What Can Asset Prices Tell Us About Historical Business Cycles?

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Abstract

This paper makes use of a large cross section of asset prices and investors' first order conditions to estimate a business cycle index based on the aggregate consumption implied by asset prices. Unlike GDP, unemployment or industrial production, historical asset prices are measured with great precision and have been contemporaneously collected for hundreds of years. The methodology outlined in this paper can therefore be employed to estimate business cycles for time periods and locations that were previously obscured by data limitations.

"NOTE: These figures should not be regarded as reliable, annual estimates. They were derived for the purpose of computing decade averages and are supplied to interested technicians for testing, not for analysis as annual series."

- Original warning attached to photocopies of Gallman's 19th Century GDP estimates.

Introduction

In his 1959 presidential address to the *AEA*, Arthur Burns, impressed with the previous decade of stability, predicted that the future business cycle "is unlikely to be as disturbing or troublesome to our children as it was to our fathers"[1]. Unlike Irving Fisher's prediction a generation earlier, history has been kind to Burns' forecast. The uninterrupted expansion of the 1960s proved so stable that the Department of Commerce decided to change the name of its *Business Cycle Digest* to the *Business Conditions Digest*[2]. When recessions did return in the 1970s and 80s they were relatively mild in comparison to the era of Burns' father when, in the words of Christina Romer, "there is simply no denying that all hell broke lose in the American economy"[3].

Some words of caution are in order. Although most measures of business cycle severity have decline since 1950, the decline is not monotonic. The current recession has witnessed the largest GDP decline since the great depression. It would probably have surprised Burns (as well as any modern economist unfamiliar with pre-B.E.A. data) to learn that despite the moderation of the business cycle the variance of annual GDP growth in the 1970s and 80s was statistically indistinguishable from the 1870s and 80s[4].

Has the business cycle really become less volatile? Are post-World War II recessions shorter in duration or less frequent then recessions 100 or 150 years ago? To answer these questions we require a consistent measure of the frequency and severity of business cycles. Unfortunately, the date and severity of historical business cycles are

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[1] 1959 Presidential Address to the American Economic Association

[2] J. Bradford DeLong Dec,12,1998 "Introduction to symposium on Business Cycles". http://www.j-bradford-delong.net/Comments/bcsymposium_intro.html

[3] Romer (1999) *Journal of Economic Perspectives* p.26

[4] Burns, of course, was quite familiar with pre-B.E.A. business cycle data. He would have likely been surprised at the magnitude of 1970s GDP fluctuations.
The GDP data are available at http://www.eh.net/hmit/gdp/. The Bartlett Test for homogeneity of variances has a P-value of .17

obscured by data limitations. In a series of influential papers, Christina Romer (1986a-c) persuasively argued that the apparent dampening of the post-war business cycle was a figment of the data. In the words of Romer; "*the statistics that economists use to measure the severity of business cycles, such as data on the unemployment rate, real gross national product, and industrial production, have been kept carefully and consistently only since World War II. Therefore, the conclusion that government policy has smoothed business cycles is based on a comparison of fragmentary prewar evidence with sophisticated postwar statistics*"[5]. Mark Watson (1994) likewise surveyed the available data and concludes that the evidence favors the hypothesis that "*the apparent stabilization is largely spurious and is caused by differences in the way that prewar and postwar business-cycle reference dates were chosen by the NBER*"[6].

Romer's findings have not gone unchallenged. Stanley Lebergott (1986) "*argued that Romer's reconstructed aggregates, like the original series, depend importantly on unverifiable assumptions and therefore are not unambiguously better than the original series*"[7]. David Weir (1986) constructed alternative estimates of pre-war output. Unlike Romer, Weir concludes that "*No one who has worked to create historical data series… would deny the possibility of improvement*" but *"To the simple question of whether cyclical fluctuations around trend in GNP and unemployment have become smaller since World War lI the data are more than adequate to deliver a definitive answer: yes"*[8]. Stimulated by the challenge of Romer's work, Balke and Gordon (1989) also constructed an alternative measure of GNP and conclude that their "*new estimates of real GNP are as volatile on average over the business cycle as the traditional Kuznets-Kendrick series*"[9].

Faced with a number of conflicting GNP series Diebold and Rudebusch (1992) concluded that "*Our reading of the literature on volatility stabilization is that the paucity of source data makes it very difficult to construct incontrovertible aggregate measures of the prewar U.S. economy"* and*" the inadequacy of aggregate measures of the prewar*

[5] Christina Romer "Business Cycles" in The Concise Encyclopedia of Economics. http://www.econlib.org/library/Enc/BusinessCycles.html
[6] Watson (1994) p.24
[7] The quote is from Diebold and Rudebusch (1992) P. 993
[8] Weir (1986) p. 365
[9] Balke and Gordon (1989) P. 38

economy undermines any comparison of prewar and postwar volatility"[10]. Diebold and Rudebusch proposed a duration test statistic based on the chronology of business-cycle turning points. Their methodology avoided the need to reliably estimate the amplitude of pre-war business cycles but required the date of business cycle turning points. While Diebold and Rudebusch "*do not accept the NBER chronology unquestioningly*"[11] their conclusions could be revisited in light of recent work by Davis (2004,2006). In an impressive undertaking Davis (2004) constructs a new annual series of Industrial production for the United States between 1790-1915. Using new output series and consistent estimation methods Davis concludes that "*the new chronology alters more than 40 percent of the [NBER] peak and troughs and removes the most questionable cycles"*[12] .

To accurately date and compare business cycles we require data series that are both linked to business cycle variation and consistently recorded over centuries. This is a stringent requirement and it is no surprise that data limitations have thus far prevented economists from forming a consensus. I propose we use of recently collected panels of cross-sectional stock prices to measure the timing and severity of business cycles. Economic theory links stock returns to aggregate consumption and unlike GDP, industrial production or unemployment, stock prices have been contemporaneously recorded for hundreds of years and measured with great precision.

