \theta \ln(T - \zeta - h_t)$, for some $\theta > 0$, where c_t and h_t denote the individual's consumption and hours worked in period t, respectively. The date-t instantaneous utility of an individual who does not go to work is given by $\ln(c_t) + \theta \ln(T)$. We have assumed that all of the household members have the same level of consumption regardless of their employment statuses.

At the end of each period, the representative household decides on the number of its members that will go to work in the next period. Likewise, at the end of each period, a firm decides on the number of its employees to be put into work in the next period. This timing assumption helps disentangle the two margins of total hours worked. It also helps capture the idea that households and firms make employment decisions conditional on the expected future states of demand and technology and it takes time for a match to form. We thus treat the extensive margins of labor (i.e., employment) and capital (i.e., stock) inputs in a symmetric way in terms of time-to-build (one period in our model), though we assume the intensive margins of labor (i.e., hours worked per employee) and capital (i.e., utilization rate) services can be adjusted instantaneously in response to aggregate shocks.

The continuum of firms are indexed on the unit interval $[0, 1]$. All firms have access to a common production function,

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

where z_t represents the stochastic level of technology common to all firms, $\alpha \in (0, 1)$ is the share of capital in value-added inputs, k_t denotes the capital stock at the beginning of time t, u_t represents the capital utilization rate, and n_t denotes the number of working individuals per household at date t. According to the production function, the production of output depends on the total amount of effective capital, $k_t u_t$, and the total effective hours of work, $n_t h_t$. Equation (1) captures the notion that capital services and labor input are complementary to each other in production.

We suppose that using capital more intensively increases the rate at which capital depreciates. Specifically, we assume that date-t depreciation rate of capital, δ_t, is given by

$$\delta_t = \bar{\delta} u_t^{\phi}, \tag{2}$$

where $0 < \bar{\delta} < 1$ and $\phi > 1$.[5] The stock of capital evolves according to $k_{t+1} = (1-\delta_t)k_t + i_t$, where i_t denotes gross investment at date t. Under these assumptions, firms can increase capital service without increasing capital stock.

Firms' capital structure consists of equity and one-period bond. We assume that firms do not retain any earnings in liquid form, and we consider two distortions/frictions that invalidate the applicability of the Modigliani-Miller theorem and allow technology and especially financial shocks to affect firms' capital structure and production decisions. First, there is a tax shelter on corporate bond (financed by a lump-sum tax on households): given a market interest rate r_{t-1}, the effective gross interest rate on corporate bond b_t is $R_{t-1} = 1 + r_{t-1}(1 - \tau)$, where τ represents the tax benefit. Second, the payout of dividend d_t is subject to a quadratic cost, $\varphi(d_t) = d_t + \kappa(d_t - \bar{d})^2$, for some $\kappa \geq 0$, where $\bar{d}$ represents firms' long-run dividend payout target. This is also the approach taken by Jermenn and Quardrini (2012). But differing from their approach, we assume that dividend

[5] See Greenwood, Hercowitz and Huffman (1988) and Burnside and Eichenbaum (1996).

and intertemporal debt payments are made at the end of each period, after production takes place and revenue for the period is realized.

Timing of events in a typical period t in our model is as follows. At the beginning of the period, aggregate technology shock z_t is realized. Before production takes place, firms must prepay workers and purchase investment goods. Since firms do not retain any earnings in liquid form and their decisions on equity and intertemporal debt finance are made at the end of each period, the required working capital, including total wage payment, $w_t n_t h_t$, where w_t denotes date-t wage rate, and investment, i_t, is financed by an interest-free intratemporal loan, l_t. That is, $l_t = w_t n_t h_t + i_t$.

After production takes place and revenue y_t is realized, firms choose dividend payment d_t that incurs the gross equity payout cost $\varphi(d_t)$, pay the intertemporal debt b_t that they have carried over from period $t-1$, and take out a new intertemporal debt b_{t+1}.

At this stage the intratemporal loan l_t needs to be repaid. In light of a firm's period-t budget constraint, $w_t n_t h_t + i_t + b_t + \varphi(d_t) = y_t + b_{t+1}/R_t$, we can see that the liquidity $L_t = y_t - b_t - \varphi(d_t) + b_{t+1}/R_t$ that the firm is holding at this point is equal to its obligation on the intratemporal loan $l_t = w_t n_t h_t + i_t$. This means that, if it wishes, the firm would be able to pay off the entire intratemporal loan using its liquidity at hand, and retain its physical capital k_{t+1} (while also committing to the number of employees n_{t+1} and promising to pay the new intertemporal debt b_{t+1} in the next period) to continue its operation into period $t+1$. Denote by V^e_{t+1} the expected equity value of this continuous operation of the firm. This clearly would be an equilibrium outcome with perfect enforcement of debt contract. However, under our assumption of imperfect enforceability of debt contract (i.e., Kiyotaki and Moore 1997), the firm can default on its debt obligation. Since the firm can easily divert its liquidity L_t, if it chooses to not repaying the intratemporal loan l_t at this point, the lender can only try to recover funds from liquidating the firm's (somewhat illiquid and thus hard-to-divert) physical capital k_{t+1}. The liquidation value of this physical capital stock is stochastic: with probability ξ_t the lender will be able to recover the full value of k_{t+1}, but with probability $1-\xi_t$ the recovery value to the lender will be zero. This uncertainty will be resolved only after the firm and the lender enter into a default-renegotiation status.

If it turns out the liquidation value of the capital is zero, the lender has no renegotiation threat, so its best option is to leave the capital with the firm to continuing its operation into period $t+1$ and then collect the intertemporal debt b_{t+1} when it is due. The ex post value of default for the firm in this case is $L_t + V^e_{t+1}$.

In the case the lender can expropriate the whole value of the capital, liquidation is a real threat to the firm. While liquidation can recover the whole k_{t+1} for the lender, it will also terminate the firm's operation so the lender will not be able to collect the intertemporal debt b_{t+1} next period. To make the lender indifferent between liquidation and leaving k_{t+1} with the firm to continuing its operation, the firm needs to pay $k_{t+1} - b_{t+1}/(1+r_t)$ now while also promising to pay b_{t+1} next period when the intertemporal debt is due. Since the total value of the firm under continuous operation (equity V^e_{t+1} plus bond $b_{t+1}/(1+r_t)$) is no less than the value of its capital stock k_{t+1}, the ex post value of default for the firm is no less under continuous operation $(L_t + V^e_{t+1} - (k_{t+1} - b_{t+1}/(1+r_t)))$ than under liquidation (L_t), so the firm prefers continuous operation to liquidation in this case.

It follows that the ex ante expected value of default for the firm is

$$\xi_t \left[L_t + V^e_{t+1} - \left(k_{t+1} - \frac{b_{t+1}}{1+r_t} \right) \right] + (1-\xi_t)\left(L_t + V^e_{t+1} \right) = L_t + V^e_{t+1} - \xi_t \left(k_{t+1} - \frac{b_{t+1}}{1+r_t} \right).$$

We consider a loosest form of enforcement constraint under which no-default arises as an equilibrium outcome. This requires that the value of not defaulting, V^e_{t+1}, while the firm uses its liquidity L_t to pay off its intratemporal debt obligation l_t, is no less than the expected value of default for the firm. This gives rise to the following borrowing constraint,

$$l_t \leq \xi_t \left(k_{t+1} - \frac{b_{t+1}}{1+r_t} \right), \tag{3}$$

which is just tight enough to ensure no-default in equilibrium. The tightness of this borrowing constraint is affected by the capital stock, which plays a role of collateral for debts. The tightness of this enforcement constraint is also affected by the random variable ξ_t, which can be thought of as prescribing general financial market conditions. As such, we refer to its stochastic innovations as "financial shocks".

In the following recursive formulations of firm's and household's optimization problems, we will suppress the time subscripts of all variables.

Denote by s the vector of aggregate state variables, consisting of aggregate total factor productivity, z, general financial market condition, ξ, aggregate capital stock, K, aggregate employment, N, aggregate bond outstanding, B, and aggregate share of equity, X. Individual state variables for a firm include its capital stock, k, its number of employees,

n, and its intertemporal debt outstanding, b. The firm's optimization problem is

$$V(s;k,n,b) = \max_{u,h,d,k_{+1},n_{+1},b_{+1}} \{d + \mathrm{E}m_{+1}V(s_{+1};k_{+1},n_{+1},b_{+1})\} \tag{4}$$

subject to the budget constraint

$$wnh + k_{+1} - (1-\delta)k + b + \varphi(d) = z(ku)^{\alpha}(nh)^{1-\alpha} + \frac{b_{+1}}{R}, \tag{5}$$

and the borrowing constraint

$$wnh + k_{+1} - (1-\delta)k \leq \xi\left(k_{+1} - \frac{b_{+1}}{1+r}\right). \tag{6}$$

The value function $V(s;k,n,b)$ represents the market value of the firm in terms of its cumulative dividends under the optimal decision rule, and m_{+1} is the stochastic discount factor consistent with household's optimization problem described below. The stochastic discount factor, wage rate, and interest rate are determined in general equilibrium and are taken as given by an individual firm.

Denote by λ and μ the Lagrange multipliers associated with the budget and borrowing constraints, respectively. The first-order conditions with respect to u, h, d, k_{+1}, n_{+1}, and b_{+1}, for the firm's problem, are

$$\alpha\frac{y}{k} = \left(1+\frac{\mu}{\lambda}\right)\phi\delta, \tag{7}$$

$$(1-\alpha)\frac{y}{nh} = \left(1+\frac{\mu}{\lambda}\right)w, \tag{8}$$

$$\lambda = \frac{1}{1+2\kappa(d-\bar{d})}, \tag{9}$$

$$\mathrm{E}m_{+1}\frac{\lambda_{+1}}{\lambda}\left[(1-\delta_{+1}) + \alpha\frac{y_{+1}}{k_{+1}} + \frac{\mu_{+1}}{\lambda_{+1}}(1-\delta_{+1})\right] + \frac{\mu}{\lambda}\xi = 1 + \frac{\mu}{\lambda}, \tag{10}$$

$$\mathrm{E}m_{+1}\lambda_{+1}\left[(1-\alpha)\frac{y_{+1}}{n_{+1}} - \left(1+\frac{\mu_{+1}}{\lambda_{+1}}\right)w_{+1}h_{+1}\right] = 0, \tag{11}$$

$$\mathrm{E}m_{+1}\frac{\lambda_{+1}}{\lambda} + \frac{\mu}{\lambda}\xi\frac{1}{1+r} = \frac{1}{R}. \tag{12}$$

As discussed before, the random variable ξ that prescribes general financial market conditions affects the tightness of the enforcement constraint. This can also be easily seen here by considering the case where the cost of equity payout is zero, that is, with $\kappa = 0$. It then follows from (9) that $\lambda = \lambda_{+1} = 1$, and then (12) becomes $\mathrm{E}m_{+1} + \mu\xi/(1+r) = 1/R$. This implies, given aggregate prices $\mathrm{E}m_{+1}$, r, and R, a negative relation between μ and ξ.

In particular, a negative financial shock, which leads to a reduction in ξ, must increase μ and thus tighten the enforcement constraint.

Individual state variables for a household include the number of its members that go to work, n, and its holdings of intertemporal debt and equity share, b and x, respectively. The household's optimization problem is

$$U(n,b,x)=\max_{c,h,n_{+1},b_{+1},x_{+1}}\{\ln(c)+\theta n\ln(T-\zeta-h)+\theta(1-n)\ln(T)+\beta\mathrm{E}U(n_{+1},b_{+1},x_{+1})\} \tag{13}$$

subject to the budget constraint

$$c+\frac{b_{+1}}{1+r}+qx_{+1}+\Upsilon=wnh+b+(q+d)x, \tag{14}$$

taking as given the wage rate, w, interest rate r, equity price q, and dividend payment, d, where β is a subjective discount factor, and Υ is a lump-sum tax that finances the tax shelter on corporate debt.

The value function $U(n,b,x)$ represents the lifetime utility of the household under the optimal decision rule. Notice that the household's optimization problem depends on the aggregate state s indirectly, through the aggregate prices and dividend payment. This implies that this value function shall also depend on the aggregate state, even though we have suppressed this dependence in order to help simplify expressions.

The first order conditions with respect to $c\backslash h$, n_{+1}, b_{+1}, and x_{+1}, for the household's problem, are

$$\frac{w}{c}-\frac{\theta}{T-\zeta-h}=0, \tag{15}$$

$$\mathrm{E}\left[\frac{w_{+1}h_{+1}}{c_{+1}}+\theta\ln(T-\zeta-h_{+1})-\theta\ln(T)\right]=0, \tag{16}$$

$$\beta\,(1+r)\,\mathrm{E}\frac{c}{c_{+1}}=1, \tag{17}$$

$$\beta\mathrm{E}\frac{c}{c_{+1}}\frac{q_{+1}+d_{+1}}{q}=1. \tag{18}$$

Since households own all the firms, their optimization problems are mutually consistent. This implies that the stochastic discount factor (m_{+1}) facing the firms is equal to the intertemporal substitution in consumption ($\beta c/c_{+1}$) chosen by the households.

Since the tax shelter on corporate debt is financed by the lump-sum tax on households, the government faces the budget constraint, $\Upsilon=B_{+1}/R-B_{+1}/\left(1+r\right)$, where we recall that $R=1+r(1-\tau)$.

The definition of a general equilibrium follows.

Definition 1 *A recursive competitive equilibrium is a collection of functions for (i) firm's policies* $u(s;k,n,b)$*,* $h^f(s;k,n,b)$*,* $d(s;k,n,b)$*,* $k_+(s;k,n,b)$*,* $n^f_{+1}(s;k,n,b)$*, and* $b^f_{+1}(s;k,n,b)$*; (ii) household's policies* $c(n,b,x)$*,* $h^h(n,b,x)$*,* $n^h_{+1}(n,b,x)$*,* $b^h_{+1}(n,b,x)$*, and* $x_{+1}(n,b,x)$*; (iii) firm's value* $V(s;k,n,b)$ *and household's value* $U(n,b,x)$*; (iv) aggregate prices* $w(s)$*,* $r(s)$*,* $p(s)$*, and* $m(s,s_{+1})$*; and (v) law of motion of aggregate state* $s_{+1}=\Psi(s)$*; such that: (i) firm's policies satisfy (7)-(12) and firm's value satisfies Bellman equation (4); (ii) household's policies satisfy (15)-(18) and household's value satisfies Bellman equation (13); (iii) wage rate, interest rate, and share price clear the labor, bond, and equity markets, and* $m(s,s_{+1})=\beta c/c_{+1}$*; (iv) the lump-sum tax* Υ *is equal to* $B_{+1}/\left[1+r(1-\tau)\right]-B_{+1}/\left(1+r\right)$*; (v) the law of motion* $\Psi(s)$ *is consistent with individual decisions and with the stochastic processes for* z *and* ξ*.*

Since the model cannot be solved analytically, we follow the standard approach in the business cycle literature to approximate the true solution numerically. In the computation we assume that the borrowing constraint is always binding and solve for a log-linear approximation of the dynamic equilibrium system around the steady state, which is defined when the productivity and financial variables z and ξ take on their unconditional means, $\bar{z}$ and $\bar{\xi}$, respectively (the log-linearized system is presented in Appendix A). The solution is then used to verify the validity of the assumption of binding constraints. For this exercise, we need to assign values to the model's parameters and specify measures of shocks.

3 Parameter Values and Measures of Shocks

Most parameters can be calibrated to match relevant steady-state conditions in the model with corresponding moment conditions that represent the long-run average behaviors of the US economy, or to standard values used in the business cycle literature. Other parameters can be determined by exploring the model-consistent stochastic properties of relevant data. Since one period in the model corresponds to one quarter of a physical year, the US data on which the model calibration is based are of quarterly frequency, for the 1967:I-2012:IV or similar periods. For capital, depreciation rate, and debt, we use end-of-period balance sheet data from the Flow of Funds Accounts. For output, we use GDP data from the Bureau of

Economic Analysis. For wage, employment, hours worked, and capacity utilization rate, we use data from the Federal Reserve Bank of St. Louis. All of the empirical series are in real terms. A more detailed description of the data is contained in Appendix B.

To begin, we set the quarterly time endowment T to 1369 hours, consistent with around 15 daily discretionary hours, as in Burnside and Eichenbaum (1996). Given this value of T, we set ζ to 60 hours, a midpoint of the reasonable range $[20, 120]$ for ζ examined by Burnside and Eichenbaum (1996), which implies that an employed worker spends about 40 minutes per day on commuting. We set the utility parameter $\theta = 1.5935$, consistent with a steady-state employment rate of 0.94. In light of the steady-state version of (18), we set the subjective discount factor β to 0.9825, to be consistent with an annual stead-state return of 7.12% from holding equity shares.

Turning to production and financing, we set the share of capital in value-added inputs, α, to 0.36, as is standard in the literature. Following Jermann and Quadrini (2012), we set the tax wedge, τ, to 0.35, representing a benefit of debt over equity if the marginal tax rate is 35%. We normalize the mean value of the productivity variable, $\bar{z}$, to 1.

To choose the mean value of the financial variable, $\bar{\xi}$, we first notice that, given β and τ chosen above, the steady-state version of (17) implies that $\bar{r} = 1/\beta - 1$ and, therefore, $\bar{R} = 1 + (1/\beta - 1)(1 - \tau)$. We set $\bar{\delta}$ to 0.025, consistent with an annual steady-state capital depreciation rate of 10%, and the steady-state value $\bar{b}/\bar{y}$ to 3, consistent with the average debt-to-GDP ratio over our sample period. Also note, from the steady-state versions of (9) and the law of motion for capital, the following steady-state results, $\bar{\lambda} = 1$ and $\bar{i} = \bar{\delta}\bar{k}$. We then use the steady-state versions of (6) and (8), (10), and (12), respectively, to derive the following three steady-state equations,

$$\bar{\xi}\left(\frac{\bar{k}}{\bar{y}} - \frac{\bar{b}}{\bar{y}}\frac{1}{1+\bar{r}}\right) = \frac{1-\alpha}{1+\bar{\mu}} + \frac{\bar{\delta}\bar{k}}{\bar{y}},$$

$$\frac{\bar{y}}{\bar{k}} = \frac{(1+\bar{\mu})\left[1 - \beta\left(1-\bar{\delta}\right)\right] - \bar{\mu}\bar{\xi}}{\beta\alpha},$$

$$\bar{R}\beta\left(1 + \bar{\mu}\bar{\xi}\right) = 1.$$

We can now solve for $\bar{\xi}$, along with $\bar{\mu}$ and $\bar{y}/\bar{k}$, from the three equations above. In addition, the steady-state version of (7) gives rise to a value of ϕ equal to $\alpha(\bar{y}/\bar{k})/[(1+\bar{\mu})\bar{\delta}]$. Here, we use a variable with a bar to denote its steady-state value.

We proceed now to the parameters governing the stochastic processes of shocks. For the productivity variable z_t, we use the series estimated by Fernald (2012) based on the method described in Basu, Fernald, and Kimbal (2006). To construct the series for the financial variable ξ_t, we appeal to the binding version of the borrowing constraint,

$$\xi_t \left(k_{t+1} - \frac{b_{t+1}}{1 + r_t} \right) = w_t n_t h_t + i_t.$$

After constructing the series of the log-deviations from the deterministic trend of these two variables, $\hat{z}_t$ and $\hat{\xi}_t$, over the period 1967:I-2012:IV (more detail of the construction is contained in Appendix B), we estimate the following bivariate VAR system,

$$\begin{pmatrix} \hat{z}_{t+1} \\ \hat{\xi}_{t+1} \end{pmatrix} = \mathbf{A} \begin{pmatrix} \hat{z}_t \\ \hat{\xi}_t \end{pmatrix} + \begin{pmatrix} \epsilon_{z,t+1} \\ \epsilon_{\xi,t+1} \end{pmatrix}, \tag{19}$$

where $\epsilon_{z,t+1}$ and $\epsilon_{\xi,t+1}$ are i.i.d. shocks, with zero means and standard deviations σ_z and σ_ξ, respectively.

