Intellectual Property Economic Analysis Insights

Estimating Intellectual Property Remaining Useful Life

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Introduction

The expected remaining useful life (RUL) should be considered in any intellectual property economic analysis. RUL considerations influence intellectual property analyses performed for valuation, transfer price, license royalty rate, or other purposes. And, RUL analysis is an integral component of any intellectual property cost, income, or market approach analysis.

When a cost approach method is used, RUL should be considered in the estimation of obsolescence. When an income approach method is performed, RUL should be considered in determining the term of the income projection period. When a market approach method is used, RUL is a factor (1) in assessing the comparability of the market transactions to the subject property and (2) in estimating any adjustments to make the guideline sale/license transactions more comparative to the subject property.

There are a variety of factors that affect RUL. Even though some intellectual properties effectively have an unlimited legal life, they often have a shorter economic life. This limited life is a fundamental factor that distinguishes intellectual property analyses from business enterprise analyses.

A business enterprise is dynamic, generally evolving over time. Though one product line may disappear, another is likely to take its place. While one of a company's patents may expire, new patents may be added. For this reason, an analyst will typically analyze a successful going-concern business enterprise by projecting an unlimited life. For example, an analyst estimating business enterprise value using a discounted cash flow method typically (1) projects cash flow for a discrete number of periods and (2) then adds a terminal value representing the cash flow generated into perpetuity.

An analyst valuing a nine-year-old patent may project profits or cost savings (1) over the patent's remaining legal term or (2) over a shorter period, depending on various factors that affect the patent economic life. These factors include:

1. the existence of competitive patented or unpatented technology,
2. market demand for products dependent on the patented technology,
3. economic factors that could affect the profitability of patent-dependent products, and
4. the likelihood of the development of newer technology that could make the subject patent obsolete.

Performing the RUL Analysis

RUL estimation is unfamiliar to analysts who only perform business valuations. Inexperienced analysts often perform intellectual property valuations using either (1) a perpetual life or (2) a legal, tax, or accounting life—without any attempt to estimate the property's expected RUL.

A variety of life measures—or life determinants—should be considered in estimating both the intellectual property life and the RUL. Statutory, contractual, judicial, economic, technological, and analytical factors all affect intellectual property RUL.

Analytical life estimation typically involves: (1) the observation of the longevity and/or decay patterns of a group of assets over time, (2) the quantification of the life-related phenomena, and (3) the application of any pattern or statistical results to the subject asset group in order to estimate RUL. The actuarial tables used by life insurance companies are the result of this type of analysis performed on human life.

In fact, actuarial statistics provide an example of why a thorough understanding of life estimation analysis will enable an analyst to reach a reliable RUL conclusion. Consider an actuarial study that concludes an average life expectancy of 72 years for human males and 79 years for human females. This means that the life expectancy of a newborn baby boy is 72 years and that of a newborn baby girl is 79 years. The naive application of this information may result in the estimation of the expected remaining life of a 60-year-old man to be 12 years (i.e., 72 years - 60 years).

However, actuarial tables indicate an estimated remaining life of a 60-year old man about 18 years. A practical explanation of this phenomenon is that the 72-year life expectancy estimate was computed using data that include: (1) infant mortality rates and (2) teenage drug, alcohol, traffic, and crime/gang-related deaths. Having already survived infancy and his teen years, the 60-year-old man is expected to surpass an average life expectancy that includes these factors.

Similarly, a simplistic estimate of the remaining life of an 80-year-old woman may be zero. However, actuarial tables indicate an estimated remaining life of 9 years. Being strong, healthy, careful, and/or lucky enough to survive until the age of 80 years, it is likely that the subject woman has a decade or so left of her life. Clearly, all 80-year-old women won't live until they are 89. In fact, some 80-year old women may not live to be 81. But other 80-year old women may live to be 105.

An intellectual property analysis using an estimated RUL will be more accurate if this gradual "mortality" or "decay" is considered. An analysis that assumes each intellectual property will survive exactly the same length of time will be less accurate.

Another lesson from the human actuarial analysis is that sub-groups of a population sometimes demonstrate different survival behaviors. In the preceding example, the total group (of humans) was divided into two sub-groups according to gender. Further group stratification (e.g., smoker/nonsmoker) provide even more precise life estimates. With respect to intellectual property, one may find that trademarks that include stylized drawings, such as logos or pictures, tend to have shorter (or longer) lives than trademarks related only to phrases or brand names.

