An equity management and planning tool for cooperatives

Jeffrey Royer
Department of Agricultural Economics, University of Nebraska-Lincoln, Lincoln, Nebraska, USA

Received 18 March 2014
Revised 22 July 2014
21 August 2014
Accepted 29 August 2014

Abstract

Purpose – The purpose of this paper is to describe an equity management and planning tool used by rural electric cooperatives (RECs) and based on the times-interest-earned ratio (TIER). The objectives of the paper are to construct a mathematical model that provides a rigorous foundation for the TIER approach, modify the approach so the rate of return on equity is a function of the cooperative's equity position, demonstrate how elements of the model can be used by RECs in setting electric rates that will enable them to accelerate the retirement of member equity, and derive a generalized form of the "modified Goodwin formula" that can be used by both RECs and agricultural cooperatives.

Design/methodology/approach – Mathematical and graphical expressions of the TIER approach are developed. Simulations are used to demonstrate how RECs can set electric rates according to a target revolving period. The modified Goodwin formula is generalized to include the payment of cash patronage refunds through use of a growth model of an agricultural cooperative developed in Royer (1993).

Findings – This paper demonstrates how TIER analysis and the modified Goodwin formula can be used by cooperatives to aid their decisions regarding debt and equity financing and their choices regarding cash patronage refunds, equity retirement, and growth. The paper demonstrates that cooperatives that fail to recognize the functional relationship between the rate of return on equity and the equity position may substantially underestimate the equity position necessary to meet interest coverage requirements and overestimate their ability to grow and retire equity. It also shows that RECs may be able to make substantial improvements in equity revolvement with only modest increases in electric rates.

Research limitations/implications – The model developed in this paper has been simplified to focus on fundamental financial relationships. To apply this model, cooperatives may need to modify it to accommodate the complexities of their business operations.

Practical implications – TIER analysis can provide a useful equity management and planning tool for both RECs and agricultural cooperatives. It also can be used by lending institutions to assess the financial health of individual cooperative organizations.

Originality/value – Constructing a mathematical model that provides a foundation for TIER analysis, modifying the approach so that the rate of return on equity is a function of the equity position, demonstrating how RECs can use the model to set electric rates according to a target revolving period, and generalizing the modified Goodwin formula so it can be used by agricultural cooperatives are all original contributions.

Keywords Agricultural cooperatives, Capitalization, Equity financing, Equity retirement, Ratio analysis, Rural electric cooperatives

Paper type Research paper

Introduction

Phillips (2001) has shown how an analytical approach based on the times-interest-earned ratio (TIER) can serve as a valuable equity management and planning tool for rural electric cooperatives (RECs). As this paper demonstrates, that tool also has potential for playing an important role in financial decisions made by agricultural cooperatives.

TIER analysis, as it will be convenient to call the approach described by Phillips, can be used by a cooperative to determine the least-cost mix of debt and equity capital that satisfies a particular interest coverage requirement given the cooperative's rate of return on equity and average interest rate. Identifying the least-cost mix of debt and

Agricultural Finance Review
Vol. 75 No. 2, 2015
pp. 267-281

0002-1466
DOI 10.1108/AFR-03-2014-0004

equity is important because if the cooperative uses too much debt in its capitalization, it may be unable to cover its interest expenses; if it uses too much equity, its capital costs may be greater than necessary.

Times interest earned is a particularly useful measure of interest coverage because its structure readily lends itself to the development of expressions describing the relationship of the mix of debt and equity to interest coverage and the respective costs of debt and equity capital. It also is a key indicator of financial performance, and loan agreements routinely require cooperative borrowers to maintain TIER values above a certain specified minimum. An attractive feature of TIER analysis is that it uses the rate of return on equity to represent the cost of equity capital. Because the rate of return on equity is equivalent to the opportunity cost of equity, it ensures that alternative uses for equity are appropriately considered in financing decisions.

Phillips also described an algebraic relationship, known as the "modified Goodwin formula," that has been used in conjunction with TIER analysis. The Goodwin formula expresses the relationship between an REC's rate of return on equity, its rate of growth in equity capital, and the length of its revolving period. An REC can use the formula to identify the tradeoffs between equity revolvement and growth given its rate of return on equity or, alternatively, what rate of return it must maintain to meet its goals for equity revolvement and growth. Because the rate of return on equity plays an integral role in both TIER analysis and the Goodwin formula, it can be used to link a cooperative's decisions regarding equity and debt financing with its choices regarding equity revolvement and growth.

Agricultural cooperatives cannot apply the Goodwin formula to their equity choices because the formula does not account for the payment of cash patronage refunds, and agricultural cooperatives, unlike RECs, generally must pay a portion of their patronage refunds in cash. Among its contributions, this paper presents a generalized form of the Goodwin formula that takes the payment of cash patronage refunds into account and can be used by both RECs and agricultural cooperatives.

In general, this paper makes four principal contributions with respect to TIER analysis and the Goodwin formula. First, we construct a mathematical model that provides a rigorous foundation for Phillips's graphical presentation. Expressing the TIER approach in mathematical form enables us to communicate it in a more precise manner and helps us clarify and correct some aspects of the approach. Second, we eliminate a major weakness in Phillips's presentation by expressing the rate of return on equity as a function of the cooperative's mix of debt and equity. Third, we demonstrate how elements of the TIER model can be used by RECs in setting electric rates that will enable them to accelerate the retirement of member equity. Fourth, we employ a growth model to derive a generalized form of the Goodwin formula and explore the relationships between cash patronage refunds, equity growth, and equity revolvement. After presenting the mathematical model of TIER analysis and describing the modified Goodwin formula and its application, the paper proceeds to discuss the other three contributions.

