Why Has the Size Effect Disappeared?

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Abstract

This paper explores why the size effect vanished after the early 1980s. We show that the size effects are significantly positive primarily at the bottom of the business cycles. More importantly, this dependency of the size effect on the business cycles is preserved even after the 1980s. Therefore, our findings suggest that while *unconditional* size effect has perished, the size effect *conditional* on the business cycles is alive and well. The less frequent occurrences of troughs, due to prolonged business cycle length, are shown to be responsible for the dissolution of the size effect.

JEL classification: E32; E44; G12; G14

Keywords: Size effect; Business cycle duration

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Abstract

This paper explores why the size effect vanished after the early 1980s. We show that the size effects are significantly positive primarily at the bottom of the business cycles. More importantly, this dependency of the size effect on the business cycles is preserved even after the 1980s. Therefore, our findings suggest that while *unconditional* size effect has perished, the size effect *conditional* on the business cycles is alive and well. The less frequent occurrences of troughs, due to prolonged business cycle length, are shown to be responsible for the dissolution of the size effect.

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1 Introduction

The small firm effect has generally been considered one of the biggest challenges to the efficient market hypothesis. Analyzing U.S. stock market data prior to 1980, Banz (1981) reports that small capitalization stocks far outperform large capitalization stocks, even after risk adjustment. His initial finding has been confirmed by a plethora of subsequent studies, suggesting that data mining is an unlikely explanation.[1] This evidence plays an important role in the development of small-cap mutual funds designed to take advantage of the size effect. Further, the size factor is commonly included in a variety of multi-factor models such as the Fama-French (1993) three-factor model and Fama-French (2015) five-factor model.

However, recent empirical literature shows that the size effect vanished after the early 1980s. Among others, Dichev (1998) and Chan, Karceski, and Lakonishok (2000) document that the relative performance of small and large firms has been much smaller and often even negative since the early 1980s. In his review article, Schwert (2003) concludes "it seems that the small-firm anomaly has disappeared since the initial publication of the papers that discovered it." His interpretation is that practitioners began to exploit the size effect in their trading activities, and the size anomaly vanished soon after its discovery. Hirshleifer (2001) also notes "the U.S. small firm effect has been weak or absent in the last 15 years."

This paper shows that a change in the duration of business cycles before and after the 1980s is the primary cause of the disappearance of the size effect. We begin our analysis by examining whether the size effect, the return differential between small and large cap stock portfolios, is dependent upon the state of the macroeconomy. We decompose the development of the business cycle into four distinct stages: 'Trough,' 'Expansion,' 'Peak,' and 'Recession.' We use the business cycle turning points identified by the National Bureau of Economic Research (NBER). We then examine the profitability of the SMB strategy, a

[1] Such studies include Reinganum (1981), Keim (1983), Lamoureux and Sanger (1989), and Fama and French (1992). Studies using data from non-U.S. stock markets confirm the robustness of the size effect. Heston, Rouwenhorst, and Wessels (1999) and Rouwenhorst (1999) find evidence of an international size effect in developed and emerging markets, respectively.

zero-cost investment strategy that is long on small firm stocks and short on big firm stocks, conditional on each phase of the business cycle over the period from March 1950 to December 2012. We also consider two subperiods as well: March 1950 to February 1983 and March 1983 to December 2012.

Our analysis uncovers some interesting stylized empirical facts. First, we find that time variation of the size effect is crucially dependent upon the economic state. The size effects are significantly positive only during the Trough stage. During the other states (Expansion, Peak, and Recession stages), the size effects are indistinguishable from zero. Specifically, over the period from March 1950 to December 2012, the average return on SMB is as large as 1.48% per month (t-statistic = 4.14) during the Trough stage, but is insignificant at the other stages.

Second, and perhaps more importantly, the dependency of the size effect on the business cycle is remarkably stable before and *after* the early 1980s. Put differently, the fact that the size effect is reliably positive only during the Trough stage is preserved even after the early 1980s during which the size effect is known to be dormant. A χ^2 statistic on the equality of the conditional size effects before and after the early 1980s reveals that there is no statistically significant difference between the two subperiods. This finding suggests that while the *unconditional* size effect vanishes after the early 1980s, its *conditional* dependency on the state of the macroeconomy is alive and well. These results remain robust even after controlling for the January effect.

The unconditional return is simply the weighted average of the conditional returns across the business cycle stages where each stage's probability of happening is assigned as a weight. Given that the cross-business cycle stage behavior of the size effect remains unchanged across the two subperiods, the natural suspect in the post-1980s disappearance of the unconditional size effect would be the substantial change in the probabilities. In fact, we find that the probability that the economy is in recessionary (expansionary) periods–defined as Recession (Expansion) through Trough (Peak) stages, significantly decreased (increased) after the early

1980s. Following Diebold and Rudebusch (1992), we formally test the statistical significance of this finding by using the Wilcoxon rank sum test. The test result statistically confirms the finding (at a 95 % confidence level). These results imply two significant changes in the shape of the business cycle. First, the duration of the business cycle itself has lengthened after 1983. Second, this longer duration is driven mostly by an elongated expansionary period. Thus the shape of the post-1980s business cycle is not only longer but also more asymmetric (longer expansion relative to recession). Of the two changes, the longer duration of the business cycle is the major driving force behind the disappearance of the size effect; it implies less frequent Troughs, the only stage where the size effect is statistically significant. The asymmetry by itself, as long as it does not accompany the longer duration of the business cycle, does not induce any change in the unconditional size effect because the size effect is essentially zero in both Expansions and Recessions.

Our finding suggests that the size effect after the 1980s may not be dead. Rather, it may be still viable but simply dormant. Like the 2,000 year-old Judean date palm seed that successfully germinated in 2009, the size effect may return if recessions become more frequent in the upcoming New Normal era. To see this, we consider a simple reduced-form model wherein the business cycle follows a stylized Markov process. First, we estimate a transition probability matrix for a Markov chain for the pre-1983 period as well as the post-1983 period. By doing so, we adopt separate data-generating processes for the evolution of the business cycle in the two subperiods. Second, we assume that small and large stock returns follow conditionally normal distributions where their means and variance/covariances depend on the business cycle stage. We use the conditional distributions estimated from the *whole* sample period. That is, we allow only the transition matrices to differ across the two subperiods, while holding all else constant. In this manner, we can attribute any difference in the (model-implied) size effect between the two subperiods entirely to the change in the transition matrix. Third, under the aforementioned assumptions, we simulate time-series of returns on small and large stocks and compare those results with estimates from the historical data. The simulation result shows that the size effect for the post-1983 period should be substantially smaller than that for the pre-1983 period. In addition, the size effect should be statistically insignificant during the post-1980s period. Our exercise demonstrates that changes in the shape of the business cycle are solely responsible for the evaporation of the size effect after 1983. The simulation exercise also enables us to compute the sensitivity of the unconditional size effect to the duration of expansionary periods.

Our result is more or less consistent with the imperfect capital market theory (Bernanke and Gertler, 1989; Gertler and Gilchrist, 1994; Bernanke, Gertler, and Gilchrist, 1996). The theory suggests that during the Recession stage, small firms are more likely to face significantly higher costs of external capital than large firms, and as a result, they are likely to be more heavily affected by adverse credit market conditions. On the other hand, during the Trough stage, when the economy begins to rebound, small firms benefit more from improving credit market conditions. If the market anticipates an improvement in credit market conditions as the economy transitions from a recessionary to expansionary state, the prices of small stocks will rebound more rapidly than those of large stocks. We interpret the significant and large profitability of the SMB strategy detected at the Trough stage as the result of the higher sensitivity of small stocks to changing credit market conditions, which is consistent with the imperfect capital market theory.

We do not attempt to measure a (conditional) risk premium (i.e., an *expected* return) on the SMB portfolio. Rather, we measure the size effect as the variation in the *realized* returns on the SMB portfolio (i.e., the profitability of the SMB strategy), and examine whether it is related to economic conditions.[2] Our goal in this paper is not to evaluate whether the size effect is a compensation for bearing some type of risk (thus providing a risk-based explanation), but rather to provide a plausible explanation for why realized return on SMB during the post-1983 period is small and insignificant. Our explanation relies on the uncovered relation between the size effect and business cycles, and should hold regardless

[2] We do not use the term, 'size premium,' to stress out that we do not study a risk premium on the SMB portfolio. Instead, we use the term, 'size effect,' throughout the paper.

of whether the detected relation reflects a risk premium or mispricing, or both. Our paper belongs to the strand of literature that examines realized returns of long-short strategies conditional on different economic conditions.[3] For instance, Chordia and Shivakuar (2002) analyze whether the profitabilities of momentum strategies is related to business cycles. Lustig and Verdelhan (2012) examine the variation in realized returns in bond and equity markets over the business cycle.

Our paper is also related to recent empirical studies of the size effect. Perez-Quiros and Timmermann (2000) show that small firms' stock returns are more sensitive to credit tightening than large firms' returns. They also report that small firms display a higher degree of asymmetry in their risk than large firms across high and low volatility states. Our study poses a different underlying question. Perez-Quiros and Timmermann (2000) attempt to directly test the predictions of imperfect capital market theories using a Markov switching regression model. In contrast, we explore why the size effect has disappeared since the early 1980s. In addition, their conditioning variables are volatilities, not business cycle stages. Even though volatility is, in general, negatively associated with the business cycle, their relationship is not described as a one-to-one mapping, as shown by Whitelaw (1994).[4]

The remainder of the paper proceeds as follows. Section 2 describes the data, presents the relation between the size effect and business cycle stages, and demonstrates that the distribution of the conditional size effect on the business cycle is stable before and after the early 1980s. Section 3 investigates whether the probability of the economy being in each

[3] An incomplete list includes: for the value premium, Lakonishok, Shleifer, and Vishny (1994), Liew and Vassalou (2000), Lettau and Ludvigson (2001); for the momentum effect, Chordia and Shivakumar (2002), Griffin, Ji, and Martin (2003), Cooper, Gutierrez, and Hammed (2004), Asem and Tian (2010), Stivers and Sun (2010), Daniel and Moskowitz (forthcoming); for the investment factor, Cooper and Priestley (2011); for the profitability factor, Wang and Yu (2013); for the accrual strategy, Chichernea, Holder, and Petkevich (2015).

[4] Our work is also related to the study of Hou and van Dijk (2012), who show that unexpected shocks to the profitability of small and large firms are responsible for the disappearance of the size premium from realized returns after the early 1980s. Specifically, they suggest that the size effect has disappeared because the returns of small firms were lower than expected due to negative cash flow shocks, whereas the returns of large firms were higher than expected due to positive cash flow shocks. Our result is not necessarily incompatible with their finding; the behavior of unexpected shocks to the profitability of small and large firms may be contingent upon the stage of the business cycle.

of the four stages has changed since the early 1980s. Section 4 illustrates the sensitivity of the unconditional size effect to the change in the duration of business cycles by using the reduced-form Markovian economy. Section 5 presents our conclusions.

2 The Size Effect and Business Cycle Stages

2.1 Data and Descriptive Statistics

We use returns on the small and large portfolios, which are constructed using the standard two-by-three independent sorts on size and the book-to-market ratio (Fama and French, 1993). Specifically, the six value-weighted portfolios (denoted S/L, S/M, S/H, B/L, B/M, and B/H) are constructed at the end of each June as the intersections of two portfolios formed on size (market capitalization) and three portfolios formed on the book-to-market ratio.[5] The S/H portfolio is composed of the stocks in the small size group that are also in the high book-to-market group, and the B/L portfolio comprises the large stocks that are also in the low book-to-market group. The small stock portfolio return is the average return on the three small size portfolios (S/L, S/M, and S/H), while the large stock portfolio return is the average return on the three large size portfolios (B/L, B/M, and B/H). The return on SMB (Small-Minus-Big) is then defined as the return spread between the small and large stock portfolios. This measure of the size effect has been used frequently in the extant literature, since Fama and French (1993). The portfolio data are from French's website.

