Litigation Economics Review
Volume 5, Number 1: 1-10

A Survey of the Legal Restrictions on Covenants Not to Compete

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Abstract

Covenants not to compete in employment law are remarkably common in practice. They are becoming increasingly widespread in industries that are highly sophisticated. This legal niche is located in the intersection of contracts and employment law, and is unique in many features.

While the common law tradition strictly prefers the damages remedy to specific performance, in non-competition restrictions specific performance is widely used to enforce covenants whenever the court does not invalidate the restriction. This custom brought commentators to the conclusion that in this area of the law, a damages relief in regards to future harm is almost unavailable. While damages will be awarded for past injury, injunctive relief will usually be the "forward-looking" remedy. Either one wins it all or loses it all.

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The author is deeply grateful for valuable comments and conversations to Prof. Harry First, Chief of the Antitrust Division for the State of New York. I also wish to thank Christine Jolls, Jaimee King and Denise Zimmerman for their contribution to this work. An earlier version of the paper was presented at the Colloquium on Innovation at New York University Law School.

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Although the underlying relationship is seemingly an arms length consensual one, courts and legislators freely compel the parties by mandatory intervening. Moreover, the courts tend to use a case-by-case approach, which hurts the ability to predict the validity of "non-competes". This paper surveys the different legal restrictions on covenants not to compete and arranges them in a manageable framework.

The History of Covenants Not To Compete

The English Common Law Tradition

A covenant not to compete is a contractual restriction purporting to limit the employee's ability, upon the termination of employment, to compete in the market niche of her employer.[1] Since the common law does not offer injunctive relief for specific performances that restrain workers to a current position, restrictive covenants have been designed to bypass this legal limitation.

Courts have generally disliked non-competition agreements in the field of labor since 1414, when the first recorded case was decided. The defendant, a dyer, was given a bond promising not to practice the trade of dying in the plaintiff's town for a period of six months. The court found the obligation void "because the condition is against

[1]*See* L. J. Kutten and Bernard D. Reams, Executive and Professional Employment Contracts 89 (Lexis Law Publishing, 1997); Reddy v. Community Health Foundation of Man, 298 S.E. 2d 906, 909 n.1 (W.Va. 1982).

common law."[2] In 1536 the English Parliament passed an "Act for Avoiding of Exaction Taken Upon Apprentices" making it illegal for a master to compel or cause any apprentice or journeyman, by oath or by bond, to promise to refrain from competing with the master.[3] Consequently, in the *Moore* case of 1578, the court determined that a covenant preventing a merchant apprentice from practicing his craft in Nottingham within four years of leaving his master was void.[4]

Further, in *Colgate v. Bacheler*,[5] the court voided a bond by an employee to an employer not to practice the trade of haberdashery within the county, or in specific neighboring cities. The court decided that the law forbids a restraint on use (by issue of a bond that will be exercised if the employee does practice haberdashery within the country) of a lawful trade at any time or at any place for it is against the benefit of the commonwealth.[6]

However, in 1711, in the case of *Mitchell v. Reynolds*[7], which involved a lease of a business, we can find a lengthy discussion of the policy reasons *justifying* upholding a non-competition covenant. The court, upheld a bond that required the defendant not to practice the baker's art in the same parish for the term of the lease of his bakeshop to the plaintiff. The court found that although there is a presumption that all restraints of trade were invalid, consideration of the condition in the specific circumstances is required. The court attributed its general dislike to non-competition clauses that the restraint placed on the weak. But in the case it was decided that the seller, by agreeing to the restriction not to compete with the buyer of his store, enjoyed a higher price upon selling his business. If the covenant was not enforceable, the buyer would have to lower his purchase price in order to fight the possible competition. This, claimed the court, harms the seller by reducing the best possible price he could hope for. While the *Colgate* case dwelled on the effect of the restriction on the benefits to the commonwealth effects, the court in *Reynolds* ignored this consideration altogether. That is, the social value of the restriction in comparison to its private value was never raised in *Mitchell*.

Mitchell also argues that the seller's ex post infringement of rights is largely law-dependant. If, after a precedent was set, the baker included a void clause in the contract, he could then blame no one but himself for taking such void clause into consideration when setting the contract price. When the court validates covenants not to compete, the buyer should be willing to pay the seller for not competing an amount that is as high as his increased sales from not being subject to competition. On the other hand, the seller will agree not to compete for an amount greater than his benefit from competition. Thus, whenever the buyer gains more from remaining free from competition than the seller loses from not competing, the parties are assumed to reach an agreement to include a non-competition clause.

After *Mitchell v. Reynolds* in 1711, English law always distinguished between post-employment contractual restraints on employees, and restraints arising out of the sale of a business. The latter were generally upheld, whereas the former were subject to much scrutiny. This approach grew into a "rule of reason" that required judicial balancing of interests.[8]

The American History of "Non-Competes"

Early American Commentaries on non-competition agreements adopted the English viewpoint. Thus, in discussing non-competition agreement, the distinction of *Mitchell v. Reynolds* between general and special restraints was adopted.[9] However, a larger spectrum of considerations, including the public interest, with greater weight to the interests of employees was entertained. General restraints "are universally prohibited…they do mischief to the party by the loss of his livelihood and the subsistence of his family, and mischief to the public, by depriving it of the services and labors of a useful member".[10] However, specific restraints "not to carry on trade in a particular place, or with particular persons, or for a limited reasonable periods" are valid since this restraint leaves all other places, and persons, and times free for the former employee's solicitation.[11]

American courts generally did not apply a per-se rule of validity with respect to either post-employment restraints or those associated with the sale of a business.[12] The balancing notion of *Mitchell v. Reynolds* was adopted in the sale of a business area. In *Price v. Fuller*,[13] the plaintiff bought the defendant's stagecoach. The liquidated damages agreed upon in the contract for breaching events of competition with the buyer in the relevant route were judicially upheld, since it was limited to a specific stagecoach run. This decision is symbolic for two legal trends. First, the court's attitude is more lax toward covenants not to compete in the sphere of sale of business, especially when they are of limited scope (e.g. specific geographic area). Secondly, while damages set by the court are a rarity in practice, liquidated damages are often honored.[14]

In the case of *Lawrence v. Kidder*[15] the court voided a non-competition agreement. The court refused to enforce a non-competition covenant not to manufacture or sell palm leaf beds for five years in the entire territory of Albany, New York. In the case of *Dunlop v. Grefory*[16] the court also considered a restriction unreasonable for restricting competition within too broad a territory. According to the Dunlop court, contracts which restrain trade entirely, as is the case of

[2] Dyer's Case, Y.B. 2 Hen V., Pl. 26 (1536).
[3] 28 Hen, VIII, Ch. 5.
[4] K.B. 115, reprinted in 72 Eng. Rep.47 (Q.B. 1578).
[5] 11 Co. 53, reprinted in 78 Eng. Rep. 1097 (Q.B. 1602).
[6] *Also see* the case of Blacksmith of South-Mims, 2 Leo. 210, reprinted in 74 Eng. Rep. 347 (Q.B. 1711).
[7] 1 P. Wms. 181, reprinted in 24 Eng. Rep. 347 (Q.B. 1711).
[8] Ronald J. Gilson, *The Legal Infrastructure of High Technology Industrial District: Silicon Valley, Route 128, and Covenants Not to Compete*", 74 N.Y.U. L. Rev. 575 (1999).51.
[9] Not to compete in the relevant market at all vis-à-vis not to compete in the particular market within a limited geographical area and for a limited period of time or with some individuals.
[10] Storey's Commentary on Equity Jurisprudence, sec. 292, Little & Brown, 1843.
[11] *Ibid*.
[12] H. Blake, *Employee Agreements Not to Compete*, 73 Harv. L. Rev. 625, 629 (1960).
[13] 8 Mass. 223 (1811).
[14] Gilson also mentions that in Massachusetts "of the ten decision on preliminary injunctions to enforce a covenant not to compete…injunctions were granted in eight", *See* Gilson, *supra* note 8.
[15] 10 Bar., 647 (N.Y. Sup. Ct. 1841).
[16] 10 N.Y. 241 (1851).

non-competition anywhere within the state, are void. The harm to the public was one of the reasons for the court's decision. However, when the restriction is reasonably limited, under the circumstances, for the necessary protection of the promisee, it may be upheld.

While the previous decisions were in the field of sales of a business, the case of *Keeler v. Taylor*[17] dated 1866 was occupied with non-competition clauses in the employment context. The plaintiff taught the defendant the art of making platform scales. The defendant, on his behalf, obliged to pay the plaintiff, who employed him, a sum of $50 for each said scale he produces for any person other than the plaintiff, unless he received the consent of the plaintiff. After seven years Taylor, the defendant, decided to open his private practice. The court found the covenant void, as the contract restrained the defendant in an unlimited territory for lifetime, contrary to public policy.[18] It was a restriction on the use of "know how" gained through employment, which resembles today's license. The court believed that this limitation created too broad a restriction to the detriment of the public interest.

To sum up, the history of the American legal approach to non-competition covenants, there is no fixed formula for determining whether a particular non-competition covenant is reasonable and therefore upheld. Hence, precedents have limited value in forecasting the legal result in a specific case.[19] The decision is on an ad-hoc basis, according to the specific circumstances.[20]

Nevertheless, some elements are recognized to be generally considered by courts in determining reasonableness.[21] An unlimited covenant in terms of duration or area is surely to be considered unreasonable and void.[22] Justifications for the covenant such as the harm caused to the employer in the absence of a non-competition requirement are taken into consideration. On the other hand, the economic hardships from which the employee suffers as a result of the contractual limitation are also considered. Further, the court takes into account the employee's ability to continue supporting himself and his next in kin. Finally, the public interest is also weighed.[23] Courts also carefully consider the reasons for the employer to insist on a noncompetiton clause. The list of justification, as described already decades ago, is long and includes: the employee's relations with his employer's customers in terms of good will that might be attributed to the employee[24] in the future, the acknowledgement of the employer's business methods and customer lists,[25] and the protection of the employer's geographical area in which he is doing business.[26]

The Fundamentals of the Legal Analysis of Restrictive Covenants

In the absence of a non-competition clause, a person who leaves his job, is generally entitled to compete with his former employer by himself or by working for a competitor. However, such competition may not misappropriate trade secrets or confidential information acquired during the period of employment.

When there is an explicit clause that forbids the employee from working for a competitor, the courts regard such a restriction with suspicion. The courts explain their disfavor to non-competition clauses on various grounds. For one, the court argues that clauses are written by the employer for his benefit without due economic compensation to the employee.[27] Put differently, courts sometimes argue that the covenants are not priced. This may be the result of unequal bargaining power, irrational bias that results in underestimation of future events or due to an asymmetric information problem. This consideration is also mentioned in the Restatement (Second) of Contracts sec. 188 comment g: "Post-employment restraints are scrutinized with particular care because they are often the product of unequal bargaining

[17] 53 Pa. 467 (1866).
[18] *Ibid* at 470.
[19] Kitten and Reams, *supra* note 1.
[20] Novelty Bias Binding Co. v. Shevrin, 342 Mass. 714, 175 N.E. 2d 375.
[21] Kutten & Reams, *supra,* note 1.
[22] Paramount Pad. Co. v. Baumrind, 4 N.Y.2d 393, 175 N.Y.S. 2d 809, 151 N.E.2d 609 (June 1958). In that case the court held that contract between company and former employee under which he was not to solicit, as a salesman, Directly or indirectly, company's customers for a period of three years in consideration for payment to him of $3,000 and he was not to divulge names of company's customers and was to obtain written permission of company before he could accept any position in the industry in which company was engaged, unreasonably prevented former employee from pursuing his occupation where no harm would come to company, and imposed restrictions exceeding degree of protection to which company was entitled in order to preserve its legitimate interests, and contract was contrary to public policy and action could not be maintained for its breach nor for inducing its breach.
[23] Alltight Auto Parts Inc. v. Berry, 219 Tenn. 280, 409 S.W.2d 361 (Nov. 1966). In that case the court held that an agreement prohibiting a former employee from competing in the automobile parking business with former employer for a period of five years in any city in which former employer operated was unreasonable and unenforceable, in view of fact area encompassed in the prohibition was beyond that necessary to shield former employer from unfair competition, former employee having been employed as manager of employer in only three of the 46 cities in which former employer operated. The court explained that among the elements which should be considered in ascertaining reasonableness of an agreement not to compete are the consideration supporting the agreement, the threatened danger to the employer in the absence of such an agreement, the economic hardship imposed on the employee by such a covenant, and whether or not such a covenant would be inimical to public interest.
[24] Silver v. Goldberger, 231 Md. 1, 188 A. 2d 155 (Feb. 1963). Employer, an operator of employment agency, was held not to be entitled to enforce restrictive covenants in employment contracts barring employees from engaging in a competing business for two years after termination of employment. The court determined that there is no justification for restraint where a former employee does no more than become an efficient competitor of his former employer, and does not do so by exploiting his personal contacts with customers or clients of his former employer.
[25] Donahoe v. Tatum, 242 Miss. 253, 134 So. 2d 442 (Nov. 1961). The court found that a covenant not to compete with his employer after that employment terminated was reasonable and that there would be no undue hardship on employee, and disclosed no tendency toward monopoly. The evidence proved to the court that Mrs. Donahoe, an employment counselor, who contracted to forbear from competition in Hinds County for five years. Working as a personnel advisor, she was exposed to confidential information, business methods and trade secrets were revealed to her by her former employer, an employment agency. The former employer has suffered, and may suffer in the future, substantial harm if she is permitted to violate the contract.
[26] Orkin Exterminating Co. v. Dewberry, 204 Ga. 794, 51 S.E.2d 669 (Jan. 1949). An exterminating company's contract of employment whereby employee agreed not to engage in pest control business or take away employer's customers for one year after termination of contract within 75 mile radius of specified cities, was reasonable as to time limitation but unreasonable and invalid as to territorial limitation. In that case the limitation practically covered the entire state of Georgia and included areas where employer merely anticipated doing business in future.
[27] *See* Reading Aviation Service, Inc. v. Bertolet, 454 Pa. 488, 311 A.2d 628 (1973).

power and because the employee is likely to give scant attention to the hardship he may later suffer through loss of his livelihood. This is especially so where the restraint is imposed by the employer's standardized printed form."

Moreover, courts often consider agreements not to compete a restraint on trade to the detriment of social welfare and find them to be a limit on the right to earn a living.[28] Further disfavor towards restrictive agreements arises because courts argue that these "agreements" have special negative implications since employees become trapped in the relations with their employers.[29]

On the other hand, courts have also realized that non-competition covenants serve useful societal purposes. Courts argue that these covenants encourage employers to provide trade secret information to their employees and prevent employees from gaining an unfair competitive advantage over their former employers. In turn, the employer may increase his overall investments and the investment in the employee's training specifically.[30] Therefore, many jurisdictions enforce such covenants to the extent that they are reasonable in relation to the need of the employer seeking enforcement, the hardship caused to the employee and the effects the covenant has on the public's interests as a whole.

In essence, the enforcement of restrictive covenants represents a balance between two competing interests: protecting the incumbent employer from unfair competition that exploits the employer's investment and the right of an individual to the unhampered pursuit of his occupations and livelihoods for which he is best suited.[31] The question of reasonableness of the restriction is a question of law and not a matter for the determination of the jury as a factual issue.[32]

The Different Approaches Among the States

State law purely governs an action for breach of covenants not to compete.[33] Ad hoc equity justifications usually determine the result of the case at hand, but the level of tolerance of the various states to non-competes is possible to identify and will be further described.[34]

As illustrated in the discussion of the history of restrictive covenants, the courts generally disfavor non-competition covenants. However, the particular approaches vary from state to state. The reasonableness criterion is used by most states evaluating agreements, but its interpretation differs among states.

There are also differences in the legal treatment that is employed once a non-competition clause is found problematic. Some states draw a clear line between a valid covenant and one that is void, while others call for a judicial modification of unreasonable covenants not to compete. Courts that refuse to modify the restrictive agreement claim that partial enforcement is in effect a judicial rewriting of the contract.[35] They also proclaim that modification, rather than invalidation, would encourage employers to include a broader than necessary non-competition agreement requiring the employee to incur litigation costs in order to narrow the restrictions.[36]

Roughly speaking, courts may apply one of the following rules when analyzing a covenant that restricts competition:

- **An All or Nothing Rule:**
  Courts applying this rule either wholly invalidate the covenant or validate it "as is."[37]
- **The "Blue Pencil" Rule:**
  Courts applying the "blue pencil" rule enforce a non-competition clause on a partial term. The court may strike out a phrase to turn the agreement into a reasonable restraint, and thus are arguably not considered to be rewriting the contract.[38]
- **The Rule of Reasonableness of the Interpretation:**
  This legal doctrine allows the court to rewrite the contract. Once the restriction is determined to be unreasonable, the court will rewrite the contract so there is a reasonable degree of restraint.[39]

While a "blue pencil" rule merely allows the court to strike out phrases in the contract, the rule of reason allows the court to amend the contract until it reaches the reasonableness level. Put differently, while a rule of reason may add a limitation on a certain overly broad restriction, the blue pencil rule may only erase the overly broad sections of a restrictive clause (while other restrictions remain valid). The "all or nothing" rule, on the other hand, will immediately invalidate the entire restrictive clause upon a determination that only part of it is too broad and unreasonable.

A representative sample of the States' current legal views in regards to covenants not to compete follows in alphabetical order. The sample contemplates the wide spectrum of attitudes among the different states.

Alabama

Alabama's statute[40] specifically limits certain employee non-competition agreements:[41]

[28] W. Miller Const., Inc. v. Schaefer, 298 N.W. 2d 455, 458 (Minn. 1980): "We have consistently taken a cautious approach to the question whether to permit an employer to enforce a restrictive covenant in an employment contract. Such covenants are looked upon with disfavor because their enforcement decreases competition in the marketplace and restricts the covenantor's right to work and his ability to earn a livelihood."
Josten's Inc. v. Cuqiet, 383 F. Supp. 295, 299 (E.D. Mo. 1974):"A covenant that serves primarily to bar an employee from working for others or for himself in the same competitive field so as to discourage him from terminating his employment is a form of industrial peonage without redeeming virtue in the American economic order".

[29] Fidelity Union Lefe Ins. Co. v. Protective Life Ins. Co., 356 F. Supp. 1199, 1202 (N.D. Tex., 1972).

[30] Winston Research Corp v. Minnesota Mining & Mfg. Co. 350 F. 2d 134 (1965). *Also see* Schulman, *An Economic Analysis of Employee Non-competition Agreements*, 69 Denver U.L.R. 97 (1992).

[31] Kutten & Reams, *supra* note 1, at 15; Wexler v. Greenberg 399 Pa. 569, 160 A. 2d 430, 434 (1960).

[32] Palmer v. Chamberlin (Ca.5 La.) 191 F.2d 532, 27 A.L.R. 2d 416 (5 Cir. La.) (1951).

[33] Fry v. Layne-Western Co. (Ca.8 Mo) 282 F.2d 97 (1960).

[34] Kutten & Reams, *supra* note 19, at 37.

[35] Phillip G. Johnson & Co. v. Salmen, 211 Neb. 123, 317 N.W. 2d 900 (1982) at 317 N.W.2d 905.

[36] Phoeniz Orthopaedic Surgeons Ltd. V. Peairs, 164 Ariz. 54, 790 P.2d 752, 1990 Ariz. App. LEXIS 323.

[37] *See* Peter Panken, Employment and Labor Law, 23 (8th ed., 1998, ALI-ABA) Howard Schultz & Associates, Inc. v. Broniec (1977) 239 Ga. 181, 236 S.E.2d 265.

[38] Hartman v. W.H. Odell and Assocs. Inc. 450 S.E.2d 912, 920 (N.C. Ct. App. 1994).

[39] Baxter Intern. Inc. v. Morris, 976 F.2d 1189, 1992 U.S. App. LEXIS 25486 (8th Cir.). *See also* The Phone connection, Inc. v. Harbst, 494 N.W.2d 445 (Iowa App. 1992).

[40] Ala. Code §8-1-1 (Michie 1993).

Sec. 8-1-1-(1975) voids any contract restraining business, except in specific circumstances.

1) Every contract by which anyone is *restrained* from exercising a lawful *profession, trade or business* of any kind otherwise than is provided by this section is to that extent *void*. (emphasis added)
2) *One who sells* the good will of *business* may agree with the buyer and *one who is employed* as an agent, servant or employee *may agree* with his employer to refrain from carrying on or engaging in a *similar* business and from carrying on or engaging in a similar business and from *soliciting* old customers of such employer within a *specified county*, city or part thereof *so long as* the buyer, or any person deriving title to the good will from him, or employer carries on a like business therein. (emphasis added)
3) Upon or in anticipation of dissolution of the *partnership, partners may agree* that none of them will carry on a similar business within the same county, city or town, or within a specified part thereof, where the partnership business has been transacted. (emphasis added)

The Alabama court was willing to apply the "blue pencil rule", and narrowed the scope of overly broad restrictions.[42] Emphasis should be put on the omission of the word "profession" restraint from subsection (2) which validates covenants that qualify the requirements. The court interpreted this as an indication for a legal invalidation of restraints of professionals' employment. Thus, Alabama's courts, in some cases, found physicians[43] and accountants[44] to be professionals, but not bankers,[45] insurance salesmen[46] and marketing vice presidents.[47]

The courts of Alabama, in a line of cases, announced their disfavor to restraints upon an individual's employment in any manner. The court requires the employer to have an interest reasonably protected in the restriction and reasonably limited in place and time, without causing undue hardship to the employee.[48]

Alaska

There is no state statute governing the issue of covenant not to compete in Alaska. The court considers the reasonableness of the contractual limitation, according to the geographical boundaries of the limitation, its length in time, as well as the effect of restricting the employee's mobility on competition in the relevant market.[49]

Arizona

In Arizona there is no governing statute dealing with covenants not to compete. Again, the court examines the reasonableness in time and space, the legitimate interest of the employer, the rights of the employee and public policy considerations such as competition and mobility of employees.[50]

California

California is the best example for harsh mandatory restraints on anti-competitive covenants.[51] California has a fierce statutory prohibition on non-competition covenants. Section 16600 of the California Business and Profession Code[52] states:

> "Unauthorized contracts: Except as provided in this chapter, every contract by which anyone is restrained from engaging in a lawful profession, trade, or business of any kind is to that extent void".

In *Application Group, Inc.* the court determined that an employer who uses an unlawful, and therefore, void, restrictive covenants in employment law can be found to be conducting unlawful business practices according to California Unfair Practices Act § 17200 *et seq.*

Authorized restrictions are very limited. California's courts enjoin a former employee from competing, on equity grounds, if it finds unwarranted disclosure of trade secrets[53] or if the covenant is required to prevent unfair competition.[54] Gilson explains that California adopted the UTA (now called the UTCA), but that litigation is "expensive and slow", and involves great "uncertainty associated with a jury trial of

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[41] Covenants Not to Compete in Alabama: Revisited, 53 Ala. Law, 180 at 18 (1992).

[42] *See Ex parte Caribe, U.S.A., Inc. v. Caribe, U.S.A., Inc.*, 702 So. 2d 1234 (1997), in which the court narrowed a five year restrictive agreement to three years.

[43] Associated Surgeons, P.A. v. Watwood, 295 Ala. 229, 326 So. 2d 721 (1976).

[44] Burkett v. Adames, 361 So. 2d 1, 3 (Ala. 1978).

[45] Central Bank of the South v. Beasley, 439 So. 2d 70 (Ala. 1983).

[46] Hoppe v. Preferred Risk Mutual Ins. Co., 470 So. 2d 1161 (Ala. 1983).

[47] Parker v. EBSCO Indus. Inc. 282 Ala. 98, 209 So. 2d 383 (1968).

[48] Calhoun v. Brendle Inc. 502 So. 2d 689, 691 (Ala. 1986). *See* also *Central Bancshares of the S. v. Puckett*, 584 So. 2d 829, 831, 6 (Ala. 1991).

[49] *See* Data Mgmt. V. Greene, 757 P.2d 62,65 (Alaska, 1988) and *Wirum & Cash, Architects v. Cash*, 837 P.2d 692, 711 (Alaska, 1992).

[50] *See* Oliver / Pilcher Ins. v. Daniels, 148 Ariz. 530, 715 P.2d 1218, 1220 (1986) and Phoenix Orthopaedic Surgeons v. Peaairs, 790 P.2d (Ariz. Ct. App. 1989). *See also* Hile, Rogal and Hamilton Company. Of Ariz. V. McKinney, 946 P.2d 464 (Ariz. Ct. App. 1997).

[51] A more laxed approach has been apparent in the context of the sale of a business, subjecting restrictive covenant in that context to the reasonableness test. *See Monogram Indus. v. SAR Indus.*, 64 Cal. App. 3d 692, 697-98, 134 Cal. Rptr. 714, 718 (1976).

[52] Cal. Bus. & Prof. Code §16600-16602.5 (Bancroft-Whitbey 1992 & Supp. 1995).
A partnership agreement requiring a geographic limitation on competition has been enforced in accordance with section 16602: "Any partner may, upon or in anticipation of a dissolution of the partnership, agree that he will not carry on a similar business within a specified county or counties, city or cities, or a part thereof, where the partnership business has been transacted, so long as any other member of the partnership, or any person deriving title to the business or its goodwill from any such other member of the partnership, carries on a like business therein". In *Howard b. Babcock*, 6 Cal. 4th 409, 415-26, 863 P.2d 150, 154-61 (Cal. 1993) the court found the partnership exception applicable to lawyers.
The 1995 supplement, effective Sept. 30, 1994, states an exception to the statutorial restriction on covenant not to compete, in the context of a dissolution of a limited liability company: "Any member may, upon or in anticipation of a dissolution of a limited liability company or a sale of his or her or its interest in a limited liability company, agree that he or she or it will not carry on a similar business within a specified county or counties, city or cities, or a part thereof, where the limited liability company business has been transacted, so long as any other member of the limited liability company, or any person deriving title to the business or its goodwill from any such other member of the limited liability company, carries on a like business therein".

[53] Ruvolo & Kaschnitz, *The dreaded 'Scott' Decision – The Status of Enforcing Non-Competition Covenants in California*, Fracise L.J. 45 (Fall 1992).

[54] *Metro Traffic Control, Inc. v. Shadow Traffic Network*, 22 Cal. App. 4th 853 (1994).

technical issues".[55] Therefore, Gilson argues that "on balance, trade secret law does not provide a significant barrier to high velocity employment and, at least in California, it apparently has not."[56] Gilson also argues "actions in response to theft and industrial espionage…are not subject to the same level of ambiguity associated with efforts to restrict employee mobility. Significant protection is provided against departing employees in circumstances where the misappropriation is clear (as when the former employee has removed or copied document), the technology obviously is confidential, and the damage to the business substantial."[57] He continues to argue that "it remains the case that protection is limited". With no evidence as required by the act, the California court offers no remedy to the employer.

The California courts have rigorously enforced section 16600, invalidating agreements that an employee will not work for a competitor upon completion of his or her employment.[58] Thus, a federal court emphasized that "section 16600 should be interpreted as broadly as it reads"[59] and refused to apply a rule of reason in interpreting a covenant restraining competition under section 16600.[60]

Colorado

Colorado Rev. Stat. §8-2-113(2) and (3)[61] sets a general prohibition on non-competition agreements in employment, with exceptions in regards to non-competition covenants in the following:[62]

1) The sale of a business;
2) The protection of trade secrets (but not to an extent that it restricts employment, beyond such protection);
3) The recovery of training expenses if the employer terminates employment within two years of employment (but the covenant ceases upon repayment of these expenses);
4) The contract entered into by management personnel and their professional staff [63] (if the employee has the "knowledge, skills or license for the successful conduct of business and is a significant factor involved in the business);[64]

Non-competition covenants restricting physicians from practicing medicine are unenforceable under subsection (3) of the Colo. Rev. Stat.; however, payment of damages for a breach of such agreement is attainable under this subsection.

Non-competition agreements that may be validated under the Colorado statute will be judged according to common law tests.

Under the Colorado statute, the reasonableness of any covenant is analyzed using a two-step approach, taking into consideration the specific circumstances of the case. First, a covenant must justifiably protect a valid interest of an employer. Second, the specific covenant must be reasonable. Knowledge of trade secrets and confidential information, relations with customers and knowledge of their needs were considered a valid interest of an employer. Special training of the employee, as well as the fact that the employee may be a key employee also support the reasonableness of a non-competition agreement. So is the mere fact that the employer's business is highly technical and competitive.[65]

Once the court determines the issue of reasonableness, it either grants an injunction or denies one. It thus employs the "all or nothing" rule rather than the "blue pencil" or "rule of reasonableness in interpretation".[66]

Interestingly, Colorado courts refuse to enforce the non-competition agreement if there is no deliberate[67] breach, and if there is a good faith attempt by the employee to remove any indications of his prior affiliation with the former employer. They also do not enforce a restrictive covenant that is not limited geographically or in time.[68] On one occasion, the Colorado court struck down a 50 percent liquidated damages clause for a period of two years in an anesthesiologist's practice.[69]

Louisiana

Non-competition agreements are not favored in Louisiana. They are viewed as being against public policy unless provided otherwise by the statute.[70] Notwithstanding the statute[71], Louisiana courts enforce non-competition covenant in order to protect customer lists (other than by memory) and

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[55] Gilson**,** supra note 8 at 28, 29.
[56] Gilson, *supra* note 8, at 32.
[57] Giloson, *ibid*, note 8 at 32.
This seems to imply that the mobility in those cases is not overall socially efficient, but is merely a distribution matter from the former employer to the new one.
[58] R. Mainland, Contracts Limiting Competition by Former Employees: A California Law Perspective, 340 PLI/Pat 119, 123.
[59] However, in *General Commercial Packaging, Inc. v. TPS Package Eng'g, Inc.*, 126 F.3d 1131, 1132-34 (9th Cir. 1997), the court enforced a one year non-competition agreement between a contractor and its subcontractor that proscribed the subcontractor from directly providing work for any othe contractor's clients because the agreement did not preclude the subcontractor from "engaging in its trade or business"). *See* Karen E. Ford, Kerry E. Notestine, Richard N. Hill, Fundamental of Employment Law (2nd ed., 2000).
[60] Scott v. Snelling and Snelling, Inc., 732 F. Supp. 1034, 1042 (N.D. Cal. 1990).
Also see Ware v. Merrill Lynch, Pierce, Fenner & Smith, Inc,, 24 Cal. App. 3d Cal. App. 3d 35, 100 Cal. Rptr. 791 (1972), Trade Cases P 74, 136 (Cal. App. 1 Dist., March 1972) (invalidating under section 16600 a profit sharing clause forfeiting a former employee's benefits if he engaged in a competitive occupation; Muggill v. Reuben H. Donnelley Corp., 62 Cal. 2d 239, 42 Cal. Rptr. 107 (1965) (refusing to enforce a retirement plan provision terminating annuity payments of retired employee who enters competitive business). Beneficial Life Insurance CO. v. Knobelauch, 6533 F.2d 393 (9th Cir. 1981) (invalidating a provision of an employment contract requiring the departed employee to repay advances upon entering a competing business).
[61] Colo. Rev. Stat. § 8-2-113(2) and (3) (Bradford 1986) Repl. Vol. 3B.
[62] Colo. Rev. Stat. § 8-2-113-(2) and § 8-3-13-(3) (1984 Pocket Supp.). *See* Powers, *Drafting Noncompete Covenants: Statutory and Common Law Constraints*, 13 Colo. Law Rev. 757 (1984).
[63] Legal, engineering, scientific and medical personnel as well as their junior staff: Porter Industries Inc. v. Higgins, 680 P.2d 1339, 1342 (Colo. App. 1984).
[64] Powers, supra note 50 at 762.
[65] Kutten & Reams, supra note 1, at 44.
[66] See page 12.
[67] The terms "deliberate" and "clear" breaches are very vague. Moreover, it seems that the intent of the employee should not play a significant role, unless the employee had such intent at the time he signed it.
[68] Management Recruiters of Boulder v. Miller, 762 P. 2d 763, 766, 3 IER cases 1265 (Colo. App. 1988).
[69] Wojtowwicz v. Anesthedia Services, P.C., 961 P.2d 520 (Colo. App. 1998).
[70] LaFourche Speech & Language Servs. Inc. v. Jucket, 652 So. 2d 679, 680 (La. App. 1 Cir. 1995).
[71] La. Rev. Stat. Ann. 23:921 (West Cum. Supp. 1994) and 1989 La. Acts, No. 629 §1.

trade secrets. However, if the termination of the employment is without cause, the restriction is frequently not enforced.[72]

Any territorial protection is limited to two years.[73] The Louisiana statute explicitly requires investment on behalf of the employer to justify the employer's protection.[74] However, consideration paid for the employment was determined to suffice for such proof.[75]

Massachusetts

Massachusetts is an example of a state that is quite permissive regarding non-competes. In Massachusetts there is no state legislation that governs the enforceability of covenants not to compete. Case law uses the guidelines of the restatement, discussed in the next section, in enforcing these covenants.