The financial shocks $\epsilon_{\xi,t}$ (that is, the stochastic innovations to the financial variable) so constructed can be thought of as a proxy for changes in credit standards. In particular, the negative of $\epsilon_{\xi,t}$ provides a measure of credit tightening in the model. An empirical counterpart of this model-based index of credit tightening is the Federal Reserve Board's Senior Loan Officer Opinion Survey on Bank Lending Practices tightening index. The survey asks the senior loan officers whether they have recently tightened the credit standards for commercial and industrial loans, and an index of credit tightness is constructed based on the percentage of officers reporting tightening standards. The two tightening indices are plotted against each other in Figure 4. To facilitate the comparison we have re-scaled the survey-based index by a factor of 1/1421. As can be seen from the figure, our model-based index tracks reasonably well the survey-based index for the period for which the latter has become available (beginning in the second quarter of 1990).

Finally, we note that only the product $\kappa \bar{d}$, but not the individual values of the parameters governing the cost of equity payout, κ, and firms' long-run dividend payout target, $\bar{d}$, matters for the log-linearized equilibrium system. With the values of the other parameters chosen above, and using the series generated by (19), we can solve the model, starting with an initial guess for the value of $\kappa \bar{d}$, and simulate a series of d_t/y_t over the period 1967:I-2012:IV. We can then check if the standard deviation of d_t/y_t generated from the simulated series equals its empirical counterpart computed from the actual data. If they differ, we vary the value of $\kappa\bar{d}$ to repeat the process, and keep doing so until they coincide. The entire set of parameters is provided in Table 1.

4 Results

Our results are based on simulating the model dynamics driven by the constructed series of shocks. In conducting the simulations, we follow a general procedure as described below for our baseline simulation: starting with the initial condition $\{\hat{z}_{1967.I}, \hat{\xi}_{1967.I}\}$, we feed the sequence of innovations $\{\epsilon_{z,t}, \epsilon_{\xi,t}\}_{1967:II}^{2012:IV}$ into the model and compute the dynamics of key macroeconomic and financial variables in a way in which the agents in the model treat the innovations as purely stochastic. Throughout this procedure, we always verify ex post that the borrowing constraint remains binding during the entire simulation period. This is done by checking the Lagrange multiplier for the borrowing constraint to make sure that the negative deviations of this variable from the steady state never exceed -100 percent, implying that the multiplier is always positive and so the borrowing constraint is indeed always binding during the simulation period. It turns out that, in all of our simulations, this indeed is the case, as exemplified by Figure 5, which displays the Lagrange multiplier for the borrowing constraint in our baseline simulation.

Figure 6 plots the series of output and employment generated from the model against their empirical counterparts over the period 1967:I-2012:IV. As can be seen from the figure, the simulated series tracks the data closely for the entire sample period.[6]

Our goal here is to assess the model's ability in explaining the slower recoveries from the three most recent recessions compared to the recoveries from the earlier recessions. To help illustrate the contrast between the speed of recovery from a typical pre-1985 recession and that from a typical post-1985 recession, we compute across each of the two subsamples the average cumulative growth rate of output and of employment eight quarters into a recovery, both from the simulated series and from data observables. Figure 7 displays the results. As the figure shows, there is indeed a significant reduction across the two subsample periods in the speed of recovery in the model, just as in the data.

We wish to reiterate that, to make a sensible comparison across recoveries from different

[6] Our model also does a good job in accounting for the cyclical behaviors of other variables, including financial flows such as debt repurchase and equity payout. These results are not reported here in order to conserve space but available upon request from the authors.

recessions, in Figure 7, both the simulated series and their empirical counterparts for each business cycle are indexed to the beginning of the recovery, that is, the trough. As discussed in the introduction, indexing in this manner is useful not only because it may help isolate the comparison from the impact of potential long term factors, but also because the value of each indexed point intuitively corresponds to the gross rate of growth in the underlying variable from the end of the relevant recession.

One may nevertheless argue that the depth of a recession may affect the speed of the subsequent recovery. To help address this potential concern, we examine a recession-depth adjusted measure of speed of recovery, where the recession depth of a business cycle for output or employment is defined as the distance from the trough to trend of that variable. To do so, we first divide the recession depth of each business cycle by that of the first business cycle in our sample period to get a relative depth of the recession. We next normalize the cumulative growth rate of output and of employment following the trough of a recession by its relative depth for that variable. We then compute across each subsample the average normalized eight-quarter cumulative growth rate of output and of employment from the simulated series and their empirical counterparts. Figure 8 displays the results.

As is apparent from Figure 8, a significant reduction in the speed of recovery from a recession trough across the two subsample periods is a robust observation from the data, while also a robust prediction from our model. In the pre-1985 era, the average normalized eight-quarter cumulative growth rate of output (employment) following a recession trough is about 4.9% (1%) in the data, matched well by the 4.4% (1.9%) predicted by the model. In the post-1985 episode, this measure of speed of output (employment) recovery reduces to 1.8% (-0.7%) in the data, once again matched well by the 2.3% (-0.5%) predicted by the model. The model tracks closely the data, in particular, the empirically observed reduction, from the pre-1985 period to the post-1985 period, in the speed of recovery from a business-cycle trough.

As explained in the introduction, one factor behind the recent slower recoveries may have to do with the widespread financial innovations and deregulations since the 1980s, which have dramatically complicated the financial architecture, turning it into a somewhat shadow and opaque system with many loose links, and which have also made it harder for monetary policy (which itself has undergone a dramatic transformation in adapting to the changing financial world) to improve financial conditions during recessions and even recoveries. It is natural to take a longer time for an adverse financial shock to dissipate in such a more complex financial system. A more persistent adverse financial shock originated in a recession can drag the subsequent recovery triggered by a positive productivity shock, as the greater persistence of the financial shock implies that credit conditions are more likely to remain tight, at least in the early phase of the recovery, so firms are more likely to continuously face difficulties in obtaining loans and thus be limited in their ability to increase labor and capital inputs to expand production. The economy may recover more slowly as a result.

That said, in order for our model's predictions to get in line with the data on employment (and on investment and capital stock), substitutions between adjustments along the two margins of the productive inputs are also important: to cope with the positive productivity shock in the face of a binding borrowing constraint, firms may rely primarily on increasing the utilization rate of capital and hours worked per employee in this early stage of the recovery, but restrain from growing employment and investment, at least not to expand along these extensive margins too aggressively. The result is slow recovery in employment growth rate accompanied by delayed investment and capital shortage in the early phase of the recovery. The increased capital utilization rate and delayed investment curtail firms' future capital stock and reduce their collateral for borrowing in the time to come. This, when put in the face of a slower improvement in the financial condition, may prolong the wait-and-see period for growing the extensive margins of the productive inputs and cause a longer period of capital shortage and a slower recovery in employment growth.

If firms were not given the flexibility of adjusting the intensive margins of the productive inputs, then they would have to expand as much as possible along the extensive margins in response to the positive productivity shock. Recovery in employment growth would be faster as a result. To drive this point home, we simulate a variant of our model in which the intensive margins of labor and capital inputs are fixed to their steady-state levels. The simulation results confirm our intuition above, as can be seen from Figure 9, which plots across each of the two subsamples the average cumulative growth rate of employment and of output eight quarters into a recovery for this case with fixed intensive margins, against our benchmark model and the observed data. As the figure illustrates, shutting off the intensive margins raises the employment growth rate following the trough of a recession, to a level dramatically beyond that in the benchmark model and that in the data, for both the pre-1985 era and the post-1985 episode.

This is also true in terms of the recession-depth adjusted measure of speed of recovery. Figure 10 displays across each subsample the average normalized eight-quarter cumulative growth rate of employment and of output for the case with fixed intensive margins, against the benchmark model and the data. As can be seen from the figure, recovery in employment growth from a recession trough is once again just too rapid for both the pre-1985 era and the post-1985 episode. For the post-1985 period, for instance, the normalized cumulative growth rate of employment is still at around -1% even eight quarters into a recovery, both in the data and in the benchmark model, while fixing the intensive margins elevates this measure of employment recovery to almost 3%.

All of the above said, some significant reduction in the speed of recovery across the two subsample periods continues to show up even in the variant of our model with fixed intensive margins of the productive inputs, as can be seen from both Figures 9 and 10. This serves to reiterate the potential importance of increased persistence in financial shocks heuristically argued above in accounting for the empirically observed reduction in the speed of recovery from the pre-1985 period to the post-1985 period.

To assess this point more formally, we divide the constructed series of the productivity and financial variables into two sub-series, one for the pre-1985 era and the other for the post-1985 episode, and use them to estimate two bivariate VAR processes separately. The estimated vector autoregressive coefficient matrices are, respectively,

$$\begin{bmatrix} 0.843 & 0.053 \\ \text{-}0.019 & 0.887 \end{bmatrix} \text{ and } \begin{bmatrix} 0.862 & \text{-}0.003 \\ 0.156 & 0.931 \end{bmatrix}.$$

The estimations suggest that the series governing financial conditions is more persistent in the post-1985 period than in the pre-1985 period: the estimated value of the autoregressive serial correlation parameter is 0.887 in the earlier subsample but 0.931 in the more recent subsample. The Chow breakpoint test for parameter instability supports this postulation. The likelihood ratio test rejects the null hypothesis that the persistence parameter for the financial variable stays the same before and after 1985, with a p-value equal to 0.014. When we conduct the analysis using the form of collateral constraint adopted by Jermenn and Quardrini (2012), we reach the same conclusion. We have also done the analysis, replacing our constructed series of the financial variable with the Chicago Fed's National Financial Conditions Index, which provides a comprehensive update on U.S. financial conditions, and obtained similar, statistically significant evidence that this measure of financial conditions has become more persistent since the mid 1980s.[7] These additional estimation and testing results are not reported here in order to conserve space, but they are available upon request from the authors.

With these subsample based estimations in hand, we can conduct some counterfactual analyse to check our intuition above. When we re-simulate the model, first using the VAR system estimated from the pre-1985 sub-series, and then using the VAR system estimated from the post-1985 sub-series, as the stochastic driving processes, we find that recovery from a recession indeed is much slower in the latter case than in the former one.[8]

To provide some details about our counterfactual experiments, we consider thirty two periods in our model, or eight physical years, as the length of a typical business cycle. Each counterfactual simulation generates artificial data series long enough to cover one hundred complete business cycles, which entails to thirty two hundred periods of simulated data.

We conduct two such counterfactual simulations. We begin each using a random number generator to produce thirty two hundred periods of productivity and financial shocks according to the vector autoregressive coefficients and standard deviations estimated from one of the two subsamples. We next feed these shocks into our model to generate simulated series of output and of employment. We then identify the one hundred periods with the lowest levels of de-trended log of output and mark them as the business cycle troughs. Finally, we compute four-quarter and eight-quarter cumulative growth rates of output and of employment following each of the one hundred marked troughs.

Based on the two sets of output and employment growth rates following the troughs obtained respectively from the two counterfactual simulations above, we find that the speed

[7] The Chicago Fed's National Financial Conditions Index, which provides a comprehensive update on U.S. financial conditions in the traditional and shadow banking systems, as well as in money markets, and debt and equity markets, covers a much longer period, extending back to 1973, than does the Board's Senior Loan Officer Opinion Survey on Bank Lending Practices index, which only dates back to 1990 and is one of the many components making up the Chicago Fed's index. The Board's index, although a closer empirical counterpart of our model-based financial index than the Chicago Fed's index, which is composed of not only indicators that proxy changes in financial conditions but also indicators that gauge the financial conditions themselves, is not suitable for the analysis here because of its short period of availability, covering only the three most recent business cycles.

[8] This is true even when we set the standard deviations for the innovation terms in the shock processes to be the same across the two subsamples, adopt the Jermann and Quadrini (2012) form of borrowing constraint, or use the Chicago Fed's National Financial Conditions Index to proxy the financial variable in our model. These additional results are not reported here in order to conserve space, but they are available upon request from the authors.

of recovery is slower when the model economy is driven by the post-1985 shock processes than when it is driven by the pre-1985 shock processes. We conduct a test for a break in the mean based on the maximum t-statistic across the two sets of recovery measures. The outcomes of the test show that the reduction in the speed of recovery from a recession trough, from the pre-1985 period to the post-1985 period, is significant at a 1 percent level, for both output and employment, at both four-quarter and eight-quarter horizons. These results are reported in Table 2.

Taken together, we view these results as providing strong evidence to suggest that the increased persistence in financial shocks can be an important contributor to the slow recoveries from the three most recent recessions. In what follows, we use a more comprehensive model to assess the importance of such financial shock relative to other shocks widely considered in the literature in contributing to the recent slow recoveries.

5 A Comprehensive Model

In this section, we present a comprehensive stochastic general equilibrium model featuring nominal price and wage rigidities and financial frictions and shocks, along with eight other – productivity, investment, monetary policy, government spending, wage mark-up, price mark-up, risk premium, and labor supply – shocks widely considered in the literature, (e.g., Gali, Smets and Wouters 2012). We estimate the model with Bayesian maximum likelihood methods using nine empirical time series – GDP, investment, labor force, working hours, wage rate, federal funds rate, government spending, nominal prices, and debt purchases. We use the estimated model to study the relative importance of the nine structural shocks in shaping the behaviors of output and employment during cyclical recoveries, in particular, their relative contributions to the recent slow recoveries.

5.1 Model

The model features a continuum of firms, each producing a differentiated intermediate goods indexed by $i \in [0, 1]$, and a representative household consisting of a continuum of infinitely-lived individuals, each with a differentiated labor skill and differing dis-utility from working. Each household member is identified by a pair $(j, \iota) \in [0, 1] \times [0, 1]$, with j representing its type of labor skill and ι determining its dis-utility from working. The firms are monopolistic competitors on the markets for their goods products, and the individuals are monopolistic competitors on the markets for their labor skills.

At each date t, there are perfectly competitive retailers that combine the differentiated intermediate goods $\{y_{i,t}\}_{i\in[0,1]}$, taking their prices $\{p_{i,t}\}_{i\in[0,1]}$ as given, to minimize the cost of fabricating a given quantity of a composite final goods Y_t, subject to $Y_t = \left(\int_0^1 y_{i,t}^{1/\eta_t} di\right)^{\eta_t}$, where η_t is stochastic and captures price mark-up shocks according to the following process $\eta_t/\eta = (\eta_{t-1}/\eta)^{\rho_\eta} \exp(\epsilon_{\eta,t})$, $\epsilon_{\eta,t} \sim N(0, \sigma_\eta)$, where η denotes the unconditional mean of η_t. The resultant demand schedule for a type i intermediate goods is $y_{i,t} = (p_{i,t}/P_t)^{\eta_t/(1-\eta_t)} Y_t$, where $P_t = \left[\int_0^1 p_{i,t}^{1/(1-\eta_t)} di\right]^{1-\eta_t}$ is the resultant cost of fabricating one unit of the final goods, which also is the price at which the retailers sell the final goods to individuals for consumption purpose, to firms for investment purpose, or to government for public spending purpose, so which can be viewed as representing the general price level.

There are also perfectly competitive distributors that combine the differentiated labor services $\{n_{j,t}\}_{j\in[0,1]}$, taking their wage rates $\{w_{j,t}\}_{j\in[0,1]}$ as given, to minimize the cost of fabricating a given quantity of a composite labor service N_t, subject to $N_t = \left(\int_0^1 n_{j,t}^{1/\nu_t} dj\right)^{\nu_t}$, where ν_t is stochastic and captures wage mark-up shocks according to the following process $\nu_t/\nu = (\nu_{t-1}/\nu)^{\rho_\nu} \exp(\epsilon_{\nu,t})$, $\epsilon_{\nu,t} \sim N(0, \sigma_\nu)$, where ν denotes the unconditional mean of ν_t. Here $n_{j,t}$ is the fraction of the household members with type j labor skill that are employed under the wage rate $w_{j,t}$.[9] The resultant demand schedule for a type j labor service is $n_{j,t} = (w_{j,t}/W_t)^{\nu_t/(1-\nu_t)} N_t$, where $W_t = \left[\int_0^1 w_{j,t}^{1/(1-\nu_t)} dj\right]^{1-\nu_t}$ is the resultant cost of fabricating one unit composite labor service, which also is the wage rate at which firms pay for hiring the composite labor. It can thus be viewed as representing the general wage level in the economy.

A type i goods is produced according to $y_{i,t} = z_t (k_{i,t} u_{i,t})^\alpha n_{i,t}^{1-\alpha}$, where z_t represents the stochastic level of technology that evolves according to $z_t = z_{t-1}^{\rho_z} \exp(\epsilon_{z,t})$, $\epsilon_{z,t} \sim N(0, \sigma_z)$, $k_{i,t}$ is firm i's capital stock at the beginning of period t while $u_{i,t}$ is its capital utilization rate, and $n_{i,t}$ is its input of the composite labor. Building new capital and operating existing capital more intensively are both costly: in terms of the former, there exists a quadratic investment adjustment cost so the law of motion for capital takes the following form, $k_{i,t+1} = (1-\delta) k_{i,t} + \varkappa_t \left[1 - 0.5\psi \left(i_{i,t}/i_{i,t-1} - 1\right)^2\right] i_{i,t}$, where $i_{i,t}$ is firm i's gross investment in

[9] For the sake of comparison with Gali, Smets and Wouters (2012), our comprehensive model abstracts away from the intensive margin of labor input.

period t, and $\varkappa_t$ is stochastic and captures investment specific technology shocks according to the following process, $\varkappa_t = \varkappa_{t-1}^{\rho_\varkappa} \exp(\epsilon_{\varkappa,t})$, $\epsilon_{\varkappa,t} \sim N(0, \sigma_\varkappa)$; as for the latter, capital utilization cost, specified as $\vartheta k_{i,t}(u_{i,t}^{1+\phi} - 1)/(1+\phi)$, increases with capital utilization rate at an increasing speed. Price adjustment is also costly in the Rotemberg (1982) sense: if firm i charged a price $p_{i,t-1}$ for its product in period $t-1$, but wishes to reset the price to $p_{i,t}$ for its product in period t, then, given period-t aggregate output Y_t, it will incur a quadratic cost of price adjustment equal to $0.5\rho\left(p_{i,t}/p_{i,t-1} - 1\right)^2 Y_t$. Also, and just as described in the parsimonious model, there is a tax benefit on corporate bond relative to equity, dividend payout is subject to a quadratic cost, and the firm faces an enforcement constraint. In such environment, if firms have identical initial conditions, they would make identical decisions in a symmetric equilibrium. We shall focus on analyzing such an equilibrium in the remaining of this paper. Thus, from now on, we can suppress the subscript index for individual firms and focus on the problem of a "representative firm."