Naturally, the reliability of an RUL estimation depends on the quantity and quality of available data. There are instances when subjective, qualitative judgments should be factored into the RUL analysis. And, there are instances when professional judgment may be used in the absence of quantitative data.

Intellectual Property Life Measurements

A number of different life measures are typically considered in an intellectual property analysis. All relevant life measures should be examined before reaching an RUL conclusion. Generally, the shortest RUL indication is the appropriate life measure.

Statutory Life

Statutory life is the term of the property's legal registration as defined by law. For example, patent statutory life generally begins on the date the patent is granted and ends 20 years after the date the patent application was filed. Prior to June 8, 1995, the term of a patent was generally 17 years from the date the patent was granted. Design patents have a shorter registration term (i.e., 14 years) than utility and plant patents.

As of the October 27, 1998, amendment to the Copyright Act of 1976, the statutory life of a copyright created on or after January 1, 1978, generally lasts 70 years beyond the death of the author (or last surviving author). For certain works (such as anonymous/pseudonymous works and works made for hire), the term of the copyright will be the lesser of (1) 95 years from first publication or (2) 120 years from creation. Copyright terms run through December 31st of the year in which they would expire. For older works, other copyright terms—and rules related to copyright renewal—may apply.

Trademarks may be renewed indefinitely, if all required paperwork is filed on a timely basis. A declaration of use must be filed between the fifth or sixth year following the trademark registration in order for the trademark registration to remain valid. In addition, a declaration of use must also be filed with a renewal application within the year prior to every 10-year period following registration in order for the trademark registration to remain valid. Prior to November 16, 1989, the trademark registration renewal period was 20 years.

Trade secrets do not require either federal or state registration. Therefore, trade secrets do not have statutory limits with respect to their legal registration term.

Contract Life

The term of a commercial contract may affect the analysis. Examples of commercial contracts include: (1) use, development, and exploitation contracts; (2) inbound and outbound licenses; and (3) transfer price agreements. Any stated contract renewal terms and the party's history of contract renewals should also be considered as part of the contract life determinant.

Judicial Life

The term judicial life refers to the life—or the term of economic damages—as awarded or ordered by a judge or similar authority. For example, a judge may order that (1) certain copyright infringement damages commenced on a specific date and ended on a specific date (as a measure of historical damages) or (2) a reasonable royalty rate must be paid to the copyright owner for a specified time period after the order (as a measure of future damages).

Economic Life

Economic life is determined by the ability of an intellectual property to generate an adequate amount of economic income to justify its continued use. Economic life is influenced by many factors, including factors outside of the control of the owner/operator.

For example, let's assume that the patent related to a proprietary product has a remaining legal life of 15 years. However, if the materials needed to manufacture the product become scarce and more costly, the demand for the more expensive product (and the profit margin on the manufactured product) may be adversely affected. This change in the product manufacturing cost could reduce the product economic life—and the associated patent economic life.

Economic life can be affected by a coincidental change in consumer perception. For example, consider the effect on the RUL of the trademarks associated with AYDS appetite suppressant candy when the medical community began referring to acquired immune deficiency syndrome as AIDS.

Technological Life

Technological life is influenced by changes in technology. Newer technology may allow for a product or service that is better, faster, or cheaper than was possible with the older technology. When a new technology is developed that is preferable to the subject intellectual property technology, technology/market substitution will likely take place. For example, the owner of a patent on a portable cassette player with a single earphone would probably experience reduced demand for that product after the introduction of the Sony Walkman with stereo headphones. Decreased demand for a patented product could make the patent technologically obsolete years before the legal term of the patent expires.

Analytical Life

Analytical life is based on the quantitative analysis of the historical survival/mortality characteristics of similar intellectual properties. RUL analyses typically examine the historical placement and retirement of intellectual property "units" (e.g., the effective usage start dates and stop dates of similar trademarks, engineering drawings, etc.). The observed survival/mortality patterns are used to estimate average life, RUL, and expected future retirements of a group of related intellectual properties. RUL analyses may also examine the historical decay of dollar volume or unit volume associated with similar intellectual properties (e.g., the pattern of royalty income associated with copyrighted songs).

