An Application of Unit Root Tests With a Structural Break to Risk-Based Capital and Bank Portfolio Composition

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An Application of Unit Root Tests with a Structural Break to Risk-Based Capital and Bank Portfolio Composition

Kevin T. Jacques*

During the 1990s, the composition of commercial bank portfolios in general and bank holdings of business loans and government securities in particular exhibited unusual behavior. One possible explanation for these unusual changes was the implementation by U.S. bank regulators of the risk-based capital standards. This paper examines the issue of nonstationarity in bank holdings of commercial loans and government securities by considering whether a trend specification with structural break model is consistent with the implementation of the risk-based capital standards.

1. Introduction

During the 1990s, considerable attention focused on the composition of commercial bank portfolios in general and the relationship between bank holdings of business loans and government securities in particular. Prior to 1992, U.S. commercial banks routinely held commercial and industrial loans in excess of U.S. government securities. But in the three-year period ending December 1993, commercial bank holdings of U.S. government securities increased by 60.1%, from $456.0 billion to $730.1 billion, while holdings of business loans fell by 8.6%, from $641.2 billion to $586.4 billion. In fact, from May 1992 through June 1995, the dollar volume of U.S. government securities held by commercial banks actually exceeded the dollar volume of business loans, a virtually unprecedented event.

The unusual behavior of the relationship between bank holdings of business loans and government securities during the 1990s generated considerable interest among economists, policymakers, and bank regulators. Early attention concerning this issue was devoted to assessing what factors were responsible for the shift, including demand factors (Bernanke and Lown 1991) and more stringent bank examination standards (Peek and Rosengren 1995). Alternatively, according to some observers, another factor influencing the changes in bank portfolio composition was the implementation by U.S. bank regulators of the risk-based capital standards. Because the risk-based capital standards account primarily for credit risk, they require banks to hold greater capital, at the margin, for assets with potentially high levels of credit risk, such as business loans, than for assets deemed to have no credit risk, such as U.S. government securities. Thus, as Berger and Udell (1994)

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note, the risk-based standards may function as a regulatory tax, one that reduces the profitability of business loans relative to government securities, thereby creating an incentive for banks to alter the composition of their portfolios.

This study examines the time-series behavior of aggregate business lending and government security holdings in the U.S. commercial banking system by considering whether a trend specification with structural break model where the structural break coincides with the implementation of the risk-based capital standards is consistent with the recent history of bank portfolio composition. While almost all existing empirical studies of the impact of the risk-based capital standards on portfolio composition are performed on individual bank data, the relationship over time between business loans and government security holdings for the banking system in the aggregate is important for a number of reasons. First, if the credit view of monetary policy is correct, then the composition of bank portfolios in the aggregate has important implications for the future level of economic activity. This is because many businesses, particularly small ones, rely solely on banks for credit, and if aggregate bank lending is reduced, then the disruption in financial intermediation may impair economic activity and growth. Second, Silber (1969) argues that a change in monetary policy may be more quickly transmitted to the economy by a change in bank loans than by a change in bank holdings of securities. This occurs because inventory investment is very responsive to changes in loan rates, while investment spending is less responsive to changes in interest rates on securities. Under these conditions, an exogenous shock to bank portfolio composition may have an impact on the speed and effectiveness of monetary policy. Third, from a regulatory perspective, the shift in portfolio composition may have important implications for the safety and soundness of the banking system because a relative increase in security holdings, if not properly immunized, may lead to an increase in interest rate risk for the banking system. And research by Allen, Jagtiani, and Landskroner (1996) finds that after implementation of the risk-based capital standards, banks substituted interest rate risk for credit risk.

Finally, Greenspan (1998), McDonough (1998), and Hawke (1999) note that efforts are currently under way by both U.S. and foreign bank regulators to revise the risk-based capital standards. Given the limited understanding of the impact of the risk-based capital standards, as noted by Dowd (1998), a time-series examination of the impact of risk-based capital on the aggregate composition of bank portfolios may provide useful insights for regulators as they revise the risk-based capital standards.

2. Risk-Based Capital Standards

In July 1988, the Basle Committee on Banking Regulation and Supervisory Practices, comprised of representatives from 12 major industrialized countries, approved adoption of the risk-based capital standard for banks in their respective countries. The primary purpose of the risk-based standards was to require banks to hold capital in accordance with the perceived credit risk in their portfolio of assets as well as the risk arising from their off-balance sheet activities. To achieve this objective, the risk-based standards classify bank assets into one of four broad risk categories: 0%, 20%, 50%, and 100%.

