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Characterizing the Unusual Path of U.S. Output During and After the Great Recession

Jonathon Lecznar, Pierre-Daniel Sarte, and Robert Sharp

The growth of the U.S. economy coming out of the 2007–09 Great Recession has been relatively muted when compared to other economic recoveries over the postwar period. Four and a half years into the current recovery, the unemployment rate remains elevated at 6.6 percent, while per capita gross domestic product (GDP) growth has consistently fallen short of its historical average. One interpretation of current economic conditions is that the U.S. economy continues to operate below potential, and that one may soon expect a return to normal conditions driven by increases in cyclical forces like productivity and employment. Another view is that the tepid recovery following the Great Recession has been driven by slower moving forces, and that a notable pick-up in economic activity hinges on variables that tend to change more slowly over time. This article investigates these two perspectives empirically and finds evidence for the latter interpretation.

The focus of the article will be on U.S. per capita GDP, where population is measured as the civilian non-institutional population (i.e., non-military, non-inmates at institutions, 16 years of age and over). As others have noted, the fall in per capita GDP that began in the

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fourth quarter of 2007 was unprecedented in U.S. postwar history.[1] In addition, the higher-than-trend growth rates that typically characterize U.S. economic recoveries were notably absent following the Great Recession: In fact, this was the only recession of the postwar period for which, 16 quarters after its end, per capita GDP had yet to reach its pre-recession peak.

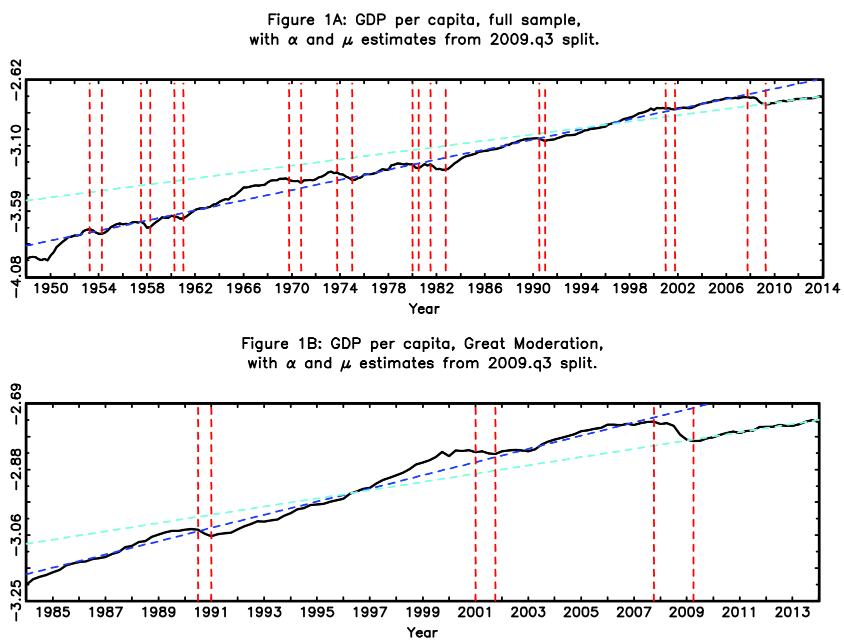
To examine these observations objectively, we first perform some statistical analysis on the per capita GDP time series. Using a range of structural break tests and univariate representations of the process governing U.S. GDP, we present evidence that the Great Recession may have left a scar on the U.S. economy in the form of a long-lasting decline in the level of GDP. Moreover, while we cannot conclusively establish that U.S. per capita GDP growth has shifted to a lower trend, we provide calculations that estimate the likelihood of realized growth rates since the end of the Great Recession to be only 21 percent. To the extent that the Great Recession was driven in part by financial factors, these findings are consistent with work by Reinhart and Rogoff (2014) that highlights the long-lasting effects of financially driven recessions. Finally, we show that unlike every other recession in the postwar period, the fall in and subsequent slow recovery of output during and after the Great Recession cannot easily be explained by shocks typical of the history up to that recession. In this respect, the Great Recession is statistically unique among postwar recessions.

The next part of our analysis focuses on a decomposition of per capita GDP. Since the definition of population used in this article represents the potential workforce of the U.S. economy, our per capita GDP series may be decomposed into the following labor market components: labor productivity, the ratio of employment to the labor force, and the labor force participation rate.[2] The time series behavior of these components can then be further decomposed into different frequencies, highlighting how their contributions to per capita GDP evolve more or less slowly over time. These decompositions lead us to several observations. First, labor productivity and the employment rate tend to move with the business cycle, and although they experienced unusually large negative shocks during the Great Recession, their behavior during and after this recession was not qualitatively different from other postwar recessions in that they soon began to recover. In contrast, the labor force participation rate moves considerably slower over time, and its

[1] For a detailed account that disentangles the various channels underlying the 2007–09 recession, see Stock and Watson (2012).

[2] At times, for convenience given our decomposition, we refer to the ratio of employment to the labor force as the employment rate, although this differs from the more conventional use of the term to denote the ratio of employment to population.

Figure 1 U.S. Per Capita GDP, Logged



behavior during and after the 2007–09 recession differs markedly from that in previous recessions. In this sense, consistent with Stock and Watson (2012), these simple decompositions show that nearly all of the slow recovery in output coming out of the Great Recession stems from a secular decline in the labor force participation rate. Remarkably, in terms of deviations from slow-moving trends, the behavior of per capita GDP and its components in the 2007–09 recession were not unlike that of the other postwar recessions.

This article is organized as follows. Section 1 examines several different univariate characterizations of per capita GDP over the postwar period and conducts a series of exercises that help put the 2007–09 recession and subsequent recovery in the context of previous business cycles. Section 2 decomposes per capita GDP into subcomponents in order to further explore key drivers of its behavior over time. Section 3 concludes.

Table 1 1948:Q1–2013:Q4

	Split Date			
	2008:Q1	2008:Q4	2009:Q2	**2009:Q3**
α Before Split	−3.853	−3.852	−3.850	**−3.849**
α On and After Split	−3.118	-3.455	−3.527	**−3.513**
μ Before Split †	1.904	1.899	1.892	**1.888**
μ On and After Split †	0.558	1.085	1.198	**1.175**
$\chi^2(2)$	*137.32	*180.87	*123.46	***111.04**

Notes: † in annualized growth rates; Critical $\chi^2(2)$ value: 1% 9.21*.

1. UNIVARIATE CHARACTERIZATIONS OF PER CAPITA GDP

Figure 1A illustrates the behavior of the natural logarithm of per capita GDP over the postwar period, from 1948:Q1 to 2014:Q1, where recessions are highlighted by vertical bars. Figure 1B zooms in on the Great Moderation period, 1984:Q1 to 2014:Q1, which we will consider separately since the nature of business cycles appears to be different during this period.[3] The most recent recession clearly stands out as unique in postwar data, both because of the size of the fall in the level of GDP during the recession and because of the tepid growth rate that characterizes the subsequent recovery. We will begin our analysis by using two simple statistical characterizations of the process driving per capita GDP growth to examine the extent to which the recent behavior of per capita output appears unusual in the context of recessions in the postwar era.

Deterministic Trend Model

From looking at Figure 1, a simple linear trend model appears to provide a reasonable first-pass description of the process generating per capita GDP prior to the beginning of the Great Recession in 2007:Q4,

$$y_t = \alpha + \mu t + \varepsilon_t, \tag{1}$$

where y_t denotes the natural logarithm of per capita GDP and ε_t is a mean-zero error term. In Figure 1A, the logarithm of per capita GDP indeed generally appears to have fluctuated around a constant slope over the postwar period. In (1), μ then represents the growth rate of

[3] Aside from changes in volatility of key macroeconomic aggregates, see Gordon (2010) on shifts in various properties of U.S. business cycles over the Great Moderation period.

Table 2 1984:Q1–2013:Q4

	Split Date			
	2008:Q1	2008:Q4	2009:Q2	**2009:Q3**
α Before Split	−3.188	−3.185	−3.182	**−3.180**
α On and After Split	−2.917	−3.066	−3.098	**−3.092**
μ Before Split †	1.977	1.946	1.905	**1.882**
μ On and After Split †	0.558	1.085	1.198	**1.175**
$\chi^2(2)$	*218.21	*219.58	*78.33	***54.84**

Notes: † in annualized growth rates; Critical $\chi^2(2)$ value: 1% 9.21*.

per capita GDP while α captures its log level at some initial date, in this case 1948:Q1.

The dashed lines in Figures 1A and 1B are the best-fit trend lines given by the ordinary least squares (OLS) estimates of α and μ both before and after the end of the Great Recession (2009:Q3). Tables 1 and 2 present findings from standard Chow tests that consider the hypothesis that the Great Recession may have been associated with joint changes in α and μ. Structural break tests for changes in α and μ separately were also carried out. The results (not shown) were similar to those we report in Tables 1 and 2. Table 1 considers the full sample while Table 2 considers only the Great Moderation period. In each table, the Chow tests are carried out using different break dates, from the beginning to the end of the recession as defined by the National Bureau of Economic Research (NBER). The tests allow for autocorrelation and heteroskedasticity in the residuals ε_t and are reported as χ^2 statistics. Regardless of the assumed break date, and over both sample periods, the tests unambiguously reject the null hypothesis of no change in α and μ. Observe that up to a given split date, the growth rate in per capita GDP, μ, averages around 1.9 percent (annualized) but falls considerably lower, to well under 1.2 percent, after the assumed break date.

It is important to note that this same method also suggests structural breaks (at the 1 percent level) for both joint and separate changes in α and μ in more than half of the other postwar recessions. However, in the 2007–09 recession, the p-values for all tests are less than 10^{-7}. Only the 1973 recession matches this level of significance, and, in this case, the change in μ is actually positive. In fact, in all other postwar recessions, either the p-values for the results of the Chow test are several orders of magnitude larger than those associated with the 2007–09 recession, or the change in μ is positive rather than negative. Thus, while Chow-type structural breaks were observed in many of the postwar recessions, the downward shift in μ coupled with extremely small p-values make the structural break of the 2007–09 recession somewhat unique.

Stochastic Trend Model

Findings from the simple structural break tests in the previous subsection rely on (1) representing a reasonable data generating process for per capita GDP. The χ^2 statistics shown in Tables 1 and 2 also rely on derivations that hold asymptotically rather than in finite samples. A popular alternative model of per capita GDP instead characterizes the series as having a stochastic trend,

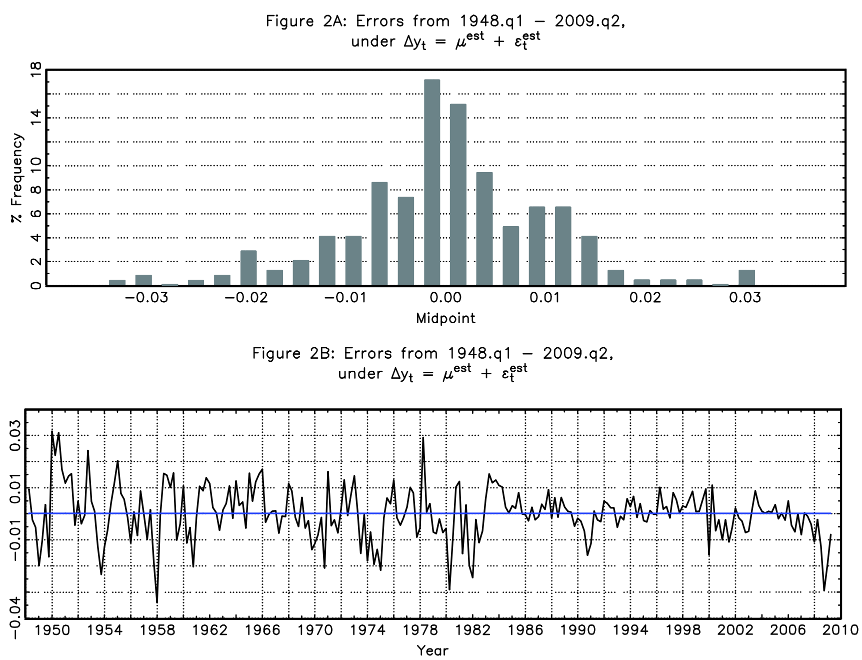
$$y_t = y_{t-1} + \mu + \varepsilon_t. \tag{2}$$

Under this approach, the growth rate of per capita GDP, $y_t - y_{t-1} = \Delta y_t$, is seen as fluctuating around a constant, as described by $\mu + \varepsilon_t$, where ε_t is assumed to be independently and identically (i.i.d.) distributed with mean zero. Importantly, in contrast to equation (1), this stochastic process is such that disturbances, ε_t, have permanent effects on the level of GDP. Nelson and Plosser (1982) argued that many economic series are in fact better described as processes that allow shocks to have permanent effects rather than effects that gradually subside over time. In practice, with finite samples, Stock (1990) and Blough (1992) argue that the question of whether per capita GDP is more accurately characterized as having a deterministic time trend as in (1) or a stochastic trend as in (2) is inherently unanswerable, so that both approaches are worth considering.

Regardless of the assumptions on the data generating process governing per capita GDP, it remains the case that the Great Recession appears unprecedented both in terms of its severity and its slow recovery. To help formalize the notion of the "uniqueness" of the 2007–09 recession, we ask two questions: First, given the set of shocks observed in the postwar period, how likely was the realization of the path characterizing per capita GDP from 2007:Q4 onward? Second, how does this likelihood compare with that of previous recessions in U.S. postwar history? In particular, were recessions preceding the most recent downturn somewhat more plausible considering the history of disturbances incurred up to that recession?

To answer these questions, in contrast to the previous subsection, we explicitly take into account the fact that observations of per capita GDP growth since the 2007–09 recession constitute a finite sample. Thus, let us think of a given date around the start of the Great Recession, denoted date s, from which we are trying to gauge the likely

Figure 2 Residuals from Stochastic Trend Model (2)



path forward for per capita GDP. If date T represents the last date for which we have an observation for per capita GDP, the exercise aims to give us a sense of the likelihood of having observed the realized path $(y_s, y_{s+1}, ..., y_T)$, relative to all other possible paths for per capita GDP, $(y_s^*, y_{s+1}^*, ..., y_T^*)$, given the history of shocks up to date s under the null hypothesis that data is generated by (2). Note that there will be a distribution of paths $(y_s^*, y_{s+1}^*, ..., y_T^*)$, and that the actual observed path $(y_s, y_{s+1}, ..., y_T)$ will generally fall somewhere within that distribution.

To make matters concrete, let s denote 2009:Q3, the start of the recovery. It is then possible to construct estimates of the paths $(y_s^*, y_{s+1}^*, ..., y_T^*)$ by way of bootstrapping, where the observed residuals $(\widehat{\varepsilon}_1, ..., \widehat{\varepsilon}_{s-1})$ from the model (2) are used to represent the unobserved distribution $(\varepsilon_1, ..., \varepsilon_{s-1})$ under the bootstrap procedure. The sample of observed residuals, $\widehat{\varepsilon}_t$, $t = 1, ..., s-1$, is obtained as $\widehat{\varepsilon}_t = \Delta y_t - \widehat{\mu}$, where the OLS estimate $\widehat{\mu}$ is simply the mean of Δy_t. In this case, as indicated in Table 1, $\widehat{\mu}$ is approximately 1.9 percent. Figures 2A and 2B illustrate the properties of the estimated residual, $\widehat{\varepsilon}_t$, from which we are sampling, and which appear close to i.i.d. as assumed. To the extent that some small degree of serial correlation characterizes $\widehat{\varepsilon}_t$, we consider a slightly different variant of (2) later in the article.

The bootstrap algorithm proceeds as follows:

1. Let $(\widehat{\varepsilon}^*_s, \widehat{\varepsilon}^*_{s+1}, ..., \widehat{\varepsilon}^*_T)$ represent a uniformly resampled version of $(\widehat{\varepsilon}_1, ..., \widehat{\varepsilon}_{s-1})$, where $\widehat{\varepsilon}_t = \Delta y_t - \widehat{\mu}$, $t = 1, ..., s-1$, and $\widehat{\mu}$ is treated as true in the bootstrap world.

2. Construct the estimated sample path $(\widehat{y}^*_s, \widehat{y}^*_{s+1}, ..., \widehat{y}^*_T)$ using the stochastic trend model, $\widehat{y}^*_t = \widehat{y}^*_{t-1} + \widehat{\mu} + \widehat{\varepsilon}^*_t$, where the starting value $\widehat{y}^*_{s-1}$ is set to the observed value y_{s-1}.

3. Repeat Steps 1 and 2 many times to obtain a distribution of estimated paths, $(\widehat{y}^*_s, \widehat{y}^*_{s+1}, ..., \widehat{y}^*_T)$.

Figure 3 illustrates examples of four sample paths for $(\widehat{y}^*_s, \widehat{y}^*_{s+1}, .., \widehat{y}^*_T)$, starting in 2009:Q3, generated by drawing disturbances from the period 1948:Q1 to 2009:Q2. Results reported in this section are ultimately based on sample paths calculated from 50,000 Monte Carlo trials. Figure 4A then gives 95 percent confidence intervals for the path of per capita GDP starting in 2009:Q3, given the history of observed shocks and an estimated trend growth rate of roughly 1.9 percent under the null. Two observations are worth noting. First, under the null hypothesis of postwar average trend growth, it is unlikely that today's level of GDP would be back in line with that predicted by the pre-Great Recession trend. This finding holds even when we take into account that, over 50,000 Monte Carlo trials, some sample paths include some of the largest positive shocks to per capita GDP in the postwar period experienced in succession. Second, since 2009:Q3, the observed per capita GDP path has consistently grown below the historical trend growth rate given by the slope of the median (50th percentile) path predicted by the bootstrap simulations.

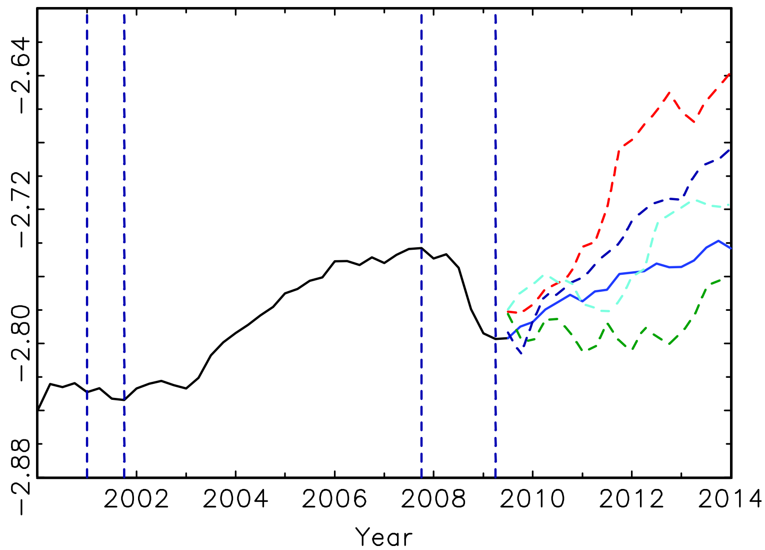
What if we had set s to be 2008:Q1, the first period of decline in the Great Recession? Using (2), we can write per capita GDP at the end of the recession, y_T, as

$$y_T = y_{s-1} + \mu(T - s + 1) + \sum_{j=s}^{T} \varepsilon_j, \tag{3}$$

so that conditioning on y_{s-1} and μ, y_T is explained by the sequence of shocks $\sum_{j=s}^{T} \varepsilon_j$.

The 95 percent confidence intervals in Figure 4B indicate that the fall in the level of per capita GDP experienced during the Great Recession, together with the subsequent recovery, cannot plausibly be explained by a sequence of bad shocks representative of historical data. As mentioned earlier, recall that the 95 percent confidence intervals illustrated in Figure 4B obtained from a large number of Monte Carlo

Figure 3 Sample Paths Versus Realized GDP Per Capita after 2009:Q3 Split

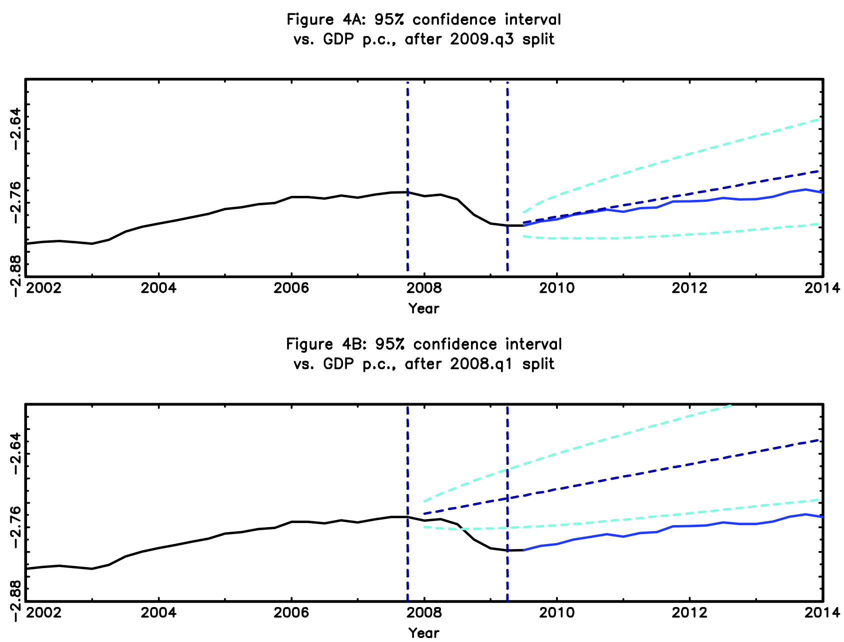


trials contain sample paths that include some of the worst shocks in postwar data experienced in succession.

One way to highlight the sense in which the Great Recession was unique relative to other postwar recessions is to consider previous recessions in the context of the bootstrapping exercise we have just carried out. Thus, Figure 5 illustrates the results obtained from carrying out analogous exercises with respect to the four most recent recessions prior to 2007. On the whole, all previous recessions fall within a 95 percent confidence interval generated by a resampling of shocks up to that recession. Only the 1980–81 recession stands as somewhat of an exception to these findings, but this is only because this recession is followed very soon after by another one, and even in this case, Figure 5 shows that per capita GDP returns to the 95 percent confidence interval as soon as the second recession ends. Statistically, therefore, the Great Recession stands as somewhat unique in the postwar era in that, compared to previous recessions, its severity cannot easily be explained by shocks incurred over the postwar period.

Figure 4 also shows that throughout the recovery period following the 2007–09 recession, per capita GDP has consistently deviated from the median path generated by (2) estimated up to 2007:Q4. Since 2009:Q3, the average per capita GDP growth rate has hovered more

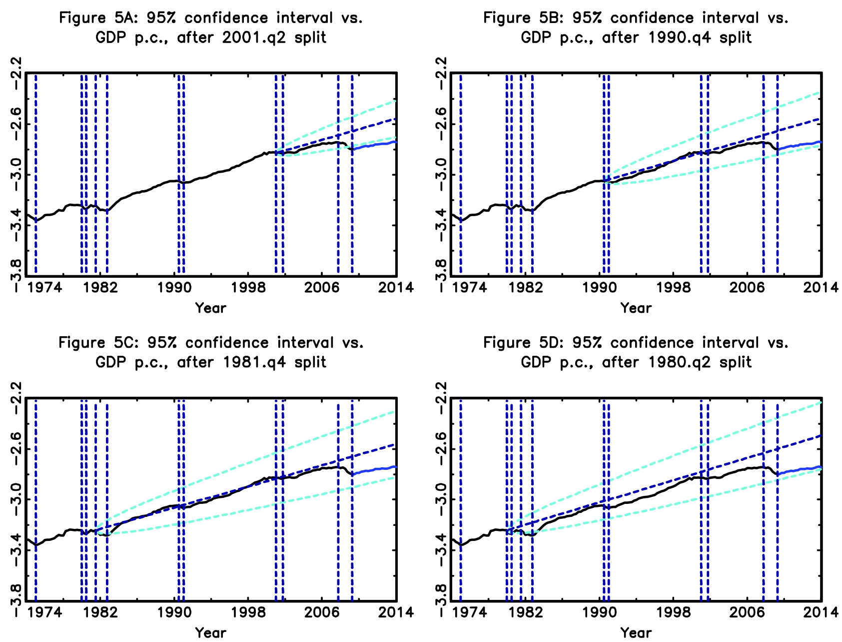
Figure 4 Confidence Intervals from Monte Carlo Trials



than 0.75 percent below the average growth rate prior to the Great Recession. One point of view regarding this is that although GDP continues to evolve below trend, it should be expected to revert back to its historical trajectory at some future date. Another interpretation is that the trend growth rate of GDP has decreased. A test of the latter hypothesis depends on two key considerations: First, the greater the distance between the observed growth rate and the growth rate under the null, the more likely the null will be rejected. In this case, the observed growth rate during the recovery period that started in 2009:Q3 is approximately 1.14 percent while the growth rate under the null was 1.9 percent. Second, the longer the sample period over which the new growth rate is calculated, the more confident we are of its estimate. In the case of the Great Recession, we are roughly 4.75 years into the recovery, or 19 quarters.

