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COMPARING THE ACCURACY FOR SIX METHODS OF CALCULATING DISCOUNTED PRESENT VALUE OF FUTURE MEDICAL EXPENSES

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It is the responsibility of the court to enforce the legal precedent stating that lump sum monetary awards must be discounted. This is done primarily to avoid the over-compensation or under compensation of the plaintiff. In order to determine the appropriate monetary amount that, when invested upon receipt, exactly equals a stream of future medical expenses; forensic economists must utilize some method for estimating the discount and health expense growth rates. This paper uses historical simulation to compare the accuracy of six different methods of estimating the net discount rate of medical expense data for 20-, 10-, and 5- year periods.

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I. Introduction

The United States Supreme Court defines a tort as “a civil wrong, which can be redressed by awarding damages.”[1] Any individual who has suffered a loss or injury to his person, property, or rights as a direct result of a negligent or unlawful act reserves the right to pursue damages in the court of law (Black 1990). Damages may be awarded in the form of punitive or compensatory damages. Compensatory damages are awarded when a future stream of income has been lost, or future costs will be incurred. Conversely, punitive damages are not awarded to replace future economic loss but instead are awarded if the court deems it necessary to punish the defendant for a malicious or negligent act.

A compensatory monetary award is a lump sum that, when invested upon its receipt, will exactly replace the future loss stream of income or expenses. In order to determine this amount, an economist must estimate the future growth rate of the plaintiff’s wages or medical expenses and the interest rate that will be earned on investment. The base equation for the discounted present value is listed below.

$$NPV_R = \frac{A_0}{(1+R)^0} + \frac{A_1}{(1+R)^1} + \cdots + \frac{A_N}{(1+R)^N} \quad (1)$$

$$NPV_R = \sum_{n=0}^{N} \frac{A_N}{(1+R)^N} \quad (2)$$

Where n represents the length of the period being discounted, A is the non-discounted annual sum, and R is the discount rate. The initial sum is then discounted by the

[1] *Smith v. United States, 507 U.S. 197 (1993)*

compound interest to determine the present value. This number represents the amount that, when invested at R, exactly equals the initial non-discounted sum.

Discounting lump sum awards is necessary so that the defendant is not unfairly punished and the plaintiff is not unfairly compensated in a way that does not reflect the actual future costs. For example, suppose you need to replace $40,000 per year for a period of 10 years or 30 years. Without discounting, the lump sum award is 10 years multiplied by $40,000 for a total lump sum of $400,000, or 30 years multiplied by $40,000 for a total of $1,200,000. Table 1 demonstrates the difference between a lump sum award when it is discounted and when it is not.

Table 1. The Importance of Interest

$40,000 per Year for 30 Years			$40,000 per Year for 10 years	
Interest	Lump Sum		Interest	Lump Sum
0%	$1,200,000		0%	$400,000
2%	$895,858		2%	$359,303
4%	$691,681		4%	$324,436
6%	$550,593		6%	$294,403
8%	$450,311		8%	$268,403
10%	$377,077		10%	$245,783
0% - 10% Interest	$822,923		0% - 10% Interest	$154,217

The highlighted sum on for both the 30-year period and the 10-year period represents the difference between the non-discounted lump sum award and the lump sum when necessary when interest earned is 10 percent annually. Controversy arises when considering how to determine the correct interest rate. As you can see, the monetary amount varies greatly as the interest rate ranges from zero to ten percent. Therefore, as the method of estimating the interest rate changes, the values also change. If the lump sum award was not discounted the plaintiff would be over compensated because he or she would be able to earn interest on the initial award. The sum of the initial award and the interest would be greater that the compensatory obligations of the defendant.

Previous literature has not fully explained the future growth rate or the most accurate way to estimate it. When calculating the discounted present value of future medical costs, a forensic economist can use historical medical expense data to estimate the costs the plaintiff will incur in the future. Estimation of the discount rate remains controversial due to the variety of methods that exist for the purposes of estimation. Forensic economists are responsible for choosing and applying the method that he or she believes provides the most accurate. Following this reasoning, there is a surprising lack of literature analyzing the most appropriate method for discounting. Due to the random nature of economic phenomena, it follows intuitively that it is almost impossible to determine the correct way to discount lump sums. However, it is possible to compare the accuracy of existing methods. An example of a controversial element of discounting is whether to use risk free treasury notes, rate of return on equities, or a combination of the two. Another controversial debate in the literature is between using the current rate or the historical rates for estimation.

In order to avoid over or under compensation, it should be the case that using some derivation of the historical average yields the most accurate results. This is because economic trends are reflected in changing bond yields from year to year. It is the case however, that the existence of past economic phenomena could introduce bias as results of severe economic fluctuation. On the other hand, current bond yields reflect the actual interest rates available at the time of the award. It follows that the most accurate method for estimation should be a combination of the historical average and current rate method, or the historical average and base period method. This is a result of using the historical average method which includes past economic trends that are based on the previous period's performance. But in order to avoid bias due to severe economic fluctuations, combining the historical average method with the current rate or some other base period method will offset the influence of previous economic fluctuation with current economic conditions. Theoretically, this would result in a more accurate indicator of future trends and interest rates.