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1 For research examining these issues, see Bernanke and Blinder (1992); Kashyap, Stein, and Wilcox (1992); and McMillin (1993).

2 The countries that make up the Basle Committee are Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, the Netherlands, Sweden, the United Kingdom, the United States, and Switzerland.
Certain assets, such as U.S. government securities, are considered to have no default risk and are assigned a risk weight of 0%, while commercial and industrial loans are assumed to have considerable credit risk and are assigned to the 100% risk-weight category. Having assigned assets to the appropriate risk-weight category, a bank computes its total risk-weighted assets by summing the dollar value of each asset times its corresponding risk weight. As a final step, banks are required to keep a certain minimum percentage of their total risk-weighted assets in the form of capital.\(^3\) Effective December 31, 1990, the risk-based capital standards required banks to hold a minimum of 7.25% of their total risk-weighted assets in the form of capital.\(^4\)

While the idea behind the risk-based capital standards was to get banks to hold capital commensurate with the level of primarily credit risk in their portfolio of assets, previous studies by Avery and Berger (1991) and Baer and McElravey (1993) recognize the many limitations of the risk-based capital standards. One problem is that by substituting assets with low risk weights, such as government securities, for assets with high risk weights, such as business loans, a bank could lower its minimum regulatory capital requirement yet not necessarily reduce the overall level of risk in their portfolio. Thus, Berger and Udell (1994) note, the risk-based capital standards may function as a regulatory tax, one that beginning December 31, 1990, places a higher marginal tax rate on commercial and industrial loans (7.25%) than on U.S. government securities (0%). This situation is further compounded because, as Avery and Berger (1991) and Keeton (1994) observe, if the risk weights used in the risk-based capital standards do not accurately reflect the true risk of an asset, then banks have an incentive to arbitrage assets both within and across risk-weight categories. Thus, for capital-constrained banks, the risk-based capital standards create an incentive to reallocate the assets in their portfolios since compliance can be achieved by shifting a bank’s portfolio toward lower risk-weighted assets, such as government securities. Former Securities and Exchange Commission Chairman Richard Breeden and former Federal Deposit Insurance Corporation Chairman William Isaac (1992, p. A2) note the incentive structure created by risk-based capital when they state,

Say what you may about bankers, they tend to be rational economic beings. Tell them they have to maintain 8% capital against business and consumer loans—and no capital or materially less capital against government bonds or single-family mortgage loans—and most bankers will put much of their money in the assets that require little or no capital.

Recent work by Haubrich and Wachtel (1993) confirms this point finding that banks shifted their existing portfolios away from high risk-weighted assets, such as business loans, to low risk-weighted assets, such as government securities, thereby reducing their risk-based capital requirements. They found that these changes occurred after implementation of the standards because the composition of bank portfolios can be quickly changed, thereby making portfolio changes before implementation of risk-based capital unnecessary.

In addition, banks that are not explicitly capital constrained also have an incentive to reallocate their portfolios toward low credit risk assets. As Hancock and Wilcox (1994), Jacques and Nigro (1997), and Aggarwal and Jacques (1998, 2001) have noted, banks may adjust their capital levels on the basis of not only the regulatory minimum but also any discrepancy between their actual and

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\(^3\) The risk-based capital standards recognize two forms of capital, tier 1 and tier 2. Tier 1 capital is comprised mainly of common stock equity but also includes other items, such as noncumulative perpetual preferred stock and undivided profits. Tier 2 capital includes items such as cumulative perpetual preferred stock and term-subordinated debt. For more details, see 12 CFR Part 9, Office of the Comptroller of the Currency (1989).

\(^4\) The 7.25% requirement was on total capital (tier 1 + tier 2). There was also a tier 1 risk-based capital requirement that became effective at the time equal to 3.25% of risk-weighted assets. Effective December 31, 1992, the minimum regulatory standards increased to 4% for tier 1 capital and 8% for total capital.
desired capital ratios. Because banks must meet the risk-based standards on a continuous basis, their desired capital ratios may exceed the regulatory minimum so as to avoid any uncertainty about being in compliance in the event of a negative shock to income. Thus, portfolio reallocation may occur even for banks that are not explicitly constrained by risk-based capital, and the results of Jacques and Nigro (1997) show just such a result.

