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INTEREST RATE SPREADS AND THE PREDICTION OF REAL ECONOMIC ACTIVITY: THE CASE OF SINGAPORE

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I. INTRODUCTION

MANY financial variables have been found to contain important information about the future of the economy. In particular, some recent research has shown that interest rate spreads have significant predictive power for the changes in real economic activity. For the U.S. economy, Stock and Watson (1989) found that the slope of the term structure (the difference between the ten-year Treasury bond rate and the six-month Treasury bill rate) and the paper-bill spread (the difference between the six-month commercial paper rate and the six-month Treasury bill rate) are powerful predictors for the business cycles. These results have been extended by Plosser and Rouwenhorst (1994) to other industrialized economies. They found that the slope of the term structure has information about future economic growth for Canada, Germany, the United States, and the United Kingdom. Similar findings have been reported by Alles (1995) for the Australian economy. In this paper we examine the empirical relation between the real economic activity and a number of interest rate spreads for the Singapore economy. To the extent that Singapore has a small and immature market of government securities, it would be interesting to see if the interest rate spreads provide useful information about future economic activity as reported for the industrialized economies.

Harvey (1991) developed an asset pricing framework that forms the basis for the forecasting model with the slope of the term structure as the predictor. He argued that when a slowdown in the economy is expected the desire to hedge would lead consumers to sell short-term securities in favor of long-term assets. This would lead to a drop in the price of short-term assets and an increase in the price of long-term assets. Thus, the yield of the short-term assets would increase while that of the long-term assets would decrease, resulting in the flattening of the yield curve. This argument suggests that the expectations of future economic growth can be extracted from the term structure. Harvey's study on the G-7 countries shows that the term structure has higher explanatory power for the variations in economic growth as compared to models based on past growth rates. Estrella and Hardouvelis (1991) confirmed that the term structure has extra predictive power for the future economic activity of the United States over a number of predictors such as the index of leading indicators and the real short-term interest rates. They analyzed the predictability of the cumulative changes in real output as well as the marginal changes. It was found that the predictive power for the cumulative changes lasts for about four years, while that for the marginal changes lasts for about six quarters.

The importance of the paper-bill spread as a predictor for the business cyles has been documented by Stock and Watson (1989), Bernanke (1990), and Friedman and Kuttner (1992, 1993). In a study comparing the predictive ability of various interest rate spreads Bernanke (1990) reported that the best single predictor is the paper-bill spread. He argued that the paper-bill spread is a useful measure of perceived default risk. When investors expect a slowdown in the economy the riskiness of commercial papers is expected to increase, resulting in a wider spread in the commercial paper rate over the Treasury yield. In other words, the paper-bill spread embodies useful information about the market's perception of the likelihood of a recession. The study by Friedman and Kuttner (1993) shows that the perception of default risk has a clearly recognizable influence on the paper-bill spread. On the other hand, variations in monetary policy may affect the paper-bill spread by changing the composition of assets available in the economy. Specifically, the widening of the paper-bill spread may be the result of the contraction in bank lending due to tightening monetary policy. Thus, the paper-bill spread may be used as an indicator of monetary policy, which in turn is an important determinant of future economic activity.

The rest of this paper is organized as follows. Section II describes the data used in this study and present a graphical summary of the data. In Section III we summarize the results of various interest rate spreads as predictors for the growth of the real gross domestic product (GDP). The paper-bill spread is found to have significant predictive power for the growth in real GDP. In contrast, the slopes of the term structure based on the bank fixed-deposit rates and the government securities have insignificant predictive power. In Section IV we examine the prediction of the components of the GDP using the paper-bill spread. Decomposition of the GDP according to expenditures as well as industrial outputs are considered. Section V presents some results on the performance of the post-sample forecasts of the models. Finally, some concluding remarks are given in Section VI.

II. THE DATA

The date for Singapore's real GDP are extracted from the electronic database TREND of the Department of Statistics, Ministry of Trade and Industry. The data cover the period from the third quarter of 1978 through the first quarter of

1995.[1] They include the real GDP and its components by output of various industrial sectors as well as by categories of expenditure. We use the seasonally adjusted quarterly series at 1985 market prices. In addition, we also extract the series of leading indicators from the *Economic Survey of Singapore*.

The Singapore interest rate data are extracted from various issues of the *Monthly Statistical Bulletin* of the Monetary Authority of Singapore. The following series are compiled: bank fixed-deposit rates of three months and one year, three-month commercial paper rates, and yields of three-month and five-year government securities. We compute the quarterly averages based on the end-of-week data. The bank fixed-deposit rates are the averages quoted by ten leading banks. They represent a long series of the term structure not available from the government securities. For the government securities, the five-year bond rates are available only from the third quarter of 1987.[2] Thus, to examine the effects of the term structure on the growth of the real GDP with a longer series, the use of the fixed-deposit rates may be an alternative. It is noted, however, that unlike the rates of the government securities, the fixed-deposit rates may not be sensitive to market conditions. Also, the use of one-year rate may not be representative of the long-end of the yield curve, resulting in an understated slope of the yield curve.

To examine the effects of the international term structure, we compile a series of the difference between the yield of the ten-year and the yield of the three-month U.S. Treasury securities. The data are obtained from the *International Financial Statistics*.