As an example, suppose that four quarters have elapsed since the end of the Great Recession, and we now find ourselves in the midst of a weak recovery in 2010:Q3. We want to know whether the observed weakness is enough to reject the null of a growth rate at least as high as 1.9 percent given the stochastic trend model (2) and the history

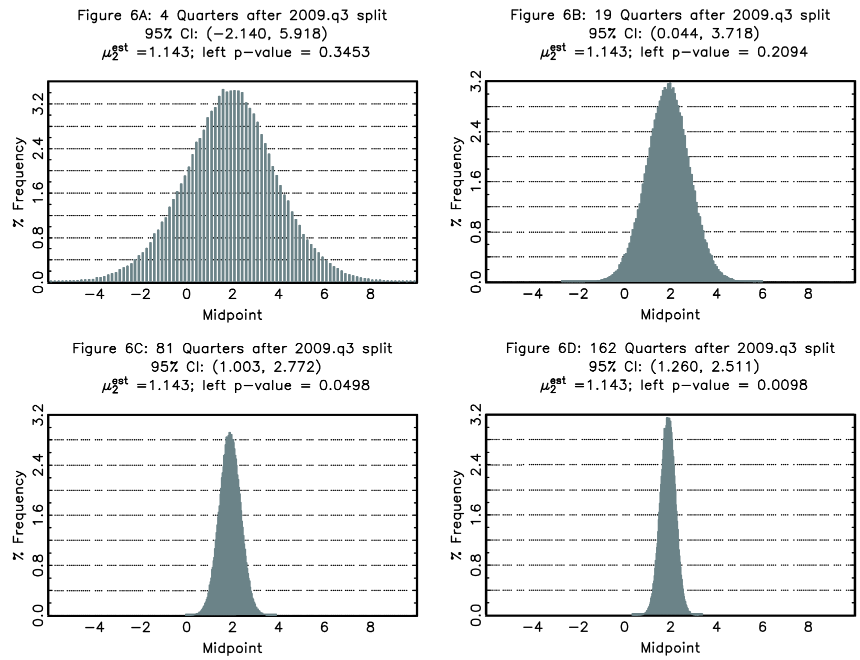
Figure 5 Confidence Intervals for Past Recessions



of observed shocks up to the beginning of the recovery. To address this question, we generate a distribution of estimated growth rates, $\widehat{\mu}^*$, computed from 50,000 Monte Carlo trials of averages over samples of size 4, $(\widehat{y}^*_s, \widehat{y}^*_{s+1}, \widehat{y}^*_{s+2}, \widehat{y}^*_{s+3})$, generated by the bootstrap algorithm described above with $s = 2009$:Q3. The resulting distribution is shown in the top left-hand panel of Figure 6. The left p-value associated with a growth rate of 1.14 percent is roughly 35 percent under the null. In other words, our findings indicate a 35 percent probability of experiencing an average growth rate at least as far below the pre-recession growth rate as 1.14 percent over four quarters. Given standard critical values, we cannot reject the null of a growth rate at least as high as 1.9 percent during the recovery. A 95 percent confidence interval in this case ranges from −2.15 percent to 5.91 percent.

That said, it's now been 19 quarters since the end of the recession. Therefore, the top right-hand panel of Figure 6 illustrates the distribution of estimated growth rates analogous to our previous scenario. With more observations over which growth rates are calculated under the null hypothesis, the distribution of $\widehat{\mu}^*$ tightens and the left p-value associated with a 1.14 percent average growth rate falls to 21 percent.

Figure 6 Distributions of Estimated Growth Rates from Monte Carlo Trials



In other words, there is now only a 21 percent chance of observing a growth rate of 1.14 percent or below given historical data. The associated 95 percent confidence interval now shrinks to $(.011, 3.764)$. The bottom two panels in Figure 6 show the distributions, along with the corresponding sample sizes, needed to generate left p-values of 5 percent and 1 percent given a growth rate of 1.14. At the 5 percent critical level, the weak recovery now characterizing the U.S. economy and its disappointing growth rate would have to persist for roughly 20 years before we could unambiguously conclude that we had indeed switched to a new lower trend growth rate.

Initially, it appears that the current weak recovery would have to last for quite a while before we could unambiguously conclude that there has been a change in the trend growth rate. However, the relationship between p-values and sample size is generally convex, which suggests that when the sample size is small, a few more observations can dramatically lower the left p-value of this test. In contrast, the size of the sample under consideration has a relatively small impact when there are many observations. Thus, for example, if the current situation were to extend three and a half more years, there would be only a 15 percent chance of observing such weak circumstances under the null. While not conclusive evidence of a change in trend growth, these calculations nevertheless suggest a relatively low likelihood of having observed the realized path of per capita GDP since 2009:Q3.

So far, we have examined the extreme cases of a pure deterministic trend and a pure stochastic trend model. To the degree that Figure 2B indicates a small degree of serial correlation in the error term of equation (2), a more flexible representation of the data-generating process is given by

$$y_t = y_{t-1} + \rho \Delta y_{t-1} + \mu + \varepsilon_t, \; y_0 \text{ given.} \tag{4}$$

In this case, $\rho \Delta y_{t-1}$ in (4) can be thought of as an error correction term that introduces smoothness in how GDP growth reverts back to trend following a shock, and thus also addresses leftover serial correlation in ε_t in the simpler stochastic trend representation (2). The properties of the estimated errors under this more flexible representation will more closely resemble those of white noise. Repeating the bootstrap exercises described in this section under the more flexible model (4) does not substantively alter our conclusions.

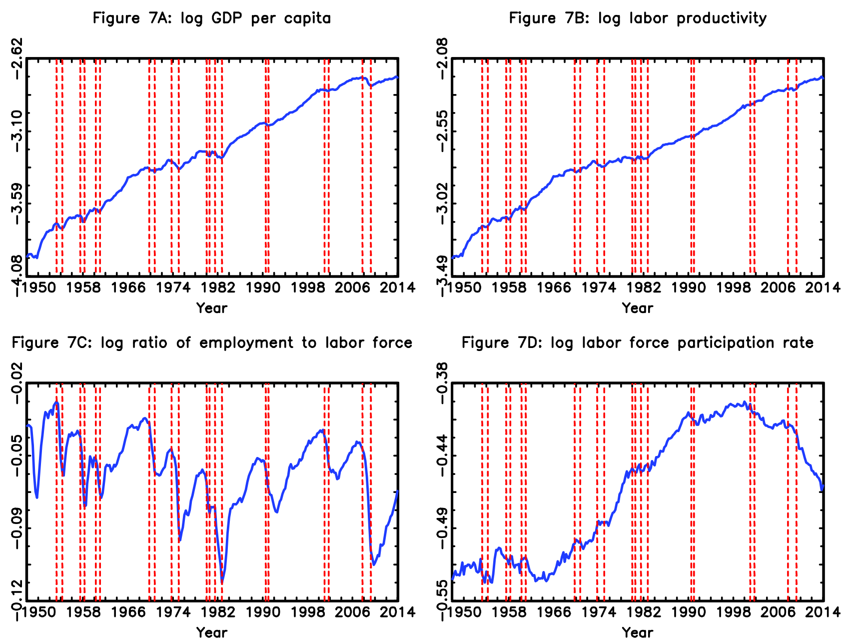
2. DECOMPOSING PER CAPITA GDP

The analysis thus far has provided simple calculations that illustrate how the Great Recession stands as relatively unique in the postwar landscape and suggest that a rapid improvement of the current situation to levels expected from pre-recession trend is questionable. A gradual increase in per capita GDP growth back toward historical trend appears more plausible. However, even in the latter case, every new quarter characterized by below trend growth adds weight to the argument that the U.S. economy has switched to a lower trend growth rate.

To provide further insight into per capita GDP over the postwar period, and in particular its unusual behavior throughout the Great Recession and the subdued recovery that followed, we now decompose per capita GDP into several components and examine the behavior of each of these components individually. Thus, throughout this section, we will work with the following decomposition of per capita GDP:

$$\underbrace{y_t - p_t}_{\text{Per Capita GDP}} = \underbrace{(y_t - e_t)}_{\text{Labor Productivity}} + \underbrace{(e_t - l_t)}_{\text{Ratio of Employment to Labor Force}} + \underbrace{(l_t - p_t)}_{\text{Labor Force Participation Rate}}, \tag{5}$$

Figure 7 Decomposition of Per Capita GDP



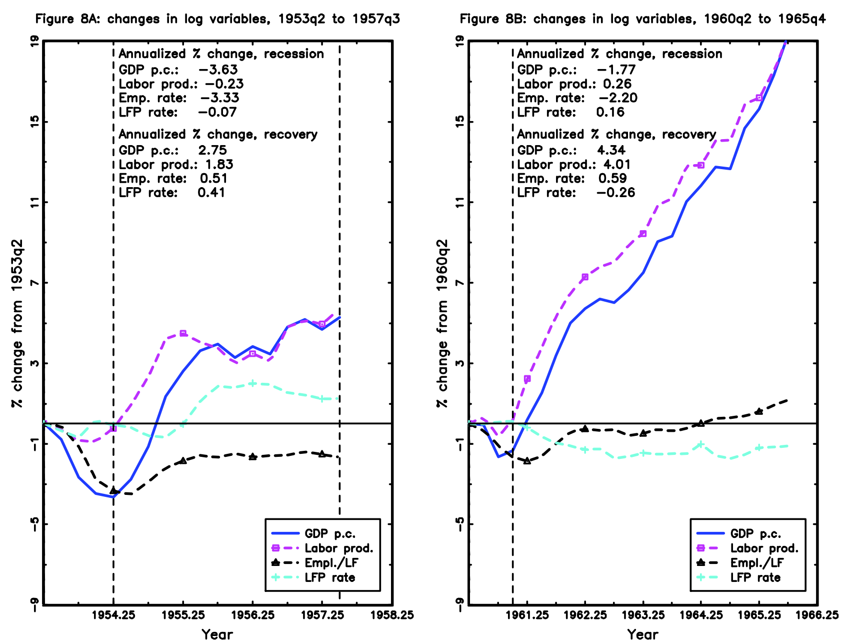
where y_t is real per capita GDP, p_t is the civilian non-institutional population (i.e., non-military, non-inmates at institutions, 16 years of age and over), e_t is employment, and l_t is the labor force, all in logarithm form.[4] We may think of the decomposition in (5) as (roughly) capturing different forces in the economic environment, namely technological considerations that affect primarily labor productivity, demographic and other structural labor market considerations that have a direct bearing on labor force participation, and other labor market factors that affect the unemployment rate.[5] Our objective will be in part to assess how the different components in (5) have contributed to per capita GDP growth during the recessions and recoveries of the postwar period.

In any decomposition of the type in (5), one issue is that the different components making up the series of interest may move at

[4] This decomposition, which lies at the core of our analysis, is a natural one but is by no means the only potentially useful decomposition of GDP. Other non-structural decompositions that can shed insight into the Great Recession might include a breakdown by GDP components in a VAR, a breakdown by regions highlighting the role of housing, or a separation into nominal GDP and inflation.

[5] Note that $e_t - l_t$ is simply one minus the unemployment rate.

Figure 8 Changes in Log Variables, 1953 and 1960 Recessions



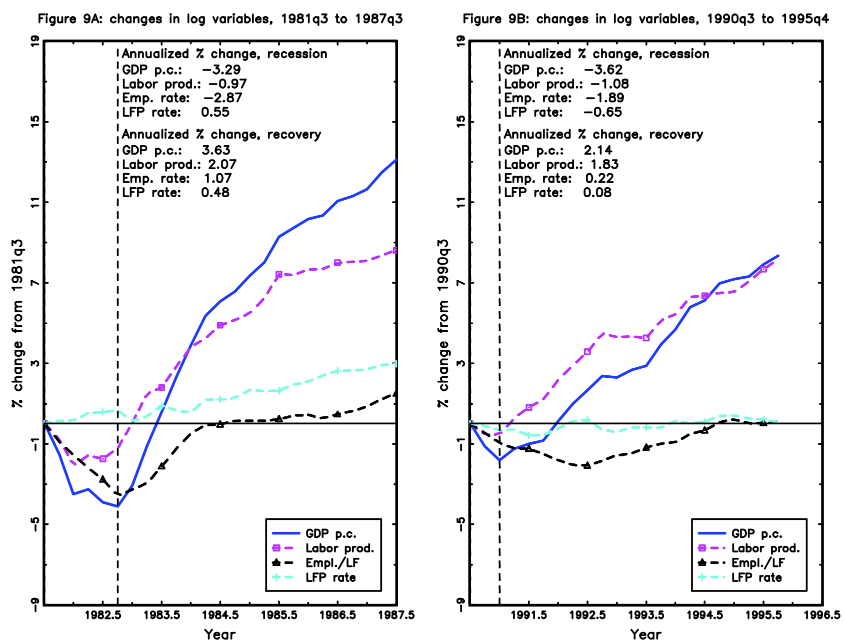
different rates, each potentially having different implications for the series' short- and medium-run forecasts. Thus, let each of the components making up per capita GDP follow a univariate stochastic process, $y_t - e_t = \Theta(L)\varepsilon_{ye,t}$, $e_t - l_t = \Theta(L)\varepsilon_{el,t}$, and $l_t - p_t = \Theta(L)\varepsilon_{lp,t}$, where the ε_ts represent identically and independently distributed disturbances to the individual component series. We then have that

$$y_t - p_t = \Theta(L)\varepsilon_{ye,t} + \Theta(L)\varepsilon_{el,t} + \Theta(L)\varepsilon_{lp,t}, \tag{6}$$

where GDP per capita at any date t reflects the realization of current, and potentially past, disturbances to the individual component series. Suppose now that labor force participation, $\Theta(L)\varepsilon_{lp,t}$, moves relatively slowly over time while the ratio of employment to the labor force, $\Theta(L)\varepsilon_{el,t}$, moves more rapidly. Then a fall in per capita GDP induced by a large shock to labor force participation might imply a relatively slow adjustment back to historical conditions when compared to the case in which the fall in GDP is caused by a shock to the unemployment rate.

Figure 7 illustrates the decomposition of per capita GDP depicted in (5) along with the recession periods indicated by vertical lines. Several observations stand out. First, the slope (or growth rate) of log per

Figure 9 Changes in Log Variables, 1981 and 1990 Recessions

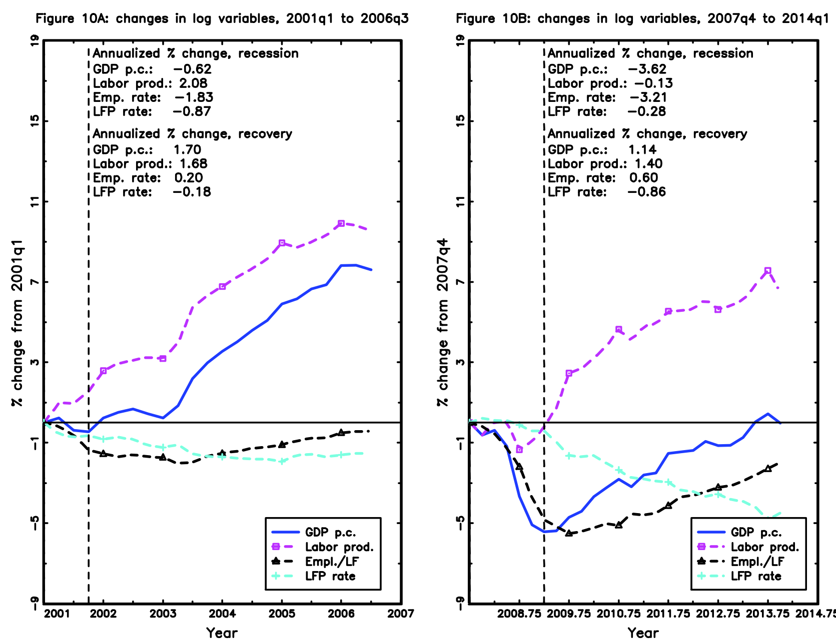


capita GDP generally appears to mimic the slope of log labor productivity. Second, there are nevertheless notable variations in GDP growth over particular periods that are evidently influenced by variations in the unemployment and labor force participation rates. Third, of the latter two variables, the unemployment rate appears to fluctuate with the business cycle, while variations in the labor force participation rate tend to occur more slowly over time.

Taken together, these observations suggest important variations in the way per capita GDP has behaved historically. Thus, in a recent effort to construct long-horizon forecasts of average growth using a univariate framework, Müller and Watson (2013) allow for flexibility in the univariate process governing per capita GDP by allowing the data to be generated by a mix of empirical representations capturing different aspects of its slow moving components. This assumption, in effect, may be thought of as capturing the idea that different components of per capita GDP, which behave noticeably different from each other, play roles of varying importance at different times.

Figures 8 through 10 illustrate the decomposition in (5) during select recessions and recoveries of the U.S. postwar period, using the

Figure 10 Changes in Log Variables, 2001 and 2007 Recessions

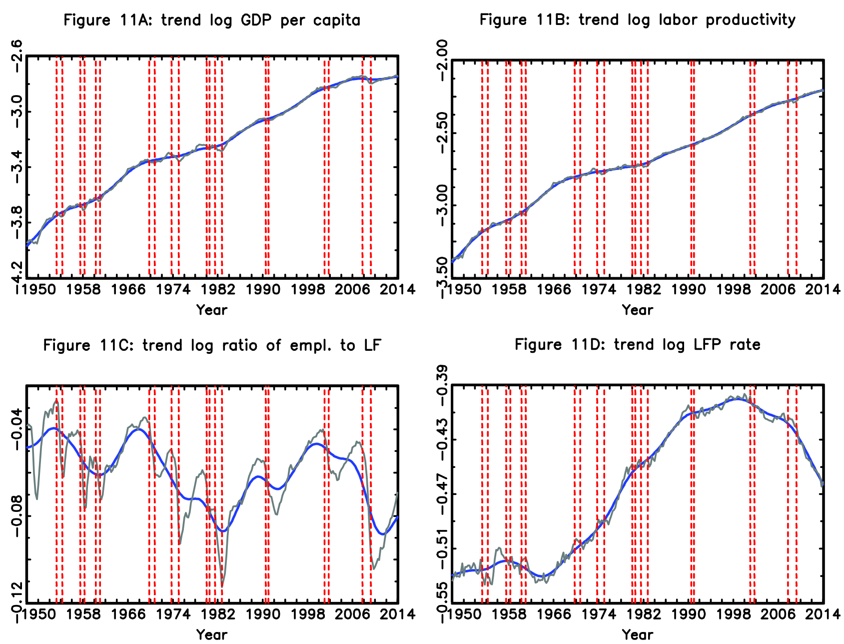


starting quarter of each recession to normalize the component series.[6] On the whole, the fall in per capita GDP during recessions tends to be reflected mostly in a fall in the ratio of employment to the labor force. In contrast, recoveries are generally associated with a pickup in labor productivity. In fact, labor productivity tends not to fall dramatically even during recessions, reflecting the fact that technology is almost always improving. Therefore, the decomposition in (5) reveals that, during most downturns, falling per capita GDP can be accounted for primarily by decreases in $e_t - l_t$ and not the other components.

More recently, however, this pattern has changed. The 2001 and 2007–09 recessions are the only recessions of the postwar period in which the labor force participation rate fell noticeably during both the recessions and subsequent recoveries, dragging down GDP per capita even after the recessions ended. Moreover, the 2007–09 recession and subsequent recovery is the only episode in the postwar period in which, four years after the end of the recession, GDP per capita had yet to

[6] To economize on space, we do not illustrate these decompositions for every postwar recession but the observations we highlight tend to hold across all business cycles.

Figure 11 Trend Components of Per Capita GDP Decomposition



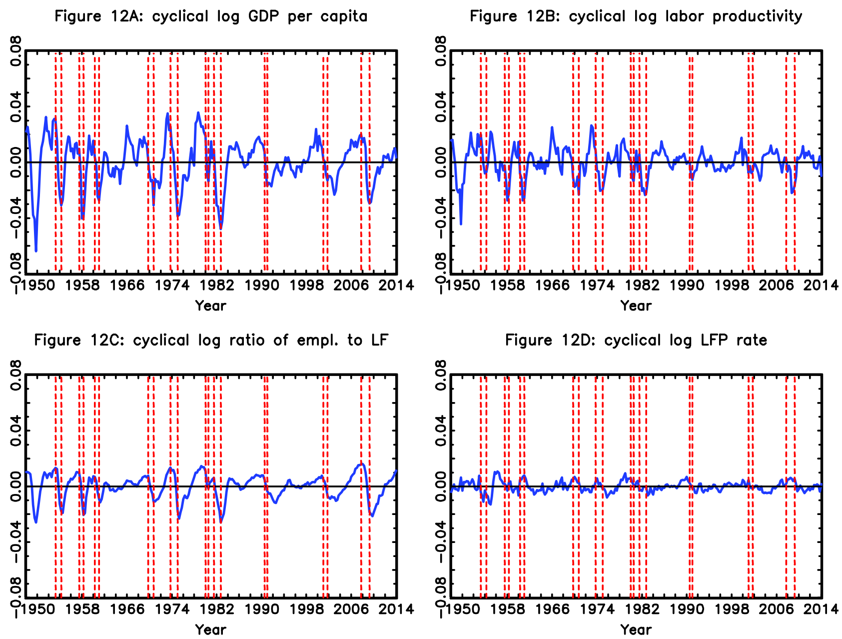
reach its pre-recession peak. However, the behavior of labor productivity in the last two recessions does not differ markedly from the other postwar recessions.

Trends and Cycles

As mentioned earlier, the various components in our decomposition of per capita GDP contribute differently to the aggregate series. Labor productivity, for instance, mostly contributes a steady increase over time, or an upward "trend," to GDP per capita. That said, the term "trend" is somewhat charged and can mean very different things in different contexts.

For the purposes of this article, we will mainly take the approach of thinking in terms of particular frequencies of a series of interest. Following the literature on business cycles and NBER practice, the business cycle component of a series will be defined as the component made up of cyclical frequencies corresponding to periods less than eight years. The remaining slower moving components, made up of cycles

Figure 12 Cyclical Components of Per Capita GDP Decomposition



with periods greater than eight years, may be thought of as one definition of "trend." Since the period, p, of a cycle is given by $\frac{2\pi}{\omega}$, where ω is its frequency, and eight years represents 32 quarters, business cycle frequencies are then given by $\omega \in [\pi/16, \pi]$ when using quarterly data. Conversely, "trend" frequencies are given by $\omega \in [0, \pi/16)$.

Definition 1 *The trend of per capita GDP corresponds to its component cycles with frequencies* $\omega \in [0, \pi/16)$.

The motivation underlying this approach is in part that slower moving cycles are thought to be generally determined by forces outside policymaking, such as ongoing technological progress or changes in demographics. From Figure 7, it is likely the case that the bulk of the contributions of labor productivity to per capita GDP occur at frequencies lower than business cycle frequencies. Contributions of labor productivity to the business cycle component of per capita GDP, relative to those of the other two components, however, may nevertheless be significant.