TIER model

The interest coverage ratio, or TIER, is generally computed by dividing earnings before interest and taxes (EBIT) by annual interest expense. Because most RECs do not pay income tax, the tax term in the numerator can usually be ignored. In fact, the definition of TIER used by RECs is net income plus annual interest expense divided by annual interest expense (Phillips, 2001, p. 30). For current purposes, it will be convenient to define both net income and annual interest expense in terms of total capital. Thus we define the cooperative's net income as:

$$N = r_k \cdot K \tag{1}$$

where r_k represents the cooperative's rate of return on capital and K represents its total capital. We define annual interest expense as:

$$I = i(1-p)K \tag{2}$$

where i represents the average interest rate and p represents the equity position, which is defined as the proportion of total capital composed of equity[1]. Consequently, the interest coverage ratio R can be expressed as:

$$R = \frac{r_k \cdot K + i(1-p)K}{i(1-p)K}. \tag{3}$$

The relationship between the rate of return on capital and the rate of return on equity can be expressed as:

$$r_e = \frac{r_k}{p} \tag{4}$$

or:

$$r_k = p \cdot r_e \tag{5}$$

where r_e represents the rate of return on equity. Substituting Equation (5) for r_k in Equation (3) and eliminating K from both the numerator and denominator, the interest coverage ratio can be rewritten as:

$$R = \frac{r_e \cdot p + i(1-p)}{i(1-p)}. \tag{6}$$

Here the interest coverage ratio is expressed as a function of the rate of return on equity, equity position, and average interest rate.

Solving Equation (6) for r_e, we can determine the rate of return on equity necessary for the cooperative to meet a particular value for the interest coverage ratio $\overline{R}$ given the cooperative's equity position and its average interest rate:

$$r_e = \frac{i(1-p)\left(\overline{R}-1\right)}{p} \quad \text{for} \quad \overline{R} > 1. \tag{7}$$

Alternatively, by setting Equation (7) equal to the cooperative's rate of return on equity r_e and solving for p, we can determine the equity position at which the interest coverage requirement is met given the cooperative's rate of return on equity and the interest rate:

$$p^* = \frac{i\left(\overline{R}-1\right)}{r_e + i\left(\overline{R}-1\right)}. \tag{8}$$

At an equity position less than p^*, the interest coverage ratio would be lower than the required value; at an equity position greater than p^*, the total cost of capital would be greater than necessary.

In effect, p^* represents the least-cost equity position, i.e., the value of p that satisfies the interest coverage requirement at the lowest total cost of capital. The total cost of capital can be computed from the weighted average cost of capital k, which can be written:

$$k = r_e \cdot p + i(1 - p) \tag{9}$$

where the rate of return r_e is used to represent the cost of equity capital.

Graphical presentation

The mechanics of TIER analysis described by Phillips for an REC are shown in Figures 1-3. In Figure 1, each of the curves R_1, R_2, and R_3 represents the combinations of r_e and p corresponding to a particular value of R (1.5, 2.0, and 3.0) as calculated from Equation (7)[2]. For any value of R, the equity position p^* is determined by the intersection of the R curve and the line representing the rate of return r_e. The weighted average cost of capital is read from the line extending diagonally from the interest rate i to the rate of return r_e. As the required value of the interest coverage ratio is increased, both the value of the equity position and the corresponding average cost of capital increase.

The effect of an increase in the average interest rate is demonstrated in Figure 2. An increase in the interest rate has two effects. First, there is the direct effect of the increase as indicated by the shift in the line representing the interest rate from i to i'. This shift does not affect the equity position, but it shifts the line representing the average cost of capital. Second, because i is an argument in Equation (7), an increase in i shifts the R curve for a particular value of the interest coverage ratio from R to R'. That shift increases the equity position from p to p'. The cost of capital increases from k to k' because of the shifts in both the R curve and the curve representing the

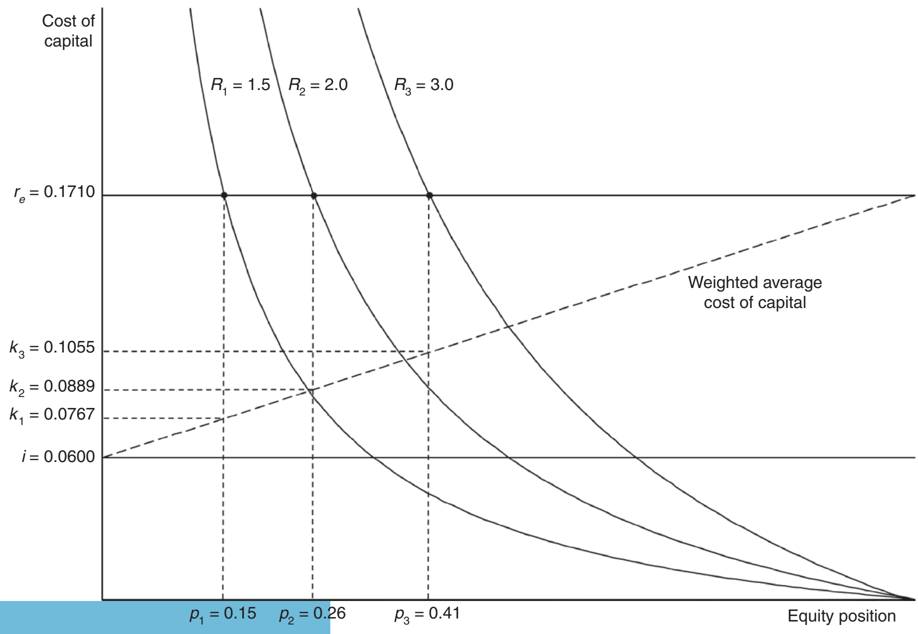

Figure 1.
Least-cost equity position and weighted average cost of capital for selected values of interest coverage ratio