The following notations are used: PBSP = paper-bill spread, FDSP = fixed-deposit spread, BBSP = bond-bill spread, and USSP = U.S. bond-bill spread. These series are defined as follows:

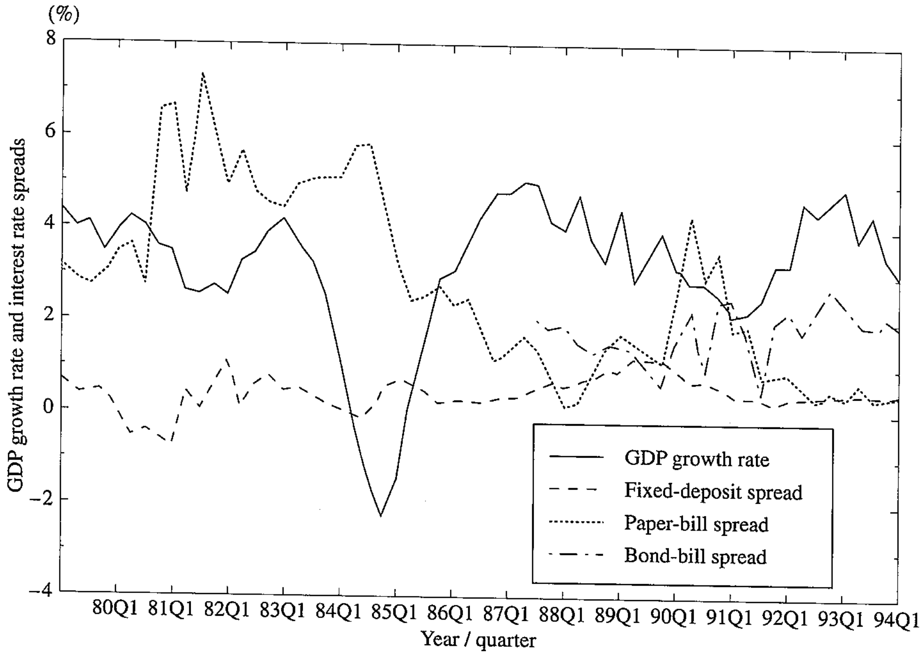
$PBSP$ = three-month commercial paper rate − three-month Treasury bill rate,
$FDSP$ = one-year fixed-deposit rate − three-month fixed-deposit rate,
$BBSP$ = five-year government bond rate − three-month Treasury bill rate, and
$USSP$ = ten-year U.S. Treasury bond rate − three-month U.S. Treasury bill rate.

A series of annualized growth rates over each four-quarter period is computed using the formula: $\log GDP_{t+4} - \log GDP_t$. This series represents the rate of growth four quarters ahead. Figure 1 presents the growth rates of the real GDP and the various spreads of the Singapore data. It can be seen that the $FDSP$ series has very small

[1] We also have the data for the real GDP and its components for the last three quarters of 1995. These observations are used for post-sample comparison.

[2] In 1987 the government securities market was revamped. The first auction of five-year government bonds took place in May 1987. Most of the long-term securities are taken up by the Central Provident Fund, while the short-term securities are bought by banks and finance companies to meet the statutory requirements. The liquidity of the market is ensured by the registered primary dealers who act as market makers. See Tan (1996) for the details.

Fig. 1. GDP Growth Rate and Interest Rate Spreads



variations. From 1987 to 1994, the *BBSP* series generally moves in tandem with the growth rates of the real GDP, except for the period from mid-1990 to mid-1991. In contrast, the *PBSP* series generally moves in the opposite direction of the GDP growth rate series. The peak of the growth rate series in 1983Q1 was picked up by the *PBSP* series, and so was the trough in 1984Q3. In more recent times, the period of high growth in 1992 and 1993 coincided with very low spreads of less than one percent. Thus, cursory observation suggests that the *BBSP* may be positively correlated with the GDP growth rate, while the *PBSP* may be negatively correlated with the GDP growth rate.

III. INTEREST RATE SPREADS AND GDP GROWTH RATES

Denoting Y_t as the real GDP, the annualized cumulative changes (in percentage) over k quarters, denoted by $y^C_{t,k}$ is computed as follows:

$$y^C_{t,k} = (\log Y_{t+k} - \log Y_t)\,400/k, \tag{1}$$

for $t = 1, \ldots, n$. Similarly, we also consider the annualized marginal percentage changes from the $(t+k-1)$th quarter to the $(t+k)$th quarter. This is denoted by $y_{t,k}^M$ and is defined as follows:

$$y_{t,k}^M = (\log Y_{t+k} - \log Y_{t+k-1})\,400. \tag{2}$$

Denoting SP_t generically as a spread variable, we examine the cumulative GDP changes with the spread variable as a predictor based on the regression model:

$$y_{t,k}^C = \alpha_0 + \alpha_1 SP_t. \tag{3}$$

For the marginal changes, similar prediction models based on the spreads are estimated as follows:

$$y_{t,k}^M = \beta_0 + \beta_1 SP_t. \tag{4}$$

The results are summarized in Table I. For the cumulative-change equations, when $k > 1$, the sampling interval overlaps the forecasting horizons. This creates autocorrelations in the residual. Although the ordinary least squares (OLS) estimates are still consistent for the parameter values, the t-ratios are asymptotically biased. To overcome this difficulty, we use the Newey-West (1987) estimates of the standard errors which are known to be consistent under autocorrelated and/or heteroskedastic errors. For the marginal-change equations, although the observation intervals do not overlap the forecasting horizon, autocorrelation may still exist for some regressions. For the cases when the residuals are found to be statistically significantly autocorrelated, we use the Newey-West estimates of the standard errors. Otherwise, the OLS estimates of the standard errors are used.