Massachusetts's courts enforce covenants to the extent that they are reasonable to protect the legitimate business interests of the former employer.[76] Of the ten decisions on preliminary injunctions to enforce a covenant not to compete between February 1994 and July 1996, injunctions were granted in eight.[77] Legitimate business interests that may justify restrictions on competition include trade secrets, confidential data, and goodwill (generally applied to customers relationships).[78] The court enforces restrictions it finds to be reasonable. The courts apply the "rule of reasonableness in interpretation" to reduce the impact of the restrictions in order to make the covenant enforceable.[79] The courts are not bounded by the blue pencil doctrine nor by the "all or nothing" in making covenant enforceable. Hence, in *Kroeger v. Stop & Shop Cos*. the trial court modified an overbroad covenant that, as written, purported to bar a former employee from competing anywhere east of the Mississippi River, except for designated states. The court modified the covenant to allow the former employee to work in New England, New Jersey, and New York – areas in which the employer had never operated. The court also modified the time term, which purported to restrict the employee for life, by reducing the covenant's proscriptive period to 1 year.[80]

Montana

Montana law generally voids any contract by which anyone is restrained from exercising a lawful profession, trade or business of any kind.[81] Trade secrets and confidential information, however, are protected to the extent they are inaccessible to others. Customer lists are considered confidential if it was purposely memorizes or otherwise copied. However, if using such information is not in violation of the former employer's confidence, the court will not enforce the restriction.[82]

In the case of *Best Dairy Farms, Inc. v. Houchen*[83] the court refused to issue an injunction against an employee who solicited customers, because information was accessible to the public. This policy was later followed in the case of *First Am. Ins. Agency*,[84] with a further explanation that the information was part of the employee's general knowledge gained through employment. However, in the case of *Dequire & Tucker v. Rutherford*,[85] the court upheld a liquidated damages provision, claiming it did not restrain the employee from engaging in public accounting or from using confidential information obtained during the course of the employment.

Nevada

Nevada Revised Statute §613.200 does not generally forbid non-competition agreements. However, such agreements may only result in a damages award.[86] The statute is applicable only in regards to those seeking employment with others, and not to those who enter competition via self-employment. The rule of award of damages as the remedy and the absence of injunctive relief are exceptions to the legal practice of other states. However, when self-employment is at hand, the statute does not limit the remedy to damages.

Nevada Revised Statute §598A.010-280 make up the Nevada Unfair Trade Practices Act (NUTPA), which prohibits restrictions on trade, presumably including unreasonable restrictive covenants.[87]

New York

In New York there is no legislation that governs the enforceability of covenants not to compete. In the 1847 codification, David Dudley Field, was charged to revise, reform, simplify and abridge the rules of the courts of record of the state.[88] While a revolutionary civil procedure code was promptly enacted, the Civil Code Field produced, was never enacted due to controversies associated with it. Interestingly, his proposed New York Civil Code was adopted in California.[89]

In New York, an employer has a legitimate interest in protecting its trade secrets and confidential customer information.[90] The court also protects goodwill of the employer's business and relief may further be available where an employee's services are unique or extraordinary, such as the way he sings.[91] To be enforced "the anticompetition covenant in employment contracts will be enforced only if they are geographically and temporally reasonable, and then only to

[72] Neeb-Kearney & Co.v. Rellstab, 593 So. 2d 741, 749, 594 So. 2d 1321 (La. 1992).
[73] Cellular One, Inc. v. Boyd, 653 So. 2d 30,33 (La. App. 1995).
[74] Orkin Extreminating Co. v. Foti, 302 So.2d 593 (La. 1974).
Chalmers Corp. v. Carnell, 479 So. 2d 990 (La. App. 1985).
[75] Allied Bruce Terminiz Co., Inc. v. Guillory, 649 So. 2d 652, 653 (La. Aoo. 3 Cir. 1994).
[76] Shipley Co. v. Clark 728 F. Supp. 818,826 (D. Mass, 1990).
[77] Gilson, supra note 8.
[78] Kroeger v. Stop & Shop Cos, 13 Mass. App. 310, 432 N.E. 2d 556 (1982); Middlesex Neurological Assocs. V. Cohen, 3 Mass. App. 126, 324, N.E.2d 911 (175).
[79] P. J. Richey, Covenants Not to Compete, A State by State Survey, 300.
[80] S. App. 310, 432 N.E.2d 566 (1982).
[81] Mont. Code Ann. §28-2-703-704 (1995).
[82] First Am. Ins. Agency v. Gould, 661 P.2d 451, 454 (Mont. 1983).
[83] 152 Mont. 194, 448 O.2d 158, 160 (1968).
[84] *Supra*, note 82, at 453.
[85] 708 P.2d 577 (Mont. 1985).
[86] Nevada Revised Statute §613.200.
[87] *See* Ford et al, *supra* note 59. For the unreasonableness test, *see* Comco, Inc. v. Baker, 936 P.2d 829, 832 (1997).
[88] Gilson, *supra* note 8**,** at 48.
[89] It was in Section 833 of Field's proposed New York Code, adopted by the California legislature in 1872, that we find the precursor of Business and Professions Code section 1660.
[90] Orkin Exterminating Co. v. Dayton, 140 A.D.2d 748, 749, 527 N.Y.S.2d 883, 884 (1988); Primo Enter v. Bachner, 148 A.D.2d 350, 351, 539 N.Y.S.2d 320, 321 (1989).
[91] Walter-Karl Inc. v. Wood, 137 A.D.2d 22, 27, 528 N.Y.S.2d 94, 97-98 (1988).

the extent they are necessary to protect the employer from unfair competition resulting from the use of trade secrets or confidential customer lists."[92]

North Carolina

Section 75-4 of the North Carolina Code[93] deals with non-competition clauses in employment. The statute requires that the agreement be in writing, reasonable in time and territory, ancillary to the employment contract, based on valuable considerations, protect legitimate interests of the employer[94] and not be against public policy.[95] Customer lists, price lists, "hard knowledge" of process and research as well as development information may all be considered legitimate employer's interests according to North Carolina. So is the knowledge of employer's contacts with customers. In the case of *Whittaker Cen. Medical Corp. v. Daniel*,[96] the court determined that it would not rewrite or enforce an overly broad non-competition agreement.[97] However, the court further announced that if the contract were separable the court would enforce the reasonable provision.

North Dakota

North Dakota Cent. Code sets a broad prohibition on non-competition covenants in employment.[98] In 1993 the North Dakota court extended this policy. In the case of *Werlinger v. Mutual Service Casualty Ins*. Co. the court found the contract restrained the employee from competing by requiring that he "purchase the freedom to compete...by forfeiting money that MSI would otherwise pay him" and therefore invalidated it.[99]

Oregon

Chapter 653.295 of Oregon's Revised Statute enforces specific restraints on trade (limited specialization within the profession, limited geographic area and period of time, specific customers), while it refuses to do so in regard to general restraints (restricting any job within the profession in general – e.g. working as a computer engineer in high tech and not only in the semiconductors field)[100]. Consideration of employer's interests, the reasonable limitation of the restriction, as well as public interest are all weighed. The court is also ready to modify a covenant that extends the restraint beyond reasonable limits.

In Oregon, consideration supports a covenant not to compete that is executed upon initial employment, at the time of the commencement of work.[101] In *Pacific Veterinary Hosp. P.C. v. White*[102], the court determined that covenants initially entered into upon employment, but subsequently modified are void.

Wisconsin

Under the language of the Wisconsin statute[103] unreasonably broad covenants not to compete are void. Public interest is considered unaffected as long as the constraint does not stifle competition, create a monopoly, or create a shortage of employee.[104] Any restrictive covenant imposing an unreasonable restraint is illegal, void and unenforceable and the court determined that the act prohibits the "blue pencil" rule.[105]

The Reasonableness Standard

In evaluating the reasonableness of the restraint, courts consider multiple aspects of the particular case at hand. While the specific state law determines the state's approach, as discussed above, the guidance of the Restatement of Contracts sheds light on the list of issues that are considered.[106] Roughly speaking, the reasonableness test can be framed by three questions aimed to uncover the nature of the contractual covenant:

1) Is it within the necessary limits to protect the employer's legitimate interest?
2) Is it not unduly harsh and oppressive on the employee?
3) Is it not injurious to the public?

The court weighs these three factors in evaluating the reasonableness of the restriction. Each of these are presented below.

The Employer's Legitimate Interests

Traditionally, the following interests were considered legitimate for protection: Trade secrets; good will; unique service by the employee and immense investment in the training of the employee.

Protection of trade secrets is based on the desire to give an enterprise proper incentive to conduct research with confidence that the trade secrets will not be revealed to competitors, unless it willfully decides to exchange ideas.[107]

The employee's duty not to disclose confidential information, which extends beyond the period of employment, is also protected by the fiduciary duty of the employee. However, a non-competition clause relieves the employer of the burden of proving that the employee's competition is detrimental to the protection of the trade secret and protects information regarding trade secrets that is not clearly confidential.[108]

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[92] Altana Inc. v. Schansinger, 111 A.D.2d 199, 489 N.Y.S.2d 84 (1985).
[93] N.C. Gen. Stat. §75-4 (Michie 1994).
[94] Hartment v. W.H. Odell and Assocs. Inc. 450 S.E.2d 912, 919 (N.C. Ct. App. 1994).
[95] Nalle Clinic Company. V. Parker, 101 N.C. App. 341, 399 S.E.2d 363, 366, 6 IER Cases 158 (1991).
[96] 523, 379 S.E.2d 824, 1989 N.C. LEXIS 299. Comment, Injunctive Russian Roulette and Employment Non-competition Cases, 63 N.C. L. Rev. 222 (1984).
[97] *Id.*
[98] N.D. Cent. Code, §9-08-06 (Michie 1987).
[99] 496 N.W.2d 26, 1993 N.D. 29.
[100] Or. Rev. Stat. §653.295 (1993).
[101] Olsten Corp. v. Sommers, 534 F. Supp. 395, 397 (D. Or. 1982).
[102] 72 Or. App. 533, 696 P.2d 570, 572.

[103] Wis. Stat. Ann. (1988) (IERM 592:11).
[104] Nalco Chemical Co. v. Hydro Technologies Inc., 984 F.2d 801, 1993 U.S. App. LEXIS 1195 (7th Cir.).
As I will describe there is a much broader spectrum of considerations that require regard, within the public interest and social efficiency.
[105] Streiff v. American Family Mut. Ins. Co., 118 Wis.2d 602, 348 N.W.2d 505, 509 (1984).
[106] Restatement (Second) of Contracts sec. 188(1)(1981).
[107] See M. Tsatalis & T. Klima, Protecting Trade Secrets from Malicious Employees, Legal Documentation for Start-Up and Emerging Companies (1997).
[108] R. Merges, P. Menell, M. Lemley & T. Jorde, Intellectual Property in the New Technological Age 89 (1997) ("In a competitive industry, preventing the disclosure of trade secrets is far preferable to suing for misappropriation after

Goodwill and customer lists are protected as proprietary interests.[109] It is intended to create an incentive to offer genuine output (service or goods) and enjoy the benefits of the goodwill thus created with the protection from the employee's competition. Otherwise, the employee may end up free riding on the investment to create the goodwill on the account of the investing employer. Professional connections, however, are considered general experience, which the employee may generally freely use.[110]

The argument of uniqueness is based on the grounds that the employer invested in the employer and is eligible not to lose an excellent employee. This is of course not a stand-alone justification, as it might punish those who succeeded without weighing the benefit to the public from the mobility of such an employee. Qualifying to be within this category are media personalities or sports.[111]

The investment in the education or training of the employee requires protection from exploitation of the knowledge he acquired to the detriment of the investor. The public interest advocates such investment that would satisfy the employer's interest and therefore the law should create proper incentives that enable recouping the investment.[112] To qualify under this exception, extensive and costly training in a specialized field is required.[113]

It should be mentioned that if the court finds that the restriction of the employer is based on the desire to constrain the use of personal skills of the employee, including his knowledge of the employers business methods ("know how"), the court would not enforce such restriction.[114]

Oppression of the Employee

Within this consideration, the period of employment restriction and the geographic area of limitation will be considered, as well as the scope of the activity limited.[115] The courts recognized that a restricting covenant not only limits the freedom of the employee's professional mobility, but also tends to reduce the employee's freedom to seek better conditions. Once the employee is limited in her choices to work elsewhere, she is at the mercy of her employer who is free to behave opportunistically towards the employee during the employment relationship.

In the sphere of high tech, the life cycle of the "knowledge" product is substantially limited, and a limitation of even merely one year may pose a major obstacle for the employee.[116]

Public Welfare

Within the public interest consideration, the court would weigh the interest of freedom of contracts, which leads to a desire for minimal intervention of the law in invalidating covenants not to compete.[117] If, for example, an employer cannot protect himself from the harm of the mobility of his employee, he might hire fewer employees and inefficient production would result. In turn, consumer welfare is reduced.

While courts in the past claimed that "restraint of employment tends to deprive the public of efficient service",[118] later courts did not find the deprivation of the employee's service to be against the public interest since in most cases, the service can be provided by someone else.[119] However, the deprivation of a public service was more likely to be realized by the court where restrictions on physicians or lawyers were at stake.[120] In the case of *Ellis v. McDaniel*,[121] for example, the court invalidated a restrictive covenant that denied the residents of Nevada their only orthopedic surgeon. Further, in the case of *Medical Specialists Inc. v. Sleweon*[122], the court held that the agreement not to compete adversely affects the public.

In the labor market for lawyers, the court may also prohibit certain restrictive covenants. In the case of *Schuhalter* the court rejected such a claim in regards to accountants, but claimed that in professions such as medicine and law, the relations "are so personal and confidential…as to prohibit restrictive covenants which impinge on the public's right of free access to the professional of its choice."[123]

Remedies Offered

Presently, courts in the vast majority of jurisdictions have placed themselves in a position where they must either grant an injunction, or invalidate the covenant. This is the primary remedy both sought and granted against breach of post-employment non-competition agreements.[124] While damages

they have already been disclosed, A noncompetitive agreement may be a reasonable way for an employer to prevent a problem – and a lawsuit – before it starts").

[109] Hitchcock v. Coker 112 E.R. (1837) 167 at 174-5.

[110] Philip Hunke, D.D.S. v. Wilcox, 815 S.W.2d 855,1991 Tec. Civ. App.LEXIS 2172.

[111] King Records, Inc. v. Brown 21 A.D.2d 593, 252 N.Y.S.2d 988 (1964) Bradford v. N.Y. Times Co. 501 F.2d 51 (2d Cir. 1974).
Moore Business Forms Inc. v. Foppiano, 382 S.E.2d 499, 1989 W. Va. LEXIS 108. ABC Mobile Brakes v. Leyland, 84 A.D.2d 914, 446 N.Y.S.2d 660(1981).
Smith, Waters, Kuehn, et al. V. Burnett, 192 Ill. App.3d 693, 548 N.E.2d 1331, 139 Ill. Dec. 617, 1989 Ill App. LEXIS 1922.

[112] P. H. Rubin & P. Shedd, *Human Capital and Covenants Not to Compete*, 10 J. Leg. Stud. 93 (1981).

[113] Nationwide Mutual Ins. Co. v. Cornutt, 907 F.2d 1085, 1990 U.S. App.LEXIS 12687 (11th Circuit).

[114] Herbert Morris Ltd. V. Saxelby 1 A.C. 688, 714 (1916) (H.L.).

[115] HCCT Inc. v. Walters, 99 Ohio App. 3d 472, 651 N.E.2d 25,27 (1994). Cox v. Simon, 278 N.J. Super. 419, 651 A.2d 476,480 (1995).

[116] Kutten & Reams, *supra* note 1, at 105.

[117] Kutten & Reams, *supra* note 1, at 107.

[118] Kadis v. Britts, 224 N.C. 154, 29 S.E. 2d 543, 546 (1944).

[119] Canfield v. Spear, 44 Ill. 2d 49, 254 N.E.2d 433, 435 (1969).

[120] Branson Ultrasonics Corp. v. Stratman, 921 F.Supp. 909, 913 (D. Conn. 1996).

[121] 596 P.2d 222 (Nev. 1979).

[122] 652 N.E.2d 517, 526 (Ind. App. 1995).

[123] Schuhalter v. Salerno, 279 N.J. Super. 504, 653 A.2d 596, 598 (1995).

[124] Michael Trebilcock, The Common Law of Restraints of Trade: A Legal economic Analysis (1986), 77. Gilson, *supra* note 8. Also see R. Meges, et al., *supra* note 108at 89: "A non-competition agreement may be a reasonable way for an employer to prevent a problem – and a lawsuit before it starts".
For examples in some states see:
Technicolor v. Traeger, 57 Haw. 116,117,551 O.2d at 166, 167 in which the court enforced a three year covenant extending throughout Hawaii protecting customer lists and pricing information. Evidence of Hardship to the employee did not invalidate the covenant.
A majority of Colorado decisions have enforced non-competition covenants (Supra, note 17 at 44). See for example Gulick v. A. Robert Strawn & Assoc., Inc., 477 P.2d 489, 492 (Colo. App. 1970). Once the reasonableness of a covenant is determined, the court will either automatically grant an injunction or deny an injunction upon an absence of any irreparable harm, but may award damages after trial.

may be granted, this remedy is used for past injuries along with the injunctive relief, if granted, and not as a remedy for itself. The existence of a liquidated damages clause is not common, though enforceable. Liquidated damages define the limit of damages recoverable for past injury,[125] and therefore parties are sometimes reluctant to limit themselves. The scope of damages may be unpredictable. Moreover, a liquidated damages clause in an employment contract may preclude the former employer from getting an injunctive relief.[126]

In regards to the employer's investment, a possible remedy to is a promissory note for the training expenses. According to the note's terms, the training expense is forgiven upon termination of employment by the employer or after the employee has worked for a certain period of time.[127] Since this note is a mechanism to enforce the covenant not to compete and is due only if the covenant is breached, the validity of the non-competition agreement is essential to the collection of the note.[128] While this is a remedy that the court is willing to accept, it is not too common for the parties to include such a consensual remedy since it is hard for the parties to evaluate the costs and benefits in advance.[129] Therefore, private parties prefer in most cases to leave the relief for ex post evaluation of the court.

In regards to the allocation of risk argument, negotiating in advance for the employer's risk of employee disclosure creates the problems of ex-ante valuation, mentioned above in regards to the investment costs, as well as liquidity constraints, thus rendering this option infeasible. Moreover, it is difficult to specify which activity exactly is constrained. A restrictive covenant can hardly be efficient in the presence of incomplete information. This is both in regards to the value of the trade secret, which is unknown until after the employment agreement has been entered into, and in regards to the estimation of the likely value of customer connections.[130]

Conclusion

Covenants not to compete frequently find their way into the courtroom. The survey conducted in this article sheds light on some of this phenomenon. Non-competes are extremely popular, but the legal restrictions on them are a vague concept. On the one hand, courts comprehensively scrutinize the private parties' intentions, but on the other hand, when a non-compete is validated, the injunction remedy is quite generously obtained.

Most of the legal restrictions are a matter of case law, developed by the courts for centuries. In some states the picture is further complicated by the existence of legislation. The prevailing legal test used by the courts to evaluate covenants not to compete is the reasonableness of the restriction test. The reasonableness of the restriction test is related to the legitimate interest of the employer, the hardship caused to the employee and the burden on the public. Each court weighs the various considerations according to its inclination, which hampers predictability and makes the work of practitioners extremely hard.

In Florida the court either found the restrictive agreement overly broad and unenforceable, (and did not award damages) (Cherry, Bakaert & Holland v. LaSalle, 413 So.2d 436, 438 (Fla. Aoo. 1982) or modified it to be enforceable: Pinch-A-Penny of Pinellas County v. Chango 557, So. 2d 940, 1990 Fla. App. LEXIS 1431 and Santana Prods. Co. v. Von Korff, 573 So. 2d 1027 (Fla. App. 2d Dist. 1991), 1991 Fla App. LEXIS 683.

[125] J.G. Collins Ins. Agencies Ltd. V. Elsley 2 S.C.R. 816, 928 (1978) (S.C.C.)

[126] Kutten and Reams, note 1 at 237.

[127] Ward, *Firms Forcing Employees to Repay Some Costs If They Quit Too Soon*, Wall St. J. (July, 1985) 29.

[128] Philip Hunke, D.D.S. v. Wilcox, 815 S.W.2d 855, 1991 Tex. Civ. App. Lexis 2172.

[129] Though the freedom itself is obviously important for preventing his exploitation by the employer who knows that the employee is "stuck" with him whether or not he will promote him, increase his salary, etc.

[130] M. Trebilcock, *supra* note 124, at 124.

Litigation Economics Review
Volume 5, Number 1: 11-18

Employee Stock Options as a Source of Compensation

Steven J. Shapiro and Matthew L. O'Connor

Abstract

Employee stock options (ESOs) have become a significant fringe benefit, particularly for salaried professionals. ESOs allow an employee to purchase shares of stock at a fixed price over a specified time horizon. This paper discusses key issues that arise in valuing stock options within a litigation environment and suggests that the Black-Scholes Model with minor adjustments can handle many situations.

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We wish to acknowledge George Schieren, Barry Ben-Zion, Edward Mathis and anonymous referees for their comments on various drafts of this paper.

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It has become commonplace for both middle and upper level executives to receive employee stock options as a fringe benefit from their employer.[1] Typically, such stock options allow individuals to purchase a specific number of shares of their employer's stock at a specified exercise price (also known as the "grant price" or the "strike price"), which is usually equal to or less than the market value of the stock on the date of issue.

Within the litigation setting, it is possible to encounter a variety of applications that require the valuation of employee stock options. In the divorce and probate settings, an analyst may need to value existing employee stock options. In personal injury, wrongful death, and employment termination cases, it may be necessary to forecast losses resulting from forced early exercise of existing options. In addition, when calculating full damages resulting from loss of earnings, it may be necessary to forecast and include the value of expected stock option grants, in the absence of injury, death or wrongful termination.

Valuation techniques for traded stock options are numerous and well documented.[2] However, employee stock option valuation requires special consideration. Key differences between employee stock options and traded options are:

> Employees cannot transfer or sell company stock options that have been granted to them;

[1] For example, Murphy (1998) reports that for a sample of 1,000 publicly traded companies over the period from October 1992 through June 1993, 67.2 percent granted options to their CEO.
[2] See for example, Hull (2000).

Tradable American style listed call options can be exercised at will, while employee stock options may have vesting restrictions;

Employee stock options are either exercised or terminated when the employee leaves the firm;

Employee stock options may have different tax liabilities; and

Employee stock options have a much longer time to expiration from date of issue (usually ten years) compared to listed call options that generally expire in at most six months from date of issue.

No general ESO valuation theory has resolved these problems. For these reasons, some practitioners use an intrinsic value approach. We argue that the intrinsic value approach fails to capture key components of option prices. We argue that within the litigation framework, a better approach is to modify known tradable option valuation formulas. These differences affect employee stock option valuation, requiring modification to the analytical models and/or parameters that are appropriate for tradable options.

This paper presents an approach to employee stock options valuation that is theoretically grounded, yet tractable enough to be useful in a litigation environment. The discussion focuses on valuation methodology, with examples related to both existing options, and the projection and valuation of future option grants by public companies.

Valuation Methodology

Terminology and Characteristics of Employee Stock Options

Unique characteristics of ESOs differentiate them from standard tradable options. Employee stock options are generally granted with an exercise period that is up to ten years from the date of issue. Typically, a vesting period restricts exercise over the first several years of the option grant. Employee stock options vary as to whether 100 percent vesting occurs after a certain number of years, or whether there is proportional vesting of the options occurring over a period of time. An option cannot be exercised until it is vested.

For tax purposes, employee stock options can be categorized as either incentive stock options or nonqualified options. When the employee exercises an incentive stock option, the employee does not have to recognize either the option grant or exercise as ordinary income for tax purposes. The employee is taxed solely on the capital gain following the sale of the actual shares of stock with the exercise price as the basis. However, there is the possibility of an alternative minimum tax liability on the difference between the value of the stock on the day that the option is exercised and the option exercise price. Nonqualified options are taxed twice: first as ordinary wage income in the first year that the option is vested and second as capital gains following the sale of the stock.[3] The capital gains tax is paid on the difference between the market price and the option exercise price the day that the option is exercised. Internal Revenue Service regulations govern the tax treatment of employee stock options and the extent to which companies can issue incentive stock options as opposed to nonqualified options.

Employee stock options are nontransferable. Normally, when an employee is terminated or voluntarily leaves the company, the employee has to exercise the option by the date of separation or else forfeit the option.[4] When an employee is terminated or leaves a company voluntarily, there is no opportunity to exercise unvested options. In the case of the death of an employee, some companies allow for the decedent's next-of-kin to hold the option until date of expiration. Companies may also allow retirees to keep their options until they expire. Typically, employee stock options are issued with a strike price either at or below the current market price of the company's stock. The strike is established at the time of grant. As a result, the option has no direct value to the employee unless company's stock price increases. To illustrate, assume that a firm issues an employee an ESO to buy 500 shares of his/her company's stock at $50.00 per share. At the time of issue, the price of the company's stock is $50.00 per share and a one-year vesting period is required before exercise is allowed. Suppose that over the next year the stock appreciates by ten percent to $55.00. With the vesting period met, the employee may exercise the option to buy 500 shares of stock for $50.00. The shares may then be sold for $55.00 per share, generating a $2,500 profit.[5] If on the other hand, the stock price falls to $45.00 per share, the executive would not exercise the option because he or she could purchase stock at $50.00 per share when it has a market value of only $45.00.

Intrinsic vs. Actual Value

No general theory of ESO valuation handles all the problems associated with long times to maturity, vesting, nontransferability, and tax liability. For this reason, many practitioners have used an intrinsic value approach in the litigation environment.

If K is the exercise price when the ESO is issued and S is the market price of the stock, the intrinsic value of the ESO is equal to: $\max\{0, S - K\}$.

When the stock price exceeds the exercise price (S>K), i.e., the option is "in the money", the employee can exercise the ESO by purchasing stock at a price equal to K and can immediately sell the stock at a price of S. Thus, when S>K, the profit earned by exercising the ESO equals S - K, its intrinsic value.

When the stock price is less than the exercise price (S<K), i.e., the option is "out of the money", the employee is not able to profit by exercising it and hence the intrinsic value of the ESO is zero.

Prior to expiration, the intrinsic value of the employee stock option does not represent its actual value. The current value of the option can be viewed probabilistically as the expected value of the difference between the stock price on date of future exercise, less the exercise price discounted to

[3] This description of the taxation of nonqualified options applies to options granted to employees of publicly traded companies.

[4] In some cases, particularly with voluntary separations, companies will allow the employee to keep their options over a short window following the separation date, such as two months.

[5] Ignoring transaction costs.

present value. In the case of out of the money options, a probability of stock price appreciation prior to exercise remains. Hence, the actual value of the option is positive even though the intrinsic value is zero. In effect, the intrinsic value places a lower boundary on the actual value of the ESO. The intrinsic value also fails to capture the economic value of the option to wait for a more optimal exercise period.

Black-Scholes Model

The Black-Scholes Model (1973), including the Merton modification (1973) (hereafter BSM Model) is among the most commonly used methods of valuing tradable call options. The mathematical formulation of the BSM Model is shown in the Appendix A.

While the BSM Model was designed for so-called European options that can only be exercised at expiration, it is not optimal to exercise American style call options on non-dividend paying stocks prior to maturity. Hence, the BSM Model generally gives appropriate values for American style call options on non-dividend paying stocks. American style call options on dividend paying stocks, may be under some circumstances, optimally exercised prior to maturity. However, it is generally not optimal to exercise early prior to that date.[6] A second assumption of the BSM Model is that investors can hedge their option positions. We argue that while employees cannot directly trade their options, they can hedge their positions by maintaining an appropriate portfolio in the underling stock, which we assume is traded. Hence, we assume risk neutral valuation is acceptable for ESO valuation, and specifically utilize it in the vesting adjustment, which is derived in Appendix C.

The following parameters are used to compute BSM option values:

- Current stock price;
- Exercise price;
- Risk-free rate of return;
- Time to option expiration;
- The annual volatility of stock returns; and
- Constant dividend yield.

Note that the exercise price and the time to exercise are from the option contract.

The stock price and risk-free rate of return are observable from financial markets. Since traded options typically have short lives, dividend yields are forecast from recent dividend history.