There have been numerous studies that examine the accuracy of predicting wage loss, but there are very few that analyze the accuracy of predicting future medical costs. The current trend of rising healthcare costs has brought new attention to forecasting methodologies. As costs continue to rise, it is difficult to accurately forecast the actual growth rate as well as the future discount rate. It may also be the case that, due to the downgrading of the United States Treasury note by grading agencies, Government bonds are no longer considered "risk free". If this proves to be true, future analysis must determine a new comparable monetary instrument. A recent survey done by the Towers study estimates that medical expense growth rates are expected to reach consistent double-digit figures in the next decade.[2] This extreme growth in the cost of healthcare may require an increase in initial lump sum awards as well as the development of new methods for discounting present value of lump sums.

II. Literature Review

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[2] Towers Watson. "2010 Healthcare Costs Survey." *21st Annual U.S. Results Reports*. 2010

The need to discount monetary awards has been non-disputed since the 1916 case of *Chesapeake & Ohio R. Co. v. Kelly* where the court ruled, “In all cases where it is reasonable to suppose that interest may be safely earned upon the amount that is awarded, the ascertained future benefits ought to be discounted in the making up of the award.”[3] In order to determine the discounted lump sum that accurately reflects future economic loss in tort litigation, there are two variables that need be considered. The discount rate and the wage growth rate[4] must be estimated in order to calculate the appropriate monetary award due to the plaintiff. It has been argued in previous literature, by authors such as Harris et al. (1977), that those who receive lump sum monetary awards are incapable of investing in a way that will produce the correct non-discounted sum in the future. However, with advancements in financial institutions and other money market instruments, this argument becomes invalid. As a result, subsequent literature has attempted to identify the most accurate method of estimating the growth and discount rate necessary for analysis.

Early literature has put greater emphasis on the real wage growth rate than the inflation rate. Dick (1972) was among the first to realize that inflation rates were instrumental in calculating tort settlements. He states, “The main reason for the long-term upward movement in wage rates is the continuous rise in the level of productivity for the American Economy.” Dick also concludes that it is highly probable that the United States will continue to experience inflation of about 2 to 3 percent per year, and therefore the most comparable money market instrument for estimation is long-term United States Government Bonds. Dick’s conclusions were incorrect in that actual interest rates far

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[3] *Chesapeake & Ohio R. Co. v. Kelly, 241 U.S. 485 (1916)*
[4] Future Medical Expenses in this analysis

exceeded his 2 to 3 percent prediction. On the contrary, Harris (1983) finds that "unanticipated inflation prevents investors from benefiting from the higher interest rates that would likely occur." Instead, the author suggests short-term instruments are more closely related to earnings growth rates because the principal and interest in full can be reinvested each period, therefore including the effects of inflation. This method incorrectly assumes the plaintiff, who is awarded compensatory damages in the form of a lump sum, is competent to roll over short-term financial instruments.

In 1980 the Pennsylvania Supreme Court ruled that in Pennsylvania cases "damages should be based on a total offset between the rate of inflation and discount rate."[5] Total offset occurs when the inflation rate exactly equals the discount rate. An implication of this ruling was to allow expert testimony regarding potential wage or cost increases an individual may experience over his or her life. Also, the court felt that it was not possible to accurately estimate future growth and interest rates, so it required economists to assume that they were equal to each other. The Courts' decision was reaffirmed in 2010 in the case of *Helpin v. Trustees of the University of Pennsylvania (2010)* where the court held that "the calculation of lost future earnings, except in medical malpractice cases, must be based on a real discount rate of 0%."[6] This implies that in the long-term, the inflation and discount rate are equal to each other.

Hosek (1982) was among the first to analyze the use of historical data to predict future growth and inflation rates in a forensic context. Contrary to current literature, Hosek's analysis determined that due to the random nature of inflation and growth rates, the most accurate method of discounting is to use current rate. Use of the historical rates

[5] *Kaczkowski v. Bolubasz, 421 A.2d 1027 (Pa 1980)*
[6] *Helpin v. Trustees of the University of Pennsylvania, 2010 Pa. LEXIS 2911 (Pa 2010)*

method may lead to biased results because of severe economic fluctuations in the past. However, Jones (1985) stated that discount rates chosen without the use of historical precedent are invalid due to the lack of consideration for current economic trends. The authors goes on to state that unfounded simplifying assumptions, such as a consistent increase in inflation estimates, are often not presented to the jury and are considered to be "immoral."

Schilling (1985) used wage rates and high-grade corporate bond interest rates to compare the compound and discount method, simplified compound-discount, and the total offset method over 30-, 20-, and 10- year periods. The compound and discount method "assigns a wage growth rate for *n* years subsequent to each base year that was projected from a trend line fitted by least squares to the n most recent past years." The simplified compound-discount "estimates the income for *n* future years subsequent to each base year by computing the geometric mean of both the growth rate of earnings and the long term interest rate over the n years leading up to the base year." Finally, the total offset method assumes the interest rate equals the growth rate thereby eliminating the need to discount. Schillings results are counterintuitive because they support the total offset method as the most accurate of the three methods. However, Brush (2011) interpreted the forecast error reported for the total offset method as too high to justify the conclusion made by Schilling.