It can be seen that the paper-bill spread is a significant predictor for the GDP changes. *PBSP* is statistically significant for the cumulative GDP changes of two quarters or more, up to a horizon of three years. On the marginal basis, *PBSP* is statistically significant for annualized incremental quarterly changes of three to seven quarters ahead. The parameter estimates of α_1 and β_1 are consistently negative, implying that a widening paper-bill spread would lead to a slowdown in real output. This result is in line with those of Stock and Watson (1989) and Bernanke (1990). Up to 35 per cent of the variations in the cumulative GDP changes can be explained by the paper-bill spread.

For the fixed-deposit and bond-bill spreads, it is found that these variables have no predictive power for the real GDP changes. For *FDSP*, the estimates of α_1 and β_1 take on both negative and positive values, and none of these estimates are statistically significant. As a result of the cartel formation in the determination of the fixed-deposit rates, *FDSP* may not be sensitive to the market conditions. Also, the use of the one-year rate as the long-end of the yield curve in the calculation of *FDSP* may have understated the yield spread. Indeed, the fact that there is little variation in *FDSP* is quite clear from Figure 1.

For *BBSP*, the estimates of α_1 and β_1 are consistently positive, as is expected

TABLE I

REGRESSION OF CHANGES IN LOGARITHMIC GDP ON INTEREST RATE SPREADS

Forecasting Horizon: k Quarters	n	*PBSP*				n	*FDSP*				n	*BBSP*			
		Cumulative		Marginal			Cumulative		Marginal			Cumulative		Marginal	
		$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$		$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$		$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$
1	66	−0.406	0.01	−0.406	0.01	66	−0.940	−0.01	−0.940	−0.01	30	0.244	−0.03	0.244	−0.03
		(−1.540)		(−1.540)			(−0.636)		(−0.636)			(0.164)		(0.164)	
2	65	−0.530	0.05	−0.628	0.04	65	−0.576	−0.01	−0.228	−0.02	29	0.280	−0.03	0.068	−0.04
		(−2.009)		(−1.924)			(−0.490)		(−0.155)			(0.308)		(0.044)	
3	64	−0.682	0.11	−0.934	0.11	64	0.200	−0.02	1.739	0.00	28	0.756	0.01	1.916	0.02
		(−2.264)		(−2.930)			(0.171)		(0.994)			(1.048)		(1.265)	
4	63	−0.779	0.17	−1.019	0.13	63	0.503	−0.01	1.413	−0.00	27	0.655	0.00	0.493	−0.04
		(−2.225)		(−3.176)			(0.392)		(0.701)			(0.940)		(0.301)	
5	62	−0.844	0.22	−1.017	0.12	62	0.938	−0.00	2.677	0.03	26	0.552	0.00	0.226	−0.05
		(−2.229)		(−3.100)			(0.674)		(1.313)			(0.857)		(0.136)	
6	61	−0.888	0.27	−0.984	0.12	61	1.010	−0.00	1.370	−0.01	25	0.556	0.01	0.334	−0.04
		(−2.271)		(−2.974)			(0.742)		(0.889)			(0.965)		(0.196)	
7	60	−0.885	0.30	−0.797	0.07	60	0.920	−0.00	0.393	−0.02	24	0.536	0.00	0.411	−0.04
		(−2.213)		(−2.290)			(0.726)		(0.385)			(1.065)		(0.236)	
8	59	−0.870	0.32	−0.681	0.04	59	0.811	−0.00	0.061	−0.02	23	0.602	0.03	0.997	−0.03
		(−2.159)		(−1.896)			(0.704)		(0.065)			(1.354)		(0.667)	
9	58	−0.841	0.33	−0.580	0.02	58	0.632	−0.01	−0.750	−0.01	22	0.395	−0.01	0.082	−0.03
		(−2.075)		(−1.559)			(0.606)		(−0.441)			(1.038)		(0.363)	
10	57	−0.802	0.34	−0.394	0.00	57	0.404	−0.01	−1.651	−0.00	21	0.584	0.05	0.175	0.11
		(−2.036)		(−1.022)			(0.435)		(−0.969)			(1.392)		(0.749)	
11	56	−0.775	0.35	−0.468	0.01	56	0.196	−0.02	−1.908	0.00	20	0.471	0.03	0.108	−0.06
		(−2.093)		(−1.194)			(0.240)		(−1.121)			(1.220)		(0.451)	
12	55	−0.736	0.35	−0.301	−0.01	55	0.022	−0.02	−1.960	0.01	19	0.477	0.06	0.165	−0.04
		(−2.151)		(−0.743)			(0.031)		(−1.143)			(1.420)		(0.681)	

Notes: *PBSP* = paper-bill spread, *FDSP* = fixed-deposit spread, *BBSP* = bond-bill spread. Denoting Y_t as the GDP and SP_t generically as a spread variable, the cumulative-change regression is given by: $y_{t,k}^C = (\log Y_{t+k} - \log Y_t)\,400/k = \alpha_0 + \alpha_1 SP_t$; and the marginal-change regression is given by: $y_{t,k}^M = (\log Y_{t+k} - \log Y_{t+k-1})\,400 = \beta_0 + \beta_1 SP_t$. The figures in the parentheses are the t-statistics.

from Harvey's (1991) arguments. None of these estimates, however, are statistically significant. As the sample sizes of these regressions are small, the lack of statistical significance may be a result of inadequate observations and thus inadequate statistical power. It is noted that the sample size for the regressions with *BBSP* as the explanatory variable is less than 50 per cent of that for the regressions based on *PBSP* (specifically, when $k = 1$, the sample size of the *BBSP* regression is thirty while that of the *PBSP* regression is sixty-six). It would be interesting to see if the bond-bill spread can emerge as a useful predictor when more observations become available. This is an interesting topic for future research.