One common quantitative life estimation analysis method is the sum-of-least-squares (SLS) curve fitting. In the SLS process, the observed percent surviving (of either dollars or units) over time is compared to several series of survivor curves developed at Iowa State University (i.e., Iowa-type curves). A similar life estimation method uses regression analysis to estimate the geometric parameters that define the Weibull-type curve that best fits the observed survivor curve. These analytical life estimation methods will be described later.

Where sufficient data are not available to perform an Iowa-type or Weibull-type curve analysis, a simple turnover rate analysis may be performed. In this simplified analytical life method, the analyst projects future property turnover/retirements (as a percentage per time period) based on historical turnover/retirement statistics.

Technology-related intellectual properties often exhibit a similar life cycle. This technology life cycle generally consists of three phases: (1) the introduction or new invention phase, (2) the rapid adoption or growth phase, and (3) the saturation or maturity phase. Eventually, newer technology may force the mature technology into a decline phase, as the market begins to adopt the newer technology. An examination of the life cycles of prior technology-related intellectual properties—or of the products/services associated with those intellectual properties—may provide information that can be used to estimate RUL, technological obsolescence, and future utility of the subject intellectual property. Future utility may be measured using revenues, unit volume, or market share for associated products/services.

Various technology-related S-curves (so named because the shape of the curve resembles the letter S) have been developed to define the technology life cycle. Statistical methods are available to project the technology life cycle based on an analysis of historical data.

Other Life Measurements

Physical life generally refers to the estimated time expected for an asset to physically wear out or to be used up. This RUL measurement is not particularly applicable to intellectual property analysis. Although intellectual properties may have some physical evidence of existence (e.g., a copyright registration document), the destruction of this physical evidence typically does not diminish the intellectual property life.

Functional life refers to the length of time that an asset is expected to be able to perform the function for which it was intended. With respect to intellectual property, the functional life is typically less restrictive than the other life measurements.

For example, the formula for a popular soft drink may be a valuable trade secret up until a link is found between one of the beverage ingredients and the occurrence of cancer. Although the soft drink formula may still function, sales of the beverage product will decrease drastically. Accordingly, the economic life of the trade secret will be adversely affected. And, economic life becomes the limiting life determinant of the beverage formula trade secret.

Similarly, a patent related to a particular product may be functional (i.e., able to perform the function of keeping competitors from using the patented technology) throughout its statutory life. However, if newer technology makes the patented product functionally obsolete, the longer legal term of the patent registration becomes moot.

Data Used in Life Estimation

Depending on the type of intellectual property, a variety of data may be used in the RUL analysis.

Registration Documents

Intellectual property registration documents include (1) patent application and issuance documents; (2) trademark application, registration, and renewal documents; and (3) copyright application and certificate of registration documents. In addition to the registration documents, the analyst may review registration documents (or summary information from such documents) related to similar active and/or cancelled/abandoned intellectual properties. In addition to evidencing intellectual property existence, registration documents provide dates that evidence intellectual property age.

Contracts

Any commercial contracts related to the subject intellectual property may be useful in an RUL estimation. Examples of such contracts include (1) use, development, or exploitation contracts; (2) inbound and outbound license agreements; and (3) transfer price agreements. Information regarding historical contract renewals would also be relevant to the RUL analysis.

Judicial Decisions/Orders

In litigation, judicial decisions or orders regarding the term of historical damages (i.e., from the first damage until the trial) are relevant. The judge may also rule on the term of any future damages (i.e., damages from the trial date going forward). These orders are particularly relevant in cases where the litigation has been bifurcated into (1) a liability phase and (2) a damages phase.

In the liability phase of the litigation, the judge (or other finder of fact) may rule on relevant time periods that could affect the analyses prepared for the damages phase of the litigation. For example, a judge may order that the infringing party may have to pay (1) for any historical damages suffered by the owner as well as (2) a fair royalty rate for the future use of the intellectual property.

Financial Statements

Financial statements are used in a variety of ways in an intellectual property analysis. An income approach analysis may rely on historical financial statements of the owner/operator. More detailed statements of revenues and expenses—including product line sales, royalty amounts, advertising expenses, research and development costs, and so forth—may also be used. The historical revenues related to an intellectual property, or to a group of intellectual properties, may provide data relevant to estimating the RUL.

In addition to historical financial statements, projected financial statements of the owner/operator (including budgets, strategic plans, or financial forecasts) may be relevant to the analysis.