Anderson and Roberts (1988) were the first to analyze the present value assessment of medical care costs via historical analysis. The authors used data from 1952 through 1985 that include the annual yields on one-year Treasury notes for January of each year, the annual effective income tax rates by income classifications, and the annual growth rates in the seven different medical care price indices. They structure a forecasting equation as an annuity to account for the fact that growth rates and the prices of different types of medical care differ. The authors found that lump sum estimations are biased towards over-payment because tax deductions for medical costs were not included in previous studies.[7] They also concluded "if the individual components of future medical costs had been projected using growth rates consistent with the historical net rates before aggregating and discounting, the estimates would have been more accurate." As a result of *Jones and Laughlin Steel Corp. v. Pfeifer (1983)*, the Supreme Court held that it is the responsibility of the district courts to decide whether the discount rate used in the analyses for court purposes is acceptable.

Brush (2003) also used the historical average method for "17 rolling 30-year periods, 37 rolling 20-year periods, and 57 rolling 10-year future periods." The author's results demonstrated that as the length of the future loss period was shortened, the accuracy of the historical average method was improved. Similarly, Cushing and Rosenbaum (2006, 2007) examined the accuracy of estimators based on historical average and current rate. The authors found that, "for U.S. data, the optimal estimator could be approximated by the simple average of the current rate and the long-term average. The authors concluded that this compromise estimator is a more accurate method of forecasting net discount rates than utilizing professional forecasts. The compromise estimator is defined as the average of the net discount rates estimated via the historical average and current rate method. Similar to this finding, the authors conclude

[7] *I.R.C. §104(a)(2):* Pennsylvania internal revenue code states that tax deductions are not applicable to personal physical injury or sickness. The author's conclusion has been deemed unnecessary in this analysis, but remains an essential piece of literature in regards to this topic.

that the net discount rate should be an average of estimates based on both long and short-term historical periods.

Fulfilling his own recommendation, in a later publication Brush (2011) identifies various methods in previous literature that have been used to estimate discounted present values. The methodologies identified include the current rate method, the base period method, the total offset method, and two versions of the historical average method. The current rate method assigns the interest and growth rates immediately preceding the loss period as the future interest and growth rates for estimation. Similarly, the base period method averages the three-year period ending the first year before the loss period for the estimated interest growth rates. The total offset method assigns an equal rate the interest and growth rates thereby rendering the net discount rate immaterial. The two methods of the historical average method vary only slightly in regard to length of the period preceding the loss period being averaged. Method number one uses a period equal in length to that of the loss period, where method number two uses all historical data available that precedes the loss period. Based on the work of Cushing and Rosenbaum (2006, 2010) and Hayden and Webb (1992), Brush identifies additional methods that combine both historical average methods with the current rate method and the base period method. The combination of these methods simply refers to an average of their generated estimates. Using historical simulation to analyze data on the annual returns of treasury bills and U.S. manufacturing wage covering the period 1926 to 2008, Brush compares the forecast accuracy of 9 different estimation methods over 30- 20- and 10-year periods. In each of the nine models, the net discounted rate is estimated and then compared to the actual. Brush found that “the best estimation method depends on the length of the period being forecasted and the most accurate net discount rate is one that is based on a combination of the historical average and current rate method."

III. Methodology

A. *Data*

Most prior studies that examine the accuracy of different discount rates do so for future wage losses. The purpose of this study is to replicate the Brush (2011) analysis in order to evaluate the accuracy of different discount rates in estimating the present value of a stream of future medical costs.

The data used in this study is the 2009-2019 National Health Expenditure Projections Price Series. This government-funded research includes 8 different categories that describe the growth of healthcare costs in the United States. The data series extends back to 1966 and includes the 10-year future forecast prepared by the Centers for Medicare & Medicaid Services, Office of the Actuary, U.S. Bureau of Labor and Statistics. Categories included are dental care, prescription drugs, durables, home healthcare, hospital services, nursing homes, personal healthcare, and physician and clinical services.

In order to expand on Brush's research, the health expenditure projections price series data set will replace the historical wage growth rates data series. This alteration in the test will provide a different application of Brush's analysis by expanding its comparison to future medical expenses instead of future wage loss. The analysis will repeat the test created by Brush with the healthcare projections data set. In order to do this I will perform six of the nine methods of calculating the discounted present value used by Brush. The three methods omitted from this test are variations of the historical average method number two due to the lack of data necessary to produce results significantly different from historical average method number one. Each of the eight medical cost categories will be forecast using the six remaining methods and then the forecast errors and percent of over- and under- compensation will be compared. Forecast errors will be generated via historical simulation. Periods of time equivalent in length to the forecast period will be chosen from the historical data for the purpose of comparison. The averages of multiple forecast periods will be taken so it is necessary that the time period chosen have an existing equal length series of data immediately following the data.

B. *Methodologies*

Rolling historical simulation will be used to compare the accuracy of the six methods explained by Brush that are applicable to this model. Historical Simulation uses each data set from a historical period that has an equal length of actual data following for comparison. The discounted present value of the future stream of costs are calculated and the estimates are then compared to the actual values reported in the subsequent period. In order to increase the accuracy of the test, this paper will follow the rolling periods methods implemented by Brush. The rolling periods methods takes the average forecast errors generated per period available for analysis. For example, considering the parameters that the subsequent period of data used for comparison must be equal in length to the set of data used for generation of the estimates, and knowing that the medial expense projections price series data set ranges from 1966 to 2008 there are 4 rolling periods available for comparison of 20- year loss periods. The periods include 1966 to 1985 compared to 1986 to 2005, 1967 to 1986 compared to 1987 to 2006, 1968 to 1987 compared to 1988 to 2007, and finally 1969 to 1988 compared to 1989 to 2008. As the loss period becomes shorter, there are more rolling periods that can be compared.

