What's Wrong With This CLV Formula?

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Most MBA-level introductory marketing courses now cover the concept of customer lifetime value (CLV). It is common to see students being given the following formula as the way to compute CLV:

$$CLV = \sum_{t=0}^{T} m \frac{r^t}{(1+d)^t} \, , \tag{1}$$

where m is the net cash flow per period (while the customer is still "alive"), r is the retention rate, d is the discount rate, and T is the time horizon for the calculation.[1,2]

There are a number of issues with this formula, which leads us to conclude that it is of limited value to anyone actually interested in computing CLV in practice.

Issue #1

The first issue is pedantic but needs to be made explicit. We never know the *true* value of a customer until they have "died." Any basic CLV calculation is an estimate of the *expected* value of a customer. In order to make this explicit, we should borrow notation from statistics and write $E(CLV)$ on the left-hand side of equation (1) instead of CLV.

Issue #2

The upper bound of summation is T. Unless we are planning to terminate our relationship with the customer at that future point in time, this will not give us a true estimate of the customer's (expected) lifetime value; it is ignoring the residual value of the customer beyond that point in time.

Now, there is nothing wrong with cutting off the calculation at T; just don't call it *lifetime* value. Call it what it is — the expected present value of the customer over a horizon of $T + 1$ periods. Alternatively, follow the example of Glady et al. (2015) and call it *truncated CLV*.

So what should the upper bound of summation be? One common solution is to set it to infinity,[3] in which case (acknowledging issue #1) equation (1) becomes

$$E(CLV) = m \sum_{t=0}^{\infty} \left(\frac{r}{1+d} \right)^t$$
$$= \frac{m(1+d)}{1+d-r} \, . \tag{2}$$

An alternative solution is to set T to a large number, well beyond the feasible lifetime of a customer (e.g., 100 years). In our experience, this will usually give a result that is within a few cents of that associated with an infinite lifetime.

Issue #3

The lower bound of summation is 0. One variant of equation (1) presented in some MBA marketing courses is

$$CLV = \sum_{t=1}^{T} m \frac{r^t}{(1+d)^t} \, . \tag{3}$$

The change from 0 to 1 for the lower bound of summation means that the first transaction which signals the start of the customer's relationship with the firm is being ignored in the calculation.[4] In other words, equation (1) (with an appropriate upper bound of summation) gives us the the expected lifetime value of an *as-yet-to-be-acquired* customer, while equation (3) gives us the expected lifetime value of a *just-acquired* customer. Nearly all introductory discussions of CLV fail to make this distinction clear.

Issue #4

The equations considered so far assume a constant retention rate r. At first glance, this may not seem to be a problem as we often observe relatively constant retention rates in company-reported summaries. However, when we track a cohort of customers (i.e., a group of customers acquired at the same time) over time, we do not observe a constant retention rate; rather, we find that the retention rates tend to increase as a function of customer tenure. The relatively constant retention rates observed in the company-reported summaries are in fact the result of aggregation across different cohorts of customers. New customers (with relatively low retention rates) are being

averaged-in with existing customers (with higher retention rates), thereby masking the pattern (of increasing retention rates over time) that we would typically see for any given cohort by itself.

The quantity r^t, which lies at the heart of equations (1) and (3), is the probability that the customer "survives" beyond period t. Given that observed cohort-level retention rates are not constant, we need to replace r^t with $\prod_{i=0}^{t} r_i$ where r_i is the period i retention rate (and $r_0 = 1$).[5]

A natural consequence of this is that as we go from computing the expected lifetime value of an as-yet-to-be-acquired (or just-acquired) customer to computing the expected *residual* lifetime value of an existing customer, we need to take the "age" of the customer (i.e., the length of the relationship to date) into consideration. For a customer who has made one renewal to date, we discard r_1 from our calculation of the probability that the customer "survives" beyond period t as they have passed the first renewal hurdle. For a customer who has made two renewals to date, we discard both r_1 and r_2 as they have passed the first and second renewal hurdles. And so on. Clearly the expected residual lifetime value of a customer who has made several renewals will be greater than the expected lifetime value of an as-yet-to-be-acquired customer. Blindly accepting equation (1) means such matters are overlooked.