Balanced Growth

In considering the decomposition (5), it is useful to think about balanced growth implications. In particular, we can think of balanced growth theory as providing long-run relationships that should broadly hold between the variables depicted in (5). Thus, suppose that output, Y_t, is produced by way of the technology

$$Y_t = A_t K_t^{\alpha}(Z_t E_t)^{1-\alpha},\ 0 < \alpha < 1,$$

where A_t denotes multifactor productivity, K_t is the capital stock, E_t is labor input, and Z_t represents a composition effect that increases the productivity of labor. Further, let L_t and P_t denote the labor force and population respectively, and let the growth rate of a given variable, x_t, be given by g_x. Then, along a balanced growth path, where ratios of variables are constant, we have that

$$g_Y = g_A + \alpha g_K + (1-\alpha)(g_Z + g_E).$$

But, along a balanced growth path, $g_Y = g_K$, so the above equation simplifies to

$$g_Y = \left(\frac{1}{1-\alpha}\right) g_A + (g_Z + g_E).$$

In the long run, it must also be the case that

$$g_E = g_P = g_L.$$

From (5), we have that

$$\underbrace{\left(\frac{1}{1-\alpha}\right) g_A + (g_Z + g_E) - g_P}_{\text{Per Capita GDP growth}} = \underbrace{\left[\left(\frac{1}{1-\alpha}\right) g_A + (g_Z + g_E) - g_E\right]}_{\text{Labor Productivity growth}}$$

$$+ \underbrace{(g_E - g_L)}_{\text{Employment Rate growth}}$$

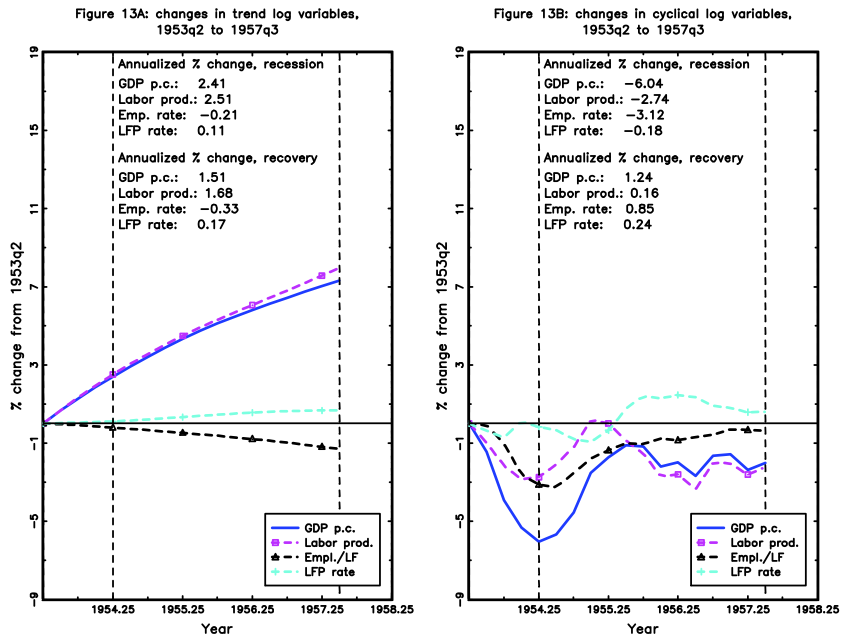
$$+ \underbrace{(g_L - g_P)}_{\text{Labor Force Participation Rate growth}}$$

or, using the balanced growth relationships,

$$\underbrace{\left(\frac{1}{1-\alpha}\right) g_A + g_Z}_{\text{Per Capita GDP growth}} = \underbrace{\left(\frac{1}{1-\alpha}\right) g_A + g_Z}_{\text{Labor Productivity growth}}. \tag{7}$$

Ultimately, therefore, per capita GDP growth follows labor productivity growth, and both are determined by technological parameters.

Figure 13 Changes in Trend and Cyclical Log Variables, 1953 Recession

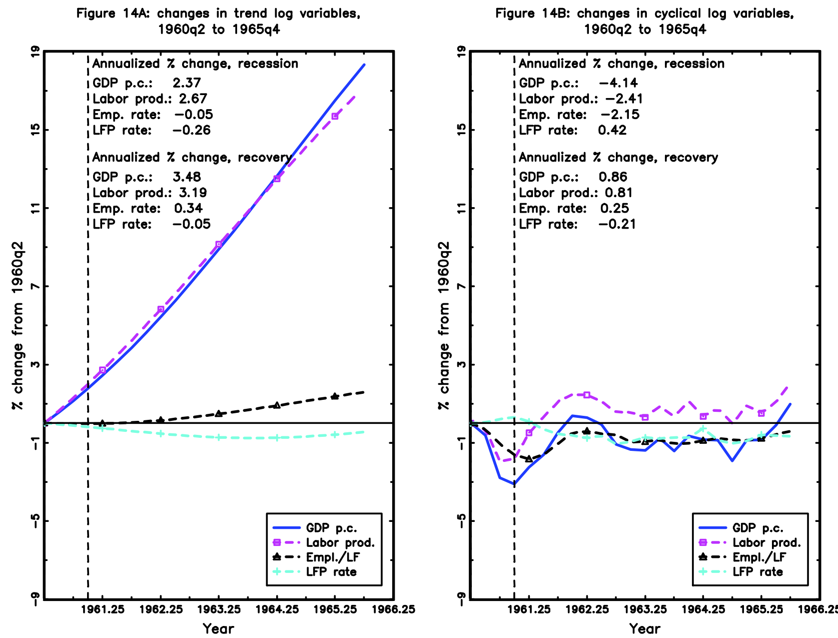


Beyond this observation, it is also important to recognize that balanced growth calculations, where we may think of $\left(\frac{1}{1-\alpha}\right) g_A + g_Z$ as an alternate definition of trend, are only informative in terms of long-run relationships. This represents a single frequency in the frequency domain, frequency zero, among all of the periodic variations that make up per capita GDP. Put another way, the mean growth rate is (in a sense) a single cycle of infinite period among all of the cycles that make up per capita GDP growth.

Definition 2 *The trend of per capita GDP is* $\left(\frac{1}{1-\alpha}\right) g_A + g_Z$.

In practice, we tend to be concerned with more than the long run, and there may be a range of slow-moving variations in per capita GDP outside frequency zero on which policy may nevertheless have very little effect. Demographic changes underlying changes in labor force participation might be an example of such variations. It is in this sense that the definition of trend in terms of frequencies corresponding to periods longer than eight years is potentially useful. In particular, a "gap"

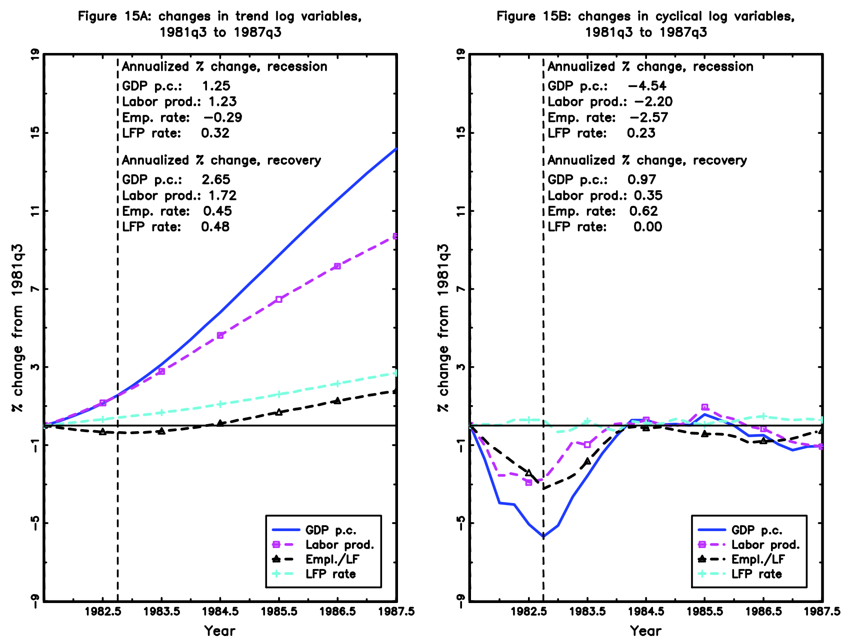
Figure 14 Changes in Trend and Cyclical Log Variables, 1960 Recession



between $y_t - p_t$ and $\alpha + \left[\left(\frac{1}{1-\alpha}\right) g_A + g_Z\right] t$, for some constant α, may be one that is expected to close very slowly or more rapidly depending on the source of the shock and the frequency at which it moves. So, if the labor force participation rate, $l_t - p_t$, experiences a negative shock, we might expect $y_t - p_t$ to fall short of $\alpha + \left[\left(\frac{1}{1-\alpha}\right) g_A + g_Z\right] t$ for a relatively long period, with policy having very little ability to quicken the closing of this gap.

Finally, there is an alternative definition of "gap" that is more model-based, defined as the deviations of sticky price allocations from flexible price allocations in a setting with nominal rigidities. To work with this definition, one must take a stance on the degree of price stickiness and the nature of the shocks affecting the economy at a given time. Comparisons with this more formal notion of trend, while important, are beyond the scope of this article.

Figure 15 Changes in Trend and Cyclical Log Variables, 1981 Recession

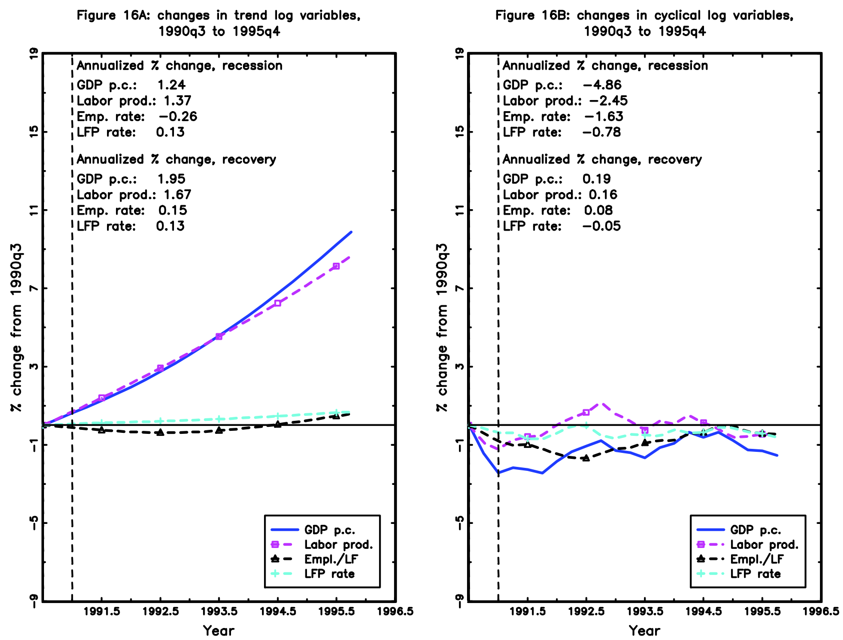


Trends and Cycles in the Decomposition of GDP

Figures 11 and 12 illustrate the trend and cyclical components of the different per capita GDP components in (5). The decomposition into trend and business cycle components is carried out using a Hodrick-Prescott (HP) filter with smoothing parameter of 1,600, given the quarterly data. Note that, because of the linearity of the HP filter, the trends of each of the per capita GDP components add up to trend per capita GDP, and likewise for the cyclical components.[7] The figures suggest that most of the variation in labor productivity and the labor force participation rate is driven by slow-moving cycles (with periods greater than eight years), while variations in the unemployment rate are more frequent. This is particularly evident in Figure 12, where

[7] Because the HP filter is a two-sided filter, estimation of the trend is biased toward the end of the sample. Depending on the nature of the data-generating mechanism, it takes roughly two years for estimation of the trend to settle.

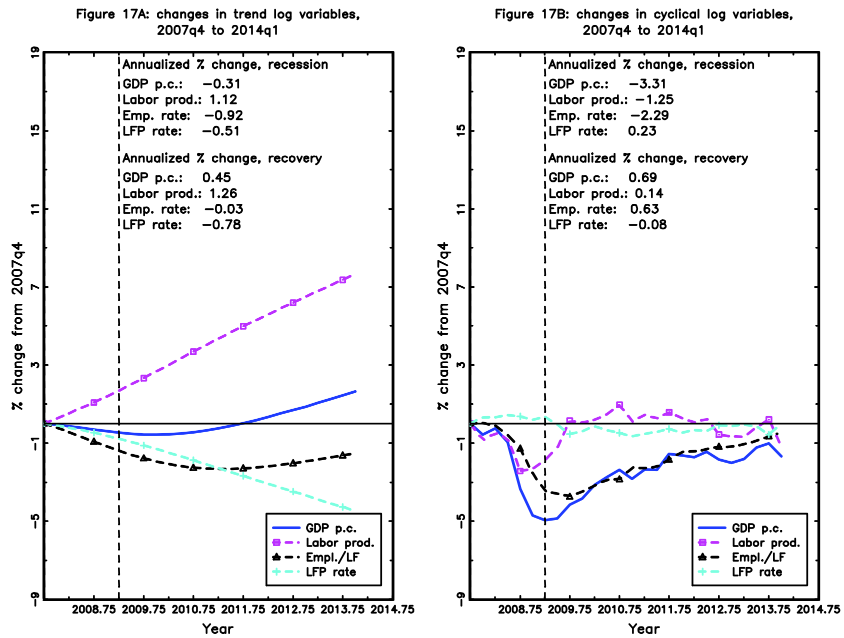
Figure 16 Changes in Trend and Cyclical Log Variables, 1990 Recession



the deviations from trend in the labor force participation rate indeed appear small.

Figures 13 through 17 illustrate the same decomposition as those in Figures 8 through 10, but are presented in terms of cycles and trends. Annualized growth rates for each of the series in Figures 8 through 10 are now broken down into contributions from "cyclical" and "trend" components. Examination of Figure 13, which illustrates the 1953 recession, reveals that the trend behavior of the series shown in the left-hand panel matches well with textbook balanced growth calculations described in the previous subsection. Trend log per capita GDP and log labor productivity have the same slope (i.e., grow at the same rate), while the trend unemployment and labor force participation rates stay relatively constant. This observation also applies to the 1957, 1960, 1980, 1981, 1990, and 2001 recessions. The slopes of labor productivity vary somewhat, ranging from 1.6 percent in the 2001 recession to 2.7 percent in the 1960 recession. However, the recessions of the 1970s, and especially that of 2007 shown in Figure 17, present a different story. In the most recent recession in particular, while labor productivity has

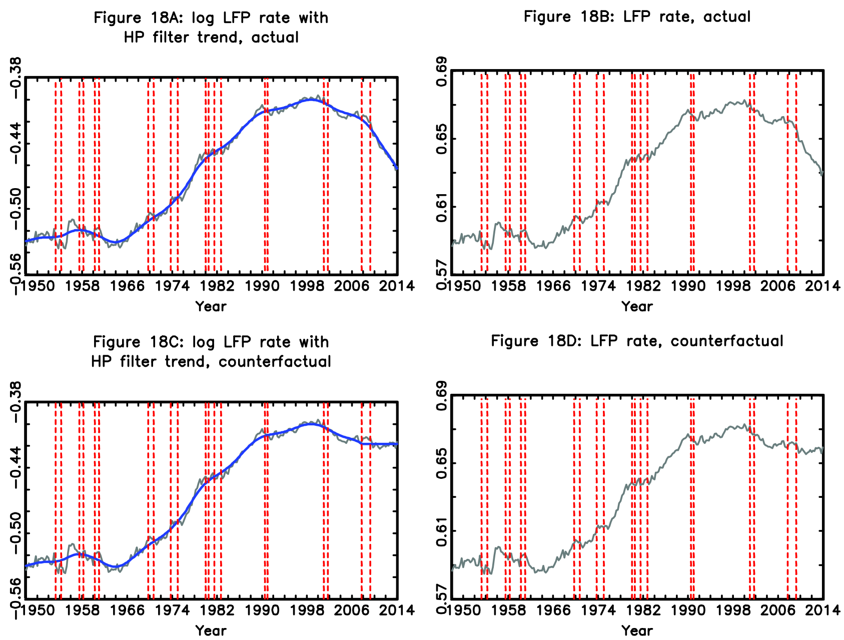
Figure 17 Changes in Trend and Cyclical Log Variables, 2007 Recession



steadily trended upward in a way typical of the postwar period, the labor force participation rate has clearly trended downward, noticeably dragging the growth rate of per capita GDP down from that of labor productivity. Remarkably, the behavior of the series' cyclical components, depicted in the right-hand panel of Figure 17, appears relatively similar to that of other postwar recessions. Put another way, at business cycle frequencies, the Great Recession is not so dissimilar to other postwar recessions. Its "uniqueness" resides almost entirely in slow-moving components of per capita GDP, in this case mostly the labor force participation rate. For the current recovery period, a small negative output gap relative to trend still persists.

While the trend labor force participation rate has fallen significantly since the start of the last recession, thereby mitigating the strength of the subsequent recovery in per capita GDP, a word of caution is in order. As mentioned earlier, the HP filter-based decomposition of a given series into business cycle and trend components tends to be biased toward the end of the sample, and it typically takes two years or more for the trend decomposition to settle. Because of this, one still

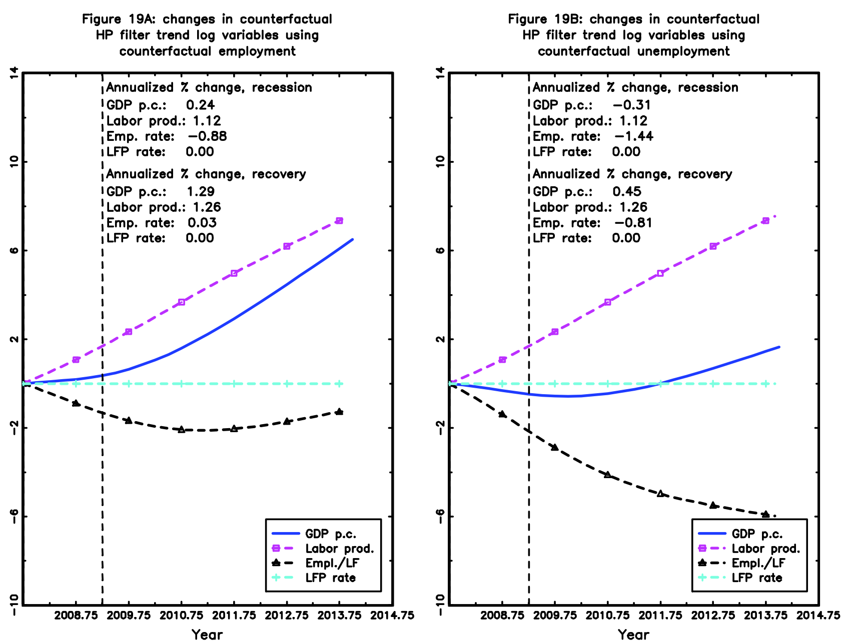
Figure 18 Labor Force Participation Rate, Actual Versus Counterfactual



might suspect that the large decline in the labor force participation rate can, in fact, be explained to a degree by cyclical factors related to the recession. If this were the case, our suggestion that the unusual behavior of output can be explained by secular changes in its components would be tenuous. However, the HP filter-based trends of the labor force participation rate, defined as component cycles with periods greater than eight years, are very similar to those calculated by Kudlyak (2013) using demographic information including age, gender, and cohort effects. In other words, a considerable portion of low frequency variations in the labor force participation rate are essentially explained by demographic factors; for example, one might attribute part of the recent low frequency decline in the labor force participation rate to the slow movement into retirement of the baby boomers.[8] If, as Kudlyak's article indicates, demographic factors are driving the decline in labor force participation, one might expect the recovery of labor force

[8] See Fujita (2014) for a detailed explanation of the causes underlying declines in the labor force participation rate.

Figure 19 A Counterfactual Exercise



participation—and therefore per capita GDP—to be protracted, with little room for improvement from policymakers.[9]

Counterfactual Labor Force Participation Rates

This subsection further investigates the extent to which the recent decline in the trend labor force participation rate has potentially contributed to the tepid recovery of per capita GDP following the Great Recession. Specifically, we carry out a counterfactual exercise in which, similar to Erceg and Levin (2013), the trend labor force participation rate flattens out after 2007:Q4. In this exercise, the counterfactual

[9] The decomposition we study, being an identity, is not necessarily inconsistent with the notion of financial factors having played a key role in the way the Great Recession played out. However, one expects that the productivity subcomponent of this decomposition, among all three subcomponents, might have been most influced by such factors, rather than the labor force participation rate where demographics clearly have a role. Indeed, productivity and employment experienced a more pronounced decline relative to other recessions, but these components appear to have recovered at a pace not too different from that of other recessions.

trend labor force participation rate is defined relative to low frequency variations isolated by the HP filter. A comparison of this counterfactual labor force participation rate series to the actual one is shown in Figure 18.

In any counterfactual calculation of this type, changing the labor force series, LF_t, to reflect a different trend path for the labor force participation rate means that we must also change either the employment series, E_t, the unemployment series, U_t, or both, so that the identity $LF_t = E_t + U_t$ continues to hold under the counterfactual.[10] We consider two polar cases: an "optimistic" case in which all of the additional labor force participation is matched by an increase in employment, and a "pessimistic" case in which the extra labor force participation is reflected by increased unemployment. Thus, the pessimistic case might be interpreted as one in which the distinction between being out of the labor force and being unemployed is not substantive for the counterfactual increase in labor force participation. In contrast, the optimistic case might be interpreted as one in which the counterfactual increased labor force participation assumes away any labor market mismatch issues or other forces that could potentially produce mismatched or discouraged workers who then leave the labor force.

The resulting implications for (HP filter-based) trend GDP per capita are shown in Figure 19.[11] In the pessimistic case, as expected, when the counterfactual increase in the labor force participation series is simply matched by increased unemployment, the path of per capita GDP is unaffected, but the ratio of employment to the labor force falls.

In the optimistic case, a flattening out of the trend labor force participation rate after 2007:Q4 results in a gain of roughly 0.8 percent in per capita GDP growth during the recovery beginning in 2009:Q3. In a sense, this figure represents an upper bound on what a flattening out of the labor force participation rate after the Great Recession might have implied for per capita GDP growth. At the same time, to the degree that the current recovery in per capita GDP has fallen short of historical trend growth by roughly 1 percent, a considerable portion of that difference may be accounted for by the behavior of the trend labor force participation rate. In principle, the implications of a flattening of the trend labor force participation rate lie somewhere between the two cases depicted in Figure 19.

[10] Here, the behavior of population is taken as given so that a counterfactual labor force series is easily constructed by multiplying the counterfactual labor force participation rate by population.

[11] In these calculations, trend labor productivity is assumed to be unchanged.

3. CONCLUDING REMARKS

A simple decomposition of per capita GDP traces the unusual behavior of output during and after the Great Recession to a large and steady decline in the labor force participation rate. The magnitude and persistence of this decline are unprecedented in U.S. postwar history, much as the fall in per capita GDP that accompanied the Great Recession was unprecedented. Moreover, the fact that the labor force participation rate moves slowly over time, at frequencies much lower than those characterizing business cycles, presaged a muted recovery from the 2007–09 recession relative to other recoveries throughout the postwar period. The persistently slow recovery of per capita GDP might continue to cause concern and potentially warrants further inquiries into the factors—particularly demographic ones—that drive fluctuations in the labor force participation rate. Such inquiries could help determine whether government policy can and should be used to raise the rate of economic growth in the years ahead.

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MBS Real Estate Investment Trusts: A Primer

Sabrina R. Pellerin, Steven J. Sabol, and John R. Walter

Real estate investment trusts (REITs) have played a significant role financing U.S. real estate going back to at least the late 1800s. However, those REITs that invest predominantly in mortgage-backed securities (MBS), the focus of this article, have a much shorter history, dating to the mid-1980s.[1] MBS-focused REITs (mREITs) grew quite rapidly after 2008—so much so that some observers have expressed concerns that the largest might pose systemic risks for the broader economy, which has led to speculation that they may be subjected to heightened supervisory oversight (Solomon 2013). The two largest mREITs, which account for 54 percent of all mREIT assets, have been the focus of special attention from policymakers and the press.[2,3,4] Currently, mREITs are not as tightly supervised as other financial entities that are thought to pose systemic risks, such as large commercial or investment banks.

Observers have raised concerns along the following three dimensions: 1) mREITs invest in fairly long-term assets but fund themselves with short-term liabilities, implying that they are sensitive to interest

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[1] See Pellerin, Sabol, and Walter (2013, 3–10) for a detailed review of the history of REITs, mREITs, and MBS.