However, volatility is not directly observable and is thus the most difficult parameter to estimate. One approach to estimating volatility is to use recent historic data. It is common to calculate continuously compounded daily rates of return for the past year as $\ln[S_1/S_0]$, where S_1 equals the current daily stock price and S_0 equals the previous daily closing price. If there are 250 trading days in the year and daily returns are independent of each other, then the volatility can be expressed as the standard deviation of the daily return multiplied by the square root of 250. An alternative approach to estimating volatility is to recover the volatility assumption that is "implied" in traded option values. Given the current market price of an option, current stock price, exercise price, dividend yield and interest rate, iterative numerical methods can be used to solve for the implied volatility.

A step-by-step calculation of a Black-Scholes call option is shown in Table 1. The effects of changes in individual parameters on BSM call values are shown in Table 2. In particular, it should be noted that a longer time to expiration is associated with a higher call value because time allows more opportunities for profitable exercise. Higher stock price volatility also increases the value of an option. In effect, higher volatility creates a larger upside stock price potential, but adds no additional downside risk, as the minimum call option value is zero. The effects of changes in volatility estimates on value, while holding other BSM values constant are shown in Table 3. Note that an ESO valued by its intrinsic value would not change as volatility and time to maturity change. In the examples shown in Table 3, the intrinsic value is zero, regardless of volatility and time to maturity.

Table 1. Illustration of the BSM Value for a Single Call Option with an Exercise Price (K) = \$1.00, Stock Price (S) = \$1.00, Annual Risk Free Rate = 5.00 Percent, Volatility (σ) = 0.1, Time to Expiration (T) = One Year and Annual Dividend Yield = 1.00 Percent.

$$\delta = \ln(1 + 0.01) = 0.0010$$

$$i = \ln(1 + 0.05) = 0.0488$$

$$\text{Cumulative Volatility} = \sigma\sqrt{T} = 0.1 * \sqrt{1} = 0.1000$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(i - \delta + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$= \frac{\ln\left(\frac{1.00}{1.00}\right) + \left(0.0488 - 0.0010 + \frac{0.1000^2}{2}\right) * 1}{0.1000}$$

$$= 0.4383$$

$$d_2 = d_1 - \sigma\sqrt{T} = 0.4383 - 0.1000 = 0.3383$$

$$N(d_1) = 0.6695$$

$$N(d_2) = 0.6325$$

$$\text{BSM Value} = e^{-\delta T} S N(d_1) - e^{-iT} K N(d_2) = 0.0605$$

Table 2. The Effects of Changes in Individual Parameters on BSM Call Values.

Parameter	**Effect of Increase on Black-Scholes Call Value**
Current stock price	+
Exercise Price	-
Risk free rate of return	+
Time to option expiration	+
Annual volatility of stock returns	+
Dividend yield	-

[6] See Hull (2000), pp. 259-263 for discussion of early exercise.

Table 3. BSM Values for a Single Call Option with an Exercise Price = $1.00, Stock Price = $1.00, Risk Free Rate = 5.00 Percent, and Dividend Yield = 1.00 Percent.

Time to Expiration = One Year

Volatility	Black-Scholes Values
0.1	$ 0.060
0.2	0.098
0.3	0.136
0.4	0.174

Time to Expiration = Four Years

Volatility	Black-Scholes Values
0.1	$ 0.160
0.2	0.221
0.3	0.286
0.4	0.351

Note: Values increase with volatility and with time to maturity.

Adjustments for Employee Stock Options

The BSM Model is designed to value European tradable options that pay no dividends or a constant dividend yield. Although ESOs share many of the characteristics of tradable call options, there are unique characteristics of employee stock options that violate some assumptions of the BSM. In particular, employee stock options have a vesting period. Appendix C shows that under the assumptions of no arbitrage and risk neutrality, the value of an option grant with vesting equals the probability of vesting times the value of a corresponding fully vested call option.[7]

In addition, ESOs are not transferable. They must be exercised to generate cash flow and this creates an incentive for early exercise, which theoretically may reduce the value of an option. For example, employee stock options are subject to forfeiture if the employee leaves the firm prior to vesting. Hence, departing employees will always exercise in-the-money vested options. Likewise, long-term employees have an incentive to exercise deep in-the-money options to capture price appreciation. It is not surprising that Huddart and Lang (1996) find that the fraction of employee stock options that are exercised in a particular month are positively correlated with prior stock price performance and are unrelated to subsequent stock price performance. Huddart and Lang's results are certainly consistent with risk averse behavior.

However, the overall impact of early exercise on employee option values may not be too severe for valuation purposes in the litigation environment. In particular, the BSM Model may provide reasonable estimates if the time to expiration is adjusted to reflect the possibility of early exercise and adjustments for the likelihood of vesting. As evidence, consider Carpenter (1998), who uses data on employee stock option exercises to compare:

> The option values obtained using a binomial American[8] option pricing model with exogenous exercise;
> A model that treats the option exercise decision within a utility maximizing framework; and
> The BSM Model with the option's actual expiration replaced with the option's expected life.

In general, Carpenter's results suggest little difference between the BSM values and the values obtained via the other two methodologies.[9] Given its relative computational ease, the BSM Model appears justified for use in valuing ESOs in the litigation environment, as long as specific adjustments are made. In particular, to factor in early exercise of options, company data or estimates of the average life of existing ESOs can be obtained from annual reports and 10-K filings. As companies comply with Financial Accounting Standards No. 123, more information concerning historic ESO exercise patterns is appearing in footnotes to financial statements (see below). See Appendix B for more information on SFAS 123.

Since ESOs have much longer time to expiration than do tradable options, the use of volatility and dividend yield estimates are especially important. Implied volatilities based upon market values of tradable call options may be problematic given that tradable options typically expire in less than a year and employee stock options have times to expiration of five to ten years. Analogously, the use of recent historic data to measure volatility requires the analyst to assume that recent volatility will persist over an extensive period into the future. Hence, when available, implied volatilities from LEAPS may be more appropriate. To estimate the dividend yield, either the current dividend yield can be used or an econometric model can be developed to forecast dividend yields.

Valuation of Existing Employee Stock Options

It may be necessary to value an existing employee stock option in a divorce action or when an employee is either terminated or disabled prior to vesting. Within this setting, the BSM Model, with the previously identified adjustments can be used to estimate the current value of the existing option.

Analysis of In the Money Option

Assume that an employee was granted options to buy 100 shares of Acme stock at an exercise price of $15.00 per share on July 1, 1999. At the time of the grant, the exercise price equaled the market price of the stock. The options expire ten years after issue and do not vest until two years after issue. Based upon the footnotes in Acme's financial statements, that

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[7] Yook (1997) uses this result, but does not present the derivation.

[8] In the literature on tradable stock options, American put options may have an early exercise premium. The binomial model (Cox, et. al., 1979) captures the value of early exercise of American put options.

[9] Without adjusting the time to expiration to reflect actual firm exercise patterns and likelihood of vesting, employee stock option values computed using the Black-Scholes Model are overstated.

Table 4. Valuation of In the Money Employee Stock Option to Buy 100 Shares of Acme Stock, Option Vests in One Year, Expected Expiration of Option is in Four Years, 6.50 Percent Risk Free Rate, 1.00 Percent Dividend Yield Volatility Equal to 0.2 and Probability of Vesting Equals 0.9.

Value of Option that Expires in Four Years

Number Of Shares	Exercise Price	Current Stock Price	Intrinsic Value	BSM Value with no Vesting Restrictions	BSM Value with Vesting Restrictions
100	$15.00	$16.00	$100.00	$448.33	$403.50

Table 5. Valuation of Out of the Money Employee Stock Option to Buy 100 Shares of Acme Stock, Option Vests in One Year, Expected Expiration of Options is in Four Years, 6.50 Percent Risk Free Rate, 1.00 Percent Dividend Yield Volatility Equal to 0.2 and Probability of Vesting Equal to 0.9.

Value of Option that Expires in Four Years

Number Of Shares	Exercise Price	Current Stock Price	Intrinsic Value	BSM Value with no Vesting Restrictions	BSM Value with Vesting Restrictions
100	$15.00	$14.00	$0.00	$301.15	$271.35

Table 6. BSM Option Values (Including Vesting Restriction) as Percent of Salary, Options Vests Two Years After Issue, Expected Life of Option is Five Years after Issue, 6.50 Percent Risk Free Rate, 1.00 Percent Dividend Yield and Volatility Equal to 0.2.

Year	Salary	Number Shares	Exercise Price	Stock Price On Grant Date	Value of Options	Value of Options as Percent of Salary
1	$100,000	3,000	$ 15.00	$ 15.00	$ 10,875.85	10.9%
2	104,000	2,400	18.00	18.00	10,440.82	10.0%
3	109,000	2,800	16.50	16.50	11,165.87	10.2%
4	113,000	2,100	21.00	21.00	10,658.33	9.4%
					Average	**10.1%**

disclose historic exercise patterns, the expected maturity of the option is five years.

Suppose that one year after the date of issue it is necessary to place a current value on the options. To illustrate the valuation, assume that the stock price has appreciated to $16.00 per share and the current intrinsic value of the option grant is $100.00. However, due to the vesting restriction, the employee cannot exercise the option for another year. Based on historical exercise patterns, the remaining term of the option is four years. The volatility parameter equals 0.20 and is assumed to be based upon the historic return volatility measured over the most recent four years of daily return data.[10] The 6.50 percent risk free interest rate is assumed to be the current yield on a four-year U.S. Treasury strip and the 1.0-percent dividend yield is a forecasted dividend yield for ACME. As shown in Table 4, the option has a BSM value equal to $448.33. This would be the value of the option grant in the absence of the vesting restriction.

[10] This is consistent with SFAS 123. Daily data is used over the four-year period because this maximizes the number of observations over this period. Campbell, et. al. (1997) have shown that the accuracy of the estimate of volatility from historic returns increases with the number of observations.

Assume that there is a 90 percent probability that the employee will vest in one year.[11] As shown in Appendix C, the BSM value of the option grant in the absence of the vesting restrictions should be multiplied by 0.9 to reflect the reduction in value that results from the vesting restriction. As shown in Table 4, the value of the option grant equals $403.50, as compared to an intrinsic value of $100.00. The difference between the intrinsic value and the BSM value with vesting restrictions reflects the effects of both the likelihood of vesting and the probabilities of future upside movements in Acme stock.

Note that the analysis in Table 4 makes no effort to compare the exercise patterns of the individual employee in question with the patterns of the company as a whole. If information concerning the individual's past exercise patterns is available, it may be used to adjust expected option life reported in the footnotes to the financial statement.

Analysis of Out of the Money Option

In Table 5, the calculations are repeated under the same assumptions, except that the stock is currently trading at a price equal to $14.00 per share, as compared to the $15.00 per share exercise price. As shown in Table 5, even though the option grant has no intrinsic value, it has a positive BSM value after factoring investing restrictions since the volatility measure allows for a positive probability of upward movement in the stock price.

Forecasting Future Option Grants

Forecasting the value of foregone option grants due to injury or wrongful termination requires a determination of option values at time of grant. This allows the analyst to project values that reflect the uncertainty concerning whether the option will be in the money at the time of exercise.

In Table 6, hypothetical historic option grants by Acme to an employer are shown for four years, along with their salary. For ease of computation, it is assumed that the average life of all options are five years and that all of the options vest two years after issue.[12] In addition, the risk free rate is assumed to be 6.50 percent, the dividend yield is assumed to be 1.00 percent and volatility is assumed to be equal to 0.2. It is also assumed for simplicity that there is an 85 percent probability at time of grant that vesting will occur after two years. In this example, the BSM values of the option grants have an average value equal to 10.1 percent of salary, which can be applied to future forecasted salary values, in order to obtain future option values.[13] The analysis in Table 6 assumes that from the viewpoint of the corporation, salary, stock options and other elements of compensation are substitutes.

[11] In an actual case, the probability of vesting could be obtained from examining data or vesting patterns in the company. Another approach might be to utilize the LPE approach used by many economists as an alternative to worklife estimation (Brookshire and Smith, 1990).
[12] Assuming review of footnotes to Acme's financial statements.
[13] This analysis does not include the necessary adjustment to the BSM values that would have to be made as the employee approaches retirement age because the employee may have to forfeit the options within a certain time period that is less than the actual time to expiration.

Conclusion

This paper has suggested the use of the BSM Model to ESO values in litigation. Although there are theoretical problems with the BSM Model, it can be used in the context of valuing employee stock options and is analytically tractable. The approach is also a considerable improvement over using intrinsic values to estimate ESO values. Although there are valuation methods that may appear to be more theoretically sound, it is not all clear that the gains from using these methods at all outweigh the costs associated with the additional complexity. With appropriate adjustments, the BSM Model can be used to deal with complexities inherent in vesting restrictions and likelihood of early exercise.

APPENDIX A

Merton Modified Black Scholes-Model

Merton's (1973) modification of the Black-Scholes value for a European call is

$$(1) \qquad C = e^{-\delta T} S N(d_1) - e^{-iT} K N(d_2)$$

Where i is the continuously compounded annual risk free rate, T is the time until expiration of the options in years, δ is the constant continuously compounded dividend yield, S is the current stock price, K is the is exercise price and $N(d_i)$ represents the probability that a normally distributed variable has a value less than d_i. The expressions for d_1 and d_2 are:

$$(2) \qquad d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(i - \delta + \frac{\sigma^2}{2}\right)}{\sigma\sqrt{T}}$$

$$(3) \qquad d_2 = d_1 - \sigma\sqrt{T}$$

where σ is the standard deviation of the annual return of the stock.

APPENDIX B

SFAS 123

The Financial Accounting Standards Board Statement of Financial Accounting Standards No. 123 (SFAS 123), *Accounting for Stock-Based Compensation* requires public companies to at a minimum include the fair market value of stock-based compensation in footnotes to financial statements. SFAS 123 suggests, but does not require companies to use the Black-Scholes Model to calculate fair market values of stock options. SFAS 123 also suggests the use of the binomial option pricing model (Cox, et. al., 1979), but the Black-Scholes Model is much less complicated to use than the binomial model. SFAS 123 allows companies to factor in separations and retirements in order to compute an average option life, as part of the calculation of fair market value via the Black-Scholes Model. As a result, SFAS 123 improves the ability of the Black-Scholes Model to generate employee option stock values.

Yook (1997) has suggested that to be consistent with SFAS 123, the risk-free rate used in a Black-Scholes calculation should be the yield, as of date of grant, on a U.S. Treasury strip with a maturity matching the expected life of the option. In order to compute the value under SFAS 123, the dividend yield should be the yield that should be expected to apply over the future until option exercise. A practical approach is to use a historic average dividend yield, which is adjusted for expected future differences from past dividend experience. Alternatively the dividend yield can be forecasted.

In theory, the Black-Scholes Model requires the use of a parameter that reflects expected future volatility. SFAS 123 recommends that historic volatility be estimated over the most recent period that is equal to the expected life of the option.

APPENDIX C

The vesting requirement introduces two important complications to employee stock option valuation. First we must factor in the probability that the employee may leave or terminate prior to vesting. Suppose that an ESO becomes fully vested with probability ρ, at some future time t_1. We assume ρ may be estimated from historical length of employment patterns or agreed upon by parties. Let C_1 be the value of the option grant at vesting. The present value of ESO, C_0, is the appropriately discounted expected value of the option at vesting or:

(1) $$C_0 = e^{-r(t_1-t_0)}\rho\hat{E}[C_1]$$

where $\hat{E}$ denotes risk neutral expectation.
The second, and much more difficult complication, is determining $\hat{E}[C_1]$. In general, the expected future value of an option is a function of option values integrated over the distribution of future stock prices.
While the preceding general solution is beyond the scope of this paper, two special cases arise in which $\hat{E}[C_1]$ is easily determined. Hull (1993) shows that if the ESO is designed so that the strike price is set equal to the underlying stock price at the time of vesting then

(2) $$\hat{E}[C_1] = \hat{E}\left[C_0^* \frac{S_1}{S_0}\right]$$

where S_1 and S are the underlying stock prices at time t_1 and t_0, and C_0^* is the current value of an at-the-money option on S with the same maturity as the ESO. Under risk neutral valuation, $\hat{E}[S_1] = S_0 e^{r(t_1-t_0)}$ giving

(3) $$C_0 = \rho C_0^*$$

In the special case where the ESO strike price is determined at the time of vesting, its current value is the probability of vesting times the current value of an at-the-money option with the same time to maturity.

We arrive at equation (3) because the particular ESO is at-the-money when it vests and because under the BSM model, an at-the-money call option is proportional to the stock price. Nevertheless, practitioners often use equation (3) to approximate the value of an ESO with vesting, even if the strike price is set when granted. See for example Yook (1997). Since readers may encounter equation (3) in practice, we show how to arrive at equation (3) by making the assumption that the forward price of an asset is an unbiased estimator of the expected future price.

Let C_0^* be a traded option with the same strike and maturity as the ESO and where the ESO strike is determined at time of grant. Suppose we were to write a forward contract on C_0^*. The standard arbitrage free forward price F would be:

(4) $$F = C_0^* e^{r(t_1-t_0)}$$

Now if we make the strong assumption that the forward price is an unbiased estimator of the future price, then

(5) $$F = \hat{E}(C_1^*)$$

However, at time t_1, C_1 and C_1^* have the same payoffs and hence the same value. Combining equations (1), (4), and (5) gives:

(6) $$C_0 = \rho C_0^*$$

If we assume that the forward price is an unbiased estimator of the expected future price, then the value of an option with a probability ρ of becoming fully vested, is equal to ρ times the value of a corresponding option with no vesting requirement. While this assumption may not be completely accurate, it provides a very tractable solution. In any event, practitioners encountering equation (3) will at least know the assumption needed to generate the result.

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Litigation Economics Review
Volume 5, Number 1: 19-27

Measuring the Intensity of Competition Across Geographic Markets

Armando E. Rodriguez and Mark D. Williams

Abstract

This paper uses a modified cointegration method to determine how prices in different geographic areas "track" each other. Arbitrage across these geographic areas would be a natural explanation for prices tracking each other. Antitrust markets are defined as a group of products where arbitrage from outside would not defeat a hypothetical small but significant price increase within a year. We use an empirical market definition methodology recently proposed by Wu & Wu (1997) to measure the geographic extent of gasoline markets. This model essentially examines correlations between different prices, but also takes into account common cost and demand shocks across markets. A significant innovation of this approach is that it allows measurement of the degree and speed of arbitrage across markets. We find this method tends to correctly find larger markets and provides a quantitative method to determine the intensity of arbitrage rather than a simple determination of whether a competitor is "in or out" of a market. This method potentially allows for a full estimation of hypothetical price effects from a merger without placing the standard disproportionate emphasis on concentration indices.

Using publicly available gasoline price data by state, we test whether California prices "follow" prices in Nevada and Arizona. We cannot conclude that California is a distinct geographic market separate from these neighboring states. This suggests that California environmental standards do not remove that state from a larger gasoline geographic market in the Western United States.

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Opinions are our own and not those of the Federal Trade Commission. We are grateful to Steven J. Shapiro, Lawrence Wu, Chetan Sanghvi and participants of the International Trade Commission's invited paper series for their comments.

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Market definition is a critical first step of economic analyses of price and welfare effects (and more important, liability and damages) before many adversarial, advocacy and regulatory proceedings involving diverse areas of law as antitrust, securities fraud, breach of contract and intellectual property. In intellectual property disputes, market definition is a first step in analyzing market power conveyed by, and therefore economic value of, an intellectual property asset. In antitrust analysis, market definition is required for subsequent analysis of competition within the market, entry conditions into the market, and, to a lesser extent, efficiencies.[1] Once again, determination of the relevant market is necessary for future determination of damages and appropriate relief.

Much of the market determination literature discusses how to operationalize the generally imprecise notion of an economic market.[2] The conventional textbook model of competition assumes numerous sellers of a homogenous product. In reality, economic goods face varying degrees of substitutability with other goods because of differences in physical attributes, geographic location, of sale and timing of consumption.

[1] Many argue that out-of-market efficiencies should not count in the analysis of the net competitive effect of a merger.

[2] Commentators point to the language in Section 7 of the Clayton Act ("…prohibiting acquisitions likely to lessen competition substantially or tend to create a monopoly in any line of commerce or … section of the country…") as requiring a court to identify the product and geographic market within which competition would be harmed by an acquisition. [15 U.S.C. 18] Beginning with *Brown Shoe Co. v. U.S.*, establishing the relevant product market has been a necessary predicate for any antitrust claim. [370 U.S. 294, 335 (1962)].

Clearly, a measure of the relative intensity of competition between goods is necessary to gauge which products should be grouped within a relevant market.

Market definition under the *Merger Guidelines*[3] asks whether a hypothetical monopolist could profitably raise prices by a small, but significant and non-transitory amount ("SSNIP").[4] If it is able to do so, then consumer substitution away from the monopolized set of goods will not defeat that profitable price increase. In the next step, the *Guidelines* ask which firms currently could (within a year without the expenditure of significant sunk costs) supply goods in the relevant market. The determination of market participants can be viewed as gauging the degree of arbitrage that will occur from outside the market in the event of a price increase that is limited to goods within a relevant market. If significant arbitrage occurs between demand-side markets, one would expect that prices in the different markets would move in parallel and the two demand-side markets would be considered in the same supply-side market.

When examining geographic market definition, the *Guidelines* offer a similar methodology. The operating question is, "If the firms in a particular region collude to raise prices by X%,[5] will arbitraging supply from outside the region defeat that price increase?" One can change the focus of the question from the amount of a price increase to the timing of its defeat. In other words, one can ask, "How long will it take for outside supply to restore prices after a permanent shock (caused by a hypothetical collusive price increase) in a hypothetical geographic market?" The *Guidelines'* suggestion that a firm that could supply product within a year without significant sunk cost be considered a market participant suggests that a one year standard should be appropriate to be deemed significantly swift arbitrage. Such a price shock may or may not result in a permanent increase in prices, depending on the "slope" of the long run equilibrium relationship between prices. A smaller permanent effect from a price shock and a faster speed of adjustment would suggest a greater degree of inter-regional competition.

The federal antitrust agencies are developing and using new tools for defining antitrust markets. In particular, there seems to be a move in the direction of estimating or otherwise characterizing quantitatively underlying systems of demand for multiple products. These multi-product demand curves may be used as inputs into theoretic models of oligopolistic pricing from which potential effects from mergers can be simulated.[6] This increased use of more theoretical pricing models has led to a greater interest in estimating demand and otherwise defining markets.

Several investigations highlight several methodologies in defining markets. There have been a number of recent consumer product mergers where consultants have estimated fairly complete systems of demand using retail scanner data.[7] In the FTC's successful challenge of the proposed Staples/Office Depot merger, the government and parties both presented elaborate price/concentration studies purporting to show the likely effect of the acquisition. Relying on thorough empirical work aided by a peculiar rhetorical twist, the FTC successfully reversed the product market methodology by first establishing an econometric result and then concluding that the superstore product market was the only one likely to support such an econometric finding. Showing a price effect in Staples stores because of entry of nearby Office Depots, the FTC argued that office supply superstores constituted a relevant product market.[8] The Justice Department also recently advanced a novel product market challenging the merger of two prominent New York hospitals in an "anchor hospital" market in Long Island.[9] There is continued discussion of how to properly define markets in intellectual property.[10] Lastly, progress in applied econometric theory and greater data availability have not only reduced the cost but have also enhanced the expected information to be drawn from demand estimation and similar market definition exercises.[11] These factors will result in greater use of econometric analysis in regulatory proceedings and litigation.

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[3] U. S. Department of Justice, "Merger Guidelines, "*Antitrust Trade Regulation Report*, 1982, No. 1069; U. S. Department of Justice, "Merger Guidelines," *Antitrust Trade Regulation Report*, 1984, No. 1169; U. S. Department of Justice and Federal Trade Commission, "Horizontal Merger Guidelines," *Antitrust Trade Regulation Report*, 1992, No. 1559; and U. S. Department of Justice and Federal Trade Commission, "Horizontal Merger Guidelines," *Antitrust Trade Regulation Report*, 1997, No. 1806.

[4] Small but significant and non-transitory increase in price.

[5] The *Merger Guidelines* suggest a 5 to 10% standard. Others have suggested that this standard be adjusted by the degree of product heterogeneity to compensate for the view that a "significant" (one that might induce customers to switch suppliers within a market) price increase is likely larger for heterogeneous products.

[6] A complete demand system allows for varying degrees of cross elasticity between products. In this sense, it may be more precise than just determining whether a firm is in or out of a market. Unfortunately, merger simulations tend not to model the supply-side very well and the results of these models tend to say that anticompetitive effects are large if the relevant cross elasticities are big. This tends to make the demand estimation important in the review process, but tends to overshadow other components in a complete analysis of a proposed acquisition.

[7] For example, Guiness/Grand Metropolitan and General Mills/Ralston.

[8] FTC v. Staples, DC District Court, 97-701 (1997). The FTC argued that Staples price falling as a result of Office Depot entering would be consistent with prices rising if Office Depot were to exit. From this effect, the government argued, it would be necessary for superstores to be a relevant market because the effect could only occur is consumers did not defeat a price increase by choosing to purchase other products.

[9] The government's complaint challenges the proposed merger of Long Island Jewish Medical Center and North Shore University Hospital. The government contends that the relevant product market consists of "anchor hospitals." These are hospitals which are "reasonably convenient" with "a prestigious reputation offering an extensive array of high quality services." See, Bloch, Robert E., Scott P. Perlman and Robert L. Bronston, "Antitrust," *The National Law Journal* (Monday, July 21, 1997) at B5. Many have argued that defining a product market that is too narrow may lead to problems in geographic definition.

[10] Despite the general uncertainty and imprecision surrounding innovation markets, the agencies have negotiated consent agreements based on self-defined innovation markets. See, generally, Intellectual Property Guidelines; Novartis, FTC File No. 961-0055 (filed 12/5/96); Boston Scientific, 60 Fed. Reg. 32,323 (1995); Sensormatic Elec., Dkt. No. C-3572 (filed 4/18/95) Professor Spencer Waller has criticized this development. Spencer Weber Waller, "Prosecution by Regulation: The Changing Nature of Antitrust Enforcement," forthcoming *Oregon Law Review* ["In so doing, the agencies have created new doctrine without the need for, and largely insulated from, judicial approval."].

[11] Jonathan Baker, former Director of the FTC's Bureau of Economics, attributes the increased popularity of econometrics in regulatory proceedings to the following: (1) increased computational power; (2) advances in econometric methodology; (3) increased availability of disaggregated data; (4) differences in regulatory climate; (5) advances in theoretical Industrial Organization; and, (6) greater willingness by regulatory agencies to entertain analysis rigorously supported by econometric methods. Jonathan B. Baker, "Contemporary Empirical Merger Analysis," prepared remarks before the George Mason University Law Review Symposium (October 11, 1996).

The *Guidelines* approach (as opposed to some econometric approaches) to merger analysis tends to compartmentalize market factors into various categories (Market Definition, Concentration, Entry, and Competitive Effect), which are then analyzed separately. This sequential approach tends to underestimate the interaction between these different categories of analysis.[12] Furthermore, the product and geographic market definitions posed by the *Guidelines* tend to elicit binomial responses. A firm is either in or out of a relevant market. Economists, however, would tend to view product spaces as continuous and would ask questions more akin to "Is Firm A closer to Firm B or Firm C?; questions designed to establish which firm conveys relatively more competitive pressure. The binomiality of a standard market definition analysis tends to not capture the relative intensity of competition between firms and may then lead to misleading results. Thus, we agree with recent work by Scheffman and Spiller and Scheffman that argue that a naive *Merger Guidelines'* approach typically results in unrealistically narrow markets.[13]

By putting more relevant factors of the merger analysis in an econometric exercise, one can conceptually jointly analyze the different categories of *Guidelines* information simultaneously with defining markets. The empirical approach of this paper examines prices and measures the relative intensity of competition from various sources. Prices contain information on likely supply responses from outside the market and the likelihood of collusion given the current structure of the market. They also contain information on consumer demand. This analysis allows for an empirical reading of the likely outcome of an acquisition that is more accurate than simply looking at concentration ratios in an arbitrarily defined market. Parties that use this empirical approach may find that it gives an early reading of an acquisition's likely effects and an agency's likely response to a proposed acquisition. This method may be a least-cost method to determine strategy before an investigating agency.

This paper extends research by De-Min Wu and Lawrence Wu to geographic market definition under the *Merger Guidelines*.[14] Wu & Wu examine the degree of integration or intensity of competition between two products by determining whether the price paths of these products are cointegrated after taking into account exogenous cost and demand shocks. In our model of geographic differentiation, estimates of the cointegration equations provide information on the long-run equilibrium between prices at different locations. The properties of the estimation errors allow for estimates on the extent and speed of arbitrage between producers in these various areas.

Previous Work

There are a variety of statistical and economic methods available to determine relevant product and geographic markets. These include price correlation tests,[15] tests of price uniformity and arbitrage,[16] Granger causality tests,[17] residual demand analysis,[18] and shipments tests. The popularity of the various empirical approaches to market definition is a result of not only econometric advances, but also to the theoretical and conceptual evolution of the underlying theories.

In an attempt to overcome the binomiality inherent in market definition, cointegration tests have been used to determine whether the prices of different products or in different locations track each other. [19] If prices do track in a long run equilibrium relationship, the price series will be cointegrated. Short-run price movements to restore the equilibrium relationships are assumed to be the result of arbitrage. Thus, estimates of the cointegrating relationships yield information on long run equilibrium relationships and short-run disequilibrium responses between the different price series.[20] Examination of the residuals from the cointegrating relationships can yield information on the speed of this arbitrage.

The cointegration approach creates a metric measuring the distance that prices have deviated from an equilibrium. Although the speed at which prices adjust has received attention by other researchers,[21] cointegration allows one to construct direct measures of how quickly prices return to equilibrium. The speed of arbitrage is a natural metric for assessing market definition, for its is determined by the willingness of consumers to switch from one product to another and the responsiveness of firms in nearby markets to divert product into areas where prices have increased.

Cointegration models and correlation approaches in general, have been challenged on various grounds. In particular, Werden and Froeb (1992) list several potential difficulties with these approaches. First, there is the danger of spurious correlation. Prices in Markets A and B may have a common determinant Z. A shock to Z can cause prices in Markets A and B to be correlated, leading to the potentially false inference that arbitrage between markets is occurring when it is, in fact, not. For example, in markets for gasoline, a common

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[12] See, for example, Robert Brogan, "Simultaneity and the Merger Guidelines," *Journal of Reprints in Antitrust Law & Economics* Vol. 21, No. 1 (1992) 423-431; M.B. Coate & A.E. Rodriguez, "Pitfalls in Merger Analysis: The Dirty Dozen," *forthcoming* Competitive Enterprise Institute Working Papers (1998).