Regardless of whether a bank is constrained by the risk-based capital standards, banks may also reallocate their portfolios in response to risk-based capital on the basis of profitability. Thakor (1996) argues that the risk-based capital standards increase the cost of funding loans but not securities. If competition limits the ability of banks to pass the increase in loan-funding costs along to borrowers, then the expected profitability of loans is decreased, thereby making lending less attractive relative to government bonds. Bleakley (1991) recognizes this point when quoting the president of a multi-billion-dollar bank who states, “Any bank with a profitability analysis system sees investments as a higher rate of return than many loans in light of new risk-based capital guidelines” (p. A2). Thus, Thakor (1996) concludes that the risk-based capital requirements lowered aggregate lending in the banking system. This result is supported empirically by Hall (1993) and Furfine (2000). The Hall (1993) study suggests that the risk-based capital standards led U.S. commercial banks to reduce business lending by $100 billion, while Furfine (2000) estimates that a one-percentage-point increase in the risk-based capital requirement reduced the growth rate of bank business lending by 5.5%.

Such a shifting of assets suggests the possibility of an underlying structural break in the relationship between bank business loans and government security holdings as a result of the risk-based capital standards. Specifically, the idea that banks adjusted their existing portfolios when the risk-based standards went into effect suggests a possible structural break in the mean of each series occurring at the time of implementation. Furthermore, if banks adjusted their future allocation of assets once the standards became effective, then the standards may have resulted in a structural change to the asset growth rates and trends. The analysis presented in this study examines the issue of nonstationarity in aggregate bank asset holdings by considering whether a trend specification with structural break model is consistent with the implementation of the risk-based capital standards.

3. Unit Roots

Recent developments in time-series econometrics have stressed the importance of testing for the presence of unit roots in macroeconomic time series. A time series \( x_t \) is integrated of order \( d \) if it must be differenced \( d \) times in order to achieve stationarity, in which case \( x_t \) has \( d \) unit roots. Of particular interest are cases where \( x_t \) is either \( I(0) \) or \( I(1) \). If \( x_t \sim I(0) \), it is stationary and has both a finite mean and variance, and exogenous shocks exert only a transitory effect on the variable. Thus, over time, an \( I(0) \) series would be expected to fluctuate around its mean, as the impact of an exogenous shock will dissipate over time. But if \( x_t \sim I(1) \), it is nonstationary, as neither its mean nor its variance is constant, and under these conditions, exogenous shocks have a permanent rather than transitory influence on the series over time. In empirical macroeconomic and financial research, such series are often found to be random walks.

With respect to bank portfolio composition, the time-series characterization has potentially important policy implications. A unit root in bank portfolio composition variables is inconsistent with the idea that changes in aggregate asset holdings of U.S. banks are stationary fluctuations around a deterministic trend. If bank portfolio variables are \( I(1) \), then exogenous shocks will exert a permanent effect on the level of bank lending, holdings of government securities, and the relative
holdings of each. Alternatively, if bank portfolio variables are \( I(0) \), then, at most, an exogenous shock will have a transitory effect on bank portfolio composition, and any distortion caused by such a shock would disappear over time. Under these two time-series characterizations, regulatory changes by bank regulators, to the degree that they act as shocks exogenous to the banks, may have very different effects on bank portfolios in the aggregate.

As a first step in analyzing the change in bank portfolios, unit root tests based on the work of Dickey and Fuller (1979, 1981) are performed. Specifically, these tests involve calculating the \( t \)-statistic for \( \alpha \) such that

\[
\Delta x_t = \mu + \alpha x_{t-1} + \beta t + \sum_{i=1}^{k} c_i \Delta x_{t-i} + e_t,
\]

where \( x_t \) is the variable under study, \( t \) is a trend term, and \( k \) lagged dependent variable terms are added to form the Augmented Dickey-Fuller (ADF). Here, \( k \) is chosen using the Akaike Information Criterion (AIC) so as to ensure that the error term, \( e_t \), is a white-noise process. The unit root tests are carried out under the null hypotheses of a unit root against an alternative hypothesis that the series is trend stationary.

In this study, the stationarity of aggregate business loans and government security holdings by U.S. commercial banks is analyzed using monthly data from January 1973 through December 1998. Data prior to January 1973 are not used because bank portfolio data underwent a significant revision in 1972. Specifically, the time series to be examined include (i) the log of commercial and industrial loans (CIL), (ii) the log of U.S. government securities held by banks (GSEC) and three bank portfolio composition ratios, (iii) the log of the ratio of commercial and industrial loans to U.S. government securities (CILGSEC), (iv) the log of the ratio of commercial and industrial loans to total bank loans and security holdings (CILTLS), and (v) the log of the ratio of government security holdings to total bank loans and securities (GSECTLS). All data are from the Federal Reserve Bank of St. Louis FRED database and are seasonally adjusted.