The analysis is performed, starting with the initial period, to generate estimates for the later periods for an assumed estimated annual loss of $1,000. The value of the discount rate is then inserted into the present value formula and used to estimate the values in the loss period. The calculation of the discounted present value is done using the following equation where R represents the interest rate and medical expense growth rate generated by each estimation method. These values are then be substituted into the discounted present value estimate equation where n represents the length of the future loss period.

$$PV_{est.} = \sum_{t=1}^{n} \left[\frac{1+M}{1+R}\right]^{t} Base\ Annual\ Loss \qquad (3)$$

The discounted present value forecasts generated by using the different discount rates are then compared to the subsequent period's actual value. This is calculated by inserting the historical yearly values of the medical expense growth and interest rates for each respective year into the discounted present value actual formula. This methodology is repeated for each of the rolling forecast periods. The discounted present actual formula multiplies the interest rates earned per loss year in order to compute the compound interest for the actual period. The compound interest is then multiplied by the annual loss value of $1000 to determine each actual annual discounted present value of the loss period. The estimate equation differs from the actual equation in that it extends the estimated value for each year of the loss period. The discounted present value actual formula takes each annual medical expense growth and interest rate to generate an actual.

$$PV_{act.} = \sum_{t=1}^{n} \left[\prod_{i=1}^{t} \frac{1+M_i}{1+R_i} \right] Base\ Annual\ Loss \qquad (4)$$

The resulting difference is reported as a percent of the actual value. This number is the mean percent error. In order to construct an accurate comparison numerous measures of the difference (error) described by Brush are used. These measures are listed in table 2.

Table 2. Measures of Error Used by Brush (2011)

Measure	Definition
Direction of Error	Number of cases of over/under compensation
Maximum Windfall	Maximum percentage of over-compensation
Maximum Shortfall	Maximum percentage of under-compensation
Mean % Error	Absolute value of the difference between the predicted value and the actual value
Mean Award Ratio	Ratio of monetary award to total future stream of income lost
Error <=20%	Number of cases where the relative error included extreme values exceeding a percent error exceeding 20%
Error <=10%	Number of cases where the relative error included extreme values exceeding a percent error exceeding 10%

This analysis uses only mean percent error, direction of error, and the standard deviation of each due to the modeling difficulty resulting from 8 categories of analysis per method.

The first method estimated uses the historical average method. Using the medical cost data series and Treasury bill return rates, this method averages values and return rates for the period of equal length preceding the loss period. These values are then used in the discounted present value estimate equation as the medical cost growth rate and interest rate respectively.[8]

The second method performed by Brush is the base period method. The base period method averages the respective values of the three years preceding the first year of the loss period. Like the historical average method, the values of the wage growth rate and the Treasury bill return rates are inputted into the discounted present value estimate formula.

The next methods are the current rate method and the total offset method. The current rate method uses the respective values of the year preceding the loss period to calculate estimates for comparison, whereas the total offset method assigns equivalent values to the medical cost rate and interest rate. The assignment of equal values leads to a non-discounted lump sum.

The last two methods performed by Brush, that this paper will compare, are a combination of the historical average method and the current rate method, and a combination of the historical average method and the base period method. Brush combines these methods by averaging the estimates generated via each method. These methods will be henceforth referred to as the HA-CR and HA-BP respectively.

Table 3. Methods Compared by Brush

Method	Description

[8] Brush's historical average method number two and its combination methods are not included in this analysis due to the lack of data necessary to adequately generate substantially different results than historical average method one

Historical Average	Method in which the discount rate and the growth rate are assigned the respective averages of the historical period preceding the loss period
Base Period	Method in which the discount rate and the growth rate are assigned the values of a simple average of the three year period ending the first year of the loss period
Current rate	Method in which the discount rate and the growth rate are assigned the values of the first year of the loss period
Total Offset	Method in which it is assumed that the discount rate and the growth rate are equal and will result in the future interest return
HA-CR	Simple average of the estimates generated by the historical average and current rate method
HA-BP	Simple average of the estimates generated by the historical average and base period method

C. *Results*

Using the same methodology described by Brush, this paper performs the analysis using the health expenditure projections price series. Table 4 lists the averages and standard deviations of the mean percent error of all 8 categories of health expenditures for each respective method and time period[9]. The averages are computed by taking the absolute value of the difference between the estimates and the actuals. This value is then taken as a percentage of the actual value for the time period.

[9] For complete average results see *Appendix 1*.

Table 4. Average Mean Percent Error By Method

Period Length	Historical Average	Base Period	Current Rate	Total Offset	HA-CR	HA-BP
20-Year	27.38% (0.1439)	22.48% (0.0931)	17.22% (0.0626)	58.32% (0.2740)	11.70% (0.0551)	10.86% (0.0616)
10-Year	15.60% (0.0792)	19.35% (0.0645)	20.20% (0.0635)	24.33% (0.1390)	16.56% (0.0643)	16.71% (0.0683)
5-Year	7.71% (0.0109)	7.45% (0.0086)	7.21% (0.0069)	9.42% (0.0324)	6.92% (0.0082)	7.48% (0.0093)
Method Avg.	**16.89%**	**16.43%**	**14.88%**	**30.69%**	**11.73%**	**11.68%**

In order to better compare the six methods of discounting present value, the average percent of over or under compensation is also measured. Table 5 reports the respective average and standard deviation of over or under compensation. These values are computed by taking the difference between the estimate and the actual value. This number is also taken as a percentage of the actual value for the time period. A negative number represents under compensation and a positive number represents over compensation.