The sample period is from March 1950 to December 2012. GDP data is available from 1947 forward but the sample data begins in March 1950 because the first few data points are discarded to synchronize the first sample date with the beginning of the first business cycle (i.e., Expansion stage in our analysis). We investigate the whole sample period (March 1950 to December 2012) as well as two subperiods (March 1950 to February 1983 and March

[5]The size breakpoint for year t is the median NYSE market equity at the end of June of year t. The book-to-market ratio for June of year t is the book equity for the last fiscal year end in $t-1$ divided by size for December of $t-1$. The book-to-market ratio breakpoints are the 30th and 70th NYSE percentiles.

1983 to December 2012). We split the sample period at 1983, because evidence suggests that the size effect disappeared in the early 1980s, and March 1983 marks the beginning of a particular business cycle.[6]

Table 1 summarizes the average monthly excess returns on the small stock portfolio and the large stock portfolio, and the average return on the SMB over the entire sample period as well as the two subperiods. During the first subperiod, the SMB earns a statistically significant return of 0.26% per month (t-statistic = 1.94), with more than 53% of the months showing positive returns. During the second subperiod, however, the size effect noticeably weakens. The average return on the SMB declines to 0.08% per month, which is statistically insignificant (t-statistic = 0.49). The aforementioned results confirm the disappearance of the size effect after the early 1980s, as documented in existing literature.[7]

2.2 Determination of Business Cycle Stages

In order to analyze the dependency of the size effect on the state of the macroeconomy, a critical issue is determining economic states. One popular approach in the literature is to dichotomize macroeconomic variations into two states–expansionary and contractionary phases.[8] This binary discretization scheme, however, has a disadvantage in that it does not separate out potentially important economic states – turning points of the business cycle. The asset-pricing literature finds that turning points are critical states for risk premium and risk-return trade-off. The theoretical models of Boudoukh et al. (1999) and Yang (2011) predict that the largest changes in asset prices or risk premium should occur around the

[6]Hou and van Dijk (2012) also split the sample period in 1983. They find that there is a structural break in the size effect in 1983 using Andrews (1993)'s structural break test. In addition, Stock and Watson (2002) document that approximately 40% of 168 macro variables have significant breaks in their conditional variance during 1983-1985.

[7]The results based on size decile portfolios show an even more dramatic change in the size effect. The difference in average returns between the smallest decile and largest decile portfolios is 0.50% per month (t-statistic = 2.23) for the pre-1983 period, and 0.01% per month (t-statistic = 0.03) for the post-1983 period.

[8]For instance, Liew and Vassalou (2000) define the 'good states' of the economy as the states that exhibit the highest 25% of future GDP growth, and 'bad states' as those with the lowest 25% of future GDP growth. Chordia and Shivakumar (2002) define expansionary and contractionary periods based on the NBER turning points.

turning points. The underlying intuition is that changes in investors' intertemporal marginal rates of substitution between current and future consumption are the largest around turning points in the economic cycle. Among empirical studies, Lustig and Verdelhan (2012) find that turning points are informative for understanding business cycle variation in equity risk premiums and Sharpe ratio. Pilotte and Sterbenz (2006) show that time-variation in risk and return on U.S. Treasury securities is crucially dependent on business cycle turning points. We therefore include turning points in our analysis and thus classify business cycle dynamics into four stages: 'Trough,' 'Expansion,' 'Peak,' and 'Recession.' Our finer discretization scheme allows us to examine whether conditioning the size effect on business cycle turning points is critical.

To this end, we adopt two different methodologies for defining business cycle stages. First, we use the business cycle turning points identified by the National Bureau of Economic Research (NBER). The NBER Business Cycle Dating Committee determines turning points based on its ex-post judgment on absolute declines in a wide spectrum of economic measures. Since the NBER designates only one particular month for a turning point, we define the Trough (Peak) stage by including three months before and after the trough (peak) month identified by the NBER, resulting in seven-month Trough (Peak) stage. In this way, we can assign a reasonably sufficient number of months to Trough and Peak stages, while also reducing potential misidentification errors of exact turning points. The Expansion (Recession) stage is defined as the path of the cycle from the Trough (Peak) stage to the Peak (Trough) stage. Any misidentification errors may affect our results negatively rather than positively.[9]

Second, we estimate the business cycles using a statistical method, and then decompose the business cycles into four stages. We employ the Hodrick-Prescott (1997) filter (HP filter, hereafter), which is designed to isolate an unobservable cyclical component from a time series with a deterministic or stochastic trend. Stock and Watson (1999) advocate this

[9] To check robustness, we also define Trough and Peak using a two-month window (instead of three), before and after the NBER turning point month. The empirical results are qualitatively similar.

filtering method. A turning point occurs when the deviation-from-trend series reaches a local maximum (peak) or a local minimum (trough). We identify the cyclical component of the GDP and use it as a business cycle in our analysis. The detailed procedure for identifying turning points and business cycle stages is presented in the Appendix.

It is worthwhile to compare the business cycle turning points determined by the NBER and those obtained using the HP filter. As noted, NBER timing is based on the *absolute cycle* approach, which measures a succession of periods of absolute growth and decline in economic activity. In contrast, the turning points determined by the HP filter are based on the *growth cycle* approach, which measures deviations from the long-term trend.[10] A decline in the output level from its local maximum (i.e., the peak of cyclical component) does not necessarily lead to a NBER recession, and the NBER determines the peak below its long-term trend, in general.[11] As a result, the NBER peak is likely to postdate the peak of cyclical component. On the other hand, NBER turning points are based on a wide spectrum of macro variables coupled with the committee's judgment, which may be more comprehensive.

Panels A and B in Table 2 report the chronology of the business cycle stages determined by the NBER and the HP filter, respectively, in the period from March 1950 to December 2012. The NBER designates ten cycles, while the HP filter identifies eight. The Trough stages identified by the NBER and HP filter are quite similar; seven out of eight Trough stages classified by the HP filter overlap with those classified by the NBER. For instance, November 1970 is classified as the Trough by the NBER. November 1970 is also the middle month of the Trough stage designated by the HP filter (which spans August 1970 through February 1971). The Trough stage determined by the HP filter completely misses the Troughs of July 1980 (the first Trough out of the double dip observed in the early 1980s) and March

[10]See Stock and Watson (1999) for an excellent summary on the empirical methods of business cycle analysis.

[11]Even the NBER press release on November 26, 2001 states that "a peak marks *the end of an expansion and the beginning of a recession*," *not* the peak of cyclical component.

1991 (the recession triggered by the S&L crisis).[12] It also fails to precisely time November 2001 as the Trough. In a sharp contrast with the Troughs, there are substantial discrepancies between the NBER Peaks and the Peaks identified by the HP filter. Only one out of ten NBER Peaks coincide with those designated by the HP filter. All the others fall within HP filter Recession stage. This inconsistency reassures that the NBER Peaks reflect the time of the cycle passing through the long-term trend and thus tend to lag behind the peak of the cycle.

2.3 The Size Effect across Business Cycle Phases

Table 3 documents the average (raw) returns and the CAPM-adjusted returns on the SMB portfolio across different business cycle stages. The CAPM-adjusted returns are the alphas (intercepts) from the regression of the time-series of the SMB returns on the market factor (CRSP value-weighted market excess return) plus the residuals averaged across months in each stage. Panels A and B report estimation results when business cycle stages are determined by the NBER and HP filter, respectively. Here we focus on the SMB returns. The behavior of small and large cap portfolios will be discussed in the next subsection.

From Table 3, it is clear that the size effects are significantly positive only at the Trough stage. At the other business cycle stages, the size effects are indistinguishable from zero. In Panel A, which shows estimation results based on business cycles designated by the NBER, the average return on SMB is large and reliably positive at the Trough stage: 1.48% per month (t-statistic = 4.14). This level of size effect (17.76% per annum without compounding) is remarkable given that the SMB is a zero-investment portfolio. As the business cycle moves toward the Expansion stage, the SMB return drops sharply toward zero (0.11% per month with t-statistic = 0.96). The return to the SMB strategy further declines and becomes negative (–0.25% with t-statistic = –0.72) at the Peak stage, remaining negative through the

[12] Most of the recessions identified by the NBER Business Cycle Dating Committee consist of two or more quarters of declining real GDP. However, the 2001 recession does not include two consecutive quarters of declining real GDP. The NBER specifically mentioned this recession as an exceptional case.

Recession stage (–0.51% with t-statistic = –1.51). The CAPM-adjusted return shows the same pattern: it is significant only at the Trough stage (0.95% with t-statistic = 2.75). That is, the return on SMB and its risk-adjusted return monotonically declines as the business cycle moves from Trough to Recession. This behavior is also observed in the probability of the positive size effect across business cycle stages. Along the path of the business cycle, the probability that the return on SMB is positive declines from 76% (Trough) to 49% (Expansion), down to 45% (Peak), and finally to 38% (Recession).

Panel B of Table 3 presents the estimation results obtained when business cycle stages are determined by the HP filter. The results are qualitatively similar; the size effect is positive and statistically significant only at the Trough stage. The average SMB raw (CAPM-adjusted) return is 1.25% (0.68%) per month with a t-statistic of 3.17 (1.83), which is similar in magnitude to that reported in Panel A. The average returns on SMB are again all indistinguishable from zero at other stages. The robustness of the finding that the size effect is significantly positive only at the Trough stage is somewhat expected, since the Troughs identified by the HP filter are almost identical to those identified by the NBER.

The only apparent difference between the NBER and the HP filter (albeit statistically insignificant) is that the size effect at the Recession stage, either in the form of raw return or risk-adjusted return, is positive when the HP filter is adopted. This is caused by two factors. First, as discussed in Table 2, the HP filter fails to identify two troughs (July 1980 and March 1991) designated by the NBER. The HP filter counts those two troughs (wherein the SMB shows strong performance) as Recession stages, thereby inflating the average SMB return at the Recession stage and deflating that at the Trough stage. Second, as discussed above, the NBER is more conservative in defining Recessions. Many of the months classified as Recession stage by the HP filter are counted as Expansion or Peak stages by the NBER. This is evidenced by the far greater number of months classified as Recession (201 months vs. 42 months), coupled with the smaller number of months classified as Expansion (434 vs 573) when the HP filter is employed. In sum, the SMB returns at Recession stage under the

HP filter scheme are diluted by those from the NBER Trough and Expansion stages. We find that the first is a more critical driver for inflating the size effect at the Recession stage. Therefore, the observed difference between the NBER and the HP filter size effects at the Recession stage provides another evidence that the size effect is significantly positive only at the Trough stages. In addition, the Troughs identified by the NBER are more convincing, given the strong size effect observed at the Trough stage.

We formally test whether the size effects at the Trough stage are different from those observed at other stages. To do so, we construct a trough-dummy, $D_{trough,t}$, which takes a value of one during the Trough stage, and zero otherwise. We consider the following regression equations:

$$SMB_t = \alpha + \beta_1 D_{trough,t} + \epsilon_t, \tag{1}$$

$$SMB_t = \alpha + \beta_1 D_{trough,t} + \beta_2 MKT_t + \epsilon_t, \tag{2}$$

where SMB_t is the monthly return on SMB, and MKT_t is the market excess return. We add the market excess return in Equation (2) to adjust for market risk. The regression intercept, α, measures the size effect during non-Trough stages, and the slope coefficient on a trough-dummy, β_1, reflects the incremental amount of size effect at the Trough. We also examine whether the business cycle variation in the profitability of the SMB strategy is driven by small stocks, large stocks, or both. To do so, we separately estimate Equation (2) by replacing SMB_t with excess return on the small portfolio and the large portfolio.

Table 4 reports estimation results. Again, Panels A and B report the results when the Trough stage is determined by the NBER and the HP filter, respectively. Panel A shows estimation results when SMB_t is used as a dependent variable; the coefficients on the trough-dummy are 1.44% (t-statistic = 3.86) and 0.97% (t-statistic = 2.67), without and with market adjustment, respectively. They are all positive and statistically significant, suggesting that the size effect is significantly higher at the Trough stage than at other stages, and this result is robust to risk adjustment. In addition, the intercept terms, which correspond to the size effect in non-trough stages, are slightly negative and not statistically significant. This confirms the fact that the size effects are trivial at non-Trough stages. Panel B presents estimation results obtained using the HP filter, and contains similar results (though the coefficient of the trough-dummy is slightly smaller). As mentioned above, the smaller value of the incremental size effect at the Trough stage implied by the HP filter is driven mainly by the fact that the HP filter fails to designate two critical troughs.

