Stock Returns and Changes in the Business Cycle

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Abstract

This study employs the production asset pricing model of Brock (1982) to examine whether changes in the business cycle can be predicted, and whether there exists a link between stock returns and forecasted changes in the business cycle. The gross domestic product (GDP) and industrial production (IP) are used as the proxies for the business cycle. The predictability of changes in the business cycle and the equilibrium relationship between stock returns and forecasted changes in the business cycle are illustrated by results using IP data in Taiwan over the period from 1972 to 2000. Nonetheless, empirical findings using GDP data show that changes in GDP are not predictable until recent period of time, and moreover, there is no link between stock returns and forecasted changes in GDP.

Keywords: Production asset pricing model; Business cycle; Stock returns; Taiwan

1. Introduction

Many studies have documented that equity returns are predictable. Fama (1981, 1990), Geske and Roll (1983), Kaul (1987), Barro (1990), Chen (1991), Lee (1992) and Ferson and Harvey (1993) found considerable evidence that variables related to the level or state of economic activity can explain equilibrium asset pricing and forecast expected stock returns. However, the ability of state variables to forecast stock returns had been criticized for its lack of a rigorous theoretical base. Fama and French (1993) argued that it is widely acknowledged in the literature that the appropriate form and measure of common risk factors are not motivated by theory but by ‘empirical experience’, which makes the choice of any particular version of the factors somewhat arbitrary.

This paper employs a production model of asset pricing based on a simple version of Brock (1979, 1982) to provide a theoretical ground and establish the link between stock returns and changes in the business cycle. The intertemporal asset pricing model of Brock (1979, 1982) is similar to the framework of the consumption-based asset pricing model (CCAPM) of Lucas (1978) and Breeden (1979), namely, the assumption of consumption smoothing. The production-based asset pricing model (PCAPM) of Brock (1982), however, allows production to become endogenous by incorporating production shocks into the model. Instead of relating asset prices to the willingness of consumer’s to substitute consumption across dates and states, the PCAPM links asset prices to economic-wide fluctuations in both gross output levels and firm’s prof-
for developed financial markets. For example, Campbell et al. (1997) and Campbell (1999) find that stock returns are not proportional to the predicted changes in economic activity in developed economies.

The emerging Taiwanese stock market has been historically characterized by very high volatility (Titman and Wei, 1999). The behavior of stock market in Taiwan could be very different from those in the US or other developed counties. Moreover, the structure of the PCAPM is tied to decisions, such as investment and production, which could have been the major forces driving the phenomenal economic growth in Taiwan. Therefore, the distinct feature of the stock market and economic development in Taiwan offers us a unique case to conduct this research. Particularly, Chen (2004) reported that the PCAPM works better than other asset pricing models in the Taiwan stock market. This empirical study hence makes a contribution to the study of the financial market in Taiwan by examining whether there is a connection between the stock market and business conditions.

Indeed, evidence that the predictability of stock returns is related to business conditions is generally consistent with the conventional theoretical explanations of trade-off between risk and expected returns in the literature on asset pricing. State variables forecast stock returns due to their ability to track changes in the business cycle, which does not necessarily imply that the stock market is inefficient. For example, when investors anticipate that the economy will be in recession in the future, they expect low income and a low level of consumption. Consequently investors have a desire to save more today, which in turn pushes up stock prices and lowers returns. For this reason, stock returns will be predictable if investors expect business conditions to change in the future.

Furthermore, Fama and French (1987) reported that return predictability is an increasing function of the return horizon. They showed that predictable variation in aggregate returns increases from around three percent for shorter horizons to more than 25 percent for longer horizons. Timmermann (1994) used a continuous time version of the asset pricing model of Lucas (1978) to explain the observed increase in predictability of returns as a function of the length of the holding period. By using data of industrial production as the proxy for the business cycle, we are able to examine whether the correlation between stock returns and changes in the business cycle increase as the horizon of the holding period rises.

The rest of the paper is organized as follows. Section 2 presents the production asset pricing model and discusses its theoretical framework. Section 3 describes the data. Empirical results are shown in section 4. Section 5 concludes the paper with a discussion of major findings and implications.

2. The Production Model of Asset Pricing

Consider a simple version of the asset pricing model with production of Brock (1982). The economy consists of one representative agent and one representative firm. The representative agent is initially endowed with one unit of stock in that firm and maximizes his/her expected discounted stream of lifetime utility, whereas the representative firm acts in the best interests of its owners and maximizes the discounted value of the dividend stream paid to the owners.