Table 5. Over Compensation/ Under Compensation By Method

Period Length	Historical Average	Base Period	Current Rate	Total Offset	HA-CR	HA-BP
20-Year	18.14% (0.2623)	-17.94% (0.1518)	-1.97% (0.1656)	58.32% (0.2740)	5.93% (0.1147)	-3.21% (0.1146)
10-Year	5.19% (0.1379)	4.31% (0.1486)	3.38% (0.1512)	23.70% (0.1500)	3.91% (0.1417)	4.53% (0.1417)
5-Year	-0.17% (0.0157)	-0.22% (0.0114)	-0.06% (0.0076)	8.21% (0.0375)	-0.18% (0.0116)	-0.21% (0.0135)
Method Avg.	**7.72%**	**-4.62%**	**0.45%**	**30.08%**	**3.22%**	**0.37%**

Unsurprisingly, due to the lack of severe economic fluctuations in the short run, the performance of each method for the 5- year period are similar. Also, in respect to the 5- year period, each method demonstrates a mean percent error below 10%. When considering the difference among the six methods in the 10- and 20- year period, the HA-CR and HA-BP method are the most accurate. It is the case that the historical average method demonstrates the lowest mean percent error in the 10- year period. This may be due to the strong correlation of historical data to future economic growth in dental care and personal health care (See Appendix 1). A similar criticism of these results includes the criticism made by Brush (2003) regarding the outputs generated by Schilling (1985). Brush states that due to the high standard errors, concluding that the historical average method is more accurate than other methods with similar results and lower standard errors is flawed. The low forecast errors are not consistent throughout all 8 categories. Dental care and personal health care errors are noticeably lower than the other 6 categories. Therefore, this paper speculates that random chance in the data set led to extremely low values in two categories thereby offseting the inflated figures of the remaing six categories of health care costs within the 10- year period analysis of the historical average method.

The results of Brush's analysis and the one in this paper are supportive of some previous literature such as Hosek (1982). Hosek concluded that due to the random nature of inflation, the current rate method is the most applicable method. Analysis of the mean percent error of the current rate method in Table 4 reveals strong performance in the 5- year period, but weak performance in the 10- and 20- year periods. However, on average the use of the current rate method by an economist over compensates the plaintiff by .45 of a percentage point. Upon consideration of actual compensation throughout the rolling periods, the current rate method is numerically superior. It is important to note that the mean percent errors for the current rate method are not the smallest for the 20- 10- and 5- year periods.

The overall performance of the current rate method was not far removed from that of the HA-CR and HA-BP methods. However, when considering the over and under compensation figures in Appendix 2, we can see that the exceptional performance of the current rate method in this respect is most likely due to the severe and consistent fluctuation of the forecasts from period to period. Although the over- and under-compensation values are relatively similar in absolute value, the severe manner in which they offset each other makes their figures biased and unreliable. For example, the average of -48 percent and 48 percent is the same as the average of -10 percent and 10 percent. The average may be the same, but the implications are not. It is with this in mind that this analysis concluded that combination methods to be, overall, most applicable.

Brush 2011 concluded that the most accurate method for calculating discounted present value of future wage loss depended on the length of the period, but overall the HA-CR method proved to be most accurate. Interestingly, the results generated using an identical anlysis with dissimilar data were consistent with those generated by Brush. As shown above in table 3, the HA-CR method demonstrates the lowest forecast error for the 5- year period length. It is important to note that the HA-BP method yielded promising results with the lowest forecast error for the 20- year period, but failed to do as well in the 10- or 5- year periods. Brush's final conclusion was that a combination of the historical average method and the base period or current rate method are the most applicable methods. He goes on to state that overall, the most accurate method for discounting is the HA-CR method. This analysis parallels the conclusion made by Brush but one possible interpretation is that the HA-BP method is the most applicable method. This is due to its overall average performance in both mean percent error, and over- and under-compensation percentage. This paper interprets the results to suggest that the three most credible methods for discounting future medical expenses are the HA-CR, HA-BP, and the current rate method with the HA-BP being the best of the three methods.

IV. Further Discussion

Brush found that, in the long run[10], the total offset method was the most accurate. The results of this analysis contradict the findings of Brush and Schilling (1985). Not only does the total offset method demonstrate an average mean percent error exceeding 50% in the 20- year period, the results also demonstrate severe and consistent over compensation exceeding 50%. Brush's analysis yielded results that support the total offset method as the most accurate in the long run, and moderate to good performance in the two shorter length periods. The analysis of the medical expense growth rates data returned results that are interpreted to mean that the total offset method is the least accurate method of the six. This conclusion is consistent for the 20-, 10- and 5- year periods.