[13] Scheffman, David T., "Buyers, Market Power, and Market Definition," in M.B.Coate & Andrew N. Kleit, *The Economics of the Antitrust Process* (1996) 117-133; David T. Scheffman & Pablo T. Spiller, "Buyers' Strategies, Entry Barriers and Competition," *Economic Inquiry* 30(3) (1987) 418-436.

[14] Wu, Laurence and De-Min Wu, "Measuring the Degree of Interindustry Competition in U.S. v. Continental Can," *The Antitrust Bulletin* (Spring 1997) 51-74.

[15] See, e.g., Stigler, George & Robert A. Sherwin, "The Extent of the Market," Journal of Law and Economics Vol. 28 (1985) 555-585.

[16] Horowitz, Ira, "Market Definition in Antitrust Analysis: A Regression-Based Approach," 48 *Southern Economic Journal* (1981) 1; Spiller, Pablo and C. J. Huang, "On the Extent of the Market: Wholesale Gasoline in the Northwestern United States," 35 *Journal of Industrial Economics* (1986) 131-145.

[17] See, e.g. Slade, Margaret, "Exogeneity Tests of Market Boundaries Applied to Petroleum Products," *Journal of Industrial Economics* Vol. 44 (1986) 291-303; Uri, Noel, John Howell, & Edward J. Rifkin, "On Defining Geographic Markets," *Applied Economics* Vol. 17 (1985) 959.

[18] Baker, Jonathan B. and Timothy F. Bresnahan, "Estimating the Demand Curve Facing a Single Firm," *International Journal of Industrial Economics* Vol.6 (1988) 283-300.

[19] See, e.g. A.E. Rodriguez and Mark D. Williams, Is the World Oil Market "One Great Pool"? A Test," *Energy Studies Review* Vol. 5, No. 121 (1993).

[20] This is the Granger Representation Theorem, for a formal discussion see, James D. Hamilton, *Time Series Analysis* (1994) at 582.

[21] See, for example, A.E. Rodriguez and Mark D. Williams, "The World Oil Market *is* 'One Great Pool:" A Response, *Energy Studies Review,* Vol. 5, No. 3, 1993, pages 231—235.

shock in the price of crude oil would cause gasoline prices to be correlated across different locations even without arbitrage between these areas. Similarly, demand shocks, like nice driving weather across locations, can cause this "spurious correlation" across different gasoline retail markets in a naive cointegration model.

The standard method of avoiding spurious correlation is by controlling for common exogenous determinants in each of the price series examined. Spulber and Doane[22] for example, correct for spurious correlation by first running regressions of gas prices on the producer price index, oil prices, and seasonal dummy variables in each relevant region. Correlation statistics are then calculated from the residuals from each of these regressions and are interpreted as the degree to which different geographic markets are linked.

The Wu and Wu model corrects for potential spurious correlation in a cointegration context. In Wu & Wu, the cointegrating equation consists not just of the endogenously-determined price series for which one tests for cointegration, but also exogenous series measuring shocks to costs and demand. Wu & Wu simultaneously estimate a system of equations and test for cointegration between the endogenous variables.

A second objection raised by Werden & Froeb is that the correlation approach can be affected by different supply and demand elasticities across markets. Consider the following situation across two hypothetical markets A and B, connected by an arbitrage mechanism with a low elasticity of response to differences in pricing between markets. Suppose a demand shock increases prices in Market A relative to Market B. In response to potential profits, producers in Market B will ship products to A. However, these shipments may not completely return prices in A to the level they were before the shock. In a cointegration exercise, one might find that the cointegrating relationship is not "flat," but rather in the long run prices in the two markets are related but do not equalize. In this case, arbitrage between markets will not fully dissipate price increases. Whether or not firm in the different locations are considered in the same market depends on what standard is adopted that says arbitrage is "complete."[23]

Wu & Wu tested whether two separate products were in the same market when they presented their model.[24] We use their model to define geographic markets. In particular, we test whether California, Nevada and Arizona are in the same geographic market for gasoline. We choose gasoline because it is a homogeneous product with what we believe to be an inelastic demand. Because gasoline is likely to be a well-defined product market, we can focus our attention entirely on whether the Wu & Wu method is useful in defining geographic markets.

We use data from Energy Information Administration of statewide[25] retail motor gasoline prices before taxes. Specifically, we interested in determining whether gasoline in California can be effectively arbitraged by gasoline in neighboring states. Some have argued that, because California has different environment-related specifications on gasoline, that state may have effectively taken itself out of a wider geographic market for gasoline. If that were true, we would likely find that arbitrage does not occur across boundaries and that California should be considered a separate relevant geographic market.

Wu & Wu devote much of their attention to the speed with which prices adjust. The failure to treat this time dimension explicitly is a discussed deficiency in many market definition exercises, both econometric and otherwise. Similarly, the appropriate time implicit in measured elasticities is an important consideration in assessing the competitive effects of acquisitions. These time periods have implications for the horizons over which pricing decisions are made. Obviously, the richness of the estimate depends on the frequency of data. For example, the availability of weekly data may permit estimation of the very short run demand functions that the seller faces from week to week.

The Deficiencies of Traditional Analysis

In a recent paper, Scheffman argues that the agencies may be defining markets far too narrowly and challenging acquisitions where the parties do not have any reasonable expectation of exercising market power.[26] In a traditional Guidelines market delineation exercise, much of the evidence used by the analyst in determining the relevant geographic market turns on the answer to the following questions. (a) What will be the response of a neighboring firm to a hypothetical 5-10% price increase in the price of the widget? (b) What do company and industry documents indicate about the location competitors viewed as being "the competition." The implicit limitation of that inquiry, according to Scheffman, is that it fails to recognize institutional features in the market that should correctly be inputs into the market definition problem. For example, firms may not look at short run elasticities of demand when choosing their pricing strategies, but rather may view price as an input into goodwill at a particular customers. Particularly in intermediate goods markets, producers tend to invest in customer-specific relationships (in goodwill or otherwise) and this limits the desirability of exercising short run market power. A naive application of the *Guidelines* in a market definition exercise (particularly if the nontransitory nature of

[22] Doane, Michael J. and Daniel F. Spulber, "Open Access and the Evolution of the U.S. Spot Market for Natural Gas," The *Journal of Law & Economics* Vol. 37 (October 1994) 477-517.

[23] Worden & Froeb (at 334-5) suggest a third potential problem with correlation models. There may be capacity constraints limiting the amount of arbitrage between markets. In the example above, a price increase in Market A could lead to a binding constraint on arbitrage from B to A. As a result, prices in A rise, prices in B rise and transport services prices rise. As arbitrage costs rise, however, the markets become less "connected." Yet a correlation analysis may indicate increased correlation between the markets during the post-demand shock period rather than before. This potential problem only arises is the cointegration model is misspecified. (This problem would also occur in other types of econometric market definition exercises, particularly demand estimation.) Presumably, if the constraint on arbitrage were important, a careful modeler would incorporate these considerations when setting up the systems of equations to estimate.

[24] Specifically, Wu & Wu determine whether metal cans and glass containers are in the same market. The question arose in U.S. v. Continental Can Co. 378 U.S. 441 (1964).

[25] There have been calls to investigate whether gasoline pricing in the San Francisco Bay area is too high relative to Los Angeles. A finding that this is true, would likely require that Los Angeles gasoline cannot arbitrage Bay area gasoline. Because we have only statewide data, we cannot address the question of whether these two locations are in separate geographic markets.

[26] Scheffman, *supra*, note 13.

the hypothetical price increase is not stressed) tends to overestimate short run effects when determining whether a firm is in or out of a market.[27]

A complete merger analysis allows for these potential shortcomings in market definition to be addressed. For example, investments in goodwill can be treated in the competitive effects section of a *Guidelines* analysis.[28] However, as Sheffman has correctly noted, market definition and concentration measures have a disproportionate weight in prosecutorial and legal decisions.[29] Formally, a showing that a merger or transaction increases concentration in a relevant market raises a rebuttable presumption of illegality and this shifts the burden of proof to the merging parties.[30]

More importantly, a similar "market definition and concentration only" logic characterizes many internal debates within the agencies. As staff level investigations compete for management's attention and support to expand the scope of an investigation, the Herfindahl concentration index becomes an important summary statistic. Although everyone understands the limited amount of information contained within a Herfindahl calculation, few fail to begin their inquiry without first asking, "What are the Herfs?" While ultimately the numerous internal reviews and procedures (with chances for input from the parties) within the agencies will reject poor cases and challenge meritorious cases, this process tends to be costly both for taxpayers and especially the parties to the transaction under scrutiny. Procedures that allow earlier and more complete determination of the likely effects of an acquisition, rather than just definition of market and calculation of concentration, should reduce these costs. We believe that the cointegration method discussed next is one such cost-minimizing approach.

Model

In this paper, we attempt to estimate a long run equilibrium relationship between gasoline prices in California, Arizona and Nevada. We model prices in these states as endogenously determined by potential arbitrage between these states and by the influence of exogenous cost and demand shocks. Conceptually, one could specify a system of equations between these endogenous and exogenous variables and estimate its parameters by two or three stage methods. Unfortunately, the standard errors of these estimates will likely be inconsistent because the endogenous price series are unlikely to be stationary. However, if two nonstationary series are cointegrated, then one can measure existing equilibrium relationships between these series.

A time series is said to be stationary if all of its covariances over different time intervals remain finite or, more intuitively, if shocks to the series die out over time. If shocks persist over time in a series, as in a random walk model for example, then the series will be non-stationary. Price series, in particular, seem to often follow random walks, which have unit roots. If one takes the first difference of a random walk, one will find that the new series is stationary. A series is said to be integrated of order N if it takes N differences to induce stationarity.

Assume that the price series is integrated of order 1 (which we will show later). In this case, prices would wander over time. We could ask, however, whether the two series wander "close" to one another. Cointegration tests this concept. Two series (integrated of order 1) are said to be cointegrated if one can find a linear combination of the series that is stationary (*i.e.* integrated of order 0). The parameters of such a linear combination is said to be the cointegrating vector and represents the long run equilibrium between the two series.

The econometric model of the proposed long-run equilibrium relationship between gasoline prices in the three states is a simple reduced form.

$$(1) \qquad P_{it} = f\,(P_{jt}, \text{ Demand Shifters, Cost Shifters}) + \text{stationary error}$$

The price of gasoline in state i is a function of the price of gasoline in other states and other exogenously-determined variables. The error of this regression equation will be stationary even if the original price series are not if there is a cointegrating relationship between the price of gasoline in different states.

Theory can help identify supply and demand shifters for gasoline. The demand for gasoline in each state depends *inter alia* on its price and gasoline prices in neighboring states.[31] Because gasoline demand is largely defined by driving habits, which display strong cyclical pattern, we include a dummy variable indicating summer. (Seasonal dummies are included as supply shocks as discussed below) We also assume unemployment rates as demand shifters.

Because much of the variability in downstream gasoline prices originates upstream, we use the price of crude oil as a cost shifter.[32] While the supply and demand for crude oil is affected by several variables, including gasoline prices, we assume that crude oil prices are exogenously determined because this three state area constitutes only as small percent-

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[27] Similar criticism noting the binomial nature of establishing whether alternative suppliers are "in the market" or "out of the market" has been advanced by Pitofsky and Baker & Bresnahan. Robert Pitovsky, "New Definitions of Relevant Market and the Assault on Antitrust," *Columbia Law Review* Vol. 90 (1990); Jonathan B. Baker & T. Bresnahan, "Empirical Methods of Identifying and Measuring Market Power," Antitrust *Law Journal* (1992).

[28] See the general description and criticism of the Guidelines' methodology in Judge Thomas opinion in U. S. v. Baker Hughes Inc., 731 F.Supp. 3 (D.D.C. 1990), *aff'd* 908 F.2d 981 (D.C.Cir. 1990).

[29] Scheffman, *supra*, note 13, at 122.

[30] However, a mere showing of increased concentration is unlikely to convince a Federal Judge to grant a Preliminary Injunction. In practice most preliminary injunction hearings end up being a de facto trial on the merits of the case. It is unlikely that an enforcement agency would seek a temporary restraining order armed only with evidence of increased concentration. Most agencies are well prepared to challenge the parties' attempts to rebutt the presumption of illegality. This preparation entails a full-fledged Guidelines economic and legal analysis.

[31] Arbitrage is expected to occur more on the supply side than the demand side.

[32] Balke, Nathan, S., Stephen P.A. Brown and Mine K. Yucel, "Crude Oil and Gasoline Prices: An Asymmetric Relationship?" *Economic Review of the Federal Reserve Bank of Dallas* (1998:Q1) 2-11; Severin Borenstein, A. Colin Cameron, and Richard Gilbert, "Do Gasoline Prices Respond Asymmetrically to Crude Oil Prices?" *Quarterly Journal of Economics* 112 (February) 305-39.

age of demand in the world crude oil market.[33] Depending on the degree of refining flexibility, distillate producers are able to vary the product composition derived from each barrel of oil, in response to fluctuations in relative demand. Thus, the supply of gasoline may depend on the relative demand for other related products such as heating oil, diesel and bunker fuels. For example, increased driving during the summer months increases the demand for gasoline, relative to heating oil. To the extent that their plant is capable, refiners will squeeze proportionately more gasoline from a barrel of oil and less heating oil and other lower-valued products. This seasonality will be captured with relevant dummy variables as supply shifters as well as demand shifters.

The time series methods we use allows us to determine the number of cointegrating relationships between the different price series. Because we have price data for three states, we may find up to two sets of cointegrating relationships. We will test whether there are zero, one, or two of these cointegrating vectors. If one were to find two cointegrating relationships, one could plot a line (assuming fixed values for the exogenous variables) representing the long run equilibrium between these three prices in three-space.

We then estimate the speed of adjustment by looking at the number of periods it takes for price shock in one state to dissipate and prices return to their long-run equilibrium relationship. We do this by forecasting a one-time permanent shock off of the long run relationship to each of the price variables in the system. We measure the speed of adjustment by the percentage of the adjustment completed in a given time period. This empirical tool is called the impulse response function. A persistence profile decomposes price variances into their sources, either shocks to exogenous variables or shocks affecting prices in other states.

Non-instantaneous price adjustments may be caused by long-term contracts, adjustment costs, natural barriers and other factors that may include institutional rigidities.[34] But ultimately, a close examination of the time it takes a price series to return to a stable equilibrium allows one to compare the speed of arbitrage to geographic market criteria in the *Guidelines.*

The impulse response function describes how the price differential between states might respond to a hypothetical one-time permanent shock in a proposed geographic market. In a *Merger Guidelines* context, this could be viewed as a hypothetical price increase from collusive behavior in a supposed geographic market. By measuring how long that price increase could be sustained reveals the extent to which the two regions are in the same geographic market. Note that a *Guidelines* market definition exercise looks solely at consumer and alternative supplier response within a year when defining markets. The characteristics of an impulse response function may reflect not only these factors but potentially also the ability of future entry and market dynamics to discipline an isolated price shock. In this sense, using a cointegration analysis in the context of a merger investigation allows one to simultaneously and quantitatively evaluate how market dynamics would discipline a hypothetical price increase arising from a merger.

We use a vector autoregression (VAR) procedure to estimate the long run equilibrium relationship between gasoline prices across states.[35] The VAR technique imposes no restrictions on the relationships between different variables and treats all as potentially endogenous. VAR procedures give summaries of empirical regularities between variables.

Using VAR's one individually regresses each variable in a system on lagged values (assuming a common lag across all endogenous variables) of itself and other variables in the system and on a common set of other terms including a constant, linear and quadratic time trends and seasonal dummies and exogenous variables. The results can allow for a number of useful tests. First, one can test whether past values of other endogenous variables have a significant effects (Granger causality). Second, autoregressive equations decompose effects from past movements of variables from present changes and, so, the residuals provide estimates of unanticipated movements, which can act as proxies for shocks. Correlations of these residuals may be interpreted as measures of short run relationships between unanticipated variable movements. Third, the VAR estimates may be transformed in a manner to yield estimates of how much of the variance of any variable in the system is attributable to itself and other variables in the system. These variance decompositions are useful in understanding the relative size of how exogenous shocks effect pricing relative to shocks in endogenous variables. Last, the stochastic process by which the market corrects or arbitrages between regions can be modeled by a vector error correction model (VECM).

Estimation

We gathered monthly, state-wide average regular gasoline prices from the Energy Information Agency over the time period from January 1983 to April 1998. The statewide average regular gasoline prices are plotted in Figure 1. Federal and state taxes were removed from these series using data from the Federal Highway Administration. The crude oil price series used was that for Domestic Crude published by the Bureau of Labor statistics. Demand shifters, including measures of unemployment rates, inflation and personal income were also downloaded from the BLS website (www.BLS.com). We further constructed seasonal dummies for summer as well as the Gulf War (September 1990 through March 1991).

The first step in our procedure is to test whether the price series are stationary and what is their order of integration. To do this, we run the Augmented Dickey Fuller ("ADF") test with 4th order differences assuming an intercept term, but no trend. As shown in Table 2, all the series can be considered at least borderline non-stationary.[36]

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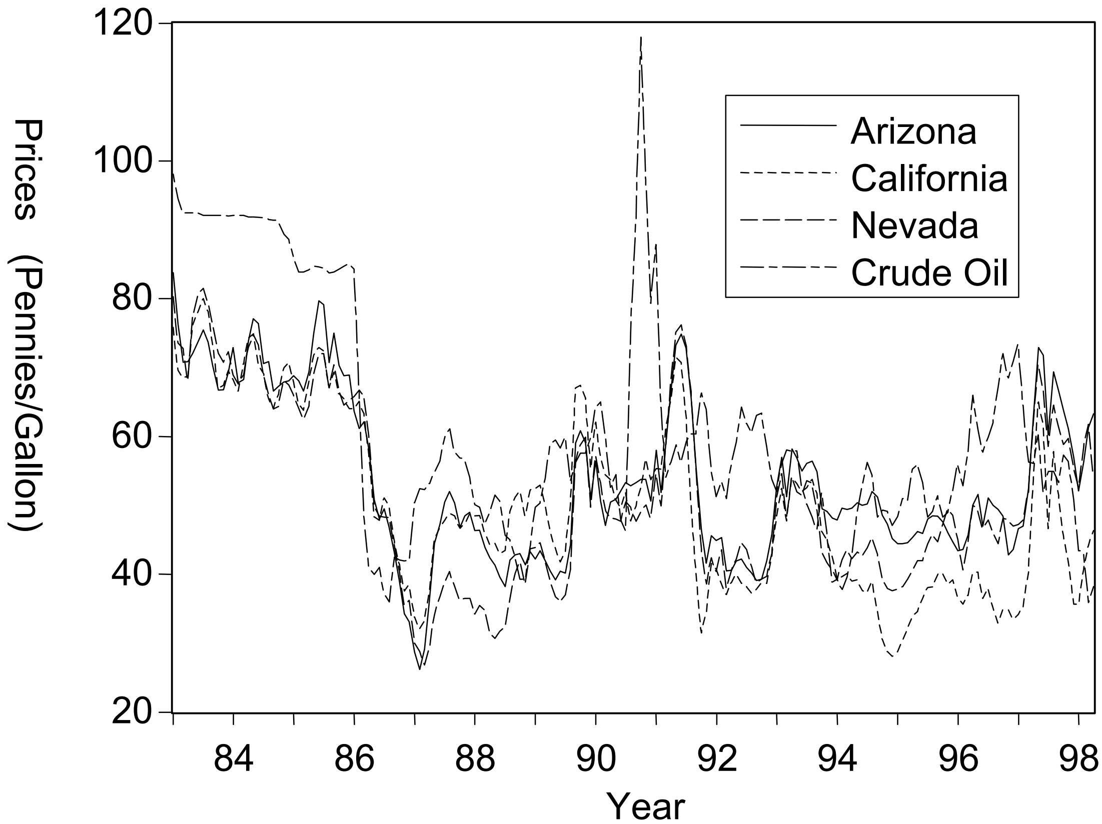
[33] For a discussion of crude oil geographic market definitions, see the article cited in footnote 19 above.

[34] J.Y. Campbell and R.J. Shiller, "Interpreting Cointegrated Models," Journal of Economic Dynamics and Control Vol. 12 (1988) 505-522.

[35] We use the VAR estimation methodology developed by Johansen (1991); viz., Soren Johansen, "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models," Vol. 59 *Econometrica* (1991), 1551–1580.

[36] If we were to find that all the price series were stationary, then all linear combinations of them would also be stationary, so a cointegration exercise would be inappropriate. If all the price series were stationary, classical regression techniques would be appropriate.

Figure 1. Statewide Gasoline Prices before Taxes



The variance of time series with unit roots increases over time. If the time series are cointegrated, the cointegrating relationship represents the long run equilibrium between the variables. The equilibrium errors (the differences between its current price and what that price would be given the value of all other variables) will have a tendency to return to zero even though each of the price series do not have a tendency to return to any particular value. We use a VAR to estimate the cointegrating relationship between the price series.

The inclusion of exogenous variables as well as the lag order of the VAR is often selected somewhat arbitrarily. Below are the likelihood ratio, the Akaike information criterion, and the Schwarz information criterion for lag lengths of two through five using the three exogenous variables that we found to most improve the fit: the price of oil, the Gulf War dummy and the rate of inflation.

Because each of the gasoline price series is integrated of order one, we can test the number of cointegrating relationships between them. Using the VAR with 4 lags (that which maximizes the Akaike Information Criteria), we test the number of cointegrating relations using Johansen's method. Here we assume that the cointegrating relation contains constants but no trends, although the data can contain linear trends.

Table 1
Unit Root Tests

Variable	Statistic	Critical Values	
California gasoline prices	-2.82	1%	-3.47
Arizona gasoline prices	-2.90	5%	-2.88
Nevada gasoline prices	-2.88	10%	-2.58

Table 2
VAR Lag-Length Determination

Lag-Length	2	3	4	5
Log Likelihood	-1230.948	-1221.168	-1207.961	-1190.867
Akaike Information Criteria	13.857	13.925	13.955	13.943
Schwarz Criteria	14.385	14.614	14.809	14.958

Table 3
Cointegrating Vectors

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.104479	47.50169	29.68	35.65	None **
0.086557	27.74918	15.41	20.04	At most 1 **
0.062453	11.54347	3.76	6.65	At most 2 **

** indicates rejection of hypothesis at 1% level.

We find that there are 3 cointegrating vectors between the price series. This means that if one knows the values of the exogenous variables, then the equilibrium relationship between the three state's prices is a point in three-space. At each equilibrium point, the difference in price between, say, California and Nevada is the same. Why did we get this result? There are two alternative explanations. First, the Johansen's test statistics are constructed assuming no exogenous variables. The other explanation is that the non-stationarity in the price series is caused by "non-stationarity" in the non-stochastic exogenous variables. If one tests whether there are any cointegrating relationships between each price series individually and the exogenous variables, one find that there may be one cointegration vector in each of the three VARs.

If there exist cointegrating relationships between the endogenous variables so that deviations from equilibrium never wander away from zero, then there must be an error correction mechanism that brings the prices back to equilibrium. A vector autoregressive system in error-correcting form ("VECM") can be written as:

$$\Delta x_t = \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \alpha \Pi_k x_{t-k} + \Phi D_t + \quad + \varepsilon_t \tag{2}$$

where $\alpha \Pi_k x_{t-k}$ represents the equilibrium error in the previous period, $\Gamma_i = -I + \Pi_1 + \ldots + \Pi_i$, I = 1, … , k -1, and Π_k is the long-run "level solution." The variables D_t are centered seasonal dummies orthogonal to the constant term and ε_t and normally with mean 0 and covariance Ω. Thus, this equation says that the change in the each of the exogenous and endogenous variables depends largely on past changes in the variables and the previous period's equilibrium errors in the three geographic areas. The coefficient matrix, denoted by α, represents a matrix of adjustment coefficients. One can estimate the VECM equations using full information maximum likelihood.

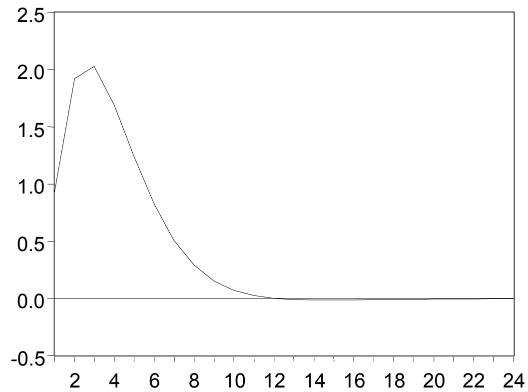
The graphs represent the impulse response functions of the system of prices and shows how price differentials should react to an exogenous shock in one of the price series. Impulse response functions for each series are drawn for a 24-month time horizon and show the effect on all price series from a shock to each of the prices.[37]

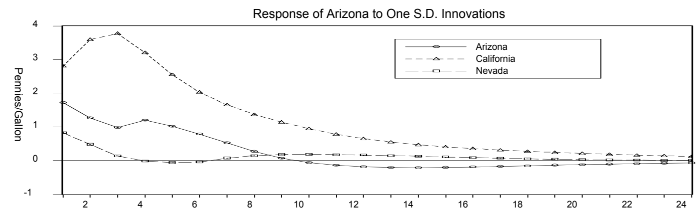
The vertical scale on these graphs is arbitrary. In merger analysis, a one unit shock could be interpreted as a 5% increase in price. Shocks to Nevada and Arizona prices are completely arbitraged out of the system in 9 months at the most (Arizona shock affecting Arizona prices) and more typically are gone after 4 months. Shocks to California take more time to dissipate. When these graphs are constructed with error bars, zero comes within the margin of error after 8 months when looking at the impulse response function of California shocks to California prices. These results suggest that if firms in California were to collectively raise prices by 5%, it would be eroded almost completely within one year by arbitrage.

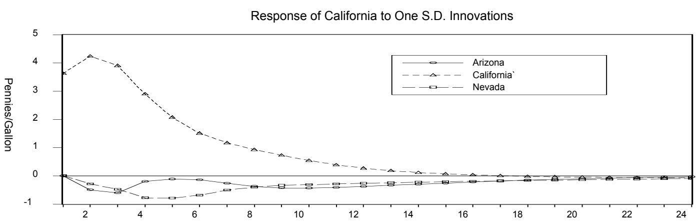
[37] These graphs depend on the ordering in which shocks are transmitted through the system. In this analysis, we assume shocks first affect California, then Nevada and lastly Arizona.

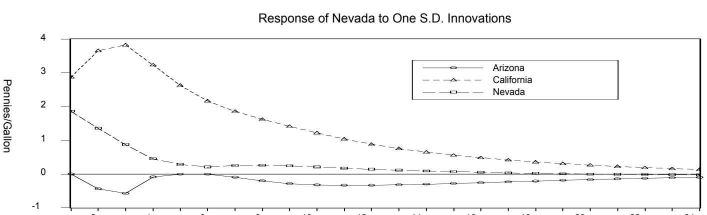
Figure 2

Response of NV to One S.D. CA Innovation









Conclusion

The methodology proposed by Wu & Wu to empirically define markets is a natural fit for market definition under the *Merger Guidelines*. For a properly defined market, it is necessary to show that prices can be increased in a sustainable manner over equilibrium competitive levels to demonstrate anticompetitive effects under the *Guidelines*. The Wu & Wu methodology complements more traditional market definition approaches by moving the debate about the measurement of the intensity of competition away from a competitive effects discussion and towards a market definition exercise. This front-loading of the analysis of an acquisition is likely to achieve more accurate predictions of market effect and thereby minimize costly investigations arising from the *Guidelines'* inherent tendency to find overly narrow markets. Contrary to the Federal Trade Commission's consent in the Exxon-Mobil matter, we find no evidence that supports the hypothesis that California constitutes a separate market for gasoline from its neighboring states because of environmental or any other reason.

The Wu & Wu model can be used in fields other than antitrust where market definition is important. For example, in international trade matters, economists look at how changing trade patterns can affect profits, employment, prices and welfare in other countries. Much of this analysis boils down to whether these countries constitute separate geographic markets in different industries. In both general and partial equilibrium approaches to trade issues, analysis requires an estimate of cross-price elasticities of substitution between imported and domestic goods. If these elasticities are parameters in a system of inter-related products, the price of which are non-stationary, an approach such as this must be used.

In intellectual property disputes, estimating damages from infringement requires finding a plausible "but-for" alternative where the patent holder would retain its monopoly right to use a patent. Losses are in direct proportion to the rightful owner's being able to exploit that market power and raise prices over the current level. This, in essence, requires a market definition exercise to determine how easily products produced under infringed patent are arbitraged by alternative products. The Wu and Wu methodology can be used to measure the interaction between different product life cycles as well as looking in the price domain and can do so with more rigor than a visual inspection of the data.

Upcoming NAFE events for your calendar

For additional information, please contact Nancy Eldredge at umkcnafe.edu or by telephone at 816-235-2833

WESTERN ECONOMIC ASSOCIATION INTERNATIONAL

SAN FRANCISCO—JULY 4-8, 2001

Organizers: Dr. Mark Kuga, Vice-President, Western Region, Conference Chair
Dr. Robert Male, Vice President At Large, Conference Co-Chair

The Western Economic Association International will have its annual conference in San Francisco, July 4 to July 8, 2001 at the Hyatt Regency Hotel, San Francisco. As in past years NAFE will sponsor a number of sessions at this outstanding conference. NAFE sessions will be on Friday, July 6, 2001 and Saturday, July 7, 2001. Other NAFE highlights include a Members Meeting and a Reception Friday, July 6, 2001.

SOUTHERN ECONOMIC ASSOCIATION

TAMPA—NOVEMBER 17-19

Organizer: David H. Ciscel, Vice-President, Southern Region

The SEA 2001 meetings will be held November 17-19 (Saturday through Monday) at the new Tampa Marriott Waterside Hotel in Tampa, FL. The NAFE sessions will be on Saturday or Sunday. View updated SEA information as it becomes available at: http://www2.bus.okstate.edu/ecls/sea. The call for paper deadline for the Southern Economic Association NAFE sessions is June 30, 2001.

ALLIED SOCIAL SCIENCE ASSOCIATION

ATLANTA —JANUARY 3-6, 2002

Organizers: Organizers: Thomas R. Ireland, University of Missouri at St. Louis,
Gary R. Skoog, De Paul University & Legal Econometrics, Inc.,
and Mark Rogers, Forensic Consultant

The ASSA meetings will be held in Atlanta, Thursday January 3 to Sunday, January 6, 2002. We may have a NAFE tour of the Atlanta Fed on Thursday. We hope to have one session with 3 papers on Friday morning, and 3 sessions with up to 9 papers on Saturday. Information about the convention will be available on the AEA website at: http://www.vanderbilt.edu/AEA/anmt.htm.