At any date t, a representative firm seeks to maximize the expected present value of its future real dividend stream $\{d_s\}_{s\geq t}$,

$$\mathrm{E_t} \sum_{s=t}^{\infty} m_{t,s} d_s,$$

where $m_{t,s} = \prod_{h=1}^{s-t} m_{t+h-1,t+h}$ is a s-period stochastic discount factor, from date $s > t$ to date t, with $m_{t,t} \equiv 1$, consistent with households optimization problem described below, subject to a sequence of budget constraints,

$$\begin{aligned} & \frac{W_s}{P_s} n_s + i_s + \frac{b_s}{P_s} + d_s + \kappa\left(d_s - d\right)^2 + \frac{\vartheta\left(u_s^{1+\phi} - 1\right)}{1+\phi} k_s + \frac{\rho}{2}\left(\frac{p_s}{p_{s-1}} - 1\right)^2 Y_s \\ = \;& Y_s^{\frac{\eta_s - 1}{\eta_s}} \left[z_s \left(u_s k_s\right)^\alpha n_s^{1-\alpha}\right]^{\frac{1}{\eta_s}} + \frac{b_{s+1}}{P_s R_s}, \end{aligned} \tag{20}$$

where d represents firms' long-run dividend payout target, borrowing constraints,

$$\frac{W_s}{P_s} n_s + i_s \leq \xi_s \left[k_{s+1} - \frac{b_{s+1}}{P_s\left(1 + r_s\right)}\right], \tag{21}$$

where $\xi_s/\xi = (\xi_{s-1}/\xi)^{\rho_\xi} \exp(\epsilon_{\xi,s})$, $\epsilon_{\xi,s} \sim N(0, \sigma_\xi)$, where ξ denotes the unconditional mean of ξ_s, demand schedules for its goods,

$$\frac{p_s}{P_s} = Y_s^{\frac{\eta_s - 1}{\eta_s}} \left[z_s \left(u_s k_s\right)^\alpha n_s^{1-\alpha}\right]^{\frac{1-\eta_s}{\eta_s}}, \tag{22}$$

and laws of motion for capital,

$$k_{s+1} = (1-\delta)\,k_s + \varkappa_s \left[1 - \frac{\psi}{2}\left(\frac{i_s}{i_{s-1}} - 1\right)^2\right] i_s, \tag{23}$$

for all $s \geq t$, where the effective gross nominal interest rate R_s paid by the firm on the one-period nominal bond b_{s+1} is linked to the bond's nominal interest rate r_s received by the household via $R_s = 1 + r_s(1-\tau)$. Denote by λ_s, μ_s, $\digamma_s$, and Q_s the Lagrange multipliers associated with (20), (21), (22), and (23), respectively. The firm's optimization conditions with respect to u_t, d_t, n_t, p_t, i_t, k_{t+1}, and b_{t+1} are respectively given by,

$$\begin{aligned} &\lambda_t \left[Y_t^{\frac{\eta_t - 1}{\eta_t}} \left(z_t k_t^{\alpha} n_t^{1-\alpha}\right)^{\frac{1}{\eta_t}} \frac{\alpha}{\eta_t} u_t^{\frac{\alpha}{\eta_t} - 1} - \vartheta u_t^{\phi} k_t \right] \\ = \;& \digamma_t Y_t^{\frac{\eta_t - 1}{\eta_t}} \left(z_t k_t^{\alpha} n_t^{1-\alpha}\right)^{\frac{1-\eta_t}{\eta_t}} \frac{\alpha(1-\eta_t)}{\eta_t} u_t^{\frac{\alpha(1-\eta_t)}{\eta_t} - 1}, \end{aligned} \tag{24}$$

$$1 = \lambda_t \left[1 + 2\kappa\left(d_t - d\right)\right], \tag{25}$$

$$\begin{aligned} &\lambda_t Y_t^{\frac{\eta_t - 1}{\eta_t}} \left[z_t \left(u_t k_t\right)^{\alpha}\right]^{\frac{1}{\eta_t}} \frac{1-\alpha}{\eta_t} n_t^{\frac{1-\alpha}{\eta_t} - 1} - \left(\lambda_t + \mu_t\right) \frac{W_t}{P_t} \\ = \;& \digamma_t Y_t^{\frac{\eta_t - 1}{\eta_t}} \left[z_t \left(u_t k_t\right)^{\alpha}\right]^{\frac{1-\eta_t}{\eta_t}} \frac{(1-\alpha)(1-\eta_t)}{\eta_t} n_t^{\frac{(1-\alpha)(1-\eta_t)}{\eta_t} - 1}, \end{aligned} \tag{26}$$

$$\lambda_t \left(\frac{p_t}{p_{t-1}} - 1\right) \frac{Y_t}{p_{t-1}} = \mathrm{E_t}\left[m_{t,t+1} \lambda_{t+1} \left(\frac{p_{t+1}}{p_t} - 1\right) \frac{p_{t+1} Y_{t+1}}{p_t^2}\right] + \frac{\digamma_t}{\rho P_t}, \tag{27}$$

$$\begin{aligned} &Q_t \varkappa_t \left[1 - \psi \frac{i_t}{i_{t-1}} \left(\frac{i_t}{i_{t-1}} - 1\right) - \frac{\psi}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] \\ = \;& -\psi \mathrm{E_t}\left[m_{t,t+1} Q_{t+1} \varkappa_{t+1} \left(\frac{i_{t+1}}{i_t}\right)^2 \left(\frac{i_{t+1}}{i_t} - 1\right)\right] + \lambda_t + \mu_t, \end{aligned} \tag{28}$$

$$\begin{aligned} &\mathrm{E_t}\left\{ m_{t,t+1} \lambda_{t+1} \left[Y_{t+1}^{\frac{\eta_{t+1}-1}{\eta_{t+1}}} \left(z_{t+1} u_{t+1}^{\alpha} n_{t+1}^{1-\alpha}\right)^{\frac{1}{\eta_{t+1}}} \frac{\alpha}{\eta_{t+1}} k_{t+1}^{\frac{\alpha}{\eta_{t+1}} - 1} - \frac{\vartheta\left(u_{t+1}^{1+\phi} - 1\right)}{1+\phi} \right] \right\} \\ = \;& \mathrm{E_t}\left[m_{t,t+1} \digamma_{t+1} Y_{t+1}^{\frac{\eta_{t+1}-1}{\eta_{t+1}}} \left(z_{t+1} u_{t+1}^{\alpha} n_{t+1}^{1-\alpha}\right)^{\frac{1-\eta_{t+1}}{\eta_{t+1}}} \frac{\alpha(1-\eta_{t+1})}{\eta_{t+1}} k_{t+1}^{\frac{\alpha(1-\eta_{t+1})}{\eta_{t+1}} - 1} \right] \\ &+ Q_t - (1-\delta)\,\mathrm{E_t}\left(m_{t,t+1} Q_{t+1}\right) - \mu_t \xi_t, \end{aligned} \tag{29}$$

$$\frac{\lambda_t}{P_t R_t} = \mathrm{E_t}\left(m_{t,t+1} \frac{\lambda_{t+1}}{P_{t+1}}\right) + \frac{\mu_t \xi_t}{P_t(1+r_t)}, \tag{30}$$

where it is worth noting that, in deriving the optimization conditions, the firm takes aggregate output Y, the general wage and price levels W and P, interest rates r and R, as well as the initial conditions p_{-1}, i_{-1}, k_0, and b_0, as given.

A household member (j, ι) has the following period-utility function,

$$\frac{(c_{j,\iota,t} - \varpi C_{t-1})^{1-\sigma}}{1-\sigma} - 1_t(j,\iota)\chi_t \iota^{\frac{1}{\epsilon}},$$

where $c_{j,\iota,t}$ is the member's consumption in period t, and C_{t-1} denotes lagged aggregated consumption, with the parameter ϖ governing the degree of external habit formation. The indicator function $1_t(j,\iota)$ takes the value 1 if the member works in period t but 0 otherwise, and the term $\chi_t \iota^{\frac{1}{\epsilon}}$ measures the member's dis-utility from working, where χ_t is stochastic capturing labor supply shocks and it evolves according to the following process, $\chi_t = \chi_{t-1}^{\rho_\chi} \exp(\epsilon_{\chi,t}),\ \ \epsilon_{\chi,t} \sim N(0, \sigma_\chi)$. The parameter σ measures the relative risk aversion in consumption, and the parameter ε governs the shape of distribution of dis-utility of work across individuals.

We assume a full consumption insurance among household members so, in equilibrium, $c_{j,\iota,t}$ are all equal to some common c_t, for all (j,ι) and all t. We can then integrate all of the household members' period-t utilities to get the period-t utility of the household,

$$\frac{(c_t - \varpi C_{t-1})^{1-\sigma}}{1-\sigma} - \chi_t \int_0^1 \int_0^{n_{j,t}} \iota^{\frac{1}{\epsilon}} d\iota dj = \frac{(c_t - \varpi C_{t-1})^{1-\sigma}}{1-\sigma} - \chi_t \int_0^1 \frac{n_{j,t}^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}} dj.$$

Hence, from the household's perspective, the inverse of the parameter ε can be thought of as the elasticity of labor supply. We suppose that the portfolio of bond and equity is re-balanced also at the household level. Thus, at any date t, the household along with all of its members seek to maximize

$$\mathrm{E_t} \sum_{s=t}^{\infty} \beta^{s-t} \gamma_s \left[\frac{(c_s - \varpi C_{s-1})^{1-\sigma}}{1-\sigma} - \chi_s \int_0^1 \frac{n_{j,s}^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}} dj \right], \tag{31}$$

where γ_s is stochastic capturing risk-premium shocks (as we will show below, its stochastic evolution affects the pricing kernel of financial assets such as corporate equity and bond) and it evolves according to the following process, $\gamma_s = \gamma_{s-1}^{\rho_\gamma} \exp(\epsilon_{\gamma,s}),\ \ \epsilon_{\gamma,s} \sim N(0, \sigma_\gamma)$, subject to a sequence of budget constraint,

$$c_s + \frac{b_{s+1}}{P_s(1+r_s)} + q_s x_{s+1} + \frac{T_s}{P_s} = \int_0^1 \frac{w_{j,s}}{P_s} n_{j,s} dj + \frac{b_s}{P_s} + (q_s + d_s) x_s, \tag{32}$$

and demand schedule for type j labor service, $n_{j,s} = (w_{j,s}/W_s)^{\nu_s/(1-\nu_s)} N_s$, for all $j \in [0,1]$, all $s \geq t$, where T_s denotes a nominal lump-sum tax that finances government spending and the tax shelter on corporate debt, and q_s and x_s denote the real equity price and household's holding of equity share, respectively, taking as given aggregate consumption C and employment N, the general wage and price levels W and P, interest rate r, equity price q and dividend payout d, as well as the initial conditions b_0 and x_0. The resultant optimization conditions with respect to c_t, b_{t+1}, and x_{t+1} give rise to

$$\mathrm{E_t}\left[m_{t,t+1}\frac{P_t\,(1+r_t)}{P_{t+1}}\right] = 1, \tag{33}$$

$$\mathrm{E_t}\left(m_{t,t+1}\frac{q_{t+1}+d_{t+1}}{q_t}\right) = 1, \tag{34}$$

where

$$m_{t,t+1} = \beta\frac{\gamma_{t+1}}{\gamma_t}\left(\frac{C_{t+1}-\varpi C_t}{C_t-\varpi C_{t-1}}\right)^{-\sigma}, \tag{35}$$

is an equilibrium stochastic discount factor, from date $t+1$ to date t, where we have used the fact that, in equilibrium, $c_t = C_t$ for all t.

While consumption is chosen and portfolio is re-balanced at every single date, the monopolistically competitive household members can adjust the nominal wages for their types of labor services only in a stochastically staggered fashion, à là Calvo (1983), with an identical and independent hazard rate ω of unable to re-setting wages. At a given date t, if the members of type j labor get the chance to re-set wage, then they would choose $w_{j,t}$ to maximize (31) subject to (32) and the demand schedule for their type of labor service, conditional on the probabilities that they will not get another chance to re-set wage and therefore must maintain the wage they are currently choosing for the indefinite future. The resultant optimal wage-setting equation is given by

$$\mathrm{E_t}\sum_{s=t}^{\infty}\frac{(\beta\omega)^{s-t}\gamma_s}{1-\nu_s}\left(\frac{w_{j,t}}{W_s}\right)^{\frac{\nu_s}{1-\nu_s}}N_s\left\{\frac{(C_s-\varpi C_{s-1})^{-\sigma}}{P_s}-\nu_s\chi_s\left[\left(\frac{w_{j,t}}{W_s}\right)^{\frac{\nu_s}{1-\nu_s}}N_s\right]^{\frac{1}{\epsilon}}w_{j,t}^{-1}\right\} = 0. \tag{36}$$

Note that $w_{j,t}$ as determined by (36) is independent of j. This implies that, at any date t, all re-setting labor types will set to some common wage w_t that solves (36). Now, note that, with the large number of labor types, at each point in time there is a fraction $(1-\omega)$ of randomly selected labor types that can re-set wages. These two observations together imply that the aggregate wage index evolves according to

$$W_t = \left[\omega W_{t-1}^{\frac{1}{1-\nu_t}} + (1-\omega) w_t^{\frac{1}{1-\nu_t}} \right]^{1-\nu_t}. \tag{37}$$

Denote by $l_{j,t}$ the labor force participation rate for individuals with type j labor skill under current economic conditions in period t, including the prevailing wage $w_{j,t}$ for their labor type. It is worth noting that $l_{j,t}$ corresponds to the index of the marginal individual with type j skill participating in date-t labor market, that is, its dis-utility of work is just offset by the shadow value of real wage for its labor type, or,

$$(C_t - \varpi C_{t-1})^{-\sigma} \frac{w_{j,t}}{P_t} = \chi_t l_{j,t}^{\frac{1}{\epsilon}}. \tag{38}$$

Other individuals with type j skill but with dis-utility indices $\iota \in (l_{j,t}, 1]$ optimally choose not to participate in date-t labor market under the prevailing wage $w_{j,t}$ for their labor type.

At any date t, the fiscal authority faces the budget constraint,

$$P_t g_t + B_{t+1} \left(\frac{1}{R_t} - \frac{1}{1+r_t} \right) = T_t, \tag{39}$$

where g_t is real government spending in period t, which follows a stochastic process,

$$\frac{g_t}{g} = \left(\frac{g_{t-1}}{g} \right)^{\rho_g} \left(\frac{z_t}{z_{t-1}} \right)^{\rho_{gz}} \exp(\epsilon_{g,t}), \quad \epsilon_{g,t} \sim N(0, \sigma_g),$$

where g denotes the average value of government spending, and monetary policy takes the following form of interest rate feedback rule,

$$\frac{1+r_t}{1+r} = \left(\frac{1+r_{t-1}}{1+r} \right)^{\rho_r} \left[\pi_t^{\nu_1} \left(\frac{Y_t}{Y} \right)^{\nu_2} \left(\frac{Y_t}{Y_{t-1}} \right)^{\nu_3} \right]^{1-\rho_r} \exp(\epsilon_{r,t}), \quad \epsilon_{r,t} \sim N(0, \sigma_r),$$

where $\pi_t = P_t / P_{t-1}$ denotes gross price inflation rate in period t, and r and Y denote the steady-state values of net nominal interest rate and aggregate output, respectively.

The log-linearized system of equilibrium conditions is presented in Appendix E.

5.2 Estimation and decomposition results

A small set of the parameters for this comprehensive model are calibrated to steady-state targets or standard values used in the business cycle literature. These include $\beta = 0.9825$, $\alpha = 0.36$, $\tau = 0.35$, $\delta = 0.025$, and $\xi = 0.1466$. In addition, we set g to 0.18, consistent with a long-run average government spending-GDP ratio in the US.

The remaining parameters are estimated with Bayesian maximum likelihood methods, using the log-linearized equilibrium system presented in Appendix E and the nine empirical series described at the beginning of this section for the period from 1955:I to 2012:IV. We follow Jermenn and Quadrini (2012) in choosing the prior distributions of the financial parameters, κd, ρ_ξ, and σ_ξ, while our choices of the prior distributions of the other parameters follow Gali, Smets and Wouters (2012). We conduct the structural estimation based on both the whole sample, and the two subsamples separately. The estimation results are collected in Table 3 (based on whole sample) and in Tables 5a-b (based respectively on the pre- and post-1985 subsamples), which report the prior densities, the modes, and the standard deviations of the posteriors. As can be seen from the tables, all of the estimations of the posteriors are statistically significant.

In simulating the estimated model, we assume that the borrowing constraint is binding, an assumption that is always verified ex post. Simulations with all of the nine structural shocks turned on indicate a significant reduction in the speed of recovery from a recession trough, from the pre-1985 era to the post-1985 episode, regardless of whether the model is estimated based on the whole sample or on the two subsamples separately. This is consistent with data observables: the last rows in the two panels of Tables 4 and 6 show a reduction across the two subsamples at the 5 percent significance level in the cumulative growth rate of output and of employment eight quarters into a recovery.

The other rows of Tables 4 and 6 demonstrate the roles of the nine structural shocks in accounting for the reduction in the speed of recovery across the two subsample periods. The decomposition exercise is conducted by computing the average contributions of each of the shocks to the cumulative growth rate of output (upper panel) and of employment (lower panel) in a recovery before and after 1985.

The decomposition results suggest that financial shocks are a dominant contributor to the recent slower recoveries: under both whole sample and subsample based estimations, the recent slower recoveries in output and employment growth are mainly due to reduced contributions by financial shocks, from the pre-1985 episode to the post-1985 era, while the reduction is statistically significant at the 5 percent level.

TFP shocks play a statistically significant role (at the 5 percent level) only in accounting for the recent slower output recoveries (under whole sample as well as subsample based estimations), and the effect is an order of magnitude smaller than that of financial shocks.

The role of wage markup shocks in accounting for the recent slower recoveries is also an order of magnitude smaller than that of financial shocks; and, under whole sample based estimation, the effect is either statistically insignificant (in accounting for the recent slower output recoveries) or statistically significant only at the 10 percent level (in accounting for the recent slower employment recoveries), even though it is statistically significant at the 5 percent level under subsample based estimation.

Subsample based estimation also assigns a role to labor supply shocks, but only at the 10 percent significance level, in accounting for the recent slower recoveries in output and employment growth; and, quantitatively, the effect is an order of magnitude smaller than that of financial shocks.

Under subsample based estimation, the role of investment shocks in accounting for the recent slower output recoveries is statistically significant at the 5 percent level, but quantitatively the effect is only about half of that of financial shocks

The other shocks do not show any statistically or quantitatively significant difference in their effects on recoveries in either output or employment growth before and after 1985, under either whole sample or subsample based estimation.

All in all, the results obtained in this section reconfirm the important role of financial shocks (and frictions) illustrated earlier in understanding the recent slower recoveries.

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Appendix A

In this appendix, we present the log-linearized recursive equilibrium conditions for the parsimonious model. As in Sections 2 and 3, a variable with a bar denotes its steady-state value; and, here, a variable with a hat denotes the percentage deviation of that variable in level from the steady state. To simplify presentation, we introduce the following auxiliary notations: $d_y \equiv \bar{d}/\bar{y}$, $b_y \equiv \bar{b}/\bar{y}$, $k_y \equiv \bar{k}/\bar{y}$, $c_y \equiv \bar{c}/\bar{y}$, $y_k \equiv \bar{y}/\bar{k}$, $i_y \equiv \bar{i}/\bar{y}$, and $wnh_y \equiv \bar{w}\bar{n}\bar{h}/\bar{y}$. The log-linearized versions of (1), (2), (5)-(12), and (14)-(17) are, respectively,

$$\hat{y} = \hat{z} + \alpha\left(\hat{k} + \hat{u}\right) + (1-\alpha)\left(\hat{n} + \hat{h}\right)$$

$$\hat{\delta} = \phi\hat{u}$$

$$-k_y\bar{\delta}\hat{\delta} + (1-\bar{\delta})k_y\hat{k} + \hat{y} + \frac{b_y}{\bar{R}}\left(\hat{b}_{+1} - \hat{R}\right) = wnh_y\left(\hat{w} + \hat{n} + \hat{h}\right) + b_y\hat{b} + k_y\hat{k}_{+1} + d_y\hat{d}$$

$$\begin{aligned}
&(wnh_y + k_y\bar{\delta})\hat{\xi} - \beta\bar{\xi}b_y\left(\hat{b}_{+1} - \frac{\bar{R}\hat{R}}{\bar{R}-\tau}\right) \\
= \; & wnh_y\left(\hat{w} + \hat{n} + \hat{h}\right) + (1-\bar{\xi})k_y\hat{k}_{+1} - (1-\bar{\delta})k_y\hat{k} + k_y\bar{\delta}\hat{\delta}
\end{aligned}$$

$$\hat{y} - \hat{k} = \frac{\bar{\mu}}{1+\bar{\mu}}\left(\hat{\mu} - \hat{\lambda}\right) + \hat{\delta}$$

$$\hat{y} - \hat{n} - \hat{h} = \frac{\bar{\mu}}{1+\bar{\mu}}\left(\hat{\mu} - \hat{\lambda}\right) + \hat{w}$$

$$\hat{\lambda} = -2\kappa\bar{d}\hat{d}$$

$$\begin{aligned}
&\beta\mathrm{E}\left[\alpha y_k\left(\hat{y}_{+1} - \hat{k}_{+1}\right) + \bar{\mu}(1-\bar{\delta})\left(\hat{\mu}_{+1} - \hat{\lambda}_{+1}\right) - (1+\bar{\mu})\bar{\delta}\hat{\delta}_{+1}\right] \\
= \; & -(1+\bar{\mu}-\bar{\mu}\bar{\xi})\mathrm{E}\left(\hat{c} - \hat{c}_{+1} + \hat{\lambda}_{+1} - \hat{\lambda}\right) - \bar{\mu}\bar{\xi}\hat{\xi} + \bar{\mu}(1-\bar{\xi})\left(\hat{\mu} - \hat{\lambda}\right)
\end{aligned}$$

$$0 = \mathrm{E}\left[\hat{y}_{+1} - \hat{n}_{+1} - \hat{h}_{+1} - \hat{w}_{+1} - \frac{\bar{\mu}}{1+\bar{\mu}}\left(\hat{\mu}_{+1} - \hat{\lambda}_{+1}\right)\right]$$

$$0 = \frac{(1-\tau)\bar{\mu}\bar{\xi}}{\bar{R}-\tau}\left(\hat{\xi} + \hat{\mu} - \hat{\lambda} - \frac{\tau\hat{R}}{\bar{R}-\tau}\right) + \beta\mathrm{E}\left(\hat{c} - \hat{c}_{+1} + \hat{\lambda}_{+1} - \hat{\lambda} + \hat{R}\right)$$

$$c_y\hat{c} + \frac{b_y}{\bar{R}}\left(\hat{b}_{+1} - \hat{R}\right) = wnh_y\left(\hat{w} + \hat{n} + \hat{h}\right) + b_y\hat{b} + d_y\hat{d}$$

$$0 = \mathrm{E}\left(\hat{w}_{+1} - \hat{c}_{+1}\right)$$

$$\bar{h}\hat{h} = (T - \zeta - \bar{h})\left(\hat{w} - \hat{c}\right)$$

$$\bar{R}\hat{R} = (\bar{R}-\tau)\mathrm{E}\left(\hat{c}_{+1} - \hat{c}\right).$$

Appendix B

We describe here how we construct the series of log-deviations from the deterministic trend of the productivity and financial variables that are used for estimating the bivariate VAR system (19). The productivity variable is constructed using the series estimated by Fernald (2012) based on the method described in Basu, Fernald, and Kimbal (2006).