The regression results for the small and large portfolios complete the remaining picture. The results show that the conditioning effect that the business cycles has on the size effect is asymmetric between the small and large size portfolios. The trough-dummy for the small portfolio in Panel A shows that the risk-adjusted average return on the small portfolio is 1.02% higher per month (t-statistic = 2.94) at the Trough stage. In contrast, the coefficient on the trough-dummy for the large portfolio is as low as 0.05% and insignificant (t-statistic = 0.50), indicating that the risk-adjusted return on the large portfolio at the Trough stage is not different from those at the non-Trough stages. We obtain very similar results when the trough-dummy is designated using the HP filter. These results suggest that the small stocks play a critical role in driving variation in the size effect across economic cycles.[13]

Although not directly related to the main theme of this study, Table 4 sheds new light on why the empirical performance of the CAPM is so poor. Panels A and B show that the intercept terms ('α's at the non-Trough stages) for the small stock portfolio are insignificant, while those for the large stock portfolio are all significantly positive. That is, excluding the Trough stage, the risk-adjusted return on the small portfolio is well explained by the CAPM while that on the large portfolio is not. It is somewhat surprising that the CAPM has difficulty explaining the return on the large stock portfolio. While it is true that the CAPM is less capable of explaining returns on the small stock portfolio, this difficulty arises mainly at the Trough stage. The poor performance of CAPM may in fact be twofold. During

[13]Perez-Quiros and Timmermann (2000) use a Markov switching framework to examine whether the expected returns on small and large firms exhibit a differential response to worsening credit market conditions. Consistent with our finding, they show that small firms display a higher degree of asymmetry in their risk across high and low volatility states than do large firms.

non-Trough periods, it has difficulty explaining returns on the large stock portfolio. At the Trough stage, it fails to explain returns on the small stock portfolio. The CAPM's predicament itself varies with the business cycle stages.

In summary, our analysis uncovers an important empirical fact: the size effect is reliably positive only at the bottom of the business cycle. Having shown that our evidence is robust to alternative specifications of business cycle stages, we hereafter only report results using the business cycle stages determined by the NBER. In the next subsection, we discuss a potential explanation for this stylized empirical fact.

2.4 State Dependency of the Size Effect and the Imperfect Capital Market Theory

The imperfect capital market theory (Bernanke and Gertler, 1989; Gertler and Gilchrist, 1994; Bernanke, Gertler, and Gilchrist, 1996) predicts that small firms are more susceptible to changes in credit market conditions. Information asymmetry between firms and their creditors increases firms' cost of external capital. Small firms suffer from the higher degree of informational asymmetry because of their weak balance sheets, poor collateralization, and heavier exposure to idiosyncratic risks. In addition, small firms rely more heavily on bank loans and other intermediary sources of credit, due to limited access to public debt and equity markets. Given these two dynamics, the theory posits that small stocks are influenced more strongly by the vicissitude of credit conditions.[14]

The theory also predicts that the aforementioned asymmetric impact of credit market conditions on small and large firms varies across the different stages of the economic cycle. At the beginning of a recession, small firms' net worth, and therefore their collateral values, decline faster. This in turn makes it difficult to raise external capital. At the outset of an

[14] There is some empirical support for the imperfect capital market theory. Gertler and Gilchrist (1994) show that small firms' sales decline more than those of large firms during recessions and after periods of worsening credit market conditions. Kashyap, Lamont, and Stein (1994) report that small firms' investments are disproportionately affected by credit crunch during recessions. Perez-Quiros and Timmermann (2000) show that small firms' stock returns are more sensitive to credit tightening than large firms' returns.

economic downturn, liquidity dries up and short-term interest rates increase, encumbering the small firms even more in raising external capital. Consequently, a recession may prompt a 'flight to quality,' causing investors to move their money out of riskier small stocks and into relatively safer large stocks.

When the economy shows signs of bouncing back, the small firms are more willing than large firms to borrow to take advantage of favorable credit market conditions. Raising external capital is less urgent for large firms since they have a stronger capital base across economic states. As a result, small firms should benefit more from improvement in credit market conditions. If the markets anticipate an upcoming improvement in credit market conditions as the economy transitions from recessionary to expansionary states, small stock prices will recover more rapidly than those of large stocks.

We interpret our findings as generally consistent with these theoretical predictions. First, consider the Peak stage when the economy shifts from an expansionary to a recessionary state. The results reported in Panel A of Table 3 suggest that the stock prices of both small and large firms fall at the Peak stage, evidence that investors anticipate an economic slowdown and tighter credit conditions. Small stock prices fall more than large stock prices do; the average returns on small stocks and large stocks are –0.95% and –0.69% per month, respectively. The negative return spread between small and large stocks increases to –0.51% per month during the Recession stage. This behavior of the return on SMB (while statistically insignificant), is indicative of the 'flight to quality' that occurs during a recession state.

Our results around the Trough stage are also compliant with the imperfect capital market theory. At the bottom of a business cycle, prices of both large and small stocks rebound, driven by investors' expectations of an imminent economic recovery. More importantly, as credit market conditions improve, small firms have a leg up on large firms in terms of a faster recovery. This effect alone is strong enough to generate the significantly positive CAPM alpha of 0.95% (with a t-statistic = 2.75). In addition, Table 4 documents that small stocks, not large stocks, cause the observed variations in the size effect across business cycles. This asymmetry between small stocks and large stocks in their response to the business cycle turning point is further evidence for the imperfect capital market theory. Overall, these results can be interpreted as evidence of the greater sensitivity of small stocks to changes in credit market conditions.

Panel B of Table 4 shows that the average return on SMB during the Recession stage, defined by the HP filter, is positive. This is inconsistent with the theory. Again, this finding is driven by the HP filter's failure to identify the two aforementioned troughs. Once we adjust for this difference, the average return changes its sign to negative at the Recession even under the HP filter scheme.

Overall, we believe that the behavior of the SMB return at the Recession and Trough stages supports the imperfect capital market theory, albeit weakly.

2.5 Has the Relation between the Size Effect and Business Cycle Stages Changed?

This subsection explores whether any significant change occurs in the dependency of the size effect on business cycle stages after 1983. If so, such a change may be the driving force behind the post-1983 disappearance of the size effect.

Table 5 reports the size effect conditional on the business cycle stages for the pre- and post-1983 subperiods. The subperiod estimation results are similar to those for the full sample results as seen in Table 3. More importantly, we cannot see any dramatic change in the conditional size effect between the pre- and post-1983 subperiods. First, small stocks significantly outperform large stocks at the Trough stage, even after 1983. The monthly average returns on SMB at the Trough stage for the pre- and post-1983 subperiods are quite large, statistically significant, and almost identical at 1.49% (t-statistic = 3.47) and 1.45% (t-statistic = 2.26), respectively.[15] The size effects at the Expansion and Peak stages are

[15] This finding holds true when the business cycle stages are determined by the HP filter. The monthly

both statistically insignificant, in line with the result obtained for the whole sample period.

The only apparent change in the size effect is observed at the Recession stage; the size effect before 1983 is significantly negative at –0.83% (t-statistic = –2.37), but becomes positive (though insignificant) after 1983, at 0.19% (t-statistic = 0.26). This change may result from a shift in monetary doctrines and practices after 1983, particularly during the Greenspan years from 1987 to 2006. As emphasized in his speech at the AEA meetings in 2004, Greenspan advocated 'forward looking' and 'preemptive' monetary policy, i.e., taking actions long before inflationary or deflationary pressures appear in the economy. During the early years of his tenure (in the aftermath of the hyperinflation of the late 1970s and the early 1980s), his stance was more inclined toward preemptive tightening to contain inflation risk. But as evidenced in 1990, 2001, and 2003, he shifted policies toward preemptive easing, injecting liquidity into the economy with drastic rate cuts whenever economic downside risk appeared on the horizon. For example, the Fed cut the federal funds rate by 100 basis points in January 2001, even before the business cycle peaked in March. Rates were cut by another 350 basis points before the end of November, the month that marked the beginning of a recession according to the NBER (Mishkin, 2005). As a result, small firms suffered far less from credit constraints, especially during the Recession stage, after 1983.[16] Thus, the apparent difference in size effect at Recession stage before and after 1983 does not reject the imperfect

average SMB returns at the Trough stage are 1.23% (t-statistic = 2.51) and 1.30% (t-statistic = 2.30) for the pre- and post-1983 subperiods, respectively. Results are available upon request.

[16]We investigate whether there is any significant change in money supply after the early 1980s. To do so, we consider normalized money supply:

$$M_{2,t}^{N} = M_{2,t}/GDP_{t-1},$$

where $M_{2,t}$ is the M2 supply at time t and GDP_{t-1} is the GDP in the previous quarter. We compute the average *growth rate* of $M_{2,t}^{N}$ at each business cycle stage and test the statistical significance of a change between the pre-1983 estimate and the post-1983 estimate for each stage. The changes are –7bp per month (p-value = 0.587) at Trough, 1bp per month (p-value = 0.813) at Expansion, 23bp per month (p-value = 0.134) at Peak and 30bp per month (p-value = 0.092) at Recession. Thus, after 1983, money supply relative to GDP has risen except at the Trough stage, though this increase is (marginally) significant only at the Recession stage. Combining the observed increase in the post-1983 money supply during the Recession stage (and also the Peak stage) with the decrease in money supply during the Trough stage implies that the Fed did indeed pump money into the economy more preemptively after 1983. In fact, the highest growth rate of the money supply after 1983 occurred at the Recession stage. Before 1983, by contrast, the highest growth rate occurred at the Trough stage. Detailed estimation results are available upon request.

capital market theory, but rather supports it.

Table 6 provides evidence as to whether this difference in size effect at the Recession stage is statistically significant. Regardless of the outcome, however, this difference cannot *per se* be the main cause for the disappearance of the unconditional size effect. Rather, if the difference is statistically significant, it makes the disappearance of the size effect more puzzling, since a shift in size effect from negative to non-negative at the Recession stage should strengthen the unconditional size effect. We come back to this issue when we discuss Table 6 below.

In addition, the CAPM-adjusted size effects are similar in the two subperiods. They are significantly positive only at the Trough stage. Unlike the raw return, the risk-adjusted return is not statistically significant in the Recession stage even before 1983, at –0.41% (t-statistic = –1.00). This implies that the above-mentioned apparent difference in size effect at the Recession stage is driven by a change in small firms' sensitivity to the market; they used to be more sensitive to the market sell-off at the Recession stage before 1983 (i.e., higher market beta). After 1983, the Fed's preemptive monetary easing caused small firms to become less sensitive to the downward move of the market induced by the recession (i.e., lower market beta). In sum, the raw and CAPM-adjusted SMB returns at the Recession stage are compatible with the imperfect market theory.

Finally, we statistically test whether there is a structural change in the distribution of the conditional size effect across the two subperiods. Specifically, we examine whether the difference in the average SMB return between the pre- and post-1983 subperiods at each stage is statistically different from zero. More importantly, we conduct a formal statistical test of whether differences in the conditional size effects between the two subperiods are *jointly* equal to zero across the four business cycle stages. To do so, we consider the following regression equations:

$$SMB_t = \sum_{s=1}^{4} \alpha_s D_{s,t} + \sum_{s=1}^{4} \beta_s D_{s,t} \cdot TIME_t + \epsilon_t, \tag{3}$$

$$SMB_t = \sum_{s=1}^{4} \alpha_s D_{s,t} + \sum_{s=1}^{4} \beta_s D_{s,t} \cdot TIME_t + \gamma_1 MKT_t + \gamma_2 MKT_t \cdot TIME_t + \epsilon_t, \tag{4}$$

where $D_{s,t}$ and $TIME_t$ are dummy variables such that

$$D_{s,t} = \begin{cases} 1 & t \in s \\ 0 & \text{otherwise} \end{cases} \qquad TIME_t = \begin{cases} 1 & t \in \text{post-1983} \\ 0 & \text{otherwise} \end{cases},$$

where s is an indicator of business cycle stage such that 1=Trough, 2=Expansion, 3=Peak, and 4=Recession. In Equation (3), α_s refers to the pre-1983 size effect at state s while β_s indicates the incremental spread of the post-1983 size effect at state s. A similar interpretation can be made for α_s and β_s in Equation (4), but they are risk-adjusted. γ_2 is introduced to account for any potential change in the sensitivity of the SMB return on the market (i.e., market beta) before and after 1983.