Litigation Economics Review
Volume 5, Number 1: 29-52

Calculating the Present Value of Expected Future Medical Damages

Kurt V. Krueger

Associate Editor's Note

This article is a first in a series of *Litigation Economics Review* articles under the Associate Editorship category of computer software, data sources and sites on the Internet of interest to litigation economists. This article examines how litigation economists work with the life table/life expectancy data source and how to take advantage of computer software to make calculations of the present value of expected future medical damages. In the appendix to this article is a set of computer macro programs written in Visual Basic® for Applications. At the Internet site http://JohnWardEconomics.com/Medical/ is a Microsoft Excel® workbook containing those macro programs and a complete working spreadsheet model to demonstrate to the reader the power of harnessing function macros to make these sorts of calculations. In future articles that appear under this *LER* Associate Editorship category, we hope to bring to readers other similar articles that take various concepts or methods used in litigation economics and show the reader various data sources or computer software addressing their usage. We encourage anyone with suggestions of relevant computer software, data sources, or Internet sites to send an email to Krueger@JohnWardEconomics.com.

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In order to calculate the present value of a plaintiff's expected future medical damages, a litigation economist needs: (1) a life care plan specifying, at each future consumption date, the current-dollar costs of required medical care items; (2) the expected value of future price growth to inflate current-dollar medical item costs and an appropriate interest rate to calculate present value; and, (3) the expected survival conditions that the plaintiff will be alive in the future and consuming the required medical care items. In some cases, medical testimony will specify the survival condition. For example, a physician might testify that he or she expects it likely that the plaintiff will live 10 additional years. However, in most cases, litigation economists incorporate information from statistical survival models in order to figure the present value of expected future medical damages (hereafter abbreviated as *PVM*). In this article, we discuss the ways in which litigation economists use the results from survival models presented as life tables to calculate *PVM*.

Survival models recognize the continuous risk of death. Litigation economists generally utilize one of the following two risk of death measures when figuring *PVM*: (1) they use life tables that present the number of survivors within a specific population cohort by single-years-of-age beginning at age 0 proceeding to an asymptotic position near zero at an advanced age when the cohort is essentially exhausted (the "*life table*" method)[1], or (2) they use life expectancy statistics calculated from life tables (the "*life expectancy*" approach). The *life table* method sets up a continuous mortality risk affecting *PVM* from the day after the last known survival date through an advanced age while the *life expectancy* approach results in a single, discrete age/time interval for certain survival and the occurrence of life care items/costs. If neither cost growth nor the time value of money are important in the calculation of medical damages and all life care costs are continuously required from the last known survival date through the end of life, there is only a small difference in *PVM* resulting from analyses using the *life table* method or the *life expectancy* approach. However, two situations (either together or separately) arise that will always make *PVM* from the *life table* method and *life expectancy* approach significantly diverge: (1) cost growth and/or the time value of money are important, and (2) medical items are consumed within discrete usage periods beginning after today and/or ending before the estimated terminal time of life.

In this article, we show the reasons why *PVM* are different under the *life table* method and the *life expectancy* approach. The information presented in this article does not cover the topic of determining the content of the life table that is most relevant to determine the expected length of the plaintiff's life; in this article, we require that, *a priori* to the calculation of *PVM*, an appropriate single-age life table relevant for the plaintiff has been assumed, discovered or calculated.[2] We also require in this article that the use of life tables or life expectancy calculated from life tables is the preferred choice of evaluation.[3] We demonstrate in the article that the life expectancy statistic is the sum of future mid-age survival probabilities from each exact age in the life table through the ending age in the life table. Therefore, calculating *PVM* with the *life expectancy* approach will always be inaccurate within the mathematics of the survival model. Since the inaccuracy of the *life expectancy* approach is mathematical, we encourage that litigation economists sparingly use the *life expectancy* approach to calculate *PVM* or use it side-by-side with the *life table* method to calculate *PVM* to show others the associated problems with the *life expectancy* approach and why the *life table* method of calculating *PVM* is preferred.

The *life table* method requires many calculations to determine survival and present value from today until each consumption date of each medical item in the life care plan. Within this article, we show a series of electronic spreadsheet function macros to simplify the litigation economist's work when performing *life table* method (and comparative *life expectancy* approach) *PVM* calculations. By setting growth and discount rates equal to zero, these same macros are also usable by life care planners who wish to calculate the expected current-dollar cost of their life care plans.

We start the article with an overview of the structure of the life table, survival model. We then show that *PVMs* differ when using the *life table* method and the *life expectancy* approach. Next in the article, we present the spreadsheet function macros that make the repetitive task of calculating risks of survival and *PVM* simple, quick, and accurate. In conclusion, we comment on the general uses of risk of death calculations in calculating and presenting *PVM*.

Quantifying the continuous risk of death

Everyone shares the lifetime event of death. Although theoretical probability models of mortality are based in a time frame where extremely advanced ages can be possible, most statistical estimates of mortality set the risk of survival nearly equal to zero by some advanced age (e.g., age 120).[4]

Life tables present statistical evidence of the mortality experience of a population.[5] Complete life tables are standardized with a beginning cohort size of live births, for example 100,000, and they present estimates of the number of survivors, l_x, from the original cohort of 100,000 births who will survive to the exact single-year age, x. The number of survivors at each age, l_x, is derived from a calculation of the probability of death, q_x, determined from actual mortality data recorded during the calendar year(s) studied.

After the first year of life, the conventional life table, survival model generalizes q_x by making an important assumption that l_x declines linearly from exact age x until age x+1.[6] For example, death between exact age x and x+1 will occur on average at age x+½. With the linearity of death assumption, the representation of l_x at exact single-year ages x can be expanded as follows:

(1) $l_x = L_x + \frac{1}{2}d_x$,

where, L_x is the average life table population at risk of dying between ages x and x+1 (the stationary population) and d_x is the death hazard (or, the number dying within age x to age x+1). The probability of death between ages x and x+1, q_x, is simply a ratio of the death hazard, d_x, to the number of survivors at any age, l_x. We can represent the probability of death as:

(2) $$q_x = \frac{d_x}{l_x} = \frac{d_x}{L_x + \frac{1}{2}d_x}.$$

To empirically estimate q_x, we can find N_x, the size of the population aged x in which every member has a chance of dying before reaching x+1, by demographically surveying to find the mid-year population, P_x (the *average* size of the observed living population from age x until age x+1) and the recorded number of deaths of persons from age x until x+1, D_x, occurring in our observation year(s). Substituting our

[1] There are several ways of delineating life tables besides age (e.g. years since the onset of disease) without significant difference in theory, estimation, or usage. In this article, for convenience of presentation, we refer to the conventional life table method that delineates an entire population by single-years of age.

[2] Note that it is not enough to have a life expectancy statistic because an infinite number of survival functions can generate the same numeric value for a life expectancy statistic.

[3] See Ciecka and Ciecka for a discussion of the properties of survival data that presents additional mortality concepts that may aid in the calculation of the present value of expected medical damages.

[4] For example, the current life tables from the National Center for Health Statistics have the survival chance at "essentially zero (somewhere between ages 110 and 120)" (see *United States Life Tables, 1998*, National Vital Statistics Reports, Volume 48, Number 18, page 37, U.S. Department of Health and Human Services' National Center for Health Statistics, 2001).

[5] The life table statistical presentation of mortality is one of the oldest methods for analyzing survival data. For a presentation of one of the original life table models, see Cutler & Ederer.

[6] During the first year of life, the mortality risk decelerates rapidly after the first few weeks of life making the linearity mortality assumption from age 0 to age 1 unrealistic.

empirical estimates into the theoretical model, we have a survival model that calculates the probability of death as:

(3) $$q_x = \frac{D_x}{N_x} = \frac{D_x}{P_x + \frac{1}{2} D_x}.$$

The methodological process of statistically estimating q_x at every possible age is detailed. Very few death records are available to estimate D_x at extremely advanced ages; hence, the estimated death hazard, D_x, asymptotically approaches 100 percent of the surviving population at advanced ages, for example at q_{120}. Putting aside further discussion of the difficulties in estimating q_x to the relevant literature, once we obtain the age vector of q_x from an empirical study for each single-year of age within the relevant population sample, we can easily construct the life table.

With a beginning size of the life table cohort, l_0, set to a number of persons born alive, for integer ages greater than 0, the survivor function, l_x, the number of survivors at exact age x, is calculated as:

(4) $$l_x = l_{x-1}(1 - q_{x-1}).$$

A standard procedure is to form the life table beginning with 100,000 persons at x_0, and then using q_x for every age thereafter, calculate l_x using equation (4) through an advanced age, $l_{\bar{x}}$, where l_x is essentially equal to zero (where $\bar{x}$ represents the age at which l_x is essentially zero).

Calculating *PVM* using the life table method

Using the life care plan, growth and discount rates, and the survivor function l_x, the litigation economist can calculate *PVM* for all ages within the life table (i.e., l_0 to $l_{\bar{x}}$).[7] The expected present value equation using the *life table* method, PV_l, for each medical item in the life care plan is:

(5) $$PV_l = \sum_{c=z}^{n} m_c \frac{l_{x|c}}{l_{x|c_0}} \frac{(1+g)^{t_c}}{(1+i)^{t_c}}.$$

where,

- m_c is the current-dollar cost of each medical item at each consumption date c;
- $l_{x|c}$ is the survivor function evaluated at the age of the plaintiff, x, at each medical item consumption date, c ($x|c$ is read as the plaintiff's numerical age at date c);
- $l_{x|c_0}$ is the survivor function evaluated at the age, x, associated with the last known date that the plaintiff is alive, c_0 (i.e., the date that *PVM* is calculated);
- g is the expected annual rate of growth in the cost of the medical item;
- i is the annual rate of interest appropriate to the calculation of present value;
- t_c is the number of years from the date c_0 to each c;
- z the first date of actual consumption, date z, can be equal to or greater than the present value date, c_0; after date z, consumption can continue to date n; and, date n can be equal to or less than $\bar{c}_l$, the date corresponding to the age $\bar{x}$ (the age at which l_x is essentially zero), hence, $c_0 \leq z \leq n \leq \bar{c}_l$.

In Table 1, we show an example of calculating the present value of expected costs for a medical item using the *life table* method. In our example, the life care plan requires consumption of a medical item beginning today, c_0, the date of the plaintiff's 65th birthday, and continuing in one-year increments from today as long as the plaintiff is alive. In column (2) of Table 1, we show the current-dollar $10,000 cost of the medical item at each consumption date c. In column (3) of Table 1, we show actual survival data for all males ages 65 to 100 from Table 2 of the *United States Life Tables, 1998* as published by the National Center for Health Statistics, NCHS).[8] Using data within the NCHS report regarding k and s values used in the 1998 life tables, we extend the published survival data through age 120, $\bar{c}$.[9] In Column (4) of Table 1, we calculate the probability of survival as $l_{x|c} / l_{65}$ for all ages 65 to 120. Column (6) of Table 1 shows the expected value of the current-dollar future medical costs by multiplying column (2) by column (4). Column (8) of Table 1 is the present value of expected future medical costs calculated using an annual 3.5 percent inflation in the cost of the medical care item and an annual 6.0 percent discount rate. Using the assumed figures in this example, 99.94 percent of *PVM* occurs by age 100; only $180 in current-dollar expected costs and $73 in present value expected costs occur after age 100.

Opposed to our example above, when making actual *PVM* calculations, consumption dates for medical items do not usually have to fall on the dates of the plaintiff's exact ages (birthdays). Using the assumption of the linearity of mortality between exact ages, we can calculate l_x for any numerical age x within the life table after age 0. For example, suppose that instead of being exactly age 65 on the present value date, the plaintiff is age 65.35 years old. In Table 1, we see that l_{65} equals 77,547 and l_{66} equals 75,926. The number dying from age 65 to age 66, d_{65}, is equal to l_{65} minus l_{66} or 77,547 minus 75,926, or 1,621. Because we assume that d_x declines linearly between ages 65 and 66, $l_{66.35}$ simply becomes l_{65} minus 0.35 times d_{65} or 77,547 minus 0.35 times 1,621, or 76,980. Using the procedure of discovering l_x at each numerical age, we can calculate *PVM* using an exact single-year age life table beginning at any numerical age with additional consumption at any future date bounded by the date where the plaintiff's numerical age is equal to one to $l_{\bar{x}}$, the age that l_x is essentially equal to zero.

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[7] When calculating *PVM* with consumption dates ranging within age 0 and age 1, the litigation economist will need a life table that refines survival probabilities during the first year of life greater than the linear survival probability assumption because of high infant mortality.

[8] *United States Life Tables, 1998*, National Vital Statistics Reports, Vol. 48, No. 18, U.S. Department of Health and Human Services' National Center for Health Statistics, Table 2, 2001.

[9] The current NCHS publication format truncates the published life table to age 100. However, within the life table publication, the NCHS gives readers the equations to calculate for themselves the balance of the life table that is not published within the life table report. For the procedure to extend the published life table, see page 37 of *United States Life Tables, 1998*, National Vital Statistics Reports, Volume 48, Number 18, U.S. Department of Health and Human Services' National Center for Health Statistics, 2001.

Table 1. Present value of expected future medical damages using the life table method

(1) Exact age	(2) Current-dollar cost of the medical care item	(3) l_x (1998 U.S. Life Tables)	(4) Probability of survival	(5) Cumulative probability of survival	(6) Expected current-dollar cost of medical item	(7) Cumulative expected current-dollar cost of medical item	(8) Discounted expected cost of medical item	(9) Cumulative discounted expected cost of medical item
65	$10,000	77,547	1.0000	1.0000	$10,000	$10,000	$10,000	$10,000
66	10,000	75,926	0.9791	1.9791	9,791	19,791	9,560	19,560
67	10,000	74,211	0.9570	2.9361	9,570	29,361	9,124	28,684
68	10,000	72,392	0.9335	3.8696	9,335	38,696	8,690	37,374
69	10,000	70,450	0.9085	4.7781	9,085	47,781	8,258	45,632
70	10,000	68,375	0.8817	5.6598	8,817	56,598	7,825	53,457
71	10,000	66,170	0.8533	6.5131	8,533	65,131	7,394	60,851
72	10,000	63,850	0.8234	7.3365	8,234	73,365	6,967	67,818
73	10,000	61,423	0.7921	8.1285	7,921	81,285	6,544	74,362
74	10,000	58,899	0.7595	8.8881	7,595	88,881	6,127	80,489
75	10,000	56,288	0.7259	9.6139	7,259	96,139	5,717	86,207
76	10,000	53,600	0.6912	10.3051	6,912	103,051	5,316	91,523
77	10,000	50,847	0.6557	10.9608	6,557	109,608	4,924	96,446
78	10,000	48,024	0.6193	11.5801	6,193	115,801	4,541	100,987
79	10,000	45,121	0.5819	12.1620	5,819	121,620	4,166	105,153
80	10,000	42,127	0.5432	12.7052	5,432	127,052	3,798	108,951
81	10,000	39,032	0.5033	13.2085	5,033	132,085	3,436	112,386
82	10,000	35,846	0.4622	13.6708	4,622	136,708	3,081	115,467
83	10,000	32,606	0.4205	14.0912	4,205	140,912	2,736	118,203
84	10,000	29,377	0.3788	14.4701	3,788	144,701	2,407	120,611
85	10,000	26,219	0.3381	14.8082	3,381	148,082	2,098	122,708
86	10,000	23,135	0.2983	15.1065	2,983	151,065	1,807	124,516
87	10,000	20,167	0.2601	15.3666	2,601	153,666	1,538	126,054
88	10,000	17,351	0.2238	15.5903	2,238	155,903	1,292	127,346
89	10,000	14,723	0.1899	15.7802	1,899	157,802	1,071	128,417
90	10,000	12,310	0.1587	15.9389	1,587	159,389	874	129,291
91	10,000	10,133	0.1307	16.0696	1,307	160,696	703	129,993
92	10,000	8,204	0.1058	16.1754	1,058	161,754	555	130,549
93	10,000	6,528	0.0842	16.2596	842	162,596	432	130,980
94	10,000	5,100	0.0658	16.3254	658	163,254	329	131,310
95	10,000	3,910	0.0504	16.3758	504	163,758	246	131,556
96	10,000	2,938	0.0379	16.4137	379	164,137	181	131,737
97	10,000	2,163	0.0279	16.4415	279	164,415	130	131,867
98	10,000	1,558	0.0201	16.4616	201	164,616	91	131,958
99	10,000	1,098	0.0142	16.4758	142	164,758	63	132,021
100	10,000	757	0.0098	16.4856	98	164,856	42	132,063
101	10,000	510	0.0066	16.4921	66	164,921	28	132,091
102	10,000	336	0.0043	16.4965	43	164,965	18	132,109
103	10,000	216	0.0028	16.4993	28	164,993	11	132,120
104	10,000	135	0.0017	16.5010	17	165,010	7	132,127
105	10,000	83	0.0011	16.5021	11	165,021	4	132,131
106	10,000	50	0.0006	16.5027	6	165,027	2	132,134
107	10,000	29	0.0004	16.5031	4	165,031	1	132,135
108	10,000	17	0.0002	16.5033	2	165,033	0.77	132,136
109	10,000	9.4	0.0001	16.5034	1	165,034	0.42	132,136
110	10,000	5.2	6.7E-05	16.5035	0.67	165,035	0.23	132,137
111	10,000	2.8	3.6E-05	16.5035	0.36	165,035	0.12	132,137
112	10,000	1.5	1.9E-05	16.5035	0.19	165,035	0.06	132,137
113	10,000	0.8	1.0E-05	16.5036	0.10	165,036	0.03	132,137
114	10,000	0.4	5.2E-06	16.5036	0.05	165,036	0.02	132,137
115	10,000	0.2	2.7E-06	16.5036	0.03	165,036	0.01	132,137
116	10,000	0.1	1.4E-06	16.5036	0.01	165,036	0.00	132,137
117	10,000	5.29E-02	6.8E-07	16.5036	0.01	165,036	0.00	132,137
118	10,000	2.66E-02	3.4E-07	16.5036	0.00	165,036	0.00	132,137
119	10,000	1.34E-02	1.7E-07	16.5036	0.00	165,036	0.00	132,137
120	10,000	6.76E-03	8.7E-08	16.5036	0.00	165,036	0.00	132,137
			16.5036		$165,036		$132,137	

The life expectancy statistic

Life expectancy is a statistic calculated from life tables. The single number life expectancy is often interpreted as the average number of years remaining to be lived by the population that survives to an exact age *x* using the age-specific rates of dying for all ages greater than *x* through the end of the life table. Using our example of a current 65-year-old, the age-specific rates of death for all persons ages 65 to the last age in the life table, age 120 in our example, quantify the life expectancy of a living 65-year-old person. Life expectancy statistics, for any age, cannot be calculated without first having a life table showing age-specific probabilities of death; or, life expectancy statistics are created from life tables.

To begin the formulation of the life expectancy statistic, we can re-write the hazard function, d_x, for the number of deaths occurring between *x* and *x*+1 as:

(6) $$d_x = l_x - l_{x+1} = l_x q_x \ .$$

At any exact age *x*, we can find the size of the stationary population, L_x, as:

(7) $$L_x = \tfrac{1}{2}(l_x + l_{x+1}) = l_x - \tfrac{1}{2} d_x \ .$$

Since L_x gives us the number of survivors at each age *x* from 0 to the end of the life table when l_x is essentially equal to zero, if we sum L_x over ages *x* to $\bar{x}$ (the age at which l_x is essentially zero), we have the total person-years yet to be lived, Y_x, as

(8) $$Y_x = \sum_{z=0}^{\bar{x}-x} L_{x+z} \ ,$$

where *z* is a series of integers to advance exact integer age *x* to the age at the end of the life table, $\bar{x}$. The life expectancy statistic, e_x, is computed by dividing remaining person-years yet to be lived after *x*, Y_x, by the number of survivors at l_x:

(9) $$e_x = \frac{Y_x}{l_x}$$

Since equation (9) is the division of two numbers, much like simple averages are calculated, it has become the reference point of the common interpretation of life expectancy as the average number of years remaining to be lived by the population that survives to an exact age *x*. However, using our understanding of the life table from the previous section of this article, we formulate an alternate equation of life expectancy (and an alternative interpretation of its meaning), by substituting equation (7) for Y_x in equation (9) through equation (8). Under this formulation, we see below in equation (10) that the life expectancy statistic equals the sum the series of mid-age survival probabilities through the end of the life table:

(10) $$e_x = \sum_{z=0}^{\bar{x}-x} \frac{l_{x+z} - \frac{1}{2} d_{x+z}}{l_x} \ .$$

Equation (10) is the survival function foundational expression for life expectancy. As seen in equation (10) the life expectancy statistic is not an expected average value of the duration of life, but simply a way of condensing a series of independent survival probabilities into one number with the summation operator.

Figure 1. Life expectancy "square" equals the total area under the probability of survival curve when probability of survival is figured at mid-year age

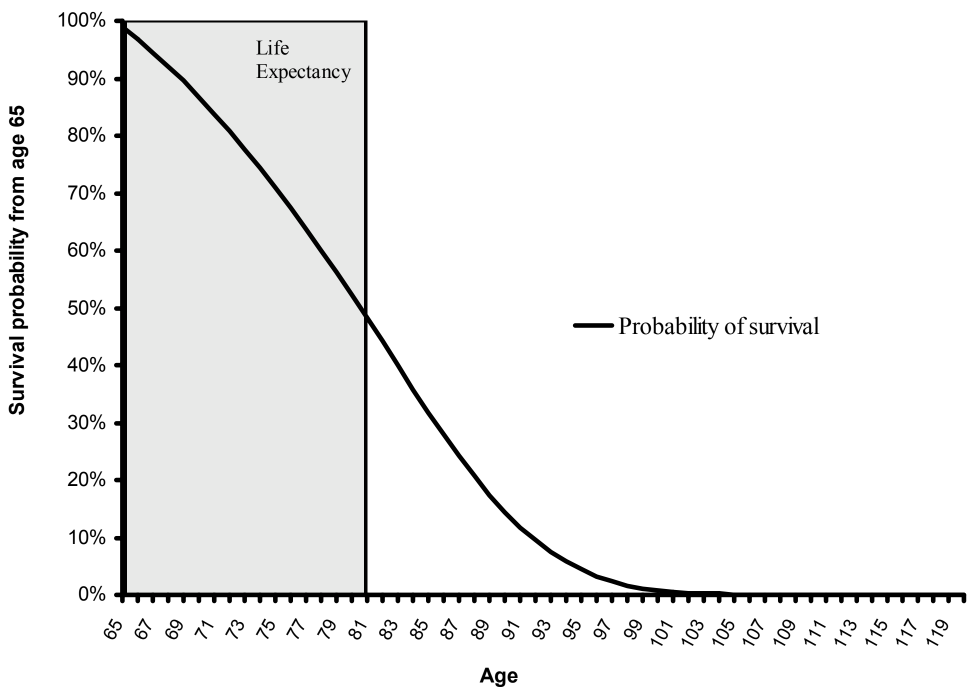

Table 2. Two different ways of calculating life expectancy

(1) Exact age	(2) l_x (1998 U.S. Life Tables)	(3) d_x - number dying between ages	(4) L_x - stationary population $= l_x - d_x/2$	(5) Y_x - stationary population in all remaining ages	(6) e_x - life expectancy $= Y_x / l_x$	(7) Probability of survival $= L_x/l_{65}$	(8) Cumulative probability of survival
65	77,547	1,621	76,736	1,241,028	**16.0036**	0.9895	0.9895
66	75,926	1,714	75,069	1,164,292	15.3346	0.9680	1.9576
67	74,211	1,819	73,302	1,089,223	14.6773	0.9453	2.9028
68	72,392	1,942	71,421	1,015,921	14.0336	0.9210	3.8238
69	70,450	2,076	69,412	944,500	13.4067	0.8951	4.7189
70	68,375	2,205	67,272	875,088	12.7984	0.8675	5.5865
71	66,170	2,320	65,010	807,816	12.2082	0.8383	6.4248
72	63,850	2,427	62,636	742,806	11.6337	0.8077	7.2325
73	61,423	2,524	60,161	680,170	11.0735	0.7758	8.0083
74	58,899	2,612	57,594	620,008	10.5265	0.7427	8.7510
75	56,288	2,687	54,944	562,415	9.9918	0.7085	9.4595
76	53,600	2,754	52,223	507,471	9.4677	0.6734	10.1330
77	50,847	2,823	49,435	455,247	8.9534	0.6375	10.7705
78	48,024	2,903	46,573	405,812	8.4502	0.6006	11.3710
79	45,121	2,994	43,624	359,239	7.9617	0.5625	11.9336
80	42,127	3,095	40,579	315,615	7.4920	0.5233	12.4569
81	39,032	3,186	37,439	275,036	7.0465	0.4828	12.9397
82	35,846	3,240	34,226	237,597	6.6283	0.4414	13.3810
83	32,606	3,229	30,992	203,371	6.2372	0.3997	13.7807
84	29,377	3,159	27,798	172,380	5.8678	0.3585	14.1391
85	26,219	3,084	24,677	144,582	5.5145	0.3182	14.4573
86	23,135	2,968	21,651	119,905	5.1829	0.2792	14.7365
87	20,167	2,815	18,759	98,254	4.8721	0.2419	14.9784
88	17,351	2,628	16,037	79,495	4.5815	0.2068	15.1853
89	14,723	2,413	13,517	63,458	4.3100	0.1743	15.3596
90	12,310	2,177	11,222	49,941	4.0569	0.1447	15.5043
91	10,133	1,929	9,169	38,719	3.8211	0.1182	15.6225
92	8,204	1,676	7,366	29,551	3.6019	0.0950	15.7175
93	6,528	1,428	5,814	22,185	3.3984	0.0750	15.7925
94	5,100	1,191	4,505	16,371	3.2097	0.0581	15.8506
95	3,910	972	3,424	11,865	3.0349	0.0442	15.8947
96	2,938	775	2,550	8,442	2.8733	0.0329	15.9276
97	2,163	604	1,860	5,891	2.7242	0.0240	15.9516
98	1,558	460	1,328	4,031	2.5867	0.0171	15.9687
99	1,098	341	928	2,703	2.4602	0.0120	15.9807
100	757	247	634	1,775	2.3441	0.0082	15.9889
101	510	174	423	1,141	2.2377	0.0055	15.9943
102	336	120	276	718	2.1404	0.0036	15.9979
103	216	80	176	443	2.0517	0.0023	16.0001
104	135	52	109	267	1.9712	0.0014	16.0015
105	83	33	66	158	1.8984	0.0009	16.0024
106	50	21	40	91	1.8328	0.0005	16.0029
107	29	12	23	52	1.7742	0.0003	16.0032
108	17	7	13	29	1.7220	0.0002	16.0034
109	9	4	7	16	1.6761	0.0001	16.0035
110	5	2	4	8	1.6359	5.14E-05	16.0035
111	3	1	2	4	1.6011	2.76E-05	16.0035
112	1	7.09E-01	1	2	1.5709	1.46E-05	16.0036
113	7.80E-01	3.76E-01	5.91E-01	1	1.5443	7.63E-06	16.0036
114	4.03E-01	1.97E-01	3.05E-01	6.12E-01	1.5189	3.93E-06	16.0036
115	2.06E-01	1.02E-01	1.56E-01	3.08E-01	1.4907	2.01E-06	16.0036
116	1.05E-01	5.19E-02	7.88E-02	1.52E-01	1.4514	1.02E-06	16.0036
117	5.29E-02	2.63E-02	3.98E-02	7.32E-02	1.3845	5.13E-07	16.0036
118	2.66E-02	1.32E-02	2.00E-02	3.35E-02	1.2571	2.58E-07	16.0036
119	1.34E-02	6.64E-03	1.01E-02	1.35E-02	1.0044	1.30E-07	16.0036
120	6.76E-03	0	3.38E-03	3.38E-03	0.5000	4.36E-08	16.0036
						16.0036	

In Table 2, we continue with our example using the *U.S. Life Tables, 1998* data for a male age 65. We show l_x, d_x, L_x, Y_x, and e_x in columns (2) through (6) of Table 2. In column (7) of Table 2, we show the probability of survival for the 65-year old male at each mid-year age using l_{65} and L_x at each age 65 to age 120. Summing all of the mid-year probabilities of survival from age 65 to age 120, our equation (10), equals the computation of Y_{65}/l_{65}, our equation (9). Visually, we show this result in Figure 1. At age 65, males have a life expectancy of 16 years. In figure 1, the rectangular life expectancy box represents 16 full years of expected life (dimension of 100 percent survival for 16 years of age). The total area underneath the partial-year probability of survival line from age 65 to age 120 also equals 16 full-years of expected life. The identical results from equations (9) and (10) can be repeated at any whole age from age 0 to age 120.

According to the *U.S. Life Tables, 1998* data for a male age 65, life expectancy is 16 years. From Table 2, we see that the cumulative sum in the probabilities of survival from age 65 to age 80 (16 years) is 12.4569 or 77.8 percent of the eventual life expectancy of 16.0036 years. In this light, 22.2 percent of life expectancy years are contributed at ages beginning at age 81 (16 years following age 65) continuing through the end of the life table. By age 94, 99.0 percent of the survival probability contributions to life expectancy have occurred (15.8506/16.0036) and by age 100, the percent of survival probability contributions to life expectancy rises to 99.9 percent. These figures point out the need for precision life care planning. Using our example of an exactly 65-year old male, age 65 plus 16 years ends medical consumption on the exact age 81. By age 81, only 77.8 percent of life expectancy years are recognized. If the life care planner states that "if the plaintiff is alive at age 81, the life care item is no longer needed," then 22.2 percent of the 16 years of life expectancy are irrelevant to the calculation of *PVM*.

Calculating *PVM* using the *life expectancy* approach

Using the life care plan, growth and discount rates, and the life expectancy statistic, e_x, the litigation economist using the *life expectancy* approach calculates the expected present value, PV_e, for each medical item in the life care plan as:

$$(11) \qquad PV_e = \sum_{c=z}^{n} m_c \frac{(1+g)^{t_c}}{(1+i)^{t_c}} .$$

where the *life expectancy* approach allows,[10]

- m_c is the current-dollar cost of the medical item at each consumption date c;
- g is the expected annual rate of growth in the cost of the medical item;
- i is the annual rate of interest appropriate to the calculation of present value;
- t_c is the number of years from the date c_0 to each c;
- z the first date of actual consumption, date z, equal to or greater than the present value date, c_0; after date z, consumption continues to date n that is less than or equal to $\bar{c}_e$, the date corresponding to the age $x + e_x$.