The results of applying the ADF tests to the various time series over the full sample period (1973.1–1998.12) are reported in Table 1. In addition, the Ljung-Box \( Q \)-statistics to test for serial correlation are reported. The results provide evidence that each of the five time series is \( I(1) \). Furthermore, the parameter estimates on \( \alpha \) range between \(-0.004\) and \(-0.014\), thus corresponding to AR(1) parameter estimates near unity. Taken as a whole, these results suggest that an exogenous random shock will have a permanent effect on the relative holdings of business loans and government securities by banks in the U.S. banking system.

4. Unit Root Tests with a Structural Break

The theoretical and empirical studies cited in the previous sections suggest that a structural break may have occurred in the time series as a result of the implementation of the risk-based capital standards. Perron (1989) notes that the occurrence of such a break may bias traditional unit root tests toward nonrejection of the null hypothesis of a unit root. One approach to examining the stationarity of a time series under these conditions is to conduct unit root tests on a split sample, and Table 1

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5 As noted by McMillin (1993).

6 ADF tests were run to examine whether the five time series are \( I(2) \) but are not reported here for the sake of brevity. The test statistics reject the hypothesis that the variables are \( I(2) \).
Table 1. Full-Sample and Split-Sample Unit Root Tests

<table>
<thead>
<tr>
<th>Variable/Time Period</th>
<th>(k)</th>
<th>(\mu)</th>
<th>(t_\mu)</th>
<th>(\beta)</th>
<th>(t_\beta)</th>
<th>(\alpha)</th>
<th>ADF</th>
<th>(Q(24))</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973.1–1998.12</td>
<td>10</td>
<td>0.023</td>
<td>2.01</td>
<td>2.05e^{-5}</td>
<td>1.62</td>
<td>-0.004</td>
<td>-1.88</td>
<td>24.15</td>
</tr>
<tr>
<td>1973.1–1990.12</td>
<td>10</td>
<td>0.052</td>
<td>1.63</td>
<td>6.92e^{-5}</td>
<td>1.40</td>
<td>-0.010</td>
<td>-1.55</td>
<td>22.53</td>
</tr>
<tr>
<td>1991.1–1998.12</td>
<td>6</td>
<td>0.103</td>
<td>2.45</td>
<td>0.0001</td>
<td>3.38</td>
<td>-0.017</td>
<td>-2.48</td>
<td>16.67</td>
</tr>
<tr>
<td>GSEC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973.1–1998.12</td>
<td>11</td>
<td>0.065</td>
<td>2.40</td>
<td>0.0001</td>
<td>2.19</td>
<td>-0.014</td>
<td>-2.29</td>
<td>16.57</td>
</tr>
<tr>
<td>1973.1–1990.12</td>
<td>11</td>
<td>0.175</td>
<td>3.18</td>
<td>0.0003</td>
<td>3.11</td>
<td>-0.039</td>
<td>-3.13</td>
<td>11.16</td>
</tr>
<tr>
<td>1991.1–1998.12</td>
<td>12</td>
<td>0.234</td>
<td>3.87</td>
<td>7.95e^{-5}</td>
<td>1.54</td>
<td>-0.036</td>
<td>-3.79**</td>
<td>12.00</td>
</tr>
<tr>
<td>CILGSEC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973.1–1998.12</td>
<td>11</td>
<td>0.006</td>
<td>2.08</td>
<td>-1.96e^{-5}</td>
<td>-1.85</td>
<td>-0.008</td>
<td>-2.39</td>
<td>19.61</td>
</tr>
<tr>
<td>1973.1–1990.12</td>
<td>11</td>
<td>0.014</td>
<td>2.71</td>
<td>-9.66e^{-6}</td>
<td>-0.75</td>
<td>-0.023</td>
<td>-2.79</td>
<td>14.69</td>
</tr>
<tr>
<td>1991.1–1998.12</td>
<td>9</td>
<td>-0.004</td>
<td>-1.83</td>
<td>9.99e^{-5}</td>
<td>2.27</td>
<td>-0.026</td>
<td>-4.24*</td>
<td>23.47</td>
</tr>
<tr>
<td>CILTLS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973.1–1998.12</td>
<td>8</td>
<td>-0.008</td>
<td>-2.08</td>
<td>-6.52e^{-6}</td>
<td>-1.68</td>
<td>-0.006</td>
<td>-2.09</td>
<td>21.28</td>
</tr>
<tr>
<td>1973.1–1990.12</td>
<td>3</td>
<td>-0.011</td>
<td>-1.38</td>
<td>-2.48e^{-6}</td>
<td>-0.51</td>
<td>-0.008</td>
<td>-1.42</td>
<td>22.04</td>
</tr>
<tr>
<td>1991.1–1998.12</td>
<td>4</td>
<td>-0.037</td>
<td>-2.87</td>
<td>2.76e^{-5}</td>
<td>1.40</td>
<td>-0.022</td>
<td>-2.73</td>
<td>21.93</td>
</tr>
<tr>
<td>GSECTLS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973.1–1998.12</td>
<td>11</td>
<td>-0.025</td>
<td>-2.57</td>
<td>1.63e^{-5}</td>
<td>1.87</td>
<td>-0.012</td>
<td>-2.62</td>
<td>17.61</td>
</tr>
<tr>
<td>1973.1–1990.12</td>
<td>11</td>
<td>-0.062</td>
<td>-3.21</td>
<td>1.26e^{-5}</td>
<td>1.15</td>
<td>-0.032</td>
<td>-3.21**</td>
<td>14.17</td>
</tr>
<tr>
<td>1991.1–1998.12</td>
<td>9</td>
<td>-0.046</td>
<td>-3.76</td>
<td>-0.0001</td>
<td>-2.81</td>
<td>-0.032</td>
<td>-4.01*</td>
<td>21.03</td>
</tr>
</tbody>
</table>