Also contrary to Brush's analysis, this paper reports that the most accurate method for estimating the medical expense growth rate and interest rate in the long run is a combination of the historical average method and either the base period or current rate method with the HA-BP method being the most accurate. The historical average method demonstrates the lowest mean percent error for the 10- year period, but as previously discussed in this paper, the high standard deviation supports the conclusion that the

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[10] 30- year period used by Brush

historical averages method is not the most applicable method for estimation. This implies, that in the long-run, the HA-CR and HA-BP methods that are the applicable methods for estimation. The HA-CR method has a slightly lower forecast error, but a higher standard deviation that the HA-BP method. The forecast error of the HA-CA is not lower to the extent that it offsets the implications of the lower standard deviation of the HA-BP. Because of this, this paper interprets the HA-BP method to be superior to the HA-CR

Analysis of the short run indicates that the method used for estimation does not greatly influence the mean percent error of the results except in the case of the total offset method. However, it is important to note that the HA-CR method did have the lowest mean percent error and standard deviation indicating that it is the most applicable method. Not surprisingly, the current rate method performed well in the short run. It is important to note that the current rate method generated results that demonstrated the lowest percent of over- or under- compensation from the actual. Particularly in the 5-year period, we can see that the average percent error is 0.06 of a percentage point in favor of under compensation. An argument could be made that, in the short run, the current rate method is the most accurate method for estimation. This is because the results of the current rate method are only slightly better than those of the HA-CR and HA-BP methods. If severe economic fluctuation were experienced in the short run, such as the great recession, the current rates method forecast errors would increase dramatically. Another interesting result that should be considered for future analysis is the 0% mean error generated in the 5- year historical average method for personal health care.

V. Concluding Comments

Discounting the present value of a lump sum will always be difficult and subjective. It is the responsibility of the expert in the area to defend his assumptions and methodologies. This paper has demonstrated the financial implications of incorrect discounting. The difference between estimated discounted value and the actual future value may be greater if expected future losses or costs extend into the millions of dollars. Therefore, comparison analysis will always be important.

The methodology used to obtain the results of this paper is a manipulable spreadsheet and available upon request. It is possible to broaden the analysis done by this paper either by period length, or content. Beneficial future analyis regarding future medical expenses would be to expand the data used as it becomes available. This may lead to more accurate results, and an even better understanding of which method is the most accurate when discounting the present value of future medical expenses. It is also the case that, due to the downgrading of the United States government bond by grading agencies, government treasury bills may not be considered “risk free”. If this were to happen, the analysis would need to be performed again with a different foundation for forecasting future interest rates. Also, the legal system would benefit if comparison of the existing methods for discounting present value were extended to other legal issues such as future childcare costs.

This paper used the historical simulation framework designed by Brush to compare the forecast accuracy of six different estimation methods that are in use or mentioned in previous literature. These methods are performed on historical medical expense growth rates and treasury bill return rates over 20- 10-, and 5- year periods for a total of 2,928 forecasts. Although the results vary with period length, this analysis identifies the HA-BP method to be the most accurate method for discouting present value of future medical expenses.

Consistent with Brush's analysis, the average forecast errors tend to decrease as the period length is decreased. This is most likely due to the lack of severe economic fluctuation in the short run. On average, the forecast errors generated via the historical average and total offset method border on extreme over-compensation, whereas the base period method deomonstrates severe under compensation. Only the current rate method, HA-CR and HA-BP methods percent over- or under- compensation are small enough to be considered accurate estimators. Although, the results of this analysis identify similarly accurate methods, this paper has interpreted the results to mean that overall the HA-BP method is the most accurate method to be used when discounting the present value of future medical expenses.

The results of the historical simulation analysis on medical expense growth rates suggests that the forecast length is an important factor when discounting present value of lump sum awards. Therefore, the most accurate method for discounting the present value of future medical costs is either the HA-CR, or HA-BP method. Use of one or the other is subjective to the type of data being compared. Theoretically, it may always be the case that the estimates derived will better reflect future rates if the estimated values are augmented by current economic trends.