In Table 3, we show an example of calculating *PVM* beginning on a plaintiff's 65th birthday and continuing as long as the plaintiff is alive using the *life expectancy* approach. In Table 3, the plaintiff's 65th birthday corresponds with the beginning present value date, c_0. In column (2) of Table 3, we show the current $10,000 cost of the medical item annually for 16 whole-years[11] corresponding to the life expectancy, e_{65}, that we calculated in Table 2. Column (4) of Table 3 is the present value of expected future medical costs calculated using an annual 3.5 percent inflation in the cost of the medical care item and an annual 6.0 percent discount rate. Using the assumed figures in this example, *PVM* is $134,587 using the life expectancy approach in contrast to the $132,137 in damages calculated in Table 1 using the *life table* method.

Table 3. Present value of expected future medical damages using the simple life expectancy approach

(1)	(2)	(3)	(4)	(5)
Exact age	Current-dollar cost of the medical care item	Cumulative expected current-dollar cost of medical item	Discounted expected cost of medical item	Cumulative discounted expected cost of medical item
65	$10,000	$10,000	$10,000	$10,000
66	10,000	20,000	9,764	19,764
67	10,000	30,000	9,534	29,298
68	10,000	40,000	9,309	38,607
69	10,000	50,000	9,089	47,696
70	10,000	60,000	8,875	56,572
71	10,000	70,000	8,666	65,237
72	10,000	80,000	8,461	73,699
73	10,000	90,000	8,262	81,961
74	10,000	100,000	8,067	90,028
75	10,000	110,000	7,877	97,904
76	10,000	120,000	7,691	105,595
77	10,000	130,000	7,510	113,105
78	10,000	140,000	7,332	120,437
79	10,000	150,000	7,160	127,597
80	10,000	160,000	6,991	134,587
	$160,000		**$134,587**	

[10] To this point in the article, we have associated the use of survival probabilities from life tables as the *life table* method to calculate *PVM* and the use of the life expectancy statistic as the *life expectancy* approach to calculate *PVM*. We have deliberately used the word "method" with life tables and the word "approach" with life expectancy. Equations (1) to (4) describe a "method" to calculate the survival probabilities in the PV_l equation (5) allowing timed, scheduled consumption of medical items at any date from today to the date associated with age $\bar{x}$. In contrast, the life expectancy statistic is a summary time-interval. Since life expectancy does not proceed with the timed, scheduled consumption of medical items within the life care plan, the usage of life expectancy to calculate *PVM* becomes an "approach" in contrast to the mathematical methodology of survival analysis that is used in the *life table* method of calculating *PVM*. So, the proceeding phrase "the *life expectancy* approach allows" indicates that the *life expectancy* approach is a substitute for the exact survival method and that it has internal inconsistencies regarding the timing of medical item consumption and survival probability that are described throughout this article.

[11] The published values of life expectancy in the *U.S. Life Tables* are rounded to the nearest one-hundredth decimal place, so if using the published table in our example life expectancy would be 16 whole-years.

PVM calculated using the *life expectancy* approach are 1.85 percent higher than damages in the *life table* method; however, damages without present value calculations are 3.15 percent higher using the *life table* method than the simple *life expectancy* approach.

In comparison to the *life table* method, serious problems with using the *life expectancy* approach appear to the reader. Below we discuss two problems glaring from the results of our simple examples:[12]

1. In Table 2, our e_x was not the integer 16, but the numeric value 16.0036. Following the "life certain" application of e_x where the date at age $x+e_x$ is interpreted as the terminal date of life, the plaintiff would purchase 17 units of the medical item because he would be "expected to die" the day after his 81st birthday. Purchasing 17 units of the medical item would be inappropriate because, according to the life table, the plaintiff's survival probabilities would result in an expected 16.5036 consumed units of the medical item. Figuring 17 units of the medical item, *PVM* under the *life expectancy* approach would be 7.02 percent higher than our Table 1 *life table* method *PVM*.

   While some medical items are subject to some level of division of consumption within time intervals, many are not and require whole units of consumption. Assume that the medical item in the example is a durable item that requires replacement each year and is not subject to division. Use of the *life expectancy* approach where the date at age $x+e_x$ sets the terminal age of life forces the litigation economist to calculate 17 units of the medical item. Since the life expectancy statistic has a 0.0036 partial-year, the consumption period of the 17th unit of the medical item is around 36 hours. These problems abound with the decimal portion of life expectancy years.[13]

   If e_x is not considered as providing the addition to current age for the terminal date of life but alternatively as expected number of units that will be consumed in the future, a litigation economist might multiply the cost of the 17th unit by a 0.36 percent chance that the 17th unit would be consumed. However, problems with the *life expectancy* approach continue to persist under this procedure of handling the decimal portion of e_x. Recognizing partial unit consumption acknowledges that it is not that plaintiffs will be partially consuming medical care items, but that the chance that the plaintiffs are alive to be able to consume medical care items in the future creates the decimal portion of e_x. Therefore, working with continuous survival risk on one hand with the survival chance of the decimal portion of e_x and calculating *PVM* inside a discrete time interval of length e_x on the other is inconsistent.
2. When the first consumption of the medical item occurs at c_0, there is an understatement of expected medical damages using the *life expectancy* approach when counting total units consumed as equal to the life expectancy. The life expectancy statistic for each exact age x is calculated using the sum of mid-age survival probabilities. As we see in equation (10), the survival contribution to life expectancy made during age x is less than one. However, when calculating expected medical damages, the first consumption occurs at exact age x where the survival probability is equal to one. We show the actual consumption ages and survival probabilities of the medical item in Table 1. Since consumption occurs at exact ages, the sum of the probabilities of survival are greater in the *life table* method than in the *life expectancy* approach which figures survival probability at the mid-year age (see Table 2). The expected units consumed using the *life table* method of survival to the exact date where consumption occurs are 16.5036, while the *life expectancy* approach, because it does not follow the timing of actual consumption but follows mid-age survival, has 16.0036 expected units consumed.

Consumption timing in life care plans and *PVM*

Since the equations for *PVM* using the *life table* method or the *life expectancy* approach are different, the levels of *PVM* that each calculate are different.[14] If we examine consumption timing in life care plans and the formulation of *PVM*, we can identify which way of calculating *PVM*, the *life table* method or the *life expectancy* approach, is mathematically appropriate.

Life is a 1/0 event (you are alive then you are dead). The range of age for calculating survival probability or life expectancy is the same, x to $\bar{x}$. The *life expectancy* approach follows the timing of life: we calculate *PVM* from today to $x+e_x$ with 100 percent survival and then with 0 percent survival after $x+e_x$ to $\bar{x}$. The *life table* method follows the frequency distribution of survival in the population after the exact age x: we calculate *PVM* from the day after today to age $\bar{x}$ with less than 100 percent survival at any age $x|c$ associated with the survival frequency table of a relevant population.

We can state that the *life table* method is the appropriate way of calculating *PVM* for the following reasons:

[12] The problems with the *life expectancy* approach are not limited to these two areas.

[13] The problem of partial units is not present with the *life table* method. From equation (5), we see that when using the *life table* method, we first set up the series of consumption dates of whole-units of each life care item, m, and then we multiply the present value of m by the chance of survival from today to m_c. Equation (5) does not force medical item consumption dates to be continuous within the boundaries of c_0 and $\bar{c}_l$ ($c_0 \le z \le n \le \bar{c}_l$) regarding medical item consumption dates. In contrast, the nature of the life expectancy statistic as shown in either equation (9) or in equation (10) forces medical item consumption dates to be continuous within the boundaries of c_0 and $\bar{c}_l$ ($c_0 = z < n = \bar{c}_e$). However, numerous items in life care plans are not consumed continuously from c_0 to $\bar{c}_e$, hence the *life expectancy* approach is always inappropriate for those medical items.

[14] Ben-Zion and Reddall wrote about these differences in 1985.

1. With or without an injury, the hazard of death for all persons is a continuous risk and greater than zero beginning with the first moment of the future. Since the life care plan specifies the date of the occurrence of consumption of the medical care item, to calculate *PVM*, the litigation economist must use a statistical method of calculating the probability of survival upon which the consumption of each medical item is conditioned. The *life table* method specifically utilizes the continuous death hazard in calculating *PVM* for any medical item consumable on any future date. Since the *life table* method calculates the probability of survival to each medical item consumption date, it mathematically calculates the correct *PVM*.
2. As shown in equation (10), life expectancy is the sum of independent survival probabilities beginning with the first mid-year age to each future mid-year age through $\bar{x}$. Therefore, the life expectancy statistic has no association to the probability of survival to each medical item consumption date in the life care plan upon which condition of being alive to make the consumption is required; hence, the *life expectancy* approach cannot mathematically calculate the correct *PVM*. Referring back to Figure 1, the life expectancy "square" (dimensioned 100% survival for 16 whole-years) equals the sum of the total area from the axes to the "probability of survival line." Although the survival probabilities that comprise e_{65} are for age 65.5, 66.5, 67.5, … , 120.5, the *life expectancy* approach front-loads 55 years of life expectancy survival probabilities into the 16 whole years from age 65-80. Herein lies a major inconsistency in the *life expectancy* approach: it takes $\bar{x}$ - x + 1 year-long age intervals to construct life expectancy, but the life expectancy approach condenses survival and present value compounding to the first e_x years after *x*.
3. The life expectancy statistic sums survival probabilities continuously from each age *x* until age $\bar{x}$. Life care plans have many medical items with consumption ending before $\bar{x}$ and in those situations, it is impossible to change the *life expectancy* approach to only account for the death hazard between the first consumption date and the last consumption date before $\bar{x}$. In the situations where medical care items end at ages $b < x+e_x$, the mortality of the population at ages greater than age *b* is irrelevant to the calculation of *PVM*. The only relevant survival probabilities for *PVM* are from the first consumption date, by date, through age *b*. Therefore, using the *life expectancy* approach is inappropriate with these medical items and it will always overstate *PVM*. In these instances, the numerators of life expectancy equations (9) or (10) will not match the time-intervals for medical item consumption, so the *life expectancy* approach will give mathematically incorrect *PVM*.
4. Life care plans have many items that begin after the last known date that the plaintiff is alive. Since the plaintiff will have to be alive in order to begin consuming those medical items, there will be a new life expectancy for the plaintiff on the first consumption date of those medical items. If medical items begin their consumption after c_0 and are continuously consumed until $\bar{x}$, we can compute *PVM* with a new life expectancy and then adjust *PVM* by the probability of survival from today to the first consumption date. However, this 'actuarial' type calculation does not fix the other problems with the *life expectancy* approach still present because the calculation of *PVM* still utilizes the life expectancy statistic, not the probability of the occurrence of medical item consumption. An example of this problem is as follows: a medical care item begins on a date after the attainment of age *x*, say *x*+4. The plaintiff must be alive at age *x*+4 in order to begin to consume the medical care item. If the plaintiff is alive at age *x*+4, he or she has a new life expectancy age other than $x+e_x$ because the mortality rates of those aged *x*, *x*+1, *x*+2, and *x*+3 are irrelevant to the separate group of persons alive at age *x*+4. The only relevant survival probabilities for *PVM* in this case are from *x*+4 to $\bar{x}$. Generally, but depending upon the specific life table, adding an extra year of life results in a net addition of life expectancy before the present value calculation. In these situations, the denominators of the life expectancy equations (9) or (10) will not match the time for medical item consumption, so the *life expectancy* approach will give mathematically incorrect *PVM*.
5. Life care plans have many medical items that are the compound of discussion items (3) and (4) above: the medical item consumption date is after the last known date that the plaintiff is alive and ends at an age less than $\bar{x}$. With those medical items, the life expectancy statistic takes on even less relevance because those dying before the first consumption date and those dying after the last consumption date are irrelevant to the survival conditions during specific ages at dates $c>c_0$ through the date of age $b < x+e_x$; hence, the *life expectancy* approach is inappropriate to the calculation of *PVM*. Alternatively, in these situations the numerators and denominators of the life expectancy equations (9) or (10) will not match the time for medical item consumption, so the *life expectancy* approach will give mathematically incorrect survival conditions.

In tables 4 through 6, we show the percent differences in *PVM* between the *life table* method and the *life expectancy* approach by sex, net discount rate, and current exact age of the plaintiff. We calculate the percent difference in each of these tables as $PV_l / PV_e - 1$: the percent differences describe how much lower or higher PV_l is as compared to PV_e. We use the *U.S. Life Tables 1998* data for all males and all females. The percentage differences between the *life table* method and the *life expectancy* approach in the following tables are unique to the use of these 1998 life tables with their estimated survival conditions from specific population estimates in a specific year. Results will vary when using different life tables, populations, and survival estimates.

Table 4. Percent differences in *PVM* (*life table* method divided by *'current' life expectancy* approach minus one) with consumption of a medical item beginning today and continuing monthly for the plaintiff's lifetime, by sex, net discount rate, and current exact age

MALES	**Net discount rate**										
Exact age	-1.0%	-0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
1	2.4%	1.1%	0.0%	-0.7%	-1.2%	-1.6%	-1.8%	-1.8%	-1.9%	-1.8%	-1.7%
5	2.3	1.0	0.0	-0.8	-1.3	-1.7	-1.9	-2.0	-2.0	-2.0	-1.9
10	2.3	1.0	-0.1	-0.9	-1.5	-1.9	-2.1	-2.3	-2.4	-2.4	-2.3
15	2.6	1.2	0.1	-0.8	-1.5	-2.0	-2.3	-2.5	-2.7	-2.7	-2.7
20	2.5	1.1	0.0	-0.9	-1.6	-2.1	-2.5	-2.8	-2.9	-3.0	-3.0
25	2.6	1.2	0.1	-0.8	-1.6	-2.1	-2.5	-2.8	-3.0	-3.2	-3.2
30	2.6	1.2	0.1	-0.9	-1.6	-2.2	-2.7	-3.0	-3.3	-3.4	-3.5
35	2.4	1.1	-0.1	-1.0	-1.8	-2.5	-3.0	-3.4	-3.7	-3.9	-4.0
40	2.5	1.1	-0.1	-1.1	-1.9	-2.6	-3.2	-3.7	-4.0	-4.3	-4.5
45	2.6	1.2	0.0	-1.1	-2.0	-2.7	-3.4	-3.9	-4.4	-4.7	-5.0
50	2.6	1.2	0.0	-1.1	-2.0	-2.9	-3.6	-4.2	-4.7	-5.1	-5.5
55	2.6	1.2	0.0	-1.1	-2.1	-3.0	-3.7	-4.4	-5.0	-5.5	-5.9
60	2.7	1.3	0.1	-1.1	-2.1	-3.0	-3.8	-4.5	-5.2	-5.7	-6.2
65	2.2	0.9	-0.3	-1.3	-2.3	-3.2	-4.0	-4.8	-5.4	-6.0	-6.6

FEMALES	**Net discount rate**										
Exact age	-1.0%	-0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
1	1.9%	0.8%	0.0%	-0.5%	-0.9%	-1.1%	-1.3%	-1.3%	-1.3%	-1.2%	-1.2%
5	1.8	0.7	0.0	-0.6	-1.0	-1.2	-1.4	-1.4	-1.4	-1.3	-1.3
10	1.9	0.9	0.0	-0.6	-1.0	-1.3	-1.5	-1.6	-1.6	-1.5	-1.5
15	1.9	0.9	0.0	-0.6	-1.1	-1.4	-1.7	-1.8	-1.8	-1.8	-1.8
20	1.9	0.8	-0.1	-0.7	-1.2	-1.6	-1.8	-2.0	-2.0	-2.0	-2.0
25	2.1	0.9	0.0	-0.7	-1.2	-1.7	-1.9	-2.1	-2.2	-2.3	-2.3
30	2.1	0.9	0.0	-0.8	-1.4	-1.8	-2.2	-2.4	-2.5	-2.6	-2.7
35	2.2	1.0	0.0	-0.8	-1.4	-1.9	-2.3	-2.6	-2.8	-3.0	-3.1
40	2.3	1.1	0.0	-0.8	-1.5	-2.1	-2.5	-2.9	-3.2	-3.4	-3.5
45	2.3	1.1	0.0	-0.9	-1.6	-2.3	-2.8	-3.2	-3.5	-3.8	-4.0
50	2.4	1.1	0.0	-0.9	-1.7	-2.4	-3.0	-3.5	-3.9	-4.2	-4.5
55	2.4	1.1	0.0	-1.0	-1.8	-2.6	-3.2	-3.8	-4.3	-4.7	-5.0
60	2.5	1.3	0.1	-0.9	-1.8	-2.6	-3.3	-3.9	-4.5	-5.0	-5.4
65	2.3	1.1	0.0	-1.0	-1.9	-2.7	-3.5	-4.1	-4.7	-5.3	-5.7

In Table 4, we show the percent differences calculated in *PVM* for any constant consumption of a medical item beginning today and continuing monthly for the plaintiff's lifetime.[15] Since the first consumption date coincides with today, PV_e is calculated using the conventional 'current' life expectancy equal to current exact age plus remaining life expectancy years. Working through an example, suppose that the life care plan is for a male currently age 50 and a medical item in the plan is consumed monthly beginning today and continuing to the expected end of life and the item currently costs $100. Then, the percent difference between PV_l and PV_e for this medical item is -3.6 percent (meaning PV_l is lower than PV_e) when the net discount rate is 2.0 percent. When medical item cost growth and the time value of money are not important (i.e., the net discount rate is equal to zero), there is minimal difference between PV_l is as compared to PV_e. As net discount rates grow further from zero, the percent differences between PV_l and PV_e also grow. As the current exact age of the plaintiff increases, so does the percent difference between PV_l and PV_e.

In Table 5, we show the percent differences calculated in *PVM* for any constant consumption of a medical item beginning fifteen years from today and continuing monthly for the plaintiff's lifetime. Since the first consumption date coincides with today, PV_e is calculated using the 'actuarial' life expectancy equal to future exact age plus remaining life expectancy years at that future age multiplied by the chance of survival from today to that future age. Working through an example, suppose that the life care plan is for a male currently age 25 and a medical item in the plan is consumed monthly beginning at age 40 and continuing to the expected end of life and the item currently costs $100. Then, the percent difference between PV_l and PV_e for this medical item is –3.7 percent (meaning PV_l is lower than PV_e) when the net discount rate is 2.5 percent. When medical item cost growth and the time value of money are not important (i.e., the net discount rate is equal to zero), there is minimal difference between PV_l is as compared to PV_e at young ages because of low death hazards at young ages. However, as age increases (and life expectancy shortens) the difference between PV_l and PV_e grows. As net

[15] Constant consumption in our examples means that the medical care item will be consumed in each consecutive month from the starting consumption date through the ending consumption date. Since we are taking the ratio of *PVM's* the current-dollar costs of the life care items cancel so the current-dollar cost of the medical care item is irrelevant to the percentage difference calculation.

Table 5. Percent differences in *PVM* (*life table* method divided by the *'actuarial' life expectancy* approach minus one) with consumption of one medical item beginning fifteen years from today and continuing monthly for the plaintiff's lifetime, by sex. net discount rate, and current exact age											
MALES	**Net discount rate**										
Exact age	-1.0%	-0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
1	2.5%	1.1%	0.0%	-0.9%	-1.5%	-2.0%	-2.4%	-2.6%	-2.7%	-2.8%	-2.8%
5	2.5	1.1	0.0	-0.9	-1.6	-2.1	-2.5	-2.8	-2.9	-3.0	-3.0
10	2.6	1.2	0.1	-0.8	-1.6	-2.1	-2.5	-2.8	-3.0	-3.2	-3.2
15	2.6	1.2	0.1	-0.9	-1.6	-2.2	-2.7	-3.0	-3.3	-3.4	-3.5
20	2.4	1.1	-0.1	-1.0	-1.8	-2.5	-3.0	-3.4	-3.7	-3.9	-4.0
25	2.5	1.1	-0.1	-1.1	-1.9	-2.6	-3.2	-3.7	-4.0	-4.3	-4.5
30	2.6	1.2	0.0	-1.1	-2.0	-2.7	-3.4	-3.9	-4.4	-4.7	-5.0
35	2.6	1.2	0.0	-1.1	-2.0	-2.9	-3.6	-4.2	-4.7	-5.1	-5.5
40	2.6	1.2	0.0	-1.1	-2.1	-3.0	-3.7	-4.4	-5.0	-5.5	-5.9
45	2.7	1.3	0.1	-1.1	-2.1	-3.0	-3.8	-4.5	-5.2	-5.7	-6.2
50	2.2	0.9	-0.3	-1.3	-2.3	-3.2	-4.0	-4.8	-5.4	-6.0	-6.6
55	2.3	1.1	0.0	-1.0	-2.0	-2.8	-3.7	-4.4	-5.1	-5.8	-6.4
60	2.4	1.3	0.3	-0.6	-1.5	-2.4	-3.2	-3.9	-4.6	-5.2	-5.8
65	2.3	1.3	0.4	-0.5	-1.3	-2.1	-2.8	-3.5	-4.2	-4.8	-5.4
FEMALES	**Net discount rate**										
Exact age	-1.0%	-0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
1	2.0%	0.9%	0.0%	-0.6%	-1.1%	-1.4%	-1.7%	-1.8%	-1.8%	-1.8%	-1.8%
5	1.9	0.8	-0.1	-0.7	-1.2	-1.6	-1.8	-2.0	-2.0	-2.0	-2.0
10	2.1	0.9	0.0	-0.7	-1.2	-1.7	-1.9	-2.1	-2.2	-2.3	-2.3
15	2.1	0.9	0.0	-0.8	-1.4	-1.8	-2.2	-2.4	-2.5	-2.6	-2.7
20	2.2	1.0	0.0	-0.8	-1.4	-1.9	-2.3	-2.6	-2.8	-3.0	-3.1
25	2.3	1.1	0.0	-0.8	-1.5	-2.1	-2.5	-2.9	-3.2	-3.4	-3.5
30	2.3	1.1	0.0	-0.9	-1.6	-2.3	-2.8	-3.2	-3.5	-3.8	-4.0
35	2.4	1.1	0.0	-0.9	-1.7	-2.4	-3.0	-3.5	-3.9	-4.2	-4.5
40	2.4	1.1	0.0	-1.0	-1.8	-2.6	-3.2	-3.8	-4.3	-4.7	-5.0
45	2.5	1.3	0.1	-0.9	-1.8	-2.6	-3.3	-3.9	-4.5	-5.0	-5.4
50	2.3	1.1	0.0	-1.0	-1.9	-2.7	-3.5	-4.1	-4.7	-5.3	-5.7
55	2.1	0.9	-0.1	-1.1	-2.0	-2.8	-3.6	-4.3	-4.9	-5.4	-6.0
60	1.9	0.8	-0.2	-1.1	-1.9	-2.7	-3.5	-4.2	-4.8	-5.4	-5.9
65	1.6	0.6	-0.3	-1.2	-2.0	-2.7	-3.5	-4.2	-4.8	-5.4	-6.0

discount rates grow further from zero, the percent differences between PV_l and PV_e also grow. As the current exact age of the plaintiff increases, the percent difference between PV_l and PV_e levels and then falls.

In Table 6, we show the percent differences calculated in *PVM* for any constant consumption of a medical item beginning today and continuing monthly for fifteen years. Working through an example, suppose that the life care plan is for a male currently age 55 and a medical item in the plan is consumed monthly beginning at age 55 and continuing to age 70 and the item currently costs $100. Then, the percent difference between PV_l and PV_e for this medical item is -9.2 percent (meaning PV_l is lower than PV_e) when the net discount rate is 1.0 percent. Again, there is minimal difference between PV_l is as compared to PV_e at very young ages because of low death hazards at young ages. However, as age increases (and life expectancy shortens), the difference between PV_l and PV_e also grows exponentially. As net discount rates grow further positive from zero, the percent differences between PV_l and PV_e shrink because the time value of money lowers PV_e increasingly.

In Table 7, we show the percent differences calculated in *PVM* for the consumption of a medical item once, exactly fifteen years from today. Working through an example, suppose that the life care plan is for a male currently age 40 and a medical item in the plan is consumed once at age 55 and the item currently costs $100. The percent difference between PV_l and PV_e for this medical item is –6.8 percent (meaning PV_l is lower than PV_e). Since the medical item is consumed only once, the growth and discount portions of the PV equations cancel leaving the difference between PV_l and PV_e equal to the survival probability from the exact age, x, to x+15. Again, as age increases (and life expectancy shortens), the difference between PV_l and PV_e also grows exponentially.

In tables 5 through 7, we presented a series of similar examples associated with medical item consumption not following a schedule of continuous consumption from c_0 to either $\bar{c}_e$ or $\bar{c}_l$. These examples focused on consumption in a combination of beginning or stopping fifteen years after the current exact age. In actual life care plans, there are many different combinations consumption durations beginning at various ages. Because of the wide-ranging possible reasons for differences in *PVM* calculated using the life table method or life expectancy approach, it is impossible to generalize how much lower (or higher) PV_l will be than PV_e.

Table 6. Percent differences in *PVM* (*life table* method divided by the *'current' life expectancy* approach minus one) with consumption of one medical item beginning today and continuing monthly for fifteen years, by sex. net discount rate, and current exact age

MALES	**Net discount rate**										
Exact age	-1.0%	-0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
1	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
5	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
10	-0.5	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
15	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
20	-1.1	-1.1	-1.1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
25	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.0	-1.0
30	-1.5	-1.4	-1.4	-1.4	-1.4	-1.4	-1.3	-1.3	-1.3	-1.3	-1.3
35	-2.0	-2.0	-2.0	-1.9	-1.9	-1.9	-1.8	-1.8	-1.8	-1.8	-1.7
40	-2.9	-2.9	-2.8	-2.8	-2.7	-2.7	-2.7	-2.6	-2.6	-2.5	-2.5
45	-4.3	-4.2	-4.1	-4.1	-4.0	-4.0	-3.9	-3.8	-3.8	-3.7	-3.7
50	-6.4	-6.3	-6.2	-6.1	-6.0	-5.9	-5.8	-5.7	-5.6	-5.6	-5.5
55	-9.7	-9.6	-9.5	-9.3	-9.2	-9.0	-8.9	-8.8	-8.6	-8.5	-8.4
60	-14.6	-14.4	-14.2	-14.0	-13.8	-13.6	-13.4	-13.2	-13.0	-12.8	-12.6
65	-21.1	-20.8	-20.5	-20.2	-19.9	-19.6	-19.3	-19.0	-18.8	-18.5	-18.2
FEMALES	**Net discount rate**										
Exact age	-1.0%	-0.5%	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
1	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
5	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
10	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
15	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
20	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3
25	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
30	-0.8	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7
35	-1.1	-1.1	-1.1	-1.1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
40	-1.6	-1.6	-1.6	-1.6	-1.5	-1.5	-1.5	-1.5	-1.4	-1.4	-1.4
45	-2.5	-2.4	-2.4	-2.4	-2.3	-2.3	-2.3	-2.2	-2.2	-2.1	-2.1
50	-3.9	-3.8	-3.8	-3.7	-3.7	-3.6	-3.5	-3.5	-3.4	-3.4	-3.3
55	-6.1	-6.0	-5.9	-5.8	-5.7	-5.6	-5.5	-5.5	-5.4	-5.3	-5.2
60	-9.3	-9.2	-9.1	-8.9	-8.8	-8.6	-8.5	-8.4	-8.3	-8.1	-8.0
65	-14.0	-13.8	-13.6	-13.4	-13.2	-13.0	-12.8	-12.6	-12.4	-12.2	-12.0

PVM Computation Algorithm

Before calculating a *PVM*, we must have an algorithm or procedure to work through each of the *PVM* computation steps. Following algorithms we can design computer software to make *PVM* calculations. The main steps required to make a *life table* method *PVM* calculation are:

1. Obtain data. Obtain the beginning and ending of the time interval bounding consumption of the medical care item. Obtain the frequency of consumption (e.g. monthly, annually, every 5 years, etc.) that the medical care item will be consumed within the interval. Obtain the current-dollar cost of the medical care item, the expected future annual growth in the cost of the medical care item, and an appropriate interest rate to calculate present value. Obtain the plaintiff's date of birth, the relevant life table, and the last known survival date of the plaintiff (also the present value date).

Beginning on the first consumption date, do: calculate the number of persons alive on the last known survival date, $l_{x|c_0}$. Calculate the number of persons alive on the consumption date, l_c. Calculate the probability of

Table 7. Percent differences in *PVM* (*life table* method divided by *life expectancy* approach minus one) with consumption of one medical item 15 years from today, by sex and current exact age

	Any net discount rate	
Exact age	**Males**	**Females**
1	-0.5%	-0.3%
5	-0.7	-0.4
10	-1.3	-0.5
15	-1.9	-0.7
20	-2.2	-0.9
25	-2.5	-1.2
30	-3.4	-1.8
35	-4.7	-2.6
40	-6.8	-3.9
45	-10.2	-6.1
50	-15.4	-9.5
55	-22.9	-14.6
60	-33.1	-22.0
65	-45.7	-32.1

survival to be alive to be able to consume the medical item as $l_{x|c} / l_{x|c_0}$. Multiply the cost of the medical item times the probability of survival times the net discount factor and store the expected present value of the medical item on that date.

2. Increment time to the next consumption date by the frequency of medical item consumption. If the next consumption date using the frequency of medical item consumption is less than the ending consumption date repeat the previous step and add the expected present value on the new consumption date to the stored value(s) from the previous consumption date(s). If the next consumption date is greater than the ending consumption date, stop and return the accumulated expected present value of the medical item.

The main steps required to make a *life expectancy* approach *PVM* calculation are:

1. Obtain data. Obtain the beginning and ending of the time interval bounding consumption of the medical care item. Obtain the frequency of consumption (e.g. monthly, annually, every 5 years, etc.) that the medical care item will be consumed within the interval. Obtain the current-dollar cost of the medical care item, the expected future annual growth in the cost of the medical care item, and an appropriate interest rate to calculate present value. Obtain the plaintiff's date of birth, the relevant life expectancy statistic to set the boundary of time from the last known survival date of the plaintiff (also the present value date) to the terminal time of life ($x+e_x$).
2. Beginning on the first consumption date, do: multiply the cost of the medical item times the net discount factor and store the present value of the medical item on that date.
3. Increment time to the next consumption date by the frequency of medical item consumption. If the next consumption date using the frequency of medical item consumption is less than the ending consumption date repeat the previous step and add the expected present value on the new consumption date to the stored value(s) from the previous consumption date(s). If the next consumption date is greater than the ending consumption date, stop and return the accumulated expected present value of the medical item.

Visual Basic and Excel

Microsoft Excel has the most extensive and flexible macro language of any spreadsheet program widely available. With Excel, we can design a table in a workbook to show the contents of the life care plan and also embed a Visual Basic for Applications (VBA) program into the workbook to make our *PVM* calculations to insert into the life care plan table.