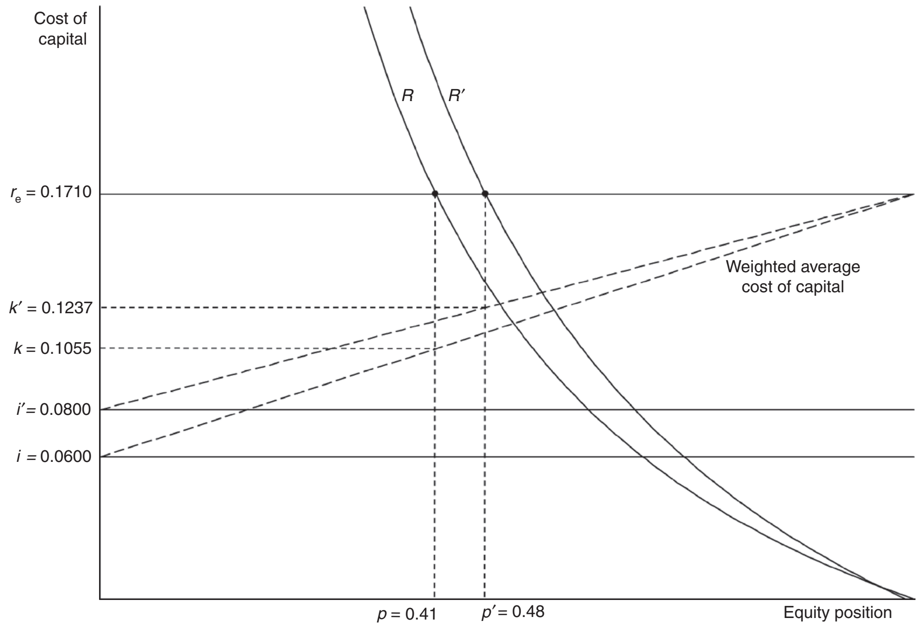

Figure 2.
Effect of increase in average interest rate on least-cost equity position and weighted average cost of capital

average cost of capital. Without a contemporaneous increase in the rate of return on equity, the cooperative will need to slow equity retirement to reach the desired equity position p'.

An increase in the rate of return on equity does not shift the R curve, but it increases the cost of equity relative to debt. As shown in Figure 3, the equity position decreases from p to p'', and the average cost of capital increases from k to k''. As a result of the shift in equity position, a lump sum of equity equal to $(p''-p)K$ is available for immediate redemption. In addition, the increase in the rate of return implies that the cooperative can adopt more ambitious goals with respect to equity growth and retirement.

Interest coverage requirements

To perform TIER analysis, a cooperative must choose an appropriate value for the interest coverage ratio. Provisions in Rural Utility Service (RUS) and National Rural Utilities Cooperative Finance Corporation (CFC) loan contracts currently require electric distribution cooperatives and power supply cooperatives to meet respective minimum TIER values of 1.25 and 1.05 to ensure margins adequate for covering debt and interest payments. However, financial experts have cautioned that TIERs at those low levels cannot be counted on to provide the margins necessary for RECs to meet their needs in private capital markets and retire equity capital on a systematic and reasonable basis. Phillips argues that most RECs need to maintain a TIER between 2.0 and 3.0 to generate the margins and cash flows necessary to achieve their financial goals. In 2013, the median TIER value for a sample of distribution cooperatives tracked by CFC was 2.62 (National Rural Utilities Cooperative Finance Corporation, 2014)[3].

Unlike RECs, which are associated with relatively stable electric rates and demand for electricity, agricultural cooperatives are subject to constantly changing market

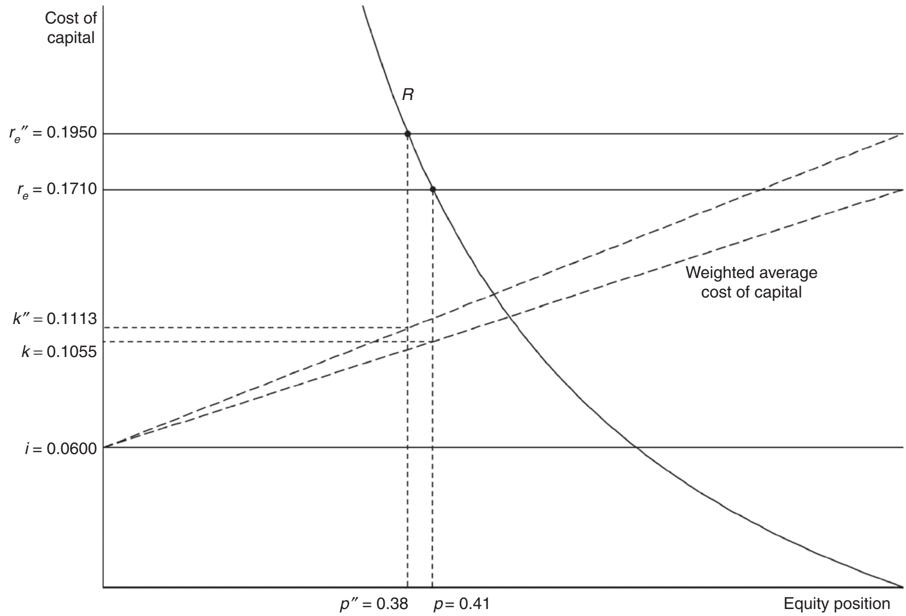

Figure 3. Effect of increase in rate of return on equity on least-cost equity position and weighted average cost of capital

conditions. Consequently, we might expect that agricultural cooperatives would need to maintain higher TIER values to protect themselves and their creditors from additional risk. Indeed, in 2009 the mean TIER value for agricultural cooperatives was 5.81 according to Penn *et al.* (2010).

