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REGIONAL BOND YIELDS AND ECONOMIC ACTIVITY: THEORY AND APPLICATION

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Interest in modeling local, state, and regional economic activity has increased in the past decade to include a variety of sophisticated economic models in addition to the traditional tax revenue anticipation models. This article reports on a promising development in regional econometric models — the regional bond yield index. Efficient Market Information Theory (EMIT), developed by Caves and Feige [1], suggests that prices determined in efficient markets, such as the stock and bond exchanges, can significatnly improve the forecasting ability of econometric models by providing timely and important information unavailable to conventionally specified models. The regional bond yield index developed in this study closely parallels the national equity indexes. However, unlike national or state stock market indexes, the regional yield index can be successfully localized for many small regions of interest. The evidence presented suggests that the regional bond market is efficient with respect to information about economic activity within the region and, therefore, that the forecasting ability of regional econometric models can be sigificantly improved by including a bond yield index as an indicator of economic activity.

The discussion is divided into four sections. In the first section, the theory of efficient markets is briefly reviewed and its applicability to regional economies is discussed. Next, a detailed explanation of the construction of a bond yield index series for the state of Nebraska is provided. In the third section, the association between the bond yield index and both Gross State Product and retail sales for Nebraska during 1969-1978 is empirically tested for conformity with the EMIT. The results demonstrate that the index reflects prices set in an efficient market and suggest that the index will be useful in economic forecasting. The final section summarizes the discussion, presents our conclusions, and points out several promising areas for future research.

Efficient Markets and Regional Economies

An efficient market is one in which relevant information is quickly impounded in market prices. The hypothesis that a market is efficient asserts that current prices fully reflect that information which is relevant to the determination of current and future market prices. This information set is usually specified to include the past sequence of prices, information about particular securities such as might be reported in financial statements, or prospects for economy-wide variables such as GNP, inflation, and government spending. The stock market, for example, has been tested for efficiency with respect to the information contained in the historical sequence of prices, in changes in accounting technique, and in macroeconomic variables. In all cases the market appears to quickly and correctly absorb this type of information as soon as it becomes publicly available.[1]

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The theoretical model of market efficiency envisions informed market participants who observe the economy and, via their transactions, cause prices to quickly adjust in response to exogenous shocks. If the efficiency property holds, market prices or suitable price indices will reflect important information about current and expected movements in marcroeconomic variables. Although the concept of efficiency is usually discussed and empirically examined in the context of national markets, the same theoretical arguments can be adapted to regional economies.

Previous work in developing financial market indicators for regional economies has concentrated upon stock prices. While the relationship between national market indices and national activity measures has been studied extensively, few researchers have dealt with the possibility of an analagous relationship at the regional level. Chandler and Legler [2] constructed a stock price index for Georgia while Pierce [10] constructed one for Nebraska. Both studies include firms in their index sample which, while headquartered in the state, serve a national market. Therefore, these indices reflect national rather than regional trends and are highly correlated with national market measures such as the Dow-Jones Industrial Average, reflecting little, if any, independent information about the regional economy.

One alternative in developing financial market indicators is to focus upon bonds. By selecting bond yields (prices) for specific political subdivisions, we can concentrate on the particular region of interest. Bonds are by their very nature tied to the political entity that issues them. The connection between yield or price and current and expected economic activity follows from the assuption that the state and municipal bond market is efficient. Market efficiency in this case is restricted to the proposition that investors do not ignore any relevant information about the regional economy in the bidding process which sets bond yields. This proposition is considerably weaker than asserting that regional bond markets are efficient in the "semi-strong" sense (reflecting *all* publicly available information). However, as long as these markets are efficient with respect to information about regional economic variables, the argument follows and the market will be termed efficient.[2] Fortunately, empirical tests of the efficiency proposition are amenable.

If the state and municipal bond market is efficient with respect to information about regional economic activity, then the argument proceeds in three steps:

(1) If the prospects for future tax receipts are relevant for the payment of interest and principal on the bonds, and,
(2) if future tax receipts are related to future levels of economic activity, then market efficiency implies that
(3) the economic prospects for the issuing unit will be reflected directly in the yields demand on the associated bonds.