CIL is the log of the dollar value of commercial and industrial (C&I) loans, GSEC is the log of the dollar value of U.S. government securities, CILTLS is the log of the ratio of C&I loans to total bank loans and securities, GSECTLS is the log of the ratio of U.S. government securities to total bank loans and securities, and CILGSEC is the log of the ratio of C&I loans to U.S. government securities. *, **, and *** denote significant ADF tests at the 1%, 5%, and 10% levels, respectively. Given that the \(t\)-statistic on \(\alpha\) is biased toward rejection of the null hypothesis, MacKinnon (1991) critical values are used. The Augmented Dickey-Fuller equation is \(\Delta y_t = \mu + \alpha y_{t-1} + \beta t + \sum_{i=1}^{k} \Delta y_{t-i} + \epsilon_t\), where \(k\) is the number of lagged terms as determined by the Akaike Information Criterion (AIC). \(Q(24)\) is the Ljung Box test statistic for serial correlation.

provides evidence of such tests for the period both before (1973.1–1990.12) and after (1991.1–1998.12) implementation of the risk-based capital standards. For the five series, the null hypothesis can be rejected in three of the cases for the post–January 1991 period and in one case for the pre–January 1991 period. And while in all cases the split-sample tests yield parameter estimates on the AR(1) term between 0.95 and 0.99, Perron (1989) notes that split sample unit root tests may suffer from low power.

An alternative approach to characterizing bank portfolio composition as containing a unit root is that the five series may be trend stationary processes that, because of the implementation of risk-based capital, experienced a structural break in their mean and trend. In order to examine that possibility, Figures 1 through 3 and the top portion of Table 2 provide evidence of the time-series behavior of the five variables in this study using monthly data. In Figures 1 through 3, a vertical line has been inserted at January 1991 to mark the date of implementation of the risk-based capital standards. The graphs and equations suggest that, with the exception of CILTLS, each of the five series experienced breaks in both their mean and their trend following the implementation of risk-based capital in 1991. For CILTLS, the results suggest that there was a significant decrease in the level of the series at the time of the implementation of risk-based capital but no change in trend during the period the standards were in effect. Consistent with the discussion in the preceding sections, CIL, CILGSEC, and CILTLS appear to exhibit a "crash" in the mean of the series (DU is negative) at the time of the structural change, and for GSEC and GSECTLS there appears to be an abrupt increase in mean (DU is positive) at the time of the structural break.
Table 2. Preliminary Equations and Tests for a Unit Root with Structural Break