[2] While some observers define mREITs as those REITs that invest in mortgages or MBS, we use the abbreviation "mREIT" to refer only to REITs that invest in MBS. Additionally, we include in our definition of mREITs only those that finance their assets predominantly with repurchase agreements (or other short-term debt, such as commercial paper).

[3] As of 2012:Q4. Please see Table 5 for data on other mREITs.

[4] For example, see Adrian, Ashcraft, and Cetorelli (2013), International Monetary Fund (2013), and Stein (2013).

rate and liquidity risks; 2) they hold large portfolios of one type of asset, such that if mREITs become troubled and are forced to liquidate holdings, MBS prices might be driven down; and 3) the assets that they hold, predominantly government agency-backed MBS, play an important role in the operation of the home mortgage market, implying that if policymakers become concerned that mREITs might fail, these policymakers could feel compelled to intervene to prevent such failures.

Typical discussions of these risks often provide only sparse information from which one can evaluate them. Therefore, this article sheds light on how mREITs operate, in what ways they are regulated, and how their regulation compares to that of other similar types of firms. It also explains factors contributing to their recent growth, provides some analysis of the risks they face, how they manage these risks, and the potential dangers for the broader financial system.

1. HOW mREITS OPERATE

mREITs are investment vehicles that hold MBS and finance these holdings with equity and debt. Currently, mREITs predominantly hold agency MBS—meaning those MBS issued by Fannie Mae, Freddie Mac, and Ginnie Mae—which enjoy implicit or explicit government backing and therefore have no credit risk. mREIT investors, i.e., the holders of mREIT equity, typically receive greater earnings than they might by simply buying MBS, because mREITs use short-term debt and leverage to magnify returns such that, on average, mREIT assets are 7.4 times equity (Table 1).

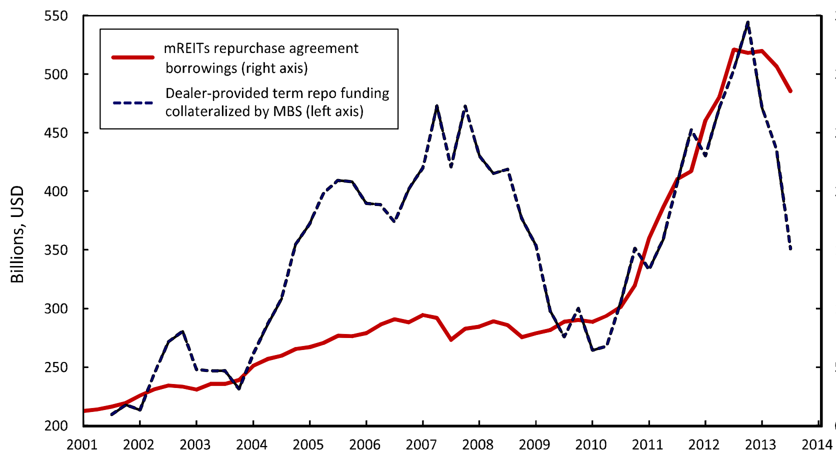
Because MBS have fairly long maturities, one might imagine that mREITs would tend to fund themselves with equity and long-term debt. Instead, mREITs typically are funded with short-term instruments—largely repurchase agreements (repos). Indeed, because short-term debt instruments typically pay a lower rate of interest than long-term instruments, borrowing short-term and holding long-term assets has tended to earn mREITs a significant spread that accounts for much of their income. The combination of a high degree of leverage with an asset-liability mix that emphasizes funding long-term assets with short-term liabilities (such an asset-liability structure is often termed maturity transformation) carries significant risks, leading them to engage in hedging activities (discussed in Section 4).

Table 1 Financial Highlights for all mREITS and the Five Largest

Five Largest mREITS	Total Assets 2012Y	Agency Securities 2012Y	Repurchase Agreements 2012Y	Total Equity 2012Y	Leverage Multiple (Assets-to-Equity)
Annaly Capital Mgmt Inc.	133,452,295	127,724,851	102,785,697	15,924,444	8.4
American Capital Agency Corp.	100,453,000	85,245,000	74,478,000	10,896,000	9.2
Hatteras Financial Corp.	26,404,118	24,057,589	22,866,429	3,072,864	8.6
CYS Investments	21,057,496	20,842,142	13,981,307	2,402,662	8.8
ARMOUR Residential REIT Inc.	20,878,878	19,096,562	18,366,095	2,307,775	9.0
Total (includes all other mREITs)	**434,421,733**	**359,902,940**	**319,384,054**	**58,888,023**	
Average (includes all other mREITS)	**14,980,060**	**12,410,446**	**11,013,243**	**2,030,621**	**7.4**

Source: SNL Financial.

Figure 1 mREIT Repo Borrowing and Broker-Dealer Lending



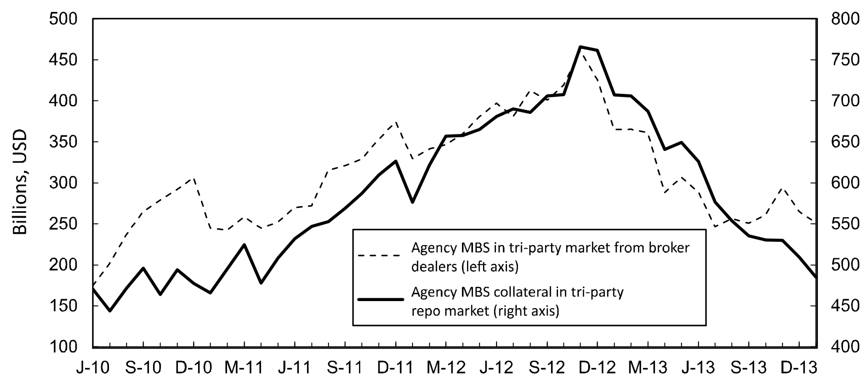
Sources: Federal Reserve Bank of New York FR2004 Form, SNL Financial, and Richmond Fed.

Because repos play such a significant part in how mREITs operate, it is fundamental to understand the broader functioning of the repo market. A repo is the sale of an asset, by the borrower, with an accompanying promise by the borrower to buy back the same (or like) asset upon maturity.[5] In fact, they typically are thought of as simply a collateralized loan, with the asset acting as the collateral. In the tri-party repo market, the predominant assets backing repos are MBS issued by Fannie Mae, Freddie Mac, or Ginnie Mae (36 percent of all tri-party repo collateral), securities issued by the U.S. Treasury (35 percent),[6] and debt securities issued by Fannie Mae or Freddie Mac (6 percent). Interest rates on repo borrowing are among the lowest in the funding markets because repos are typically fairly short-term borrowings, repos are collateralized, and repo borrowing receives especially beneficial treatment in bankruptcy.

[5] Ennis (2011, 389–92) provides background on the repo market.

[6] Percentage figures from Federal Reserve Bank of New York (2012).

Figure 2 Broker-Dealer Agency MBS Financing and Tri-Party Repo



Sources: Federal Reserve Bank of New York FR 2004 Form, Tri-party Repo Task Force, Richmond Fed, Haver Analytics.

A review of the financial statements of several of the largest mREITs indicates that most of their repo funding comes from broker-dealers.[7] Brokers receive agency MBS as collateral in bilateral repo transactions with the mREITs and then subsequently use this high-quality collateral to borrow from other financial firms (e.g., money market mutual funds) via the tri-party repo market.[8] As illustrated in Figure 1, over the last several years the amount of the increase in MBS-backed broker-dealer lending (approximately $300 billion between June 2010 and December 2012) is almost exactly equivalent to the amount of the increase in mREIT borrowing. In turn, as can be seen in Figure 2, the amount of agency MBS collateral posted to the tri-party market by broker-dealers—the dotted line—increased by about this same $300 billion between June 2010 and December 2012. The total value of agency

[7] For mREITs that disclose details on their repo borrowings, broker-dealers appear to be the predominant source of repo financing. See, for instance, the second quarter 2013 10-Qs of the following mREITs: Bimini Capital Management Inc., p. 15; Invesco Mortgage Capital Inc., page 21; CYS Investments, p. 41; or page 11 of Armour Residential REIT, Inc., "Company Update," December 19, 2013 (available at www.armourreit.com/updates/ARR_Company_Update_Dec_19_2013.pdf).

[8] A bilateral repo transaction is one in which there are only two parties to the transaction. In contrast, a tri-party repo transaction is one in which the two counterparties use a custodian bank or clearing organization (the third party) to act as an intermediary, and typically the holder of the collateral, to settle the transaction. For more information on the tri-party repo market, see Ennis (2011, 389–92), Copeland et al. (2012), and Adrian et al. (2013, 4–6).

MBS collateral in the tri-party repo market—the solid line—appears to mirror movements in the dotted line, and both increase by about $300 billion over the same period. Therefore, taken together, Figures 1 and 2 suggest that the agency MBS that mREITs have pledged for most of their recent borrowing has flowed through to the tri-party market via broker-dealers and accounts for much of the growth over the last several years in that market.

Broker-dealers benefit in two ways by performing an intermediary role between mREITs and the tri-party repo market. First, broker-dealers earn a spread between the interest rate paid to them by mREITs and what they must pay to finance these loans. For example, in 2012 the largest mREIT by assets, Annaly, paid a weighted average repo rate for its borrowings with maturities of two to 59 days of 45 to 50 basis points (Annaly 2012, F-19), whereas, the average 30-day MBS-backed repo rate in the tri-party market was 25 basis points in 2012 (Bloomberg 2014). Beyond the spread, broker-dealers also face lower "haircuts" on their repo borrowings than do mREITs.[9] A haircut is the difference between the current market value of the collateral and the amount the creditor will lend, and it is typically stated as a percentage of the value of the collateral. It provides a buffer to protect the lender if the market value of the collateral declines. The lower the haircut a firm faces, the more it can borrow and re-invest for a given amount of collateral.

While mREITs face no regulatory leverage limits, the haircut itself places a limit on the amount they can lever up, meaning haircuts limit how large an mREIT can grow, given its equity. For example, if an mREIT starts with $10 million in equity from shareholders and faces a 5 percent haircut, then the maximum amount it can grow without raising more capital is $200 million. Here is how the process for this mREIT would proceed: 1) starting with the $10 million in new equity, the mREIT buys $10 million worth of MBS; 2) it then uses the $10 million in MBS as collateral for a repo loan of $9.5 million because the lender requires a 5 percent haircut; 3) it buys an additional $9.5 million in MBS and repos it out to receive $9.025 million in a second loan; and 4) it buys an additional $9.025 million in MBS. This buying and "repoing out" (meaning borrowing in the repo market) of MBS could go on until the firm has MBS holdings equal to one divided by the haircut (in this case $\frac{1}{.05}$) times the original equity ($10 million), or

[9] For instance, Annaly's (2012, 69) average repo collateral haircut in 2012 was 5 percent, while the median repo haircut for cash investors in agency MBS in the tri-party market was only 2 percent (see Federal Reserve Bank of New York [2012], Cash Investor Margin Levels, Agency MBS).

20 times the original equity (meaning $200 million). However, mREITs' leverage ratios are not typically this high—as of December 31, 2012, their assets (mostly MBS) were on average 7.4 times their equity (see Table 1).

The borrower not only must provide the lender with extra collateral to cover the haircut percentage at the time the loan is initially entered into, but also must ensure that the lender's haircut is maintained throughout the life of the loan (Choudhry 2010, 151–3). If the value of the posted collateral falls more than a specified amount, the lender will issue a margin call requiring the borrower to send the lender additional collateral to reestablish the haircut percentage.[10] The possibility that the value of MBS collateral might fall—for example, when market interest rates increase—provides one explanation of why mREITs do not lever up as much as haircuts might allow. Instead, they must maintain a portfolio of unencumbered assets—that is, assets not used to back loans—in order to be prepared to respond to any margin calls.[11] For example, as of the end of 2012, Annaly (2012, F-3) had unencumbered MBS in its portfolio equal to 16 percent of its repo borrowings.

Beyond these market-imposed limitations, an mREIT's payouts, investments, and management and ownership structures must meet a set of requirements found in the federal tax code (see Table 2) in order to ensure that its income is not taxed.[12] Given that one of these requirements is that an mREIT must pass 90 percent of its taxable income to investors in the form of dividends (rather than retaining earnings), it must fund its growth by acquiring new debt or equity financing.

2. HOW mREITS ARE REGULATED

Currently, mREITs face very limited regulatory oversight. In addition to complying with the rules associated with maintaining REIT tax treatment, the mREITs reviewed in this article are registered with the U.S. Securities and Exchange Commission (SEC) and publicly traded and therefore must comply with SEC disclosure and reporting requirements and the rules of the exchange on which they trade (e.g., NYSE or

[10] Specifically, mREITs are subject to two types of margin calls: valuation and factor calls. Valuation calls occur when the value of the collateral falls, whereas factor calls occur when prepayment frequencies (prepayment factors) change, based on prepayment tables published by Fannie Mae and Freddie Mac.

[11] Unencumbered assets can include cash, MBS, and other securities.

[12] Note that mREIT distributions are taxable income for their investors.

Table 2 REITs Requirements to Maintain REIT Status

1. Distribute at least 90 percent of each year's income to shareholders.
2. Earn at least 75 percent of its gross income from real estate investments, specifically from a) rents on real property; b) interest earned on obligations secured by mortgages on real property; c) gains from the sale or other disposition of real property or mortgages; d) distributions from other REITs or gains from the sale of shares in other REITs; and e) other real estate-related activities.
3. Earn at least 95 percent of its gross income from: dividends; interest; rents on real property; gains from the sale or other disposition of stock, securities, and real property; and other real estate-related activities.
4. Less than 30 percent of its gross income is derived from the sale or other disposition of: stock or securities held for less than six months; and real property held for less than four years.
5. At least 75 percent of the value of its total assets is represented by real estate assets (which includes interests in mortgages), cash and cash items, and government securities; and not more than 25 percent of the value of its total assets is represented by non-mortgage or non-government securities.
6. The entity issues transferable shares owned by at least 100 persons.
7. The entity is managed by one or more trustees or directors.

Notes: Government Printing Office (2010). The Cigar Excise Tax Extension Act of 1960 (Public Law 86-779) amended Subchapter M such that tax protection was given to REITs.

NASDAQ).[13] However, all SEC-registered and publicly traded financial companies are subject to these rules.

One feature that makes the mREIT unique among its non-REIT competitors is that its business model relies heavily on an exception contained in the Investment Company Act of 1940 (the "1940 Act") that excludes, from the definition of investment company (and therefore from the Act's rules), certain companies involved in "purchasing or otherwise acquiring mortgages and other liens on and interest in real estate."[14] The rationale behind this exception is to differentiate companies exclusively engaged in the mortgage banking business from those in the investment company business and allow the former to benefit from less regulatory oversight since their activities are providing important liquidity into the housing market (National Association of

[13] Publicly listed companies must satisfy rules related to corporate governance (including having a majority of independent directors), liquidity, earnings, share price, and an internal audit function. For the rule manuals of the NYSE and NASDAQ, see http://nysemanual.nyse.com/lcm/ and http://nasdaq.cchwallstreet.com/, respectively.

[14] The 1940 Act is the primary law that governs investment companies. See Section 3(a)(1) of the Investment Company Act, p. 18, for a definition of an investment company. The exclusion is contained in Section 3(c)(5)(C) of the 1940 Act.

Real Estate Investment Trusts 2011; Securities and Exchange Commission 2011; Securities Industry and Financial Markets Association 2011). To qualify for this exception, the SEC requires that the exempt company invest at least 55 percent of its assets in mortgages and other liens on and interest in real estate (or "qualifying real estate assets") and at least 80 percent of its assets in the more broadly defined "real estate-related assets."[15]

Traditional REITs that predominantly hold mortgages clearly fit the mortgage banking exemption contained in the 1940 Act (Securities and Exchange Commission 2011, 55,301). However, mREITs, the first of which appeared in 1985 (based on our definition of an mREIT), have relied on SEC staff interpretations of the 1940 Act, which identify "whole pool" agency and non-agency residential mortgage-backed securities (RMBS) as being functionally equivalent to mortgage loans, and therefore "qualifying real estate assets."[16,17] Thus, most mREITs hold at least 55 percent of their assets in whole pool agency MBS and treat any "partial pool" agency MBS as satisfying the broader requirements of a real-estate related asset.[18]

In 2011, the SEC released a proposal for comment expressing their concerns that certain types of mortgage-focused companies that exist today, such as mREITs, may not be the type of company originally intended to be exempt from the rules of the 1940 Act (Securities and Exchange Commission 2011). Moreover, while traditional REITs engage in activities that are clearly tied to the mortgage banking business, the SEC questions whether the mREIT business model is more similar to that of an investment company and should therefore face the same regulatory oversight as one. For instance, both mREITs and investment companies pool investor assets to purchase securities, provide professional asset management services, publicly offer their securities to retail and institutional investors, and most avoid paying corporate income taxes (Securities and Exchange Commission 2011, 55,303). While

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[15] These thresholds are based on SEC staff no-action letters and other interpretations (Securities and Exchange Commission 2011, 55,305) and are broadly recognized by mREITs as indicated in their 10-K financial statements (see, e.g., Annaly [2012, 49] and CYS Investments Inc. [2012]).

[16] From Annaly's (2012, 49) Annual Report: "This interpretation was promulgated by the SEC staff in a no-action letter over 30 years ago, was reaffirmed by the SEC in 1992 and has been commonly relied on by mortgage REITs."

[17] A "whole-pool" certificate is a security that represents all of the ownership interest in a specific mortgage pool. From CYS Investments Inc. (2012): "We treat Fannie Mae, Freddie Mac and Ginnie Mae whole-pool residential mortgage pass-through securities issued with respect to an underlying pool of mortgage loans in which we hold all of the certificates issued by the pool as qualifying real estate assets."

[18] A partial pool certificate is a security that represents partial ownership interest in a specific mortgage pool.

mREITs generally have a higher concentration of their assets in real estate, many other investment companies invest in some of the same kinds of assets.[19] Nonetheless, according to a congressional statement associated with the Investment Company Act Amendments of 1970, mortgage REITs are excluded from the 1940 Act's coverage "because they do not come within the generally understood concept of a conventional investment company investing in stocks and bonds of corporate issuers." So it seems likely that mREITs would meet this congressional intent.[20]

If mREITs became subject to the 1940 Act, they would face stricter regulation. Most importantly, the 1940 Act places limits on investment companies' use of leverage. The Act also gives the SEC the authority to monitor the companies' activities to ensure that, for instance, they are accurately computing the value of their assets and are not engaging in activities with affiliates that benefit insiders at the cost of investors (Securities and Exchange Commission 2011, 55,303).[21] In addition, it restricts affiliate transactions between the investment company and any affiliate that holds at least 5 percent ownership interest in the company.[22]

These additional restrictions could be very costly for mREITs, especially the leverage requirements. Unlike their investment company competitors, mREITs are able to rely more heavily on debt financing because they have no statutory leverage limits.[23] In other words, they can purchase more assets for a given amount of capital compared to their competitors. Imposing additional restrictions would eliminate any advantage they might have compared to investment companies that are subject to greater regulatory oversight. Beyond investment companies, mREITs also compete with other financial entities, which face even greater regulatory oversight, such as banks, investment banks, insurance companies, and other lenders. This comparatively light regulatory oversight is likely one of the contributing factors to the growth of the mREIT sector.

[19] Securities and Exchange Commission 2011, p. 55,303, fn. 27, p. 55,300, fn. 3.

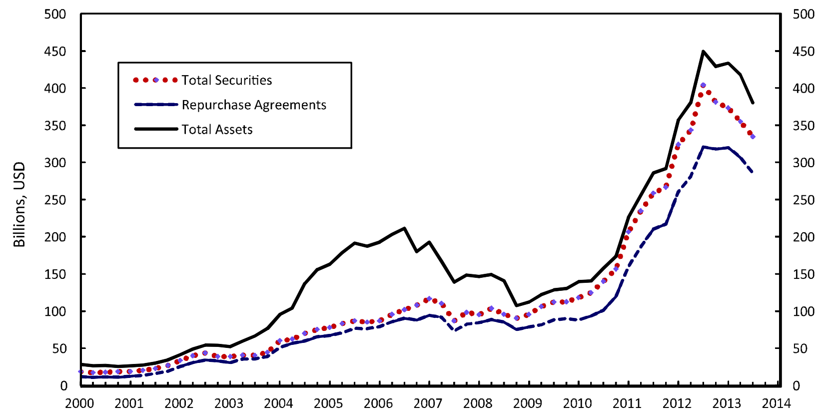
[20] U.S. House Investment Company Act Amendments of 1970. House Report 91-1382 (August 7, 1970), at 17.

[21] From ICI (2013) Factbook in reference to leverage limitations: "these limitations greatly minimize the possibility that a fund's liabilities will exceed the value of its assets." See Section 2(a)(41) of the 1940 Act to see how registered investment companies are required to value their assets.

[22] See Section 17 of the 1940 Act for prohibitions related to registered investment companies engaging in certain transactions with their affiliates.

[23] Note that repurchase agreements have restrictive covenants that may also put restrictions on leverage.

Figure 3 Total Assets, Repos, and Securities of mREIT Industry



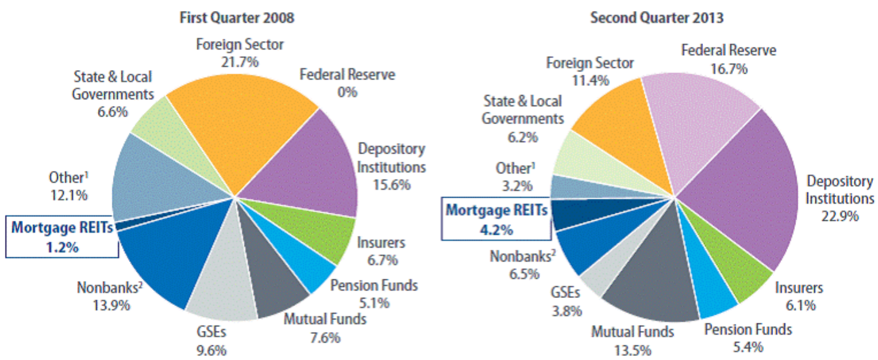
Sources: SNL Financial and Richmond Fed.

3. GROWTH OF mREITS

mREIT assets have grown eight-fold over the last decade (Figure 3). They increased fairly significantly from 2003 until the time of the financial crisis and then grew especially rapidly beginning in 2009. mREITs' share of agency MBS (and agency debt) has also increased considerably (Figure 4). While their share remains fairly small, mREITs have grown to be important suppliers of agency MBS collateral. As of September 2013, mREITs supplied, through broker-dealers, 54 percent of the agency MBS collateral used in the tri-party repo market.[24] Clearly, an important reason for their growth is their strong returns. As seen in Figure 5, their dividend yield over the last five years has consistently been around 15 percent, considerably higher than equity REITs. One reason for mREITs' strong performance is the favorable tax treatment that they receive compared to many of their competitors. Of course this cannot be the only explanation given that, at least recently, mREITs have produced much stronger returns than equity REITs, which also enjoy this tax advantage.

[24] SNL Financial and Federal Reserve Bank of New York (2013).

Figure 4 Holders of Agency MBS and Agency Debt in 2008 and 2013



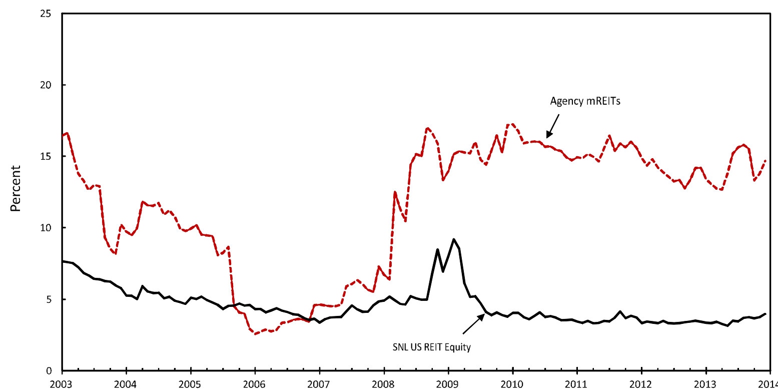
Notes: "Other" includes nonfinancial corporations, households, U.S. government, and credit unions; "Nonbanks" include security brokers and dealers, ABS issuers, holding companies, and money market mutual funds; as of the second quarter of 2013, total agency MBS and agency debt equals $7.6 trillion, according to Z.1 data. Of this total, $5.8 trillion is agency MBS, according to Securities Industry and Financial Markets Association data.