To construct the financial variable, we begin by log-linearizing $b^e_{t+1} \equiv b_{t+1}/(1+r_t)$ and $R_t = 1 + r_t(1-\tau)$ to get

$$\hat{b}^e_{t+1} = \hat{b}_{t+1} - \frac{\bar{R}\hat{R}_t}{\bar{R}-\tau},$$

while log-linearizing $k_{t+1} = (1-\delta_t)k_t + i_t$ to get

$$\bar{\delta}\hat{i}_t = \hat{k}_{t+1} - (1-\bar{\delta})\hat{k}_t + \bar{\delta}\hat{\delta}_t.$$

Substituting these two relations into the log-linearized version of firms' borrowing equation, that is, the fourth equation in Appendix A, we obtain

$$\hat{\xi}_t = \frac{\bar{w}\bar{n}\bar{h}(\hat{w}_t + \hat{n}_t + \hat{h}_t) + \bar{i}\hat{i}_t - \bar{\xi}\bar{k}\hat{k}_{t+1} + \beta\bar{\xi}\bar{b}\hat{b}^e_{t+1}}{\bar{w}\bar{n}\bar{h} + \bar{i}}.$$

It is now a matter of getting the series of $\hat{w}_t$, $\hat{n}_t + \hat{h}_t$, $\hat{i}_t$, $\hat{k}_t$, and $\hat{b}^e_t$.

For the wage series w_t, we use the business sector real compensation per hour. For the total hours series $n_t h_t$, we use the Index of Aggregate Weekly Hours: Production and Non-supervisory Employees: Total Private Industries (AWHI), $Index2002 = 100$, Quarterly, Seasonally Adjusted. These labor market data are downloaded from the Federal Reserve Bank of St. Louis's web sites, *http://research.stlouisfed.org/fred2/series/RCPHBS* and *http://research.stlouisfed.org/fred2/series/AWHI*, respectively.

For the investment series i_t, we use $investment_t$ from the Flow of Funds Accounts with the series number FA145050005.Q. To construct the capital series k_t, we appeal to the law of motion, $k_{t+1} = k_t - depreciation_t + investment_t$, and an initial value for capital. As $investment_t$, the data series $depreciation_t$ is also taken from the Flow of Funds Accounts which includes two parts: depreciation in corporation (FA106300015.Q) and depreciation in noncorporation (FA116300005.Q). The debt series b^e_t is also taken from the Flow of Funds Accounts with the series number FA144104005.Q.

We take log of the variables w_t, $n_t h_t$, i_t, k_t, and b^e_t, and then we detrend these logged variables using the Hodrick-Prescott filter with a smoothing parameter 16000 to get the series of $\hat{w}_t$, $\hat{n}_t + \hat{h}_t$, $\hat{i}_t$, $\hat{k}_t$, and $\hat{b}^e_t$.

Appendix C

To appreciate the ability of our benchmark model in tracking the overall dynamics of data observables, and in explaining the observed reduction in the speed of recovery from a recession trough from the pre-1985 era to the post-1985 period, we here contrast the model's performance against the performance of two of its variants, which both adopt the Jermann and Quardrini (2012) form of borrowing constraint. One variant includes only the extensive margins of capital and labor, while the other variant includes both the extensive and the intensive margins of capital and labor. We label the former as 'J&Q' and the latter as 'J&Q with intensive margins' in Figures 11-14.

Figure 11 displays side-by-side across each of the two subsample periods the average cumulative growth rates of output and employment eight quarters into a recovery, both for the actual data and for the data simulated from the three models. Figure 12 displays similar plots for the recession-depth adjusted measure of recovery speed. Figure 13 and 14 display respectively the standard and recession-depth adjusted measures of recovery speed not only at the eight-quarter horizon, but also at the four-quarter and the twelve-quarter horizons. These figures convey a consistent message: both 'J&Q' and 'J&Q with intensive margins' generate faster recoveries, especially in employment growth, both before and after 1985, and smaller reductions in the speed of recovery across the two subsample periods, than observed from the actual data and predicted by our benchmark model.

Appendix D

An alternative measure of recovery speed is the number of quarters that it takes for the growth rate of output or of employment to go from a business cycle trough to back on its trend, either as is, or adjusted for the recession depth.

Figures 15 and 16 plot across each subsample period this alternative measure, standard and recession-depth adjusted, respectively, for both the actual data and the data simulated from our benchmark model and its variant with fixed intensive margins of capital and labor. We see from these figures a significant reduction in the speed of recovery across the two subsample periods in terms of this measure, especially the recession-depth adjusted one, and that our benchmark model tracks very well such reduction and overall dynamics of the data observables. Fixing the intensive margins of capital and labor generates a much faster recovery in employment growth both before and after 1985, though some significant reduction in the speed of recovery in both output and employment growth across the two subsample periods continues to show up even in this case.

Figures 17 and 18 display across each subsample this alternative measure, standard and recession-depth adjusted, respectively, for the data simulated from 'J&Q' and 'J&Q with intensive margins' against the actual data and simulation from our benchmark model. The figures convey a message similar to that contained in Appendix C: both 'J&Q' and 'J&Q with intensive margins' generate faster recoveries, especially in employment growth, both before and after 1985, and smaller reductions in the speed of recovery across the two subsamples, than seen in the actual data and predicted by our benchmark model.

Appendix E

In this appendix, we present the log-linearized sequential equilibrium conditions for the comprehensive model. Here, a variable with no time subscript denotes its steady-state value, and a variable with time subscript and a hat denotes the percentage deviation of that variable in level from the steady state. To simplify presentation, we introduce the following auxiliary notations: $d_Y \equiv d/Y$, $B_{PY} \equiv B/(PY)$, $k_Y \equiv k/Y$, $C_Y \equiv C/Y$, $Y_k \equiv Y/k$, $i_Y \equiv i/Y$, $g_Y \equiv g/Y$, $WN_{PY} \equiv (WN)/(PY)$, and $\Phi \equiv (1-\beta\omega)/\{1-\nu/[\epsilon(1-\nu)]\}$.

The aggregated version of the log-linearized system for (20), (21), (23)-(30), (32), (33), (35)-(38), production function, fiscal and monetary policy rules, and stochastic driving processes other than fiscal and monetary policy shocks is given by,

$$\hat{Y}_t + \frac{B_{PY}}{R}\left(\hat{B}_{t+1} - \hat{P}_t - \hat{R}_t\right) = WN_{PY}\left(\hat{W}_t + \hat{N}_t - \hat{P}_t\right) + i_Y \hat{i}_t + B_{PY}\left(\hat{B}_t - \hat{P}_t\right) + d_Y \hat{d}_t + \vartheta k_Y \hat{u}_t$$

$$\begin{aligned} & \frac{WN_{PY}}{WN_{PY}+i_Y}\left(\hat{W}_t + \hat{N}_t - \hat{P}_t\right) + \frac{i_Y}{WN_{PY}+i_Y}\hat{i}_t \\ = \ & \hat{\xi}_t + \frac{k_Y}{k_Y - \beta B_{PY}}\hat{k}_{t+1} - \frac{\beta B_{PY}}{k_Y - \beta B_{PY}}\left(\hat{B}_{t+1} - \hat{P}_t - \frac{R}{R-\tau}\hat{R}_t\right) \end{aligned}$$

$$\hat{k}_{t+1} = (1-\delta)\hat{k}_t + \delta\left(\hat{\varkappa}_t + \hat{i}_t\right)$$

$$F_t = \frac{Y}{1-\eta}\left[\hat{Y}_t - \hat{\eta}_t - (1+\phi)\hat{u}_t - \hat{k}_t\right]$$

$$\hat{\lambda}_t = -2\kappa d\hat{d}_t$$

$$F_t = \frac{Y}{1-\eta}\left[\hat{Y}_t - \hat{\eta}_t - \hat{N}_t + \frac{\mu}{1+\mu}\left(\hat{\lambda}_t - \hat{\mu}_t\right) - \hat{W}_t + \hat{P}_t\right]$$

$$\digamma_t = \rho Y \hat{\pi}_t - \beta \rho Y \mathrm{E_t} \hat{\pi}_{t+1}$$

$$\hat{\lambda}_t + \mu \hat{\mu}_t = (1+\mu)\left(\hat{Q}_t + \hat{\varkappa}_t\right) - \psi(1+\mu)\left(\hat{i}_t - \hat{i}_{t-1}\right) + \beta\psi(1+\mu)\mathrm{E_t}\left(\hat{i}_{t+1} - \hat{i}_t\right)$$

$$\begin{aligned} & (1+\mu)\hat{Q}_t - \mu\xi\left(\hat{\mu}_t + \hat{\xi}_t\right) \\ = \;& (1+\mu-\mu\xi)\mathrm{E_t}\hat{m}_{t,t+1} + \beta(1-\delta)(1+\mu)\mathrm{E_t}\hat{Q}_{t+1} + \beta\vartheta\mathrm{E_t}\left(\phi\hat{u}_{t+1} - 2\kappa d\hat{d}_{t+1}\right) \end{aligned}$$

$$\frac{\hat{R}_t}{\beta R} + \mu\xi\left(\hat{\mu}_t + \hat{\xi}_t + 2\kappa d\hat{d}_t - \frac{R}{R-\tau}\hat{R}_t\right) = \mathrm{E_t}\left[\hat{\pi}_{t+1} - \hat{m}_{t,t+1} - 2\kappa d\left(\hat{d}_t - \hat{d}_{t+1}\right)\right]$$

$$C_Y\hat{C}_t + g_Y\hat{g}_t + \frac{B_{PY}}{R}\left(\hat{B}_{t+1} - \hat{P}_t - \hat{R}_t\right) = WN_{PY}\left(\hat{W}_t + \hat{N}_t - \hat{P}_t\right) + B_{PY}\left(\hat{B}_t - \hat{P}_t\right) + d_Y\hat{d}_t$$

$$\frac{R}{R-\tau}\hat{R}_t = \mathrm{E_t}\left(\hat{\pi}_{t+1} - \hat{m}_{t,t+1}\right)$$

$$\hat{m}_{t,t+1} = \hat{\gamma}_{t+1} - \hat{\gamma}_t - \frac{\sigma}{1-\varpi}\left[\left(\hat{C}_{t+1} - \varpi\hat{C}_t\right) - \left(\hat{C}_t - \varpi\hat{C}_{t-1}\right)\right]$$

$$\hat{w}_t = \Phi\left[\hat{P}_t + \hat{\nu}_t + \hat{\chi}_t + \frac{\sigma}{1-\varpi}\left(\hat{C}_t - \varpi\hat{C}_{t-1}\right) - \frac{\nu}{\epsilon(1-\nu)}\hat{W}_t + \frac{\hat{N}_t}{\epsilon}\right] + \beta\omega\mathrm{E_t}\hat{w}_{t+1}$$

$$\hat{W}_t = \omega\hat{W}_{t-1} + (1-\omega)\hat{w}_t$$

$$\hat{W}_t - \hat{P}_t = \hat{\chi}_t + \frac{\hat{l}_t}{\epsilon} + \frac{\sigma}{1-\varpi}\left(\hat{C}_t - \varpi\hat{C}_{t-1}\right)$$

$$\hat{Y}_t = \hat{z}_t + \alpha\left(\hat{k}_t + \hat{u}_t\right) + (1-\alpha)\hat{N}_t$$

$$\hat{g}_t = \rho_g\hat{g}_{t-1} + \rho_{gz}\left(\hat{z}_t - \hat{z}_{t-1}\right) + \epsilon_{g,t}$$

$$\hat{r}_t = \rho_r\hat{r}_{t-1} + (1-\rho_r)\left[\nu_1\hat{\pi}_t + \nu_2\hat{Y}_t + \nu_3\left(\hat{Y}_t - \hat{Y}_{t-1}\right)\right] + \epsilon_{r,t}$$

$$\hat{\upsilon}_t = \rho_\upsilon\hat{\upsilon}_{t-1} + \epsilon_{\upsilon,t}, \text{ for } \upsilon = \eta,\ \nu,\ z,\ \varkappa,\ \xi,\ \chi,\ \gamma.$$

REFERENCES

Aaronson, Daniel; Rissman, Ellen and Sullivan, Daniel G. "Can Sectoral Reallocation Explain the Jobless Recovery?" Federal Reserve Bank of Chicago's *Economic Perspectives*, 2004, 28, pp. 36-49.

Acemoglu, Daron. "Credit Market Imperfections and Persistent Unemployment." *European Economic Review*, 2001, 45, pp. 665-679.

Andolfatto, David and MacDonald, Glenn M. "Jobless Recoveries." Working Paper, Simon Fraser University and Washington University in St. Louis, 2006.

Bachmann, Rudiger. "Understanding the Jobless Recoveries After 1991 and 2001." Working Paper, University of Michigan, 2011.

Basu, Susanto; Fernald, John G. and Kimball, Miles S. "Are Technology Improvements Contractionary?" *American Economic Review*, 2006, 96, pp. 1418-1448.

Benassy, Jean-Pascal. "Imperfect Competition, Capital Shortages and Unemployment Persistence." *Scandinavian Journal of Economics*, 1997, 99, pp. 15-27.

Berger, David. "Countercyclical Restructuring and Jobless Recoveries." Working Paper, Yale University, 2012.

Braumann, Benedikt. "Unemployment Persistence and Capital Shortage: The Case of Trinidad and Tobago." IMF Working Paper No. 77, 1997.

Burnside, Craig and Eichenbaum, Martin. "Factor-Hoarding and the Propagation of Business-Cycle Shocks." *American Economic Review*, 1996, 86, pp. 1154-1174.

Calvo, Guillermo A. "Staggered Prices in a Utility Maximizing Framework." *Journal of Monetary Economics*, 1983, 12, pp. 383-398.

Di Tella, Rafael and MacCulloch, Robert J. "The Consequences of Labour Market Flexibility: Panel Evidence Based on Survey Data." *European Economic Review*, 2005, 49, pp. 1225-1259.

Engemann, Kristie M. and Owyang, Michael T. "Whatever Happened to the Business Cycle? A Bayesian Analysis of Jobless Recoveries." *Macroeconomic Dynamics*, 2010, 14, pp. 709-726.

Faberman, Jason. "Job Flows, Jobless Recoveries and the Great Moderation." Working Paper, Federal Reserve Bank of Philadelphia, 2008.

Fernald, John G. "A Quarterly, Utilization-Adjusted Series on Total Factor Productivity." Working Paper, Federal Reserve Bank of San Francisco, 2012.

Gali, Jordi; Smets, Frank and Wouters, Rafael. "Slow Recoveries: A Structural Interpretation." *Journal of Money, Credit and Banking*, 2012, 44, pp. 9-30.

Garin, Julio; Pries, Michael and Sims, Eric. "Reallocation and the Changing Nature of Economic Fluctuations." Working Paper, University of Notre Dame, 2011.

Gertler, Mark and Hubbard, R. Glenn. "Financial Factors In Business Fluctuations," in Federal Reserve Bank of Kansas City's *Financial Market Volatility - Causes,* *Consequences, and Policy Responses*, 1989.

Gertler, Mark and Gilchrist, Simon. "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms." *Quarterly Journal of Economics*, 1994, 109, pp. 309-340.

Gomme, Paul. "Accounting for the Jobless Recoveries." Federal Reserve Bank of Cleveland's *Economic Commentary*, 2005, pp. 1-8.

Greenwood, Jeremy, Hercowitz, Zvi and Huffman, Gregory W. "Investment, Capacity Utilization, and the Real Business Cycle." *American Economic Review*, 1988, 78, pp. 402-417.

Groshen, Erica L. and Potter, Simon. "Has Structure Change Contributed to a Jobless Recovery?" Federal Reserve Bank of New York's *Current Issues in Economics and Finance*, 2003, 9, pp. 1-7.

Hansen, Gary D. "Indivisible Labor and the Business Cycle." *Journal of Monetary Economics*, 1985, 16, pp. 309-327.

Hodgson, Ashley; Schreft, Stacey and Singh, Aarti. "Jobless Recoveries and the Wait-and-See Hypothesis." Federal Reserve Bank of Kansas City's *Economic Review*, 2005, pp. 81-99.

Hatzius, Jan; Hooper, Peter; Mishkin, Frederic S.; Schoenholtz, Kermit L. and Watson, Mark W. "Financial Conditions Indexes: A Fresh Look after the Financial Crisis." NBER Working Paper No. 16150, 2010.

Jaimovich, Nir and Siu, Henry. "The Trend is the Cycle: Job Polarization and Jobless Recoveries." NBER Working Paper No. 18334, 2012.

Jermann, Urban and Quardini, Vincenzo. "Macroeconomic Effects of Financial Shocks." *American Economic Review*, 2012, 102, pp. 238-271.

Kashyap, Anil K.; Lamont, Owen A. and Stein, Jeremy C. "Credit Conditions and the Cyclical Behavior of Inventories." *Quarterly Journal of Economics*, 1994, 109, pp. 565-592.

Kiyotaki, Nobuhiro and Moore, John H. "Credit Cycles." *Journal of Political Economy*, 1997, 105, pp. 211-248.

Knotek, Edward and Terry, Stephen. "How Will Unemployment Fare Following the Recession?" Federal Reserve Bank of Kansas City's *Economic Review*, 2009, Issue Q III, pp. 5-33.

Koenders, Kathryn and Rogerson, Richard. "Organizational Dynamics Over the Business Cycle: A View on Jobless Recoveries." Federal Reserve Bank of St. Louis's *Economic Review*, 2005, pp. 555-579.

Lintner, John. "Distribution of Incomes of Corporations Among Dividends, Retained Earnings, and Taxes." *American Economic Review*, 1956, 46, pp. 97-113.

Loutskina, Elena and Strahan, Philips E. "Securitization and the Declining impact of Bank Finance on Loan Supply: Evidence from Mortgage Acceptance Rates." *Journal of Finance*, 2009, 64, pp. 861-889.

Ma, Jinpeng. "Jobless Recovering and Equilibrium Involuntary Unemployment with a Simple Efficiency Wage Model." Working Paper, Rutgers University-Camden, 2003.

Panovska, Irina B. "What Explains the Recent Jobless Recoveries?" SSRN Working Paper No. 2384110, 2014.

Rotemberg, Julio J. "Monopolistic price adjustment and aggregate output." *Review of Economic Studies*, 1982, 49, pp. 517-531.

Schreft, Stacey and Singh, Aarti. "A Closer Look at Jobless Recoveries." Federal Reserve Bank of Kansas City's *Economic Review*, 2003, pp. 45-73.

Schweitzer, Mark. "Another Jobless Recovery." Federal Reserve Bank of Cleveland's *Economic Commentary*, 2003, pp. 555-579.

Shimer, Robert. "Wage Rigidities and Jobless Recoveries." Working Paper, University of Chicago, 2010.

Smets, Frank and Wouters, Rafael. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach." *American Economic Review*, 2007, 97, pp. 586-606.

Van Rens, Thijs. "Organizational Capital and Employment Fluctuations." Working Paper, CREI and Universitat Pompeu Fabra, 2004.