2.1 The Agent’s Optimization Problem

Following Lucas (1978), the representative agent maximizes the present value of the expected discounted stream of utility given by Eq. (1) below:

$$\max_{r_t, s_t} E_0 \left[ \sum_{t=0}^{\infty} \theta u(C_t) | \Omega_t \right]$$

subject to the budget constraint:

$$C_t + P_t S_{t+1} = D S_t + P_t S_t,$$  (2)

where $C_t$ is the agent’s consumption at time $t$, $S_{t+1}$ represents units of the single asset held from time $t$ to $t+1$, $P_t$ is the real price per unit of the asset, $D_t$ is the real endowment (dividend), $\theta$ is the discount factor ($0 < \theta < 1$), $u(C_t)$ is a utility function, and the term $E_t$ denotes mathematical expectation conditioned by the information set $\Omega_t$ about the future available to agent at time $t$. The first-order Euler equation of the model is:

$$u'(C_t) P_t = \theta E_t \left[ u'(C_{t+1}) (P_{t+1} D_{t+1}) | \Omega_t \right].$$  (3)

The economic rationale behind the first-order condition given in Eq. (3) is that the cost in terms of foregone current consumption of purchasing one unit of the asset should be equivalent to the expected future consumption benefit from the dividend and capital value of the asset. In other words, the asset price per share equates the current utility cost of buying the share to the discounted future utility benefits derived from dividends and the share’s resale value. Such a relation plays the major role in the dynamic asset pricing of Lucas (1978) and other intertemporal equilibrium models (Merton, 1973; Rubinstein, 1976; Breeden, 1979; Cox et al., 1985; Abel, 1988) in determining optimal consumption and portfolio decision.
2.2 The Firm’s Optimization Problem

The representative firm maximizes its market value, i.e. the present value of its expected profit:

\[
MAX \ E_0 \left\{ \sum_{t=0}^{\infty} [Y_t - K_{t+1}] M_t \Omega_t \right\},
\]

and

\[
Y_t = A^t K^\alpha \epsilon_t,
\]

where \( Y_t \) is the gross output and \( K_t \) is the capital stock prevailing at the beginning of time \( t \), \( A \) is the exogenous technical progress component and its technology parameter \( \alpha \) denotes the portion of capital in national income, hence \( \alpha \in (0,1) \). The productivity shock \( \epsilon_t \) captures the uncertainty arising from production and is assumed to be serially uncorrelated. The firm, after observing the realization for \( \epsilon_t \), makes the decision regarding the purchase of new capital goods. The residual between the gross output \( Y_t \) and the investment spending \( K_{t+1} \) is distributed as the shareholder’s dividend.

In addition, the firm faces a sequence of time-varying discount factor \( M_t \) when it solves the capital accumulation problem. Under the rational expectation equilibrium, these discount factors are endogenously determined by the agent’s intertemporal marginal rate of substitution in consumption given by:

\[
M_t = \theta \left[ U'(C_t)/U'(C_0) \right].
\]

2.3 The Social Planner’s Problem

Following Brock (1979 and 1982), we can solve the competitive equilibrium of the asset pricing problem by developing the following social planner’s problem:

\[
MAX \ E_0 \left\{ \sum_{t=0}^{\infty} \theta^t U(C_t) \right\},
\]

subject to:

\[
C_t + K_{t+1} = Y_t,
\]

where \( Y_t = A^t K^\alpha \epsilon_t \). Given \( C_t = D_t \) in equilibrium and a logarithmic utility function, \( U(C_t) = \log C_t \), we can derive the equilibrium law of the asset price and the capital stock based on the first-order Euler equations:

\[
P_t = \left[ \theta/(1-\theta) \right] D_t,
\]

\[
D_t = (1-\alpha \theta) Y_t,
\]

\[
K_{t+1} = \alpha \theta Y_t.
\]

Using Eqs (9)-(11), we can yield the equilibrium gross equity returns held from period \( t \) through period \( t+1 \):

\[
R_{t+1} = \theta^{-1} (Y_{t+1}/Y_t).
\]

Moreover, Eq. (11) implies that gross output evolves as:

\[
Y_{t+1} = (a \theta)^\alpha \ A^t \epsilon_{t+1} Y_t^\alpha.
\]

The empirical part of the predictability of equity returns in the framework of our production asset pricing model is based on Eqs. (12) and (13). The logarithmic transformation generates:

\[
\ln R_{t+1} = -\ln \theta + \ln Y_{t+1} - \ln Y_t,
\]

\[
\ln Y_{t+1} = \alpha \ln(\theta^\alpha) + (\ln A) Y_t +\alpha \ln Y_t + \ln \epsilon_{t+1},
\]

Subtracting \( \ln Y_t \) from both sides of Eq. (15), we have:

\[
\Delta y_{t+1} = \alpha \ln(\theta^\alpha) + \ln A + \alpha \ln Y_t + \ln \epsilon_{t+1},
\]

where \( \Delta y_{t+1} = \ln Y_{t+1} - \ln Y_t \) and \( y_t = \ln Y_t \). Eq. (16) illustrates that changes in output are predictable using a lagged output with a time trend.