<table>
<thead>
<tr>
<th>Preliminary Equations:</th>
<th>Variable</th>
<th>$\mu$</th>
<th>$t_\mu$</th>
<th>$DU$</th>
<th>$t_{DU}$</th>
<th>TREND</th>
<th>$t_{TREND}$</th>
<th>DT</th>
<th>$t_{DT}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIL</td>
<td>5.042</td>
<td>558.980</td>
<td>-0.410</td>
<td>-26.698</td>
<td>0.0072</td>
<td>92.103</td>
<td>0.264</td>
<td>3.500</td>
<td></td>
</tr>
<tr>
<td>GSEC</td>
<td>4.435</td>
<td>461.946</td>
<td>1.128</td>
<td>16.169</td>
<td>0.0078</td>
<td>100.401</td>
<td>-0.004</td>
<td>-15.175</td>
<td></td>
</tr>
<tr>
<td>CILGSEC</td>
<td>0.586</td>
<td>34.780</td>
<td>-0.889</td>
<td>-7.265</td>
<td>-0.0003</td>
<td>-2.473</td>
<td>0.002</td>
<td>3.273</td>
<td></td>
</tr>
<tr>
<td>CILTLS</td>
<td>-1.376</td>
<td>-193.586</td>
<td>-0.130</td>
<td>-2.517</td>
<td>0.0001</td>
<td>1.245</td>
<td>-0.001</td>
<td>-1.929</td>
<td></td>
</tr>
<tr>
<td>GSECTLS</td>
<td>-1.962</td>
<td>-170.686</td>
<td>0.759</td>
<td>9.094</td>
<td>0.0004</td>
<td>4.395</td>
<td>-0.002</td>
<td>-5.991</td>
<td></td>
</tr>
</tbody>
</table>

Preliminary equations are of the form $x_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \epsilon_t$, where $t$, $DU$, and $DT$ are defined as in the text.

Unit Root with Structural Break Equations:

<table>
<thead>
<tr>
<th>Variable</th>
<th>$k$</th>
<th>$\mu$</th>
<th>$t_\mu$</th>
<th>$DU$</th>
<th>$t_{DU}$</th>
<th>TREND</th>
<th>$t_{TREND}$</th>
<th>$\gamma$</th>
<th>$t_\gamma$</th>
<th>$d$</th>
<th>$t_d$</th>
<th>$\alpha$</th>
<th>$t_\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIL</td>
<td>10</td>
<td>0.059</td>
<td>2.45</td>
<td>-0.005</td>
<td>-0.83</td>
<td>7.86e-5</td>
<td>2.12</td>
<td>-0.005</td>
<td>-0.89</td>
<td>3.53e-6</td>
<td>0.12</td>
<td>0.989</td>
<td>-2.35</td>
</tr>
<tr>
<td>GSEC</td>
<td>7</td>
<td>0.141</td>
<td>4.07</td>
<td>0.046</td>
<td>3.71</td>
<td>0.0002</td>
<td>3.86</td>
<td>0.003</td>
<td>0.30</td>
<td>-0.0002</td>
<td>-3.61</td>
<td>0.969</td>
<td>-3.97***</td>
</tr>
<tr>
<td>CILGSEC</td>
<td>3</td>
<td>0.011</td>
<td>3.35</td>
<td>-0.033</td>
<td>-2.76</td>
<td>-5.87e-6</td>
<td>-0.49</td>
<td>9.02e-5</td>
<td>2.03</td>
<td>-0.009</td>
<td>-0.82</td>
<td>0.981</td>
<td>-3.93***</td>
</tr>
<tr>
<td>CILTLS</td>
<td>3</td>
<td>-0.020</td>
<td>-3.13</td>
<td>-0.003</td>
<td>-2.37</td>
<td>-3.81e-7</td>
<td>-0.08</td>
<td>—</td>
<td>—</td>
<td>-0.002</td>
<td>-0.48</td>
<td>0.985</td>
<td>-3.15</td>
</tr>
<tr>
<td>GSECTLS</td>
<td>7</td>
<td>-0.047</td>
<td>-3.82</td>
<td>0.031</td>
<td>3.08</td>
<td>7.51e-6</td>
<td>0.74</td>
<td>-9.36e-5</td>
<td>-2.53</td>
<td>0.006</td>
<td>0.68</td>
<td>0.976</td>
<td>-3.87***</td>
</tr>
</tbody>
</table>

CIL, GSEC, CILGSEC, and GSECTLS are estimated using Perron’s crash-with-breaking-trend model, Equation 5, and CILGSEC is estimated using Perron’s crash model, Equation 4. For Equation 5, the critical values for the $t$-statistic on $\alpha$ are $-4.18$ and $-3.86$ at the 5% and 10% levels, respectively. For Equation 4, the critical values are $-3.80$ and $-3.51$ at the 5% and 10% levels, respectively. Critical values are taken from Perron (1989).
A priori, such changes are to be expected. A change in mean (crash) is consistent with the idea that once the risk-based capital standards went into effect, banks had a strong incentive to immediately alter their portfolios, particularly if they were capital constrained. Since banks can rapidly adjust the composition of their portfolios, the higher capital requirement on business loans and lower requirement on government securities suggests an abrupt shift in the composition of bank portfolios, at the time of implementation of risk-based capital, from loans to securities. Thus, CIL, CILTS, and CILGSEC would be expected to show a significant decrease in mean and GSEC and GSECTLS a significant increase in mean at the time the standards became effective.