Wen, Yi. "What Does It Take to Explain Procyclical Productivity?" *The B.E. Journal of Macroeconomics*, 2004, 4, pp. 1-40.

Willems, Tim and Van Wijnbergen, Sweder. "Imperfect Information, Lagged Labor Adjustment and the Great Moderation." Working Paper, University of Amsterdam, 2012.

Table 1. Parametrization of the parsimonious model

Description	Parameter/Value
Discount factor	$\beta = 0.9825$
Utility parameter	$\theta = 1.5935$
Tax advantage	$\tau = 0.3500$
Capital share	$\alpha = 0.3600$
Utilization para.	$\phi = 1.4727$
Time endowment	$T = 1369$
Fixed cost.	$\zeta = 60$
Payout cost	$\kappa\bar{d} = 0.012$
Mean finan. vari.	$\bar{\xi} = 0.1345$
Stan. dev. of z	$\sigma_z = 0.00668$
Stan. dev. of ξ	$\sigma_\xi = 0.02096$
Matrix for shocks	$A = \begin{matrix} 0.8525 & -0.0017 \\ 0.0275 & 0.9134 \end{matrix}$

Table 2. Counterfactuals based on pre- and post-1985 shock processes

	Pre-1985	Post-1985	Difference
Employment 4 quarter	0.0223	0.0135	-0.0089***
Employment 8 quarter	0.0337	0.0248	-0.0089***
Output 4 quarter	0.0345	0.0203	-0.0142***
Output 8 quarter	0.0491	0.0329	-0.0162***

Note: Asterisks indicate rejection of equality of means across subsamples at 10% (*), 5% (**), and 1% (***) significance levels (one-sided t-test)

Table 3. Whole sample based estimation of the comprehensive model

Estimated parameters	Prior[mean,std]	Mode	Post_d
Elasticity of labor, ε	Norm$[2.00, 0.75]$	0.083	0.0108
Utility parameter, σ	Norm$[1.50, 0.37]$	1.014	0.0512
Habit in consumption, ϖ	Beta$[0.70, 0.10]$	0.679	0.0083
Wage adjustment, ω	Beta$[0.50, 0.15]$	0.291	0.0096
Investment adjustment cost, ψ	IGamma$[0.15, 0.15]$	0.626	0.0177
Price adjustment cost, ρ	IGamma$[0.10, 0.30]$	0.744	0.0528
Equity payout cost, $2\kappa d$	IGamma$[0.02, 0.01]$	0.027	0.0009
Capital utilization cost, ϕ	Beta$[0.10, 0.3]$	0.022	0.0029
Average price mark-up, η	Beta$[1.20, 0.10]$	1.239	0.0064
Average wage mark-up, ν	Beta$[1.20, 0.10]$	1.216	0.0071
Monetary policy, ν_1	Norm$[1.50, 0.25]$	1.697	0.0205
Monetary policy, ν_2	Norm$[0.12, 0.05]$	0.263	0.0075
Monetary policy, ν_3	Norm$[0.12, 0.05]$	0.121	0.0067
Productivity shock persistence, ρ_z	Beta$[0.50, 0.20]$	0.898	0.0217
Labor supply shock persistence, ρ_χ	Beta$[0.50, 0.20]$	0.966	0.0365
Financial shock persistence, ρ_ξ	Beta$[0.50, 0.20]$	0.858	0.0149
Investment shock persistence, $\rho_\varkappa$	Beta$[0.50, 0.20]$	0.537	0.0106
Wage mark-up shock persistence, ρ_ν	Beta$[0.50, 0.20]$	0.477	0.0089
Price mark-up shock persistence, ρ_η	Beta$[0.50, 0.20]$	0.959	0.0129
Intertemporal shock persistence, ρ_γ	Beta$[0.50, 0.20]$	0.971	0.0298
Government shock persistence, ρ_g	Beta$[0.50, 0.20]$	0.924	0.0126
Interaction prod-government, ρ_{gz}	Beta$[0.50, 0.20]$	0.150	0.0159
Monetary policy persistence, ρ_r	Beta$[0.75, 0.10]$	0.643	0.0066
Productivity shock volatility, σ_z	IGamma$[0.001, 0.005]$	0.0046	0.0003
Labor supply shock volatility, σ_χ	IGamma$[0.001, 0.05]$	0.0413	0.0011
Financial shock volatility, σ_ξ	IGamma$[0.001, 0.05]$	0.0177	0.0010
Investment shock volatility, $\sigma_\varkappa$	IGamma$[0.001, 0.05]$	0.0449	0.0022
Wage mark-up shock volatility, σ_ν	IGamma$[0.001, 0.05]$	0.1492	0.0020
Price mark-up shock volatility, σ_η	IGamma$[0.001, 0.05]$	0.0061	0.0007
Intertemporal shock volatility, σ_γ	IGamma$[0.001, 0.05]$	0.2102	0.0079
Government shock volatility, σ_g	IGamma$[0.001, 0.05]$	0.0271	0.0018
Monetary policy shock volatility, σ_r	IGamma$[0.001, 0.05]$	0.0080	0.0004

Table 4. Decomposition under whole sample based estimation

eight quarter cumulative growth of output

Shocks	*Pre-1985*	*Post-1985*	*Difference*
TFP	0.01164	0.00329	-0.00835**
Financial	0.04624	0.01919	-0.02705**
Investment	0.00804	0.00318	-0.00486
Monetary	0.00426	0.00876	0.00451
Gov. spending	-0.01390	-0.01598	-0.00208
Wage markup	-0.00315	-0.00486	-0.00171
Price markup	-0.00050	0.00390	0.00439
Risk premium	-0.00879	-0.00116	0.00763
Labor supply	-0.00256	-0.00550	-0.00295
Initial state	0.00045	-0.00196	-0.00241
Total	0.04173	0.00886	-0.03287**

eight quarter cumulative growth of employment

Shocks	*Pre-1985*	*Post-1985*	*Difference*
TFP	-0.01722	-0.01013	0.00709
Financial	0.04826	0.02134	-0.02691**
Investment	0.00743	0.00651	-0.00092
Monetary	0.00456	0.00836	0.00381
Gov. spending	-0.01390	-0.01900	-0.00510
Wage markup	-0.00310	-0.00583	-0.00273*
Price markup	-0.00204	0.00069	0.00273*
Risk premium	-0.00904	-0.00177	0.00727*
Labor supply	-0.00262	-0.00561	-0.00299
Initial state	0.00192	-0.00196	-0.00389**
Total	0.01425	-0.00739	-0.02164**

Note: Asterisks indicate rejection of equality of means across subsamples at 10% (*), 5% (**), and 1% (***) significance levels (one-sided t-test)

Table 5a. Estimation based on the pre-1985 subsample

Estimated parameters	Prior[mean,std]	Mode	Post_d
Elasticity of labor, ε	Norm$[2.00, 0.75]$	0.163	0.0098
Utility parameter, σ	Norm$[1.50, 0.37]$	0.452	0.0451
Habit in consumption, ϖ	Beta$[0.70, 0.10]$	0.815	0.0184
Wage adjustment, ω	Beta$[0.50, 0.15]$	0.106	0.0122
Investment adjustment cost, ψ	IGamma$[0.15, 0.15]$	0.957	0.0276
Price adjustment cost, ρ	IGamma$[0.10, 0.30]$	1.245	0.0308
Equity payout cost, $2\kappa d$	IGamma$[0.02, 0.01]$	0.012	0.0014
Capital utilization cost, ϕ	Beta$[0.10, 0.3]$	0.021	0.0029
Average price mark-up, η	Beta$[1.20, 0.10]$	1.228	0.0032
Average wage mark-up, ν	Beta$[1.20, 0.10]$	1.058	0.0074
Monetary policy, ν_1	Norm$[1.50, 0.25]$	1.641	0.0119
Monetary policy, ν_2	Norm$[0.12, 0.05]$	0.277	0.0041
Monetary policy, ν_3	Norm$[0.12, 0.05]$	0.189	0.0046
Productivity shock persistence, ρ_z	Beta$[0.50, 0.20]$	0.793	0.0119
Labor supply shock persistence, ρ_χ	Beta$[0.50, 0.20]$	0.941	0.0267
Financial shock persistence, ρ_ξ	Beta$[0.50, 0.20]$	0.784	0.0188
Investment shock persistence, $\rho_\varkappa$	Beta$[0.50, 0.20]$	0.227	0.0131
Wage mark-up shock persistence, ρ_ν	Beta$[0.50, 0.20]$	0.392	0.0204
Price mark-up shock persistence, ρ_η	Beta$[0.50, 0.20]$	0.911	0.0099
Intertemporal shock persistence, ρ_γ	Beta$[0.50, 0.20]$	0.909	0.0079
Government shock persistence, ρ_g	Beta$[0.50, 0.20]$	0.914	0.0180
Interaction prod-government, ρ_{gz}	Beta$[0.50, 0.20]$	0.730	0.0173
Monetary policy persistence, ρ_r	Beta$[0.75, 0.10]$	0.473	0.0118
Productivity shock volatility, σ_z	IGamma$[0.001, 0.005]$	0.0049	0.0003
Labor supply shock volatility, σ_χ	IGamma$[0.001, 0.05]$	0.0279	0.0016
Financial shock volatility, σ_ξ	IGamma$[0.001, 0.05]$	0.0217	0.0014
Investment shock volatility, $\sigma_\varkappa$	IGamma$[0.001, 0.05]$	0.0757	0.0030
Wage mark-up shock volatility, σ_ν	IGamma$[0.001, 0.05]$	0.0862	0.0033
Price mark-up shock volatility, σ_η	IGamma$[0.001, 0.05]$	0.0084	0.0009
Intertemporal shock volatility, σ_γ	IGamma$[0.001, 0.05]$	0.0837	0.0022
Government shock volatility, σ_g	IGamma$[0.001, 0.05]$	0.0361	0.0016
Monetary policy shock volatility, σ_r	IGamma$[0.001, 0.05]$	0.0108	0.0005

Table 5b. Estimation based on the post-1985 subsample

Estimated parameters	Prior[mean,std]	Mode	Post_d
Elasticity of labor, ε	Norm$[2.00, 0.75]$	0.127	0.0233
Utility parameter, σ	Norm$[1.50, 0.37]$	1.160	0.0386
Habit in consumption, ϖ	Beta$[0.70, 0.10]$	0.689	0.0110
Wage adjustment, ω	Beta$[0.50, 0.15]$	0.228	0.0132
Investment adjustment cost, ψ	IGamma$[0.15, 0.15]$	0.533	0.0307
Price adjustment cost, ρ	IGamma$[0.10, 0.30]$	0.052	0.0292
Equity payout cost, $2\kappa d$	IGamma$[0.02, 0.01]$	0.027	0.0007
Capital utilization cost, ϕ	Beta$[0.10, 0.3]$	0.032	0.0018
Average price mark-up, η	Beta$[1.20, 0.10]$	1.235	0.0031
Average wage mark-up, ν	Beta$[1.20, 0.10]$	1.170	0.0090
Monetary policy, ν_1	Norm$[1.50, 0.25]$	1.547	0.0133
Monetary policy, ν_2	Norm$[0.12, 0.05]$	0.171	0.0087
Monetary policy, ν_3	Norm$[0.12, 0.05]$	0.139	0.0082
Productivity shock persistence, ρ_z	Beta$[0.50, 0.20]$	0.661	0.0207
Labor supply shock persistence, ρ_χ	Beta$[0.50, 0.20]$	0.965	0.0075
Financial shock persistence, ρ_ξ	Beta$[0.50, 0.20]$	0.915	0.0189
Investment shock persistence, $\rho_\varkappa$	Beta$[0.50, 0.20]$	0.541	0.0178
Wage mark-up shock persistence, ρ_ν	Beta$[0.50, 0.20]$	0.641	0.0193
Price mark-up shock persistence, ρ_η	Beta$[0.50, 0.20]$	0.925	0.0110
Intertemporal shock persistence, ρ_γ	Beta$[0.50, 0.20]$	0.972	0.0071
Government shock persistence, ρ_g	Beta$[0.50, 0.20]$	0.928	0.0168
Interaction prod-government, ρ_{gz}	Beta$[0.50, 0.20]$	0.632	0.0235
Monetary policy persistence, ρ_r	Beta$[0.75, 0.10]$	0.608	0.0167
Productivity shock volatility, σ_z	IGamma$[0.001, 0.005]$	0.0021	0.0002
Labor supply shock volatility, σ_χ	IGamma$[0.001, 0.05]$	0.0291	0.0025
Financial shock volatility, σ_ξ	IGamma$[0.001, 0.05]$	0.0105	0.0010
Investment shock volatility, $\sigma_\varkappa$	IGamma$[0.001, 0.05]$	0.0280	0.0012
Wage mark-up shock volatility, σ_ν	IGamma$[0.001, 0.05]$	0.0644	0.0029
Price mark-up shock volatility, σ_η	IGamma$[0.001, 0.05]$	0.0052	0.0007
Intertemporal shock volatility, σ_γ	IGamma$[0.001, 0.05]$	0.1533	0.0091
Government shock volatility, σ_g	IGamma$[0.001, 0.05]$	0.0202	0.0015
Monetary policy shock volatility, σ_r	IGamma$[0.001, 0.05]$	0.0061	0.0004

Table 6. Decomposition under subsample based estimation

eight quarter cumulative growth of output

Shocks	*Pre-1985*	*Post-1985*	*Difference*
TFP	0.00750	0.00146	-0.00604**
Financial	0.03913	0.01786	-0.02127**
Investment	0.01758	0.00526	-0.01232**
Monetary	0.00782	0.01132	0.00350
Gov. spending	-0.01788	-0.01951	-0.00163
Wage markup	-0.00242	-0.00527	-0.00285**
Price markup	0.00241	0.00514	0.00273
Risk premium	-0.01071	-0.00476	0.00595
Labor supply	-0.00160	-0.00398	-0.00238*
Initial state	-0.00010	0.000136	0.00144
Total	0.04173	0.00886	-0.03287**

eight quarter cumulative growth of employment

Shocks	*Pre-1985*	*Post-1985*	*Difference*
TFP	-0.01328	-0.00437	0.00891*
Financial	0.04257	0.01976	-0.02281**
Investment	0.01575	0.00928	-0.00647
Monetary	0.00799	0.01129	0.00330
Gov. spending	-0.01777	-0.02297	-0.00520
Wage markup	-0.00239	-0.00627	-0.00388**
Price markup	-0.00647	-0.00574	0.00073
Risk premium	-0.01110	-0.00598	0.00512
Labor supply	-0.00163	-0.00411	-0.00249*
Initial state	0.00057	0.00173	0.00116
Total	0.01425	-0.00739	-0.02164**

Note: Asterisks indicate rejection of equality of means across subsamples at 10% (*), 5% (**), and 1% (***) significance levels (one-sided t-test)

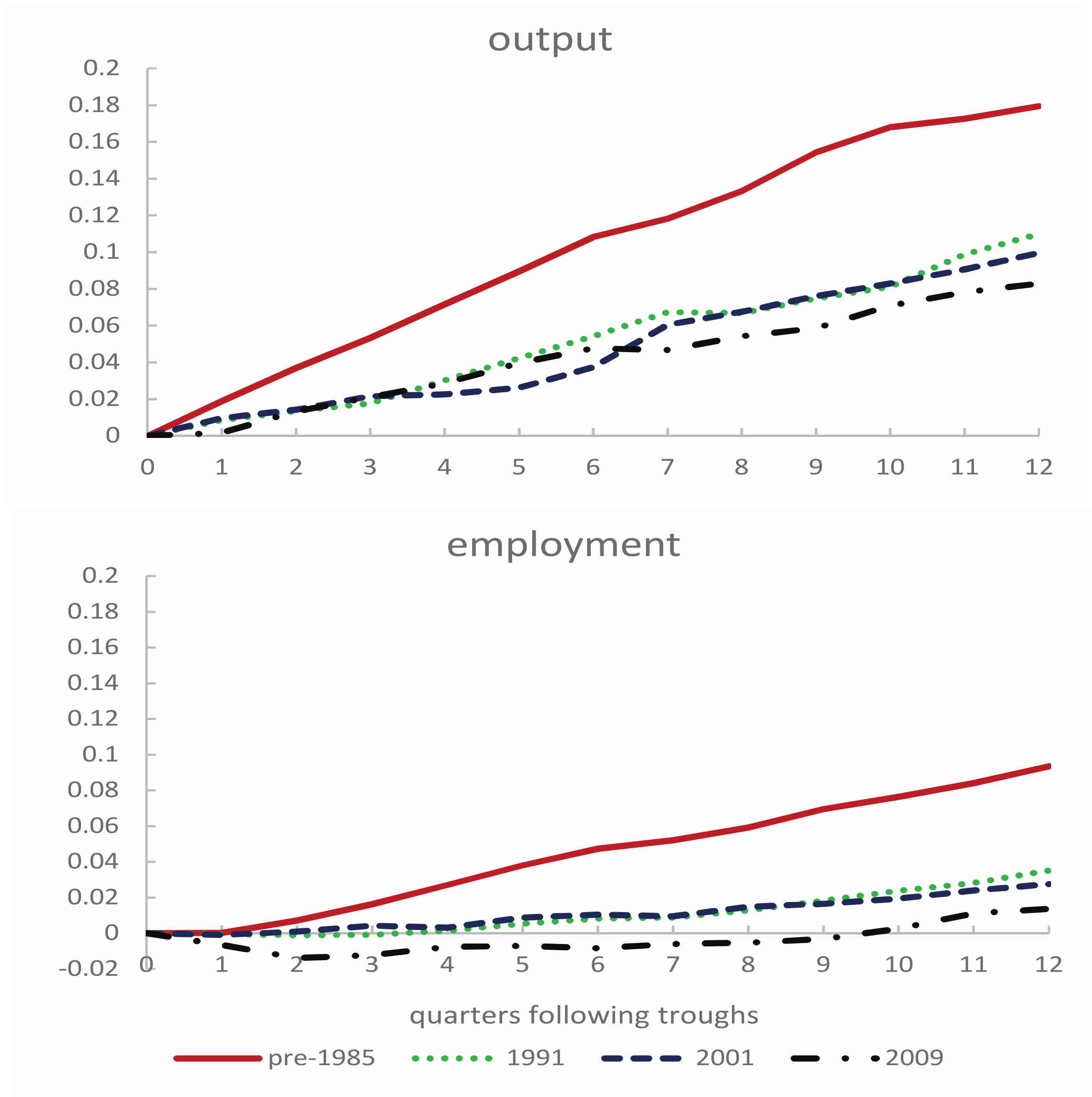

Fig. 1. Pre- versus post-1985 recoveries
Real GDP data from the Bureau of Economic Analysis and civilian employment data from the Bureau of Labor Statistics