Given the basis in Eq. (16), we can run the regression in Eq. (17) to forecast changes in the business cycle:

\[
\Delta y_{t+1} = \hat{a}_0 + \hat{a}_1 \Delta y_t + \hat{a}_2 y_t + \epsilon_{t+1},
\]

where \( \hat{a}_0, \hat{a}_1, \) and \( \hat{a}_2 \) are estimated regression parameters and \( \epsilon_{t+1} \) are regression errors. Accordingly, to examine the linear predictive relationship between stock returns and forecasted change in output, we incorporate the predictable fraction of changes in output as in Eq. (17) into Eq. (14) and run the following regression:

\[
\ln R_{t+1} = \hat{b}_0 + \hat{b}_1 \Delta y_{t+1} + \epsilon_{t+1},
\]

where \( \hat{b}_0, \hat{b}_1, \) and \( \hat{b}_2 \) are estimated regression parameters and \( \epsilon_{t+1} \) are regression residuals.

The empirical examination follows the two-step approach as in Campbell et al. (1997). First, we run regressions based on Eq. (17) to estimate the predicted changes in the business cycle. Second, we test whether stock returns are related in a linear way to the predicted changes in the business cycle according to Eq. (18). To account for the possible existence of autocorrelation and heteroscedasticity, we the approach of to run run regression sons based Eqs. (17)-(18)

3. Data

In this study, the gross domestic product (GDP) is used as the proxy for the output or business cycle. The quarterly data of real GDP are taken from the financial
Real monthly logarithm stock returns are calculated from changes in real stock price indices (CPI-adjusted P), given as the natural logarithmic difference of real stock price index:

\[ R_{t+1} = \ln \left( \frac{P_{t+1}}{P_t} \right) \times 100. \]  

where \( P_t \) is the real stock price index at month \( t \). The monthly changes in the business cycle are computed as the natural logarithmic difference of real IP (CPI-adjusted IP) in the similar way:

\[ \Delta y_{t+1} = \Delta IP_{t+1} = \ln \left( \frac{IP_{t+1}}{IP_t} \right) \times 100. \]  

The quarterly changes in the business cycle using GDP data are given:

\[ \Delta y_{t+1} = \Delta GDP_{t+1} = \ln \left( \frac{GDP_{t+1}}{GDP_t} \right) \times 100. \]  

We then calculate real quarterly stock returns using continuously compounded monthly real returns, as in Fama (1990). Similarly, we computed the quarterly changes in IP.

Table 1 provides descriptive statistics for the stock returns and changes in the business cycle. The skewness test a group of \( n \) autocorrelations is significantly different from zero. The Jarque-Bera normality test statistic (Jarque and Bera, 1980), \( Q(n) \), is the Ljung-Box (1978) Q-statistic at lag \( n \) and is used to test whether from zero. The Ljung-Box Q-statistics for both the monthly and the quarterly series of stock returns indicate that real stock returns have no statistically significant sample autocorrelations. Monthly equity returns are negatively skewed while quarterly stock returns are positively skewed. All two different horizon returns series are fat tailed. The JB tests indicate that both return series are not normally distributed.

For the changes in the business cycle, both monthly and quarterly IP growth rates are negatively skewed, while quarterly GDP growth rates are positively skewed. All of three growth rates have fat tails. JB tests reject the normality hypothesis for all of them. The Q-statistics indicate that all of three growth rates also have statistically significant sample autocorrelations.

4. Empirical Results

4.1 Prediction of Changes in the Business Cycle

To examine whether predicted changes in the business cycle can forecast returns, the first step is to generate predictions of changes in the business cycle. Thus, we investigated whether and to what extent changes in the business cycle can be predicted. When predicting changes in the business cycle, we ran the regression based on Eq. (17). Test results of prediction of changes in the business cycle are presented in Table 2.

Table 2 shows that over the period from January 1972 to March 2000, both monthly and quarterly changes in IP are predictable. Regression results show that the lagged IP and the time trend are statistically significant in forecast...
ing changes in IP. Moreover, changes in IP are positively correlated with the time trend, but negatively correlated with the lagged IP. The monthly changes in IP can be predicted up to 22 percent, while 13 percent of the quarterly series can be forecasted. We further partitioned the 28-year sample into two sub-periods of 14 years each. Similar results are detected.