This is far from the first paper to use stock data to measure business cycles. Burns and Mitchell (1946) included aggregate stock indexes among the hundreds of series used to choose the original NBER business cycle dates[13]. More recently, Shapiro (1988) and Watson (1994) employed aggregate stock index returns to draw inferences about the severity or duration of business cycles.

Shapiro noted the conflicting conclusions from the new series of Romer, Weir, and Balke and Gordon and concluded that "*even more detailed study of the underlying data is perhaps needed to resolve the impasse. I am skeptical, however, that such*

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[10] Diebold and Rudebusch (1992) p.993
[11] Diebold and Rudebusch (1992) p.994
[12] Davis (2006) p.103
[13] Moore and Zarnowitz (1986)

research would help most economists frame an opinion concerning the debate"[14]. Shapiro was pessimistic for the same reason Lebergott objected to the choice of one GNP estimate over another "*the steps in constructing the data are complicated and require judgment. Ultimately, only the participants in the debate may be able to make informed judgments about each of these detailed steps and how they color the final answer*"[15]. Shapiro proposed a test of business cycle volatility based on the volatility of the market index between 1872 and 1987. Likewise Watson (1994) examined the duration of stock index cycles between 1860 and 1990.

This paper differs from Shapiro (1988) and Watson (1994) in both methodology and scope. Rather than test for changes in the duration or magnitude of aggregate market fluctuations this paper uses a recently collected cross-section of stock returns to estimate a times series of implied consumption and date business cycle peaks and troughs. Economic theory links differences in average cross-sectional stock returns to aggregate consumption fluctuations via a simple law of one price relationship. I exploit the theoretical relationship between asset returns and consumption growth to estimate aggregate consumption fluctuations implied by asset returns over the past 183-years.

The Link between Asset Prices and Consumption

Asset returns are linked to consumption via investors' first order conditions. Consider an investor who may buy or sell an asset at time t. A necessary condition for expected utility maximization is that the marginal cost of the asset equal its marginal benefit

$$P_t u'(c_t) = E_t[u'(c_{t+1})(P_{t+1} + D_{t+1})] \qquad (1)$$

Here P_t and P_{t+1} denotes the price of the asset at time t and $t+1$, and D_{t+1} is the asset's

[14] Shapiro (1988) p. 1067
[15] Ibid.

stochastic time *t+1* dividend (if any). The left hand side of equation (1) is the marginal cost (measured in utility) of purchasing the asset at time t. The right hand side is the expected gain in future utility resulting from the purchase. Since price and consumption are known at time *t* we can rewrite (1) in terms of asset returns and the *stochastic discount factor* (SDF).

$$P_t = \mathrm{E}_t[m_{t+1}X_{t+1}] \qquad (2)$$

$m_{t+1} = \frac{\partial u(c_{t+1})}{\partial u(c_t)}$ is the investors' stochastic discount factor and $X_{t+1} = (P_{t+1}+D_{t+1})$ is the asset's stochastic payout at time *t+1*. Equation (2) relates the price of a risky asset to its expected payout and covariance with utility. If all investors are free to buy or sell at the same price, the law of one price requires a common m_{t+1} that satisfies (2) for all investors.

Equation (2) also links expected asset returns to fluctuations in consumption. To see this, expand $E_t[m_{t+1}X_{t+1}]$ to express price in terms of expected payout and covariance with investors' SDF.

$$P_t = E_t[m_{t+1}]E_t[X_{t+1}] + \mathrm{cov}_t(m_{t+1}, X_{t+1}) \qquad (3)$$

Imagine a risk-free asset granting its holder one dollar at time *t+1*. If such an asset existed, its price would be equal the conditional expectation $E_t[m_{t+1}]$. Thus, $E_t[m_{t+1}]$ is equal to the reciprocal of the gross risk-free rate.

$$E_t[m_{t+1}] = \frac{1}{R_{f,t+1}}$$

Substituting the definition of the risk free rate into (3) yields

$$P_t = \frac{E_t[X_{t+1}]}{R_{f,t+1}} + \textit{risk adjustment} \qquad (4)$$

$$\textit{risk adjustment} = \mathrm{cov}_t[m_{t+1}, X_{t+1}]$$

In other words, the price of a risky asset is equal to the sum of its expected payout discounted by the risk free rate and a risk adjustment. The risk adjustment is determined by the covariance of the asset's payout with the investor's consumption.

m_{t+1} tells us about expected consumption at time $t+1$. In states where investors expect to have a lot of consumption the marginal value of another dollar is small and investor's are unwilling to pay much for assets with high payouts in good times. However, in states where m_{t+1} is high, times are tough and investors are "hungry". An additional dollar of consumption is very valuable in these states and investors are willing to give up a lot of wealth at time t to hold assets that have high payouts when marginal utility is high.

All else equal, risk-averse investors would prefer to hold assets that pay well when times are bad and the marginal value of a dollar is high. But all else, isn't equal, in equilibrium all assets must be held – even "risky" assets that pay well during good times and poorly during bad times. Eq (4) describes the price adjustment necessary to clear the market. Assets with high expected payouts during good times and low expected returns during bad times are "risky" while assets with high expected payouts during bad times and low expected payouts during good times provide consumption insurance. If these assets traded at the same expected return everyone would want to hold the insurance. But in the aggregate we can't all insure. During business cycle contractions when aggregate production falls someone has to consume less. Therefore the price of risky assets must fall (and expected return rise) until investors are indifferent between holding "risky" assets and "insurance".