Usage Data

Intellectual property usage data are often used in the RUL estimation. These data include: advertising placements, unit production volume, unit sales volume, number of displays, use on product packaging, number in a library, number in an archives, unit rentals, number in a distribution system, units printed, and any contracts or correspondence referring to usage. As with financial statement data, projected intellectual property usage data may be as relevant as historical usage data.

Operational Documents

With respect to operational documents, the analyst will typically gather inventories or lists of identification numbers, dates, and descriptions of items such as: engineering drawings, mylars, schematics, blueprints, product/process flowcharts, manuals, lines of computer software source code, memos, procedures, policies, packaging materials, or contracts. Relevant document dates may include creation date, revision dates, and cancellation/retirement date.

Technology Data

Relevant data include information about prior related technologies and competitive technologies. Technology information may be found in patents, patent applications, marketing materials, technical journals, or conference proceedings. Start dates and stop dates of prior generations of technology may be useful in estimating RUL. In addition, quantitative life cycle or technology replacement data may be relevant.

Age/Life Data Summary

Some of the age/life data used in RUL estimation are used qualitatively, as background information to assist in making life estimates based on professional judgment. However, when quantitative age/life data such as placement and retirement data—or start dates and stop dates—are available, these data can be used in a quantitative actuarial-type analysis. Also, data related to decreasing or increasing historical/projected revenues (or unit sales volumes) may be used to perform additional quantitative analyses.

Definitions and Analytical Methods

In order to understand the methods used in—and the conclusions drawn from—a quantitative RUL estimation, it is important to define some of the terms used in such an analysis.

Age

While it may seem obvious that age is how old something is or how long it has been in existence, as of a certain date, the analysis should be specific. For example, is the age of a patent to be measured from the date of the patent application or the date the patent was granted? The answer may vary depending on the data available, the "as of" date of the analysis, the purpose of the analysis, and how any RUL conclusions will be used in the analyses. However, it is important (1) to select the best definition of age, given the facts and circumstances of the case; (2) to document how age is defined; and (3) to consistently use the same definition of age throughout the analyses.

Analysts often refer to "vintage age groups" when describing RUL estimation analyses. Most often, a vintage age group consists of members of the population that came into existence during the same one-year time frame. For example, trademarks that were registered between three and four years prior to the analysis date may be referred to as the three-to-four-year vintage age group (or as the 3.5-year age group).

Average Life

The average life conclusion of an RUL estimation analysis represents the expected average life for a new unit or member of the group. Referring to our actuarial analysis of human life expectancy example earlier in this chapter, the average life conclusion of 72 years for human males represents the expected average life of a newborn baby boy.

Total Life

Total life for a group generally refers to the age at which the last member of the group is expected to retire/expire. Total life for a group of people, to return to our actuarial example, is clearly finite. We may estimate the total life for a group of people to be 105 years or 115 years. And, we can be fairly certain that the total life of a group of people will not be as long as 150 years. The total life for a group of trademarks may be more difficult to estimate. This is because there is no natural upper limit to the total life of intellectual property.

Probable Life

The probable life for a particular age group of surviving members is the average expected life of those surviving members. For example, the probable life of a group of 80-year-old women may be 89 years. This 89 year estimate represents an average of the expected lives of the members of the group. A certain percentage of the women are expected to survive to age 81, a certain percentage are expected to survive to age 82, and so on.

Average RUL

The average RUL for a particular age group of surviving members is equal to the probable life for that group less their age. The RUL represents the expected time the group, or a member of the group, is expected to survive after the analysis date. For example, if the analytical method indicates that the probable life of a group of 7-year-old engineering drawings was 12 years, then the RUL for 7-year-old drawings would be 5 years. This may be true even if the average life of the engineering drawings is 10 years.

Survivor Curve

A survivor curve represents the relationship between age and percent surviving for a population. A survivor curve for a group of intellectual properties can be determined if sufficient placement and retirement data (i.e., start dates and stop dates) are available. The curve starts with 100 percent surviving at age zero, with the percent surviving (of the total population) decreasing over time.

Probable Life Curve

A probable life curve represents the relationship between age (or percent surviving) and probable life. The probable life of an intellectual property when its age is zero (and the percent surviving is 100 percent) is equal to its average life.