[1]For a sample of this literature see Fama [3], Rozeff [14], and Rogalski and Vinso [13]. For a specific study on the sensitivity of market prices to macroeconomic variables see Reilly and Drzycimski [12].

[2]The proposition also does not strictly guarantee that regional markets are efficient in the "weak" sense (reflecting the historical sequence of prices). However, the data required for tests of various degrees of efficiency are not readily available and such efforts are outside the scope of this article.

For example, consider an agricultural region that relies on either property, sales, or income taxes (or some combination) and issues general obligation bonds. At the time of issue the prospects for tax revenues over the life of the bond are incorporated into the yield demanded on the bonds. If an exogenous shock occurs in the region, say an unanticipated increase in fuel costs, these prospects will be altered and, *certeris parabis,* the value of farm land will be depressed in the long run and net farm income will fall in the short run. These effects combine to make it more difficult for the region to pay its debts and, therefore, the yield required to sell the bonds will increase. Intuitively, the yield series represents the collective judgment of vitally interested and knowledgeable participants about the economic prospects for the region. In an efficient market, any unexpected change in those prospects will be reflected immediately in the yeild required on the region's bonds. Therefore, current values of the yield series are useful for forecasting broad indicators of the region's future economic health.

Caves and Feige [1] have formalized the role of efficient financial markets within the context of a national macroeconomic model. Their "Efficient Market Information Theory" (EMIT) begins with the standard assumption that macroeconomic activity is driven by distrubances which are exogenous to the system. Political and social events, sudden shifts in economic policy, and other changes in the distribution of trader expectations concerning movements in markets or the course of future economic activity could be included among these disturbances. Disturbances are usually treated as unobserved effects by analysts constructing macro models but, in reality, are quickly observed and accounted for to some extent by participants in financial markets. In an efficient market, even though the actual effects of these disturbances upon the economy are subject to lags of variable lengths, *information* about the disturbances is immediately processed and incorporated into the prices and interest rates of the financial markets. The contribution of the EMIT is to indentify these efficient market prices and rates as sources of information about economic variables which were, in effect, previously relegated to the error term in macroeconometric models. Caves and Feige suggest that market prices should be used to partition the error term and, thereby, improve forecasting ability.

Although the EMIT was formulated in the context of national economic activity and financial markets, the same theoretical model is plausible for state or regional economies and the associated markets that deal in financial instruments issued by the region. If the market for these instruments is efficient, then the market prices will contain varable information about regional economic prospects.

Our present concern is with the market for municipal bonds issued by subdivisions within a state so we have adapted the empirical propositions of the EMIT, as given by Caves and Fiege [1, p. 23], to this particular case. These empirical propositions are:

(1) If the regional bond market is efficient, then the interest rate (price) set in the market will be exogenous with respect to aggregate measures of regional economic activity. This proposition summarizes the notion that information on regional economic activity is immediately and fully reflected in bond rates. Alternatively, we may say that the activity measures do not "cause" the interest rate in the sense of Granger's [4]

popular definition.[3] Caves and Feige have termed this state of affairs "incremental efficiency." Thus, if regional measure X is exogenous to regional interest rate Y, then the market in which Y is determined is "incrementally efficient" with respect to X.

(2) If the regional bond market is efficient, then aggregate measures of regional activity will be "Granger caused" by the prevailing interest rate. In essence, the direction of causality is expected to run from the bond rates to regional activity since events that impact regional activity with a lag are promptly accounted for by the bond market.

(3) If the regional bond market is efficient then forecasts of the aggregate measures of regional activity can be improved by using the interest rate as a leading indicator. This proposition follows directly from (1) and (2).

Only the first two propositions will be investigated, leaving the incorporation of the yield series into a full econometric model of the region to further research.

