THE PROBABILITY DISTRIBUTION OF FUTURE BAD DEBT LOSSES FOR A GIVEN PORTFOLIO OF ACCOUNTS RECEIVABLE

by

Christoph Haehling von Lanzenauer*
and Don Wright**

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Abstract

With the present trend towards a higher proportion of sales being on a credit basis, the valuation of accounts receivable has become more important. This valuation, however, poses a problem since in spite of the best credit granting policies and collection practices, some fraction of accounts receivable will undoubtedly prove to be uncollectible and become bad debt losses. Sufficient information about the potential bad debt losses is therefore of vital importance in the valuation process. Various methods are used in practice to provide information about the future bad debt losses. A common feature in all these methods is that only one value is estimated. Such procedures cannot reflect the random nature of bad debt losses. The purpose of this paper is to derive the probability distribution of future bad debt losses. The managerial use of the distribution is discussed and the approach is illustrated by an example.
1. INTRODUCTION

With the present trend towards a higher proportion of sales being on a credit basis, accounts receivable tend to represent a more significant portion of the assets of many businesses. Consequently, the valuation of accounts receivable has become more important. This valuation, however, poses a problem since in spite of the best credit granting policies and collection practices, some fraction of accounts receivable will undoubtedly prove to be uncollectible and become bad debt losses. The accepted vehicle for adjustment in the valuation of the accounts receivable is an allowance account. The dollar value used as the allowance for doubtful receivables is a managerially determined quantity and is based on an estimate of existing accounts receivable that will become future bad losses. Sufficient information about the potential bad debt losses is therefore of vital importance in the valuation process.

Various methods are used in practice to provide information about the future bad debt losses resulting from existing accounts receivable. In the most simplistic procedures, these future bad debt losses are estimated by multiplying a historically experienced loss ratio with some quantity such as accounts receivable, credit sales, or net sales. More sophisticated procedures take the age of the accounts receivable in to consideration and use age-related loss ratios. More detailed descriptions of these methods can be found in standard accounting texts such as Welsh [13]. A common feature of all these methods is that only one value is estimated. Such procedures treat future bad debt losses as a point estimate and do not account for their variability. Future bad debt losses must be considered as
a random variable. Cyert, Davidson, and Thompson [5] have formulated this problem by modelling the process as an absorbing Markov chain. This approach produces the mean and variance of the random variable, but does not provide the probability distribution itself.

The purpose of this paper is to derive the probability distribution of future bad debt losses for an existing portfolio of accounts receivable. This new approach has various distinct advantages:

(a) Deriving the probability distribution not only reflects the stochastic nature of the problem, but also provides all information about the random variable.

(b) The probability distribution will prove useful to the financial officer in determining and justifying the allowance for doubtful accounts: Rather than taking a point estimate (which may or may not represent the mean) and loading it to reflect conservatism, one can now set the allowance at a level such that the probability of the actual bad debt losses exceeding the allowance is less than a managerially acceptable level. Any disagreement between management and external parties such as auditors, bankers, and tax authorities could then be resolved on a more objective basis.

(c) The approach is consistent with the growing literature relating to the incorporation of uncertainty into accounting models and financial statements [1, 3, 9, 10, 11, 12, 14], and provides probabilistic input for internal accounting purposes, e.g. projected cash flows from receivables.
While not dealt with in this paper, the approach could also be applied to predict future bad debt losses from sales expected to be made in subsequent periods. This again would serve internal accounting purposes.

The paper is divided into two sections. In the first section, the probability distribution is defined, its moments are determined, and the process of finding a distribution is explained. The second section presents an example wherein the approach is applied.

2. THE PROBABILITY DISTRIBUTION OF FUTURE BAD DEBT LOSSES

Let \( X \) represent the variable bad debt losses, and \( f(X) \) the probability distribution of \( X \). The purpose of this section is to define \( f(X) \) and to outline the approach used to derive \( f(X) \). The approach presented was based on concepts developed by the authors and used in risk theory [8].

2.1 The Definition of \( f(X) \)

Let \( V_T \) be the aggregate amount of accounts receivable at the end of period \( T \) and represent the sum of outstanding credit sales made in previous periods. Typically, credit sales older than \( J \) periods are declared as bad debt and are written off. Of course, \( J \) is the result of company policy. If we let the index \( j (j=0,1,2,...,J) \) represent the age of receivables, we can express \( V_T \) as

\[
(1a) \quad V_T = \sum_{j=0}^{J} S_{T-j} q_j
\]
where \( S_{T-j} \) represents all credit sales in period \( T-j \) and \( q_j \) the fraction of age \( j \) unpaid. The quantity \( S_{T-j} \) is the sum of credit sales made in period \( T-j \) by account \( k \) \( (k=1,2,\ldots,K_j) \). Thus