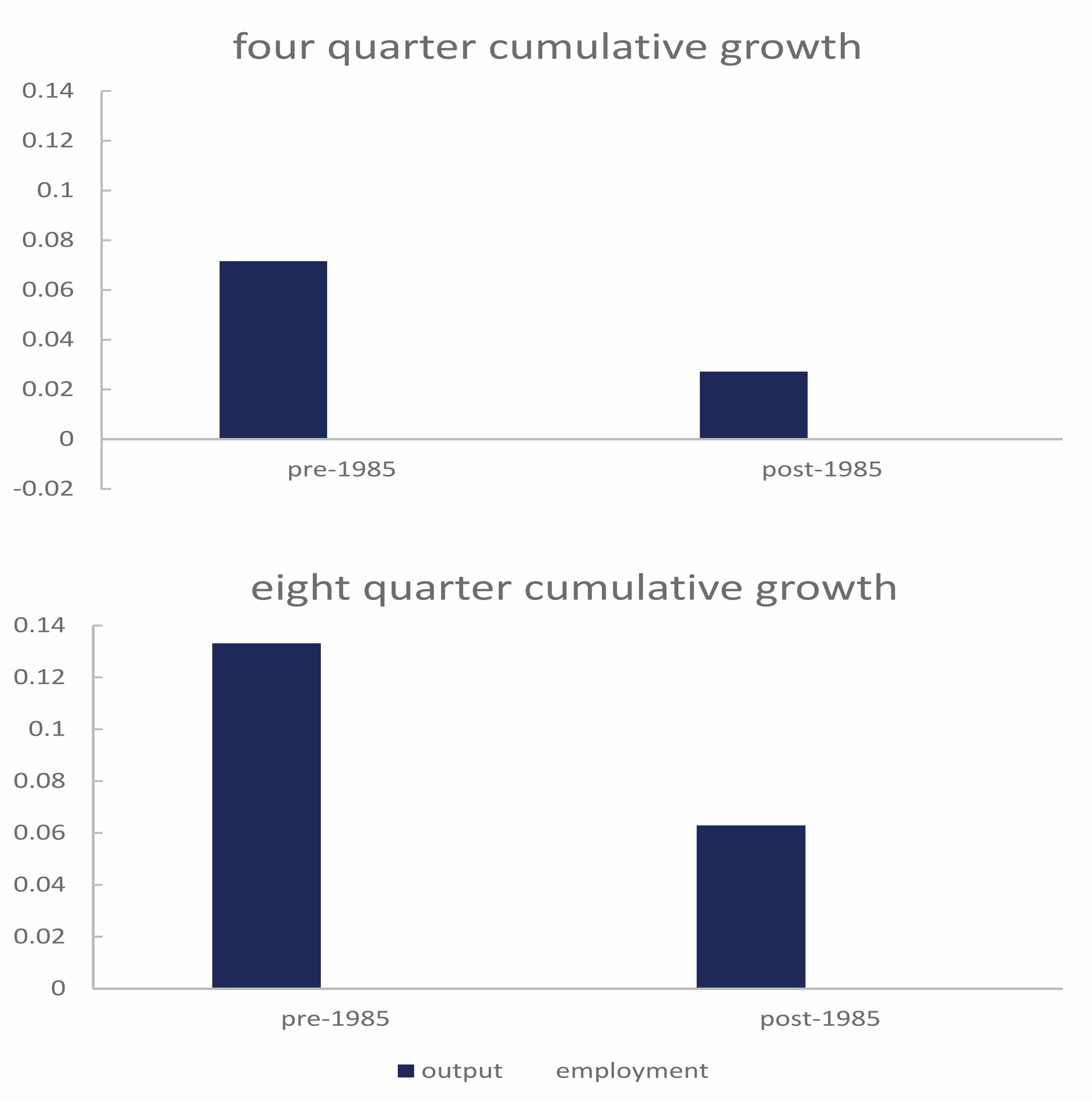

Fig. 2. Recoveries from troughs

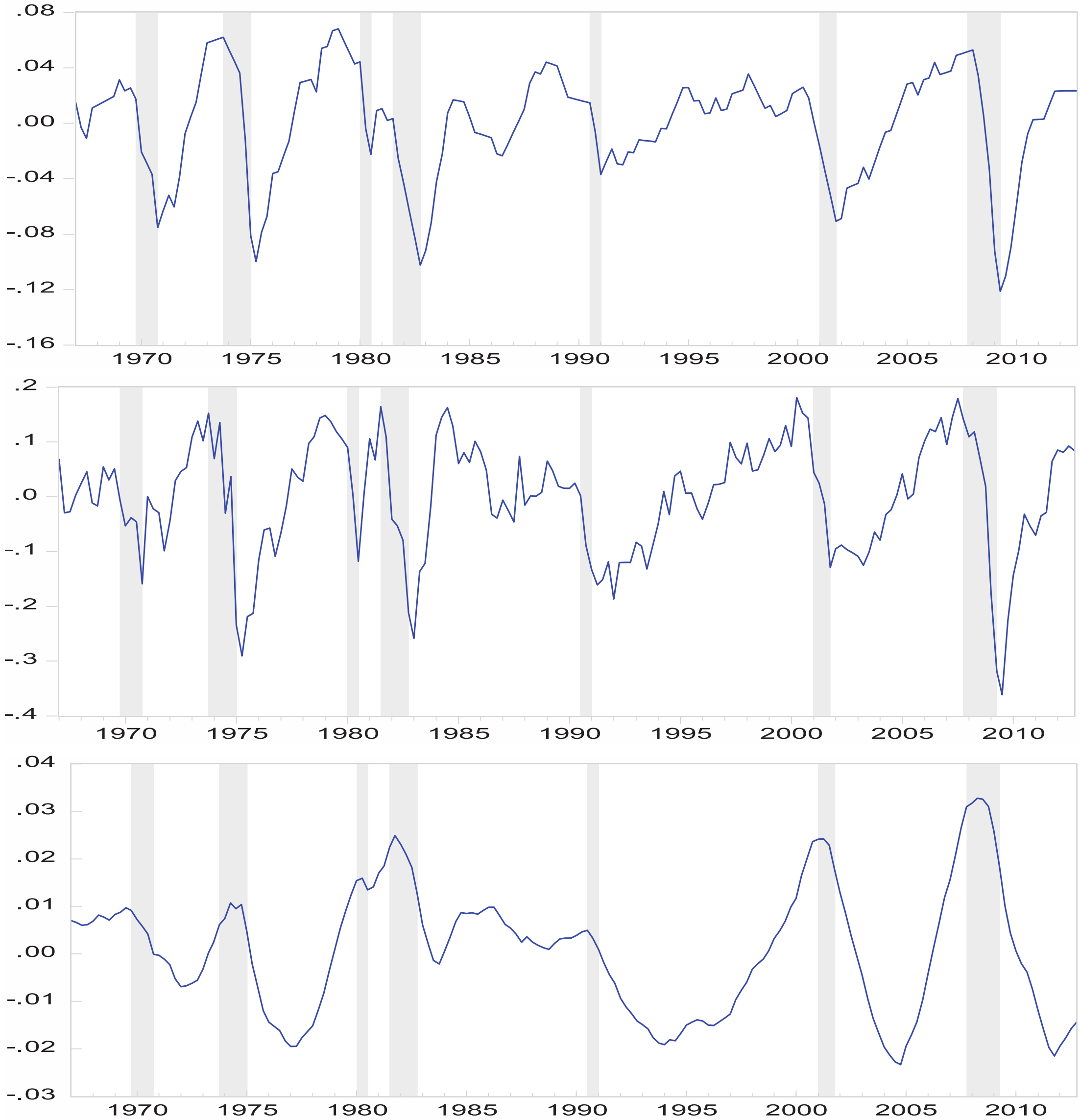

Fig. 3. Cyclical fluctuations of utilization rate, investment, and capital
Data for capital utilization from the Board of Governors of the Federal Reserve System and data for investment and capital stock from the Flow of Funds Account and authors' calculation. Shaded areas are NBER-dated recession dates