Construction of the Yield Index

The yield on a municipal or state bond reflects investor expectations about changes in purchasing power over the life of the bond and the likelihood of the payment of interest and redemption of the issue on schedule. The inflation premium is assumed common to all fixed income instruments but the security of the payment schedule is specific to the bond issue and depends on:

(c) the strength and stability of the revenue tax base and projected taxable income for the authority underlying the issue;

(b) risk introduced (or mitigated) by special provisions of the issue such as callability or a sinking fund;

(c) the precedence of the claim of the bond holders over other existing and future creditors;

(d) the desirability of the maturity structure of the bond, and so on.

As the yields fluctuate in the market over time, they mirror changing investor perceptions of the future economic health and stability of the issuing political subdivision since the other features are constant over the life of the issue. Assuming that the propositions listed in the previous section are true, a yield series can aid in regional economic model building and forecasting by reflecting the collective judgment of all participants in the market about the future course of the region's economy. To the extent that repayment depends on the level of economic activity, changes in yield signal changes in the economic health of the region. By combining bonds from subdivisions within a region, any region can be represented. Ideally, construction of a yield series would involve continuous primary and secondary market data on general obligation bonds backed by activity levies such as income and sales taxes for each political entity comprising the region. Practically, these conditions are rarely met. In building a Nebraska yield series for this study, the following procedures were followed:

(1) Collection of market data. Since the state of Nebraska is prohibited by law from issuing debt, the bonds of various political subdivisions were

[3]Grangler's [4] definition of causality may be phrased in terms of two variables, X and Y. We begin by assuming than an information set exists which includes at least the histories of X and Y. X causes Y if the current value of Y can be predicted more accurately by using the history (or part of it) of X than by not using it.

combined. Because secondary market data is typically scarce and unreliable, only data on newly issued bonds could be collected. Five newly issued bonds for each month were chosen at random from those with a par value of $50,000 or more. The resulting sample contained bonds with a par value of up to $50 million. This yield series is based on yields demanded on successive newly issued bonds rather than on continuous observation of seasoned bonds. As long as the series meets the conditions outlined in the next paragraph, however, the practical difference is immaterial.

(2) Integrity of the series. Specious movements in yields can arise from structural rather than economic causes and should be avoided. For example, if the maturity structure, enabling legislation, or face amount of new bonds changes significantly over the period studied, yields could be altered wthout the economic prospects for the issuing entity changing. In this study the bond issues were checked for integrity and no significant structural variations were found. However, a marked seasonality was noted in the monthly volume of issues. According to several investment bankers handling the state's bond placements, this was due to the seasonal financing patterns for construction projects and is typical of many regions.
(3) Computation of yields. After the bonds characteristics and prices were collected, yields were approximated. Since the maturity structures of the bonds were quite complex, finding a yield comparable to that used to construct the standard Treasury bond series would have been tedious.[4] To save time and clerical costs, the yield to maturity was approximated by a time weighted average of the various coupon rates. A simulation study showed that for the range of interest rates and maturity encountered in this study, the mean error was 30 basis points with a three standard deviation limit of 150 basis points. The yield approximation assumes that the coupon rate is the initial market yield; that is, the bonds were sold at par. Due to the way the bonds were marketed, this was almost always the case.
(4) Construction of the series. The individual bond yields were weighted by their total par value and combined into a monthly index.

The EMIT requires that the regional bond market be efficient. Since these issues are thinly traded when compared to the national stock or bond markets the extent to which this requirement holds *a priori* can be questioned. However, in Nebraska as well as other regions the yields on new bonds are typically set by one of several regional or national investment banking houses who underwrite the bonds for resale to corporate individual investors. Since the investment bankers do not intend to keep the bonds in inventory, yields must be attractive to a well informed local market. If the bonds were marketed nationally without significant local interest and local and national markets were segmented (not completely homogeneous), adequate information about the regional economy might not be available to investors to ensure efficiency. However, given the special appeal of the bonds to Nebraska residents (for whom the interest is free from state income tax), the alternative investments

[4]The Treasury yields are yields to maturity computed as internal rates of return.

available in national markets which compete with the regional bonds, and the active local market for new issues, the basic conditions for efficiency appear to be met.