To examine if the paper-bill spread provides extra information about the GDP growth not available in other variables, we consider augmented regressions with additional explanatory variables. The variables included in the augmented regressions are the index of leading indicators, denoted by *LIND*, and the bond-bill spread of the United States, denoted by *USSP*. The index of leading indicators has been used by Estrella and Hardouvellis (1991) and Alles (1995) to provide benchmark comparison on competing forecasting models for real output. The index of leading indicators is a composite of some macroeconomic variables.[3] It is constructed to summarize the aggregate information of its components and is meant to have predictive power for future economic activity. The U.S. bond-bill spread is used as a proxy for the world term structure. The work of Harvey (1991) shows that the U.S. term structure has the ability to forecast economic growth of some of the G-7 countries. Improvement in the regression equation can be obtained by combining the local term structure with the U.S. term structure. The research by Plosser and Rouwenhorst (1994) also supported the finding that the world term structure contributes significantly to the predictive power of a country's cumulative and marginal economic growth. Denoting y_t generically as the dependent variable (cumulative logarithmic GDP change $y^C_{t,k}$ or marginal logarithmic GDP change $y^M_{t,k}$), we consider the following regression:

$$y_t = \alpha_0 + \alpha_1 PBSP_t + \alpha_2 USSP_t + \alpha_3 LIND_t. \tag{5}$$

The results are summarized in Table II.

It can be seen that the statistical significance of *PBSP* remains unchanged in the augmented regression. In particular, the ability of *PBSP* to predict the cumulative GDP growth remains significant up to three years. Its predictive power on the marginal basis is significant for three to seven quarters ahead. In comparison, the index of leading indicator has no predictive power in the augmented model. None of the

[3] *LIND* has nine components. These are: new orders, company formation, wholesale prices of manufactured goods, real unit labour costs of manufacturing, business forecast for wholesale trade, stocks of finished goods, money supply, stock prices, and Central Provident Fund default rates for manufacturing.

TABLE II

REGRESSION OF CHANGES IN LOGARITHMIC GDP ON PAPER-BILL SPREAD, U.S. BOND-BILL SPREAD, AND LEADING INDICATOR

Forecasting Horizon: k Quarters	n	Cumulative Changes					Marginal Changes				
		$\hat{\alpha}_0$	$\hat{\alpha}_1$	$\hat{\alpha}_2$	$\hat{\alpha}_3$	$\bar{R}^2$	$\hat{\alpha}_0$	$\hat{\alpha}_1$	$\hat{\alpha}_2$	$\hat{\alpha}_3$	$\bar{R}^2$
1	66	5.837	−0.303	−1.126	0.035	0.07	5.837	−0.303	−1.126	0.035	0.07
		(1.310)	(−0.676)	(−2.400)	(1.255)		(1.310)	(−0.676)	(−2.400)	(1.255)	
2	65	7.625	−0.526	−1.044	0.025	0.13	10.483	−0.800	−0.949	0.007	0.07
		(1.859)	(−1.582)	(−1.755)	(0.816)		(2.658)	(−1.760)	(−2.006)	(0.239)	
3	64	10.232	−0.824	−0.988	0.107	0.21	17.255	−1.500	−0.869	−0.032	0.16
		(2.984)	(−2.541)	(−1.677)	(0.391)		(5.678)	(−3.437)	(−1.922)	(−1.096)	
4	63	12.375	−1.038	−0.938	−0.002	0.28	19.627	−1.708	−0.793	−0.047	0.19
		(4.046)	(−2.858)	(−1.617)	(−0.094)		(5.237)	(−3.962)	(−1.780)	(−1.611)	
5	62	13.817	−1.176	−0.889	−0.011	0.34	20.786	−1.755	−0.696	−0.057	0.20
		(4.866)	(−3.009)	(−1.593)	(−0.510)		(5.180)	(−4.031)	(−1.548)	(−1.870)	
6	61	14.317	−1.231	−0.816	−0.015	0.39	18.267	−1.533	−0.428	−0.047	0.14
		(5.464)	(−3.057)	(−1.546)	(−0.748)		(4.525)	(−3.433)	(−0.928)	(−1.449)	
7	60	14.383	−1.222	−0.769	−0.017	0.43	13.287	−0.951	−0.401	−0.020	0.07
		(6.050)	(−3.013)	(−1.612)	(−0.930)		(2.452)	(−2.510)	(−0.993)	(−0.834)	
8	59	14.252	−1.189	−0.723	−0.017	0.45	13.289	−0.951	−0.401	−0.020	0.03
		(6.382)	(−2.932)	(−1.716)	(−1.084)		(2.747)	(−1.970)	(−0.804)	(−0.552)	
9	58	13.923	−1.132	−0.689	−0.016	0.47	10.294	−0.685	−0.394	−0.002	0.00
		(6.218)	(−2.791)	(−1.875)	(−1.129)		(1.889)	(−1.387)	(−0.774)	(−0.055)	
10	57	13.219	−1.047	−0.658	−0.014	0.48	6.198	−0.286	−0.275	0.020	−0.03
		(5.746)	(−2.694)	(−2.017)	(−0.971)		(1.001)	(−0.566)	(−0.524)	(0.515)	
11	56	12.640	−0.976	−0.641	−0.011	0.50	5.205	−0.305	−0.380	0.030	−0.01
		(5.505)	(−2.786)	(−2.144)	(−0.736)		(1.225)	(−0.608)	(−0.725)	(0.761)	
12	55	11.896	−0.891	−0.636	−0.007	0.50	1.960	0.006	−0.378	0.049	−0.01
		(5.124)	(−2.838)	(−2.327)	(−0.476)		(0.459)	(0.012)	(−0.708)	(1.230)	