Source: Z.1 Federal Reserve Board of Governors' Financial Accounts of the United States, Table L.210, 2013:Q2.

Other factors that may have contributed to their strong growth and high returns include a lack of regulatory restrictions on mREITs' use of leverage, federal policies supporting the agency MBS market (and therefore mREITs' main asset), and advantages associated with using repo (their main liability) as a primary method of financing. mREITs' ability to produce rapid growth has been dependent on these factors taken together, as well as various external factors, including the growth of securitization and of the repo market, and the interest rate environment.

By investing predominantly in agency MBS, not only do mREITs avoid credit risk, but they are also reliant on a sector that has benefited from a large amount of government support. As a result of the recent financial crisis, the Treasury and the Federal Reserve took actions that stabilized the market for mortgage-related securities (see Table 3 for a list of policy actions that have supported MBS). For instance, in an effort to stimulate the economy, the Federal Reserve purchased a

Figure 5 Dividend Yield for Agency mREITs and Equity REITs



Sources: SNL Financial and Richmond Fed.

significant amount of MBS (holdings total $1.3 trillion as of September 30, 2013) as part of its large-scale asset purchase program.[25]

While many sectors were contracting during the financial crisis, existing mREITs continued to grow and new ones were formed. Of the 42 mortgage REITs (both listed and unlisted) existing today, 19 of them were formed between 2008 and 2012 (see Figure 6).[26] One of the recently formed mREITs—Five Oaks Investment Corporation—notes that the government policies that support the MBS market created an attractive investment opportunity for mREITs. In its registration statement, it indicates that if such policies were to change, they could experience significant financial hardship.[27] Even though some of this support has dwindled, the MBS market has remained liquid and these securities have consistently been relied on as high-quality collateral in repo transactions with broker-dealers. Additionally, the fact that

[25] While Fed purchases of MBS could certainly be viewed as making agency MBS more attractive (enhancing liquidity and, therefore, safety), they have also driven up agency MBS prices to some extent, which tends to make agency MBS somewhat less attractive. Data for Federal Reserve MBS holdings from the Board of Governors (2013).

[26] Note that these figures include both listed and non-listed mortgage REITs. As of December 31, 2012, 24 of these are publicly traded mREITs (per our definition).

[27] From the Five Oaks Investment Corporation (2012, 32–3).

Table 3 Policy Interventions

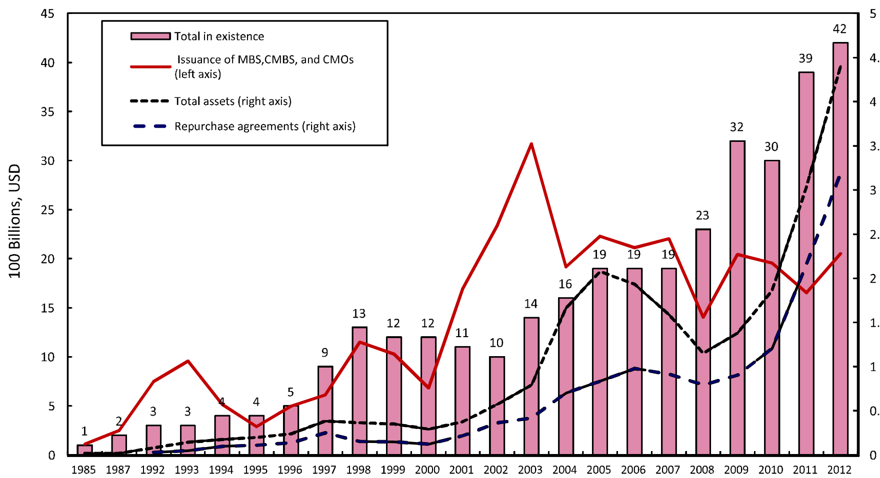
Date	Agency	Policy	Description
Mar-08	Federal Reserve	Primary Dealer Credit Facility (PDCF)	Overnight loans by the Fed against essentially tri-party eligible collateral
Mar-08	Federal Reserve	Term Securities Lending Facility (TSLF)	The TSLF loaned Treasury securities to primary dealers for one month against eligible collateral. For so-called "Schedule 1" auctions, the eligible collateral comprised Treasury securities, agency securities, and agency mortgage-backed securities. For "Schedule 2" auctions, the eligible collateral included schedule 1 collateral plus highly rated private securities.
Jul-08	FHFA	HERA established FHFA as new regulator for Fannie Mae and Freddie Mac	FHFA becomes the new regulator and overseer of Fannie and Freddie
Sep-08	FHFA	FHFA appointed as conservator of Fannie Mae and Freddie Mac	Increase the availability of mortgage financing by allowing these institutions to grow their guarantees without limit, while limiting the size of retained mortgage and security portfolios and requiring these portfolios to be reduced over time
Sep-08	Federal Reserve	Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility	Lending facility that financed the purchases of high-quality asset-backed commercial paper (ABCP) from money market mutual funds by U.S. depository institutions and bank holding companies. The program was intended to assist money funds that hold such paper to meet the demands for redemptions by investors and to foster liquidity in the ABCP market and money markets more generally.
Oct-08	Federal Reserve	Commercial Paper Funding Facility (CPFF)	The CPFF provided a liquidity backstop to U.S. issuers of commercial paper through a specially created limited liability company (LLC), the CPFF LLC. This LLC purchased three-month unsecured and asset-backed commercial paper directly from eligible issuers.
Oct-08	Federal Reserve	Money Market Investor Funding Facility (MMIFF)	Intended to provide liquidity to U.S. money market mutual funds and certain other money market investors, thereby increasing their ability to meet redemption requests and hence their willingness to invest in money market instruments, particularly term money market instruments
Nov-08	Federal Reserve	Term Asset-Backed Securities Loan Facility	Issued loans with terms of up to five years to holders of eligible asset-backed securities (ABS). The TALF was intended to assist the financial markets in accommodating the credit needs of consumers and businesses of all sizes by facilitating the issuance of ABS collateralized by a variety of consumer and business loans; it was also intended to improve the market conditions for ABS more generally.
Nov-08	Federal Reserve	Large-Scale Asset Purchases	$500 billion in purchases of Agency MBS
Mar-09	Treasury	Home Affordable Modification Program (HAMP)	Provides homeowners with assistance in avoiding residential mortgage loan foreclosures
Mar-09	Federal Reserve	Large-Scale Asset Purchases	Additional $750 billion in purchases of agency MBS
2008	FHA	Hope for Homeowners Program (H4H)	Allows certain distressed borrowers to refinance their mortgages into FHA-insured loans in order to avoid residential mortgage loan foreclosures
2009	FHFA	Home Affordable Refinance Program (HARP)	Allows borrowers current on their mortgage payments to refinance and reduce their monthly mortgage payments at loan-to-value ratios of up to 125 percent and without new mortgage insurance
Sep-11	Federal Reserve	Re-investments	Begin reinvesting interest and principal payments in agency MBS
Oct-12	FHFA	HARP 2.0	Increase HARP LTV ratio above 125 percent. Enables borrowers to go to any lender to refinance
Sep-12	Federal Reserve	"Open-ended" LSAPs	Begin open-ended purchases of agency MBS at a pace of $40 billion per month

issuance of non-agency MBS dried up following the crisis (see Figure 7) provides further evidence that government support in the agency MBS market was fundamental to the survival (and growth) of mREITs.

As can be seen in Figure 6, mREITs' total assets (predominantly MBS) grew following a period in which MBS issuance had risen significantly and mREIT assets have increasingly been funded by repos (also see Figure 8), indicating that MBS and repo growth may have contributed importantly to mREIT growth. The repo market is part of the so-called "shadow banking system," which has grown significantly over the last several decades.[28] The ratio of private securitization to

[28] Shadow banking "comprises a diverse set of institutions and markets that, collectively, carry out traditional banking functions—but do so outside, or in ways only loosely linked to, the traditional system of regulated depository institutions. Examples

Figure 6 mREITs in Existence, Issuance of Securitized Mortgages, Repo, Assets, and Major Federal Policies

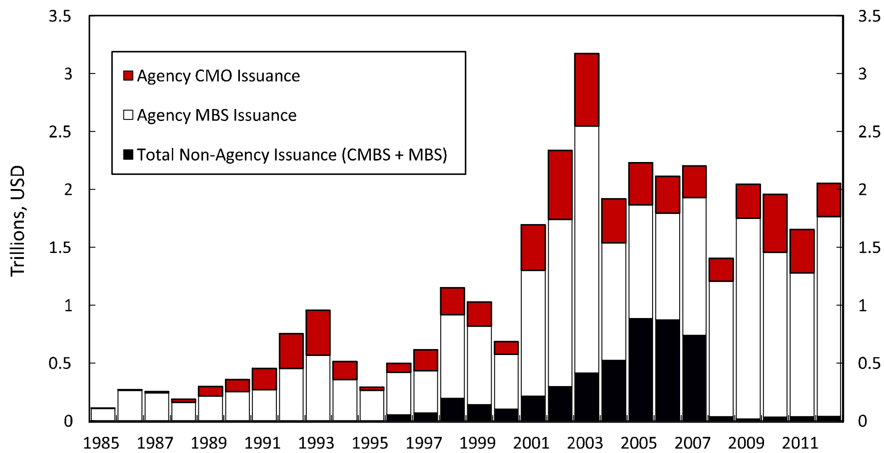


Sources: SNL Financial, SIFMA, Flow of Funds, and Richmond Fed.

total bank loans grew from zero in the early 1980s to over 60 percent prior to the financial crisis (Gorton and Metrick 2010, 265). The overall growth in repo usage and MBS issuance over the last two decades has been attributed to the reduced competitive advantage held by banks for deposits (due to certain innovations and regulations) and the rise in "securitization and the use of repo as a money-like instrument" (Gorton and Metrick 2010, 266). As institutional investors, pension funds, mutual funds, states and municipalities, and nonfinancial firms had a growing demand for nonbank alternatives for deposit-like products, they turned to the repo market, which allowed nonbank financial entities such as mREITs to acquire financing for their activities

of important components of the shadow banking system include securitization vehicles, asset-backed commercial paper conduits, money market mutual funds, markets for repurchase agreements, investment banks, and mortgage companies" (Bernanke 2012). Also see Pozsar et al. (2013) for a thorough discussion of shadow banking.

Figure 7 MBS, CMBS, and CMO Issuance from 1985 to 2012



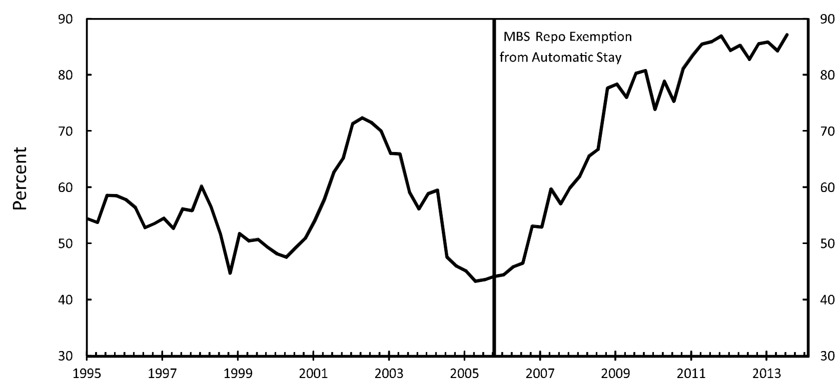
Source: Fannie Mae, Federal Reserve, Freddie Mac, Ginnie Mae, HUD, FHFA; data compiled by SIFMA.

in return for collateral.[29] The growth in securitization meant that an increasing amount of collateral was available for repo financing.

Additionally, bankruptcy's favorable treatment of repos, which limits counterparty risk, may be another factor contributing to mREIT growth. In a repo transaction, if the borrower defaults, the lender is not subject to the automatic stay provisions of the code (whereby creditors of a bankrupt firm are prevented, or "stayed," from making any attempts to collect what they are owed) and can take possession and immediately liquidate the assets pledged as collateral under the repurchase agreement. Financial contracts that receive this special treatment in bankruptcy (exemption from the stay) are called qualified financial contracts (QFCs) and include repurchase agreements, commodity contracts, forward contracts, swap agreements, and securities contracts. While special treatment for certain financial contracts has existed since 1978, only in 2005 was the definition of a QFC expanded to include

[29] "In 2003, total world assets of commercial banks amounted to USD $49 trillion, compared to USD $47 trillion of assets under management by institutional investors" (Bank for International Settlements 2007, 1, fn. 2).

Figure 8 Repurchase Agreements as a Percentage of Total mREIT Liabilities



Notes: Quarterly observations of repo liabilities as a percentage of total liabilities for mREITs.

Sources: SNL Financial and Richmond Fed.

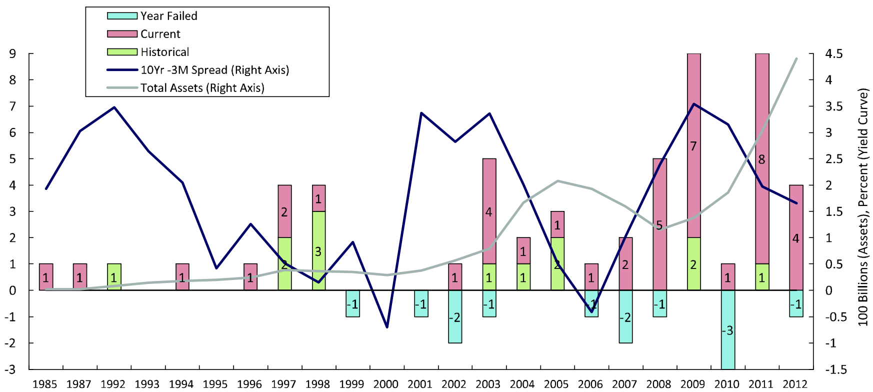
repos backed by MBS (Government Accountability Office 2011, 14).[30] Because the risk to mREIT counterparties is greatly reduced, mREITs receive repo financing on favorable terms (fees and haircuts), and counterparties may be more willing to be heavily exposed to mREITs. As a result, repos' special treatment in bankruptcy could be a significant factor in mREITs' growth.[31] Notably, the vast majority of mREIT asset growth took place after the MBS repo exemption and, as seen in Figure 8, repos have accounted for an increasing share of mREIT liabilities since 2005. Importantly, mREITs rely, almost exclusively, on the use of repo financing to attain leverage.

mREITs' ability to lever up without regulatory restriction seems to be a critical part of their ability to produce high returns and grow rapidly. According to Annaly, the largest mREIT, if leverage limits

[30] For the types of contracts currently exempt from the stay, see the following sections of the Bankruptcy Code: 11 U.S.C. § 362(b)(6), (b)(7), (b)(17), 546, 556, 559, 560.

[31] For a discussion of potential inefficiencies that might arise because of exemption of QFCs (e.g., repos) from the stay, see Roe (2011).

Figure 9 Formation and Failures of mREITs and the Yield Curve



Notes: "Historical" refers to MBS REITs that were founded but are currently no longer in existence. "Current" refers to MBS REITs that are still in existence. Asset data only for listed mREITs.

Sources: SNL Financial, FRED, and Richmond Fed.

were imposed its business model would have to be changed in a way that would have a material adverse impact (Annaly 2012, 49).

While equity REITs also use leverage, their returns over the last six years have been considerably lower than returns produced by mREITs (Figure 5). An important differentiating feature that could account for this earnings difference is that mREITs lever up using short-term debt. This ability to lever up with short-term debt (repo) is particularly advantageous during periods in which short-term interest rates are low relative to long-term rates, for example over the last six years. During such periods, mREITs benefit from holding long-term assets (MBS) at favorable spreads over their funding (repo) costs and utilize leverage to amplify returns. Figure 9 shows that when the yield curve environment is favorable (when the spread between 10-year and three-month Treasury securities is greatest), mREITs' asset growth and formations increased.

The Effect of the Recent Increase in Interest Rates

In late 2012, long-term interest rates increased slightly and then significantly in mid-2013, producing a less favorable environment for mREIT earnings and growth. In the third quarter of 2012, mREIT assets peaked at $449 billion (see Figure 3) and declined afterward in response to this increase in interest rates.

The selloff of mREIT assets as rates increased could be explained by three things. First, to the extent that investors shifted into mREITs when interest rates were low and falling to "reach for yield," when interest rates started increasing these same investors may have started shifting back to less risky investments. Second, mREIT managers themselves may have developed concerns about the adverse effect that increasing interest rates would have on their MBS portfolio and therefore reduced leverage to an extent (by 1.4 percent to 7.2 percent over a period of nine months) by selling assets and repaying debt.[32] Third, repo counterparties could have become concerned about increased mREIT risks and the risks of holding MBS collateral in a rising rate environment and therefore may have become less willing to roll over MBS-based repo funding or may have increased funding-related costs (e.g., interest rates, haircuts, and fees).

Although recently mREIT assets have decreased somewhat, their business model has generally remained favorable—meaning they continued to provide investors with high dividend yields (Figure 5)—even in 2014. However, mREITs carry some significant risks. In the following section, we will look more closely at the risks inherent in their business model and how they manage them.

4. mREIT RISKS AND RISK MANAGEMENT

mREITs are exposed to: 1) interest rate risk, 2) prepayment risk, 3) credit risk to the extent that mREITs hold assets other than government-guaranteed MBS, and 4) liquidity risk. To mitigate these risks, mREITs engage in measures such as hedging and taking steps to reduce the fragility of their funding structure.

[32] Leverage here is assets divided by equity (data from SNL Financial). The leverage calculations here are not weighted by mREIT assets, as they were in Table 1.

Interest Rate Risk

Because of the maturity mismatch between mREITs' assets and liabilities, interest rate movements can affect their earnings and, indeed, their solvency. As of December 31, 2012, mREITs' repo maturities were, on average, about 48 days,[33] while their average MBS maturity was 4.5 years.[34] This maturity mismatch implies that when interest rates increase, mREITs' earnings will decline because their repos re-price quickly while the yield on their MBS remains unchanged or increases slowly.

If interest rates increase rapidly, the value of MBS holdings could decline enough to threaten mREIT solvency. The way in which this could happen is as follows. An interest rate-driven decline in the value of an mREIT's MBS holdings will lead its creditors to issue margin calls, requiring the mREIT to use its unencumbered assets to post additional collateral to secure their repo funding. If interest rates increase enough, all of the mREIT's unencumbered assets will be expended, and the mREIT will be unable to meet additional margin calls.

Prepayment Risk

Prepayment risk exists because most mortgage contracts allow the borrower the option to prepay, meaning pay back their mortgage prior to maturity. Because 82 percent of mREITs' assets are agency MBS (as of December 31, 2012), mREITs are highly exposed to prepayment risk. The prepayment option can produce losses for mREITs when interest rates fall or rise. When interest rates fall, homeowners are more likely to refinance their mortgages, meaning they will prepay. As a result, MBS holders are repaid more quickly than they would be if there were no prepayment option, and they are likely to suffer losses when their funds are returned to them and must be reinvested at the prevailing lower market yields. When interest rates rise, homeowners are less likely to refinance their mortgages, meaning MBS maturities (or, alternatively, durations[35]) are extended. Therefore, the value of the MBS declines in response to this rise more than it would for a "plain vanilla"

[33] Figures are for the 26 firms that fit our mREIT definition and are as of December 31, 2012. See Table 5.

[34] We don't have a figure for the average maturity of all mREITs' MBS holdings. This figure (4.5 years) is the weighted average maturity of Annaly (2012, F-16) and American Capital Agency Corporation (2012, 44) only.

[35] From Vickery and Wright (2013): "Duration is a measure of the maturity of a fixed-rate security or, equivalently, its sensitivity to movements in interest rates. A duration of four years implies that a 1 percent change in yields is associated with a 4 percent change in price. Note that this market rule-of-thumb estimate of MBS duration is approximate—because future prepayment rates are unknown, the expected duration

bond (one without any call or prepayment features). This is because the increase in interest rates extends the maturity or duration of the MBS—due to the embedded prepayment option in mortgages—thereby producing more losses.

Credit Risk

Agency MBS has come to dominate mREIT holdings as non-agency MBS issuance declined to just a few billion per year starting in 2008 (see Figure 7).[36] Therefore, today's mREITs face little credit risk—the danger that the issuer of the security (the borrowing firm) will be unable to repay all of the principal or interest promised in the security contract, leading to a loss for the security holder. However, mREITs have historically held a mix of mortgage-related securities, including non-agency MBS and therefore at times have been exposed to credit risk (Figure 10). If the non-agency MBS market recovers, mREITs may, once again, increase their holdings of non-agencies, thus making credit risk a greater concern.

Liquidity Risk

Liquidity risk arises for mREITs because of their reliance on short-term funding. If an mREIT's counterparties grew concerned about its financial health, these counterparties could become unwilling to roll over their repo funding. Because mREITs are highly dependent on short-term funding, such unwillingness could quickly cause mREITs to go out of business. For instance, the mREIT Thornburg Mortgage (Thornburg) financed $29 billion of non-agency MBS it owned in the second quarter of 2007 with repurchase agreements and asset-backed commercial paper. Between the second and third quarter of 2007, Thornburg began having trouble rolling over its repos and eventually had to repay $14.2 billion[37] of its repo borrowings, in part by selling assets.[38,39] Ultimately, Thornburg defaulted on JPMorgan when

of an MBS will fluctuate over time because of variation in market conditions and the term structure of interest rates."

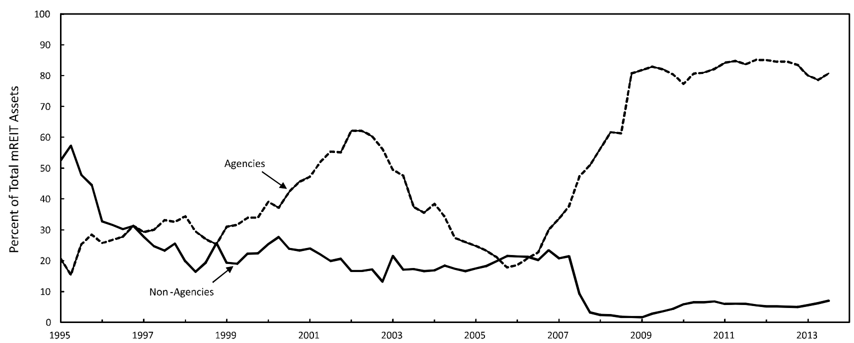
[36] www.sifma.org/research/statistics.aspx, "U.S. Mortgage-Related Issuance and Outstanding."

[37] Figure from the difference in repo holdings between 2007:Q3 and 2007:Q4 from Thornburg's 10-Qs.

[38] See Kingsbury and Wei (2007).

[39] From class action complaint: Case 1:07-cv-00815-JB-WDS Document 68 Filed 05/27/2008, UNITED STATES DISTRICT COURT, DISTRICT OF NEW MEXICO, IN RE THORNBURG MORTGAGE, INC Case No. 07-815 JB/WDS, SECURITIES LITIGATION.

Figure 10 Non-Agency and Agency Holdings for All mREITs



Notes: Quarterly holdings of non-agency MBS and agency MBS as a percentage of total assets of mREITs. Data from mREITs listed in Table 5.

Sources: SNL Financial and Richmond Fed.