Table 6 reports the estimates of β_ss with corresponding t-statistics. The estimated β_s indicates that at the Trough stage, the difference in the conditional size effect between the two subperiods is –0.04% per month and is statistically insignificant (t-statistic=–0.05). Similar results are shown across other business cycle stages. Notice that the SMB return difference even at the Recession stage, which is as large as 1.02% per month, is not statistically different from zero (t-statistic = 1.25). So the aforementioned change in monetary policy after 1983 has been successful in bolstering small firms, but not strong enough to make its effect statistically signficant.

More importantly, we use a standard $\chi^2(4)$ test to determine whether the four β_s coefficients are jointly zero. Its statistic is 2.505 with a p-value of 0.644, suggesting that we cannot reject the null that the conditional size effects are identical across the two subperiods. The results from the CAPM-adjusted returns also suggest that the conditional size effect on the economic state has not changed; the estimated χ^2 statistic is 3.315 with a p-value of 0.507.

Overall, these results confirm that there is no significant change in the relation between the size effect and business cycle stages before and after the early 1980s.

These results shed new light on the size effect. The dependency of the size effect on the business cycle stage has not gone through any structural change after 1983, the period during which the size effect is known to be dormant. So we can make the following important conclusion about the size effect: whereas the *unconditional* size effect is dead after the early 1980s, the size effect *conditional* upon the state of the economy is 'alive' and 'well.'

2.6 The January Effect

It is well documented that the size effect is particularly strong in January. For instance, Keim (1983) shows that about a half of the average magnitude of the size effect over the 1963–1979 period is made in January.[17]

We investigate whether our finding that size effect is significant at the Trough stage is driven by the January effect. In particular, we are interested in examining whether the conditional size effect on the Trough stage is also detected during non-January months.

Table 7 reports both unconditional and conditional size effects across two separate samples: January and non-January months. It confirms the strong January effect in the size effect for the pre-1983 subperiod. The monthly average SMB is 2.96% (t-statistic = 5.53) in January, but only 0.01% (t-statistic = 0.07) during non-January months. In the post-1983 subperiod, the January effect seems to be still present (0.83%), if only marginally (t-statistic = 1.58).

We next turn to the results for the size effect conditional on the business cycle stages. In January, the relation between the size effect and economic states is robust at the Trough

[17] Many researchers use the tax-loss selling hypothesis to explain the January seasonality of the size effect. Tax-motivated investors have an incentive to sell stocks that decline in price toward the end of the calendar year to realize capital losses and to take advantage of tax benefits, which leads to downward pressure on stock prices. After the turn of the year, in the absence of selling pressure, prices rebound. The effect could be particularly important for small stocks, since the stock prices of small firms tend to be more volatile than those of large firms. Empirical evidence for this explanation is mixed (Roll, 1983; Brown et al. 1983; Berges, McConnell, and Schlarbaum, 1984). Other proposed explanations include the information hypothesis (Keim, 1983) and window dressing hypothesis (Ritter and Chopra, 1989).

stage. Specifically, the average SMB returns at the Trough stage are consistently positive and significant for both subperiods: 5.25% (t-statistic = 3.25) and 2.45% (t-statistic = 2.54) for the pre-1983 and post-1983 subperiods, respectively. At other stages, by contrast, the size effects in January are inconclusive across the two subperiods. At the Peak and Expansion stages, the size effect is significantly positive before 1983 but loses significance (but remains positive) after 1983. Thus the January effect generally weakens after 1983, but remains significantly effective at the Trough stage.

The results most relevant to our study involve the behavior of the conditional size effect during non-January months. At the Trough stage, the returns on SMB during non-January months continue to be positive for both subperiods. The non-January SMB return at the Trough stage is 1.06% (t-statistic = 2.70) and 1.35% (t-statistic = 1.93) per month for the pre-1983 and post-1983 subperiods, respectively. These results suggest that our finding that small stocks outperform large stocks at the bottom of the business cycle is distinct from the January effect. The ability of Trough stage to detect the size effect remains robust even after controlling for the January effect.

Although not directly relevant to the theme of our study, we test whether there is any significant change in the January effect before and after the early 1980s. Table 8 shows that before 1983, the difference in the size effect between January and non-January months is significantly positive across all the business cycle stages except Recession. In contrast, the difference becomes insignificant across all the business cycle stages after 1983. Put differently, it is the January effect, not the conditional size effect, which vanished after the early 1980s!

3 A Change in Duration of Business Cycle

By definition, the unconditional size effect is the weighted average of conditional size effects over the business cycle stages where the weight is the probability of each business cycle stage. In the previous section, conditional size effects are found to have remained the same after the early 1980s while unconditional size effect vanished after that time. The only possible cause for the unconditional size effect vanishing after 1983 would therefore be changes in the weights, i.e., the probability of business cycle stages. In this section, we examine whether the probabilities of the U.S. business cycle stages genuinely shifted after early 1980s.

In our analysis, we define the length of business cycle turning points – the Peak and Trough stages – as seven months. As such, by construction, the durations of the Peak and Trough stages are not different between the pre- and post-1983 periods. In contrast, the durations of the Expansion and Recession stages are allowed to change over time. To investigate a structural change in the durations across our two subperiods, we therefore merge the Peak and Expansion stages; we define an *expansionary period* as the period from the first month of the Expansion stage to the final month of the Peak stage. Similarly, a *recessionary period* is defined as the period from the first month of the Recession stage to the final month of the Trough stage. Table 9 presents the durations of all expansionary and recessionary periods from March 1950 to September 2009.[18] We divide the whole sample into two subperiods with the latter period beginning with the expansionary period that started in March of 1983.

Table 9 shows a snapshot of changes in the business cycles. The expansionary period lengthens after 1983; the average duration is 45 months before 1983, but more than doubles to 95 months after 1983. In contrast, the average duration of the recessionary period remains the same at 11 months. These results imply two structural changes in the shape of the business cycle. First, the duration of the entire business cycle is lengthened, increasing from 56 months to 106 months, on average. Second, the shape of the business cycle became more asymmetric. The ratio of the duration of the expansionary period to that of the recessionary period jumps from 4.6 to 10.2.

We formally test whether the changes in the shape of the business cycle mentioned above

[18]June 2009 is the last turning point determined by the NBER. Since the duration of the expansionary period that began in October 2009 is yet to be designated, we exclude October 2009 to December 2012 from the sample period.

are statistically significant. For this purpose, we use the Wilcoxon rank sum test following Diebold and Rudebusch (1992). Consider the samples before and after the early 1980s. Let X_i and Y_j denote a particular sample duration from the pre-1983 period and the post-1983 period, respectively. The corresponding distribution functions of the two samples are denoted as F and G, respectively. The null hypothesis is that the durations are the same across the two subperiods; i.e., F and G are identical. We use a one-sided alternative hypothesis, reflecting our prior expectation that the duration of the post-1983 expansionary period is longer and that of the post-1983 recessionary period is shorter. Specifically, the alternative hypothesis on the expansionary period is that Y is stochastically larger than X; i.e., (i) $F \neq G$ and (ii) $G(k) \leq F(k)$ for all k. Likewise, for the recessionary period, the alternative hypothesis is that X is stochastically larger than Y.

In order to implement the Wilcoxon rank sum test, we replace observations $(X_1, ..., X_{N_x}, Y_1, ..., Y_{N_y})$ with their ranks $(R_1, ..., R_{N_x}, R_{N_x+1}, ..., R_N)$, where N_x and N_y are the sizes of the two samples, and $N = N_x + N_y$.[19] The Wilcoxon test statistic is simply the sum of the ranks in the second sample (i.e., the post-1983 subperiod):

$$W = \sum_{i=N_x+1}^{N} R_i. \tag{5}$$

The intuition underlying this test statistic is clear: under the null hypothesis of no change in the durations across the two samples, the average rank of durations in the first subperiod should equal that of durations in the second subperiod, and W is a sufficient statistic for this comparison.

Table 10 presents the results of the Wilcoxon tests for the expansionary periods (Panel A), the recessionary periods (Panel B), and the whole cycles (Panel C). For the expansionary periods, the test rejects the null hypothesis of no change in the durations. The data favors the alternative hypothesis that after 1983, expansionary periods have a longer duration (at the 5% level). In contrast, we cannot reject the null hypothesis that the recessionary periods

[19] As in Diebold and Rudebusch (1992), we resolve ties by using an average of the ranks of the tied observations.

before 1983 have the same length as those in the post-1983 period. This is expected, given that the average durations of both pre- and post-1983 periods are almost identical at 11 months. Finally, the results for the whole business cycle (the sum of the expansionary period and the recessionary period) show that the test rejects the null hypothesis in favor of the alternative hypothesis that the durations of the whole business cycles are longer after 1983 (at the 5% level).[20] Altogether, the tests imply that the longer length of the whole business cycle stems from the longer length of expansionary periods.

In sum, we find evidence of two major changes in the shape of the business cycle after 1983. First, the duration of the business cycle is longer after 1983. Second, the business cycle is more asymmetric. Figure 1 graphically illustrates the change in the hypothetical shape of the business cycle after 1983. The longer duration of the expansionary period not only elongates the business cycle itself but also makes the business cycle more asymmetric. Which one among the two accounts for the disappearance of the unconditional size effect? It must be the first. To illustrate, suppose that the duration of a business cycle is five years. This implies that a Trough occurs, on average, twice in ten years. As such, the SMB portfolio itself can produce excessively positive returns twice in ten years. In contrast, if the duration of the business cycle is lengthened to ten years, the economy falls into the Trough only once every ten years and, as a result, the SMB ends up with only one chance of excessive performance in ten years.

How about the stronger asymmetry? As long as it does not accompany the elongation of the business cycle, the asymmetry cannot *per se* induce any change in the unconditional size effect because the conditional size effects are essentially zero in both the Expansion and Recession stages.

Our evidence that the durations of business cycle lengthened after 1983 is related to the existing macroeconomic literature, which documents that the structural break in the

[20]We repeat the Wilcoxon rank sum tests using the expansionary and recessionary periods determined by the HP filter. We obtain qualitatively similar results. Specifically, we reject the null hypothesis in favor of the alternative hypothesis that the durations of expansionary periods are longer after 1983 (at the 10% level). For the recessionary periods, we cannot reject the null hypothesis of no change in durations.

volatility of GDP growth occurred in the early 1980s (Kim and Nelson, 1999; McConnell and Perez-Quiros, 2000; Blanchard and Simon, 2001; Stock and Watson, 2002). For instance, Stock and Watson (2002) estimate a 67% confidence interval for the break date in the conditional variance of (four-quarter) GDP growth as 1982:Q4 to 1985:Q3. Note, however, that the decline in volatility referred to as the 'Great Moderation' is related to, but not the same as a change in duration. The duration perspective explicitly considers the *length* of the business cycle phase, whereas the volatility perspective focuses on the *amplitude* of the business cycle.[21]

The macroeconomic literature has delivered three competing explanations for the change in the business cycle (Stock and Watson, 2002; Cecchetti, Flores-Lagunes, and Krause, 2006; Clark, 2009). The first explanation points to improved monetary policy (Clarida, Gali, and Gertler, 2000; Boivin and Giannoni, 2006; Lubik and Schorfheide, 2004; Coibion and Gorodnichenko, 2011). According to this explanation, in the late 1960s and 1970s, the Fed's monetary policy was too accommodative, thereby increasing economic instability. Beginning in 1979, monetary policy began to respond more systemically and consistently to inflation and GDP growth. As a result, monetary policy stabilized the economy more effectively beginning in the early 1980s. Empirical evidence does show systematic changes in the monetary policy during the Volcker-Greenspan era, consistent with this explanation.[22]

The second explanation suggests structural changes in the economy as the cause, including financial innovations (Dynan, Elmendorf, and Sichel, 2006) and improved inventory management (McConnell and Perez-Quiros, 2000).[23] Dynan, Elmendorf, and Sichel (2006) propose financial innovations, such as improved assessment and pricing of risk, expanded lending to households without strong collateral requirement, more widespread securitization

[21] These two perspectives are certainly related to each other. Since recessions are defined as the periods of absolute decline in economic activity, a decline in volatility with the same mean growth rate may result in fewer and shorter recessions.