Notes: Denoting $PBSP_t$ as the paper-bill spread, $USSP_t$ as the U.S. bond-bill spread, $LIND_t$ as the leading indicator and y_t as the dependent variable (cumulative logarithmic GDP change $y^C_{t,k}$ marginal logarithmic GDP change $y^M_{t,k}$), the estimated regressions are given by: $y_t = \alpha_0 + \alpha_1 PBSP_t + \alpha_2 USSP_t + \alpha_3 LIND_t$. The figures in the parentheses are the t-statistics.

TABLE III

REGRESSION OF CHANGES IN LOGARITHMIC GDP

Forecasting Horizon: k Quarters	n	*USSP* Cumulative $\hat{\alpha}_1$	*USSP* Cumulative $\bar{R}^2$	*USSP* Marginal $\hat{\beta}_1$	*USSP* Marginal $\bar{R}^2$	*LIND* Cumulative $\hat{\alpha}_1$	*LIND* Cumulative $\bar{R}^2$	*LIND* Marginal $\hat{\beta}_1$	*LIND* Marginal $\bar{R}^2$
1	66	–0.671 (–1.528)	0.02	–0.671 (–1.528)	0.02	0.028 (1.390)	0.01	0.028 (1.390)	0.01
2	65	–0.583 –(1.258)	0.03	–0.510 (–1.141)	0.00	0.029 (1.466)	0.03	0.025 (1.188)	0.01
3	64	–0.521 (–1.105)	0.03	–0.423 (–0.891)	–0.00	0.030 (1.424)	0.04	0.021 (0.937)	–0.00
4	63	–0.489 (–1.070)	0.02	–0.377 (–0.821)	–0.01	0.029 (1.311)	0.04	0.018 (0.759)	–0.01
5	62	–0.459 (–0.898)	0.02	–0.331 (–0.603)	–0.01	0.028 (1.246)	0.04	0.013 (0.541)	–0.01
6	61	–0.399 (–0.771)	0.02	–0.091 (–0.163)	–0.02	0.028 (1.266)	0.04	0.019 (0.752)	–0.01
7	60	–0.378 (–0.784)	0.02	–0.184 (–0.396)	–0.01	0.027 (1.238)	0.04	0.019 (0.709)	–0.01
8	59	–0.361 (–0.756)	0.02	–0.148 (–0.350)	–0.02	0.027 (1.240)	0.04	0.019 (0.680)	–0.01
9	58	–0.364 (–0.814)	0.02	–0.157 (–0.352)	–0.02	0.026 (1.218)	0.04	0.024 (0.836)	–0.01
10	57	–0.373 (–0.878)	0.03	–0.087 (–0.147)	–0.02	0.026 (1.233)	0.04	0.029 (0.987)	–0.00
11	56	–0.393 (–0.976)	0.04	–0.168 (–0.257)	–0.02	0.026 (1.265)	0.05	0.039 (1.264)	0.01
12	55	–0.426 (–1.136)	0.06	–0.212 (–0.431)	–0.02	0.026 (1.300)	0.06	0.044 (1.392)	0.02

Notes: *USSP* = U.S. bond-bill spread, *LIND* = leading indicator. Denoting Y_t as the GDP and x_t generically as the regressor (*USSP* or *LIND*), the cumulative-change regression is given by: $y^C_{t,k} = (\log Y_{t+k} - \log Y_t)\,400/k = \alpha_0 + \alpha_1 x_t$; and the marginal-change regression is given by: $y^M_{t,k} = (\log Y_{t+k} - \log Y_{t+k-1})\,400 = \beta_0 + \beta_1 x_t$. The figures in the parentheses are the t-statistics.

estimated coefficients of *LIND* is statistically significant. There is also no regularity in the sign of the estimated parameters. For the U.S. term structure, we observe some predictive power in the short term of up to two quarters ahead on a marginal basis. There is, however, an anomaly of a negative effect of the U.S. term structure on the GDP growth rates. Overall, the inclusion of *LIND* and *USSP* increases the $\bar{R}^2$ to 50 per cent for the prediction of the cumulative changes of three years.

To examine closely the use of *LIND* and *USSP* as single predictors for the real output, we consider the regressions with these variables as explanatory variables separately. The results are summarized in Table III. It can be seen that both *LIND* and *USSP* have no predictive power for the GDP growth rates on their own. The estimated coefficients of *USSP* are all negative, while those of *LIND* are all positive. Thus, the index of leading indicator has the expected effect on the changes in future real outputs, although this effect is very weak. It is noted that the leading indicator is constructed to provide indications of turning points in the economy. As such, it may not provide good forecasts in the regression context, which is based on the assumption of a linear relationship. In addition, it is interesting to note that interest rate is not a component of the leading indicator. Thus, the results we have found may suggest reconsidering interest rate spreads as a possible component in the leading indicator. On the other hand, unlike many of the G-7 countries, the U.S. term structure is not useful in predicting the GDP changes in Singapore.