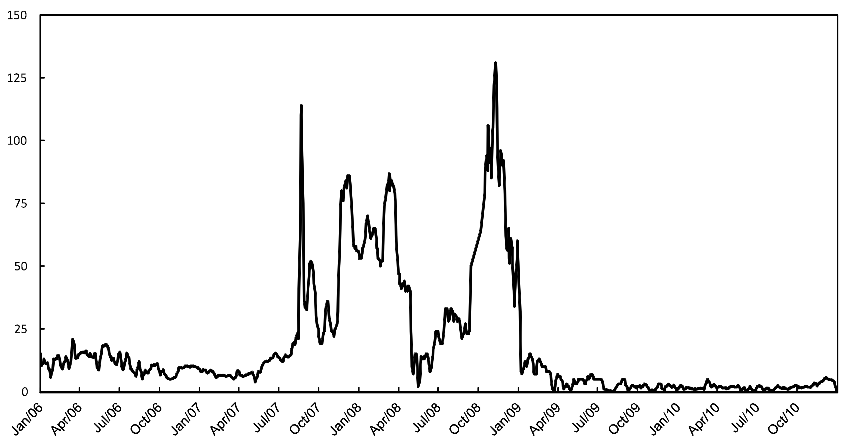
they failed to meet a margin call on a repo agreement.[40,41] This default triggered "cross-default provisions"—a feature that is common to the repo market—whereby the default on one repo contract automatically puts the borrower in default on other repo contracts. These provisions can exacerbate liquidity risk because they create the possibility that all of an mREIT's repo creditors may instantly demand their money back regardless of the maturity of repo contracts.

While for Thornburg the losses occurred because of its non-agency MBS holdings, today's mREITs invest predominantly in agency MBS. Excluding other problems at an agency-MBS-focused mREIT, one would imagine that liquidity risk would be a fairly minor problem given that repos backed by agency MBS could easily be rolled over because they enjoy an implicit government guarantee. However, if lenders were to become unwilling to accept agency MBS collateral, mREITs could experience trouble rolling over their repos. Figure 11 suggests that during the financial crisis repo lenders did become less willing to accept agency

[40] See Bogoslaw (2008), Mildenberg (2008), and Thornburg (2008).

[41] Thornburg ultimately declared bankruptcy on April 1, 2009, at which point any remaining repo contracts would have been terminated and may have been immediately liquidated. See McCarty (2009).

Figure 11 Spread between Agency MBS Term Repo Rate and Treasury Term Repo Rate



Notes: Five-day centered moving average of spread between 60-day agency MBS repo and 60-day Treasury repo, in basis points.

Sources: ICAP/Bloomberg and Richmond Fed.

MBS as collateral, at least relative to U.S. Treasury securities, as evidenced by the widened spread between MBS-backed and Treasury-backed repo rates (Figure 11). As some observers have claimed, there was a flight to the highest quality securities, i.e., Treasury securities, during the financial crisis, which could be one explanation for the widened spread.[42]

Risk Management

mREITs engage in several forms of risk management in order to limit some of the risks we have just outlined. Because the fundamental feature of mREITs is that they engage in maturity transformation, most of their risk management efforts are focused on addressing interest rate risk, but some efforts simultaneously address liquidity risk and

[42] http://research.stlouisfed.org/publications/regional/10/07/treasury_securities.pdf, p. 18.

prepayment risk. One such activity that addresses both interest rate risk and liquidity risk is laddering—spreading out the maturities of their financing so that all of their liabilities do not come due at once. Beyond laddering, mREITs also hedge using simple and complex derivative-based strategies to address interest rate risk and the risks associated with the prepayment option embedded in MBS.[43] Currently, mREITs are less concerned with managing credit risk since their portfolios are comprised largely of agency MBS.

Figure 12 illustrates the magnitude of the asset-liability mismatch of one of the largest mREITs (AGNC) and the extent to which it hedges. The size of the "bubbles" indicates the amount of either the notional values of swaps and swaptions or market values of agency MBS and repos. The vertical axis represents the interest rates earned on assets (positive numbers), repo rates paid (positive numbers), and net swap rates on hedges (fixed pay less floating receive rate).[44] The horizontal axis represents the maturity (in days) of assets, liabilities, or derivative contracts. From the figure, it is clear that AGNC's MBS have a much greater average maturity (and yield) than their repo liabilities, but some of this mismatch is offset by the swaps and swaptions, albeit at a cost.

Laddering

Repo financing is typically thought of as being very short term—having an overnight maturity.[45] If all mREIT repo financing was overnight, they would be exposed to bank-like runs, since all of their liabilities would mature daily. In other words, it is possible that all mREIT creditors could, on a given day, refuse to roll over their repo financing; just like all depositors of a bank could demand their funds on a given day—producing a run. mREITs typically will arrange their repo funding such that their contracts have various terms to maturity, which can mitigate the possibility of bank-like runs.

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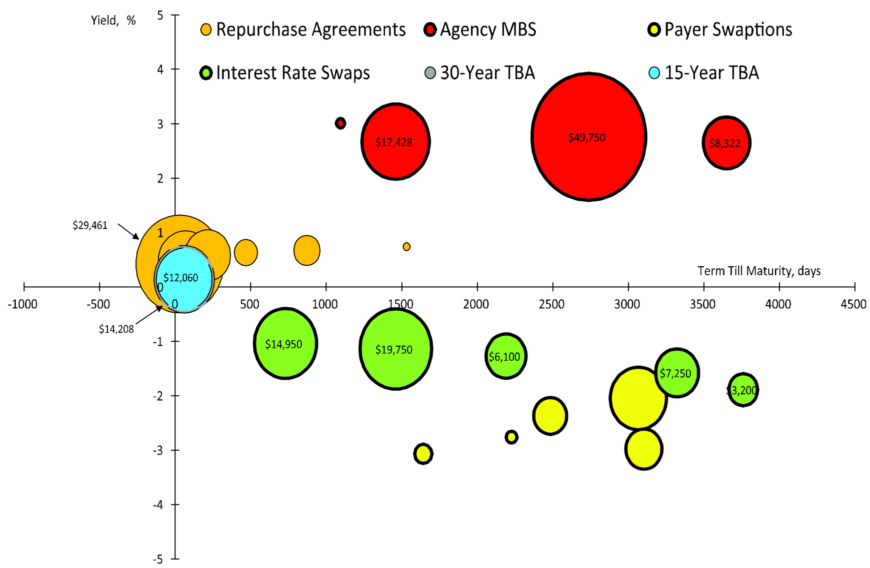
[43] One might imagine that mREITs would need to address prepayment risk associated with declining interest rates (the chance that falling interest rates will cause mortgage borrowers to refinance, and therefore repay their mortgages, forcing mREITs to need to reinvest these received funds at the new lower interest rate) because MBS contains such risk. However, because mREITs' have longer-term assets than liabilities, a decline in interest rates would reduce their funding costs, tending to offset any losses produced by prepayments.

[44] Interest payments on repos are expressed as a positive number, rather than a negative number, to allow readers to more easily visualize the net interest margin (spread).

[45] Investopedia defines a repo contract as "a form of short-term borrowing for dealers in government securities. The dealer sells the government securities to investors, usually on an overnight basis, and buys them back the following day" (www.investopedia.com/terms/r/repurchaseagreement.asp).

Figure 12 AGNC's Balance Sheet and Hedges



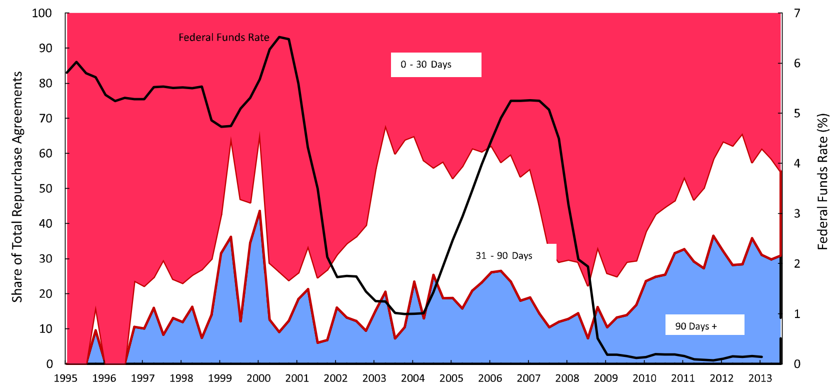
Notes: For swaps and swaptions, the "yield" is the receive rate minus the pay rate; the size of the bubble refers to the notional dollar amount. For agency MBS the value is their fair value, the yield is the current yield, and the life is the estimated average life. For repos, notional is the size and yield rate is the repo rate. The term until maturity for ARMS was their average number of days until reset. TBAs are net notionals, rate is dollar roll, implied financing rate, and maturity is 60 days. The 30-year TBA bubble lies behind the 15-year TBA bubble and is of similar size, so it is obscured. All dollar amounts are in millions.

Sources: Richmond Fed and AGNC 2013:Q1 10Q.

While over the last couple of decades the majority of mREITs' repo contracts have had maturities of fewer than 30 days, a large portion of their repo financing has still been for greater than 30 days, particularly in periods when interest rates were expected to rise.[46] As seen in Figure 13, mREITs increased the proportion of repos with maturities greater than 30 days beginning in 2002 and again in 2009, periods during which it seemed clear that interest rates could only increase. Creditors may have greater concerns about the health of firms, such

[46] The decline in the use of repos with maturities greater than 30 days during the 2007–09 financial crisis could have been, in part, due to broker-dealers' efforts to shorten the maturities of their repo loans.

Figure 13 mREITs Share of Repo Borrowing by Maturity and Federal Funds Rate



Sources: SNL Financial, Haver Analytics, and Richmond Fed.

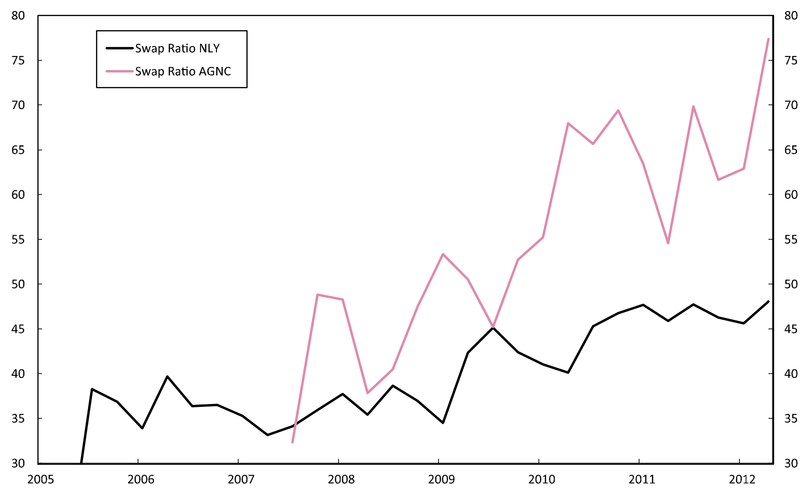
as mREITs, which have significant maturity mismatch, when rising interest rates are expected to produce losses.

In addition to protecting them somewhat from liquidity risk, lengthening repo maturities also reduces interest rate risk to a limited extent because it reduces the maturity gap between their assets and liabilities. Despite their use of laddering, as seen in Figure 12, their liabilities (orange bubbles) still have significantly shorter maturities than most of their assets (red bubbles). Thus, while laddering can mitigate some of the rollover risk mREITs face, it still leaves them exposed to interest rate risk.

Fixed-for-floating interest rate swaps

Of all their risk management activities, mREITs rely most heavily on interest rate swaps to manage interest rate risk. In fact, the notional value of their swaps at the end of 2012 totaled $160 billion (equal to 37 percent of all mREIT assets) (Table 5). Because mREITs' funding costs (determined by repo rates) adjust more quickly than the interest earnings on their MBS portfolio, when interest rates rise, their net income declines. To compensate for the increased funding costs, mREITs enter into fixed-for-floating rate swap contracts that pay off when interest rates rise. Fixed-for-floating swaps, in this case, will pay the mREIT's swap counterparty a fixed rate while the mREIT receives a

Figure 14 Annaly and AGNC's Swap Ratio



Notes: Swap ratio is defined as the notional amount of swaps divided by the repo borrowings outstanding.

Sources: AGNC and NLY 10K/10Qs, Richmond Fed.

floating rate tied to some short-term market interest rate index, such as the London Interbank Offered Rate (LIBOR). Since short-term interest rates tend to move together, the income that an mREIT receives on its contract will increase at the same time that their repo costs are increasing.

The average swap ratio for all mREITs—total notional value of swaps divided by total repos—was only 50 percent as of December 31, 2012 (Table 5). This means that approximately 50 percent of any rise in mREITs' repo funding costs resulting from an increase in market rates will be offset by the income received on these swap contracts. However, given that the two largest mREITs have recently added, rather aggressively, to the amount of their interest swaps, this figure is larger than it was in recent years and appears to continue to trend upward. Combined, these mREITs increased the notional amount of their swaps by $68 billion from 2010 to the second quarter of 2013, providing evidence that they were expecting interest rates to rise (Figure 14).

Other commonly used hedging activities

Beyond laddering and entering into interest rate swaps, mREITs engage in a number of other activities to hedge interest rate risk caused by their maturity mismatch. mREITs use the measure duration to estimate the size of their maturity mismatch. Specifically, mREITs control their duration gap (duration of assets minus duration of liabilities) by engaging in hedging activities such as swaptions, options, futures, and short sales.[47] Table 4 shows the market values and durations of all of AGNC's assets, liabilities, and hedges as of the first quarter of 2013 and the resulting net duration gap. A positive duration gap, such as AGNC's, means that a firm will experience losses when interest rates rise. The larger the positive duration gap, the larger the losses.

Some observers argue that there exists a feedback between hedging and the volatility of market interest rates. Hedging, therefore, is seen as one way mREITs potentially pose risks for the broader financial system (Financial Stability Oversight Council 2013, 88–9).

5. RISKS mREITS POSE (SYSTEMIC RISKS)

While mREITs' holdings of MBS are only a small share of all MBS outstanding (see Figure 4), a number of observers have raised concerns about the potential systemic impact of mREIT problems. A sudden rise in interest rates, a decline in MBS prices caused by other market forces, or any event that causes mREITs to lose a significant portion of their funding, could lead to rapid deleveraging by mREITs and possibly declines in MBS prices broadly and problems for other financial firms.[48]

For example, one observer argues that a 50-basis-point sudden increase in interest rates could lead to a decline in the values of mREITs' MBS portfolios and significant mREITs sales, and generate "temporary dislocations in MBS markets" (International Monetary Fund 2013, 10).[49] More specifically, the idea seems to be that an initial increase in market interest rates could produce mREIT actions—sales of MBS—that could amplify the initial interest rate movement, thereby producing large enough increases in mortgage rates to slow the growth of home sales.

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[47] mREITs may also modify their portfolio holdings as a means of controlling their duration gap.

[48] These concerns are raised in the following: Financial Stability Board (2013, 38–9), Financial Stability Oversight Council (2013, 7 and 87–90), International Monetary Fund (2013, 9–14), and Office of Financial Research (2013, 16–8).

[49] See the Financial Stability Board (2013, 39) and the Office of Financial Research (2013, 16) for a discussion of similar concerns.

Table 4 AGNC Balance Sheet and Hedges

Assets	**Market Value**	**Duration**
Fixed	74.8	4.2
ARM	0.8	1.8
CMO	0.7	6.7
TBA	27.3	4.4
Cash	3.3	0.0
Total	106.9	4.1
Liabilities and Hedges	**Market Value/Notional**	**Duration**
Liabilities	−66.3	−0.3
Liabilities (Other)	−0.9	−7.0
Swaps	−51.3	−4.5
Preferred	−0.2	−8.4
Swaptions	−22.9	−1.9
Treasury/Futures	−13.6	−6.8
Total		−3.6
Net Duration Gap		0.5

Notes: CMO balance includes interest-only, inverse interest-only, and principal-only securities; "Liabilities (Other)" represents other debt in connection with the consolidation of structured transactions under generally accepted accounting principles; the "Net Duration Gap" is derived from the weighted duration of assets and liabilities and is not calculated by simply summing the various durations listed here.

Source: American Capital Agency Group, Investor Presentation, June 12, 2013, p. 24.

Observers have also noted that mREITs are important suppliers of MBS collateral to the tri-party repo market, and that rapid mREIT sales of MBS could have negative effects on this market (Office of Financial Research 2013, 16). Presumably, the concern here is that the withdrawal of this collateral from the market could impede the smooth functioning of the tri-party market and perhaps reduce the ability of other tri-party-dependent borrowers to raise funds in the tri-party market. Still, this could only be a problem if the buyers of the MBS that are being sold by mREITs tend to hold these MBS in portfolio, rather than themselves returning them to the tri-party market in repo loan transactions.[50]

[50] Some observers refer to this as a reduction in "collateral velocity." See Singh (2011) for more information on collateral velocity.

Table 5 mREITS—Financial Highlights

Name	Some Facts: External Manager	Some Facts: Date Established	Some Facts: Type	Some Facts: Net Interest Margin (3)	Some Facts: Short-Term Leverage (1)	Swaps: Swap Ratio (2)	Swaps: Swaps Notional (Bil. USD)	Swaps: Weighted Average Pay Rate	Swaps: Weighted Average Recieve Rate	Swaps: Weighted Average Years to Maturity
AG Mortgage Investment Trust	1	3/7/2011	Hybrid	2.54	5.3	51.8	2.17	1.172	0.309	4.42
American Capital Agency Corp.	1	1/7/2008	Agency	1.87	6.8	62.9	46.85	1.46	0.29	4.4
American Capital Mortgage Investment Corp.		3/15/2011	Hybrid	2.31	6.8	47	2.94	1.33	0.32	5.5
Annaly Capital Mgmt Inc.	1	11/25/1996	Agency	1.14	6.5	45.6	46.91	2.21	0.24	4.77
Anworth Mortgage Asset Corp.	1	10/20/1997	Agency	1.03	7.5	39.4	3.16	1.98	3M LIBOR	2.8
Apollo Residential Mortgage	1	3/15/2011	Hybrid	2.7	5.1	41.1	1.5	1.2	3M LIBOR	5.3
ARMOUR Residential REIT Inc.	1	2/5/2008	Hybrid	1.45	8	47.4	8.7	1.2	0.21	5.3
Bimini Capital Mgmt Inc.	1	12/19/2003	Agency	0.87	42.6	0	0			
Capstead Mortgage Corp.		9/5/1985	Agency ARM	1.09	8.5	0	0			
Chimera Investment Corp.	1	6/1/2007	Hybrid	3.64	0.4	88.2	1.35	1.81	0.21	
CYS Investments	0	1/3/2006	Agency	1.14	5.8	53.6	7.49	1.27	3M LIBOR	2.7
Dynex Capital Inc.	0	12/18/1987	Hybrid	2.05	5.8	41	1.46	1.53	1-3M LIBOR	3.4
Five Oaks Investment Corp.		3/28/2012	Hybrid	5.3	2.5	50	0.04			
Hatteras Financial Corp.	1	11/5/2007	Agency ARM	1.16	7.4	46.8	10.7	1.47		2.6
Invesco Mortgage Capital Inc.	1	6/5/2008	Hybrid	1.81	6.1	50.9	8	2.13	1M LIBOR	
JAVELIN Mortgage Investment Corp.**	1	6/18/2012	Hybrid	0.66	7.7	28.9	0.33	1.5		9.3
MFA Financial Inc.	0	4/10/1998	Hybrid	2.7	2.6	28.8	2.52	2.31	0.22	1.4
New York Mortgage Trust Inc.		6/24/2004	Hybrid	3.38	2.8	40.4	0.36	0.74		
Newcastle Investment Corp.	1	10/10/2002	Multiple	4.23	0.9	16.1	0.15	5.04		
Orchid Island Capital Inc.	1	8/17/2010	Agency	1.66	7.06	0	0			
PennyMac Mortgage Investment		5/18/2009	Multiple	2.21	1.05	0	0			
Resource Capital Corp.	1	3/8/2005	Multiple	4.85	0.2	127.3	0.14	4.94	.21 (1M LIBOR)	
Starwood Property Trust Inc.		5/26/2009	CMBS & CRE	7.58	0.5	19.5	0.255	1.39	LIBOR	
Two Harbors Investment Corp.	1	5/21/2009	Hybrid	2.64	3.7	99.6	12.57	0.85	0.426	2.85
Western Asset Mrtg Cap Corp	1	6/3/2009	Agency	3.68	9.2	58.7	2.81	1.2		7.2
ZAIS Financial Corp	1	5/24/2011	Hybrid	3.92	1.8	25	0.03	1.51	0.31	5.3
Summary Statistics				2.6	6.3	50.2	160.435	1.82	0.28	4.48

Name	Repurchase Agreements: Repurchase Agreements (Bil. USD)	Repurchase Agreements: Weighted Avg. Repo Rate	Repurchase Agreements: Weighted Avg Days Till Maturity	Repurchase Agreements: Weighted Avg. Haircut	Repurchase Agreements: Counterparties (list specific counterparties*)	Portfolio Composition and Assets: Agency Secs as a % of Total Assets	Portfolio Composition and Assets: Total Assets (Bil. USD)	Portfolio Composition and Assets: Total Agency Holdings (Bil. USD)
AG Mortgage Investment Trust	4.19	0.78	36.9	6.90%	30	77.98	4.86	3.79
American Capital Agency Corp.	74.48	0.51	118	<5%	32	83.33	100.45	83.71
American Capital Mortgage Investment Corp.	6.25	0.57	50	4.7% Agency, 29.5% Non-Agency	29	82.73	7.7	6.37
Annaly Capital Mgmt Inc.	102.79	0.63	191	5%		92.89	133.45	123.96
Anworth Mortgage Asset Corp.	8.02	0.47	34	4.86%		99.46	9.29	9.24
Apollo Residential Mortgage	3.65	0.61	20	3-7% for Agency MBS, 10-50% for non-Agency MBS	17	73.27	4.49	3.29
ARMOUR Residential REIT Inc.	18.37	0.49	34	4.80%	26*	91.48	20.88	19.1
Bimini Capital Mgmt Inc.	0.15	0.49	14	5.10%	6*	89.47	0.19	0.17
Capstead Mortgage Corp.	12.78	0.47		4.50%	23	95.78	14.47	13.86
Chimera Investment Corp.	1.53	0.52	56	5%		23.39	7.74	1.81
CYS Investments	13.98	0.48	19.6	3-6%	23*	98.77	21.06	20.8
Dynex Capital Inc.	3.56	0.7	67	7.4% Agency, 19.5% non-Agency	19*	81.54	4.28	3.49
Five Oaks Investment Corp.	0.08	0.85	17	10%	4*	58.33	0.12	0.07
Hatteras Financial Corp.	22.87	0.47	24.8	4.34%	24	90.61	26.4	23.92
Invesco Mortgage Capital Inc.	15.72	0.78	17	4.74% Agency, 17.86% non-Agency, 18.91% CMBS	26*	67.69	18.91	12.8
JAVELIN Mortgage Investment Corp.**	1.14	0.62	41	6.40%	18	86.05	1.29	1.11
MFA Financial Inc.	8.75	0.85	79	4.8% Agency, 30.49% non-Agency, 1.74% Treasuries	26*	53.48	13.52	7.23
New York Mortgage Trust Inc.	0.89	0.54	39	5% Agency RMBS (excluding Agency IOs), 25% Agency IOs, 35% CLOs, total weighted average “haircut” of 6.9%	11*	13.97	7.16	1
Newcastle Investment Corp.	0.93	0.81	36.5	5% FNMA/FHLMC, 34% non-Agency RMBS, 50% CDO VI	5*	20.76	3.95	0.82
Orchid Island Capital Inc.	0.1	0.49	15	5.60%	4*	100	0.12	0.12
PennyMac Mortgage Investment	0.16	0.64	69		5*	0	2.56	0
Resource Capital Corp.	0.11	2.28	18	3.60%	3*	0	2.48	0
Starwood Property Trust Inc.	1.31				8*	0	4.32	0
Two Harbors Investment Corp.	12.62	0.72	85	8.40%	21*	69.01	16.81	11.6
Western Asset Mrtg Cap Corp	4.79	0.48	19	3-5.5 percent for agency, up to 25 percent of IOs and IIOs, 30 percent for Non-Agency	14	95.15	5.36	5.1
ZAIS Financial Corp	0.12	.49 Agency, 2.15 Non-Agency		3 - 5% Agency, 20 - 40% non-Agency.	3	35	0.2	0.07
Summary Statistics	319.34	0.68	47.86	5.4% (Agency), 29%(non-Agency)	17.05	81.8	432.06	353.43

Notes: As of December 31, 2012. Short-term leverage is defined as the amount of repurchase agreement liabilities as a ratio of equity. Leverage ratios below 6 are in blue. Swap ratios above 50 percent are in blue with the red text and below 50 percent is in pink with light blue text. NIM are from the SNL Financial (Financial Highlights) for 2012:Q4. Year-end measures are used instead of 2012:Q4 if no 2012:Q4 estimate is provided.