[22] Our empirical results mentioned in footnote 14 also supports a structural break in monetary policy.

[23] McConnell and Perez-Quiros (2000) show that the volatility of production in manufacturing fell sharply in the mid-1980s, while the volatility of sales did not. They also suggest that the decrease in the volatility of goods production can fully explain the statistical significance of the lower volatility in GDP.

of loans, and development of markets for riskier corporate debt. These financial innovations made credit available to more households and firms, thus smoothing out consumption and investment over the course of the business cycle, which, in turn, stabilizes economic activity.

The third explanation, known as the 'good luck' hypothesis, states that the volatility reduction is the result of smaller exogenous structural shocks (Stock and Watson, 2002; Ahmed, Levin, and Wilson, 2004). According to this view, from the 1960s through the early 1980s, the economy was subject to unusually large shocks, such as skyrocketing oil prices. In contrast, from the early 1980s until the recent global financial crisis, the structural shocks to the economy had been much weaker.

Despite extensive empirical studies, the exact cause of the great moderation remains controversial. Various empirical studies support different explanations, and any single explanation can only partially account for the great moderation. This paper does not aim to disentangle the different explanations for the change in the behavior of business cycles. Regardless of the precise cause, the longer duration of the business cycle during the Great Moderation is responsible for the disappearance of the unconditional size effect.

4 The Implication of Shifts in the Transition Probabilities for the Size Effect

So far, we have established two empirical facts: (i) the dependency of the size effect on the business cycle stage is stable and (ii) the duration of the business cycle lengthens after the early 1980s. Combining these two facts leads us to conclude that the longer duration of the business cycle is the main cause for the downfall of the size effect. However, one may argue that this conclusion is hasty, as it may be an outcome of statistical artifact. First, one may question the sample size. For example, the number of months classified as Recession may not be large enough to ensure that the test result on the equality of size effect in Table 6 is not induced by a lack of efficiency in estimation. That is, the first fact, (i), could be challenged.

Second, the number of business cycles may not be sufficiently large; only ten cycles occur during the entire sample period. Thus, empirical results of Table 10 based on those ten cycles, though statistically significant, may not be convincing enough. So even the second fact, (*ii*) could also be challenged. Simply put, while the conclusion is 'statistically' significant, it may not be 'economically' significant.

To investigate the economic significance of our findings, this section explores a simple Markov chain economy in a reduced form. The purpose of this exercise is twofold. First, we investigate whether a change in a transition probability matrix alone is capable of prolonging the business cycle and, more importantly, undermining the size effect. By doing so, we can check whether our empirical findings are induced by inefficient estimations. Second, if the model can approximate the data reasonably well, we can analyze the sensitivity of the unconditional size effect to a potential change in the shape of the business cycle.

Of special interest is the second issue. In the wake of continuing economic woes in the aftermath of 2008 financial crisis, economists postulate the advent of a 'New Normal' era, which is essentially characterized by an output growth that is permanently below the previous long-term trend. While its fatalism may be controversial, the recent struggle with reviving economic growth amidst the financial panic, the European debt crisis, deleveraging and downtrending demographics at least portends slower growth on the horizon. In our context, this implies a potential seismic change in the shape of business cycle, and thus in the (unconditional) size effect. Our analysis indicates that the size effect is affected only by the length of the business cycle or equivalently the probability of an economy falling into the Trough. It is not susceptible to any other change in the shape of the business cycle, including increased asymmetry. We cannot predict the directional impact that the structural economic slowdown will have on the duration of the business cycle. It may prolong the overall business cycle by lengthening recoveries or recessions. Alternatively, it may shorten business cycle length if short-term recessions are more frequent. However, it is still meaningful to investigate what will happen to the size effect when the duration of the business cycle is structurally changed by the upcoming new economic era.

We consider four states of economic activity, each of which corresponds to a stage of the business cycle. The dynamic evolution of the economy is described by a four-by-four transition matrix, which designates the probability of transitioning from one state to another. Any change in the shape of business cycle, including the elongation of expansion or increased asymmetry, can be easily accommodated by simply changing transition probabilities in a Markov chain.

We take the following procedures. We first estimate a transition matrix for the pre-1983 and post-1983 periods, and assess whether the estimated transition matrices differ from each other. By estimating transition matrices separately across the two subperiods, we allow the data generating process for the dynamics of the business cycle to be different. Second, we assume that continuously compounded returns on small and large stocks follow conditional normal distributions where their means, variances, and covariance depend on business cycle stages. More importantly, we estimate these conditional distributions for the *whole* sample period. By doing so, we can attribute any change in the shape of the business cycle and the (model-implied) unconditional size effect entirely to the change in the transition matrix. Third, given the assumed conditional distributions of small and large stocks, with the data generating process for the evolution of the economic state, we simulate a time-series of returns on small and large stocks. These time-series are generated for the pre-1983, post-1983, and whole periods by using corresponding transition matrices. We then compare our simulated results with estimates from the historical data.

We define a regime indicator variable, I_t, representing each business cycle stage as

$$I_t = \begin{cases} 1 & \text{if time } t \text{ belongs to the Trough stage,} \\ 2 & \text{if time } t \text{ belongs to the Expansion stage,} \\ 3 & \text{if time } t \text{ belongs to the Peak stage,} \\ 4 & \text{if time } t \text{ belongs to the Recession stage,} \end{cases} \tag{6}$$

where I_t evolves in accordance with a first-order Markov process with a transition probability matrix with an entry

$$p_{i,j} = \text{Prob}[I_t = j | I_{t-1} = i] \quad i = 1, 2, 3, 4, \quad j = 1, 2, 3, 4.$$

The transition matrix is constructed in the following manner. Each month is assigned to an economic state corresponding to the four business cycle stages. The elements in each row of the transition matrix are calculated as the relative sample frequencies of moving from a particular state to each of the four states. We estimate transition matrices for the sample as a whole sample (from March 1950 to December 2012) as well as the two sub-samples (pre-1983 and post-1983 periods). Table 11 presents the transition matrix estimated for each sample and the unconditional probabilities implied by the matrix. When any entry in the post-1983 transition matrix is significantly different (at a 5% level) from the corresponding entry in the pre-1983 transition matrix, it appears in bold in Table 11.[24]

In Table 11, of particular interest is whether the probability of the Trough stage changes before and after 1983, since we detect a significantly positive size effect only at the Trough stage. While the pre-1983 transition matrix implies that on average, 13.9% of all months belong to the Trough stage, the post-1983 transition matrix implies that Trough months decrease by half (5.9%). When comparing the transitional probabilities in the pre- and post-1983 matrices, this difference is mainly attributable to changes in $p_{2,2}$ and $p_{2,3}$, i.e., the probability of transitioning from Expansion to Expansion and the probability of transitioning from Expansion to Peak. Among the eight non-zero transition probabilities in the matrix, only $p_{2,2}$ and $p_{2,3}$ change in a statistically significant way. Such a significant increase in persistence of the Expansion stage accounts not only for the elongation of the business cycle, but also for the increased asymmetry in duration between expansion and recession. Trivial differences exist in the probabilities associated with the other stages, but their im-

[24]The corresponding standard errors are calculated under the assumption that the future state is conditionally independent of the past given the current stage. Let $p_{i,j}$ and $\hat{p}_{i,j}$ denote the population and sample probabilities of a transition from stage i to j. If we consider $\hat{p}_{i,j}$ as a binomial variable that transitions to stage j or to $k = 1, ..., N$ where $k \neq j$ starting from stage i, the standard error for $\hat{p}_{i,j}$ can be computed as a standard binomial standard error $\sqrt{\hat{p}_{i,j}(1 - \hat{p}_{i,j})/n}$ where n is the number of months starting from stage i.

pact on the unconditional size effect is less meaningful since the conditional size effects are indistinguishable from zero at these stages.

Using the estimated transition probability matrix, we can compute the steady-state probability of each state implied by the matrix. If the steady-state probabilities are significantly different from the historical probabilities, one may argue that the observed historical probabilities (in particular, the less frequent occurrence of Trough stages after 1983) may be induced by the small number of business cycle observations. As shown in Table 11, in the entire sample as well as the post-1983 subperiod, the steady-state probabilities are almost identical to their corresponding historical probabilities. As for the pre-1983 subperiod, the steady-state probability of Trough implied by the transition matrix (13.9%) is slightly higher than the historical probability (12.4%), but this difference is not economically meaningful.[25] We must, therefore, conclude that the longer duration of the post-1983 business cycle is not an artifact related to the small number of business cycles observed.

Next, we model continuously compounded returns on small and large stocks as conditionally bivariate normal where their mean vector and covariance matrix depend on the business cycle stage. Specifically, continuously compounded returns on small stocks ($\ln R_{S,I_t}$) and large stocks ($\ln R_{L,I_t}$) at state I_t, $\ln R_{I_t} = (\ln R_{S,I_t}, \ln R_{L,I_t})$, are assumed to be bivariate-normally distributed:

$$\ln R_{I_t} \sim MVN_2\left(\mu_{I_t}, \Omega_{I_t}\right) \tag{7}$$

where μ_{I_t} and Ω_{I_t} are the mean vector and the covariance matrix at state I_t.

As explained above, the mean vector and the covariance matrix, $(\mu_{I_t}, \Omega_{I_t})$, corresponding to each business cycle stage, I_t are estimated from the *entire* set of sample. Panel A of Table 12 reports the estimates for small firms, large firms, and SMB.[26]

Finally, the assumpted conditional distributions of small and large stocks, combined with

[25] We conduct the following reverse engineering analysis. Rather than the actual estimate of $p_{2,2}$, we solve for $p_{2,2}$, which results in the steady-state probability of Trough matching its historical probability. Based on this $p_{2,2}$, we re-compute the size effects in Table 12. The results are qualitatively similar.

[26] To save space, we do not report the covariance between the small stocks and the large stocks.

the estimated transition probabilities, are used to generate time-series data on SMB. These time-series are generated for the whole, pre-1983, and post-1983 periods by using corresponding transition matrices. We then compare the first and second moments of generated data with those of the historical data. The specific procedure is as follows: first, using the transition matrix estimated from the whole sample, we generate a sequence of 754 business cycle stages, I_t. The sample size of 754 is chosen to match the 754 monthly observations of the whole sample. Second, given a sequence of I_t, independent draws from a normal distribution defined in equation (7) are taken to form a sequence of returns on small and large stocks. A sequence of SMB is computed as the difference between generated returns on small and large stocks. Third, we repeatedly simulate data for 10,000 times. We calculate the means of the averages, standard deviations, and t-statistics for the simulated returns on small and large stocks, along with SMB. Finally, we repeat this experiment by changing the transition matrix estimated using the whole sample to those estimated using the pre-1983 and post-1983 periods.[27]

Panel B of Table 12 compares our simulated results with the estimates from the historical data. The results for the whole sample period (March 1950 to December 2012) show that the model is well able to explain the observed small firm effect. The average return on the model-implied SMB is 0.19% per month, which is fairly comparable to the 0.17% observed in the data. The standard deviation of return on SMB, across simulations, averages 2.91%, which is very close to the 2.88% in the data. This result is somewhat expected, since we use the transition matrix and conditional distributions of returns, both estimated from the whole sample period. The results for the first subperiod (March 1950 to February 1983) show that the model also does a decent job of replicating the historical spread between returns on small and large stocks. The model-implied size effect is 0.24% per month, which is fairly close to the 0.26% observed in the data. In the model, consistent with the data, the return spread between small and large stocks are statistically significant (at the 10% level); t-statistics of

[27] For the pre-1983 period, a sequence of 396 SMB is generated, while a series of 358 SMB is simulated for the post-1983 period to match the number of observations in each sample.

return on SMB, across simulations, average 1.61 (its sample counterpart is 1.94).