Eq(4) is the basis for an empirical link between observable asset returns and the state of the economy. In equilibrium, assets with high expected returns should do well during "good" times and poorly during "bad" times. Assets with low expected returns should have the opposite time series payouts. One can draw inference about the state of the economy over time by looking at the time series of high return and low return stocks.

There is a large literature employing modern data to examine the links between consumption and the cross section of asset returns. Mankiw and Shapiro (1996) and Breeden, Gibbons, and Litzenberger (1989) find modest correlations between contemporaneous consumption growth and expected returns. Lettau and Ludvigson (2001a 2001b), Parker and Julliard (2004), and Bansal, Dittmar, and Lundblad (2004) document stronger links when long run consumption correlations or contemporaneous variables that forecast long run consumption growth are used in place of contemporaneous consumption growth. These papers are motivated by the desire to explain cross-sectional differences in expected return via a link to consumption. This paper adds to the finance literature by documenting an historical link between asset price implied consumption and the business cycle.

This paper also draws on a long tradition in economic history. Historians are often interested in time periods and locations where variables of interest are either poorly measured or entirely unobservable. In these cases it's common to estimate variables of interest via theoretical links to data that is available and measured with more precision. Fogel and Engerman's (1974) use of anthropometric data to infer consumption and Friedman and Schwartz's (1963) used of money and prices to infer GDP growth are two prominent examples of this technique.

Estimating A Candidate SDF From the Cross-Section of All Available Assets Without a Factor Model via Volatility Constraints

We wish to use historical assets to estimate a candidate SDF and draw inferences about business cycles. Historical data limitations and our goal of deriving a measure of the state of the business cycles rather than test asset pricing implications motivate a departure from the traditional formula of sorting assets into portfolios and estimating a parameterized function of m.

Typically, one estimates a candidate SDF by restricting m_t to be a function of observable variables that are hypothesized to be correlated with changes in aggregate consumption. For instance, the CAPM, the models of Chen Roll and Ross (1986) and Lettau and Ludvigson (2001a,b) each imply factor model SDFs of the form $m_t = \alpha + \beta_1 F_1 + \cdots \beta_K F_K$ with respectively the excess return on the market index, innovations in GDP, inflation or interest spreads and consumption wealth ratios as factors. Typically assets are sorted into test portfolios based on traits likely to generate a spread in expected return. The betas are then estimated to best fit the data. That is, betas are chosen to minimize the mispricing of the test assets.

We depart from the standard procedure. We do not group assets into portfolios or restrict m to be a parameterized function of observable state variables. These changes free us from the requirement of observable historical factors or traits to sort on. However, this freedom comes at a cost. We are unable to evaluate the model via the traditional overidentifying test and are forced to impose an identification restriction on the variance of the candidate discount factor.

Asset returns are observable throughout the 19th century but many of the traits commonly used to sort assets into portfolios such as book-value and even size are unobservable for much of our sample. We also refrain from restricting the candidate SDF to a parameterized function of observable state variables. Again few of the economy wide series thought to be good candidates for factors are available throughout our period of study and the ones that are available happen to be the same series whose accuracy is the subject of debate.

Instead of sorting assets into portfolios, we alter the moment conditions in (2) to account for an unbalanced panel of individual asset returns and estimate a sequence $\{m_t\}_{t=1\ldots T}$ to price the individual assets. Fitting the model to individual asset returns rather than portfolios comes at a cost. With many moment conditions we are unable to evaluate the model in the traditional manner of formerly testing the hypothesis that all assets mispricings are jointly zero. To evaluate the accuracy of the estimation method we compare the post-war stock market implied consumption to post-war consumption and production estimates. We should be reasonably confident in these modern consumption and production estimates. The ability of the stock market implied consumption to match postwar business cycles should therefore serve as a good measure of the stock market based estimation technique.

Estimating m subject to volatility constraints

We alter the moment condition in (2) to account for an unbalanced panel of asset returns.[16]

$$E(R_{n,t}m_t) = D_{n,t} \qquad (5)$$

where $R_{n,t}$ is the return on asset n at time t, with zeros in place of missing observations, and $D_{n,t}$ is a dummy variable equal to zero if asset *n* does not exist at time *t*. Define the following error model

$$u(m)_{n,t} = R_{n,t}m_t - D_{n,t} \qquad (6)$$

Our goal is to pick a sequence $\{m_t\}_{t=1\ldots T}$ to best price the observable asset returns. Let T_n be the number of observations for asset n. Then $g(\widehat{m})_n$ is the average pricing error of n-th asset:

$$g(\widehat{m})_n = \sum_1^{Tn} \frac{u(\widehat{m})_n}{T_n} \qquad (8)$$

To estimate $\{m_t\}_{t=1\ldots T}$, form the vector of average pricing errors $\boldsymbol{G}(\widehat{m})$=$[g(\widehat{m})_1 \ldots g(\widehat{m})_N]'$ and choose $\{\widehat{m}_t\}_{t=1\ldots T}$ to solve (9) for a positive-definite weighting matrix **W** .

$$min_m \;\; J(m) = \boldsymbol{G}(m)'\boldsymbol{W}\boldsymbol{G}(m) \;\; s.t. \; m > 0, var(m) < K \qquad (9)$$

The first term: $min_m \;\; J(m) = \boldsymbol{G}(m)'\boldsymbol{W}\boldsymbol{G}(m)$ is the pricing constraint "pick *m* to best

[16] This assumes that the missing asset returns are missing at random.

price the historic returns". The first constraint: $m > 0$ rules out arbitrage by requiring all strictly positive payoffs to be assigned positive prices. In practice, the no arbitrage constraint is never binding given our data and the second constraint: $std(m) < K$ prevents the SDF from being excessively volatile.