Modified Goodwin formula

The modified Goodwin formula can be used by an REC to identify the tradeoffs between equity retirement and growth given the cooperative's rate of return on equity. The formula is based on the assumption that the cooperative operates a first-in/first-out revolving fund plan for the accumulation and retirement of member equity. Under that plan, the cooperative retains a proportion of the patronage refunds it allocates each year. Those retained patronage refunds are added to the revolving fund to provide equity capital and to be eventually redeemed in turn. The oldest equities are redeemed first, usually at the discretion of the board of directors and according to the financial needs of the cooperative. The revolving fund plan is the most popular equity management plan among both RECs and agricultural cooperatives[4].

Given that, the Goodwin formula can be expressed as:

$$r_e = \frac{(1+g)^{T+1} - (1+g)^T}{(1+g)^T - 1} \quad (10)$$

where r_e is the rate of return on equity, g is the rate of equity growth, and T is the length of the revolving period[5]. From Equation (10), we can determine the rate of return necessary to maintain a particular rate of growth and revolving period, as represented in Table I. For example, to maintain a 6 percent growth rate and a 20-year

Table I. Required rate of return on equity for various rates of equity growth and revolving periods for an REC

	Revolving period (yrs)					
Growth rate	5	10	15	20	25	∞
0.00	0.2000	0.1000	0.0667	0.0500	0.0400	0.0000
0.01	0.2060	0.1056	0.0721	0.0554	0.0454	0.0100
0.02	0.2122	0.1113	0.0778	0.0612	0.0512	0.0200
0.03	0.2184	0.1172	0.0838	0.0672	0.0574	0.0300
0.04	0.2246	0.1233	0.0899	0.0736	0.0640	0.0400
0.05	0.2310	0.1295	0.0963	0.0802	0.0710	0.0500
0.06	0.2374	0.1359	0.1030	0.0872	0.0782	0.0600
0.07	0.2439	0.1424	0.1098	0.0944	0.0858	0.0700
0.08	0.2505	0.1490	0.1168	0.1019	0.0937	0.0800
0.09	0.2571	0.1558	0.1241	0.1095	0.1018	0.0900
0.10	0.2638	0.1627	0.1315	0.1175	0.1102	0.1000
0.11	0.2706	0.1698	0.1391	0.1256	0.1187	0.1100
0.12	0.2774	0.1770	0.1468	0.1339	0.1275	0.1200
0.13	0.2843	0.1843	0.1547	0.1424	0.1364	0.1300
0.14	0.2913	0.1917	0.1628	0.1510	0.1455	0.1400
0.15	0.2983	0.1993	0.1710	0.1598	0.1547	0.1500
0.16	0.3054	0.2069	0.1794	0.1687	0.1640	0.1600
0.17	0.3126	0.2147	0.1878	0.1777	0.1734	0.1700
0.18	0.3198	0.2225	0.1964	0.1868	0.1829	0.1800
0.19	0.3271	0.2305	0.2051	0.1960	0.1925	0.1900
0.20	0.3344	0.2385	0.2139	0.2054	0.2021	0.2000

revolving period, a cooperative would need to earn an 8.72 percent rate of return. To increase its growth rate or shorten its revolving period, the cooperative would need to raise its rate of return, as shown in Table I.

Because the rate of return on equity determines which choices between equity growth and retirement are feasible, it represents the opportunity cost of equity. Thus use of the rate of return on equity as the cost of equity capital in TIER analysis ensures that alternative uses for equity are appropriately considered in financing decisions. A cooperative's failure to take the opportunity cost of equity into account can result in an undervaluation of the cost of equity, thereby contributing to an overreliance on equity capital and an overinvestment in assets.

The Goodwin formula in Equation (10) does not take the payment of cash patronage refunds into consideration in determining the required rate of return. Thus it cannot be applied to agricultural cooperatives because, unlike RECs, agricultural cooperatives generally pay cash patronage refunds.

Incorporating variable rate of return on equity

An important shortcoming in Phillip's graphical presentation of the TIER approach is that it fails to take into account the relationship $r_e = r_k/p$ in Equation (4). That relationship is essential to expressing the interest coverage ratio in terms of the rate of return on equity in Equation (6) and deriving Equation (7), which is used to plot the R curves in Figures 1-3. Graphing the rate of return on equity in those figures as a constant independent of the equity position is inconsistent with Equation (4), and failure to consider that equation when determining the equity position can lead to serious errors.

We would expect the return on capital before interest expense to be independent of the mix of equity and debt capital. However, interest expense, which is a function of the debt load, must be deducted from that return in calculating net income. Thus the rate of return on capital can be expressed as:

$$r_k = r_{kb} - i(1-p) \tag{11}$$

where r_{kb} represents the rate of return on capital before interest expense, a value we will assume is exogenously determined. The rate of return on capital is an increasing function of the equity position because interest expense decreases as the proportion of equity is increased.

Moreover, from Equation (4) we know that the rate of return on equity is a function of the equity position. At low equity positions, the return on capital is large relative to the stock of equity, but as the equity position is increased, that leverage decreases and the return on capital declines relative to equity. Substituting Equation (11) into Equation (4), we obtain:

$$r_e = \frac{r_{kb} - i(1-p)}{p}. \tag{12}$$

The rate of return on equity is a function of both the equity position and average interest rate.