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VII. Appendices

Appendix 1. Mean Percent Error By Health Expenditure Category

Method	Period Length	Dental Care	Prescription Drugs	Durables	Home Health Care	Hospital Services	Nursing Home	Personal Health Care	Physician & Clinical Services
Historical average	*20-Year*	**7.94%**	**29.03%**	**24.19%**	**17.69%**	**58.34%**	**25.26%**	**28.16%**	**28.41%**
	10-Year	**7.54%**	**25.73%**	**13.79%**	**11.78%**	**29.65%**	**15.28%**	**8.97%**	**12.03%**
	5-Year	**6.53%**	**9.31%**	**6.15%**	**7.19%**	**8.41%**	**8.51%**	**7.26%**	**8.30%**
Base period	*20-Year*	**31.10%**	**13.69%**	**15.08%**	**19.12%**	**18.48%**	**41.52%**	**19.50%**	**21.37%**
	10-Year	**12.01%**	**31.52%**	**17.81%**	**15.09%**	**26.05%**	**18.16%**	**14.66%**	**19.47%**
	5-Year	**6.65%**	**8.76%**	**6.10%**	**7.07%**	**7.92%**	**7.96%**	**7.19%**	**7.98%**
Current rate	*20-Year*	**16.16%**	**24.65%**	**16.22%**	**6.34%**	**24.49%**	**20.01%**	**11.23%**	**18.65%**
	10-Year	**14.16%**	**32.63%**	**18.89%**	**16.02%**	**26.52%**	**17.22%**	**15.38%**	**20.79%**
	5-Year	**6.71%**	**8.32%**	**6.68%**	**6.79%**	**7.93%**	**7.16%**	**6.42%**	**7.70%**
Total Offset	*20-Year*	**26.55%**	**29.50%**	**112.84%**	**49.85%**	**68.91%**	**71.59%**	**58.15%**	**49.17%**
	10-Year	**10.88%**	**46.81%**	**23.10%**	**28.45%**	**36.98%**	**25.09%**	**20.83%**	**2.53%**
	5-Year	**6.68%**	**7.34%**	**16.38%**	**7.80%**	**9.57%**	**11.81%**	**8.06%**	**7.76%**
HA/CR	*20-Year*	**12.15%**	**7.37%**	**11.37%**	**10.30%**	**14.37%**	**5.12%**	**9.57%**	**23.38%**
	10-Year	**10.24%**	**26.01%**	**16.34%**	**11.41%**	**26.44%**	**14.67%**	**10.86%**	**16.50%**
	5-Year	**6.20%**	**8.18%**	**5.76%**	**6.44%**	**7.55%**	**7.42%**	**6.44%**	**7.36%**
HA/BP	*20-Year*	**20.72%**	**11.12%**	**5.40%**	**6.88%**	**15.09%**	**14.79%**	**1.43%**	**11.42%**
	10-Year	**9.36%**	**27.02%**	**15.92%**	**11.55%**	**26.94%**	**16.04%**	**10.98%**	**15.86%**
	5-Year	**6.54%**	**8.83%**	**6.09%**	**7.05%**	**8.04%**	**8.11%**	**7.10%**	**8.09%**

Appendix 2. Average Over / Under Compensation as a Percent By Health Expenditure Category

Method	Period Length	Dental Care	Prescription Drugs	Durables	Home Health Care	Hospital Services	Nursing Home	Personal Health Care	Physician & Clinical Services
Historical Average	*20-Year*	**-7.94%**	**-29.03%**	**24.19%**	**17.69%**	**58.34%**	**25.26%**	**28.16%**	**28.41%**
	10-Year	**-5.61%**	**22.21%**	**-8.83%**	**11.48%**	**25.67%**	**1.46%**	**5.94%**	**-10.80%**
	5-Year	**-0.93%**	**-3.77%**	**0.52%**	**0.37%**	**0.75%**	**0.78%**	**0.00%**	**0.92%**
Base Period	*20-Year*	**-31.10%**	**10.85%**	**-15.08%**	**-17.31%**	**-18.48%**	**-41.52%**	**-19.50%**	**-11.40%**
	10-Year	**-5.09%**	**29.56%**	**-11.22%**	**10.24%**	**20.32%**	**-2.46%**	**4.36%**	**-11.21%**
	5-Year	**-0.90%**	**-2.77%**	**0.39%**	**0.11%**	**0.44%**	**0.40%**	**-0.10%**	**0.64%**
Current rate	*20-Year*	**-16.16%**	**24.65%**	**-3.83%**	**3.38%**	**-16.46%**	**-20.01%**	**-5.94%**	**18.65%**
	10-Year	**-11.21%**	**-4.66%**	**31.02%**	**-12.19%**	**9.36%**	**17.35%**	**-4.75%**	**2.80%**
	5-Year	**-0.73%**	**-1.65%**	**0.39%**	**0.10%**	**0.47%**	**0.30%**	**0.04%**	**0.58%**
Total Offset	*20-Year*	**26.55%**	**29.50%**	**112.84%**	**49.85%**	**68.91%**	**71.59%**	**58.15%**	**49.17%**
	10-Year	**10.88%**	**46.81%**	**23.10%**	**28.45%**	**36.98%**	**25.09%**	**20.83%**	**-2.53%**
	5-Year	**5.39%**	**5.82%**	**16.38%**	**6.97%**	**7.24%**	**11.03%**	**7.14%**	**5.71%**
HA-CR	*20-Year*	**-12.15%**	**-6.10%**	**8.99%**	**10.30%**	**13.79%**	**-0.34%**	**9.57%**	**23.38%**
	10-Year	**-5.40%**	**25.98%**	**-10.79%**	**10.06%**	**21.14%**	**-2.07%**	**4.11%**	**-11.74%**
	5-Year	**-0.88%**	**-2.78%**	**0.40%**	**0.18%**	**0.55%**	**0.48%**	**-0.03%**	**0.66%**
HA-BP	*20-Year*	**-20.72%**	**-11.12%**	**2.17%**	**-2.02%**	**13.70%**	**-14.79%**	**1.43%**	**5.65%**
	10-Year	**-5.49%**	**25.52%**	**-10.17%**	**10.63%**	**22.79%**	**-0.78%**	**4.99%**	**-11.27%**
	5-Year	**-0.93%**	**-3.29%**	**0.44%**	**0.23%**	**0.58%**	**0.58%**	**-0.06%**	**0.76%**

Appendix 2. Actual Values per Period According to $NPV_{Act.}$ Equation

Actuals (20-Year)							
Dental Care	Prescription Drugs	Durables	Home Health	Hospital Services	Nursing Home	Personal Health Care	Physician & Clinical Services
764.03	797.51	460.99	666.35	561.22	557.12	618.16	682.74
782.06	780.93	465.04	660.72	583.74	572.54	626.03	665.62
797.07	759.00	474.70	667.06	607.51	592.10	638.51	666.44
819.63	752.90	479.03	675.44	619.10	612.26	647.26	667.09