The volatility constraint seems out of place given our goal of drawing inference about business cycles. Why are we constraining the candidate SDF from being excessively volatile? We are forced to impose the volatility constraint to identify the SDF in the early years of our sample when the number of assets is small. The number of observable assets range from many thousands during the CRSP era to less than 200 in the years before the Civil War. We therefore have a subset of time periods when the number of available assets is smaller than the number of time periods. Before the Civil War we have more choice variables then moment conditions and more than one candidate *m* sequence can perfectly price each asset. *m* estimated before the Civil War is not identified from the moment conditions alone but we identify *m* by imposing a volatility constraint.

Hansen and Jagannathan's (1991, 1997) show that a bound on the volatility of the SDF places an upper bound on the sharp ratio of all possible portfolios priced by the SDF. The Hansen-Jagannathan bound is a lower bound on the variance of all SDFs that price all assets correctly. Cochrane and Saa-Requejo (2001) use bounds on the SDF to price assets ruling out "deals to good to be true". We estimate (9) with monthly data and a bound of 10% monthly standard deviation on our candidate SDF. This bound is a binding constraint. While many candidate discount factors can price all assets perfectly before the Civil War all of them have a standard deviation greater than 10% per month. By choosing a K that is lower than the Hansen-Jagannathan bound we select the unique SDF that does the best job of pricing assets out of all candidate SDFs with $\sigma = K$.

What do we mean by "best" job of pricing assets? Obviously, best means minimize a weighted mispricing $J(m)$ but what weighting matrix should we choose? Surely we should pay more attention to some moments than others but so many moment conditions we cannot use the traditional efficient GMM weighting matrix $\mathbf{W} = \mathbf{Var}(\mathbf{G})^{-1}$. Instead we use a diagonal weighting matrix with the inverse of the sample variances of

$E[R_n]$ on the diagonal and zeros elsewhere. Equation (3) tells us that assets with high expected returns are highly correlated with the SDF. We don't observe expected return, however, only its sample estimate so our diagonal weighting matrix places tells us to pay more attention to the assets whose expected return is measured with confidence.

Data Sets Used To Estimate Candidate SDFs

Our estimation strategy relies on large cross-sections of stock returns. We use our own hand collected data for 1866-1925 stock returns. We colleced the closing prices, dividends and shares outstanding for 929 stocks listed on the New York Stock Exchange between 1866 and 1925. The prices were sampled every 28-days from the quotation lists published in the *Commercial and Financial Chronicle*. The data set contains 118,929 28-day holding period returns and includes every NYSE stock listed for at least one year.

We use the well known Center For Research in Security Prices' *CRSP* data set for January 1926- December 2008 and a combination of Goetzmann, Ibbotson, and Peng's (2001) and Sylla, Wilson and Wright's (2004) data sets for pre-Civil War returns. The combines pre-1866 data sets contain almost 14,000 monthly holding period returns on 179 stocks.

Results

We estimate candidate discount factors for each data set. That is, we solve (9) once for with the 1825-1865 data, once with the 1866-1925 data and again with the 1926-2008 data. The result is a continuous time series from January 1825 to December 2008 subject to the constraint that the monthly standard deviation is the same over the three sub-periods. This variance restriction prevents us from comparing the variance of our 19th century SDF sequence to the CRSP sequence but does not restrict the timing of business cycle peaks and troughs.

Table 1 reports sample average of the $\{\widehat{m}_t\}_{t=1\ldots T}$ sequence during NBER expansion and recession months during the 1825-1865, 1866-1925 and 1926-2008 samples. Regardless of sample, the stock market implied SDF rises during NBER recessions and falls during expansions. The difference is statistically significant at the 5% level during the CRSP era but the significance falls to the 10% level during the 1866-1925 era and becomes insignificant in the 1825-1865 sample.

The B.E.A. has reported real monthly non-durable personal consumption expenditures (RPCEND) starting since January 1959. If our candidate SDF accurately reflects consumption changes the level of our stock market implied SDF should be correlated with consumption growth. We should be reasonably confident in these modern consumption estimates. The co-movement between the B.E.A. estimates and the stock market implied SDF should therefore serve as a good test of the stock market based estimation technique. We regress the monthly change in RPCEND on the monthly level of *m*:

$$(RPCEND_{t+1}/RPCEND_t) = \underset{(568.6)}{1.0075} - \underset{(-3.04)}{.0054}m_{t+1}$$

The candidate SDF implied by asset prices varies with consumption growth.

The Consumption Stream Implied by Historical Asset Returns and CRRA Utility

To this point we have relied on no more than the first order condition to estimate a sample SDF from asset prices. Now that we have a time series of SDF realizations what consumption stream does this imply? To answer this question we need to specify a functional form for utility. We estimate consumption streams implied by constant relative risk aversion preferences. Time-Separable constant relative risk aversion (CRRA) preferences are perhaps the most common specification in the macroeconomic literature. CRRA preferences are described by the following utility function

$$U = E_0[\sum_{t=1}^{\infty} \beta^t \frac{c_t^{1-\gamma}}{1-\gamma}] \qquad (10)$$