Issue #5

Not only do all the equations considered so far assume a constant retention rate r, they also assume the existence of a retention rate number in the first place. The retention rate is defined as "the ratio of customers retained to the number at risk" (Farris et al. 2010, p. 156). In order to compute this quantity, we need to know how many customers we actually have at any point in time and how many we have "lost" over the period of interest.

If we are a publisher selling magazine subscriptions or an insurance provider we have a formal contract with our customers. The loss of a customer is observed as they either have to contact the firm to terminate the relationship or they do not renew their contract or subscription when it comes up for renewal. It is therefore possible to compute retention rates. Firms operating in such a setting are deemed to have a *contractual* relationship with their customers.

However for many businesses, (e.g., retailers and hotel chains, amongst countless others), the time at which a customer is "lost" is not observed by the firm. All that is observed is a lack of purchasing, and the firm cannot tell whether this is due to the customer deciding to end their "relationship" with the firm or simply due to the fact that they in the midst of a long hiatus between transactions. Firms operating in such a setting are deemed to have a *noncontractual* relationship with their customers.

As we do not know how many customers we have lost in a given period,

we cannot compute a retention rate. This means the above CLV formulas are of no use in noncontractual settings. We can compute a repeat (buying) rate, which is defined as "the percentage of brand customers in a given period who are also brand customers in the subsequent period" (Farris et al. 2010, p. 48). But this is not the same as a retention rate; it simply reflects the presence/absence of purchasing activities as opposed to the observed "survival"/"death" that is associated with the notion of a retention rate.

As previously noted, the r^t term in equation (1) is simply the probability that the customer is "alive" in period $t+1$. If we used a repeat rate as the (constant) retention rate r, we are actually computing the probability that the customer makes purchases in $t+1$ consecutive periods, which will be less than the probability of being "alive" in period $t+1$ in any noncontractual setting. As such, it is completely wrong to attempt to compute CLV in noncontractual settings by using a repeat rate in equation (1) (or any of its variants).

Beyond the Formula: CLV in the Real-world

> *The bottom line is that there is no "one formula" that can be used to compute customer lifetime value.*

First and foremost, we need to distinguish between contractual and non-contractual settings.[6] (In contractual settings we need to acknowledge the phenomenon of increasing cohort-level retention rates.) Furthermore, we need to distinguish between the expected lifetime value of an as-yet-to-be-acquired customer (or a just-acquired customer) and the expected residual lifetime value of an existing customer. It is therefore misleading to present equation (1) (or a variant of it) to students or analysts and give them the impression that they now know how to compute CLV.

How then should we introduce the calculation of customer lifetime value? The natural starting point is the definition of CLV, which is "the present value of the future cashflows attributed to the customer relationship" (Pfeifer et al. 2005, p. 17). This can be expressed mathematically as

$$E(CLV) = \sum_t \text{expected net cash flow in period } t \,|\, \text{alive}$$
$$\times P(\text{alive in period } t) \times \text{discount factor for period } t . \quad (4)$$

(The upper bound of summation is infinity, while the lower bound is purposively left vague to allow for the differences between an as-yet-to-be-acquired customer and an existing customer.) Of course, this formula is of no use in and of itself. What the analyst needs to do is operationalize the various elements of equation (4) for the specific setting at hand and then evaluate the sum.[7,8] See Fader and Hardie (2015a) for an introductory discussion of this for both contractual and noncontractual settings. A more detailed review can be found in Fader and Hardie (2015b).

Notes

[1]See Fader and Hardie (2012) for a discussion of other "here's how to compute CLV" formulas that are commonly used in the MBA classroom.

[2]Note that m is the *net* cashflow; any "account maintenance" costs have been taken into consideration. Some authors add a $-AC$ term to equation (1), thereby subtracting the customer acquisition cost. If we are computing CLV in order to estimate an upper bound for spending on customer acquisition, the $-AC$ term should clearly be excluded.