Previous researchers investigating the structure of regional markets have concentrated on the over-the-counter stock markets. Although several authors including Reilly [11], Senchack and Beedles [15], and Jessup and Upson [7] have found evidence that regional markets may be partially segmented, Hagerman and Richmond [5] looked specifically at regional market efficiency and found no evidence to reject the hypothesis of efficiency.

Empirical Tests for Regional Bond Market Efficiency

We shall test for efficiency by examining the relationships between regional activity measures and the bond rate with a statistical methodology that seeks to determine causality patterns in a bivariate framework. Pierce and Haugh [9] and Pierce [8] have described the methodology in great detail so a rather short outline of it will be presented here. For illustration, assume that we have two time series, X and Y, and wish to test for the existence of a causal relationship between them. The first step is to consider the "prewhitened" or filtered versions of the X and Y series, denoted by u and v, respectively. We will eventually obtain the filtered versions of our regional activity measures and the bond rate from ARIMA models. For the X and Y series the models are:

$$\phi_1(B)\cdot(1-B)^d Y_t = \theta_1(B)\, v_t$$

$$\phi_2(B)\cdot(1-B)^d X_t = \theta_2(B)\, u_t,$$

where the $\phi_i(B)$ and $\theta_i(B)$ are polynomials in the lag operator B and t is the time index. For purposes of exposition, trends and seasonal factors have been excluded from the models above although they may be important in practice. It should be apparent that the u and v are the theoretical disturbances in the models of X and Y, respectively.

Next, we define the cross correlation between lag k of u and the current value of v as $\rho_{uv}(k) = E(u_{t-k}v_t)/[E(u^2)E(v^2)]$. The absense or presence ofcausality between X and Y is determined by the nature of the $\rho_{uv}(k)$ which are obtained by varying the lag time k.[5] Pierce [8, p. 15] has presented a catalog of causality patterns along with the properties of the $\rho_{uv}(k)$ that will signal each particular pattern.[6] For ease of reference, we reproduce his catalog in Table 1. Regional activity measures will assume the role of the X series while the municipal bond rate will be the Y series. Several pairwise combinations of activity measures and the bond rate are examined in this bivariate framework. They include:

(a) Nebraska Gross State Product (GSP) - Quarterly Municipal Bond Rate
(b) Growth rate of Nebraska GSP - Quarterly Municipal Bond Rate
(c) Nebraska net taxable retail sales (NTRS) - Monthly Municipal Bond Rate
(d) Growth rate of Nebraska NTRS - Monthly Municipal Bond Rate

[5]The k index can alternatively be thought of as the lead time from u to v and, therefore, from X to Y.

[6]An even more extensive catalog of causality events is available in Pierce and Haugh [9].

Quarterly observations on Nebraska GSP are available from 1969I through 1978IV while monthly observations on NTRS span 1970(1) - 1978(12). Conversion to growth rates deletes one observation from the frnt of each seres. As descrbed above, the municipal bond rate was first calculated on a monthly basis and the quarterly series was formed as a straight three-month average.

The choice of GSP and NTRS as activity measures is somewhat arbitrary and is not meant to suggest that investors are interested in the values of either series per se. Investors are interested in the economic events which these series are designed to reflect. To insure that no potentially significant relationships are disregarded the bond rates are tested for efficiency with respect to both the levels and growth rates in each series.

ARIMA models were estimated for each of the series in the respective pairs (a) - (d) listed above. These models appear in Table 2. The residuals from these models were then cross-correlated at lag times ranging from k=-8 to k=8 for the quarterly series in pairs (a) and (b) and from k=-24 to k=24 for the monthly series in pairs (c) and (d). These estimated cross-correlations are reported in Table 3. Haugh [6] has derived a variance formula for the estimated cross-correlations, $\hat{r}_{uv}(k)$:

$$\text{Var}\,(\hat{r}_{uv}(k)) = N^{-1}(1 - |k/N|)$$

where N is the number of observations after the required degree of differencing has been applied to the original series. If a particular $\hat{r}_{uv}(k)$ exceeds its computed $2\hat{\sigma}$ limit, we conclude that its theoretical counterpart, $\rho_{uv}(k)$, is significantly different from zero. Causality directions are determined from the catalog of patterns shown in Table 1.