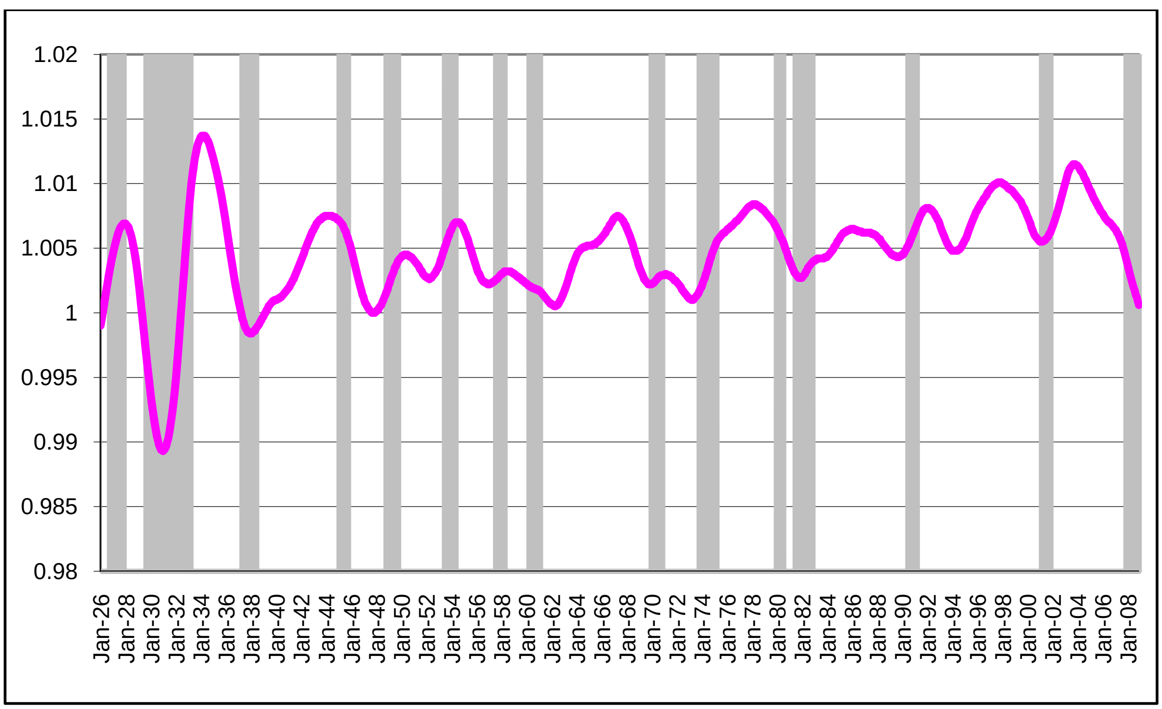
Where $\beta < 1$ is the time discount factor and $\gamma > 0$ is the coefficient of risk aversion. CRRA utility implies the following SDF

$$m_{t+1} = \beta(\frac{c_{t+1}}{c_t})^{-\gamma} \tag{11}$$

The CRRA SDF is not sufficient to identify consumption in levels. However, we can compute the growth rate of consumption. Given our SDF time series we can compute the implied consumption path by normalizing consumption in the initial period to 1 and using (11) to compute the remaining consumption sequence.

Figure 1 graphs the gross consumption growth implied by our SDF during the CRSP era. The time series matches the Great Depression 1929-1932 collapse, the 1933-36 boom and 1937 decline. The series also matches the high average growth rate after 1980 and the sharp decline in 2008. The level of implied consumption growth is not noticeably effected by the recessions of the 1950s and 1960s, however, and the growth rate dips but remains well above average during the recessions of the early 90s and early 2000s.

Figure 1: SDF Implied Gross Consumption Growth 1926-2008



SDF implied gross consumption growth smoothed with HP-filter. Shaded regions = NBER recessions. Souce: Author's calculations (see text. Eq.(11)).

Figure 1 suggests that the SDF implied consumption series misses captures major recessions but misses a number of NBER contractions. The implied consumption growth rate remains high and sometimes rises during the recessions of 1946, 1954, 1991 and 2001. To a large extent this reflects differences in what the NBER and SDF implied series measure. The NBER recessions largely reflect falls in output, while the SDF implied consumption series reflects changes in the growth rate of consumption. Normally, we would expect the consumption and output to coincide but that is not always the case.

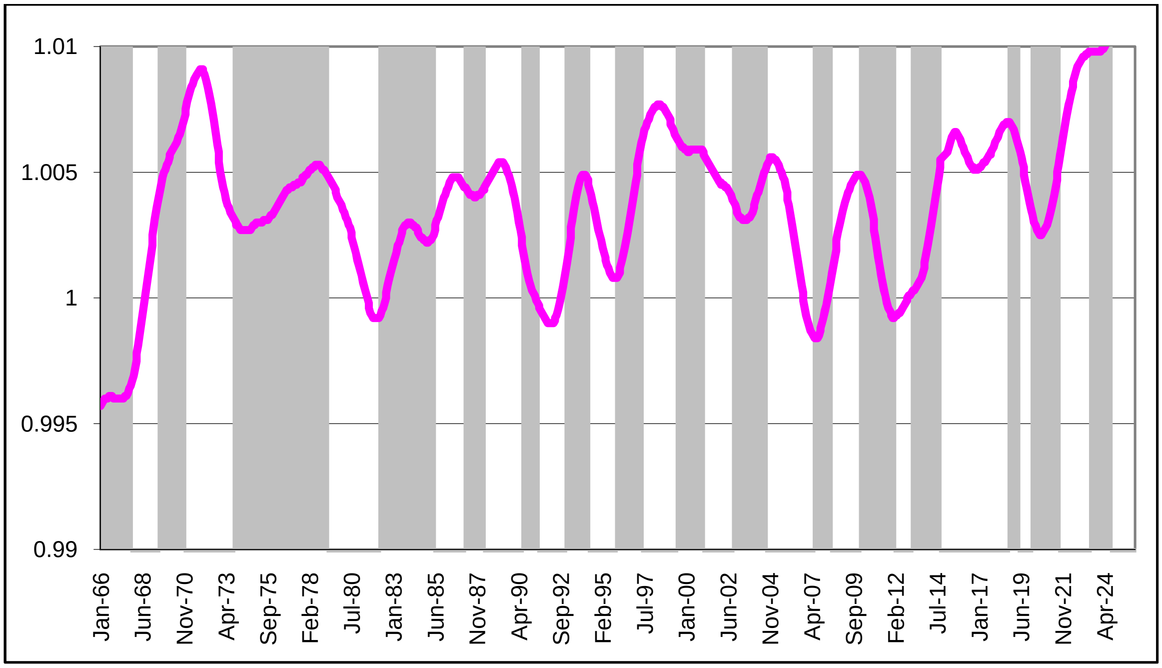
Figure 2 graphs the SDF implied consumption for 1866-1925. The stock market implied consumption is very low at the end of the Civil War. Implied consumption also falls during the recessions of the early 1880s, after the panics of 1893 and 1907. The implied consumption growth rate falls during the recession of 1873-79 and 1921 but the level remains above average. The recession of 1873-1879 is the longest contraction in the NBER chronology. It's also one of the most controversial. Davis's (2006) alternative business cycle turning points date the recession end in 1875. Friedman and Schwartz (1963) examined the growth of money and prices and concluded real GNP must have grown at an above average rate between 1873 and 1879. Stock market implied consumption agrees with Davis and Friedman and Schwartz.