Actuals (10-Year)							
Dental Care	Prescription Drugs	Durables	Home Health	Hospital Services	Nursing Home	Personal Health Care	Physician & Clinical Services
862.59	700.67	821.72	928.35	759.83	871.06	865.87	1006.89
888.91	691.27	801.12	877.26	731.59	839.31	833.95	1006.14
896.64	670.06	782.44	830.83	700.20	809.05	812.30	1005.52
895.35	656.92	773.10	810.91	671.61	793.33	800.64	1006.68
910.17	643.26	763.70	798.72	656.79	784.29	793.57	1009.44
941.85	622.46	752.27	775.65	646.52	771.55	790.29	1011.83
980.74	628.10	764.44	753.75	647.41	767.00	796.70	1015.16
997.56	651.35	789.45	739.68	657.10	770.33	817.52	1017.35
979.84	665.80	812.40	754.95	672.53	787.19	841.34	1016.50
970.64	684.64	829.86	758.47	692.70	797.61	862.21	1020.03
937.82	689.52	846.75	749.26	714.81	800.57	883.69	1020.43
903.18	676.46	834.17	752.79	715.46	795.05	863.47	1022.46
874.94	676.67	824.50	752.16	722.00	789.11	843.94	1023.88
869.30	677.77	824.61	741.65	733.40	785.22	838.59	1026.51
868.62	679.91	821.40	724.64	732.23	775.02	825.15	1030.07
843.84	686.09	818.14	715.79	740.96	768.58	817.15	1030.22
831.45	699.93	821.21	726.06	761.10	775.72	820.30	1034.53
832.10	691.23	815.50	744.41	777.39	782.79	811.49	1041.13
857.76	686.80	812.43	755.78	791.97	789.17	803.41	1049.25
880.08	706.97	832.14	786.00	816.03	812.90	821.73	1053.07
913.71	718.36	845.55	804.81	837.44	829.64	830.13	1052.95
929.33	738.89	851.33	833.46	860.12	846.32	828.54	1051.21
933.29	754.74	870.43	868.96	882.29	870.54	849.57	1050.76

Actuals (5-Year)							
Dental Care	Prescription Drugs	Durables	Home Health	Hospital Services	Nursing Home	Personal Health Care	Physician & Clinical Services
973.25	774.45	945.00	985.34	1055.20	1011.00	994.57	1000.49
961.56	806.40	936.53	998.00	1059.03	1019.01	1007.52	1029.49
983.08	851.01	945.92	1032.11	1070.75	1032.70	1035.38	1081.38
1006.84	906.33	960.91	1060.74	1083.09	1050.86	1060.94	1118.96
998.42	939.74	941.30	1043.82	1051.42	1022.87	1043.24	1101.00
978.34	933.59	934.06	1010.19	1027.23	993.81	1013.96	1048.45

945.79	927.14	896.99	958.30	1006.60	955.45	981.24	981.40
897.22	923.54	851.37	909.83	994.02	910.66	953.40	930.09
874.69	930.51	821.99	886.37	968.96	867.12	928.92	903.97
851.27	922.93	784.30	852.63	935.14	813.60	893.90	864.13
819.11	936.94	760.69	824.88	916.45	775.32	871.15	837.47
839.88	971.70	781.06	847.26	883.26	776.04	866.90	861.22
871.11	984.03	797.71	871.64	847.16	779.31	860.09	885.18
890.42	977.87	812.17	886.39	850.50	787.12	867.92	900.10
904.47	1002.95	834.11	910.94	868.64	820.99	892.31	933.96
922.78	1024.21	833.73	929.19	862.33	849.62	902.39	961.47
938.32	1036.04	825.47	926.14	875.98	856.35	908.20	949.59
954.59	1048.73	844.70	936.97	903.26	872.27	926.54	955.42
970.82	1040.78	851.48	951.98	922.00	887.48	942.07	970.88
974.57	1007.20	854.23	948.09	908.74	878.10	930.28	960.77
975.91	950.42	858.42	945.87	901.86	873.27	920.86	954.00
961.99	903.96	849.75	933.96	891.11	866.33	907.75	942.89
942.72	862.64	828.30	909.87	861.01	855.85	880.61	913.34
933.00	861.51	821.02	893.45	829.69	852.38	859.73	890.91
942.04	890.39	821.75	894.47	823.27	860.92	860.12	886.69
941.54	914.10	822.86	890.52	817.14	873.57	859.31	881.86
950.71	946.91	847.97	905.20	838.80	904.43	879.75	895.64
970.83	992.93	859.03	922.61	889.97	935.01	915.03	914.58
990.44	1028.30	863.95	939.15	940.79	959.59	948.04	931.36
1012.60	1025.29	892.41	965.01	990.33	983.20	980.34	961.30
1042.96	1037.39	906.03	985.43	1022.17	994.90	1002.00	976.95
1051.94	1016.47	902.47	974.06	1029.09	984.95	996.34	958.10
1051.84	974.16	910.59	977.78	1011.94	977.97	986.02	962.74
1063.67	950.70	923.39	984.45	1001.52	981.97	981.41	964.07