Let Figure 4 represent an REC that is thinking about increasing its equity position as a means of raising its TIER value. Assume the cooperative currently earns a rate of return on equity of 17.1 percent, maintains an equity position of 0.15, and has a TIER of 1.5. If the rate of return on equity were constant, as indicated by the horizontal line labeled $r_e = 0.1710$, the cooperative could raise its TIER to 2.0 by increasing its equity position to 0.26 or raise its TIER to 3.0 by increasing its equity position to 0.41. However, according

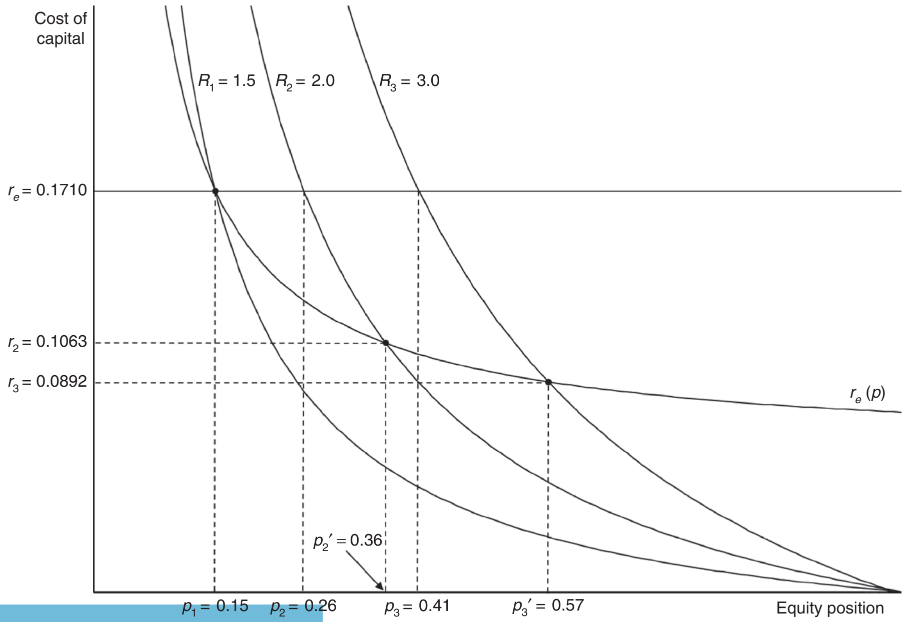

Figure 4.
Effects of treating rate of return on equity as a function of equity position

to Equation (12), the rate of return on equity decreases as the equity position is increased, as along the curve labeled $r_e(p)$. Given the decreasing rate of return, the cooperative would need to maintain substantially higher equity positions to meet its TIER goals. To raise its TIER to 2.0, it would need to increase its equity position to 0.36. To raise its TIER to 3.0, it would need to increase its equity position to 0.57.

Because of the lower rates of return on equity associated with those higher equity positions, the cooperative would need to adopt less ambitious goals for equity growth and retirement. According to the Goodwin formula in Equation (10), given a 17.1 percent rate of return the cooperative would be able to maintain a 15 percent rate of growth while retiring equity on a 15-year cycle. However, it if were to expand its equity position to 0.36 to meet a 2.0 TIER goal, its rate of return would fall to 0.1063. At that rate, the cooperative would be unable to retire any equity without reducing its growth rate substantially. The necessary reduction in the growth rate would be even greater given the 8.92 percent rate of return associated with the 0.57 equity position needed to meet a 3.0 TIER goal.

As this example demonstrates, failure to recognize the functional relationship between the rate of return on equity and the equity position would result in a cooperative underestimating the equity position necessary to meet a particular TIER requirement and overestimating its ability to grow and retire equity. To incorporate a variable rate of return on equity into the analysis illustrated in Figures 1-3, the horizontal lines representing r_e should be replaced by Equation (12). Equation (12) also should be substituted for r_e in Equation (8) to determine the equity position p^*. In addition, recognition that the rate of return on equity is also a function of the interest rate implies that in an analysis of the effect of a change in the interest rate, such as shown in Figure 2, the rate of return on equity must be modified to account for the change[6].

Rate setting and equity revolvement by RECs

RECs have been criticized for not retiring capital credits on a timely basis. Cooper (2008) suggests that many RECs maintain unnecessarily high levels of equity relative to debt and could easily redeem capital credits by lowering the level of equity and replacing it with debt. The framework presented in this paper could be used to demonstrate the mechanics and effects of such a strategy.

A second approach is for RECs to raise the rates they charge for electricity to provide cash flow sufficient for redeeming capital credits according to a target revolving cycle. As early as the mid-1970s, the NRECA and CFC Capital Credits Study Committee (1976) recommended that RECs should set their retail electric rates high enough to generate margins adequate for accumulating and retiring equity. More specifically, the committee suggested that RECs should set their electric rates according to a rate of return that took the costs of both debt and equity into consideration. It also recommended that RECs should develop programs for systematically retiring capital credits on a 10- to 20-year cycle[7]. In most states, RECs have authority to raise electric rates without permission of the state utility commission, unlike investor-owned utilities[8].

Here we demonstrate how an REC could set its electric rate according to such a plan and the effects of the plan on various rates of return and the cooperative's TIER value. We do so by exploring two examples – "Cooperative D," a large retail distribution cooperative, and "Cooperative G," a mid-size generation and transmission (G&T) cooperative.

Let T^* represent the target revolving period. From the modified Goodwin formula in Equation (10), it can be shown that the rate of return on equity required to revolve equity according to T^* is:

$$r_e^* = \frac{g}{1-(1+g)^{-T^*}} \tag{13}$$

for a given rate of growth and a constant equity-to-capital ratio. From Equation (5), the required rate of return on capital can be determined from the required rate of return on equity:

$$r_k^* = p \cdot r_e^* \tag{14}$$

where p is once again the proportion of total capital composed of equity.