Most importantly, the model predicts that the size effect for the second subperiod (March 1983 to December 2012) is substantially smaller than that for the first subperiod (and not statistically significant), which is qualitatively the same as in the data. The model-implied size effect is 0.18% per month. Although somewhat higher than its sample counterpart (0.08%), it lies within two standard error bounds of the data estimate. The mean of t-statistics for SMB across simulations is 1.14, compared to 0.49 in the data.

We replicate the same analysis based on the HP filter. The results are qualitatively similar but the amount of change in the SMB return is much larger under this scheme.[28] The theoretically implied SMB average return is 0.28% per month (with t-statistic of 1.79) before 1983. Its value plummets to 0.11% (with t-statistic of 0.75) after 1983; the Markov chain model with the transition matrix estimated by the HP filter is more successful in replicating the historical change in the SMB return. Overall, the reduced-form Markov chain model is able to reasonably replicate the weaker size effect after the early 1980s. Recall that the subperiod analyses are based on the conditional size effects estimated from the whole sample, not the subperiod sample. Thus we can conclude that the empirically observed change in the size effect before and after the early 1980s is not a statistical artifact and instead an economically significant finding.

Given the reasonable performance of the Markov chain model in replicating the size effect, we conduct an analysis of the sensitivity of the unconditional size effect to expansion duration. That is, under the assumption that everything else remains the same, we change the value of $p_{2,2}$, which governs the duration of Expansion. Then, we perform the simulation analysis again to compute the corresponding SMB return as well as the probability of the Trough stage occurring. Figures 2(a) and 2(b) (Figures 2(c) and 2(d)) illustrate the result when the business cycle stage is designated by the NBER (HP filter). Figure 2(a) depicts the probability that the business cycle stage falls into the Trough stage as a function of

[28] To save space, we do not report the results based on the HP filter.

expansion duration. The locus of the SMB return in response to the duration of Expansion is illustrated in Figure 2(b). Given that both locuses are downward-sloping, the longer expansion duration attenuates the size effect as well as the Trough probability. We focus on Figure 2(b), the SMB return. Its shape is convex from the origin, which implies that the sensitivity (the slope of a tangent line) decreases as the duration increases, and vice versa. Figures 2(c) and 2(d) plot similar graphs, but under the HP filter instead of the NBER cycle. Its shape is essentially the same but its slope is somewhat steeper.[29]

As for the NBER cycle, a one-month decrease in expansion duration increases the SMB return by about 4 basis points (5 basis points for the HP filter) per month, when the length of expansion duration is identical to the post-1983 one. If the duration shrinks further, the size effect will increase faster. For example, when the expansion duration is 70 months (80 months under the HP filter), about an average of the pre-1983 expansion duration and the post-1983 duration, the size effect rises by 7 basis points per month (11.6 basis points under the HP filter). Finally, when the expansion duration is close to the pre-1983 one, this number skyrockets to 26 basis points (50 basis points under the HP filter). Therefore, if the New Normal era shrinks the expansion duration, the size effect regains its momentum on the back of more frequent visits of recessions. If the New Normal era elongates the duration due to sluggish recovery without accompanying recessions, the hibernation of the size effect could be even longer than the status quo.

5 Conclusion

The purpose of this paper is to account for the disappearance of the small firm effect after the early 1980s. Based on three empirical premises, we posit that a change in the duration of the business cycle is its main cause. First, the size effect is significantly positive only at the Trough stage. Second, the conditional size effects have not gone through any structural

[29]The two plots show different expansion durations on their x-axis. This difference is driven by different historical durations designated by the two cycles.

changes after 1983. Third, the duration of the business cycle lengthens so that the Trough stage occurs less frequently. Combining these three empirical facts yields an explanation for the dissipation of the size effect. In addition, we analyze how sensitive the size effect is to the length of the business cycle.

However, there are still a few questions yet to be answered. For example, why is the size effect positive only at the Trough stage? The imperfect capital market theory delivers a partial answer. If the size effect is positive at the Trough stage due to a rapid recovery in credit market conditions, we may have to observe significantly negative size effect before the Trough stage. That is, the imperfect capital market theory may imply that credit market conditions have a symmetric impact on the conditional size effect. Such symmetry is observed before 1983, but not after 1983. The difference in the conditional effects at the Recession stage between the pre- and post-1983 periods is not statistically significant, but it may be still economically meaningful. If so, the exact reason for this change warrants an explanation. We propose preemptive monetary easing policy as the potential reason for this change. Deductive reasoning suggests that the forward-looking and preemptive monetary policy, which injects money into the economy far before any signs of a recession, alleviates downward pressure from the credit market on small firms. However, this hypothesis should be more formally analyzed.

Another area for future research involves analyzing why the duration of the business cycle lengthens after 1983 in the first place. Existing literature suggests some important explanations regarding the output volatility reduction. These theories may provide a clue to the elongation of the business cycle, but we need a more full-fledged structural explanation for the longer duration of the business cycle as well as its lower volatility.

However, all these questions are beyond the scope of this paper. They themselves are independently important questions worthy of further investigation. We reserve these issues for future research.

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A Appendix: Determination of Business Cycle Stages by the HP filter

We adopt the Hodrick-Prescott (1997) filter to estimate the cyclical component of the GDP. The HP filter detrends the time series while penalizing the roughness of the estimated series. The HP filter solves the following standard-penalty program:

$$\mathrm{Min}_{\tau_t} \quad \sum_{t=1}^{T}(y_t-\tau_t)^2+\lambda\sum_{t=2}^{T-1}\left[(\tau_{t+1}-\tau_t)-(\tau_t-\tau_{t-1})\right]^2, \tag{A.1}$$

where λ controls the smoothness of the adjusted trend series. The first term captures the goodness-of-fit of the filter while the second term penalizes the roughness. Following Ravn and Uhlig (2002), we set λ at 1600. The estimated cyclical component is

$$\phi_t = y_t - \tau_t. \tag{A.2}$$

Simply put, the HP filter decomposes the log of output into two components: a cyclical and a trend component.

Next, we use the following criteria for defining four business cycle stages at each quarter t conditioning on ϕ_t, the cyclical component:

$$\begin{array}{llcll}
\text{(i)} & \text{Trough}(t) & : & \phi_t < c_l, & \Delta\phi_{t-1}<0,\ \Delta\phi_{t+1}>0,\ \phi_t<\min\{\phi_s\}_{s=t-4}^{t+4}, \\
\text{(ii)} & \text{Expansion}(t) & : & & \max\left(t_-^{min}, t_-^{trough}\right) < t < \max\left(t_+^{max}, t_+^{peak}\right) \\
\text{(iii)} & \text{Peak}(t) & : & \phi_t > c_h, & \Delta\phi_{t-1}>0, \Delta\phi_{t+1}<0,\ \phi_t>\max\{\phi_s\}_{s=t-4}^{t+4}, \\
\text{(iv)} & \text{Recession}(t) & : & & \max\left(t_-^{max}, t_-^{peak}\right) < t < \max\left(t_+^{min}, t_+^{trough}\right)
\end{array} \tag{A.3}$$

where $c_l << 0$ and $c_h >> 0$ are the critical values for judging troughs and peaks, respectively. Troughs and peaks are defined as local minima and maxima of the cyclical component based on the critical values, c_l and c_h, respectively. These business cycle turning points occur infrequently and their identification is subject to higher errors than those of the other stages. On the back of these concerns, we include the nearest few months around peaks and troughs.

Specifically, we define the 'Trough' stage as not only the quarter to which a trough belongs, but also the period including two months before and two months after–a total of seven months. Similarly, the "Peak" stage is classified as not only the quarter to which a peak belongs, but also the period including two months before and after, constituting a total of seven months. A critical issue is how to deal with double dips and double peaks; i.e., when a particular trough is not followed by a peak, and vice versa. First, we eliminate double dips or double peaks that occur within a year by imposing a condition, $\phi_t < \min\{\phi_s\}_{s=t-4}^{t+4}$ and $\phi_t > \max\{\phi_s\}_{s=t-4}^{t+4}$, respectively. Second, if double dips or double peaks occur beyond the one-year horizon, we identify the quarter of the local maximum between the two troughs (in the case of a double dip) and the local minimum between the two peaks (in the case of a double peak). These local maxima or minima are necessary for defining other stages.

Expansions are defined as the path of the business cycle (i) from a trough to either a peak or a local maximum (in the case of a double dip) or (ii) from a local minimum (in the case of a double peak) to a peak. Put differently, it postdates either a trough $\left(t_{-}^{trough}\right)$ or a local minimum $\left(t_{-}^{min}\right)$ (in the case of a double peak) and predates either a peak $\left(t_{+}^{peak}\right)$ or a local maximum $\left(t_{+}^{max}\right)$ (in the case of a double dip). A condition, $\max\left(t_{-}^{min}, t_{-}^{trough}\right) < t < \max\left(t_{+}^{max}, t_{+}^{peak}\right)$, formally defines such a definition. Recessions are similarly defined. We set critical values as $c_h = 1.9, c_l = -1.9$.

Table 1
Descriptive Statistics

	Small	Big	SMB
Full sample period (1950:03 - 2012:12)			
Mean return (%)	0.84	0.67	0.17
(t-stat)	(4.16)	(4.32)	(1.64)
% of (return > 0)	59%	60%	51%
Pre-1983 subperiod (1950:03 - 1983:02)			
Mean return (%)	0.94	0.69	0.26
(t-stat)	(3.44)	(3.34)	(1.94)
% of (return > 0)	60%	59%	53%
Post-1983 subperiod (1983:03 - 2012:12)			
Mean return (%)	0.72	0.64	0.08
(t-stat)	(2.43)	(2.77)	(0.49)
% of (return > 0)	59%	61%	48%

The table documents average monthly excess returns and their corresponding t-values on small and big stock portfolios along with SMB (Small-Minus-Big portfolio). '% of (return >0)' reports the percentage of positive returns. The table reports the results for the full sample period (March 1950 – December 2012) as well as two subperiods (March 1950 – February 1983 and March 1983 – December 2012).

Table 2
Determination of Business Cycle Stages

	cycle 1	cycle 2	cycle 3	cycle 4	cycle 5	cycle 6	cycle 7	cycle 8	cycle 9	cycle 10	cycle 11
Panel A: Business Cycle Stages Determined by the NBER											
Expansion	50:03-53:03	54:09-57:04	58:08-59:12	61:06-69:08	71:03-73:07	75:07-79:09	80:11-81:03	83:03-90:03	91:07-00:11	02:03-07:08	09:10-12:12
Peak	53:04-53:10	57:05-57:11	60:01-60:07	69:09-70:03	73:08-74:02	79:10-80:03	81:04-81:10	90:04-90:10	00:12-01:06	07:09-08:03	
Recession	53:11-54:01	57:12-57:12	60:08-60:10	70:04-70:07	74:03-74:11		81:11-82:07	90:11-90:11	01:07-01:07	08:04-09:02	
Trough	54:02-54:08	58:01-58:07	60:11-61:05	70:08-71:02	74:12-75:06	80:04-80:10	82:08-83:02	90:12-91:06	01:08-02:02	09:03-09:09	
Panel B: Business Cycle Stages Determined by the HP filter											
	cycle 1	cycle 2	cycle 3	cycle 4	cycle 5	cycle 6	cycle 7	cycle 8	cycle 9	cycle 10	cycle 11
Expansion	50:03-51:04	54:09-55:04	58:09-59:01	61:06-65:10	71:03-73:01	75:06-78:07	83:03-00:01	03:06-07:07	09:09-12:12		
Peak	51:05-51:11	55:05-55:11	59:02-59:08	65:11-66:05	73:02-73:08	78:08-79:02	00:02-00:08	07:08-08:02			
	52:11-53:05										
Recession	51:12-52:10	55:12-58:01	59:09-60:10	66:06-70:07	73:09-74:10	79:03-82:07	00:09-02:10	08:03-09:01			
	53:06-54:01										
Trough	54:02-54:08	58:02-58:08	60:11-61:05	70:08-71:02	74:11-75:05	82:08-83:02	02:11-03:05	09:02-09:08			

The table presents the chronology of the business cycle stages determined by the NBER and the HP filter in the period from March 1950 to December 2012. We define the Trough (Peak) stage by including three months before and after the Trough (Peak) month identifed by the NBER and the HP filter.