The estimated cross-correlation structures for positive lags of the bond rate coupled with the dollar value of GSP and the growth rate of GSP show no evidence of causality running from these two activity measures to the bond rate. Thus, the bond rate is exogenous with respect to both GSP variables and proposition (1) of the EMIT holds. In the terminology of the EMIT, the municipal bond market is "incrementally efficient" with respect to the two GSP variables employed here. Table 3 also shows that $\hat{r}_{uv}(-1)$ exceeds its $2\hat{\sigma}$ limit in both combinations of the GSP variables with the bond rate. This result indicates that the GSP variables are not exogenous with respect to the bond rate and, in fact, both are "Granger caused" by the bond rate. Thus, proposition (2) of the EMIT theory holds and forecasts of the GSP variables may be improved by use of the bond rate.

Examination of the extimated cross-correlations for the bond rate coupled with the dollar value of net taxable retail sales and the rate of growth in sales reveals that causality does not run from either of these activity measures to the bond rate. Therefore, the bond rate is again exogenous and the market is "incrementally efficient" with respect to both sales variables. Proposition (1) of the EMIT appears to hold. In the case of dollar sales, $\hat{r}_{uv}(-4)$ exceeds its $2\hat{\sigma}$ limit indicating that the causal direction is from the bond rate to saies. No such direction can be attributed to the rate of growth in sales. These results concerning the sales variables imply that the dollar value of sales is consistent with proposition (2) of the EMIT, i.e., the bond rate may be valuable as an indicator of dollar sales but not of the growth rate.

TABLE 2
ARIMA Models of Activity Measures and the Bond Rate

Series	Model
GSP 69I-78IV	$(1-B)GSP_t = \underset{(110.02)}{254.82} + \hat{u}_t$ $Q = 6.9 \quad 12$ d.f.
Bond Rate 69I-78IV	$R_t = \underset{(.289)}{5.778} + (1 + \underset{(.297)}{.392}B)\hat{v}_t$ $Q = 13.2 \quad 11$ d.f.
GSP Growth Rate 69II-78IV	$GSP_t = \underset{(.887)}{2.560} + \hat{u}_t$ $Q = 7.8 \quad 12$ d.f.
Bond Rate 69II-78IV	$R_t = \underset{(.292)}{5.796} + (1 + \underset{(.302)}{.381}B)\hat{v}_t$ $Q = 13.3 \quad 11$ d.f.
NTRS 70(1)-78(12)	$(1 + \underset{(.098)}{.789}B + \underset{(.098)}{.339}B^2)(1 + \underset{(.097)}{.473}B^{12})(1-B)(1-B^{12})NTRS_t = \hat{u}_t$ $Q = 19.6 \quad 21$ d.f.
Bond Rate 70(1)-78(12)	$R_t = \underset{(.168)}{5.794} + (1 + \underset{(.166)}{.309}B + \underset{(.238)}{.508}B^2)\hat{v}_t$ $Q = 26.1 \quad 22$ d.f.
NTRS Growth Rate 70(2)-78(12)	$(1-B^{12})NTRS_t = (1-\underset{(.131)}{.780}B)(1-\underset{(.102)}{.812}B^{12})\hat{u}_t$ $Q = 14.4 \quad 22$ d.f.
Bond Rate 70(2)-78(12)	$R_t = \underset{(.237)}{5.786} + (1 + \underset{(.167)}{.300}B + \underset{(.164)}{.498}B^2)\hat{v}_t$ $Q = 27.7 \quad 22$ d.f.

Notes: Numbers in parentheses below the coefficients are their $2\hat{\sigma}$ values. The Q statistic report for each model provides a X^2 test of model adequacy. The null hypothesis of this test stipulates that the residuals are random. Failure to reject the null hypothesis indicates that the series being modeled has been successfully "prewhitened" or filtered.