IV. PAPER-BILL SPREAD AND GDP COMPONENTS

Having identified the paper-bill spread as a significant predictor for future economic growth, we now examine the prediction of the cumulative and marginal changes of the real GDP components. By way of decomposing the GDP by expenditure, we consider the two main real GDP components, namely, private consumption and investment. These two components constitute more than 80 per cent of the total real GDP. Denoting E_t as one of the real GDP components, we consider the cumulative change defined by $E^C_{t,k} = (\log E_{t+k} - \log E_t)\, 400/k$ and the marginal change defined by $E^M_{t,k} = (\log E_{t+k} - \log E_{t+k-1})\, 400$. The following regression equations are estimated for the cumulative and marginal changes:

$$E^C_{t,k} = \alpha_0 + \alpha_1 PBSP_t. \tag{6}$$

$$E^M_{t,k} = \beta_0 + \beta_1 PBSP_t. \tag{7}$$

The results are summarized in Table IV.

It can be seen that the paper-bill spread is a significant predictor for the real consumption changes. *PBSP* is statistically significant for the cumulative real consumption changes up to three years. On the marginal basis, *PBSP* is statistically significant for the annualized incremental quarterly real consumption changes of two to five quarters. In contrast, the paper-bill spread has no predictive power for the real investment expenditure. This finding is unlike the results of Estrella and Hardouvelis (1991), who found that for the U.S. economy the term structure is a significant predictor for the private consumption as well as investment. The lack of predictive power for the real investment in Singapore may be due to the high proportion of direct foreign investment. The expenditure on capital goods by multinationals may be more dependent on the global economic performance than the local Singapore market.

By way of decomposing the GDP by industrial output, we consider the following industrial sectors: manufacturing, commerce, transportation and communication, construction, and finance and business. These five sectors constitute more than 90 per cent of the total GDP in most quarters of the sample period. Denoting $I^C_{t,k}$ and

TABLE IV

REGRESSION OF CHANGES IN LOGARITHMIC GDP COMPONENTS (BY EXPENDITURE) ON PAPER-BILL SPREAD

Forecasting Horizon: k Quarters	n	Consumption				Investment			
		Cumulative		Marginal		Cumulative		Marginal	
		$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$	$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$
1	66	−0.959 (−1.958)	0.02	−0.959 (−1.958)	0.02	1.213 (0.811)	−0.01	1.213 (0.811)	−0.01
2	65	−1.000 (−3.084)	0.10	−1.043 (−2.351)	0.03	0.766 (0.693)	−0.01	0.270 (0.176)	−0.02
3	64	−1.042 (−3.549)	0.20	−1.088 (−2.445)	0.03	0.267 (0.237)	−0.01	−0.695 (−0.426)	−0.01
4	63	−1.080 (−3.842)	0.30	−1.155 (−2.597)	0.04	0.024 (0.019)	−0.02	−0.778 (−0.457)	−0.01
5	62	−1.102 (−3.710)	0.36	−0.960 (−2.181)	0.02	−0.395 (−0.323)	−0.01	−1.870 (−1.538)	−0.00
6	61	−1.118 (−3.864)	0.42	−0.949 (−1.467)	0.02	−0.710 (−0.558)	0.00	−2.088 (−1.311)	0.00
7	60	−1.081 (−3.752)	0.42	−0.566 (−0.853)	−0.00	−0.819 (−0.596)	0.01	−1.333 (−0.714)	−0.01
8	59	−1.066 (−3.879)	0.45	−0.719 (−1.106)	0.00	−1.089 (−0.818)	0.04	−2.731 (−2.089)	0.01
9	58	−1.042 (−3.944)	0.47	−0.523 (−0.801)	−0.01	−1.170 (−0.840)	0.04	−1.518 (−0.816)	−0.01
10	57	−0.957 (−3.636)	0.44	−0.040 (−0.060)	−0.02	−1.204 (−0.838)	.0.05	−1.218 (−0.693)	−0.01
11	56	−0.960 (−4.191)	0.45	−0.711 (−1.040)	0.00	−1.458 (−1.081)	0.08	−3.820 (−3.594)	0.03
12	55	−0.917 (−4.278)	0.43	−0.211 (−0.297)	−0.02	−1.661 (−1.272)	0.11	−3.434 (−2.216)	0.02

Notes: Denoting E_t as the GDP component (by expenditure) and $PBSP$ as the paper-bill spread, the cumulative-change regression is given by: $E^M_{t,k} = (\log E_{t+k} - \log E_t)\,400/k = \alpha_0 + \alpha_1 PBSP_t$; and the marginal-change regression is given by: $E^C_{t,k} = (\log E_{t+k} - \log E_{t+k-1})\,400 = \beta_0 + \beta_1 PBSP_t$. The figures in the parentheses are the t-statistics.

$I^M_{t,k}$ as the cumulative and marginal changes, respectively, of the output of an industrial sector, we consider the following regressions:

$$I^C_{t,k} = \alpha_0 + \alpha_1 PBSP_t. \tag{8}$$

$$I^M_{t,k} = \beta_0 + \beta_1 PBSP_t. \tag{9}$$

The results are summarized in Table V.