Sources: Respective 2012 10K/10Qs, Richmond Fed.

Regardless of such systemic concerns, and the various risks faced by mREITs (interest rate, prepayment, credit, and liquidity risks), the mREIT industry seems to have weathered recent stresses reasonably well. During the crisis of 2007 and 2008 only two mREITs failed, both of which invested primarily in non-agency MBS, and the industry as a whole produced fairly consistent earnings through the crisis (see Figure 5). In the years following the crisis, short- and long-term interest rates had been consistently falling or flat until long-term rates bottomed out in mid-2012 and then, beginning in May 2013 increased rapidly through the summer (10-year Treasury rate increased from 1.70 percent in May to 2.92 percent in September). One might expect that such an increase would lead to significant MBS sales by mREITs, and that such sales could have an impact on MBS interest rates. Indeed mREITs did sell following the rate increase and interest rates on MBS rose over this period. However, it is not clear that mREIT sales amplified interest rate increases. Surprisingly, given mREITs' heavy reliance on leverage and significant maturity mismatch, mREITs don't seem to have reacted as strongly to rising interest rates as some other players. As illustrated in Figure 1, mREITs' repo borrowings only account for about one-quarter of the decline of dealer-provided MBS repo funding, indicating that other parties reduced their MBS repo funding even more, and likely sold even more MBS.

6. CONCLUSION

Policymakers, the press, and other observers have raised concerns about possible systemic risks that may flow from mREITs, especially given the speed with which they have grown over the last five years. mREITs invest heavily in MBS, a long-term asset, and fund these investments largely with term repo, a fairly short-term liability.

Clearly investors in mREITs have reason to be concerned given that this asset-liability mix leaves mREITs critically exposed to interest rate risk. In fact, recent interest rate increases have caused mREITs to shrink and have produced significant declines in mREIT stock prices.

Still, the danger to the financial system more broadly is less clear. For one thing, interest rates would need to increase significantly and rapidly to cause widespread mREIT insolvencies. Additionally, mREITs' share of all MBS outstanding, while not insignificant, is only about 6 percent as of December 31, 2012 (Securities Industry and Financial Markets Association 2011; Table 5), so that any problems at mREITs would have to be magnified by counterparty actions in order to produce system-wide problems.

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Does Intra-Firm Bargaining Matter for Business Cycle Dynamics?

Michael U. Krause and Thomas A. Lubik

We analyze the aggregate implications of intra-firm bargaining in a fully fledged, yet simple, general equilibrium business cycle model with search and matching frictions in the labor market. The notion and relevance of intra-firm wage bargaining in such a setting was introduced to the labor economics literature in a classic article by Stole and Zwiebel (1996).[1] The central idea is that a firm is a web of bargaining relationships between its factors of production, or more narrowly and specifically, between the owners of the firm and the workers it employs. Under the assumption that labor contracts are nonbinding, that is, workers can quit any time and firms can lay off workers at will, wage determination can therefore be understood as an ongoing bargaining process *within* the firm. Before production takes place, and within a time period, both workers and the firm can revisit an existing wage negotiation. As Stole and Zwiebel (1996) have demonstrated, this intra-firm bargaining has implications for allocations whenever the scale of the firm changes non-linearly with its labor input. In this case, marginal revenue depends explicitly on the number of workers employed, which changes the incentives for a firm in a noncooperative bargaining setting. In particular, it leads to over-hiring

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[1] Their article takes inspiration from and shares many features with the seminal article by Jensen and Meckling (1976) on the theory of the firm from an organizational design perspective.

compared to an environment where intra-firm bargaining does not play a role.

This idea has bearing for macroeconomic models that incorporate search and matching frictions in the labor market. Intra-firm bargaining is not an issue in the standard search and matching model of Shimer (2005), which uses the assumption of one-worker one-firm matches such that the scale of the firm is independent of the labor input. However, in frameworks that incorporate concave production and downward-sloping demand,[2] such as in the New Keynesian search and matching model of Krause and Lubik (2007), intra-firm bargaining would have to be taken into account through its effect on steady-state allocations and business cycle dynamics.

In this article, we thus demonstrate by means of a simple search and matching model how intra-firm bargaining implies a feedback effect in the bargaining process from a firm's marginal product to wage setting. The firm has an incentive to increase production in order to decrease the marginal product, and thus the wages of existing employees, in order to capture higher rents. In effect, the firm reduces the bargaining position of the marginal worker by over-hiring. This partial equilibrium scenario, however, implies a general equilibrium feedback effect in that it leads to an expansion in production and thus a higher surplus to be shared among more workers. With a tighter labor market, the additional hiring of firms improves the outside options of workers and thus raises their wage in general equilibrium.

The main contribution of this article lies in the analysis of business cycle dynamics in addition to the above steady-state effects. It is motivated by the observation that these feedback effects are not taken into account in many business cycle models that incorporate search and matching frictions, which may raise concerns as to the robustness of their results. When compared to a specification that neglects intra-firm bargaining, we find that the dynamic response of the economy to a productivity shock is barely affected. The response of unemployment is slightly magnified, depending on the degree of returns to scale and the elasticity of demand. Similarly, employment and vacancies rise slightly more than without taking intra-firm bargaining effects into account. In this respect, intra-firm bargaining plays a role as the bargaining position of workers improves by less than is mandated by the rise in labor market tightness. However, intra-firm bargaining does not affect the

[2] Intra-firm bargaining under concave production has previously been studied by Smith (1999), Cahuc and Wasmer (2001), Cahuc, Marque, and Wasmer (2008), and Rotemberg (2008). The implications of downward-sloping demand schedules have been analyzed by Ebell and Haefke (2003) and also Rotemberg (2008).

qualitative response of the economy and an overall effect on output is virtually nonexistent.

We interpret our findings to the effect that, in many circumstances, researchers may safely ignore intra-firm bargaining even when analyzing business cycle models with large firms that face decreasing returns or downward-sloping demand. This is not meant to imply that there may not be important and interesting effects on the steady state of a model. This has been explored, for example, by Ebell and Haefke (2003). However, if we falsely calibrate a model without this strategic feedback on wages to actual data where it is present, the mistake we make is likely to be small. We therefore conclude that intra-firm bargaining is not the driving force of significant cyclical dynamics.

The article closest to ours conceptually is Rotemberg (2008), who incorporates intra-firm bargaining issues in a New Keynesian model with search and matching frictions. While he conducts a quantitative analysis, it is based on comparative statics around the steady state. In contrast, we perform a full calibration-based business cycle analysis, where we attempt to match the key labor market stylized facts. Cahuc and Wasmer (2001) and Cahuc, Marque, and Wasmer (2008) are similar in spirit in that they work out in detail qualitatively how the partial equilibrium effects of intra-firm bargaining have general equilibrium feedback. They work with a continuous-time framework, whereas we use a discrete-time setting that is common in business cycle literature. More recently, Hertweck (2013) provides independent quantitative and qualitative evidence in a model with strategic wage bargaining that intra-firm bargaining effects are negligible for aggregate dynamics.

In the rest of the article we proceed as follows. We first provide a simple static example to develop some intuition about the implications of intra-firm bargaining. The subsequent section outlines the model under the assumption of decreasing returns to labor and matching frictions in the labor market. This allows us to disentangle the relevant effect without much complexity. We then add general equilibrium constraints, calibrate the model, and proceed to analyze the steady state and business cycle implications graphically and numerically. In Section 5, we discuss the similarities of the results to the case of monopolistic competition, and show the robustness of our findings to its inclusion alongside decreasing returns. The final section concludes and highlights some further connections to the literature.

1. THE SIMPLE INTUITION OF INTRA-FIRM BARGAINING

The gist of our analysis can be illustrated by means of a simple static example that abstracts from search and matching frictions. Consider a simple bargaining problem of a large firm that negotiates with each worker individually. Employed workers bargain over the wage w, with their outside option being unemployment that generates benefits b. The firm's bargaining position is given by the surplus that an additional worker generates, net of its outside option, which is the value of leaving the job unfilled. This outside option is zero.

Let the firm's price be p and its output y. The firm pays wage w and employs n workers. Its value is given by its revenue minus cost, which consists of the wage bill and the hiring cost:

$$V = py - wn. \tag{1}$$

Consider value maximization with respect to employment:

$$\frac{\partial V}{\partial n} = \underbrace{\left[\frac{\partial p}{\partial y}y + p\right]\frac{\partial y}{\partial n}}_{mr} - \underbrace{\left[\frac{\partial w}{\partial n}n + w\right]}_{mc}, \tag{2}$$

where we allow for the price to depend on output, which in turn depends on labor input. This covers the cases of downward-sloping demand and concave production. Moreover, we take into account that the wage schedule depends on the level of employment, which is the source of the intra-firm bargaining problem. The first term in the brackets on the right-hand side would not be present if the firm were a price taker in the product market; without concavity in the production function, the partial derivative $\partial y/\partial n$ would be independent of employment. If the firm were a price taker in the labor market, the first term in the second brackets would be absent. It would equal zero when firms can only hire one worker, or when the firm does not internalize the feedback from its employment choice to the wage schedule. The value of a marginal worker is therefore the difference between marginal revenue and marginal cost, $mr(n) - mc(n)$, which we indicate as depending on the level of employment.

In a standard search and matching framework, wages are typically determined using the Nash bargaining solution, which maximizes the weighted product of the involved parties' surpluses. Given a worker's bargaining weight η, the solution would be

$$w - b = \frac{\eta}{1-\eta}\left[mr(n) - mc(n)\right]. \tag{3}$$

Inserting the marginal cost term and taking account of the dependence of the wage on employment yields

$$w(n) = \eta \left[mr(n) - \frac{\partial w(n)}{\partial n} n \right] + (1-\eta)b. \quad (4)$$

The wage is a weighted average of the firm's marginal revenue and the worker's outside option. The second term in brackets captures the effect from intra-firm bargaining. Marginal revenue is adjusted for the feedback of the employment choice on the wage, which in turn affects the optimal number of employees.[3] Stole and Zwiebel (1996) have shown that this prompts the firm to over-hire. This feedback effect crucially relies on the assumption that the firm's marginal revenue function is not independent of employment. Otherwise, as in the basic one-worker one-firm setup of Pissarides (2000) or Shimer (2005), the wage would not depend on n as $mr(n) = p$, for all n, and the firm would have no incentive to strategically adjust its marginal revenue schedule since hiring an additional worker would have no effect (Smith 1999).

2. A BUSINESS CYCLE MODEL WITH SEARCH FRICTIONS AND INTRA-FIRM BARGAINING

We now embed the above mechanism in a simple model in which production is characterized by decreasing returns to labor and firms are large in the sense that they employ multiple workers. This contrasts with the standard search and matching framework in which production originates in one-worker one-firm pairs. We assume an economy with a continuum of firms that use labor as the only input in production. The production function of a typical firm is given by

$$y_t = A_t n_t^{\alpha}, \quad (5)$$

where $0 < \alpha \leq 1$, and A_t is a stochastic productivity process common to all firms; n_t is the measure of workers employed by the firm. We assume that all firms behave symmetrically, and consequently suppress firm-specific indices. With the total labor force normalized to one, aggregate employment is identical to firm-level employment. Unemployment is defined as

$$u_t = 1 - n_t. \quad (6)$$

The labor market is characterized by search and matching frictions encapsulated in the matching function $m(u_t, v_t) = m u_t^{\xi} v_t^{1-\xi}$. It

[3] This expression is a partial differential equation that we can solve under parameteric assumptions for the marginal revenue function. We will demonstrate that the solution implies a wage schedule that in equilibrium scales the marginal revenue component of the wage schedule.

describes the outcome of search behavior of firms and workers in that unemployed job seekers u_t are matched with vacancies v_t at rate $m(u_t, v_t)$ to produce new employment relationships. $0 < \xi < 1$ is the match elasticity of the unemployed, and $m > 0$ describes the efficiency of the match process. Using the definition of labor market tightness $\theta_t = v_t/u_t$, the aggregate probability of filling a vacancy (taken parameterically by the firms) is $q(\theta_t) = m(u_t, v_t)/v_t$. The evolution of employment is then

$$n_{t+1} = (1-\rho)[n_t + v_t q(\theta_t)]. \quad (7)$$

$0 < \rho < 1$ is the (constant) separation rate that measures inflows into unemployment.

Firms maximize profits by choosing employment next period and vacancies to be posted, subject to the firm-level employment constraint. This job creation comes at a flow cost $c > 0$. The Bellman equation is

$$\mathcal{V}(n_t) = \max_{n_{t+1}, v_t} \left\{ A_t n_t^{\alpha} - w(n_t)n_t - cv_t + E_t\beta_t \mathcal{V}(n_{t+1}) \right\}. \quad (8)$$

$\mathcal{V}(\cdot)$ is the value of the firm, β_t is the time-varying discount factor, and $w(n_t)$ is the wage schedule, which will be determined below. The notation indicates that the wage of the marginal worker potentially depends on the existing number of workers in the firm. The first-order conditions are

$$c = \mu_t(1-\rho)q(\theta_t), \quad (9)$$

$$\mu_t = E_t\beta_t \mathcal{V}'(n_{t+1}), \quad (10)$$

where μ_t is the Lagrange-multiplier on the employment constraint (7). The corresponding envelope condition is

$$\mathcal{V}'(n_t) = \alpha A_t n_t^{\alpha-1} - w(n_t) - \frac{\partial w(n_t)}{\partial n_t} n_t + E_t\beta_t \mathcal{V}'(n_{t+1}) \frac{\partial n_{t+1}}{\partial n_t}. \quad (11)$$

The presence of the derivative of the wage schedule reflects the impact of intra-firm wage bargaining. When choosing employment, firms take into account how an additional worker affects their bargaining position and thus wage setting.

We define the value of the marginal job $J(n_t) = \mathcal{V}'(n_t)$, and rewrite the envelope condition using $\partial n_{t+1}/\partial n_t = (1-\rho)$ from the law of motion (7):

$$J(n_t) = \alpha A_t n_t^{\alpha-1} - w(n_t) - \frac{\partial w(n_t)}{\partial n_t} n_t + (1-\rho)E_t\beta_t J(n_{t+1}). \quad (12)$$

With constant returns to scale, $\alpha = 1$, the marginal product of labor is A_t (the "one-worker one-firm" case), and the wage is independent of the firm's current employment level. The equation then reduces to the one in Pissarides (2000).

Combining this with the first-order conditions results in a vacancy-posting, or job creation, condition:

$$\frac{c}{q(\theta_t)} = (1-\rho)E_t\beta_t J(n_{t+1}), \tag{13}$$

which can alternatively be written as

$$\frac{c}{q(\theta_t)} = (1-\rho)E_t\beta_t \left[\alpha A_{t+1}n_{t+1}^{\alpha-1} - w(n_{t+1}) - \frac{\partial w(n_{t+1})}{\partial n_{t+1}}n_{t+1} + \frac{c}{q(\theta_{t+1})}\right]. \tag{14}$$

To gain some intuition, suppose firms anticipate an increase in productivity A_{t+1}. This raises the present value of profits and thereby the marginal benefit of hiring more workers at given marginal cost $c/q(\theta_t)$. Other things being equal, more vacancies are posted, and n_{t+1} is expected to be higher, which, in turn, reduces expected marginal product of labor until equality is restored.

This adjustment is affected by two additional channels. The first takes place within the firm, hence the label intra-firm bargaining. Adding a worker reduces the effective bargaining power of current workers and thus their wage. Assuming $E_t\partial w(n_{t+1})/\partial n_{t+1} < 0$, which we will show below to be true, this amplifies the incentive to post vacancies and employment increases further. In order to determine the quantitative significance of this effect, we need to solve for the equilibrium wage schedule $w(n_t)$, which is done below. The other channel is a feedback effect that arises in general equilibrium. As all firms post more vacancies, aggregate vacancies increase, the labor market tightens, and it becomes more costly to recruit additional workers with the rise in $c/q(\theta_t)$. Therefore, employment in each firm increases by less than it would if θ_t were constant.

Determining the Wage Schedule

Wages are determined based on the Nash bargaining solution: Surpluses accruing to the matched parties are split according to a rule that maximizes the weighted average of the respective surpluses. Denoting the workers' weight in the bargaining process as $\eta \in [0,1]$, this implies the sharing rule

$$W_t - U_t = \frac{\eta}{1-\eta}J_t, \tag{15}$$

where W_t is the asset value of employment, U_t is the value of being unemployed, and J_t is, as before, the value of the marginal worker to the firm.[4]

The value of employment to a worker is described by the following Bellman equation:

$$W_t = w_t + E_t\beta_t[(1-\rho)W_{t+1} + \rho U_{t+1}]. \tag{16}$$

Workers receive the wage w_t, and transition into unemployment next period with probability ρ. The value of searching for a job, when currently unemployed, is

$$U_t = b + E_t\beta_t[f_t(1-\rho)W_{t+1} + (1 - f_t(1-\rho))U_{t+1}]. \tag{17}$$

An unemployed searcher receives benefits b and transitions into employment with probability $f_t(1-\rho)$. The job finding rate f_t is defined as $f(\theta_t) = \theta_t q(\theta_t) = m(u_t, v_t)/u_t$, which is increasing in tightness θ_t. It is adjusted for the probability that a completed match gets dissolved before production begins next period.

We substitute these equations into the sharing rule (15) and, after some algebra, find the wage equation

$$w(n_t) = \eta\left[\alpha A_t n_t^{\alpha-1} - \frac{\partial w(n_t)}{\partial n_t}n_t + c\theta_t\right] + (1-\eta)b. \tag{18}$$

Because of the presence of the derivative of the wage schedule on account of intra-firm bargaining, this is a first-order differential equation, the solution of which is

$$w(n_t) = \frac{\alpha\eta}{1-\eta(1-\alpha)}A_t n_t^{\alpha-1} + \eta c\theta_t + (1-\eta)b. \tag{19}$$

The derivative with respect to employment is given by

$$\frac{\partial w(n_t)}{\partial n_t} = -\frac{(1-\alpha)\alpha\eta}{1-\eta(1-\alpha)}A_t n_t^{\alpha-2} < 0, \tag{20}$$

which, when inserted into (18), verifies the validity of the solution.

For given employment, intra-firm bargaining increases the wage by virtue of the scale factor $1/\left[1-\eta(1-\alpha)\right] > 1$. The addition of a worker to the workforce implies a higher value to the firm as it lowers the marginal product of all incumbent workers. A new worker has therefore a higher value to the firm than just his marginal product because he contributes to lowering the firm's wage bill. By the logic of bargaining, the surplus is split, and workers get their share in terms of a higher wage. However, for the very reason that adding workers reduces

[4] In models with one-worker firms, the net surplus of a firm is usually given by $J_t - V_t$, with V_t the value of a vacant job. By free entry, V_t is then assumed to be driven down to zero.

the wage bill, firms post more vacancies to increase employment. This lowers the marginal impact of adding workers, which falls in n_t. Thus, workers' marginal product declines with employment and hence their wage. Equation (19) gives the overall effect of the declining marginal product on the wage, corrected for intra-firm bargaining.[5]

The wage schedule can be used in the job creation condition (14) to yield

$$\frac{c}{q(\theta_t)} = (1-\rho)E_t\beta_t \left[\begin{array}{c} \frac{(1-\eta)}{1-\eta(1-\alpha)}\alpha A_{t+1}n_{t+1}^{\alpha-1} - \eta c\theta_{t+1} \\ -(1-\eta)b + \frac{c}{q(\theta_{t+1})} \end{array} \right]. \tag{21}$$

The effects of intra-firm bargaining are captured by the term $\frac{1}{[1-\eta(1-\alpha)]}$, which reflects the firm's internalization of the feedback from employment on the wage. It exerts a level effect in that the marginal benefit from adding workers is perceived to be higher. This induces more job creation. For the case of constant returns, $\alpha = 1$, the equation collapses to the usual form, and intra-firm bargaining is irrelevant. However, our argument has so far relied on partial equilibrium reasoning from the perspective of the firm. We will analyze the general equilibrium feedbacks both on the steady-state allocation and on the model's adjustment dynamics below.

Wage Determination without Intra-Firm Bargaining

We assume from the outset that firms internalize the dependence of the wage schedule on employment (see [8] and [11]). This allows them to act strategically and extract rents from workers. Alternatively, assume that firms behave myopically by taking the wage of their incumbent workforce as given when choosing employment. This amounts to setting $\partial w_t/\partial n_t = 0$ in the firms' problem. In this case, the value function of the firm is

$$J(n_t) = \alpha A_t n_t^{\alpha-1} - w_t + (1-\rho)E_t\beta_t J(n_{t+1}). \tag{22}$$

Following the same steps as outlined above, we find the corresponding wage equation

$$w_t = \eta\alpha A_t n_t^{\alpha-1} + \eta c\theta_t + (1-\eta)b, \tag{23}$$

[5] In a sense, this setup can be interpreted from the perspective of insider-outsider theory: Firms are willing to expand employment and incur vacancy costs in order to reduce the bargaining power of insiders. What is crucial is that incumbents' wages are not protected by long-term contracts but are constantly renegotiated. The term "bargaining power" is of course used loosely in the sense that the Nash bargaining parameter η is fixed.

and the job creation condition

$$\frac{c}{q(\theta_t)} = (1-\rho)E_t\beta_t\left[(1-\eta)\alpha A_{t+1}n_{t+1}^{\alpha-1} - \eta c\theta_t - (1-\eta)b + \frac{c}{q(\theta_{t+1})}\right]. \tag{24}$$

When comparing the two job creation conditions, the only algebraic difference is the term multiplying the marginal product of labor, namely $(1-\eta) < (1-\eta)/[1-\eta(1-\alpha)]$. Intra-firm bargaining scales the marginal product of labor and thereby introduces an additional incentive for vacancy posting. The wage equations and job creation conditions under both scenarios will be the reference points from which we evaluate the general equilibrium effects of intra-firm bargaining.

Closing the Model

We assume that all workers belong to a representative household that insures its members perfectly against income risk implied by the two states of employment and unemployment. By means of a complete internal asset market, incomes are pooled in such a way that all households choose the same level of consumption.[6] Assuming a CRRA-utility function for the household, we can thus construct an implied stochastic discount factor

$$\beta_t = \beta\frac{c_{t+1}^{-\sigma}}{c_t^{-\sigma}}, \tag{25}$$

which firms use to evaluate future revenue streams. $0 < \beta < 1$ is the household's subjective discount factor, and $\sigma > 0$ is the intertemporal elasticity of substitution; c_t is the household's consumption, which draws from production as described by the social resource constraint

$$c_t = y_t - cv_t. \tag{26}$$

Total hiring costs cv_t are subtracted from gross production as resources are lost in the search process.

3. THE GENERAL EQUILIBRIUM EFFECTS OF INTRA-FIRM BARGAINING

This simple search and matching model with concave production provides a laboratory for analyzing the qualitative and quantitative effects of intra-firm bargaining. We proceed in two steps. We first compute

[6] This assumption is standard in the literature following Merz (1995) and Andolfatto (1996). Note that the unemployed enjoy a higher level of utility than the working since they do not suffer the disutility of working.

the model's steady state and compare allocations across the two wage-setting assumptions. This discussion parallels the results in Cahuc and Wasmer (2001). In the second step, we study the dynamic behavior of the model and the implications for business cycle statistics.