Summary

The results for both the Gross State Product and net taxable retail sales strongly suggest that the regional bond market is efficient with respect to information captured in these series about regional economic activity. As

TABLE 1

Causality Patterns and Values of the Cross Correlations

Pattern	Values of $\rho_{uv}(k)$
1. X causes Y	$\rho_{uv}(k) \neq 0$ for some $k > 0$
2. Y causes X	$\rho_{uv}(k) \neq 0$ for some $k < 0$
3. Instantaneous causality	$\rho_{uv}(0) \neq 0$
4. Feedback	$\rho_{uv}(k) \neq 0$ for some $k > 0$ and for some $k < 0$
5. Y does not cause X	$\rho_{uv}(k) = 0$ for all $k < 0$
6. Unidirectional causality from X to Y	$\rho_{uv}(k) \neq 0$ for some $k > 0$ and $\rho_{uv}(k) = 0$ for all $k < 0$
7. X and Y are related instantaneously but in no other way	$\rho_{uv}(k) = 0$ for all $k \neq 0$ and $\rho_{uv}(0) \neq 0$
8. X and Y are independent	$\rho_{uv}(k) = 0$ for all k

shown in Table 3 the financial markets tend to react to economic information one quarter before GSP records the same information. Given that GSP is published quarterly and necessarily lags behind current events, this relationship is not surprising. The bond rate is also sensitive to the GSP growth rate which is appropriate in an efficient market. The relationship between NTRS and the bond rate is less clear. Since none of the positive lags has a significant correlation the bond market is efficient with respect to the sales series. However, significant correlation appears at a lag of -4 indicating that the bond market "leads" NTRS by four months. Since the growth rate results do not confirm this cross-correlation these results may be spurious with the market processing the information within one month. In addition, since municipal revenue is not tied directly to sales or sales taxes the response of the market to economic events that impact specifically on retail sales may be slight.

Certainly, neither GSP nor NTRS contain all information or even all economic information that is of interest to bond investors. However, analysts wishing to project the types of economic activity represented by these series could probably produce between forcasts by including bond market prices in their models. Future research using the forecasts of specific regional econometric models must be conducted to provide the necessary corroborating evidence.

As noted above the current research does not attempt to establish that regional bond markets are completely efficient in the "weak" or "semi-strong" sense. Sufficient data is not corrently available for classical tests of efficiency. Although the market appears to be efficient wth respect to the types regional economic activity captured in the GSP and NTRS indexes, further study is needed to establish broad-based efficiency. In addition, this research should be replicated for other regions before further conclusions are drawn. In general, however, the prospects for similar regional financial market indexes

are bright. The bond index used in this study is easy and inexpensive to compute and promises to return an increase in forecasting accuracy at a minimal cost.

TABLE 3

Cross-Correlations Between Prewhitened Series

Lag (k)	(a) GSP and Bond Rate	(b) GSP Growth Rate and Bond Rate	(c) NTRS and Bond Rate	(d) NTRS Growth Rate and Bond Rate
-8	-.039	-.066	.115	.095
-7	.130	.073	-.108	.162
-6	-.035	-.029	.033	.016
-5	-.055	-.030	-.051	.001
-4	.095	.025	-.233*	-.141
-3	.087	-.003	.048	.021
-2	.095	.036	.138	.074
-1	-.344*	-.363*	-.092	-.058
0	.160	.067	-.113	-.190
1	-.077	-.137	-.045	-.006
2	.018	-.018	.007	-.002
3	.148	.160	-.112	.002
4	-.020	-.057	.035	-.105
5	-.042	-.080	.028	.059
6	.075	.032	.042	.071
7	.051	.043	-.196	-.111
8	-.006	-.022	.169	.127

Notes: * denotes those estimated cross-correlations which exceed their $2\hat{\sigma}$ limits. The time periods over which the cross-correlations were calculated for (a)-(d) above are 69I-78IV, 69II-78IV, 70(1)-78(12), and 70(2)-78(12), respectively. Lags beyond -8 and 8 are not shown since none of those cross-correlationsexceeded their $2\hat{\sigma}$ limits.

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