Visual Basic is a programming language that has many built-in functions that operate the same way as Excel's built-in functions. Any user of Excel (or other spreadsheets) is probably familiar with functions such as PV(rate,nper,pmt), a function that returns the present value of an investment. To use the PV function in Excel, the user types into a cell, for example, the formula =PV(6%,10,$100). This Excel function would return the present value of $100 payments for 10 years with a 6 percent discount rate. Within Excel's built-in function library is a small program that calculates present value when the PV function is called for and supplied with the required parameters rate, nper, and pmt. Using VBA, we can write our own functions for use within Excel to perform practically any series of calculations using parameters we pass to the VBA program and then the VBA program makes its programmed series of calculations and returns to us a result.

Using VBA to write your own function macros is simple. In the following steps, we show how to create a simple macro for adding two numbers together and then return the sum to the spreadsheet. The example below uses Microsoft Excel 2000. Other versions of Excel have similar steps for creating VBA function macros but the names of the Windows will be slightly different.

1. Open a blank Excel workbook and save it with the name "SUM".
2. Using your mouse, under the "Tools" menu, slide down to "Macro" and then slide over to select "Visual Basic Editor" (the shortcut for this step is to hit Alt+F11 on your keyboard). A new window titled "Microsoft Visual Basic – SUM.xls" will now appear on your computer.
3. Within the "Microsoft Visual Basic – SUM.xls" window, using your mouse go to the "Insert" menu and then slide down and select "Module". A new window titled "Microsoft Visual Basic – SUM.xls – [Module 1 (Code)]" will now appear on your computer. In this window, type the following text:
```
Function macro_sum(number_1, number_2)
macro_sum = number_1 + number_2
End Function
```
4. Using your mouse, go to the "File" menu and then slide down to the choice "Close and Return to Microsoft Excel" (the shortcut for this step is to hit Alt+Q on your keyboard). You will now close the VBA windows and return to the Excel workbook.
5. In any cell in any worksheet within the "SUM" workbook, type the following formula:
`=macro_sum(5,12)`
6. When you hit the "enter" key, Excel will look for a function titled "macro_sum" within the macro modules stored in the workbook, pass the two parameters 5 and 12 to the function macro, run the macro, and return the value 17.

You have just created a macro in Excel! The sophistication of any Excel VBA macro is limited only to your imagination in writing a set of instructions for Excel and/or VBA to make a series of calculations returning its result to a worksheet. There are many good books available to learn more about Excel VBA and the help system within Excel provides definitions and examples of all of VBA's internal functions and syntax.

A VBA Excel macro for calculating *PVM*

In this article's Appendix, we show the complete text of a series of VBA function macros that calculate *PVM*. These macros are a part of an Excel workbook that provides a

Figure 2. The life care table with PVM calculations called from VBA function macros

Table 1. Present value of expected future medical damages

Plaintiff's name: Joe Plaintiff

Today's date: 9/25/2000

Medical care item	Beginning consumption date	Ending consumption date	Cost per unit of each medical care item	Units required	Consumption frequency	Consumption frequency time units	Medical item annual cost growth	Appropriate medical item discount rate	Current-dollar expected costs to life expectancy	Current-dollar expected costs over remaining lifetime	Present value expected costs to life expectancy	Present value expected costs over remaining lifetime
Medical care item #1	Today	Lifetime	$120,000	1.0	1	Year	3.5%	6.0%	$6,360,000	$6,417,928	$3,651,933	$3,576,487
Medical care item #2	Today	Lifetime	$10,000	1.0	1	Month	3.5%	6.0%	$6,360,000	$6,363,078	$3,612,394	$3,521,329
Medical care item #3	Age 25	8/25/2015	$10,000	1.0	1	Month	3.5%	6.0%	$1,800,000	$1,785,217	$1,514,582	$1,502,970
Medical care item #4	Age 40	8/25/2035	$10,000	1.0	1	Month	3.5%	6.0%	$2,400,000	$2,274,224	$1,335,468	$1,269,958
Medical care item #5	Age 60	Lifetime	$10,000	1.0	1	Month	3.5%	6.0%	$2,160,000	$2,303,637	$762,343	$748,401
								Sum	**$6,360,000**	**$6,363,078**	**$3,612,394**	**$3,521,329**
Medical care item #6	Today	Lifetime	$10,000	5.0	5	Years	4.0%	7.0%	$550,000	$554,847	$298,288	$291,908
Medical care item #7	Age 60	Age 60	$100	5.0	1	Month	3.5%	6.0%	$500	$446	$217	$193
Medical care item #8	1/1/2015	12/1/2019	$10,000	1.0	3	Months	4.0%	7.0%	$200,000	$195,510	$124,701	$121,917
Column A	**Column B**	**Column C**	**Column D**	**Column E**	**Column F**	**Column G**	**Column H**	**Column I**	**Column J**	**Column K**	**Column L**	**Column M**

Table column title	Function macro call with parameters
Current-dollar expected costs to life expectancy	macro_lifecare("Current","Current",date_dob,integer_race_sex,date_t0,$B7,$C7,$D7,$E7,$F7,$G7,$H7,$I7)
Current-dollar expected costs over remaining lifetime	macro_lifecare("Survive","Current",date_dob,integer_race_sex,date_t0,$B7,$C7,$D7,$E7,$F7,$G7,$H7,$I7)
Present value expected costs to life expectancy	macro_lifecare("Current","PV",date_dob,integer_race_sex,date_t0,$B7,$C7,$D7,$E7,$F7,$G7,$H7,$I7)
Present value expected costs over remaining lifetime	macro_lifecare("Survive","PV",date_dob,integer_race_sex,date_t0,$B7,$C7,$D7,$E7,$F7,$G7,$H7,$I7)

complete software solution for calculating *PVM*. The workbook is downloadable from the Internet site http://JohnWardEconomics.com/Medical/. Documentation on how to use the workbook in making *PVM* calculations is contained within the workbook. Documentation for the macro is contained within the macro itself. Readers are encouraged to download the workbook and try different scenarios of *PVM* calculations.

Within the Appendix's "ForensicMacros Module", there are four different function macros: macro_lifecare, macro_prob_alive, macro_date_life_expectancy, and macro_double_yearfrac. The macro_lifecare function calculates the present value of expected future medical damages using the *life table* method or two different *life expectancy* approaches. The function macro_prob_alive calculates the probability of survival from the date of last known survival to any future date. The function macro_date_life_expectancy looks up remaining life expectancy in a lookup table and calculates the date associated with the life expectancy age. The function macro_double_yearfrac calculates the numeric difference between two dates.

In Figure 2, we show an example table within an Excel workbook to show *PVM* for a life care plan. The boxed area represents an example table that depicts the medical care items in a life care plan and each item's *PVM*. Below the table, we show the columns within a worksheet in the workbook and the associated function macro formulas contained within columns *J* through *M* of the worksheet. Medical care items within a life care plan are describable by the information in columns *A* through *G* of Figure 2. The litigation economist supplies the expected cost growth and appropriate discount rate by item in columns *H* and *I*. Using the variables "date_dob", "integer_race_sex", and "date_t0" contained elsewhere in the workbook, the litigation economist can choose the type of *PVM* calculation for the first parameter of the function macro "macro_lifecare", the type of dollars calculated with the second parameter, and the last eight parameters are simply references to the data contained in columns *B* through *I* of the table showing the medical items in the life care plan. The macro macro_lifecare allows a variety of ways of inputting beginning and ending consumption dates; it allows for various units and frequencies of consumption; and, each medical item can have its own expected growth and appropriate discount rate.

Within Figure 2, we show a variety of *PVM* for medical items for a 25-year old plaintiff using the *U.S. Life Table, 1998* data for all persons. Assume that medical care items #1 and #2 both present the cost of supportive care. In item #1, we show the annual cost of supportive care while in item #2, the monthly cost of supportive care (annual cost divided by twelve) is listed. Using the *life expectancy* approach, the total current-dollar costs are the same no matter if costs are calculated annually or monthly, however, future-dollar costs and *PVM* are remarkably different in all other calculations. Medical care items #3, #4, and #5 all sum to the continuous consumption timeframe as shown in item #2, but the differences in between *PVM* under the life table method and life expectancy approach are again illustrated as we saw in tables 5, 6, and 7. Medical care items #6, #7, and #8 show various ways to depict information in a life care plan.

Conclusion

The life care plan presents the required consumption of medical items on specific future dates. Litigation economists use the present value formula, the current-dollar amounts of medical items on each specific consumption date, and a mortality risk to calculate the present value of expected future medical damages. As described in this article, litigation economists rely on life tables for calculating the probability that the plaintiff would be alive at each specific future date in order to consume the required medical item. An alternative approach to accounting for mortality risk has been the use of the life expectancy statistic that is calculated from life tables. However, we have shown in this article that use of the life expectancy statistic embeds certain inaccuracies to the calculation of the present value of expected future medical damages. In nearly every litigation economics assignment, the economist makes a projection of anticipated economic losses absent risk, adjusts those losses for the risks that they would occur, and then discounts the risk-adjusted losses to present value. From this viewpoint, the calculation method of the present value of expected future medical damages points squarely to the usage of the *life table* method of calculating economic damages as described in this article.

In this article, we show that *PVM* under the *life table* method is comparable with *PVM* from the *life expectancy* approach only when the following two conditions exist within the analysis: (1) all medical items begin today and continue as long as the plaintiff is alive, and (2) the net discount rate is zero. Seldom are the above two conditions present throughout each item in a life care plan, therefore the *life expectancy* approach introduces certain inaccuracies to the calculation of *PVM*. In the introduction to this article, we are clear to point out that the procedures presented within this article require that the use of life tables or life expectancy calculated from life tables is the preferred choice of evaluation. The life expectancy statistic does not exist without the life table and its associated survival probabilities. An expert may believe that the life table calculations are too burdensome to explain to a jury. However, this comment flies in the face of the fact that the life table survival probabilities have primacy to the life expectancy statistic. Hence, experts using $x + e_x$ as the terminal age of life care consumption should be careful to distinguish that they are not actually following the timing of the occurrence of e_x, but are using an approach outside the survival model that generates e_x in stating that they are expecting a "life certain" to age $x + e_x$.

A traditional approach by litigation economists to calculate the present value of expected future medical damages is to construct a custom table within an electronic spreadsheet showing age or years down the first column and medical item costs and discount factors in adjacent columns. While this approach presents a columnar view of how the present value of expected medical damages appears over time, it certainly is not concisely descriptive of how the individual medical care items are consumed/discounted. Such a columnar method results in pages upon pages of numbers, especially when each row in a table represents a month where consumption occurs. As an alternative to the undescriptive columnar method, we present a series of electronic spreadsheet macros that allow a clear descriptive tabular method of calculating the present value of expected medical damages. The tabular calculation method with macros allows medical damages to be calculated consistently, accurately, and quickly as opposed to the tedious columnar approach that can easily result in errors because the litigation economist is forced to work with literally tens-of-thousands of numbers in a lengthy life care plan.

References

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Appendix: VBA Excel Macro Module

```
' ForensicMacros Module
Function macro_lifecare(string_life_type As String, _
                        string_dollar_type As String, _
                        date_dob As Date, _
                        integer_race_sex As Integer, _
                        date_t0 As Date, _
                        date_item_begins As Variant, _
                        date_item_ends As Variant, _
                        double_cost_per_unit As Double, _
                        double_units_required_in_time_interval As Double, _
                        integer_time_interval As Double, _
                        string_year_or_month As String, _
                        double_cost_growth As Double, _
                        double_cost_discount As Double _
                        ) As Double
' Purpose:
' This function macro is used for calculating total life care costs in current, future, or present value
' dollars.

' The life table method calculates the probability of survival from the last known date that the plaintiff
' is alive to any future date.
'
' This macro also includes two other life expectancy approaches that are often used by forensic economists
' (1) the current life expectancy approach where the termination of life occurs with the life expectancy
' figured at the Plaintiff's current age, and (2) the actuarial life expectancy approach where any need that
' begins at a date after today, life expectancy is figured at that day and then the result is adjusted by
' the chance of survival to that future beginning date.

' Conventions:
' The input variable descriptions follow the format variable-type_description.

' Description of macro parameters:
' Parameter #1 - string_life_type
'   This parameter specifies the type of life care calculation desired:
'     Valid entries:
'       "Current_Life_Expectancy"   - life expectancy at today's date
'       "Actuarial_Life_Expectancy" - life expectancy at future beginning date actuarially adjusted for
'                                     survival
'                                     to today's date
'       "Survival_Life_Table"       - probability of survival period to period.
'     The following abbreviations are allowed "Current", "Actuarial", and "Surviv" (to allow "Survive"
'     or "Survival").
'
' Parameter #2 - string_dollar_type
'   This parameter specifies the type of dollar calculation desired:
'     Valid entries:
'       "Current_Dollars"       - no growth or discounting
'       "Future_Dollars"        - growth but no discounting
'       "Present_Value_Dollars" - growth and discounting.
'     The following abbreviations are allowed: "Current", "Future", and any string starting with the word
'     "P" (e.g. "PV" or "Present").
'
' Parameter #3 - date_dob
'   This parameter specifies the date of birth of the plaintiff.
'     Valid entries:
'       Any valid Excel date is required.
'       In this macro workbook, the date of birth is asked for in the opening worksheet and is stored under
'       the name date_dob.
'
' Parameter #4 - integer_race_sex
'   This parameter signifies the column number of the life expectancy
'   and whole life table representing the race and sex combination of the
'   plaintiff.
'     Valid entries:
'       In this macro, the life data used has 9 race/sex combinations so valid entries are 1 to 9.  This
'       data is stored in the this workbook's variable name integer_race_sex that is set by selecting
'       a list in a pop-down menu on the DataInput-Plaintiff worksheet.
'
```

```
' Parameter #5 - date_t0
'   This time=0 date is used to identify the certain date of: (1) the date used to calculate the present
'   value of lifecare costs, and (2) the date where the chance of being alive is certain.  This date
'   is most often set to the data the analysis was prepared or the trial or settlement date.
'     Valid entries:
'       Any valid Excel date is required.
'       In this macro workbook, this date is asked for in the opening worksheet and is stored under the
'       name date_t0.
'
' Parameter #6 - date_item_begins
'   This is the date that the lifecare cost item begins.
'     Valid entries:
'        "Today" - the date associated with date_t0
'        "Age #" - a future birthday associated with age (e.g. "Age 40","Age 50.5")
'        Any valid Excel date is also accepted (e.g. 9/1/2000).
'
' Parameter #7 - date_item_ends
'   This is the date that the lifecare cost item ends.
'     Valid entries:
'        "Today"    - the date associated with date_t0
'        "Age #"    - a future birthday associated with an age (e.g. "Age 40","Age 50.5")
'        "Lifetime" - when using the life expectancy approaches, the date of remaining life expectancy is
'                     calculated within the macro; when using the life table approach, the last birthday
'                     within the life table is calculated (the life table within this macro ends at age
'                     120).
'        Any valid Excel date is also accepted (e.g. 9/1/2000).
'
' Parameter #8 - double_cost_per_unit
'   This is the per unit cost of life care item.
'     Valid entries: Any numeric data with the format #.#.
'
' Parameter #9 - double_units_required_in_time_interval
'   This is the number of units required per year or per month.
'     Valid entries: Any numeric data with the format #.#.
'
' Parameter #10 - integer_time_interval
'   This is the time interval between the years or months in which the lifecare item are used (e.g. 10 units
'   needed every "3" months). The macro is set up to accept this parameter as a double variable type in
'   order to check for input error in the advent that an integer was not inputted.
'     Valid entries: Any integer with the format #.
'
' Parameter #11 - string_year_or_month
'   This parameter specifies the time interval or periodic use of the lifecare item in year or month
'   intervals.
'     Valid entries:
'       String values only of:
'          "Month", "Months", "Monthly", "M" or "Year", "Years", "Yearly", "Y".

' Parameter #12 - double_cost_growth
'   This is the annual percent change in cost of the lifecare item.
'     Valid entries:
'       Any numeric data with the format #.#.
'
' Parameter #13 - double_cost_discount
'   This is the annual interest rate for discounting lifecare costs to present value.
'     Valid entries:
'       Any numeric data with the format #.#.

'I. TRANSFORM AND CHECK THE INPUT DATA
' A. The parameters date_item_begins and date_item_ends are variant variable types allowing either string
'    (VarType=8) or date (VarType=7) input.  In this section, the macro transforms the string input to the
'    dates to which the strings correspond.
  If VarType(date_item_begins) = 8 Then
    If UCase(date_item_begins) = "TODAY" Then
      date_item_begins = date_t0
    ElseIf UCase(Left(date_item_begins, 4)) = "AGE " Then
      date_item_begins = DateSerial(Year(date_dob) + _
        Int(CDbl(Right(date_item_begins, Len(date_item_begins) - 4))), _
                                   Month(date_dob), _
                                     Day(date_dob) _
                                    ) _
                       + _
         (CDbl(Right(date_item_begins, Len(date_item_begins) - 4)) - _
     Int(CDbl(Right(date_item_begins, Len(date_item_begins) - 4)))) * 365
```

```
    Else
    ' Return #VALUE! because of bad parameter data
      macro_lifecare = CVErr(2015)
    ' Go to the end of the macro to exit with an error value set.
      GoTo GetOut
    End If
  ElseIf VarType(date_item_begins) <> 7 Then
   ' Return #VALUE! because of bad parameter data
     macro_lifecare = CVErr(2015)
   ' Go to the end of the macro to exit with an error value set.
     GoTo GetOut
  End If

  If VarType(date_item_ends) = 8 Then
    If UCase(date_item_ends) = "TODAY" Then
      date_item_ends = date_t0
    ElseIf UCase(Left(date_item_ends, 4)) = "AGE " Then
      date_item_ends = DateSerial(Year(date_dob) + _
        Int(CDbl(Right(date_item_ends, Len(date_item_ends) - 4))), _
                                Month(date_dob), _
                                  Day(date_dob) _
                                 ) _
                     + _
        (CDbl(Right(date_item_ends, Len(date_item_ends) - 4)) - _
     Int(CDbl(Right(date_item_ends, Len(date_item_ends) - 4)))) * 365
    ElseIf UCase(Left(date_item_ends, 4)) = "LIFE" Then
      If UCase(Left(string_life_type, 6)) = "SURVIV" Then
        date_item_ends = DateSerial(Year(date_dob) + 120, _
                                  Month(date_dob), _
                                    Day(date_dob) _
                                   )
      ElseIf UCase(Left(string_life_type, 9)) = "ACTUARIAL" Then
        date_item_ends = macro_date_life_expectancy( _
                                                    date_dob, _
                                                    integer_race_sex, _
                                                    (date_item_begins) _
                                                    )
      ElseIf UCase(Left(string_life_type, 7)) = "CURRENT" Then
        date_item_ends = macro_date_life_expectancy( _
                                                    date_dob, _
                                                    integer_race_sex, _
                                                    (date_t0) _
                                                    )
      End If
    Else
    ' Return #VALUE! because of bad parameter data
      macro_lifecare = CVErr(2015)
    ' Go to the end of the macro to exit with an error value set.
      GoTo GetOut
    End If
  ElseIf VarType(date_item_ends) <> 7 Then
   ' Return #VALUE! because of bad parameter data
     macro_lifecare = CVErr(2015)
   ' Go to the end of the macro to exit with an error value set.
     GoTo GetOut
  End If

' B. Perform a check on the order of parameter dates for consistency.
    If date_dob > date_t0 _
       Or date_dob > date_item_begins _
       Or date_dob > date_item_ends _
       Or date_t0 > date_item_begins _
       Or date_t0 > date_item_ends _
       Or date_item_begins > date_item_ends _
    Then
     ' Return #VALUE! to the worksheet because one of the parameter dates are out of order.
       macro_lifecare = CVErr(2015)
     ' Go to the end of the macro to exit with an error value set.
       GoTo GetOut
    End If
```

```
' C. Make sure that integer_time_interval is an integer and then reset the variable to an integer because
'    function DateAdd only wants integer values.
     If (integer_time_interval - Int(integer_time_interval)) <> 0 Then
       macro_lifecare = CVErr(2015)
     ' Go to the end of the macro to exit with an error value set.
       GoTo GetOut
    End If
    integer_time_interval = Int(integer_time_interval)

' D. Only accept yearly and monthly intervals for the timing of life care costs.
     Dim string_y_or_m As String
     string_y_or_m = UCase(Left(string_year_or_month, 1))
   ' Set the interval for the dateadd function
     If string_y_or_m = "Y" Then
        string_y_or_m = "YYYY"
     ElseIf string_y_or_m = "M" Then
            string_y_or_m = "M"
     Else
      ' Return #VALUE! because first character of time interval of the periods was not "Y" or "M"
        macro_lifecare = CVErr(2015)
      ' Go to the end of the macro to exit with an error value set
        GoTo GetOut
     End If

  ' Check race and sex value to be in the range of 1 to 9
    If Not (1 <= integer_race_sex And integer_race_sex <= 9) Then
     ' return #VALUE! to the worksheet because the race and sex range is out of order
       macro_life_care = CVErr(2015)
     ' Go to the end of the macro to exit with an error value set
       GoTo GetOut
    End If

  ' Reset leap year dates for same cost estimation and programming of leap and non-leap years
    If date_dob = DateSerial(Year(date_dob), 2, 29) Then _
       date_dob = DateSerial(Year(date_dob), 3, 1)
    If date_t0 = DateSerial(Year(date_t0), 2, 29) Then _
       date_t0 = DateSerial(Year(date_t0), 3, 1)
    If date_item_begins = DateSerial(Year(date_item_begins), 2, 29) Then _
       date_item_begins = DateSerial(Year(date_item_begins), 3, 1)
    If date_item_ends = DateSerial(Year(date_item_ends), 2, 29) Then _
       date_item_ends = DateSerial(Year(date_item_ends), 3, 1)

'II. SET-UP VARIABLES AND ARRAYS USED WITHIN MACRO
   ' Establish and set the beginning value of the sum of lifecare item cost over equal to zero before
   ' looping
     Dim double_sum_cost As Double
     double_sum_cost = 0
   ' Establish the date for iterating to ending date
     Dim date_valuation As Date
   ' Establish the life expectancy table array
     Dim array_life_expectancy As Range
   ' The workbook must contain a named range called "range_life_expectancy" with life expectancy data from
   '  age 0 to age 120.
     Set array_life_expectancy = Range("range_life_expectancy")

'III. SET-UP GROWTH AND DISCOUNT DATA
    ' Change the values of double_cost_growth and double_cost_discount to fit the type of calculation
    ' desired: (1) current dollars, (2) future dollars, (3) present value dollars.
      If UCase(Left(string_dollar_type, 7)) = "CURRENT" Then
       double_cost_growth = 0
       double_cost_discount = 0
      ElseIf UCase(Left(string_dollar_type, 6)) = "FUTURE" Then
       double_cost_discount = 0
      ElseIf UCase(Left(string_dollar_type, 1)) <> "P" Then
     ' return #VALUE! to the worksheet because of bad string_dollar_type input
       macro_lifecare = CVErr(2015)
     ' Go to the end of the macro to exit with an error value set
       GoTo GetOut
      End If
```

Appendix: VBA Excel Macro Module, continued

```
'IV. LOOP FOR TOTAL LIFECARE COSTS
   ' Set the initial loop value and then perform calculations for total lifecare costs.
     date_valuation = date_item_begins
     Do Until date_valuation > date_item_ends
      ' Multiply cost per unit and units needed within time interval for period costs and then compute
      ' present value by life type.
        If UCase(Left(string_life_type, 7)) = "CURRENT" Or _
           UCase(Left(string_life_type, 9)) = "ACTUARIAL" Then
         ' Working with the life expectancy calculation method.
           double_period_cost = double_cost_per_unit * _
             double_units_required_in_time_interval * _
             ((1 + double_cost_growth) / (1 + double_cost_discount)) ^ _
             macro_double_yearfrac(date_t0, date_valuation)
        ElseIf UCase(Left(string_life_type, 6)) = "SURVIV" Then
         ' Working with the life table survival calculation method.
           double_period_cost = double_cost_per_unit * _
             double_units_required_in_time_interval * _
             macro_prob_alive(date_dob, _
                              integer_race_sex, _
                              date_t0, _
                              date_valuation _
                              ) * _
             ((1 + double_cost_growth) / (1 + double_cost_discount)) ^ _
             macro_double_yearfrac(date_t0, date_valuation)
        Else
         ' return #VALUE! to the worksheet because of bad string_life_type parameter input.
           macro_lifecare = CVErr(2015)
         ' Go to the end of the macro to exit with an error value set.
           GoTo GetOut
        End If
      ' Add this loop's present value of costs to the accumulating present value of costs.
        double_sum_cost = double_period_cost + double_sum_cost
      ' Increment date_valuation to the next time interval.
        date_valuation = DateAdd(string_y_or_m, _
                                 integer_time_interval, _
                                 date_valuation _
                                 )
     Loop

'V. RETURN SUM OF COSTS AT THE END OF THE LOOP

    If UCase(Left(string_life_type, 9)) = "ACTUARIAL" Then
       macro_lifecare = macro_prob_alive(date_dob, _
                                         integer_race_sex, _
                                         date_t0, _
                                         (date_item_begins) _
                                         ) * _
                        double_sum_cost
    Else
       macro_lifecare = double_sum_cost
    End If

GetOut:
End Function
```

```
Function macro_prob_alive(date_dob As Date, _
                          integer_race_sex As Integer, _
                          date_q0 As Date, _
                          date_value As Date _
                          ) As Double
' Purpose:
' Function macro in Visual Basic for Excel for calculating the chance of survival (1- probability of death)
' between two dates: "date_q0" which is the date that assumes Prob(Alive) = 1 and "date_value" which is the
' date after "date_q0" that you want to calculate Prob(Alive) < 1.
'
' The data requirements for this macro are a life table of number of survivors from any whole life table.
' The survivor table is placed within the workbook and given the name "range_life_table_survivors".  This
' table should consist solely of the survivors by age running down the worksheet.  The dimension should be:
' rows = # of ages which survivor data is available; and,
' columns = # of race, sex combinations for which survivorship data are available.
' This macro is designed for a survivor table ranging from age 0 to age 120.  The macro can easily be
' changed to accommodate a whole life table of differing dimensions.

' Description of macro parameters:

' Parameter #1 - date_dob
'   This parameter specifies the date of birth of the plaintiff.
'     Valid entries:
'       Any valid Excel date is required.
'
' Parameter #2 - integer_race_sex
'   This parameter signifies the column number of the life expectancy and life table representing the race
'   and sex combination of the plaintiff.
'     Valid entries:
'       In this macro, the life table used has 9 race/sex combinations so valid entries are 1 to 9.
'
' Parameter #3 - date_q0
'   This time=0 date is used to identify the certain date of the last date where the chance of being alive
'   is certain.
'     Valid entries:
'       Any valid Excel date is required.
'
' Parameter #4 - date_value
'   This is a date >= date_q0 that you want to calculate the chance of survival from date_q0 to date_value.
'     Valid entries:
'       Any valid Excel date is also accepted (e.g. 9/1/2000).
'
'I. CHECK FOR GOOD INPUT DATA
  ' Check the order of input dates.
    If date_dob > date_q0 _
     Or date_dob > date_value _
     Or date_q0 > date_value _
    Then
      ' Return a #VALUE! to the worksheet because the input dates
      ' were out of order.
       macro_prob_alive = CVErr(2015)
      ' Go to the end of the macro to exit with an error value set.
       GoTo GetOut
    End If

  ' Reset leap year dates for same cost estimation and programming of leap/non-leap years.
    If date_dob = DateSerial(Year(date_dob), 2, 29) Then _
       date_dob = DateSerial(Year(date_dob), 3, 1)
    If date_q0 = DateSerial(Year(date_q0), 2, 29) Then _
       date_q0 = DateSerial(Year(date_q0), 3, 1)
    If date_value = DateSerial(Year(date_value), 2, 29) Then _
       date_value = DateSerial(Year(date_value), 3, 1)

  ' Check race and sex value to be in the range of 1 to 9
    If Not (1 <= integer_race_sex And integer_race_sex <= 9) Then
      ' return #VALUE! to the worksheet because the race and sex range is out of order
       macro_prob_alive = CVErr(2015)
      ' Go to the end of the macro to exit with an error value set
       GoTo GetOut
    End If
```