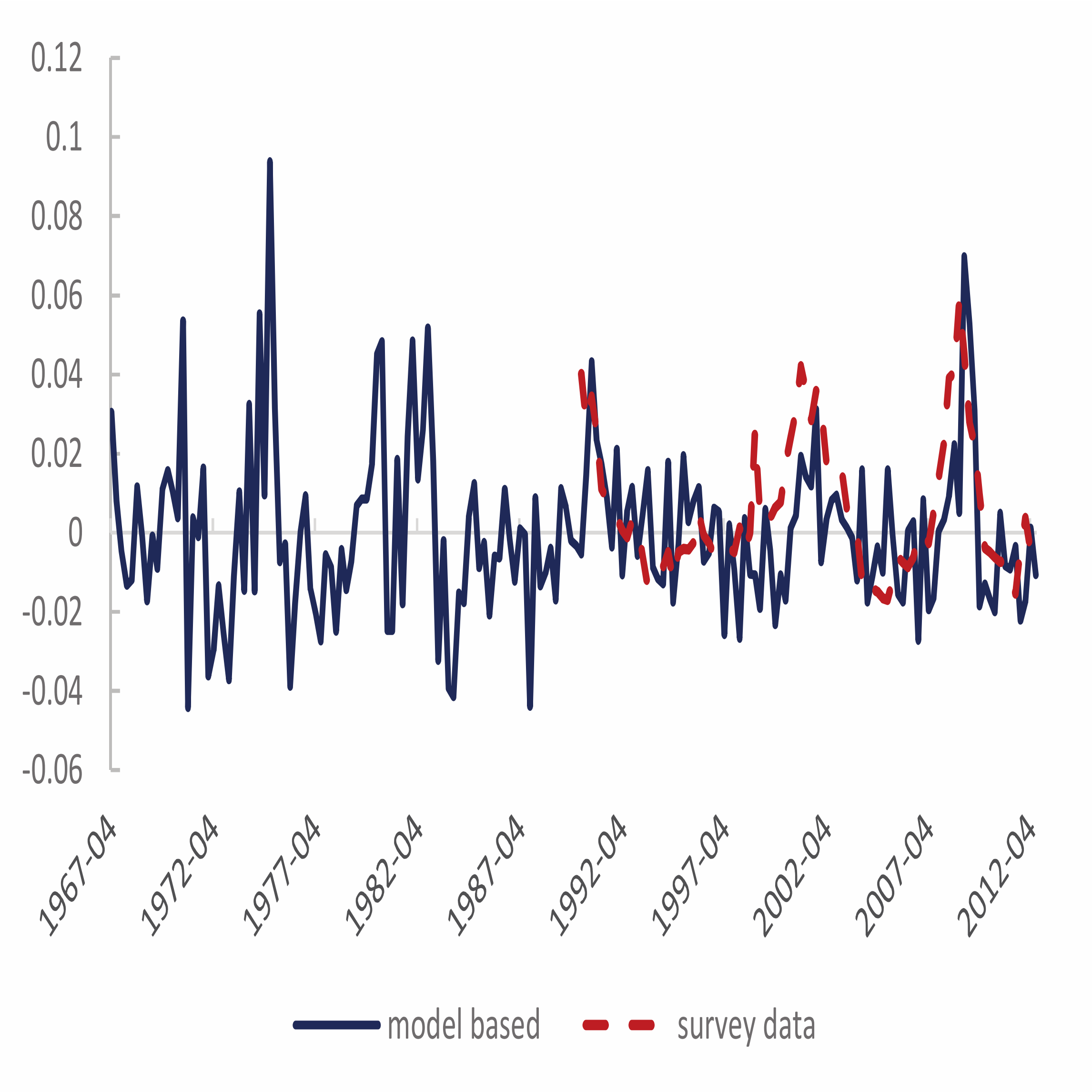

Fig. 4. Model versus survey based credit tightness indices

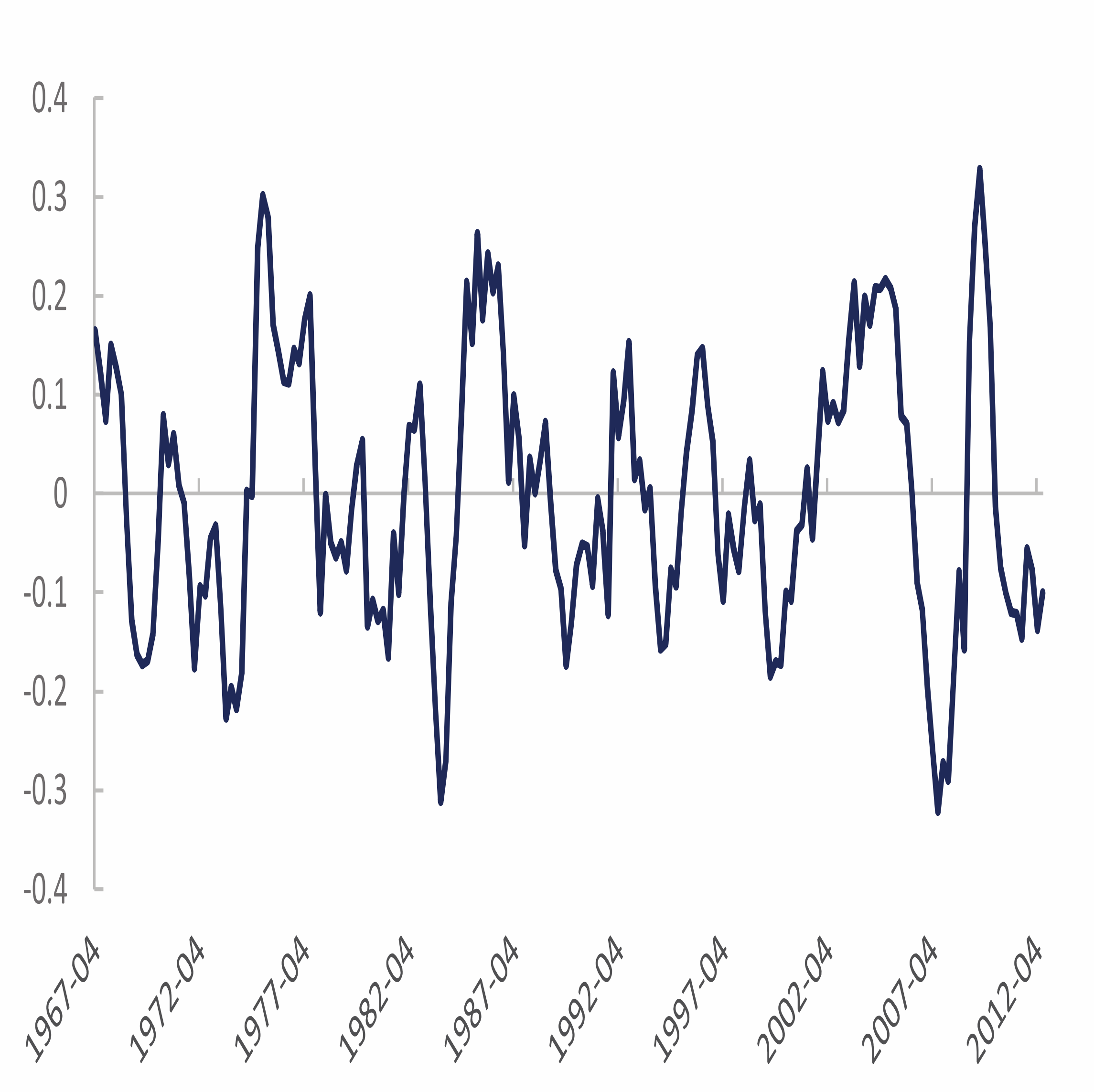

Fig. 5. Lagrange multiplier μ in the baseline simulation

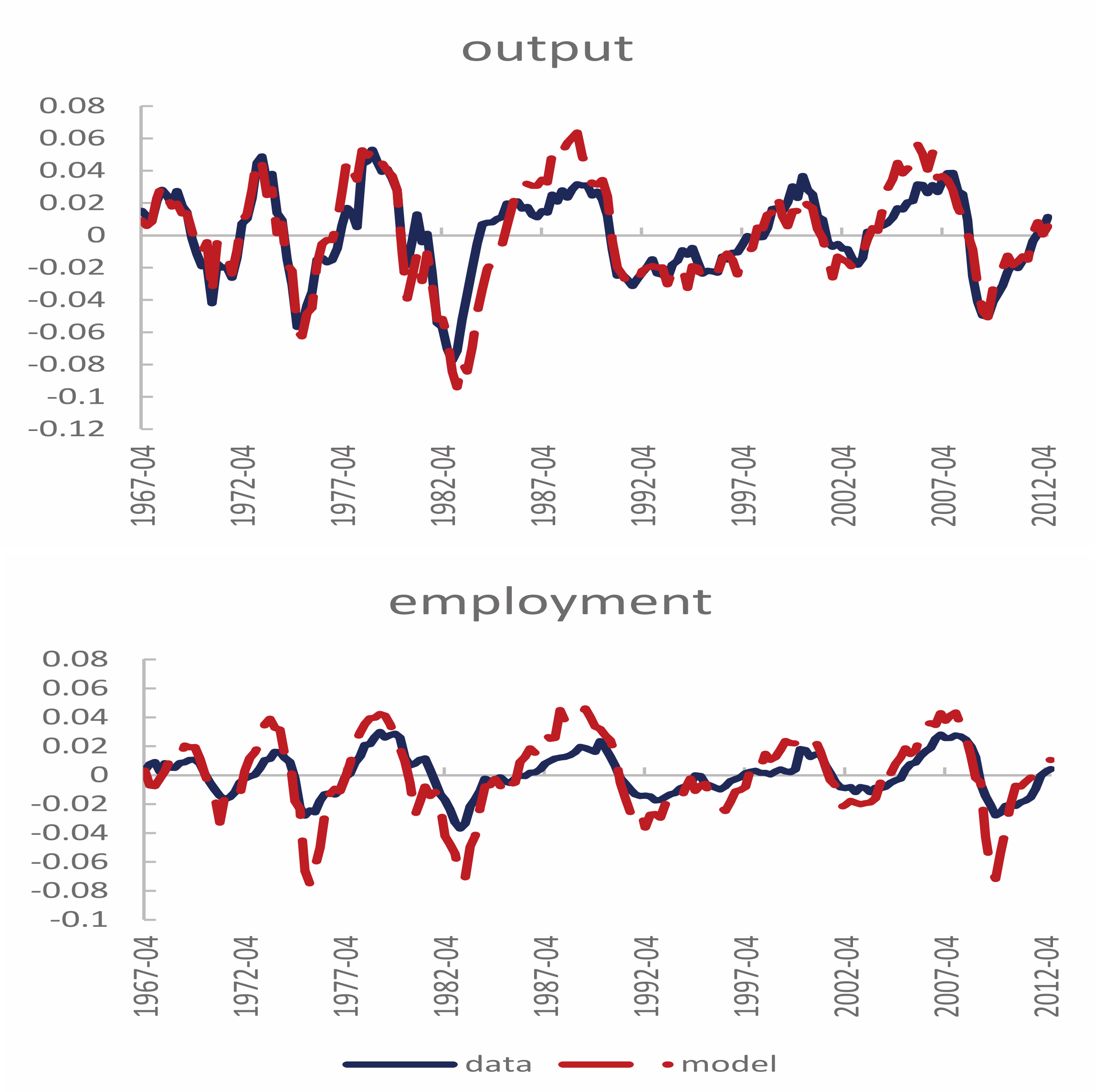

Fig. 6. Cyclical fluctuations of output and employment: Model versus data

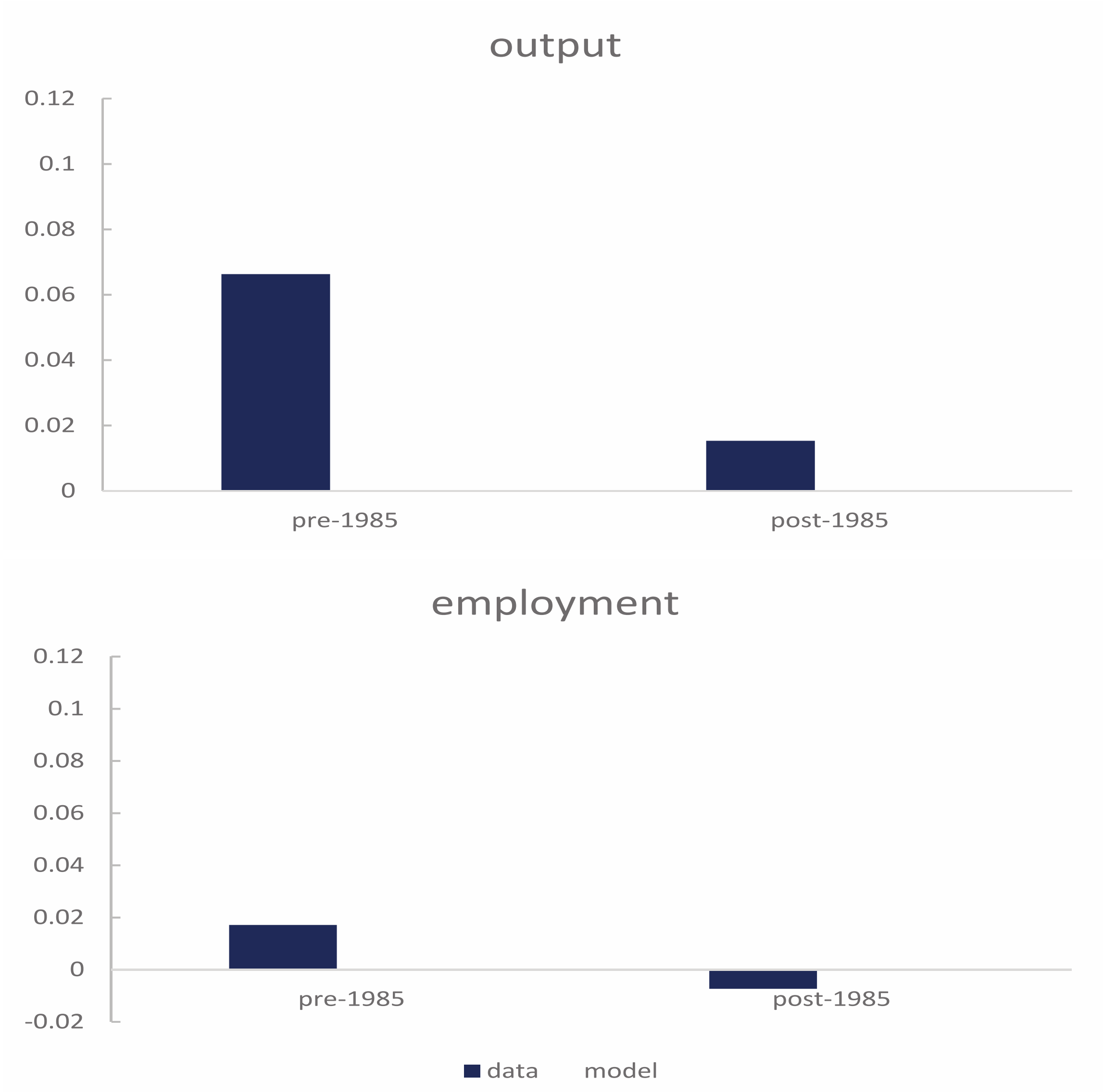

Fig. 7. Eight quarter cumulative growth: Model versus data

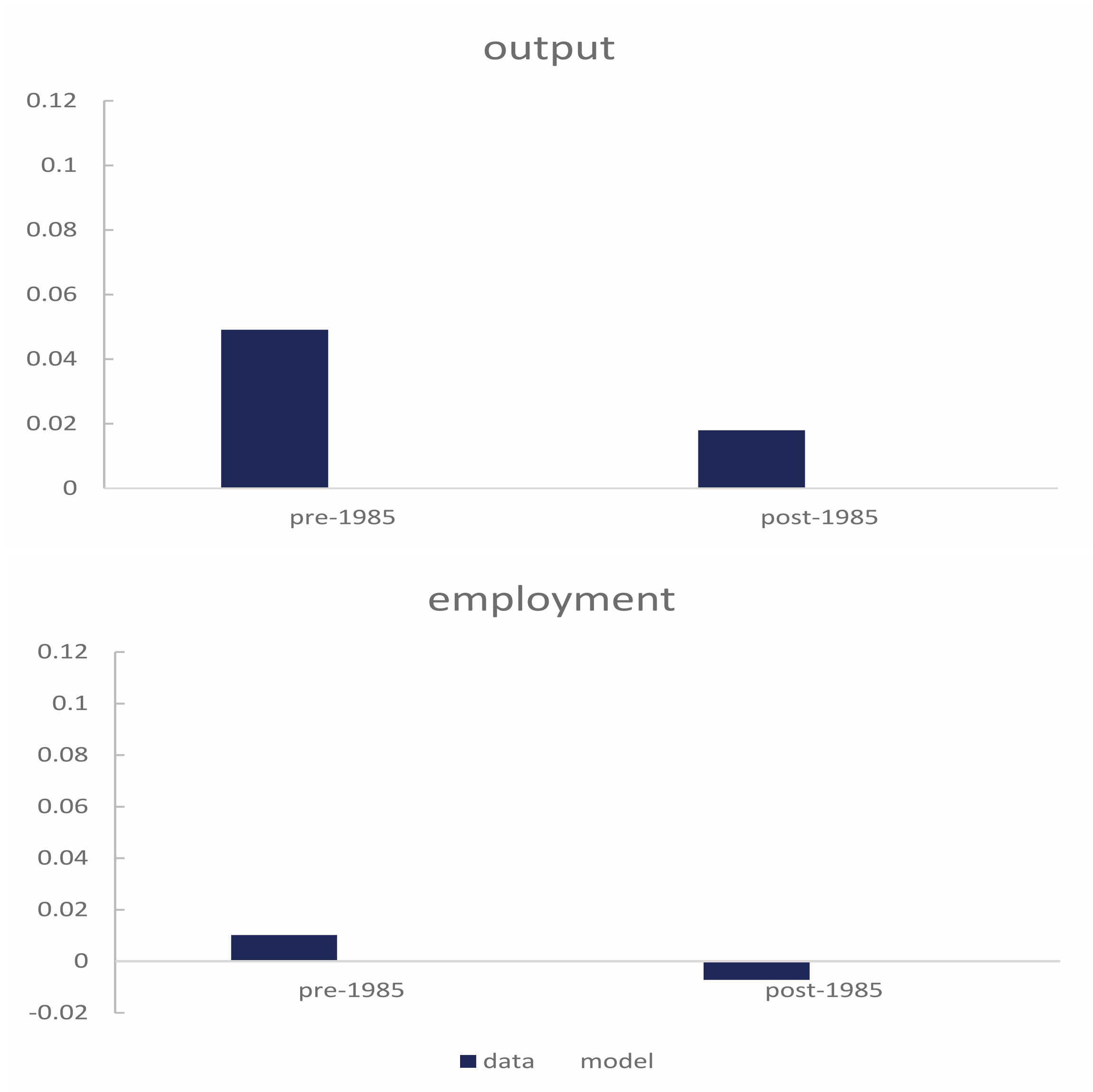

Fig. 8. Eight quarter cumulative growth: Model versus data (recession-depth adjusted)

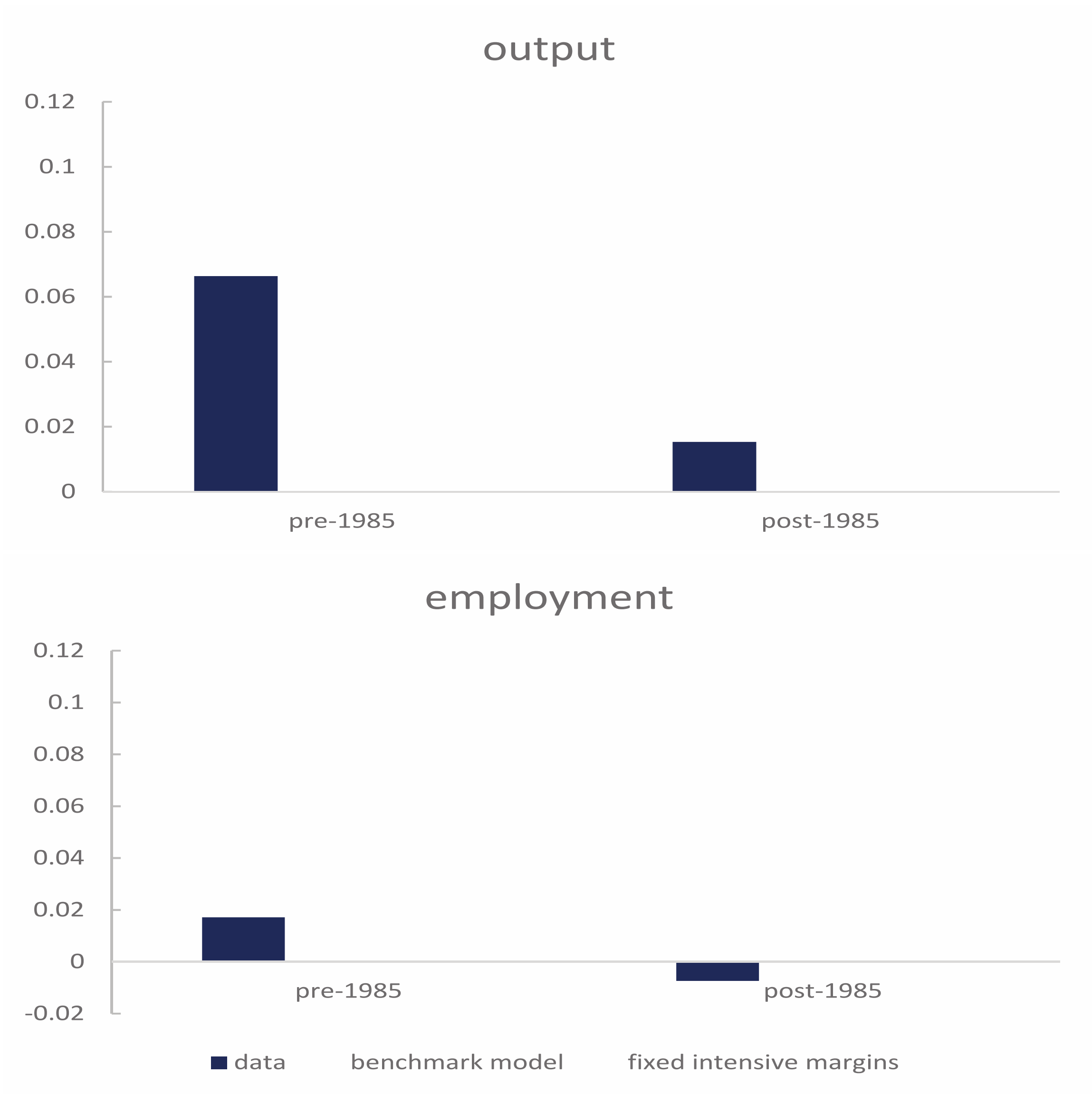

Fig. 9. Eight quarter cumulative growth: Fixed intensive margins versus benchmark model and data

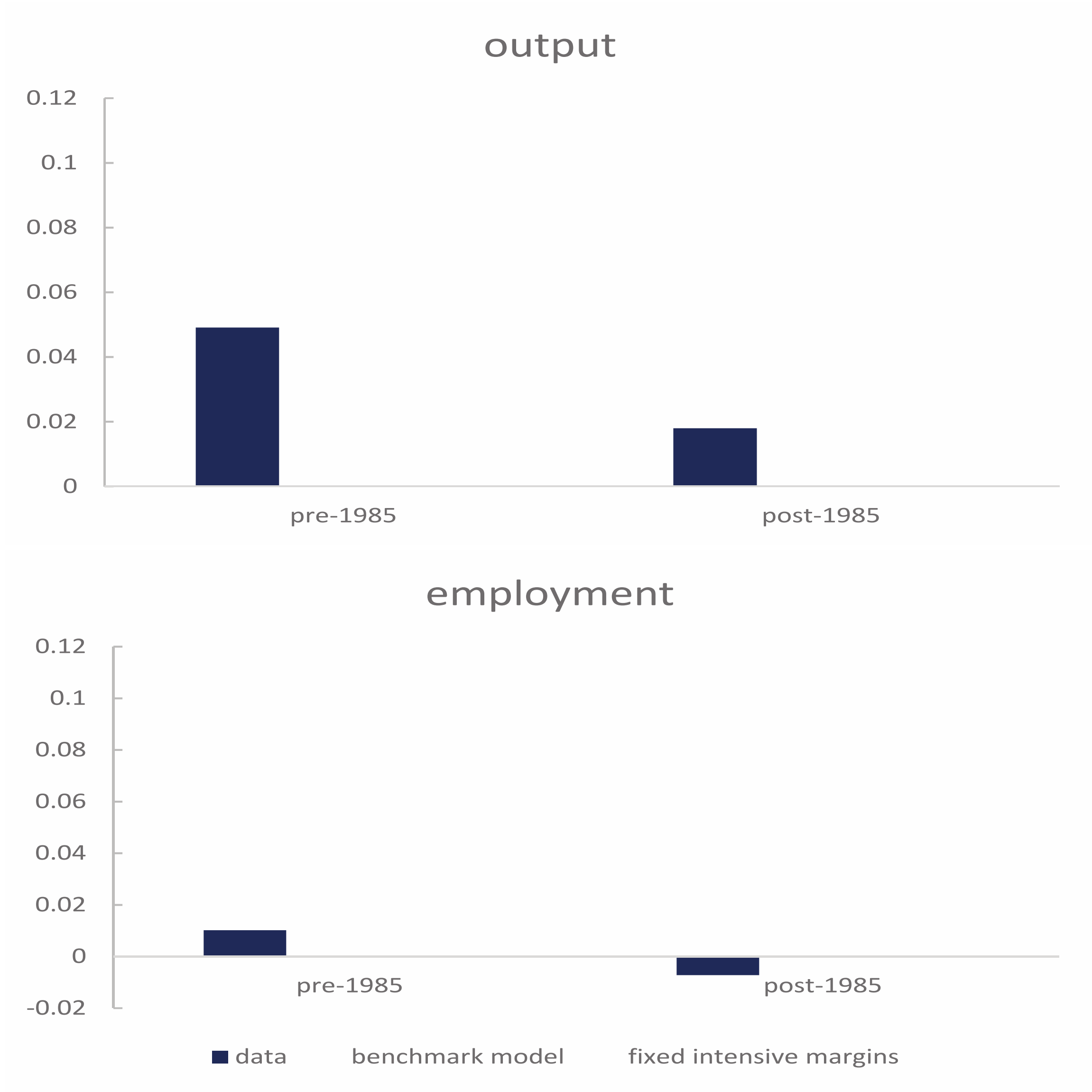

Fig. 10. Eight quarter cumulative growth: Fixed intensive margins versus benchmark model and data (recession-depth adjusted)

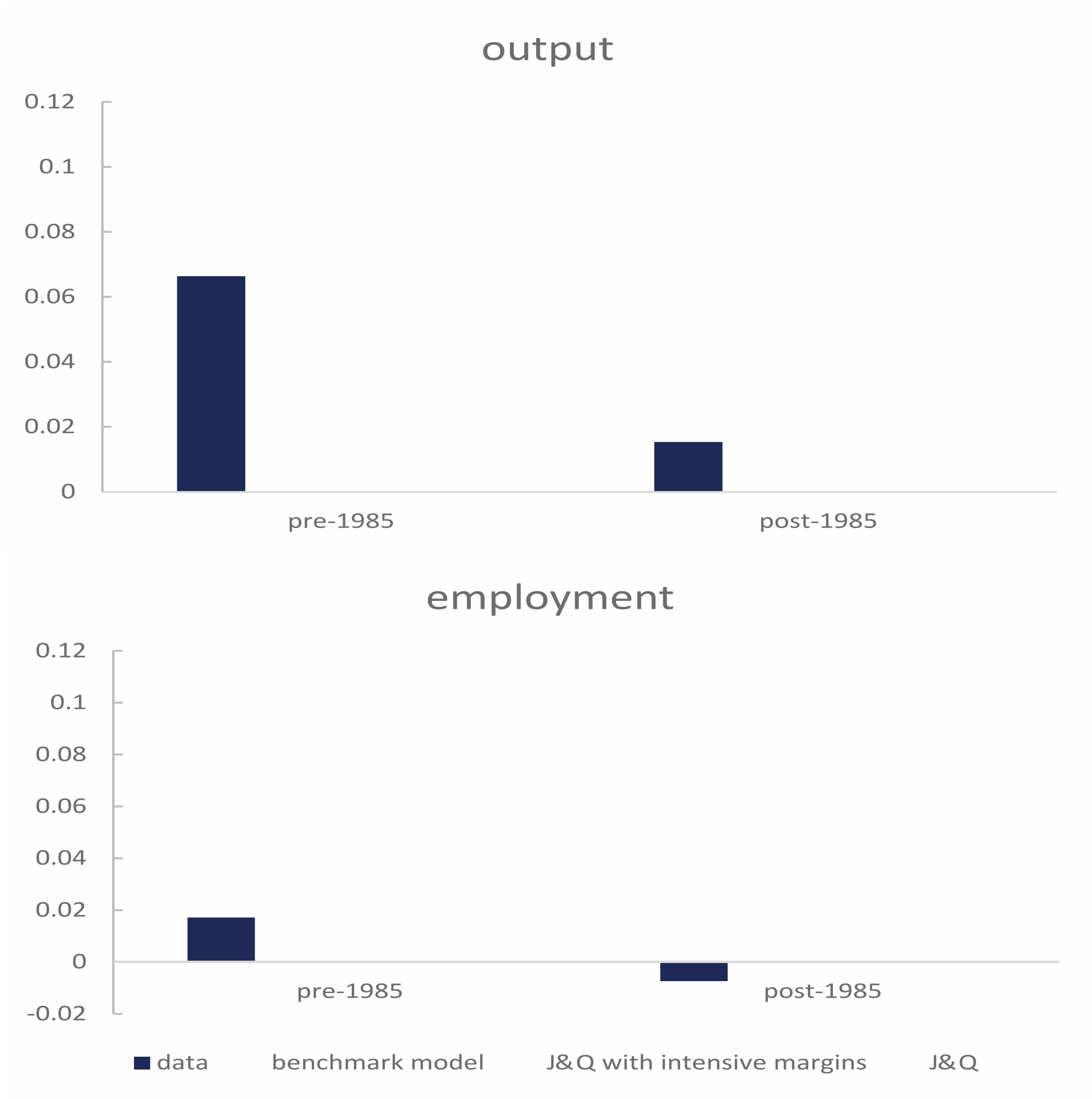

Fig. 11. Eight quarter cumulative growth: J&Q with and without intensive margins versus benchmark model and data

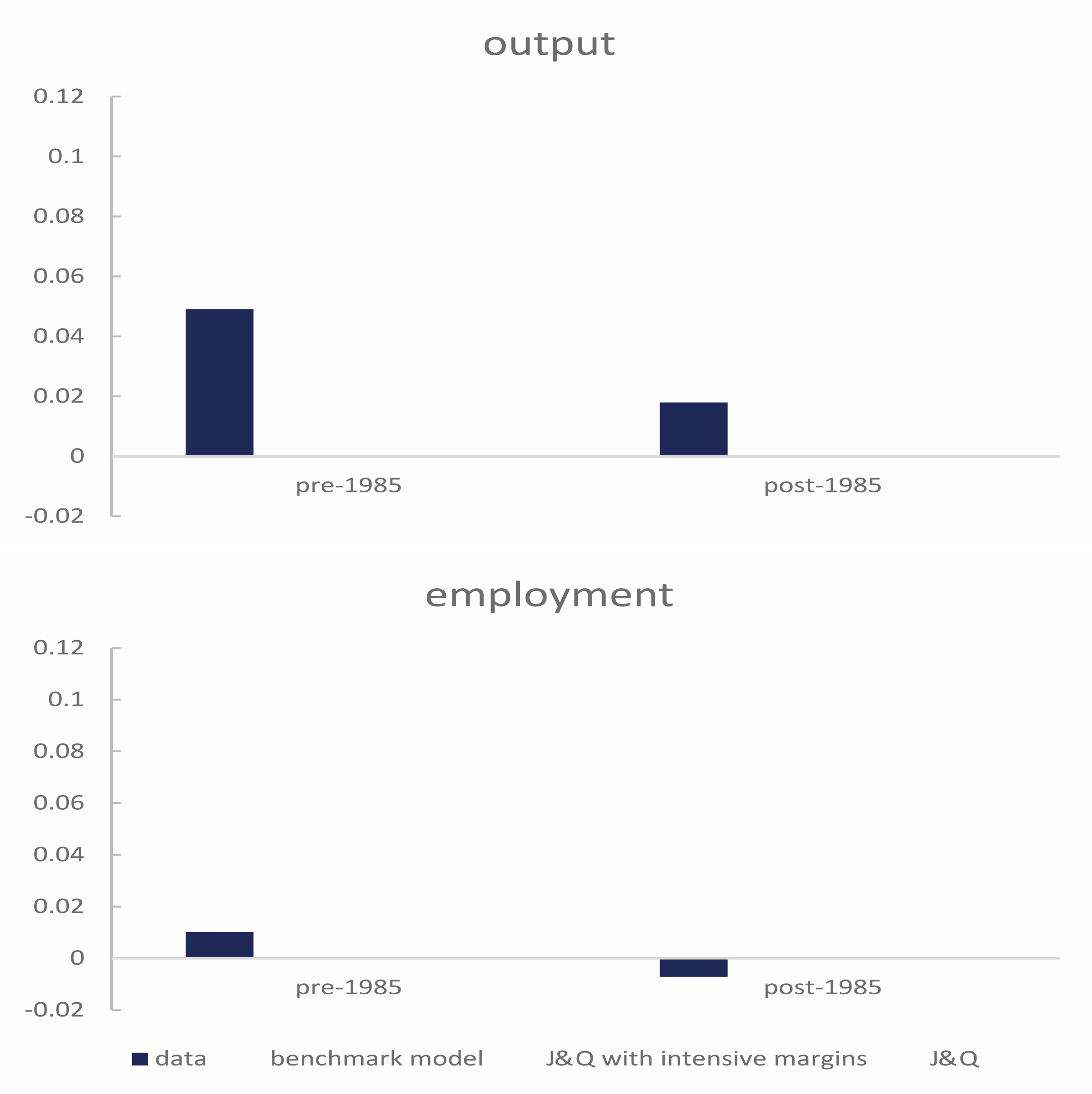

Fig. 12. Eight quarter cumulative growth: J&Q with and without intensive margins versus benchmark model and data (recession-depth adjusted)