[3]An alternative — but incorrect — "solution" proposed by some authors is let it be informed by the average lifetime of a customer. For example, suppose we have a constant 80% annual retention rate ($r = 0.8$). In this case, the average customer lifetime is $1/(1 - 0.8) = 5$ years. (For the sake of this example, let us assume a 10% discount rate ($d = 0.1$).

One way the resulting "CLV" calculation can be made is

$$\sum_{i=0}^{4} m \left(\frac{0.8}{1.1} \right)^i = 2.92 \, m \, ,$$

which is less than the expected customer lifetime value of $3.67 \, m$ computed using equation (2). This underestimate occurs because it ignores the future cashflows from the $100 \times (0.8)^5 = 32.8\%$ of the customers with a longer-than-average lifetime.

Another way calculating "CLV" given knowledge of the average customer lifetime is to assume all customers will survive for that period of time. For $r = 0.8$ and $d = 0.1$ we have

$$\sum_{i=0}^{4} m \left(\frac{1}{1.1} \right)^i = 4.17 \, m \, ,$$

which is greater than the expected customer lifetime value computed using equation (2). This is clearly flawed as it ignores the fact that 20% of the customers will not survive beyond the first year, another 16% beyond the second year, and so on.

[4]Another variant of equation (1) presented in some MBA marketing courses is

$$CLV = \sum_{t=1}^{T} m \frac{r^{t-1}}{(1+d)^t} \, . \tag{i}$$

In this case, the analyst is assuming that the net cashflow associated with each time period is "booked" at the end of the period. In contrast, an analyst

using equations (1) or (3) is assuming that the net cashflow associated with each time period is "booked" at the beginning of the period.

The different assumptions implicit in these three formulas regarding the recognition and timing of the net cashflows is illustrated below:
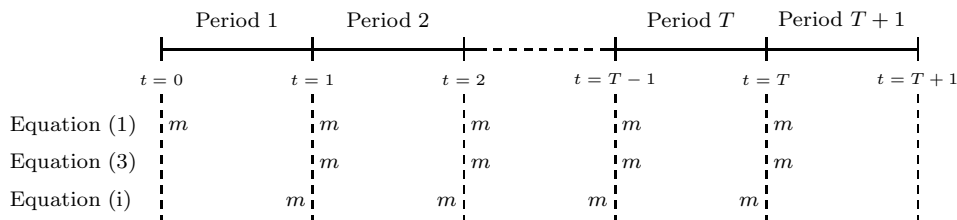
It is obvious that they will yield different estimates of CLV. Which one is correct? It all depends on the exact nature of the business setting being examined and why CLV is being computed in the first place.

[5]As a result, we do not get simple closed-form expressions for $E(CLV)$ along the lines of that given in equation (2). Furthermore, there is the added complication that we need to project retention rates into the future. A simple statistical model for making such projections is presented in Fader and Hardie (2014).

[6]A secondary distinction concerns the treatment of time. Implicit in our use of summation is the idea that opportunities for transactions occur at discrete points in time (e.g., a magazine subscription lapses at a specific point in time and the subscriber either renews or does not renew). In other settings, transactions can occur at any point in time. For example, a residential utilities contract can be cancelled anytime; we do not take out annual contracts for electricity. Online purchases can be made 24/7. Therefore we can talk of a second distinction: are the opportunities for transactions restricted to discrete points in time or can they occur at any point in time? While it has implications for the specific analytical tools we use to compute CLV, this distinction is not as fundamental as the contractual/noncontractual divide.

[7]One thing that most discussions of CLV — including our own — gloss over is what discount rate should be used to reflect the time value of money. (Typically some arbitrary number is used to illustrate the required calculations.) This is something that should be discussed with the finance department of the firm in which the resulting numbers will be used.

[8]When we compute expected residual lifetime value, it is important that our operationalization of "expected net cash flow in period t | alive" (which is simply m in the preceding discussion) accounts for any between-customer differences in underlying spending patterns.

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