In order to fix a baseline for the model's quantitative analysis, we calibrate the parameters to typical values found in the literature.[7] We set the discount factor $\beta = 0.98$ and choose $\sigma = 1$. The mean of the technology process A_t is normalized to one. We assume that the input elasticity $\alpha = \frac{2}{3}$, which is roughly the labor share in U.S. aggregate income. The separation rate is fixed at a value of $\rho = 0.1$, which is a midpoint of the range of values used in the literature. The match elasticity ξ is calibrated at 0.4 based on the empirical estimates in Blanchard and Diamond (1989), while the match efficiency parameter $m = 0.4$ is chosen to generate an unemployment rate of roughly 8 percent to 10 percent for the different model specifications. To be consistent with this, we fix vacancy creation costs c at 0.1. The benefit parameter b, which captures the outside option of the worker, is set to 0.4 as in Shimer (2005). Finally, the Nash bargaining parameter is set at $\eta = 0.5$.[8]

Steady-State Effects

The model's first-order conditions can be reduced to a two-equation system in unemployment u and vacancies v. The first equation is the Beveridge curve, and is derived from the employment accumulation equation (7) in steady state, after substituting the expression for the firm-matching rate $q(\theta)$ and unemployment $n = 1 - u$. After rearranging, this results in a relationship between v and u:

$$v = \left[\frac{\rho(1-u)}{(1-\rho)mu} \right]^{\frac{1}{1-\xi}} u. \tag{27}$$

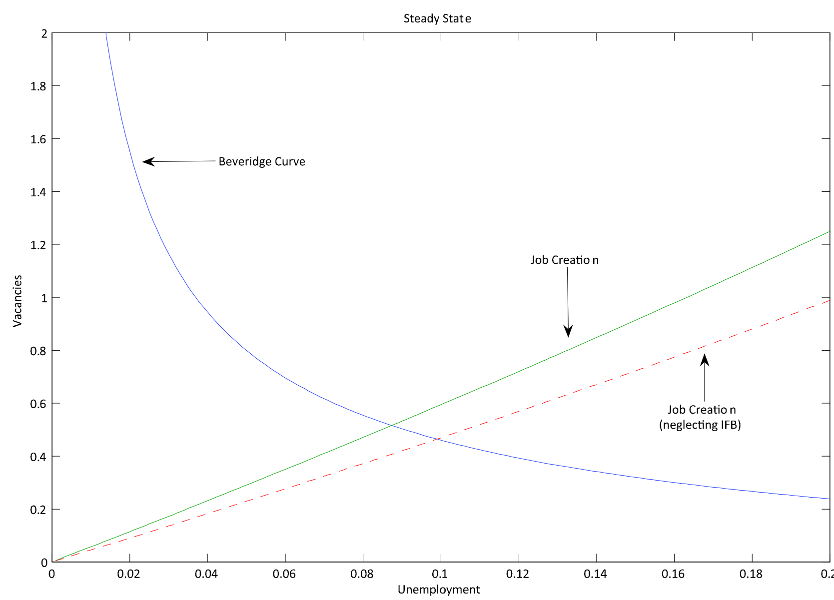
It is straightforward to show that this relationship is downward-sloping and concave in v-u space.

The second steady-state relationship is derived from the job creation condition (21). Substitution and rearrangement results in the

[7] A more detailed discussion of the calibration of a closely related model can be found in Krause and Lubik (2007).

[8] Note that this violates the efficiency condition in Hosios (1990). We do not regard this as restrictive for our purposes since, as Cahuc and Wasmer (2001) have shown, the efficiency condition is modified under intra-firm wage bargaining. Moreover, we are not explicitly concerned with welfare considerations. Tripier (2011) discusses the implications of intra-firm bargaining on efficiency grounds in a model with hiring and training costs. He finds that intra-firm bargaining internalizes the thus created externalities.

Figure 1 The Steady-State Effects of Intra-Firm Bargaining



following expression:

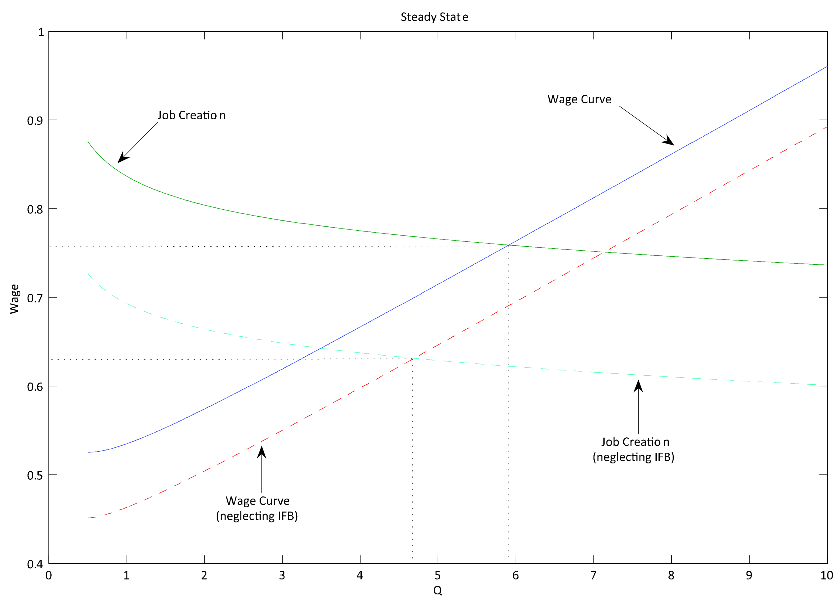
$$\frac{1-(1-\rho)\beta}{(1-\rho)\beta}\frac{c}{m}\left(\frac{v}{u}\right)^{\xi} = \frac{(1-\eta)}{1-\eta(1-\alpha)}\alpha A\,(1-u)^{\alpha-1} - \eta c\frac{v}{u} - (1-\eta)b, \tag{28}$$

for which no closed-form solution in terms of v is available. We note, however, that this equation defines the steady-state value of $\theta = v/u$, so that this is a linear function in v-u space, namely $v = \theta * u$. Consequently, the two curves intersect once, so that the model delivers a unique steady-state equilibrium. We solve the steady-state job creation condition numerically for our baseline calibration.[9] The two curves determining the steady state are depicted in Figure 1. The graph also contains the job creation curve that neglects the feedback from intra-firm bargaining, which is derived from (24).

Steady-state equilibrium is at the intersection of both curves, which yields an unemployment rate of 8.5 percent. Without intra-firm bargaining, the job creation schedule is flatter and tilts downward,

[9] See Lubik (2013) for further discussion of the simple analytics of the search and matching model.

Figure 2 Wage Determination in Steady State



resulting in steady-state unemployment of 10 percent. This confirms the result by Stole and Zwiebel (1996), subsequently refined by Cahuc and Wasmer (2001), Ebell and Haefke (2003), and Cahuc, Marque, and Wasmer (2008), that intra-firm bargaining leads to over-hiring. Firms have an incentive to add more employees since the wage paid to all workers is declining in employment. This effect is mitigated by the feedback that hiring has on unemployment, as it raises labor market tightness and thus marginal hiring costs $c/q(\theta)$. Overall, the levels of vacancies and employment are higher in the intra-firm bargaining case since firms can generate higher surplus by diluting the effective bargaining power of their workers.[10]

The same reasoning can be illustrated with an alternative description of the steady state. We use the Beveridge curve to substitute out n in the wage equation (19), from which we derive a relationship

[10] The underlying mechanism is not a labor supply effect in the traditional sense, which would require increases in the wage in order to attract additional workers. More searchers find employment since the increase in vacancy postings increases labor market tightness, and thus increases the job-finding rate, which is enough to compensate the marginal unemployed worker for the lower wage rate.

between w and θ, labeled the "wage curve." The job creation condition can be rewritten in a similar way. Both schedules are depicted in Figure 2. We also plot the two schedules for the specification in which intra-firm bargaining is neglected. The graph shows that both wage and tightness are lower compared to the baseline with intra-firm bargaining.[11] Recall that, for given labor market tightness θ, higher employment allows a firm to reduce wages paid to workers and to increase overall profits. However, when all firms act in this manner, labor market tightness rises both due to more vacancy postings and a decline in unemployment. The overall effect on the wage is positive, so that intra-firm bargaining raises wages in general equilibrium, which Figure 2 illustrates.

Adjustment Dynamics and Business Cycle Statistics

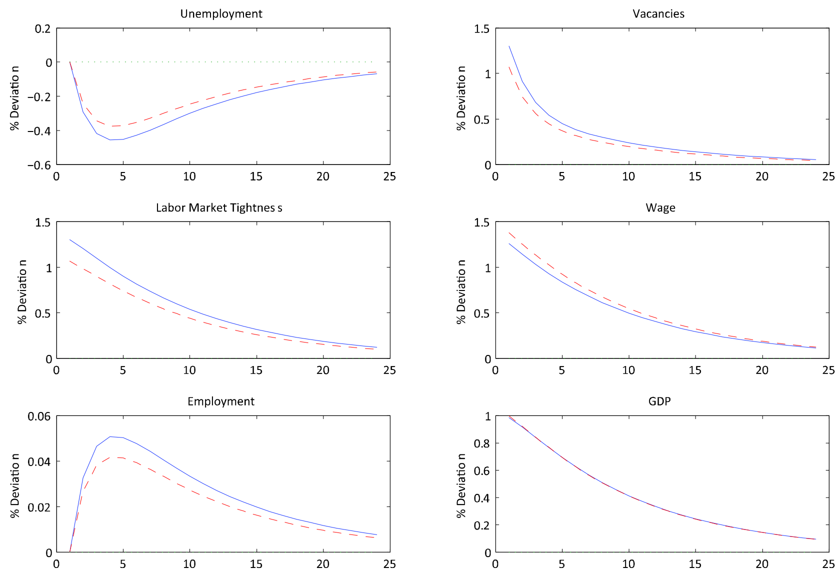
We now turn to an analysis of the effects of intra-firm bargaining on the dynamic properties of the model. In order to do so, we linearize both the baseline specification and the model that neglects intra-firm bargaining around their respective steady states. Strictly speaking, this analysis conflates two effects: the differences in steady state, and the differences in the coefficients in the dynamic model. It is quite conceivable that models with identical steady states can have different dynamic properties. Similarly, differences in responses (which are themselves measured in percentage deviations from the steady state) have to be interpreted with care as they are relative to different steady states. This implied error in our framework is likely to be small since the differences in steady states are small.[12]

The resulting linear rational expectations models are solved using standard techniques. We first compare dynamic adjustment paths toward the steady state after a productivity disturbance. Second, we contrast their predictions for business cycle statistics based on simulated data. In order to describe the stochastic properties of the model we have to calibrate the technology process. We assume that

[11] Since both schedules are affected under the different specifications, it may be conceivable that, say, the wage increased or decreased. Analytically, the schedules with and without IFB differ by a factor of $1/\left[1-\eta(1-\alpha)\right]$ that multiplies the marginal product of labor $\alpha A n^{\alpha-1}$. The schedules thus shift both in the same direction. It is only for very small values of θ that such a reversal can occur.

[12] The conceptual background we have in mind is that a researcher might ask how much of an error he commits when neglecting intra-firm bargaining. The reason for this neglect might be difficulty in solving differential equations of the type (18), and the possibly burdensome underlying first-order conditions. Alternatively, a researcher may be interested in exploring the implications of myopic behavior by firms that ignores the strategic incentives to expand employment.

Figure 3 The Dynamic Effects of Intra-Firm Bargaining



Notes: Impulse responses to a 1 percent productivity shock. Solid lines refer to the baseline, and dashed lines refer to the model without intra-firm bargaining.

productivity A_t follows an AR(1) process with autoregressive coefficient $\rho_A = 0.90$, and that it is driven by a zero mean innovation ε_t with variance $\sigma_\varepsilon^2 = 0.007^2$. This value is chosen to replicate the observed U.S. gross domestic product (GDP) standard deviation of 1.62 percent.

The impulse response functions for both specifications are depicted in Figure 3. Two observations stand out immediately. First, the model exhibits an almost complete lack of internal propagation. The behavior of GDP follows virtually in its entirety the adjustment path of the productivity process. This observation has been emphasized by Krause and Lubik (2007) and is a corollary to the Shimer (2005) argument that the standard search and matching model is unable to replicate the volatility of unemployment and vacancies. Second, and more importantly for our discussion, the responses are remarkably similar in terms of shape, size, and direction. A persistent 1 percent increase in productivity raises current production and future marginal products of labor. This raises the value of jobs, and thus vacancies posted, per

Table 1 Business Cycle Statistics

	Standard Deviations				
	u	v	θ	w	y
Intra-Firm Bargaining	0.78	0.95	1.55	0.98	1.62
Neglecting Intra-Firm Bargaining	0.68	0.84	1.36	1.02	1.62
U.S. Data	6.90	8.27	14.96	0.69	1.62
	Correlations				
	u	v	θ	w	y
u	1.00	−0.58	−0.85	−0.84	−0.86
v		1.00	0.91	0.92	0.91
θ			1.00	0.99	0.99
w				1.00	0.99
y					1.00

the job creation condition (21). This leads to increased employment in the following period (see equation [7]). Workers experience a rise in wages on account of higher productivity and labor market tightness. However, wages rise by less than productivity because of the strategic hiring decisions by firms. Thus, intra-firm bargaining does not change the basic dynamics of search and matching, but it (slightly) modifies its strength.

We also compare business cycle statistics computed from simulations of the two model specifications. The results are reported in Table 1. The baseline model is calibrated so as to replicate the standard deviation of U.S. GDP; the standard deviations of all other variables are then measured relative to this value. The overall impression is that the cyclical properties of the model with and without intra-firm bargaining are virtually identical. There is no difference in the behavior of output, which has already been apparent from the impulse response functions. However, when intra-firm bargaining is neglected, unemployment, vacancies, and tightness are roughly 10 percent less volatile than in the baseline case. When compared to the corresponding business cycle facts for the U.S. economy, both models fall woefully short: The latter statistics are off by a factor of 10, and the wage is 50 percent more volatile than in the data.

In terms of contemporaneous correlations, both specifications produce identical results. The models are reasonably successful in matching unemployment correlations. A benchmark statistic is the correlation between unemployment and vacancies. The model-implied value of −0.58 is not too far away from the value in U.S. data of −0.95. However, the models produce perfect correlation between the wage, θ, and output, which is inconsistent with the data. Overall, these results support the impression that a model with intra-firm bargaining is essentially observationally equivalent to one without. An empirical, likelihood-based test of both specifications would find it very difficult to distinguish between the two alternatives as they exhibit identical comovement and only minor differences between variable-specific volatilities. While intra-firm bargaining is a conceptually compelling idea, and quite conceivably relevant at the firm level, we conclude that it does not have a significant effect on aggregate dynamics.

4. MONOPOLISTIC COMPETITION AND INTRA-FIRM BARGAINING

An alternative source of declining marginal revenue is downward-sloping demand in an environment with monopolistically competitive firms. Even with linear production, firms would feel compelled to expand hiring since they can capture rents by moving down the demand curve. The assumption of price-setting monopolistic competitors has been used, for instance, in New Keynesian models of output and inflation dynamics with search and matching in the labor market. Key examples are Krause and Lubik (2007) and Trigari (2009).

We assume that output of a representative monopolistically competitive firm is linear in labor, $y_t = A_t n_t$, and that each firm faces a downward-sloping demand function for the product variety it produces, $y_t = (p_t/\overline{p}_t)^{-\epsilon} Y_t$, where Y_t is aggregate demand, and $\overline{p}_t$ is the aggregate price level, both taken as given by the firm; $\epsilon > 1$ is the elasticity of substitution between competing varieties, and p_t is the individual firm's price. The firm's real revenue is then given by

$$\left(\frac{p_t}{\overline{p}_t}\right) y_t = A_t^{\frac{\epsilon-1}{\epsilon}} Y_t^{\frac{1}{\epsilon}} n_t^{\frac{\epsilon-1}{\epsilon}}. \tag{29}$$

The asset equation for the value of a marginal job can be derived following the same steps as before:

$$J(n_t) = \frac{\epsilon-1}{\epsilon} A_t^{\frac{\epsilon-1}{\epsilon}} Y_t^{\frac{1}{\epsilon}} n_t^{\frac{\epsilon-1}{\epsilon}-1} - w(n_t) - \frac{\partial w(n_t)}{\partial n_t} n_t + (1-\rho) E_t \beta_t J(n_{t+1}). \tag{30}$$

Note that despite linear production, marginal revenue responds to changes in employment, which opens the possibility of intra-firm bargaining.

The asset equation for workers remains unchanged, and so does the sharing rule. We can consequently derive a wage equation as before:

$$w(n_t) = \eta \left[\frac{\epsilon-1}{\epsilon} A_t^{\frac{\epsilon-1}{\epsilon}} Y_t^{\frac{1}{\epsilon}} n_t^{-\frac{1}{\epsilon}} - \frac{\partial w(n_t)}{\partial n_t} n_t + c\theta_t\right] + (1-\eta) b. \tag{31}$$

The solution to this differential equation is

$$w(n_t) = \frac{\frac{\epsilon-1}{\epsilon}\eta}{1-\eta(1-\frac{\epsilon-1}{\epsilon})} A_t^{\frac{\epsilon-1}{\epsilon}} Y_t^{\frac{1}{\epsilon}} n_t^{-\frac{1}{\epsilon}} + \eta c\theta_t + (1-\eta)b. \tag{32}$$

It is straightforward to verify that this expression corresponds to the wage equation (19), derived under concave production, if $\alpha = \frac{\epsilon-1}{\epsilon}$. However, this neglects the general equilibrium feedback effect from the aggregate demand condition, captured by Y_t, which both parties in the bargaining process take as given. Substituting $Y_t = y_t = A_t n_t$, i.e., assuming a symmetric equilibrium, results in

$$w_t = \frac{\frac{\epsilon-1}{\epsilon}\eta}{1-\eta/\epsilon} A_t + \eta c\theta_t + (1-\eta)b. \tag{33}$$

The aggregate wage equation is now independent of employment (on account of constant returns in production), but the feedback effect from intra-firm bargaining modifies the productivity coefficient. If intra-firm bargaining is neglected, this coefficient is $\frac{\epsilon-1}{\epsilon}\eta < \frac{\frac{\epsilon-1}{\epsilon}\eta}{1-\eta/\epsilon}$.

This wage equation can be used to derive the job creation condition, which closely parallels (21):

$$\frac{c}{q(\theta_t)} = (1-\rho)E_t\beta_t \left[\frac{(1-\eta)\frac{\epsilon-1}{\epsilon}}{1-\eta/\epsilon} A_{t+1} - \eta c\theta_{t+1} - (1-\eta)b + \frac{c}{q(\theta_{t+1})} \right]. \tag{34}$$

Since the employment equation (7) is unaffected by the presence of monopolistic competition, we can describe the steady-state solution by references to Figures 1 and 2. In the former graph, the shape of the curves is unaffected, there is a unique equilibrium, and intra-firm bargaining results in over-hiring as the job creation curve tilts downward when intra-firm bargaining is neglected. Similarly, the steady-state relationships depicted in Figure 2 remain the same qualitatively. In the literature, the substitution elasticity ϵ is often calibrated with a value of 11, which implies a steady-state markup of 10 percent. Given our baseline specification with $\eta = 0.5$, the intra-firm bargaining feedback coefficent is $1/(1-\eta/\epsilon) \approx 1.05$, which is negligible with respect to steady-state values and dynamics.

5. A FINAL GENERALIZATION

Concave production and downward-sloping demand do not produce substantial effects of intra-firm bargaining on their own for plausible calibrations. We therefore combine both elements from before in the simple search and matching framework. Following the steps outlined earlier, the wage equation that takes into account the feedback from

Table 2 Intra-Firm Bargaining: Robustness

	$\eta = 0.5$		$\eta = 0.9$	
	$\alpha = 2/3$ $\varepsilon = 11$	$\alpha = 2/3$ $\varepsilon = 2$	$\alpha = 2/3$ $\varepsilon = 2$	$\alpha = 1/2$ $\varepsilon = 2$
Scale Factor	1.25	1.50	2.50	3.08
Employment w/ IFB	0.92	0.88	0.73	0.72
Percent Increase due to IFB				
Employment	3.7	6.0	35.2	41.2
Wage	30.6	48.4	137	167
Standard Deviation of θ				
Relative to Output	1.60	1.90	0.55	0.53
Percent Increase due to IFB	16.8	35.7	52.8	60.6

intra-firm bargaining is

$$w_t = \frac{\alpha\eta\frac{\epsilon-1}{\epsilon}}{1-\eta\left(1-\alpha\frac{\epsilon-1}{\epsilon}\right)} A_t n_t^{\alpha-1} + \eta c\theta_t + (1-\eta)b. \tag{35}$$

The job creation condition is

$$\frac{c}{q(\theta_t)} = (1-\rho)E_t\beta_t \left[\begin{array}{c} \frac{(1-\eta)\alpha\frac{\epsilon-1}{\epsilon}}{1-\eta\left(1-\alpha\frac{\epsilon-1}{\epsilon}\right)} A_{t+1} n_{t+1}^{\alpha-1} - \eta c\theta_{t+1} \\ -(1-\eta)b + \frac{c}{q(\theta_{t+1})} \end{array} \right]. \tag{36}$$

The specification without intra-firm bargaining results in the same equations, the difference being the denominator of the term pre-multiplying the marginal product of labor. The scale factor that measures the feedback from intra-firm bargaining is now $\frac{1}{1-\eta\left(1-\alpha\frac{\epsilon-1}{\epsilon}\right)}$. This factor is increasing in η, decreasing in α, and decreasing in ε. In other words, intra-firm bargaining affects steady-state allocations and business cycle dynamics more in economies in which workers enjoy higher bargaining power (large η), the labor share of income is small (low α), and markets are not very competitive (low ε).[13]

We illustrate the role of intra-firm bargaining in the extended model by a few numerical examples, which are reported in Table 2. We compute various model statistics for variations of the parameters affecting the scale factor. In particular, we contrast our baseline calibration with a high worker bargaining parameter ($\eta = 0.9$), a lower labor share ($\alpha = 0.5$), and inelastic demand ($\varepsilon = 2$). We first note that for an extreme parameterization, shown in the right-most column, the scale

[13] This reasoning underlies Ebell and Haefke's (2003) finding that product market deregulation can have substantial employment and welfare effects. In fact, their implied values for the substitution elasticity is $\varepsilon = 3$.

factor goes up to 3, compared to a baseline of 1.25. That this implies stronger effects of intra-firm bargaining is confirmed by the percentage increase of steady-state employment and wage over the case when intra-firm bargaining is neglected, as the percentage change is monotonically related to the scale factor. For baseline bargaining power, the change in employment is, however, fairly small, but more substantial for wages. With higher worker bargaining power, these numbers increase dramatically. What the percentages hide, however, are the actual steady-state levels. The second row in the table shows that employment actually falls with increases in the scale factor.

An increase in the scale factor also has a monotonic effect on the percentage change in the standard deviation of labor market tightness. For a given parameterization, the inclusion of intra-firm bargaining improves the predictive power of the model as far as the volatility of key labor market variables is concerned. However, this scale effect again masks the fact that with high η and low ε the standard deviation of θ is implausibly low. We conclude that the combination of concave production and downward-sloping demand can increase the strength of the feedback effect of intra-firm bargaining. From a pure calibration perspective, there is, however, a tradeoff between "maximizing" the intra-firm bargaining effect and the plausibility of key model predictions. For empirically relevant parameter values, the intra-firm bargaining effect still remains negligible as far as business cycle dynamics are concerned.

6. CONCLUSIONS

Intra-firm bargaining yields a strategic incentive for firms to expand employment in order to weaken their workers' bargaining position. This increases employment and raises wages in general equilibrium because lower unemployment and higher vacancies raise workers' outside options, thereby offsetting the partial equilibrium effect. While this is a conceptually compelling story of hiring behavior at a microeconomic level, we have shown in this article that the aggregate effects of intra-firm bargaining are negligible in a standard search and matching framework with concave production and downward-sloping product demand.

The results in this article should not be taken to imply that we regard intra-firm bargaining as irrelevant *per se*. The specification that combines both sources of declining marginal revenue product shows that somewhat extreme, but still plausible calibrations can imply large effects. This raises a few questions for further research. Given aggregate data, do the restrictions implied by intra-firm bargaining help with parameter specification? Specifically, the bargaining parameter η is difficult to pin down. Furthermore, it is often difficult to fit the behavior of the marginal product of labor, which might be ameliorated by the inclusion of the scale factor. A related question is to what extent it is possible to distinguish between the two specifications in aggregate data. Hertweck (2013) contains some effort in this direction using a structural VAR. A second line of research delves deeper into the production side. Cahuc, Marque, and Wasmer (2008) show that intra-firm bargaining has different effects with capital and heterogenous labor. Depending on the bargaining power of workers, it may actually lead to underemployment. Their analysis, however, is restricted to the steady state only.

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