Figure 3 plots the SDF implied consumption growth for the 1825-1865 data. *Antebellum* economic data are notoriously sparse. Much of what we know about the pre-Civil War U.S. business cycle is derived from indirect measures not unlike our current strategy of using stock market implied consumption to draw inferences about the state of the economy.

The state of the economy during this *"statistical dark age"* is the basis of much debate. Just how costly was the Bank war and depression of 1839-43? How hungry were the "hungry forties" in the United States? Did the late 1840s and early 1850s witnessed a "hidden" depression? The NBER chronology places the U.S. in recession for all but 5 years between 1836 and 1858! Davis, on the other hand, places the U.S. in recession for only 6 of these years.

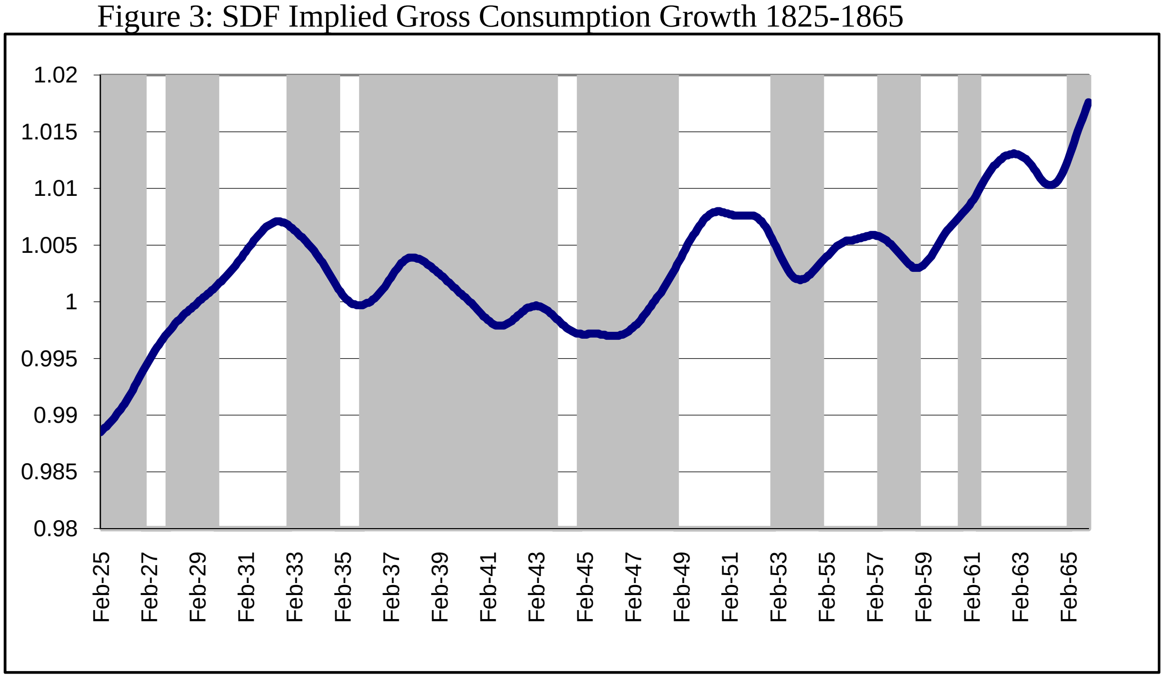
The implied consumption series matches the NBER chronology. Implied consumption growth is low between 1837-1849 and suffers outright decline for many of these years. The "hidden" recession of the 1850s is hidden from these data as well. SDF implied consumption grows at a robust rate throughout the 1850s.

Figure 2: SDF Implied Gross Consumption Growth 1866-1925



SDF implied gross consumption growth smoothed with HP-filter. Shaded regions = NBER recessions. Souce: Author's calculations (see text. Eq.(11)).

Figure 3: SDF Implied Gross Consumption Growth 1825-1865



SDF implied gross consumption growth smoothed with HP-filter. Shaded regions = NBER recessions. Souce: Author's calculations (see text. Eq.(11)).

A Business Conditions Index: 1825-2008

We summarize our implied consumption data in Table 2. We do not attempt to date the peaks and troughs of business cycles. Instead, we construct an index based on SDF implied consumption. Our index reflects the business cycle condition of each year between 1825 and 2008. We rank each year on a scale of 1 through 10 with *1 = severe depression, 2 = depression, … 5 = Normal ,… 9 = strong expansion, 10 = euphoria*.

Although our data is available monthly we construct the index annually to compare to existing annual consumption and GDP series. Although no monthly consumption data is available before 1958 we do have annual consumption estimates. Chapter 26 in Robert Shiller's (1989) *Market Volatility* draws on a number of sources to compute annual consumption estimates dating back to 1890[17]. Table 2 compares the stock market based consumption growth estimates to the annual consumption estimates reported in Shiller (1989).