Survivor Curve and Probable Live Curve Example

Exhibit 1 presents the survivor curve and probable life curve for the O_4 series of Iowa-type curves. The curve to the left is the survivor curve. At age zero, the percent surviving is 100 percent. As age (as a percent of average life) increases, the percent surviving decreases. If an analysis is performed that concludes a 10-year average life, then the long vertical dotted line would represent 10 years (i.e., 100 percent of the 10-year average life). The curve to the right is the probable life curve. The probable life at age zero (or at 100 percent surviving) is equal to the average age.

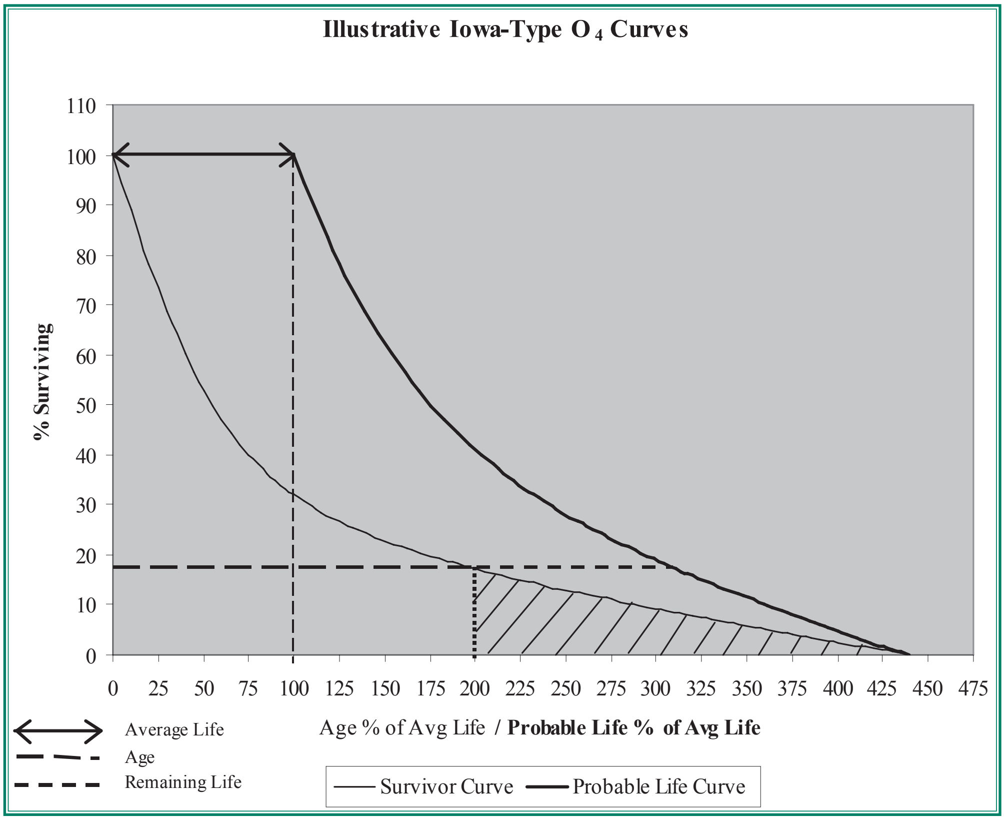
In this example, at age 20 (or at 200 percent of the average life of 10 years), the percent surviving is approximately 17 percent and the corresponding probable life is approximately 311 percent of average life (or 31.1 years). Therefore, the expected RUL at 20 years is 10.1 years (i.e., the probable life of 31.1 years minus the age of 20 years). This RUL can also be measured by (1) calculating the total shaded area under the survivor curve and (2) dividing the total shaded area by the percent surviving. The indicated total life of the group is approximately 44 years (i.e., 440 percent times 10 years).

Turnover or Retirement Rate

In many cases, data related to the retirement of intellectual properties are limited. For example, the analyst may know (1) how many computer programs the owner/operator had at the beginning of the last three years and (2) how many programs were purged from the program libraries in each of these three years. However, the analyst may not know the age of any of these deleted/retired programs. The ratio of the number of retired programs to the number of programs at the beginning of the year is the turnover or retirement rate.

For example, if the owner/operator had 300 programs at the beginning of the year and 60 of the programs were deleted during the year, that would indicate a turnover rate of 20 percent. In order to estimate the future turnover rate (and the average life of the property), turnover rates are often calcu-

Exhibit 1
Survivor Curve and Probable Life Curve



lated for several years and averaged. To estimate future turnover and average life, annual turnover rates may be assigned different weights, depending on (1) interviews with the owner/operator or (2) the experience/judgment of the analyst.