Table 3
Size Effects Conditional on the Business Cycle Stages

Panel A: Business Cycle Stages Determined by the NBER

	Trough	Expansion	Peak	Recession
N	70	573	69	42
SMB	1.48	0.11	–0.25	–0.51
(t-stat)	(4.14)	(0.96)	(–0.72)	(–1.51)
% of (return > 0)	76%	49%	45%	38%
CAPM alpha	0.95	–0.01	–0.02	–0.05
(t-stat)	(2.75)	(–0.10)	(–0.06)	(–0.15)
Small portfolio	5.00	1.29	–0.95	–2.77
(t-stat)	(7.39)	(6.18)	(–1.33)	(–2.70)
Big portfolio	3.52	1.18	–0.69	–2.26
(t-stat)	(7.43)	(7.34)	(–1.37)	(–2.49)

Panel B: Business Cycle Stages Determined by the HP filter

	Trough	Expansion	Peak	Recession
N	56	434	63	201
SMB	1.25	0.01	–0.08	0.30
(t-stat)	(3.17)	(0.12)	(–0.12)	(1.48)
% (return > 0)	68%	49%	43%	52%
CAPM alpha	0.68	–0.16	–0.08	0.43
(t-stat)	(1.83)	(–1.38)	(–0.14)	(2.22)
Small portfolio	4.67	1.38	0.40	0.12
(t-stat)	(5.67)	(5.92)	(0.54)	(0.27)
Big portfolio	3.42	1.37	0.48	–0.18
(t-stat)	(5.63)	(7.45)	(1.04)	(–0.55)

The table reports the average monthly (raw) returns and the CAPM-adjusted returns on SMB across different stages of the business cycle over the period from March 1950 to December 2012. Panels A and B report the estimation results when business cycle stages are identified by the NBER and HP filtered GDP, respectively. '% (return > 0)' means the percentage of positive SMB returns. The table also reports the average monthly excess returns on small and large stock portfolios.

Table 4
Trough-Dummy Regressions for the Size Effect

Panel A: Business Cycle Stages Determined by the NBER				
	Intercept	D_{trough}	MKT	$Adj.R^2(\%)$
SMB	0.04	1.44		1.98
	(0.36)	(3.86)		
SMB	–0.02	0.97	0.17	7.90
	(–0.15)	(2.67)	(5.77)	
Small portfolio	0.08	1.02	1.12	78.88
	(0.86)	(2.94)	(38.01)	
Big portfolio	0.10	0.05	0.95	95.45
	(2.79)	(0.50)	(85.74)	
Panel B: Business Cycle Stages Determined by the HP filter				
	Intercept	D_{trough}	MKT	$Adj.R^2(\%)$
SMB	0.09	1.16		0.98
	(0.80)	(2.84)		
SMB	0.02	0.69	0.17	7.36
	(0.19)	(1.78)	(6.07)	
Small portfolio	0.12	0.77	1.13	78.73
	(1.23)	(2.01)	(38.75)	
Big portfolio	0.10	0.08	0.95	95.46
	(2.79)	(0.68)	(85.28)	

The table presents the estimation results of equations (1) and (2). Reported are regression coefficients, their corresponding t-values (in parentheses), and adjusted R-squares. Panels A and B report the estimation results when D_{trough} is determined by the NBER and HP filtered GDP, respectively.

Table 5
Size Effects Conditional on the Business Cycle Stages: Subperiods Analysis

	Trough	Expansion	Peak	Recession
Pre-1983 subperiod (1950:03–1983:02)				
N	49	270	48	29
SMB	1.49	0.24	–0.25	–0.83
(t-stat)	(3.47)	(1.58)	(–0.60)	(–2.37)
% (return > 0)	76%	52%	44%	34%
CAPM alpha	0.86	0.11	–0.02	–0.41
(t-stat)	(2.05)	(0.76)	(–0.04)	(–1.00)
Small portfolio	5.42	1.39	–0.97	–2.32
(t-stat)	(7.44)	(4.73)	(–1.12)	(–2.27)
Big portfolio	3.93	1.15	–0.72	–1.50
(t-stat)	(8.23)	(5.19)	(–1.18)	(–1.61)
Post-1983 subperiod (1983:03 – 2012:12)				
N	21	303	21	13
SMB	1.45	0.01	–0.26	0.19
(t-stat)	(2.26)	(0.03)	(–0.39)	(0.26)
% (return > 0)	76%	47%	48%	46%
CAPM alpha	1.09	–0.12	0.00	0.78
(t-stat)	(1.82)	(–0.70)	(–0.01)	(1.13)
Small portfolio	4.02	1.21	–0.90	–3.76
(t-stat)	(2.75)	(4.07)	(–0.73)	(–1.58)
Big portfolio	2.56	1.20	–0.64	–3.95
(t-stat)	(2.35)	(5.22)	(–0.70)	(–1.99)

The table reports the average monthly (raw) returns and the CAPM-adjusted return on SMB across different business cycle stages. Panels A and B report the results obtained from the pre-1983 period (March 1950 – February 1983) and post-1983 period (March 1983 – December 2012), respectively. The results using the business cycle stages determined by the NBER are presented. '% (return > 0)' refers to the percentage of positive SMBs. The table also reports the average monthly excess return of small and large stock portfolios.

Table 6
Size Effects Conditional on the Business Cycle Stages: Subperiods Analysis

	Trough	Expansion	Peak	Recession	Joint	p-value
△ SMB	–0.04	–0.23	–0.01	1.02	2.505	[0.644]
(t-stat)	(–0.05)	(–0.98)	(–0.01)	(1.25)		
△ CAPM alpha	0.23	–0.24	0.01	1.20	3.315	[0.507]
(t-stat)	(0.31)	(–1.03)	(0.02)	(1.49)		

The table reports the estimation results of equations (3) and (4), which test whether the differences in average SMB returns (and CAPM-adjusted returns) between the pre-1983 (March 1950 – February 1983) and post-1983 period (March 1983 – December 2012) at each business cycle stage are statistically different from zero. The table reports the β_s coefficients, which measure the differences in the conditional size effects between the pre- and post-1983 subperiods. The column titled 'Joint' reports χ^2 statistic, which determines whether the four β_s coefficients are jointly zero. The corresponding p-value is reported in square brackets.

Table 7
Conditional Size Effects in January and Non-January Months

	January					Non-January				
	Unconditional	Conditional				Unconditional	Conditional			
		Trough	Expansion	Peak	Recession		Trough	Expansion	Peak	Recession
Full sample period (1950:03 – 2012:12)										
Mean return (%)	1.97	4.45	1.52	3.78	–0.59	0.01	1.15	–0.01	–0.64	–0.51
(t-stat)	(4.91)	(3.48)	(3.65)	(2.59)	(–1.35)	(0.11)	(3.31)	(–0.07)	(–1.98)	(–1.39)
CAPM alpha	1.78	3.61	1.34	4.13	–0.25	–0.08	0.67	–0.13	–0.42	–0.05
(t-stat)	(4.59)	(3.30)	(3.17)	(3.04)	(–0.94)	(–0.82)	(1.93)	(–1.06)	(–1.43)	(–0.12)
Pre-1983 subperiod (1950:03 – 1983:02)										
Mean return (%)	2.96	5.25	2.54	4.12	–0.39	0.01	1.06	0.03	–0.65	–0.86
(t-stat)	(5.53)	(3.25)	(4.67)	(2.46)	(–0.64)	(0.07)	(2.70)	(0.22)	(–1.72)	(–2.32)
CAPM alpha	2.74	4.12	2.44	4.54	–0.55	–0.10	0.51	–0.09	–0.44	–0.41
(t-stat)	(5.58)	(2.87)	(4.80)	(2.68)	(–5.22)	(–0.79)	(1.24)	(–0.62)	(–1.36)	(–0.94)
Post-1983 subperiod (1983:03 – 2012:12)										
Mean return (%)	0.83	2.45	0.59	3.11	–0.98	0.01	1.35	–0.04	–0.61	0.29
(t-stat)	(1.58)	(2.54)	(1.05)	(1.13)	(–)	(0.09)	(1.93)	(–0.23)	(–1.00)	(0.36)
CAPM alpha	0.67	2.19	0.33	3.36	0.32	–0.07	0.98	–0.16	–0.36	0.82
(t-stat)	(1.25)	(3.52)	(0.56)	(1.51)	(0.99)	(–0.43)	(1.50)	(–0.88)	(–0.58)	(1.11)

The table reports the average returns on the SMB portfolio across two separate samples, January and Non-January months. The column titled 'Unconditional' represents the unconditional average monthly returns on the SMB, while the column titled 'Conditional' represents the average monthly returns on the SMB across different business cycle stages. The CAPM-adjusted mean differences are also reported. The results using the business cycle stages determined by the NBER are presented. t-statistic of the January mean return at the Recession stage is not computable because its sample size is a singleton.

Table 8
Spreads of Size Effects between January and Non-January Months

	Conditional size effect				Joint	p-value
	Trough	Expansion	Peak	Recession		
Full sample period (1950:03 – 2012:12)						
△ Mean return (%)	3.30	1.53	4.42	–0.08	27.038	[0.000]
(t-stat)	(2.49)	(3.52)	(2.96)	(–0.14)		
△ CAPM alpha	2.94	1.47	4.55	–0.20	28.474	[0.000]
(t-stat)	(2.58)	(3.34)	(3.28)	(–0.44)		
Pre-1983 subperiod (1950:03 – 1983:02)						
△ Mean return (%)	4.19	2.50	4.77	0.47	33.583	[0.000]
(t-stat)	(2.52)	(4.45)	(2.78)	(0.66)		
△ CAPM alpha	3.61	2.53	4.98	–0.14	36.693	[0.000]
(t-stat)	(2.45)	(4.80)	(2.90)	(–0.29)		
Post-1983 subperiod (1983:03 – 2012:12)						
△ Mean return (%)	1.10	0.63	3.72	–1.27	6.150	[0.188]
(t-stat)	(0.92)	(1.07)	(1.32)	(–1.61)		
△ CAPM alpha	1.21	0.50	3.72	–0.50	5.450	[0.244]
(t-stat)	(1.36)	(0.80)	(1.61)	(–0.69)		

The table reports the spreads of SMB between January and non-January months across business cycle stages. 'Joint' refers to the $\chi^2(4)$ statistic on whether those differences are jointly different from zero. The CAPM-adjusted mean differences are also reported.

Table 9
Business Cycle Stages and Durations

Expansionary Period			Recessionary Period			Ratio
Period (‘Expansion’+‘Peak’)	Duration (months)	Percentage	Period (‘Recession’+‘Trough’)	Duration (months)	Percentage	(Expan/Recess)
Pre-1983 subperiod (March 1950 – February 1983)						
Mar 1950 – Oct 1953	44	81%	Nov 1953 – Aug 1954	10	19%	4.4
Sep 1954 – Nov 1957	39	83%	Dec 1957 – Jul 1958	8	17%	4.9
Aug 1958 – Jul 1960	24	71%	Aug 1960 – May 1961	10	29%	2.4
Jun 1961 – Mar 1970	106	91%	Apr 1970 – Feb 1971	11	9%	9.6
Mar 1971 – Feb 1974	36	69%	Mar 1974 – Jun 1975	16	31%	2.3
Jul 1975 – Mar 1980	57	89%	Apr 1980 – Oct 1980	7	11%	8.1
Nov 1980 – Oct 1981	12	43%	Nov 1981 – Feb 1983	16	57%	0.8
Average	**45**	**75%**	Average	**11**	**25%**	**4.6**
Post-1983 subperiod (March 1983 – September 2009))						
Mar 1983 – Oct 1990	92	92%	Nov 1990 – Jun 1991	8	8%	11.5
Jul 1991 – Jun 2001	120	94%	Jul 2001 – Feb 2002	8	6%	15.0
Mar 2002 – Mar 2008	73	80%	Apr 2008 – Sep 2009	18	20%	4.1
Average	**95**	**89%**	Average	**11**	**11%**	**10.2**

The table reports the durations of all expansionary and recessionary periods from March 1950 to September 2009. An expansionary period is defined as the period from the first month of the Expansion stage to the final month of the Peak stage in a particular cycle. A recessionary period is similarly defined. The two columns titled ‘percentage’ represent the percentages of the expansionary and the recessionary periods, respectively. ‘Ratio’ represents the ratio of the duration of expansionary period relative to the duration of the following recessionary period.