Recall that our graphs in Figures 1-2 did a poor job of matching many NBER business cycles. A comparison of the consumption and GDP columns in Table 2 highlights the difference between our consumption based measure of the business cycle and the production based NBER dating procedures. Real per-capita consumption grew at a 2.08% annual rate between 1889 and 2008. Real GDP per capita grew at a 2% rate over the same time period. Over long time horizons consumption cannot grow much faster than GDP but the year to year growth rates need not be the same. Many years that witness negative per-capita GDP growth are coded as recessions by the NBER and expansions by our BC index. This appears to be a contradiction but many of these years witnessed both falling GDP and robust consumption growth. GDP declined and an NBER recession occurred during 1982, 1954, 1945, 1933, 1928, 1910, 1908, 1904 & 1894 but in each of these years consumption grew by significantly more than 2% and the BC Index was 7 or greater in each of these years. This apparent contradiction does not mean one measure is in error. The disagreement between the NBER production based recession dates and SDF

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[17] Shiller's (1989) data is available online at http://www.econ.yale.edu/~shiller/data/chapt26.xls

consumption based measure simply reflects the fact that production and consumption do not always co-move.

The BC Index is not always right. It assigns an 8 and a 9 in 1979 and 2007 despite below average GDP growth and negative consumption growth in both years. Given its derivation we would not recommend giving undue weight to the BC Index in instances where it disagrees with accurately measured modern consumption and GDP. The fact that the BC Index closely matches and often agrees with well measured business cycles variables should instill confidence that SDF based measures of the business cycle can fill the void for time periods and locations where production based measures are unavailable.

Before concluding, let us return to the 19th century results. Recall that the 1840s, 1850s and 1873-79 recession are all subjects of some controversy. The BC Index values imply that the 1840s were indeed a "hungry" time on this side of the Atlantic as well. Three years are rank in the bottom 10% or severe depression. Only the 1930s match this dismal record. On a happier note, the 1850s and 1873-79 appear to be times of robust growth. The 1850s BC Index reflects healthy consumption growth as does the 1870s after a brief downturn in 1873 and 74.

Conclusion

This paper makes use of recently collected stock data and the restrictions of the investors' first order conditions to estimate the consumption stream implied by asset prices. The abundance of 19th century stock data allows us to extend consumption estimates back to 1825 and construct a consistently measured business cycle index. The consumption implied by asset prices does a poor job of matching the timing of many NBER business cycles but with is similar to available consumption series.

The 1820s, 1840s and 1930s witnessed the worst implied business cycle downturns. The 1850s and 1980's and 90s were periods of high implied consumption growth. Finally, the long depression of the 1870s does not appear long in our data. Consistent with Davis (2006) and earlier calculations of Friedman and Schwartz (1963) the long depression of the 1870s appears to actually be a average downturn in 1873-74 followed by healthy above average growth for the remainder of the decade.

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Table 1

Stochastic Discount Factors and the Business Cycle

Sample years:	1925-2000	1866-1925	1825-1865
	Average m	*Average m*	*Average m*
NBER Expansion month [1]	.9984	0.9873	.9986
	(.0035)	(0.0051)	(.0066)
NBER Recession month [1]	1.0014	1.001	1.0019
	(.0071)	(.005)	(.0057)
Ho: E[m|rec] = E[m|expan] (t-stat) [2]	2.22**	1.95*	1.47

1) The NBER began dating business cycle Peaks and Troughs at a monthly frequency in 1854. 1825-1853 business NBER business cycles are coded annually from Davis (2006) Table I. If a year prior to 1854 was a recession in the NBER Chronology we code each month of that year as a recession.

2) The test statistic is computed by regressions m_t *on a constant a NBER BC dummy. The reported statistic is the HAC t-stat for the null hypothesis that the dummy regression coefficient is equal to zero.*

Table 2: An Index of Business Cycle Conditions

BC Index based on rank value of SDF implied consumption growth

1 = severe depression ... 5 = Normal ... 10 = euphoria

* = year with NBER recession

Year	*BC Index*	Cons Growth	GDP Growth
1825*	1		1.48%
1826*	1		0.49%
1827	2		0.07%
1828*	3		-1.66%
1829*	5		0.77%
1830	3		5.99%
1831	6		5.19%
1832	9		3.69%
1833*	6		0.06%
1834*	6		-1.27%
1835	1		2.38%
1836*	4		0.18%
1837*	9		-1.96%
1838*	3		1.33%
1839*	4		-0.12%
1840*	6		-2.40%
1841*	1		-0.61%
1842*	4		0.25%
1843*	7		2.03%
1844	1		2.84%
1845*	7		3.35%
1846*	1		4.95%
1847*	3		3.36%
1848*	2		-0.05%
1849	5		-2.05%
1850	10		1.07%
1851	1		4.29%
1852	10		7.52%
1853*	4		4.39%
1854*	2		-0.18%
1855*	10		0.86%
1856*	2		1.21%
1857*	7		-2.22%
1858*	4		1.36%
1859	6		4.79%
1860*	8		-1.33%
1861*	10		-0.43%
1862	5		10.10%
1863	10		5.38%
1864*	2		-1.13%