Appendix: VBA Excel Macro Module, continued

```
'II. LOCATE SURVIVOR DATA
   ' Establish the array survivors.
     Dim array_survivors As Range
   ' The workbook must contain a named range called
   ' "range_life_table_survivors".  In this workbook, this range contains data from ages 0 to 120.
     Set array_survivors = Range("range_life_table_survivors")
'III. COMPUTE AGES AND SURVIVORS
  ' Compute the number of survivors at date_q0 and date_value.
    Dim double_survive_now As Double
    double_survive_now = _
     array_survivors(Int(macro_double_yearfrac(date_dob, date_q0)) + 1, integer_race_sex) + _
    (array_survivors(Int(macro_double_yearfrac(date_dob, date_q0)) + 2, integer_race_sex) - _
     array_survivors(Int(macro_double_yearfrac(date_dob, date_q0)) + 1, integer_race_sex)) * _
    (macro_double_yearfrac(date_dob, date_q0) - Int(macro_double_yearfrac(date_dob, date_q0)))

    Dim double_survive_value As Double
    double_survive_value = _
    array_survivors(Int(macro_double_yearfrac(date_dob, date_value)) + 1, integer_race_sex) + _
   (array_survivors(Int(macro_double_yearfrac(date_dob, date_value)) + 2, integer_race_sex) - _
    array_survivors(Int(macro_double_yearfrac(date_dob, date_value)) + 1, integer_race_sex)) * _
(macro_double_yearfrac(date_dob, date_value) - Int(macro_double_yearfrac(date_dob, date_value)))

'IV. CALCULATE PROBABILITY ALIVE
     macro_prob_alive = double_survive_value / double_survive_now

GetOut:
End Function
```

```
Function macro_date_life_expectancy(date_dob As Date, _
                                    integer_race_sex As Integer, _
                                    date_q0 As Date _
                                    ) As Date
' Purpose:
' Function macro for calculating the date of life expectancy at "date_q0" which is the date of evaluation
' that assumes Prob(Alive) = 1.
'
' The data requirements for this macro are a life expectancy table calculated from any whole life table.
' The life expectancy table is placed within the workbook and given the name "range_life_expectancy".
' This table should consist solely of the remaining life expectancies by age running down the worksheet.
' The dimension should be: rows = # of ages which the life expectancy data is available; and, columns =
' # of race, sex combinations for which survivorship data are available.  This macro is designed for a
' life expectancy table ranging from age 0 to age 120.

' Description of macro parameters:
' Parameter #1 - date_dob
'   This parameter specifies the date of birth of the plaintiff.
'     Valid entries: Any valid Excel date is required.
' Parameter #2 - integer_race_sex
'   This parameter signifies the column number of the life expectancy and life table representing the race
'   and sex combination of the plaintiff.
'     Valid entries:
'       In this macro, the life table used has 9 race/sex combinations so valid entries are 1 to 9.
' Parameter #3 - date_q0
'   This time=0 date is used to identify the certain date of the last date where the chance of being alive
'   is certain.
'     Valid entries: Any valid Excel date is required.

'I. CHECK FOR GOOD INPUT DATA
  ' Check the order of input dates.
    If date_dob > date_q0 _
    Then
     ' Return a #VALUE! to the worksheet because the input dates were out of order.
      macro_date_life_expectancy = CVErr(2015)
     ' Go to the end of the macro to exit with an error value set.
      GoTo GetOut
    End If
  ' Check to see if the race and sex value to be in the range of 1 to 9
    If Not (1 <= integer_race_sex And integer_race_sex <= 9) Then
     ' Return a #VALUE! to the worksheet because the race and sex range is out of order.
      macro_date_life_expectancy = CVErr(2015)
     ' Go to the end of the macro to exit with an error value set.
      GoTo GetOut
    End If

'II. LOCATE LIFE EXPECTANCY DATA
   ' Establish the array of life expectancy values
     Dim array_life_expectancy As Range
     Set array_life_expectancy = Range("range_life_expectancy")

' Calculate the date of life expectancy assuming survival to the date_q0.
  macro_date_life_expectancy = _
    DateSerial(Year(date_dob) + _
      Int(Int(macro_double_yearfrac(date_dob, date_q0)) + _
      array_life_expectancy(Int(macro_double_yearfrac(date_dob, _
                                                       date_q0)) + 1, _
                                                       integer_race_sex _
                                                       )) _
               , _
               Month(date_dob) _
               , _
               Day(date_dob)) _
     + _
      (array_life_expectancy(Int(macro_double_yearfrac(date_dob, _
                                                        date_q0)) + 1, _
                                                        integer_race_sex _
                                                        ) - _
   Int(array_life_expectancy(Int(macro_double_yearfrac(date_dob, _
                                                        date_q0)) + 1, _
                                                        integer_race_sex _
                                                        ))) * 365
GetOut:
End Function
```

Appendix: VBA Excel Macro Module, continued

```
Function macro_double_yearfrac(date_start As Date, _
                               date_end As Date _
                               ) As Double
' Purpose:
' A function macro for calculating numeric difference in dates.
' Parameters:
' Description of macro parameters:
'
' Parameter #1 - date_start
'   This parameter specifies the beginning date.
'     Valid entries:
'       Any valid Excel date is required.
'
' Parameter #2 - date_end
'   This parameter specifies the ending date.
'     Valid entries:
'       Any valid Excel date is required.

'I. CHECK FOR GOOD KEY INPUT DATA
  ' Check the order of the input dates.
    If date_start > date_end _
    Then
     ' Return a #VALUE! to the worksheet because the input dates were out of order
      macro_double_yearfrac = CVErr(2015)
     ' Go to the end of the macro to exit with an error value set.
      GoTo GetOut
    End If

'II. CHANGE FEBRUARY 29th DATES
   ' Change February 29th dates so we can consistently use 365 days in a year.
    If Month(date_start) = 2 And Day(date_start) = 29 Then
      date_start = DateSerial(Year(date_start), 2, 28)
    End If
    If Month(date_end) = 2 And Day(date_end) = 29 Then
      date_end = DateSerial(Year(date_end), 2, 28)
    End If

'III. CALCULATE NUMERIC DIFFERENCE IN DATES
   ' Calculate the difference in dates based upon if in the current year the beginning month and day
   ' has been reached
      If DateSerial(Year(date_end), _
                    Month(date_start), _
                    Day(date_start _
                    )) > _
                    date_end Then
     ' Have not yet arrived to beginning month and day this year. Compute numeric date difference using
     ' 1998 to avoid leap year problems for fraction of age.
      macro_double_yearfrac = (Year(date_end) - Year(date_start) - 1) + _
        (DateSerial(1998, Month(date_end), Day(date_end)) - _
         DateSerial(1998 - 1, Month(date_start), Day(date_start))) / 365
      Else
    ' Or, have already had birthday this year.
    ' Do the same as above except fraction of age occurs entirely in the current year.
        macro_double_yearfrac = (Year(date_end) - Year(date_start)) + _
          (DateSerial(1998, Month(date_end), Day(date_end)) - _
           DateSerial(1998, Month(date_start), Day(date_start))) / 365
       End If
    ' Check for a bad age at date_end because the rest of the macros in this workbook terminate at age 120.
      If Not (0 <= macro_double_yearfrac And macro_double_yearfrac <= 120) _
        Then
        macro_double_yearfrac = CVErr(2015)
        GoTo GetOut
      End If

GetOut:
End Function
```

Litigation Economics Review
Volume 5, Number 1: 53-58

The Literature Corner: Recent Publications of Interest to Forensic Economists

James D. Rodgers and Robert J. Thornton

Associate Editor's Note

In this new feature of the *Litigation Economics Review*, it is our intention to provide an annotated listing of recent publications that are likely to be of considerable interest to forensic economists in their work and in their research. To compile such a list, we will primarily be scouring the regular *non-forensic* economics literature, a literature that because of time constraints or narrow sub-disciplinary interests is not likely to be visited as frequently (or maybe not at all) as many of us would wish. Although some of the publications that we will note are of the type that might be periodically brought to the attention of NAFE members via the LISTSERV, we feel that a regular feature such as this has several advantages. First, not all NAFE members subscribe to or read the LISTSERV. Secondly, information about recent publications provided on the LISTSERV is presented in a random, non-systematic way—one that is dependent on the time and goodwill of those providing the information. Finally, in a regular feature such as this, we are able to summarize, categorize, and link the publications in a way that is not always possible with the LISTSERV.

Because this feature is new, we welcome any suggestions from the NAFE readership about items to include, format, etc. The reader is cautioned that the article descriptions appearing below are necessarily brief and cannot convey all the richness of detail, qualifications, and caveats appearing in the articles themselves. Also, it should be noted that most of the works we highlight will generally have appeared in the last year or two. However, we have elected to follow no strict statute of limitations.

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In this issue, we highlight articles of interest in the areas of crime, disability and health, discrimination, earnings and education. As a result, articles have been arranged by topical area.

Crime

Grogger, Jeffrey. "The Effect of Arrests on the Employment and Earnings of Young Men," *Quarterly Journal of Economics*, Vol. 90, No. 1, February 1995, pp. 51-72.

Summarizing this article in the author's own words: "The primary conclusion of this paper is that the effects of arrests on employment and earnings are moderate in magnitude and rather short-lived.... Most of the negative correlation between arrest records and labor market success stems from unobserved characteristics that jointly influence crime and labor market behavior, rather than from the causal effects of arrests.

"This finding helps resolve an apparent conflict between theory and observation. The cross-sectional correlation between earnings and arrest records is strongly negative, suggesting that the market penalty for committing crime is quite severe. Indeed, unless the risk of arrest is quite small, the occurrence of widespread crime in the face of such large market penalties would seem to cast doubt on whether youth crime could be explained by optimizing behavior. In fact, recent research shows that arrest risks are fairly large. In a world where arrests have small and short-lived consequences, however, and most of the correlation between arrests and earnings is due to unobserved heterogeneity, widespread crime may well be consistent with optimizing behavior.

"My results are at odds with Freeman [Richard B. Freeman, "Crime and the Employment of Disadvantaged Youth," in Adele Harrell and George Peterson, eds., *Drugs, Crime and Social Isolation: Barriers to Urban Opportunity* (Washington, D.C.: Urban Institute Press, 1992)], who, based on an analysis [of data] from the NLSY, concluded that jail terms had substantial long-term effects on earnings and employment. The differences in our results may be due in part to differences in the measures of jail spells available in our samples....It may be that long sentences have long-lasting effects, while the typical sentence has only a shorter effect. Since my data do not include an explicit measure of time served, however, I am unable to test this hypothesis directly." (p. 70)

Grogger, Jeffrey. "Market Wages and Youth Crime," *Journal of Labor Economics*, Vol. 16, No. 4, October 1998, pp. 756-91.

The author uses data from the NLSY for 1979 for young men not in the military and not in school to test various hypotheses about participation in criminal activities. A key feature of the article is the notion that the level of a person's market wages in legal activities affects that person's likelihood of participation in illegal activities. The empirical results support the conclusion that young men are responsive to wage incentives. The article links falling real wages of young less educated men in the 1970s and 1980s to increases in criminal activities during these decades. It also links greater participation by blacks in criminal activities to the lower relative wages of blacks. Finally, it explains the falling rate of participation in criminal activities with age by pointing to the higher real wages earned as males age and gain more work experience. The author estimates a market wage equation, a structural crime probit equation, and a labor supply equation. Two results from the wage equation are especially interesting. First, individuals who were charged or convicted of a crime in 1979 had wages that were 15% lower on average than those for other individuals. Second, being on probation reduced wages by 29% on average. Because employment is often stipulated as a condition for probation with a return to jail if employment is not maintained, individuals (for whom freedom is presumably very valuable) are willing to work for lower wages than would an otherwise identical person who is not subject to the conditions of probation.

Disability and Health

Cater, Bruce I. "Employment, Wage, and Accommodation Patterns of Permanently Impaired Workers," *Journal of Labor Economics,* Vol. 18, No. 1, January 2000, pp. 74-97.

The author develops a model which seeks to explain employment, wage, and accommodation patterns experienced by permanently impaired workers after an occupational injury. Although the model is rather technical, the major implication for forensic economists and vocational experts is nicely summarized by the author as follows: It is important to "look beyond the initial return to work [period] when attempting to measure the impact of impairment. The initial post-injury wages earned by impaired workers will, in many cases, overstate post-injury productivity. In addition, the 'return to work' should not be interpreted as the cessation of injury-related employment disruptions." (p. 93)

Frank, Richard; Susan Busch; and Ernst Berndt. "Measuring Prices and Quantities of Treatment for Depression," *American Economic Review*, Vol.88, No.2, May 1998, pp. 106-11.

Spending on depression and other mental illnesses has been pointed to as a major factor driving up overall medical spending in the U.S. The authors construct PPI and CPI versions of price indices for five treatment "bundles" for depression (e.g., psychotherapy alone, psychotherapy plus prescription drugs, etc.). They find that their price indices actually *fall* over the period studied (1991-95) in contrast to the substantial rise in the BLS medical CPI over the same period. An important implication of their results, in the words of the authors, is that "the use of standard indices may result in mistaking quantity changes for price changes."

Kahn, Matthew. "Health and Labor Market Performance: The Case of Diabetes," *Journal of Labor Economics,* Vol. 16, No. 4, October 1998, pp. 878-99.

The author uses data from the 1976 and the 1989 waves of the National Health Interview Survey (NHIS) and data from wave 1 (1991 to 1993) of the Health and Retirement Survey (HRS) to document changes in the labor market performance of diabetics from 1976-92. The bulk of his results compare labor market outcomes of nondiabetics and persons with Type II diabetes. He finds differential trends for males and females. Female diabetics have significantly increased their employment rates (from 28.0% in 1976 to 44.0% in 1992) while rates for male diabetics have fallen (from 69.3% in 1976 to 61.9% in 1992). This compares to smaller percentage increases in employment rates for nondiabetic women (47.7% in 1976 to 61.4% in 1992) and smaller decreases for nondiabetic men (82.9% in 1976 to 79.5% in 1992). The author speculates that the employment gains of diabetic women relative to diabetic men in part reflects a greater investment by diabetic women in their health and greater compliance with a regimented routine (blood testing, exercise, smoking cessation, reduced sugar and fat consumption) than is true for diabetic men. Concerning the income of employed diabetics, little difference is found in family income using the NHIS data. While tabular comparisons show lower family income for diabetics, the income differences disappear or become statistically insignificant in a regression equation controlling for body mass index, education, race and marital status of the family head. It is also found that diabetics have experienced a 6% growth in family income from 1976-1989 as compared to nondiabetics. Regressions with the HRS data reveal no salary gap for diabetic women but a substantial gap for diabetic men. However, the author puts little weight on the result for men due to the small sample (98) of diabetic men, a quarter of whom reported annual salaries of less than $1,000. The author discusses the puzzle of why employment rates differ between diabetics and nondiabetics as much as they do while, given that they are working, their incomes differ so little. He speculates that diabetics divide into two groups: compliant and non-compliant, who are and are not in control of their disease, respectively. He predicts that the size of the latter group will shrink over time as the cost of compliance continues to be reduced by health innovations. The author is unable to study the income of Type I diabetics because the HRS sample is too small.

Attanasio, Orazio P., and Hilary Williamson Hoynes. "Differential Mortality and Wealth Accumulation," *Journal of Human Resources*, Vol. 35, No. 1, Winter 2000, pp. 1-29.

This paper makes contributions in two areas: first, it identifies and estimates the relationship between wealth and mortality; second, it uses this relationship to correct estimates of the age-wealth profile using a time series of repeated cross-sections. Forensic economists will be particularly interested in the paper's wealth/mortality results and how these might be tailored to fit the circumstances of a particular individual. [An interesting reference in the bibliography of this paper that we were unable to review for this issue is Jonathan Feinstein, "The Relationship between Socioeconomic Status and Health: A Review of the Literature," *The Milbank Quarterly*, Vol. 71, No. 2, 1993, pp. 279-322.] The paper pools data from SIPP for 1984 (containing 21,000 families) and 1987 (containing 12,000 families). The SIPP mortality rates are very similar to those found in the U.S. life tables for various age/gender/race groupings. For the presentation on wealth and mortality linkages, the data are limited to a sample of 7,025 married couples age 50 and over. A summary of the data is presented by showing the probability of death of either head or spouse by age of head of household and wealth quartile. Within each age group, death rates are inversely related to wealth quartile. Mortality in the lowest wealth quartile is, on average, three times as high as mortality in the highest wealth quartile. Most of the effect of wealth shows up in the high death rates in the lowest quartile compared to the other three, with the relationship being much less strong among the upper three quartiles. The mortality information is used to correct a bias in age-wealth profiles that arises from a sample selection problem. As the authors state: "If wealth and mortality are inversely related, then as one samples in subsequent years from a given cohort of individuals, one is drawing from a population that is becoming progressively richer as the poorest individuals die younger. To correct for this bias, therefore, one can compute weights that are inversely proportional to the probability that each individual in the sample has survived to the observed age." (p. 10)

Discrimination

Biddle, Jeff, and Daniel Hamermesh. "Beauty, Productivity, and Discrimination: Lawyers' Looks and Lucre," Journal *of Labor Economics,* Vol. 16, No. 1, January 1998, pp.172-201

In their path breaking 1994 article ("Beauty and the Labor Market," *American Economic Review*, Vol. 84, Dec. 1994, pp. 1174-94), Hamermesh and Biddle found that, *ceteris paribus*, wages of people with below-average looks are lower (by about 5-10%) than those of average-looking workers, and there is also a (slightly smaller) premium for good-looking people (like Rodgers and Thornton). Here the authors find that better-looking attorneys earn more than others, an effect that increases with experience. The authors attribute the effect to clients preferring better-looking attorneys, although it is unclear whether the clients' choices stem purely from discrimination or from their (correct) belief that judges, juries, and other attorneys treat better-looking attorneys more favorably. We believe that additional implications for the forensic economist are to be wary of dealing with unattractive attorneys (you might not get paid) and to devote more attention to one's own appearance in case the Hamermesh-Biddle effect extends to forensic economists also.

Brown, Charles, and Mary Corcoran. "Sex-Based Differences in the Male-Female Wage Gap," *Journal of Labor Economics,* Vol. 15, No. 3, Part 1, July 1997, pp.431-65.

Using data from the Survey of Income and Program Participation (SIPP) and the National Longitudinal Study (NLS), the authors find that differences in college majors are strongly related to the male-female earnings gap. A major reason is that the college major affects the kinds of occupations and industries in which graduates work. For forensic economists, this finding implies that appropriate "tailoring" to account for major fields of study can have substantial effects on lost earnings estimates.

Baldwin, Marjorie, and William G. Johnson. "Labor Market Discrimination against Men With Disabilities," *Journal of Human Resources*, Vol. 29, No. 1, Winter 1994, pp. 1-19.

In the words of the authors, "This article examines the effect of employer discrimination on employment and wages of handicapped and disabled men in 1972 and 1984." Disabled men are defined as men with heart trouble, back problems, diabetes, high blood pressure, and other conditions subject to little or no prejudice; handicapped men are defined as men with conditions that are subject to greater prejudice (missing limbs, blindness, deafness, cancer, senility, stroke, paralysis, mental retardation, mental illness, alcohol or drug problems). Survey of Income and Program Participation (SIPP) data for 1984 are used to generate empirical results, which are then compared to similar empirical work conducted using 1972 data in the Social Security Survey of the Disabled. The authors report that in both years discriminatory wage differentials were higher for men with handicaps than for men with disabilities. As they put it, "In 1984, the offer [hourly] wages for handicapped men were $2.44 less than for nondisabled men. Approximately 40 percent of the differential ($0.98) was attributable to discrimination and a residual. We attribute the discrimination to prejudice, appealing to the attitudes measured by the Tringo scale." (p. 13). [The reference is to John L. Tringo, "The Hierarchy of Preference toward Disability Groups," *Journal of Special Education*, Vol. 4, No. 3, 1970, pp. 295-306.] They conclude that "barriers to employment are a more important problem than wage discrimination for men with disabilities and that the causes of discrimination are different for different impairments....The employment prospects for less skilled, inexperienced workers who are impaired by an injury or illness are limited since the benefits to employers from investments in job modifications are very small." (p. 14)

Earnings

Mar, Don. "Four Decades of Asian American Women's Earnings: Japanese, Chinese, and Filipino American Women's Earnings, 1960-1990," *Contemporary Economic Policy*, Vol. 18, No. 2, April 2000, pp.228-37.

The article compares the earnings progress of Asian American women from 1960-90 using Census of Population data. Unadjusted earnings show a marked earnings advantage to Asian American women relative to white women, a result of the former group's higher educational levels, a higher proportion working in the professional and technical occupations, and the tendency to reside in urban areas outside the South. Nevertheless, the author still finds evidence of discrimination toward Asian American women.

Hecker, Daniel. "Earnings of College Graduates: Women Compared with Men," *Monthly Labor Review*, Vol. 121, No. 3, March 1998, pp. 62-71.

Hecker uses data from a 1993 National Science Foundation survey of 215,000 persons who reported in the 1990 census that they had at least a bachelor's degree. He compares women's and men's full-time earnings at a level of detail (by major and occupation) not possible with the commonly used Current Population Survey data. He finds that, although female college graduates overall aged 25-64 had median earnings that were 73% as high as men's, when the major field of study was considered the gender earnings ratio rose (e.g., to an average of 83% for young women graduates). Similarly, when occupation was considered, women's median earnings were generally much closer to those of men than the overall ratio. Hecker also provides two detailed tables showing median earnings of women relative to those of men by field of study, occupation, and degree level.

Education

Cameron, Stephen V., and James J. Heckman. "The Nonequivalence of High School Equivalence," *Journal of Labor Economics*, Vol. 11, No. 1, Part 1, January 1993, pp. 1-47.

This is most definitely a "two-thumbs up" article that has been very influential. Using National Longitudinal Survey of Youth (NLSY) data for males, Cameron and Heckman reach the conclusion that exam-certified high school equivalents are statistically indistinguishable in the labor market outcomes from high school dropouts. In the words of Cameron and Heckman, both groups "have comparably poor wages, earnings, hours of work, unemployment experiences and job tenure..Even after controlling for ability, GED recipients have inferior labor market status compared to high school graduates. GED recipients have lower employment rates and less work experience than high school graduates. Both anecdotal and empirical evidence also suggests that employers and the military discount the GED.Whatever difference is found among GED recipients, dropouts and high school graduates is largely accounted for by years of schooling. There is no cheap substitute for classroom instruction....Whatever economic return exists from GED recipiency arises from its value in opening postsecondary schooling and training opportunities." (p. 44) In addition, the authors find that the returns to GED recipients from college education are lower than for persons who are high school graduates. A qualification noted by Cameron and Heckman is that the sampling frame of the NLSY data permit them to analyze only the early stages of labor market careers (no older than age 28). At later stages, GEDs might become more like high school graduates and less like high school dropouts, but analysis of the relative impact of the GED on the entire life cycle of labor market experience requires data for older persons. (pp. 43-44). One implication of the Cameron/Heckman article for forensic work is that when forecasting the future earnings of a young male with a GED, one might consider using the earnings of male high school dropouts–at least in the early stages of the age-earnings cycle.

Cao, Jian; Ernst W. Stromsdorfer; and Gregory Weeks. "The Human Capital Effect of the GED on Low Income Women," *Journal of Human Resources*, Vol. 31, No. 1, Winter 1996, pp. 206-28.

The authors attempt to assess the labor market impact of the GED for women in a fashion parallel to the work of Cameron and Heckman for men. They use data from the NLSY mother and children file from 1987 to 1990, when the mothers are 22-33 years old, and from the Washington State Family Income Study (FIS) containing mothers aged 25 to 50. For hours of work, the authors find no difference between dropouts, GED recipients and high school graduates. For hourly wage rates, the results are mixed. Using the FIS data, no difference is found in the hourly wage rates of the three educational attainment categories. Using the NLSY data, the authors find that GED recipients have hourly wage rates greater than dropouts but less than high school graduates.

They conclude that “Years of education completed is found to be capable of explaining the observed wage differential among high school graduates, GED recipients, and highs school dropouts–the basic finding of Cameron and Heckman.” (pp. 217-18)

Murnane, Richard; John Willett; and Kathryn Boudett. “Does a GED Lead to More Training, Post-Secondary Education, and Military Service for School Dropouts?” *Industrial and Labor Relations Review*, Vol. 51, No. 1, October 1997 pp. 100-116.

Using data from the National Longitudinal Survey of Youth for 1979-91, the authors find that receipt of a GED increases the probability that school dropouts will attend college and participate in non-company training. However, fewer than 20% of GED recipients had completed at least a year of college by the age of 26, despite the expressed intention of 2/3 of them to obtain further study after receiving the GED credential.

Kane, Thomas and Cecilia Rouse. “The Community College: Educating Students at the Margin between College and Work,” *Journal of Economic Perspectives*, Vol. 13, No. 1, Winter 1999, pp. 63-84.

Although most of this article deals with such topics as subsidies and enrollments, financing, and absorption rates into higher educational institutions, one very useful section addresses the labor market payoffs to community college. As many forensic economists know, there has been very little research done on the relation between community college attendance and earnings. (The Current Population Survey publishes information on years of schooling and earnings, but not by the *type* of institution attended.) Summarizing the results from three studies, the authors report that one year of community college is associated with about a 5-8 % increase in annual earnings, which is about the same as the estimated value of a year of education at a four-year college. The returns appear to be the same for those who attend community college immediately after high school as for those who attend community college after age 25. There is also an additional payoff to completing the associate’s degree, although only about 16% of community college entrants complete that degree.

Evans, William N., and Robert Schwab. “Finishing High School and Starting College: Do Catholic Schools Make a Difference?” *Quarterly Journal of Economics*, Vol. 90, No. 4, November 1995, pp. 941-74.

The authors summarize their conclusions as follows: “We find a great deal of support for the argument that Catholic schools are more effective than public schools. Single-equation estimates suggest that for the typical student, attending a Catholic school raises the probability of finishing high school or entering a four-year college by thirteen percentage points. Unlike single-equation estimates of the effect of Catholic schools on test scores, these results are qualitatively important and robust. This Catholic school effect is very large. It is twice as large as the effect of moving from a one- to a two-parent family and two-and-one-half times as large as the effect of raising parents’ education from a high school dropout to a college graduate. In models where we treat the decision to attend a Catholic school as an endogenous variable, we find almost no evidence of selection bias. Bivariate probit estimates of the average treatment effect of Catholic schools on high school graduation and entering college are very similar to single-equation probit estimates.”(p. 944) The results in the Evans and Schwab paper relate to attending a Catholic school and can be compared to those of Gill and Foley, who examine the influence of being “raised Catholic,” which does not necessarily imply attendance at Catholic school. (Andrew M. Gill and Jack Foley, “Predicting Educational Attainment for a Minor Child,” *Journal of Forensic Economics*, Vol. 9, No. 2, pp. 101-112.) In models 2 and 3, Gill and Foley find an insignificant coefficient for the “raised Catholic” variable for girls in their ordered probit equation explaining educational attainment, though for boys the “raised Catholic” variable is found to be a highly significant and important positive influence. Whether this result is due to the fact that more Catholic boys attend Catholic schools than do Catholic girls is unknown.

Vella, Francis. “Do Catholic Schools Make a Difference? Evidence from Australia,” *Journal of Human Resources*, Vol. 34, No. 1, Winter 1999, pp. 208-224.

According to the author, “This paper examines whether the substantial benefits reported for attending Catholic school in the United States also exist for students of Catholic schools in Australia. We find that despite its relatively low cost, attendance at Australian Catholic schools increases the probability of completing high school by 17 percentage points. The evidence also suggests that attendance at Catholic schools increases the probability of obtaining higher education and is associated with superior performance in the labor market [higher employment rates and hourly wages]. ” (p. 208). The author notes that it is difficult to determine what aspects of Catholic education are responsible for these higher rates of success (more discretion with respect to curriculum and hiring practices, better facilities, greater discipline?) even though there is an increasing body of evidence supporting their existence.

Brewer, Dominic J.; Eric Eide; and Ronald G. Ehrenberg. “Does It Pay to Attend an Elite Private College?” *Journal of Human Resources*, Vol. 34, No. 1, Winter 1999, pp. 104-119.

In the words of the authors: “In this paper we have presented estimates of the effect of attending colleges of different quality on labor market outcomes. Unlike previous studies, we are able to utilize longitudinal data which permit us to examine how the labor market return changes across time for a given cohort, and how the return changed for those cohorts that attended college in the early 1970s and the early 1980s. In addition, we allow for the fact that students systematically select the college quality type they attend on the basis of the net costs they face. Although we find little evidence that this correction for selectivity significantly affects our results, it is important in principle. We find a large premium to attending an elite private institution and a smaller premium to attending a middle-rated private institution, relative to a bottom-rated public school. Evidence is weaker of a return to attending an elite public university. Our analysis suggests the return to elite private colleges increased significantly for the 1980s cohorts as compared to the 1972 cohort. We do not attempt to determine the *cause* of this change, but it is a potentially important finding in light of the large tuition increases concentrated at these institutions during the past two decades. These results suggest that the rising tuition at these elite private institutions was at least partially made possible by the increasing returns to quality that took place." (p. 119)

Employment

Neumark, David; Daniel Polsky; and Daniel Hansen. "Has Job Stability Declined Yet? New Evidence for the 1990s," *Journal of Labor Economics,* Vol. 17, No. 4, Part 2, October 1999, pp. S29-S64.

The authors update the evidence on job stability through the mid-1990s using CPS data. They find evidence of "modest declines" in job stability in the first half of the 1990s, but argue that aggregate job stability was stable in the 1980s. This latter contention has been in dispute, however, since other research has claimed that there was a substantial decline in job stability in the 1980s.

Schmidt, Stefanie, and Shirley Svorney. "Recent Trends in Job Security and Stability," *Journal of Labor Research*, Vol. 19, no. 4, Fall 1998, pp. 647-68.

This article reviews the current research on job tenure and job separations over the past several decades. The authors find that the most consistent result in the literature is that women's job tenure has increased markedly but that there has not been a dramatic change in job security in general over the past two decades. The studies they review also do not point to consistent losses in job security for any particular demographic group, although there is some evidence that supports the conventional wisdom about the growing incidence of involuntary job loss among older workers and workers with a college education since the late 1980s. Neither does the research find consistent evidence of worsening conditions for less skilled workers between the 1970s and the 1990s. There appears to have been a decline in job security for high school dropouts during the 1980s, but it does not appear to be part of a consistent trend.

Hipple, Steven. "Worker Displacement in the Mid-1990s," *Monthly Labor Review*, Vol. 122, No. 7, July 1999, pp. 15-32.

This article summarizes the results of the most recent biennial survey of worker displacement undertaken by the US Department of Labor. The latest survey results show that for the 1995-96 period the number of displaced workers fell, and those displaced spent fewer weeks without work and suffered less severe earnings losses than workers in the previous two surveys.

Rodriguez, Daniel, and Madeline Zavodny. "Are Displaced Workers Now Finished at Age Forty?" *Economic Review*. Federal Reserve Bank of Atlanta, Second Quarter, 2000.

This is an excellent review and analysis of the controversies and evidence concerning worker displacement. The authors provide data that suggest that much of the concern about displacement may soon abate since displacement rates during 1995-97 have fallen to levels similar to those experienced in the 1980s expansion and the gap between pre- and post-displacement earnings has shrunk.

Barrow, Lisa. "An Analysis of Women's Return-to-Work Decisions Following First Birth," *Economic Inquiry,* Vol. 37, No. 3, July 1999, pp. 432-451.

The author uses information from the National Longitudinal Survey of Youth to analyze women's decisions to return to work within a year of the birth of their first child. She finds that women facing lower child care costs are more likely to return to work, as are women with higher wages and lower family income. These findings, of course, are consistent with what basic economic theory would predict, but the author also provides estimates of the elasticity of the re-employment rates for new mothers with respect to child care costs (-0.18), wages (0.12), and family income (-0.04).

Hours of Work

U.S. Department of Labor. *Report on the American Workforce.* 1999.

This (fourth) *Report on the American Workforce* contains a chapter ("Hours of Work") that will be useful to many forensic economists. The chapter was written by 14 economists (which is most likely a record for a labor economics article – Howard Hayghe, William Wiatrowski, et al.) and examines trends in work time using data from BLS surveys and other sources. The major survey, the Current Population Survey, indicates that average weekly hours of work for employed workers has been fairly stable since 1960, fluctuating between 38-40 hours per week. However, the stability of the overall average masks some changes in subgroups. First, there has been a small increase in the number of hours worked by women. Second, there has been an increase in the proportion of men who are working extended workweeks (i.e., 40 hours or more). Third, data show that married couples with small children are spending considerably more combined hours at work. This, along with the growing number of single-parent families, has resulted in a "time squeeze" for many individuals. Still, some people are working fewer hours than in the past, particularly men aged 25-54 with less than a high school education and men at the lower end of the earnings distribution.