Table 10
Wilcoxon Rank Sum Test

Sample		Sample Size		Average Duration		Wilcoxon Test	
X	Y	N_x	N_y	X	Y	W	p-value
Panel A: *Wilcoxon Test for Expansionary Periods*							
March 1950 – February 1983	March 1983 – August 2009	7	3	45.4	95.0	8	0.033
Panel B: *Wilcoxon Test for Recessionary Periods*							
March 1950 – February 1983	March 1983 – August 2009	7	3	11.1	11.3	16	0.467
Panel C: *Wilcoxon Test for Whole Cycles (Expansionary to Recessionary Periods)*							
March 1950 – February 1983	March 1983 – August 2009	7	3	56.6	106.3	8	0.033

The table presents the results of the Wilcoxon rank sum tests for the expansionary periods (Panel A), the recessionary periods (Panel B), and the whole business cycles (Panel C). The table reports sample sizes, average durations, the Wilcoxon statistic (W) and its one-sided p-value.

Table 11
Transition Probability Matrix

Stages	Historical Percentage	Steady-state Probability	Probability of moving to Trough	Expansion	Peak	Recession
Full sample period (1950:03 – 2012:12)						
Trough	0.093	0.093	0.857	0.143	0.000	0.000
Expansion	0.760	0.760	0.000	0.983	0.018	0.000
Peak	0.092	0.092	0.015	0.000	0.855	0.130
Recession	0.056	0.056	0.214	0.000	0.000	0.786
Pre-1983 subperiod (1950:03 – 1983:02)						
Trough	0.124	0.139	0.875	0.125	0.000	0.000
Expansion	0.682	0.670	0.000	**0.974**	**0.026**	0.000
Peak	0.121	0.119	0.021	0.000	0.854	0.125
Recession	0.073	0.072	0.207	0.000	0.000	0.793
Post-1983 subperiod (1983:03 – 2012:12)						
Trough	0.059	0.059	0.857	0.143	0.000	0.000
Expansion	0.846	0.846	0.000	**0.990**	**0.010**	0.000
Peak	0.059	0.059	0.000	0.000	0.857	0.143
Recession	0.036	0.036	0.231	0.000	0.000	0.769

The table presents the transition probability matrix estimated from the whole period (March 1950 – December 2012), the pre-1983 period (March 1950 – February 1983), and the post-1983 period (March 1983 – December 2012). When any entry in the post-1983 transition matrix is significantly different (at the 5% level) from the corresponding entry in the pre-1983 transition matrix, it appears in bold. The table also reports historical probability of each business cycle stage from the data, and its corresponding steady-state probability implied by the transition probability matrix.

Table 12
Implied Moments of the Size Effect

Panel A: Summary Statistics of the Small, Big, and SMB Portfolios Conditional on the Business Cycle Stages

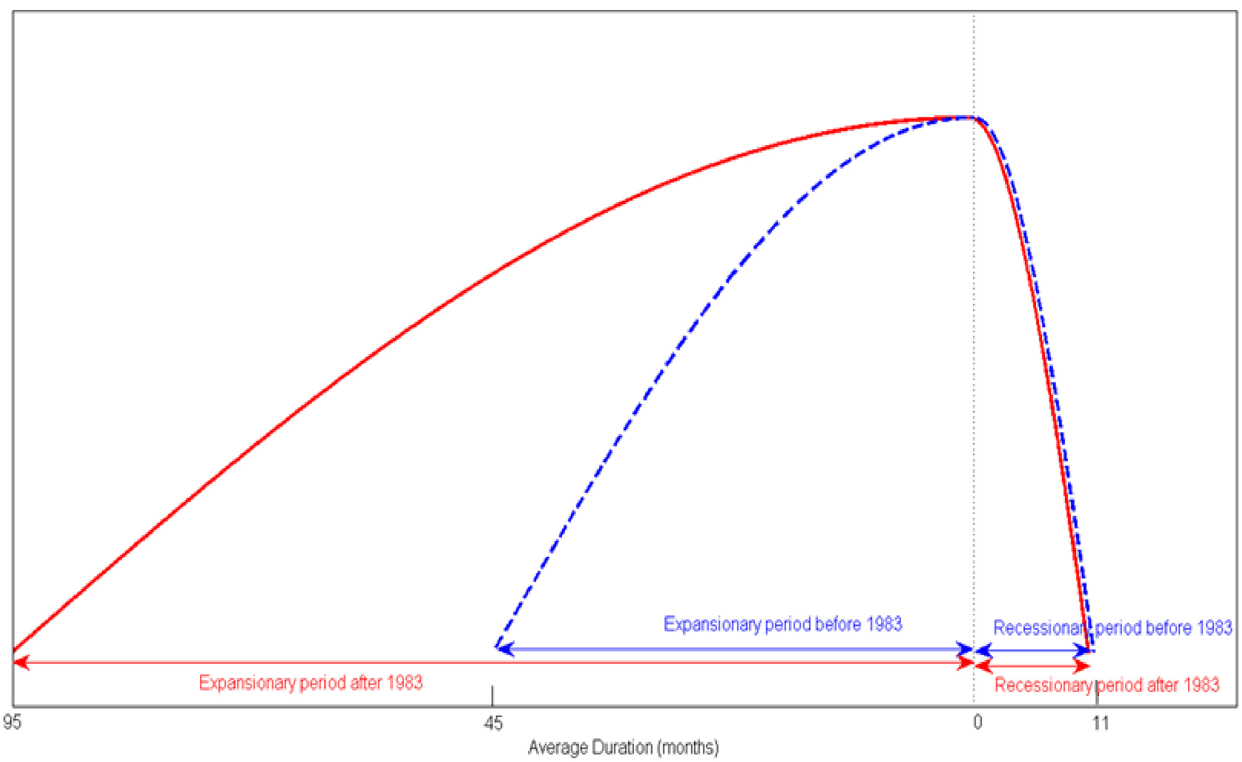
		Business Cycle Stages			
		Trough	Expansion	Peak	Recession
Small	Mean	5.00	1.29	–0.95	–2.77
	Std. dev.	5.70	5.02	5.93	6.74
Big	Mean	3.52	1.18	–0.69	–2.26
	Std. dev.	3.99	3.85	4.23	5.96
SMB	Mean	1.48	0.11	–0.25	–0.51
	Std. dev.	3.01	2.86	2.96	2.22

Panel B: Implied vs. Sample Moments of the Size Effect

	Implied by the model			Sample values		
	Mean	Std. dev.	*t*-stat	Mean	Std. dev.	*t*-stat
Full sample period (1950:03 – 2012:12)						
Small	1.24	5.63	6.08	1.21	5.51	6.01
Big	1.06	4.25	6.85	1.03	4.21	6.74
SMB	0.19	2.91	1.75	0.17	2.88	1.64
Pre-1983 subperiod (1950:03 – 1983:02)						
Small	1.31	5.80	4.52	1.33	5.43	4.88
Big	1.07	4.36	4.93	1.08	4.05	5.29
SMB	0.24	2.93	1.61	0.26	2.62	1.94
Post-1983 subperiod (1983:03 – 2012:12)						
Small	1.30	5.47	4.52	1.07	5.61	3.60
Big	1.13	4.13	5.19	0.99	4.39	4.26
SMB	0.18	2.90	1.14	0.08	3.15	0.49

Panel A reports the summary statistics on small and large size portfolios along with SMB. Therefore it is essentially the same as Panel A of Table 3 but additionally reports standard deviations across different business cycle stages. Panel B reports the moments of returns on the small and big size portfolios and the SMB implied by the Markov Chain model. Their corresponding sample estimates are also reported.

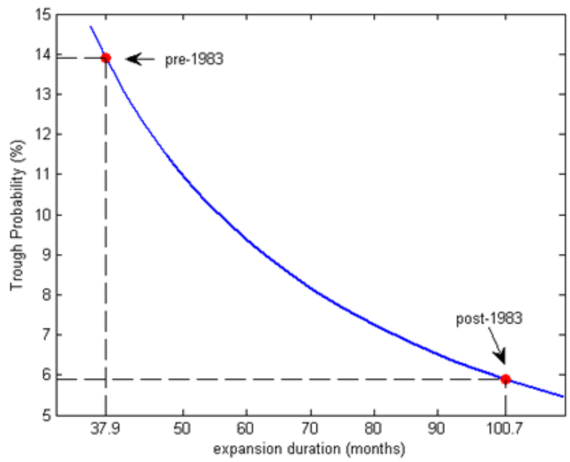
Figure 1
Average Durations of Expansionary and Recessionary Periods



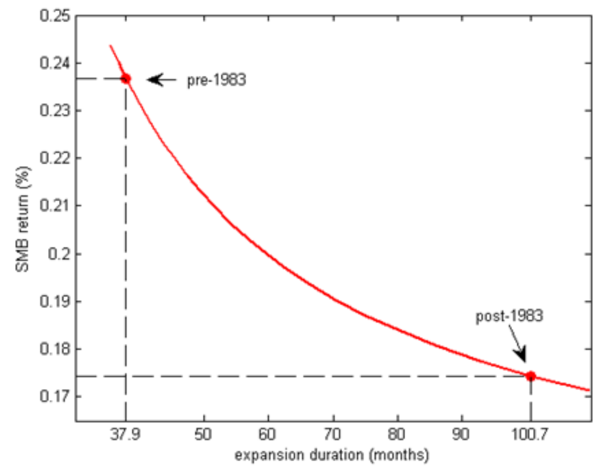
The figure displays the hypothetical shapes of a business cycle, which is based on the historical average durations of expansionary and recessionary periods obtained from the pre-1983 period (dotted line) and post-1983 period (solid line).

Figure 2
Average Durations of Expansionary and Recessionary Periods

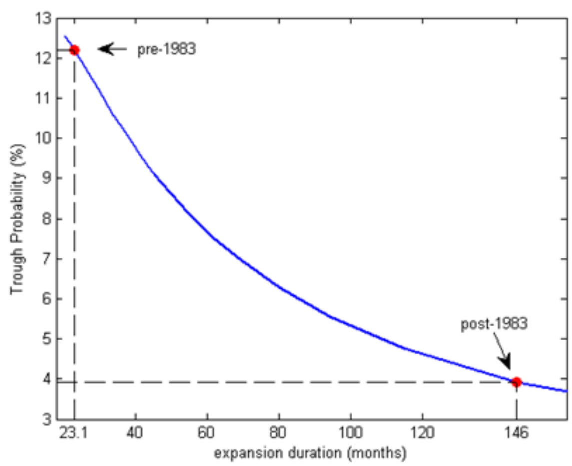
(a) NBER: Trough Probability



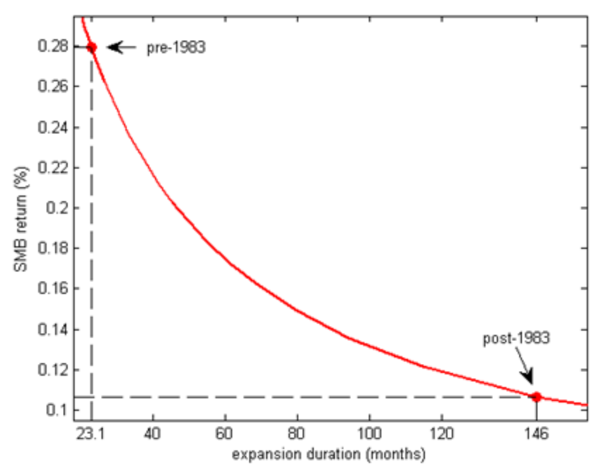
(b) NBER: SMB Average Return



(c) HP filter: Trough Probability



(d) HP filter: SMB Average Return



The figure illustrates the Trough probability and the unconditional size effect delineated as functions of the expansion duration. The results based on the business cycle stages determined by the NBER are presented in (a) and (b). Figure (c) and (d) plot similar graphs but under the HP filter.