What is surprising is that for CIL and CILGSEC, the trend increases (DT is positive) after implementation of the risk-based standards, and for GSEC and GSECTLS, the trend decreases (DT is negative). A priori, the regulatory tax hypothesis suggests that once the risk-based capital standards are implemented, the higher capital charge on business loans functions as a tax, thereby creating an incentive for banks to reduce their future originations of business loans (decreasing trend) and increase their future holdings of government securities (increasing trend). Thus, this result seems counterintuitive, as it suggests an increase in the growth rate of business loans and a decrease in the growth rate of securities once risk-based capital becomes effective. But this finding is consistent with Milne and Whalley (1999), who argue that the effects of the standards may unwind over time as banks replenish their capital levels. In this case, if banks significantly decreased the business loans and increased the government securities when risk-based capital was implemented and were quick to replenish their capital levels, then their growth rates of business loans and government securities may return to previous rates once the effects of risk-based capital had been accounted for.

Perron (1989) developed unit root tests that allow for a one-time structural break in the mean and trend of a time series occurring at a breakpoint, $T_b$. For series that appear to exhibit a change in the mean but not the trend, the “crash” model takes the form

$$x_t = \mu + \theta U_t + \beta t + d(TB)_t + \alpha x_{t-1} + \sum c_i \Delta x_{t-i} + e_t,$$  \hspace{1cm} (2)

and for series that exhibit a change in both the mean and trend, the “crash with breaking trend” model, the equation is
Figure 2. Ratio of Commercial Loans to Government Securities (1973:1–1998:12)

\[ x_t = \mu + \theta u_t + \beta t + \gamma DT_t + dD(TB)_t + \alpha_{x_{t-1}} + \sum c_i \Delta x_{t-i} + e_t, \]  

(3)

where \( u_t = 1 \) if \( t > T_b \) and 0 otherwise, \( D(TB)_t = 1 \) if \( t = T_b \) and 1 and 0 otherwise, and \( DT_t = t \) if \( t > T_b \) and 0 otherwise. Equations 2 and 3 are Dickey-Fuller types of equations that allow for a structural break in the mean and trend occurring at time \( T_b \).

As noted earlier, an examination of Figures 1 through 3, the results of the preliminary equations at the top of Table 2, and the preceding discussion suggest that most of the aggregate bank variables in this study experienced a structural break in their level and trend consistent with the introduction of risk-based capital. Specifically, all the variables are modeled using Equation 3, Perron’s crash-with-breaking-trend model, except CILTLS, which Table 2 suggests did experience a crash but not a change in trend. The breakpoint, \( T_b \), is set at January 1991, the time during which the risk-based capital standards first took effect.\(^7\) For the crash-with-breaking-trend model, the null hypothesis is \( \alpha = 1, \gamma = 0, \theta = 0, \beta = 0, \) and \( d \neq 0 \), while the alternative is \( \alpha < 1, \gamma \neq 0, \beta \neq 0, \theta \neq 0, \) and \( d = 0 \). Here, the null hypothesis suggests that the bank portfolio variables contain a unit root and therefore did not experience an underlying structural shift as a result of the risk-based capital standards. Under these conditions, shocks to bank portfolios would have a nontransitory effect. On the other hand, the alternative hypothesis suggests that implementation of the risk-based capital standards by bank regulators was of such significance for the banking system as a whole that it caused a structural break that resulted in not only an initial change in relative asset holdings but also a change in the future growth rates of the variables. Under these conditions, while risk-based capital caused a one-time structural shift in the mean and trend of the aggregate bank variables, shocks to the U.S. banking system are transitory and will not have a permanent influence on the composition of bank portfolios.