It can be seen that the paper-bill spread has no predictive power for the construction, transportation and communication, and finance and business sectors. The changes in the outputs in the manufacturing and commercial sectors, however, are

TABLE

REGRESSION OF CHANGES IN LOGARITHMIC GDP COMPONENTS

k	Construction				Manufacturing			
	Cumulative		Marginal		Cumulative		Marginal	
	$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$	$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$
1	2.33 (1.78)	0.02	2.33 (1.78)	0.02	−1.49 (−2.28)	0.06	−1.49 (−2.28)	0.06
2	2.23 (1.72)	0.04	2.42 (1.65)	0.03	−1.76 (−2.75)	0.14	−2.01 (−3.16)	0.12
3	2.11 (1.49)	0.04	2.15 (1.05)	0.02	−2.05 (−3.34)	0.23	−2.54 (−4.11)	0.20
4	1.97 (1.10)	0.04	1.60 (0.71)	0.00	−2.26 (−3.70)	0.34	−2.70 (−4.36)	0.22
5	1.69 (0.87)	0.03	0.56 (0.26)	−0.01	−2.34 (−4.28)	0.42	−2.50 (−3.87)	0.19
6	1.56 (0.75)	0.02	0.67 (0.26)	−0.01	−2.32 (−5.05)	0.47	−2.05 (−2.13)	0.12
7	1.25 (0.57)	0.01	−0.81 (−0.29)	−0.01	−2.22 (−5.56)	0.50	−1.47 (−1.74)	0.05
8	0.89 (0.38)	−0.00	−1.85 (−0.66)	0.00	−2.05 (−5.86)	0.48	−0.65 (−0.78)	−0.00
9	0.61 (0.25)	−0.01	−2.09 (−0.69)	0.01	−1.87 (−5.77)	0.45	−0.24 (−0.30)	−0.02
10	0.34 (0.14)	−0.02	−2.01 (−0.78)	0.01	−1.75 (−5.41)	0.44	−0.39 (−0.52)	−0.01
11	0.04 (0.02)	−0.02	−3.31 (−1.48)	0.04	−1.60 (−4.88)	0.40	0.04 (0.38)	−0.02
12	−0.31 (−0.13)	−0.02	−4.32 (−1.99)	0.08	−1.47 (−4.28)	0.37	0.11 (0.99)	−0.02

Notes: Denoting I_t as the GDP component (by industrial output) and *PBSP* as the paper-bill the marginal-change regression is given by: $I_{t,k}^M = (\log I_{t+k} - \log I_{t+k-1})400 = \beta_0 + \beta_1 PBSP_t$. The

predictable by the paper-bill spread. The most important contributions to the manufacturing sector are electronics and machinery, while the commerce sector mainly consists of trade, tourism activities, and retail sales. *PBSP* is significant for the cumulative changes in these sectors up to three years. On the marginal basis, *PBSP* is statistically significant for the quarterly incremental changes of the manufacturing sector up to six quarters, and for the commercial sector up to eight quarters. It is noted that these two sectors jointly constitute about 50 per cent of the total GDP.

V. POST-SAMPLE FORECASTS

We have so far examined the in-sample modeling of the paper-bill spread as a predictor for future economic activity. As a criterion for model validation, it may be

V

(BY INDUSTRIAL OUTPUT) ON PAPER-BILL SPREAD

Commerce				Transportation				Finance			
Cumulative		Marginal		Cumulative		Marginal		Cumulative		Marginal	
$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$	$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$	$\hat{\alpha}_1$	$\bar{R}^2$	$\hat{\beta}_1$	$\bar{R}^2$
−0.83	0.02	−0.83	0.02	−0.04	−0.02	−0.04	−0.02	0.58	−0.01	0.58	−0.01
(−1.99)		(−1.99)		(−0.12)		(−0.12)		(0.80)		(0.80)	
−0.89	0.06	−0.96	0.03	−0.13	−0.01	−0.23	−0.01	0.56	0.01	0.53	−0.01
(−2.55)		(−1.77)		(−0.35)		(−0.60)		(1.35)		(0.72)	
−0.98	0.13	−1.18	0.06	−0.22	−0.00	−0.40	0.00	0.54	0.02	0.53	−0.01
(−3.04)		(−2.18)		(−0.58)		(−1.08)		(1.70)		(0.71)	
−1.08	0.19	−1.37	0.08	−0.25	0.01	−0.43	0.01	0.46	0.02	0.23	−0.01
(−3.13)		(−2.51)		(−0.70)		(−1.15)		(1.78)		(0.30)	
−1.18	0.27	−1.56	0.10	−0.29	0.03	−0.47	0.01	0.36	0.01	0.09	−0.02
(−3.19)		(−2.84)		(−0.83)		(−1.24)		(1.78)		(0.11)	
−1.27	0.34	−1.66	0.12	−0.33	0.05	−0.59	0.03	0.20	−0.01	−0.29	−0.01
(−3.30)		(−2.99)		(−1.06)		(−1.73)		(1.13)		(−0.37)	
−1.32	0.39	−1.55	0.10	−0.36	0.08	−0.57	0.03	0.14	−0.01	−0.12	−0.02
(−3.32)		(−2.69)		(−1.26)		(−1.65)		(0.73)		(−0.15)	
−1.32	0.44	−1.28	0.06	−0.38	0.10	−0.60	0.03	0.09	−0.01	−0.08	−0.02
(−3.29)		(−2.15)		(−1.43)		(−1.71)		(0.47)		(−0.09)	
−1.30	0.46	−1.01	0.03	−0.33	0.10	−0.38	0.00	0.06	−0.02	−0.27	−0.02
(−3.24)		(−1.63)		(−2.43)		(−1.07)		(0.30)		(−0.32)	
−1.27	0.48	−0.89	0.02	−0.33	0.08	−0.15	−0.02	0.08	−0.02	0.28	−0.02
(−3.26)		(−1.38)		(−1.28)		(−0.41)		(0.41)		(0.33)	
−1.26	0.51	−0.92	0.02	−0.30	0.07	−0.21	−0.01	0.05	−0.02	−0.17	−0.02
(−3.44)		(−1.40)		(−1.21)		(−0.58)		(0.29)		(−0.20)	
−1.22	0.50	−0.54	−0.01	−0.29	0.07	−0.37	0.00	0.11	−0.01	0.74	−0.01
(−3.54)		(−0.79)		(−1.24)		(−0.86)		(0.54)		(0.84)	