In general, the rate of return on capital for an REC is computed from the ratio of net income to total capital, which is convenient to express here as:

$$r_k = \frac{ES \times ER + OI}{K} \tag{15}$$

where ES represents electric sales, ER represents the electric rate, and OI represents other items. The product $ES \times ER$ represents operational revenues. The OI term represents the sum of several other components of net income, including operational expenses (–), other income (+), interest expense (–), and income taxes (–). Setting Equation (15) equal to r_k^*, and solving for ER results in the electric rate necessary to revolve equity according to the target revolving period T^*:

$$ER^* = \frac{r_k^* \cdot K - OI}{ES}. \tag{16}$$

Results from applying this approach to Cooperatives D and G are shown in Table II. The current electric rates and rates of return for the cooperatives are based on average

Table II.
Increase in electric rate required to meet target revolving period and effects of rate increase on rates of return and TIER value

		Target revolving period (yrs)				
	Current state	25	20	15	10	5
Cooperative D						
Electric rate (ct./kWh)	9.56	9.92	9.98	10.09	10.33	11.06
Increase (%)		3.79	4.44	5.60	8.06	15.73
Rate of return on equity	0.0356	0.0858	0.0944	0.1098	0.1423	0.2439
Rate of return on capital	0.0139	0.0334	0.0357	0.0427	0.0554	0.0949
Rate of return on assets	0.0120	0.0290	0.0319	0.0371	0.0481	0.0824
TIER	1.41	1.98	2.08	2.25	2.62	3.78
Cooperative G						
Electric rate (ct./kWh)	4.99	5.06	5.08	5.11	5.18	5.39
Increase (%)		1.41	1.79	2.45	3.84	8.11
Rate of return on equity	0.0455	0.0791	0.0880	0.1037	0.1366	0.2381
Rate of return on capital	0.0050	0.0087	0.0097	0.0115	0.0151	0.0363
Rate of return on assets	0.0040	0.0070	0.0078	0.0092	0.0122	0.0212
TIER	1.10	1.17	1.19	1.23	1.30	1.52

data from their financial statements over nine-year periods (2004-2012 for Cooperative D and 2003-2011 for Cooperative G). The electric rates are expressed in cents per kilowatt hour (kWh). The rate charged by Cooperative G is a wholesale rate charged the retail distribution cooperatives that constitute its membership and hold its equity capital. The owners of Cooperative D's equity are its retail customers, including commercial, residential, and educational entities. Neither cooperative has a record of retiring equity in recent years nor is capable of equity revolvement given its current rate of return on equity and growth rate.

As Table II shows, each of the cooperatives could maintain a 25-year revolving cycle by increasing the electric rate it charges its customers by only a modest proportion (3.79 percent for Cooperative D and 1.41 percent for Cooperative G). Shorter revolving periods would require greater rate increases, but both cooperatives could substantially shorten their revolving periods with less than a 5 percent increase. Increasing the electric rates also would increase the rates of return.

Increases in the rates of return on equity would in turn increase the TIER values, which could provide benefits to the cooperatives in the form of access to additional debt capital and lower interest rates. The increased rates of return on equity also would increase the cost of equity capital. As a result of the increased cost of equity and perhaps reduced interest rates, equity would become relatively more expensive, encouraging the cooperatives to further decrease their equity positions.

Generalizing the modified Goodwin formula

For agricultural cooperatives, the practice of paying cash patronage refunds is related to how their net income is taxed. The tax treatment of agricultural cooperatives is defined by Subchapter T of the US Internal Revenue Code, which consists of sections 1381-88 and applies to any corporations operating on a cooperative basis except mutual savings banks, mutual insurance companies, and cooperatives engaged in furnishing electric energy or telephone service to rural areas. In most circumstances, Subchapter T requires cooperative members to include both cash and noncash patronage refund distributions in their taxable income. In turn, a cooperative can exclude patronage refund distributions from its taxable income as long as it pays at least 20 percent of the distributions in cash. Most cooperatives pay a higher proportion of patronage distributions in cash to ensure members have cash adequate for paying tax on them. According to calculations based on data reported by Eversull (2010), US agricultural cooperatives paid about 45 percent of patronage refunds in cash in 2008. RECs generally do not pay cash patronage refunds because they are exempt from federal income taxation under section 501(c)(12) of the Internal Revenue Code.

To generalize the Goodwin formula for use by agricultural cooperatives, we must replace Equation (10) with a relationship that allows for the payment of cash patronage refunds. We accomplish that using a growth model developed in Royer (1993). In that model, the cooperative's net income in any year t (N_t) is defined as:

$$N_t = r_e \cdot E_{t-1} \tag{17}$$

where r_e represents the cooperative's rate of return on equity and E_{t-1} is the amount of equity at the end of year $t-1$ (beginning of year t). The cooperative refunds this income to members as a combination of cash and noncash patronage refunds. Let c represent the proportion of patronage refunds the cooperative pays in cash. Then retained patronage refunds (i.e., the noncash portion retained to finance the cooperative) in year t (RPR_t) are:

$$RPR_t = (1-c)N_t = (1-c)r_e \cdot E_{t-1}. \quad (18)$$

The growth in the cooperative's equity stock during year t is equal to retained patronage refunds less equity retired. Expressed another way, equity retired by the cooperative in year t (ER_t) is equal to retained patronage refunds less growth in equity:

$$ER_t = RPR_t - g \cdot E_{t-1} = [(1-c)r_e - g]E_{t-1} \text{ for } g \geqslant 0 \quad (19)$$

where g represents the rate of growth[9].

Under a first-in/first-out revolving fund plan, the cooperative redeems the retained patronage refund allocations issued T years earlier, where T is the length of the revolving period, the value of which is left unspecified at this point. Thus from Equation (18), equity retired by the cooperative in year t under the revolving fund plan is:

$$ER_t = RPR_{t-T} = (1-c)r_e \cdot E_{t-T-1}. \quad (20)$$

If the rate of growth in equity is positive:

$$E_{t-T-1} = (1+g)^{-T} E_{t-1}. \quad (21)$$

Replacing E_{t-T-1} in Equation (20) with Equation (21), equity retired by the cooperative in year t is:

$$ER_t = (1+g)^{-T}(1-c)r_e \cdot E_{t-1}. \quad (22)$$

Substituting the equity retired under the revolving fund plan in Equation (22) for ER_t in Equation (19) and eliminating ER_{t-1} yields an implicit function in four variables:

$$F(c, r_e, g, T) = \left[1-(1+g)^{-T}\right](1-c)r_e - g = 0. \quad (23)$$

In Royer (1993), this function is solved for T, the length of the revolving period, in terms of the other variables.