Exhibit 2 presents the calculation of an average retirement rate for three years. The approximate RUL is equal to the reciprocal of the average retirement rate.

Expected Decay or Depreciation

The decay or depreciation for an intellectual property is the expected loss in number or utility over time. This could mean the expected decrease in royalty revenues for a copyrighted publication over time. It could also mean the expected cancellations of trademarks over time. It could mean the decreasing sales volume of patented products, over time. Ideally, the estimation of future decay for a group of intellectual properties considers the age of each individual property.

The expected decay of the intellectual properties presented in Exhibit 2 is illustrated in Exhibit 3. In this example, the number of active property units at the beginning of year 2001 is 284. The number of property units at the beginning of a year is equal to: (1) the number of units at the beginning of the previous year (2) less the unit retirements during the year (3) plus the number of new units added during the year.

Additionally, in this exhibit, the average RUL is calculated using both mid-year and end-of-year unit retirement assumptions. Note that the end-of-year retirement calculation is equal to the approximate RUL calculated in Exhibit 2.

When data are available to perform a more comprehensive analysis (i.e., when (1) start dates are known for all active properties and (2) start dates and stop dates are known for several years for retired properties), an actual survivor curve can be calculated. This actual survivor curve may be matched to the standard survivor curves (e.g., Iowa-type curves, Weibull-type curves, etc.) to find the best-fitting curve type and average age. The decay of the group can then be estimated as a composite of the decay of each age group over time, given (1) the survivor curve type and (2) the average life.

Iowa-Type Survivor Curves

The curves generally referred to as the "Iowa-type curves" are the 22 survivor curves described in *Statistical Analyses of Industrial Property Retirements*. This book provides the mathematical equations—as well as the percent surviving and probable life tables—for each of these curves. In addition, various methods to analyze retirement data are described.

The Iowa-type curves include seven symmetrical curves (S0 – S6), five right-modal curves (R1 – R5), six left-modal curves

Exhibit 2
Turnover/Retirement Rate Analysis
and RUL Based on a Retirement Rate Analysis

	Year 1	Year 2	Year 3
Intellectual property active at beginning of the year	213	250	300
Intellectual property retired during the year	41	53	59
Intellectual property retirement rate	19.25%	21.20%	19.67%
Average retirement rate, rounded			20%
Estimated RUL = 1/Retirement rate			5 years

Exhibit 3
Survivor Decay Rate and RUL
Based on a Constant Retirement Rate Analysis

			Decay/Depreciation		Mid-Year Calculation		End-of-Year Calculation	
Year	Survivors at Beginning of Year	Retirement Rate	Retirements During Year	Survivors at End of Year	Age at Retirement	Number Retiring Times Age	Age at Retirement	Number Retiring Times Age
2001	284	20%	57	227	0.5	28.5	1	57
2002	227	20%	45	182	1.5	67.5	2	90
2003	182	20%	36	146	2.5	90.0	3	108
2004	146	20%	29	117	3.5	101.5	4	116
2005	117	20%	23	94	4.5	103.5	5	115
2006	94	20%	19	75	5.5	104.5	6	114
2007	75	20%	15	60	6.5	97.5	7	105
2008	60	20%	12	48	7.5	90.0	8	96
2009	48	20%	10	38	8.5	85.0	9	90
2010	38	20%	8	30	9.5	76.0	10	80
2011	30	20%	6	24	10.5	63.0	11	66
2012	24	20%	5	19	11.5	57.5	12	60
2013	19	20%	4	15	12.5	50.0	13	52
2014	15	20%	3	12	13.5	40.5	14	42
2015	12	20%	2	10	14.5	29.0	15	30
2016	10	20%	2	8	15.5	31.0	16	32
2017	8	20%	2	6	16.5	33.0	17	34
2018	6	20%	1	5	17.5	17.5	18	18
2019	5	20%	1	4	18.5	18.5	19	19
2020	4	20%	1	3	19.5	19.5	20	20
2021	3	20%	0	3	20.5	0.0	21	0
2022	3	20%	1	2	21.5	21.5	22	22
2023	2	20%	0	2	22.5	0.0	23	0
2024	2	20%	1	1	23.5	23.5	24	24
2025	1	20%	0	1	24.5	0.0	25	0
2026	1	20%	0	1	25.5	0.0	26	0
2027	1	20%	0	1	26.5	0.0	27	0
2028	1	20%	0	1	27.5	0.0	28	0
2029	1	20%	1	0	26.5	26.5	27	27
Total number of units retiring times age						1275.0		1417
Divided by number of intellectual property units						284		284
Estimated average intellectual property RUL (in years)						4.5		5.0