spread, the cumulative-change regression is given by: $I^C_{t,k} = (\log I_{t+k} - \log I_t)\,400/k = \alpha_0 + \alpha_1 PBSP_t$; and figures in the parentheses are the t-statistics.

interesting to investigate the out-of-sample performance of the forecasts. In this section we present some results of the out-of-sample forecast performance of the paper-bill spread.

The regression equations reported in the last two sections provide a battery of forecasting models, depending on the forecasting horizon selected. To avoid proliferation of forecasting models, we specify the forecasting horizon to be one year. That is, $k = 4$ is the selected forecasting models for comparison.[4] Both cumulative-change and marginal-change models are considered. However, only the regressions for which the paper-bill spread is found to be a significant predictor are used. Thus,

[4] For the variables we forecast, the $\bar{R}^2$ of the marginal-change equations are maximized at $k = 4$ for the total GDP, the manufacturing output and the private consumption expenditure. For the commercial output, $\bar{R}^2$ is maximized at $k = 6$.

TABLE VI

POST-SAMPLE FORECAST PERFORMANCE

Forecasting Method	Quarter	GDP	Manufacturing	Commerce	Consumption
Cumulative change	95Q2	0.496	3.981	−0.066	1.170
	95Q3	−0.327	−0.250	−0.166	2.844
	95Q4	0.260	0.298	0.909	3.063
	MAPE	0.361	1.510	0.380	2.359
Marginal change	95Q2	−0.794	−0.251	0.339	0.184
	95Q3	−1.089	−2.754	−0.220	1.525
	95Q4	1.553	2.907	1.772	1.501
	MAPE	1.145	1.971	0.777	1.070
Random walk	95Q2	−1.273	−0.607	−2.489	−1.291
	95Q3	−1.820	−4.525	−2.284	0.714
	95Q4	−1.205	−3.897	−1.124	0.979
	MAPE	1.433	3.010	1.966	0.955

Notes: MAPE = mean absolute percentage error. The figures are the forecast errors in percentage.

we consider the forecast for the total GDP, the manufacturing output, the commercial output and the private consumption expenditure. To provide benchmarks for comparison, we use the random walk model. Thus, the benchmark forecast specifies that the forecasted variable four quarters ahead is equal to the current value of the variable plus the sample mean of the four-quarterly differenced observations.[5] Table VI summarizes the results of the forecasts for 1995Q2, 1995Q3, and 1995Q4.

It can be seen that on the mean absolute percentage error (MAPE) criterion, the forecasts based on the cumulative-change and marginal-change models outperform the benchmark forecasts for three out of the four variables. Of the twelve forecasts reported, the cumulative-change model provides lower absolute percentage error than the random walk model for nine cases. The cumulative-change model also outperforms the marginal-change model for eight out of twelve forecasts. Indeed, for the total GDP and the commercial output, the cumulative-change model provides very good forecasts, with none of the errors exceeding 1 per cent.

VI. CONCLUSION

We have compared the predictive power of a number of interest rate spreads for the changes in real GDP. The paper-bill spread is found to have significant predictive

[5] It should be noted that the marginal-change model uses more recent data than the cumulative-change and the random walk models. Specifically, when we forecast the output for quarter $n + 4$, the cumulative-change and the random walk models use the observations in quarter n. The marginal-change model, however, uses the output data for quarter $n + 3$.

power for future economic growth. The cumulative GDP changes are predictable by the paper-bill spread up to three years, while the marginal quarterly changes are predictable up to about seven quarters ahead. The bond-bill spread and the fixed-deposit spread, however, are found to be statistically insignificant. As the fixed-deposit rates appear to be insensitive to the changes in economic factors, it is unlikely to provide useful information for future economic activity. In contrast, the bond-bill spread may be potentially a useful predictor. The lack of statistical significance may be the result of inadequate observations required for more precise statistical estimation.

The world term structure as proxied by the U.S. bond-bill spread is not useful in predicting the total GDP changes. Somewhat disappointingly, the index of leading indicator provides no useful information in forecasting future economic activity. It is an insignificant predictor both individually and jointly with other predictors in an augmented regression.

When the components of the total GDP are examined, the paper-bill spread is found to have significant predictive power for the real private consumption but not for the real investment. Also, outputs in the manufacturing sector and the commercial sector can be usefully predicted by the paper-bill spread. In contrast, the paper-bill spread has no predictive power for the construction, transportation and communication, and finance and business sectors. For the post-sample prediction, the paper-bill spread provides very good results. Given that the models are small in size (thus can be easily revised) and use quarterly data (thus can incorporate more up-to-date information), they will emerge as strong competitors for the short-term forecasting of the real GDP and some of its components.

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