In the current application, we are interested in solving the function in Equation (23) for r_e:

$$r_e = \frac{g}{(1-c)\left[1-(1+g)^{-T}\right]} \text{ for } g > 0. \quad (24)$$

Equation (24) represents the rate of return on equity required to meet the cooperative's goals in terms of c, the proportion of patronage refunds paid in cash, g, the rate of growth of the equity stock, and T, the length of the revolving period[10]. Equation (24) is analogous to the modified Goodwin formula in Equation (10) except it takes into consideration cash patronage refunds paid by agricultural cooperatives. If we set $c = 0$, Equation (24) reduces to:

$$r_e = \frac{g}{1-(1+g)^{-T}} \text{ for } g > 0, \quad (25)$$

which is but a simpler expression of the Goodwin formula.

The rate of return on equity necessary to maintain various equity growth rates and revolving periods is shown in Table III for an agricultural cooperative that pays 45 percent cash patronage refunds. Comparison of Table III to Table I shows that an agricultural cooperative must earn a substantially greater rate of return than an REC for any combination of growth rate and revolving period due to the payment of cash patronage refunds.

In Figure 5, the relationship between the length of the revolving period and the equity growth rate is presented for various levels of cash patronage refunds given an 8.72 percent return on equity, the rate of return that is necessary for an REC to maintain a 6 percent rate of growth while revolving equity on a 20-year cycle. For any particular level of cash patronage refunds, the revolving period increases as the growth rate is increased. Moreover, the revolving period increases more rapidly as the proportion of patronage refunds paid in cash is increased. Of course, the revolving period increases least rapidly for RECs, which do not pay cash patronage refunds.

Conclusions

TIER analysis, which is based on a common measure of interest coverage, has been a useful equity management and planning tool for RECs. This paper has presented a mathematical model of the TIER approach and demonstrated its use. The approach also was modified by expressing the rate of return on equity as a function of the cooperative's equity position, thus eliminating a major weakness. In addition, the paper has demonstrated how elements of the TIER model can be used by RECs to set retail electric rates according to a target revolving period. In the two examples presented here,

	Revolving period (yrs)					
Growth rate	5	10	15	20	25	∞
0.00	0.3636	0.1818	0.1212	0.0909	0.0727	0.0000
0.01	0.3746	0.1920	0.1311	0.1008	0.0826	0.0182
0.02	0.3857	0.2024	0.1415	0.1112	0.0931	0.0364
0.03	0.3970	0.2131	0.1523	0.1222	0.1044	0.0545
0.04	0.4084	0.2242	0.1635	0.1338	0.1164	0.0727
0.05	0.4200	0.2355	0.1752	0.1459	0.1290	0.0909
0.06	0.4316	0.2470	0.1872	0.1585	0.1422	0.1091
0.07	0.4434	0.2589	0.1996	0.1716	0.1560	0.1273
0.08	0.4554	0.2710	0.2124	0.1852	0.1703	0.1455
0.09	0.4674	0.2833	0.2256	0.1992	0.1851	0.1636
0.10	0.4796	0.2959	0.2390	0.2136	0.2003	0.1818
0.11	0.4919	0.3087	0.2528	0.2283	0.2159	0.2000
0.12	0.5044	0.3218	0.2670	0.2434	0.2318	0.2182
0.13	0.5169	0.3351	0.2813	0.2588	0.2480	0.2364
0.14	0.5296	0.3486	0.2960	0.2745	0.2645	0.2545
0.15	0.5424	0.3623	0.3109	0.2905	0.2813	0.2727
0.16	0.5553	0.3762	0.3261	0.3067	0.2982	0.2909
0.17	0.5683	0.3903	0.3415	0.3231	0.3153	0.3091
0.18	0.5814	0.4046	0.3571	0.3397	0.3326	0.3273
0.19	0.5946	0.4190	0.3729	0.3564	0.3500	0.3455
0.20	0.6080	0.4337	0.3889	0.3734	0.3675	0.3636

Table III. Required rate of return on equity for various rates of equity growth and revolving periods for an agricultural cooperative paying 45 percent cash patronage refunds