(L0 – L5), and four origin-modal curves (O1 – O4). In a typical RUL analysis using Iowa-type curves, the observed survivor curve (based upon historical property placements and retirements) is compared to each Iowa-type curve over a reasonable range of average lives. Ideally, a least-squares curve-fitting program is used to select the Iowa-type curve that best fits the actual survivor curve. In the absence of such a program, it is possible to visually compare the curves using the graphing capabilities of a spreadsheet program such as Microsoft Excel.

Once the best-fitting Iowa-type curve is selected, the analyst will (1) know the average life of the property group, (2) be able to predict the percent surviving past the time period for which actual property survivor data exists, and (3) be able to calculate the probable life of any property age group.

Weibull Curves

Weibull curves are a family of curves developed by Waloddi Weibull. They are defined by two parameters: (1) shape and (2) scale. (A third Weibull parameter, location, is not used for survivor curve–fitting). When the shape parameter is equal to one, the resulting Weibull curve is an exponential curve. When the shape parameter is equal to two, the resulting Weibull curve is a Rayleigh curve. The equation for a Weibull survivor function is:

$$\% \text{ Surviving} = \exp(-(\text{Age}/\text{Scale})^{\text{Shape}})$$

Note that the shape exponent is to be applied before the negative sign. In some spreadsheet programs, an additional set of parentheses may need to be used so that the order of the mathematical operations is correctly calculated.

Once this Weibull survivor function equation is algebraically transformed into a linear form, a regression analysis can be performed using actual survival data. A full discussion of the conversion of the Weibull survivor function to a linear expression is presented in *Valuing Intangible Assets* by Robert F. Reilly and Robert P. Schweihs. The linear form of the Weibull survivor function equation is:

$$\ln(\ln(1/s) = B \ln(t) + c$$

where:

s = percent surviving at time t

B = the shape parameter

t = time, or age

c = the y intercept such that $\exp(c) = (1/a)^B$, where a = the scale parameter

This regression analysis can be performed using a standard spreadsheet program such as Microsoft Excel. The shape parameter is equal to the x-coefficient or slope. The scale parameter is calculated by solving the $\exp(c) = (1/a)^B$ equation for a (where c is the y intercept from the regression analysis):

$$a = \exp(c)^{(-1/B)}$$

Once the shape and scale parameters are determined, the percent surviving values for the Weibull curve can be calculated. These values can be used to predict the percent surviving after the time period for which actual survivor data are available for the intellectual property group.

The mean, or average, life can be computed as (1) the scale multiplied by (2) the gamma function of (1+1/shape); the mean, or average, life can also be computed using the gammaln function in Microsoft Excel, as follows:

$$\text{mean} = a \exp(\text{gammaln}(1+1/B))$$

One practical problem with the use of Weibull curves in RUL analysis is that the curves often "flatten out." That is, the percent surviving indicated by the Weibull curve may not reach zero percent in any meaningful time frame. This may result in unusually long RUL estimates (as calculated using (1) the area under the curve to the right of age (2) divided by the percent surviving) as the age of the property increases.

Technology Forecasting

There are a number of technology forecasting RUL methods available using (1) technology substitution and (2) technology trend analyses. Common technology forecasting models include the Fisher-Pry, Gompertz, and Pearl-Reed models. There is a technology forecasting software product called tf.Innovate that facilitates the use of these three models.

Summary and Conclusion

In an RUL analysis, all applicable life determinants should be examined. Analytical, quantitative RUL methods may be used when relevant data are available. Technology forecasting and technology life cycle analysis should be considered when relevant data are available.

Sometimes, RUL estimation conclusions cannot be used quantitatively in the economic analysis. In such cases, the RUL may be considered qualitatively through professional judgment related to the selection of the analysis variables. RUL estimation is an important component of any type of intellectual property economic analysis.

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