Table 2 also illustrates that the predictable portion of changes in IP has increased more recently. For monthly series, the forecasted percentage of change in IP increases from 15 percent over the period from 1972 to 1986, to 42 percent over the period from 1987 to 2000. Similar results are found using the quarterly IP. The predicted portion of changes in the business cycle also grows from 12 percent over the period from 1972 to 1986, to 29 percent over the period from 1987 to 2000. Similar results are detected.

However, it is found that, over the full sample period, quarterly changes in GDP are unpredictable using the lagged GDP with a time trend. As shown in Table 2, estimated coefficients of the lagged GDP and the time trend are not statistically significant. The results remain the same over the period from the first quarter of 1972 to the forth quarter of 1986. However, quarterly changes in GDP are predictable over the recent sub-period from 1987 to 2000. Both the lagged GDP and the time trend can significantly predict changes in GDP. In addition, changes in GDP have a positive correlation with the time trend and a negative correlation with the lagged GDP. These results are in line with those using IP data.

4.2 Stock Returns and Forecasted Changes in the Business Cycle

The final implication of the model in this study is that stock returns should be related in a linear way to the predictions of changes in the business cycle. Based on Eq.(18), stock returns are regressed on predicted changes in the business cycle as obtained in the first step to test the predictive relationship between returns and forecasted changes in the business cycle. The test results are shown in Table 3.

As showed in Table 3, the estimated coefficients of monthly forecasted changes in the business cycle IP on monthly returns were negative over the period from January 1972 to March 2000. The negative correlation implies that during business troughs, one-period ahead stock returns are expected to fall. This is consistent with both the consumption smoothing theory and asset pricing models.

Table 3 also presents evidence that the predictive power of forecasted changes in monthly IP on monthly stock returns has grown lately. Empirical results indicate that forecasted changes in the business cycle over the period from 1972 to 1986 cannot significantly explain returns, and the explanatory power is low at 1 percent, while forecasted changes in the business cycle over the period from 1987 to 2000 can significantly explain returns, and the predictive power increases to 5 percent. The findings are consistent using the quarterly IP data. Stock returns are negatively correlated with forecasted changes in the business cycle. Forecasted changes in quarterly IP over the full sample and two sub-samples can significantly explain quarterly returns. The explanatory power is 11 percent over the full sample period. In addition, the predictive power of forecasted changes in IP on returns has also increased recently, increasing from 6 percent over the period from 1972 to 1986, to 29 percent over the period from 1987 to 2000.

Table 2. Tests of Predictions of Changes in the Business Cycle

<table>
<thead>
<tr>
<th>Business Cycle</th>
<th>Sample Period</th>
<th>Estimated Coefficient</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly IP</td>
<td>1/1972-3/2000</td>
<td>$\hat{a}_0 = 11.53 (6.43)^{***}$</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>1/1972-12/1986</td>
<td>$\hat{a}_1 = 0.22 (8.79)^{**}$</td>
<td>-0.76 (-8.63)^{***}</td>
</tr>
<tr>
<td></td>
<td>1/1987-3/2000</td>
<td>$\hat{a}_2 = 0.35 (12.14)^{***}$</td>
<td>-1.05 (-11.75)^{***}</td>
</tr>
<tr>
<td>Quarterly IP</td>
<td>1972: I-2000: I</td>
<td>$\hat{a}_3 = 0.56 (4.16)^{**}$</td>
<td>-0.63 (-4.41)^{**}</td>
</tr>
<tr>
<td></td>
<td>1972: I-1986: IV</td>
<td>$\hat{a}_4 = 0.61 (3.45)^{**}$</td>
<td>-0.86 (-3.36)^{***}</td>
</tr>
<tr>
<td></td>
<td>1987: I-2000: I</td>
<td>$\hat{a}_5 = 0.98 (5.82)^{**}$</td>
<td>-0.94 (-6.20)^{**}</td>
</tr>
<tr>
<td>Quarterly GDP</td>
<td>1972: I-2000: I</td>
<td>$\hat{a}_6 = 0.63 (3.68)^{**}$</td>
<td>-1.93 (-4.12)^{**}</td>
</tr>
</tbody>
</table>

Note: The $t$-statistics corrected for the heteroskedasticity and autocorrelation based on Newey and West (1987) are shown in parentheses. The symbol "***" indicates statistical significance at the 1% level.
Table 3. Predictive Relationship between Stock Returns and Forecasted Changes in the Business Cycle