Table 2: An Index of Business Cycle Conditions

BC Index based on rank value of SDF implied consumption growth

1 = severe depression ... 5 = Normal ... 10 = euphoria

Year	*BC Index*	Cons Growth	GDP Growth
1865*	10		0.53%
1866*	3		-6.91%
1867*	2		-0.81%
1868	2		1.39%
1869*	9		0.12%
1870*	2		0.32%
1871	7		1.93%
1872	10		5.67%
1873*	2		5.59%
1874*	3		-0.92%
1875*	9		-2.53%
1876*	7		1.97%
1877*	4		2.90%
1878*	8		1.25%
1879	5		9.49%
1880	7		6.16%
1881	4		9.88%
1882*	1		2.45%
1883*	8		-0.13%
1884*	7		-4.11%
1885*	2		-1.95%
1886	10		6.05%
1887*	2		5.28%
1888*	5		3.56%
1889	9	-2.08%	0.75%
1890*	5	4.79%	7.69%
1891*	6	2.65%	-0.98%
1892*	1	-1.47%	2.73%
1893*	6	-4.80%	-7.98%
1894*	10	10.40%	-6.72%
1895*	3	-2.12%	9.58%
1896*	2	5.93%	-3.19%
1897	9	-0.13%	2.51%
1898	9	9.87%	9.19%
1899*	4	-0.82%	5.12%
1900*	9	10.13%	0.76%
1901	3	-1.16%	3.29%
1902	8	4.05%	3.05%
1903*	2	-0.59%	1.03%
1904*	9	3.64%	-5.33%

Table 2: An Index of Business Cycle Conditions

BC Index based on rank value of SDF implied consumption growth

1 = severe depression ... 5 = Normal ... 10 = euphoria

Year	*BC Index*	Cons Growth	GDP Growth
1905	8	8.93%	9.08%
1906	5	0.07%	2.10%
1907*	1	-8.11%	0.73%
1908*	7	8.76%	-12.52%
1909	4	-0.26%	5.13%
1910*	10	3.20%	-1.03%
1911*	1	1.02%	1.64%
1912*	6	1.29%	3.06%
1913*	1	-3.11%	1.92%
1914*	4	-3.14%	-9.41%
1915	10	7.50%	1.27%
1916	1	-3.40%	12.27%
1917	3	-0.40%	-3.84%
1918*	10	3.11%	7.84%
1919*	7	2.92%	0.31%
1920*	2	4.43%	-2.24%
1921*	2	2.26%	-4.16%
1922	10	7.23%	4.10%
1923*	9	5.38%	11.25%
1924*	8	-4.36%	1.13%
1925	9	6.74%	0.83%
1926*	3	0.84%	5.11%
1927*	8	1.01%	-0.43%
1928	9	4.35%	-0.09%
1929*	2	-6.35%	4.84%
1930*	1	-3.82%	-9.59%
1931*	1	-9.46%	-7.14%
1932*	2	-2.75%	-13.56%
1933*	10	6.39%	-1.86%
1934	10	5.41%	10.11%
1935	9	9.41%	8.16%
1936	5	3.07%	12.29%
1937*	1	-2.38%	4.50%
1938*	5	4.71%	-4.19%
1939	7	4.33%	7.19%
1940	2	6.11%	7.87%
1941	4	-3.34%	16.00%
1942	6	1.45%	17.24%
1943	8	1.68%	14.81%

Table 2: An Index of Business Cycle Conditions

BC Index based on rank value of SDF implied consumption growth

1 = severe depression ... 5 = Normal ... 10 = euphoria

Year	*BC Index*	Cons Growth	GDP Growth
1944	7	5.02%	6.82%
1945*	9	11.05%	-2.20%
1946	4	-0.09%	-11.95%
1947	3	0.47%	-2.81%
1948*	4	0.99%	2.57%
1949*	8	4.64%	-2.22%
1950	6	-0.12%	6.94%
1951	7	1.41%	5.93%
1952	3	3.04%	2.06%
1953*	5	0.26%	2.87%
1954*	10	5.41%	-2.40%
1955	6	1.08%	5.27%
1956	3	0.65%	0.16%
1957*	4	-0.87%	0.19%
1958*	8	3.81%	-2.58%
1959	5	0.69%	5.30%
1960*	3	0.41%	0.42%
1961*	7	3.35%	0.66%
1962	1	2.63%	4.45%
1963	7	4.54%	2.88%
1964	7	5.00%	4.36%
1965	6	4.47%	5.09%
1966	4	1.86%	5.30%
1967	10	4.69%	1.41%
1968	7	2.70%	3.78%
1969*	3	1.14%	2.07%
1970*	6	2.52%	-0.98%
1971	4	4.99%	2.07%
1972	7	3.91%	4.18%
1973*	2	-1.67%	4.75%
1974*	5	1.31%	-1.41%
1975*	5	4.49%	-1.16%
1976	8	3.20%	4.31%
1977	8	3.29%	3.57%
1978	6	1.30%	4.46%
1979	8	-1.42%	2.02%
1980*	8	0.42%	-1.37%
1981*	3	0.44%	1.50%
1982*	8	4.76%	-2.87%
1983	4	4.39%	3.58%

Table 2: An Index of Business Cycle Conditions

BC Index based on rank value of SDF implied consumption growth

1 = severe depression ... 5 = Normal ... 10 = euphoria

Year	*BC Index*	Cons Growth	GDP Growth
1984	6	4.26%	6.25%
1985	5	3.11%	3.21%
1986	5	2.41%	2.53%
1987	9	3.11%	2.46%
1988	6	1.85%	3.19%
1989	7	0.90%	2.57%
1990*	3	-1.15%	0.74%
1991*	8	1.91%	-1.48%
1992	8	2.01%	1.96%
1993	3	2.49%	1.34%
1994	6	1.49%	2.77%
1995	9	2.29%	1.30%
1996	6	2.46%	2.50%
1997	9	4.03%	3.25%
1998	5	4.27%	2.97%
1999	8	3.92%	3.26%
2000	5	1.67%	2.53%
2001	4	1.68%	-0.27%
2002	5	1.87%	0.63%
2003	10	2.53%	1.57%
2004	9	2.42%	2.71%
2005	4	1.93%	2.00%
2006	8	1.66%	1.82%
2007*	9	-1.16%	1.04%
2008*	1	-1.89%	0.18%