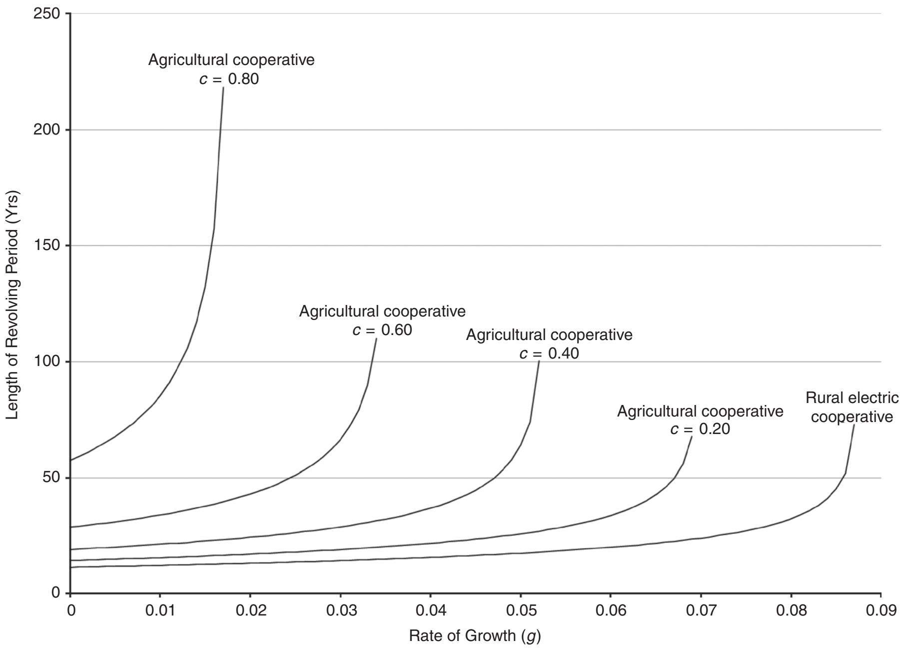

Figure 5.
Length of revolving period for various rates of equity growth given proportion of patronage refunds paid in cash

substantial improvements in equity revolvement could be made with only modest rate increases. Finally, the modified Goodwin formula was generalized for use by agricultural cooperatives by incorporating the payment of cash patronage refunds.

Notes

1. In Phillips (2001), total capital consists of equity and long-term debt, and annual interest expense consists of the interest on long-term debt. Alternatively, we can consider total capital to include both long- and short-term debt and interest expense to include interest on all debt regardless of term.
2. Note that these curves are not linear, as indicated in Phillips (2001, p. 32).
3. In 1976, a report by the National Rural Electric Cooperative Association (NRECA) and CFC suggested that RECs should maintain TIER values no lower than 3.0 (Capital Credits Study Committee, 1976). According to that report, RECs had historically maintained TIER values between 3.0 and 3.5 but those ratios had begun to decline substantially by the mid-1970s.
4. A 2003 survey of RECs (Capital Credits Task Force, 2005) showed that 43 percent used first-in/first-out revolving fund plans exclusively and an additional 36 percent used revolving fund plans in combination with another plan. According to a survey of agricultural cooperatives (Eversull, 2010), 61 percent of local cooperatives that redeemed equity in 2008 used revolving fund plans, either exclusively or in combination with other plans. Among regional cooperatives, 68 percent of those that redeemed equity used revolving plans.
5. The original Goodwin formula (Edwards, 2011) can be written as $r_e = (1+g)^T - (1+g)^{T-1}/(1+g)^{T-1} - 1$. This formula understates the required rate of return, as a comparison of Table I to the corresponding table in Capital Credits Study Committee (1976, p. 61) demonstrates. Adding one year to each of the exponents corrects the problem.

6. As a cooperative borrows additional debt, it may face higher interest rates. Although the average interest rate will rise more slowly than the marginal rate, it follows that the average interest rate may be a decreasing function of the equity position. Rather than arbitrarily choosing a function to represent the average interest rate in Figures 1-3, it is shown as constant.
7. More recently, the NRECA and CFC Capital Credits Task Force (2005, p. 7) recommended that, "Every electric cooperative should develop and implement an equity management plan," and, "The equity management plan should include [electric] rates that will generate adequate cash to provide capital credits retirements."
8. According to Cooper (2008), cooperative electric rates are regulated in only thirteen states, and in six of those states, the regulations are less restrictive than those for investor-owned utilities.
9. This simple accounting identity is the basis for the "Boatman theorem" used by RECs (see National Rural Utilities Cooperative Finance Corporation, 2012, p. 41). Setting $c=0$ and dividing through by E_{t-1} results in $ER_t/E_{t-1}=r_e-g$, i.e., the percentage equity redeemed is equal to the difference between the rate of return and the growth rate.
10. If the rate of growth in the equity stock is zero, then the required rate of return is simply $r_e = 1/(1-c)T$.

References

Capital Credits Study Committee (1976), *Final Report and Recommendations*, National Rural Electric Cooperative Association and National Rural Utilities Cooperative Finance Corporation.

Capital Credits Task Force (2005), *Capital Credits Task Force Report: A Distribution Cooperative's Guide to Making Capital Credits Decisions*, National Rural Electric Cooperative Association and National Rural Utilities Cooperative Finance Corporation, Arlington, VA and Herndon, VA.

Cooper, J. (2008), "Electric co-operatives: from New Deal to bad deal?", *Harvard Journal on Legislation*, Vol. 45 No. 2, pp. 335-375.

Edwards, B. (2011), "Electric cooperative ratemaking: theory, insights, and practical observations", presentation at CFC Independent Auditors Conference, Herndon, VA, May 10.

Eversull, E.E. (2010), *Cooperative Equity Redemption*, Rural Business-Cooperative Programs Research Report No. 220, US Department of Agriculture, Washington, DC.

National Rural Utilities Cooperative Finance Corporation (2012), *Considering Equity Management: A Distribution Cooperative's Guide to Equity Management Planning*, Dulles, VA.

National Rural Utilities Cooperative Finance Corporation (2014), "CFC releases final results from 2013 key ratio trend analysis", press release, June 26, available at: www.nrucfc.coop/content/cfc/news_analysis/news/20140626-final-results-2013-key-ratio-trend-analysis.html (accessed August 20, 2014).

Penn, J.E., DeVille, K.C. and Eversull, E.E. (2010), *Cooperative Statistics, 2009*, Rural Development Service Report No. 70, US Department of Agriculture, Washington, DC.

Phillips, C. (2001), "Revisiting equity management – the art of wise compromise", *Management Quarterly*, Vol. 42 No. 2, pp. 24-34.

Royer, J.S. (1993), "Patronage refunds, equity retirement, and growth in farmer cooperatives", *Agricultural Finance Review*, Vol. 53, pp. 42-54.

Corresponding author
Dr Jeffrey Royer can be contacted at: jroyer@unl.edu