<table>
<thead>
<tr>
<th>Business Cycle</th>
<th>Sample Period</th>
<th>( \hat{b}_0 )</th>
<th>( \hat{b}_1 )</th>
<th>Adjusted ( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly IP</td>
<td>1/1972-3/2000</td>
<td>1.69 (18.09)**</td>
<td>-0.03 (-1.94)**</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>1/1972-12/1986</td>
<td>1.49 (11.98)**</td>
<td>-0.03 (-0.93)</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>1/1987-3/2000</td>
<td>1.90 (15.75)**</td>
<td>-0.05 (-2.05)**</td>
<td>0.05</td>
</tr>
<tr>
<td>Quarterly IP</td>
<td>1972: I-2000: I</td>
<td>2.44 (16.06)**</td>
<td>-0.13 (-3.76)**</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>1972: I-1986: IV</td>
<td>2.40 (12.55)**</td>
<td>-0.12 (-2.56)**</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>1987: I-2000: I</td>
<td>2.25 (12.51)**</td>
<td>-0.17 (-5.62)**</td>
<td>0.29</td>
</tr>
<tr>
<td>Quarterly GDP</td>
<td>1972: I-2000: I</td>
<td>2.29 (6.12)**</td>
<td>0.10 (0.86)</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>1972: I-1986: IV</td>
<td>1.72 (2.19)**</td>
<td>0.20 (1.05)</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>1987: I-2000: I</td>
<td>3.12 (6.80)**</td>
<td>-0.21 (-0.99)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note: The \( t \)-statistics corrected for the heteroskedasticity and autocorrelation based on Newey and West (1987) are shown in parentheses. The symbols ** and *** indicate statistical significance at the 5% and 1% level, respectively.

Test results further indicate that the correlation between stock returns and changes in \( IP \) grows as the horizon of the holding period increases. These results are also in line with findings of Fama and French (1987). The explanatory power of forecasted changes in \( IP \) on returns increases from 2 percent using monthly data to 5 percent using the quarterly data over the full sample, while rises from 1 and 5 percent to 6 and 29 percent over two sub-samples respectively. In comparison, the estimated coefficients of quarterly forecasted changes in \( GDP \) on quarterly stock returns are positive over the full sample and the sub-period from the first quarter of 1972 to the forth quarter of 1986, and negative over the sub-period from the first quarter of 1987 to the first quarter of 2000. However, they are not statistically significant in predicting returns over the full sample and two sub-period samples. In sum, stock returns are not correlated with forecasted changes in \( GDP \).

5. Conclusions

This study shows the theoretical link between stock returns and changes in the business cycle based on the PCAPM of Brock (1982). Given the gross domestic product and industrial production as the proxies for the business cycle, we examine whether and to what extent changes in the business cycle can be predicted and whether forecasted changes in the business cycle can predict stock returns in Taiwan.

Contrary to the findings in Campbell et al. (1997) and Campbell (1999) that there are no links between stock returns and predicted changes in industrial production in developed countries, the predictability of changes in the business cycle and the ability of forecasted changes in the business cycle to forecast stock returns are evidenced by empirical results using the industrial production data over the period from 1972 to 2000 in Taiwan. Empirical results demonstrate that both monthly and quarterly changes in \( IP \) can be predicted up to 22 percent and 15 percent respectively over the period from January 1972 to March 2000. The predictable portion of change in \( IP \) has risen lately.

Moreover, forecasted changes in \( IP \) are able to predict stock returns in general. The predictive power of forecasted changes in \( IP \) on returns has grown recently, increasing from 1 percent over the period from 1972 to 1986, to 5 percent over the period from 1987 to 2000 for monthly data, while increasing from 6 percent to 29 percent for quarterly data. We also detect a negative correlation between forecasted changes in \( IP \) and returns for both monthly and quarterly series. This negative link is in line with the asset pricing model and consumption smoothing theory.

It is further found that the degree of correlation between stock returns and forecasted growth rates of \( IP \) increases with the length of the time period. These results support the findings presented in Fama and French (1987). As explained by Fama (1990), a possible reason is that information about a certain period is spread over many previous periods, and not all information about future returns becomes publicly known over a short time period. Hence monthly changes in \( IP \) explain a small fraction of stock returns, and this fraction gets larger as the time horizon increases to quarterly. Empirical evidence shows that the fraction of returns explained by forecasted changes in \( IP \) grows as the horizon of the period increases.

Lastly, empirical findings using GDP data indicate no predictability of changes in GDP and no link between stock returns and forecasted changes in GDP over the full sample and the sub-period from the first quarter of 1972 to
the forth quarter of 1986. Although changes in GDP are predictable for the recent period from 1987 to 2000, we still find that there exists no relationship between stock returns and forecasted changes in GDP during this sub-period sample.

References