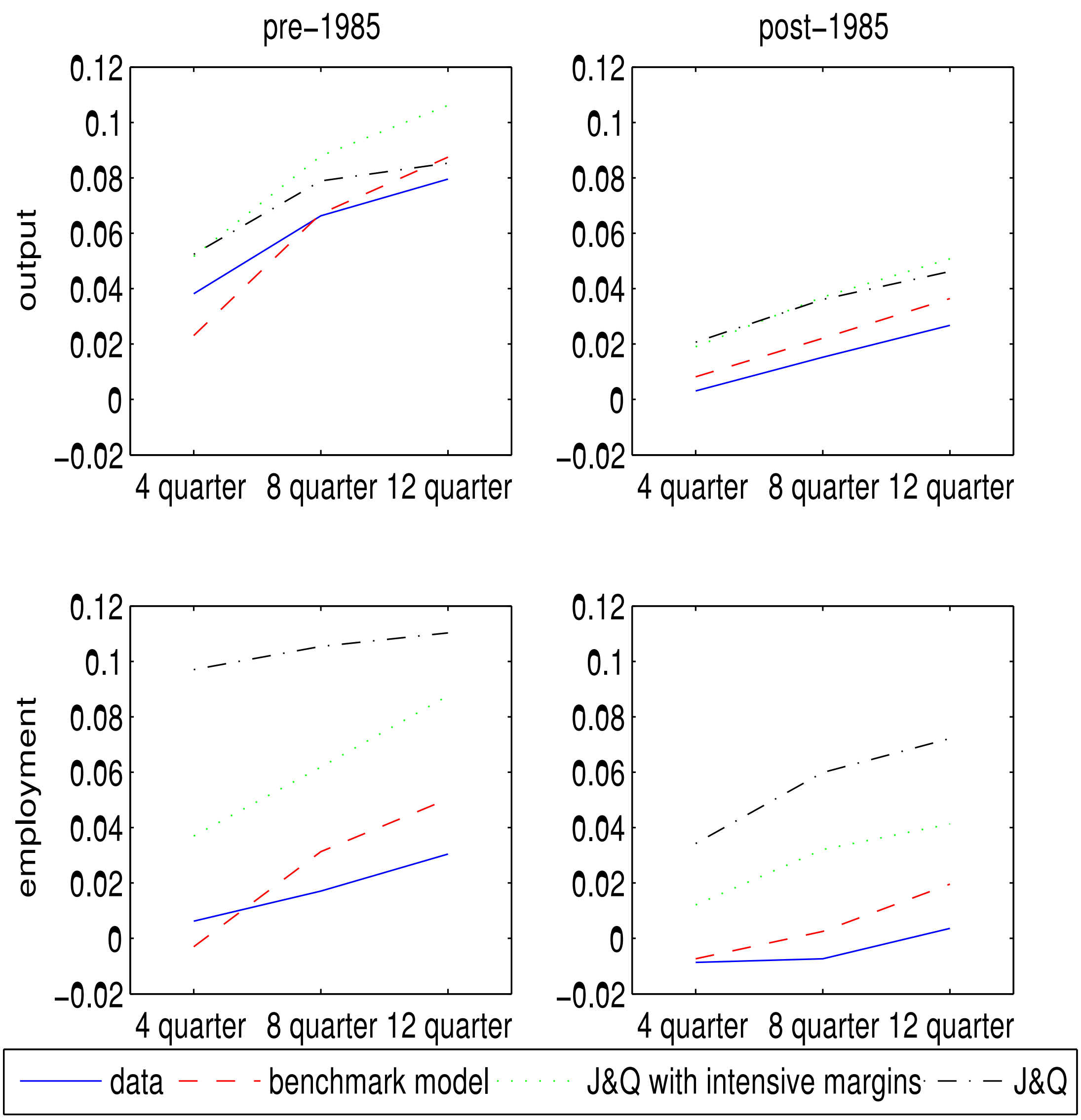

Fig. 13. Cumulative growth four, eight, and twelve quarters into a recovery: J&Q with and without intensive margins versus benchmark model and data

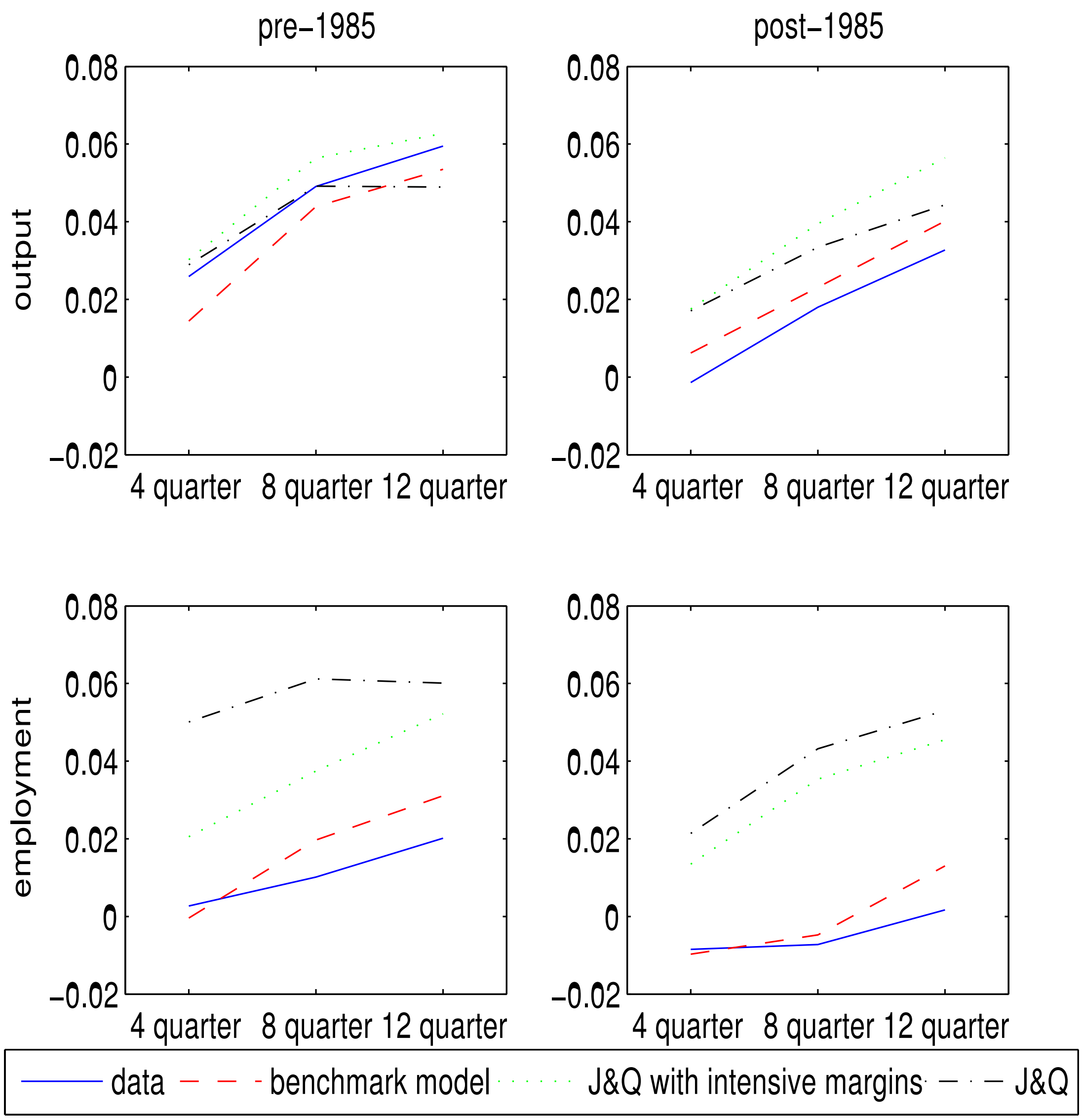

Fig. 14. Cumulative growth four, eight, and twelve quarters into a recovery: J&Q with and without intensive margins versus benchmark model and data (recession-depth adjusted)

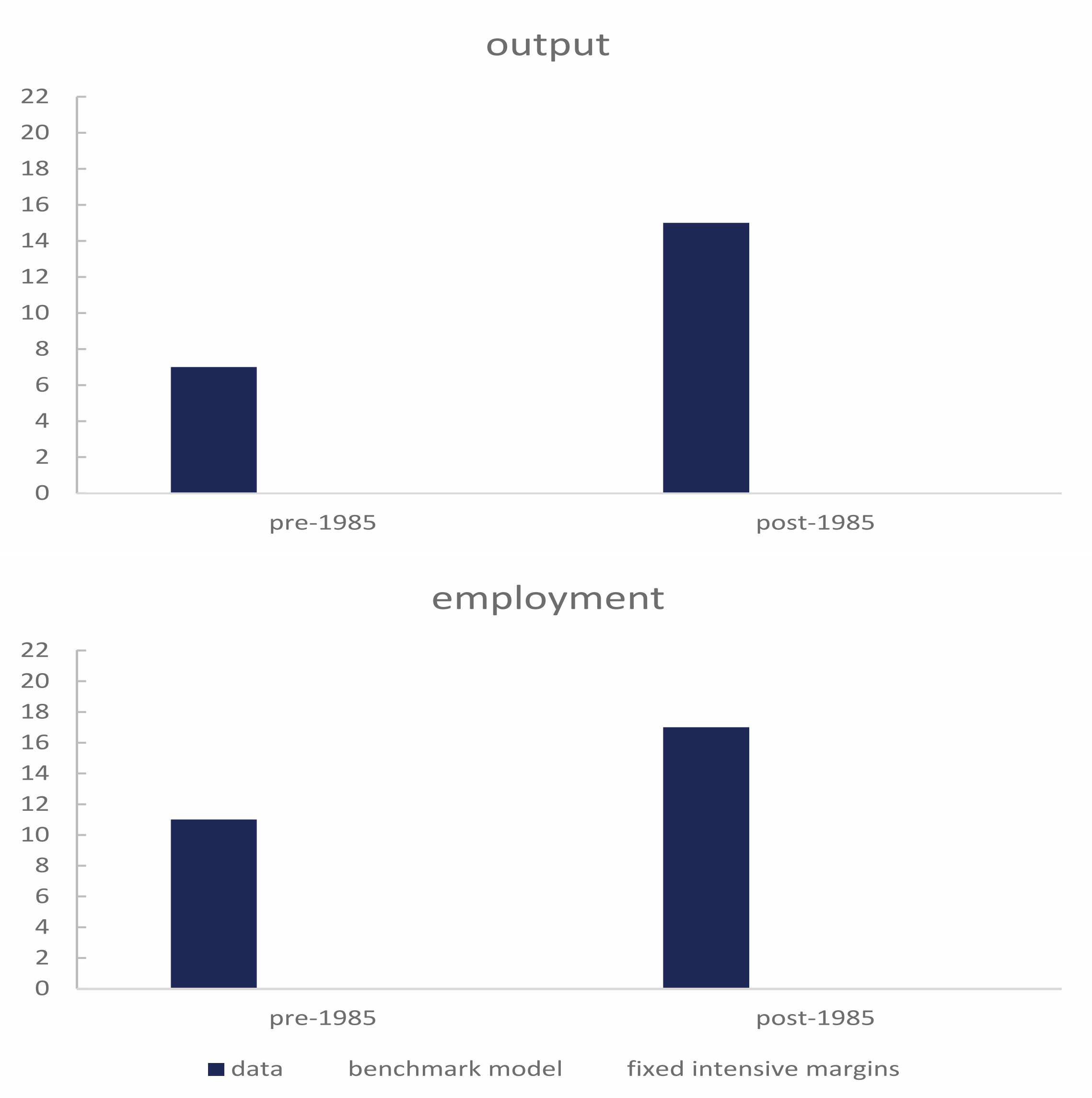

Fig. 15. Quarters from trough to trend: Fixed intensive margins versus benchmark model and data

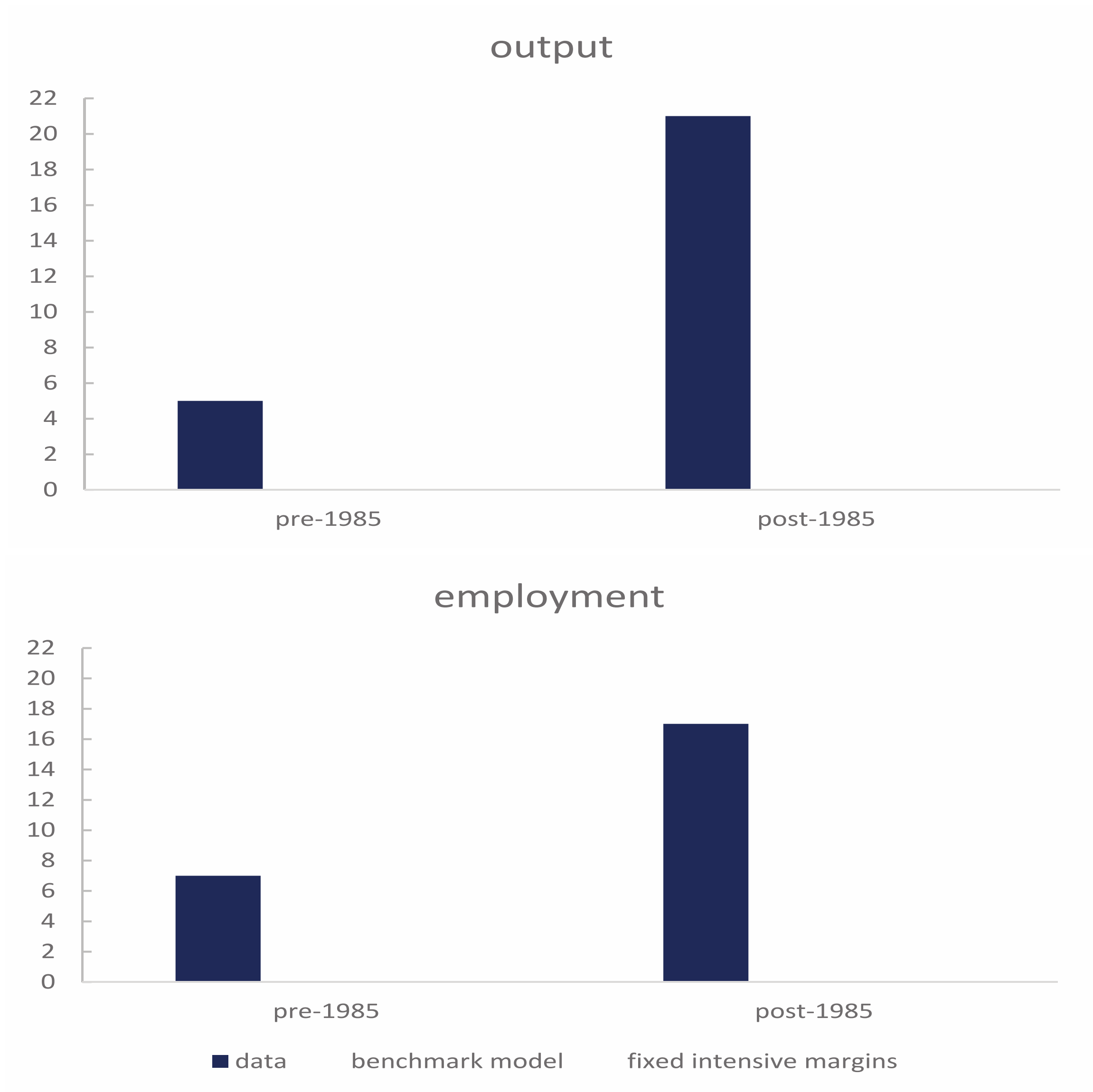

Fig. 16. Quarters from trough to trend: Fixed intensive margins versus benchmark model and data (recession-depth adjusted)

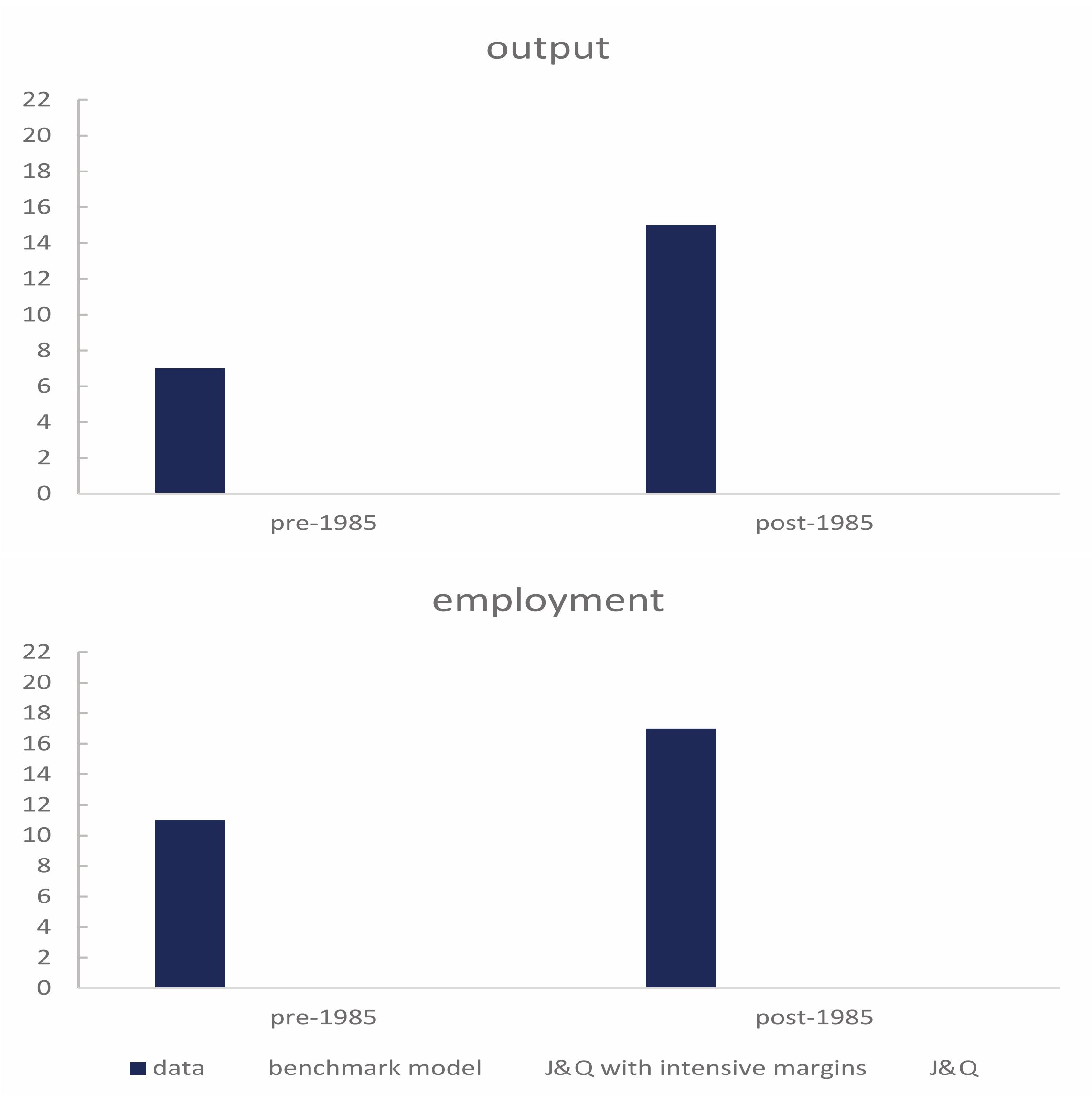

Fig. 17. Quarters from trough to trend: J&Q with and without intensive margins versus benchmark model and data

Fig. 18. Quarters from trough to trend: J&Q with and without intensive margins versus benchmark model and data (recession-depth adjusted)