\(^7\) A critical factor in the use of the Perron unit root tests is the estimate of the breakpoint, \( T_b \). Following Perron (1989) and Simkins (1994), the chronology of changes to the time series is used to exogenously determine the breakpoint. In this case, January 1991 was chosen as the breakpoint since this is the effective date of the implementation of the risk-based standards, and research by Haubrich and Wachtel (1993) shows that banks adjusted their portfolios once the risk-based capital standards took effect.
Figure 3. Commercial Loans to Total Loans and Securities (CILTLS); Government Securities to Total Loans and Securities (GSECTLS) (1973:1–1998:12)

The crash model, Equation 2, is applied to CILTLS and examines whether the ratio experienced a one-time structural break in level due to implementation of risk-based capital. Here the null hypothesis is $\alpha = 1, \beta = 0, \theta = 0,$ and $d \neq 0$ with the alternative hypothesis being $\alpha < 1, \beta \neq 0, \theta \neq 0,$ and $d = 0.$ Similar to Equation 3, the null hypothesis suggests the presence of a unit root, while the alternative hypothesis is consistent with empirical findings in other research that implementation of the risk-based capital standards caused an underlying structural shift in relative asset holdings at the time the standards were implemented.

The lower portion of Table 2 provides estimates of Equations 2 and 3 for the five bank portfolio composition variables. The results suggest that for all five variables, the null hypothesis of a unit root cannot be rejected at the 5% level. Here the $t$-statistics on $\alpha$ for CIL, GSEC, CILGSEC, and GSECTLS are $-2.35, -3.97, -3.93,$ and $-3.87$, respectively, with the 5% critical value for $\alpha$ being $-4.18.$ For the crash model, the $t$-statistic on $\alpha$ equals $-3.15$ in the CILTLS equation, with the 5% critical value being $-3.80.$ Furthermore, it is interesting to note that the $t$-statistics on $\alpha$ in the GSEC, CILGSEC, and GSECTLS equations are all greater than the 10% critical value of $-3.86.$ But in these cases, an examination of the parameter estimates on $\alpha$ shows that they all range between 0.969 and 0.981, thus making the variable practically indistinguishable from one. Taken as a whole, these results suggest that aggregate bank business lending and government security holdings are effectively nonstationary series. As such, the evidence is not consistent with that of a trend-stationary series that experienced a structural break in the level and trend of bank portfolio variables that can be attributed to implementation of the risk-based capital standards. Furthermore, it is not surprising that bank business loans and security holdings exhibited unusual behavior during the 1990s, as nonstationary variables have no inherent tendency to fluctuate around their mean. For policymakers and bank regulators, what is troublesome about these results is that under the unit root hypothesis, shocks have a permanent rather than transitory effect on the system. Under these conditions, risk-based capital was not of such importance so as to structurally shift the level and growth rate of aggregate bank loan and security holdings. Rather, because the series contain unit roots, the composition of aggregate asset
holdings in the U.S. banking system may be viewed as potentially being influenced by a whole range of possible shocks emanating from any one of a number of potential sources of which the risk-based capital standards is but one possible source. Under these conditions, what becomes important is the magnitude of the shock because if it is of sufficient intensity, it could have significant macroeconomic implications as well as ramifications for the safety and soundness of the banking system.

Finally, a word of caution is in order. While the results suggest that aggregate bank variables are nonstationary series that did not experience a significant structural break at the time the risk-based capital standards were implemented, this study has analyzed their time-series behavior allowing for only one structural shift. Campbell and Perron (1991) have noted the near observational equivalence of unit root and trend stationary processes in finite samples. For financial time series, there are a number of other possible structural shifts that may have influenced bank portfolio composition as well as a number of other possible time-series models that can be used to represent the series. Furthermore, if aggregate bank portfolio variables are I(1), the unit roots may be the result of some other aspect of the variable, such as a change in the variance of the process or because some variable underlying bank loans and securities contains a unit root.

5. Conclusion

This study has examined the time-series behavior of five measures of bank portfolio composition to see if the processes are consistent with theoretical and empirical arguments about the impact of risk-based capital on bank portfolio composition. The results suggest that bank holdings of business loans, government securities, and the ratio between the two are nonstationary processes. Thus, the risk-based capital standards were not an event of such importance as to structurally alter the level and trend of bank portfolios in the aggregate at the time the standards were implemented. Rather, the results suggest that exogenous shocks to bank portfolio composition will have persistent effects over time. Further research is needed to identify whether changes in regulatory capital standards are exogenous shocks to bank portfolio composition and, if so, what is the magnitude of such shocks.

For bank regulators and policymakers, the results of this study point to some important issues regarding any forthcoming change in the risk-based capital standards. Specifically, to what degree will the revised standards cause banks to become capital constrained? And what incentives are created by any revisions to risk-based capital? If the revised standards either explicitly or implicitly cause banks to become capital constrained or alter the desirability of holding one type of asset relative to another, then the U.S. banking system may experience an exogenous shock. As such, the results of this study suggest that such a shock could have effects on bank portfolio composition, in the aggregate, that will persist indefinitely.

References


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