\[
(2) \quad S_{T-j} = \sum_{k=1}^{K_j} S_{T-j,k}
\]

with \( S_{T-j,k} \) representing the credit sales of account \( k \) in period \( T-j \). Therefore, we have for \( V_T \)

\[
(lb) \quad V_T = \sum_{j=0}^{J} \left\{ \sum_{k=1}^{K_j} S_{T-j,k} q_j, k \right\}
\]

with \( q_j,k \) being the unpaid fraction of age \( j \) and account \( k \). The accounts receivable \( V_T \) according to \((lb)\) must be adjusted for the estimated uncollectible amount. This uncollectible amount can be thought of as the sum of credit sales of accounts which will never be paid. The number of accounts which become defaulted is a random variable. Similarly, the uncollectible amount of each defaulted account is not known in advance and has to be treated as a random variable. The aggregate amount uncollectible is therefore composed of both random variables and is thus a random variable itself.

Let \( F(X \leq z) \) represent the distribution function of \( X \) with \( 0 \leq X \leq V_T \). As explained above, \( F(X \leq z) \) is determined by the random variables number of defaulted accounts and the value they amount to. Let \( \pi(m) \) with \( m=0,1,2,\ldots,M \) be the probability distribution of the number of defaults. A discussion of \( \pi(m) \) and estimation problems is referred to the sample problem. The amount lost given a defaulted account is denoted by \( x(x>0) \). This may be the balance of that defaulted account or some portion of it to take into consideration partial payments. Let \( g(x) \) represent the probability distribution of \( x \)
and \( G(x \leq z) \) the corresponding distribution function. \( g(x) \) may be a discrete, continuous, or mixed density and mass function. Without loss of generality, we assume for the following analysis that \( g(x) \) is continuous.

Assuming \( m \) defaulted accounts, the amount that cannot be collected is defined as \( X^{(m)} \) and is the sum of \( m \) identically distributed random variables \( x \). The distribution function of \( X^{(m)} \) is defined as \( H(X^{(m)}) \). Since statistical independence between individual defaults is a realistic assumption, \( H(X^{(m)}) \) can be expressed as the \( m \)-fold convolution of \( G(z) \) with itself \([6] \). This independence assumption does not imply that the "propensity" to become defaulted is independent of economic conditions or any socio-economic characteristics. Thus

\[
H(X^{(m)} \leq z) = G^{m*}(z) = \int_0^z G^{(m-1)*}(z-x) g(x) dx.
\]

To complete our definition, we must define \( H(X^{(m)}) \) for \( m=0 \)

\[
H(X^{(m)} \leq z) = G^{m*}(z) = 1.
\]

The distribution function of \( X \), \( F(X \leq z) \), can now be written as

\[
F(X \leq z) = \sum_{m=0}^{M} \pi(m) G^{m*}(z).
\]

Since

\[
\frac{dF(X \leq z)}{dz} = f(X = z)
\]

we have

\[
f(X) = \sum_{m=0}^{M} \pi(m) g^{m*}(X).
\]

\( f(X) \) is a compound distribution and requires the knowledge of \( \pi(m) \) and \( g(x) \). Data for both distributions are either available or can
be obtained through sampling. The probability distribution of the aggregate amount of accounts receivable which cannot be collected is herewith defined.

The immediate problem is the numerical evaluation of \( f(X) \). Since explicit results can only be obtained for very special cases (eg. \( \pi(m) \) being Poisson and \( g(x) \) exponential), a two stage process is suggested to determine \( f(X) \). In the first stage the mean and higher moments about the mean of \( X \) are determined. In the second stage, a distribution to represent \( f(X) \) is selected and its parameters are determined.

2.2 The Moments of \( f(X) \)

Let \( \Omega \) be the mean of \( X \) and \( \Omega_r \) the rth \( (r=2, 3, \ldots) \) moment about the mean of \( X \). Similarly, we define as \( \Omega^{(m)} \) the mean of \( X^{(m)} \) and \( \Omega_r^{(m)} \) the rth moment about the mean of \( X^{(m)} \) and as \( \omega \) the mean of \( x \) and as \( \omega_r \) the rth moment about the mean of \( x \).

Thus

\[
\Omega = \int_{0}^{V_T} f(X) X \, dX. \tag{7}
\]

Since \( f(X) \) is given in (6) we have

\[
\Omega = \sum_{m=0}^{M} \pi(m) \left[ \int_{0}^{V_T} g^{m*}(X) X \, dX \right]. \tag{8}
\]

The term in brackets in (8) is defined as \( \Omega^{(m)} \). Since

\[
\Omega^{(m)} = m \omega
\]

as shown in Feller [6], we have

\[
\Omega = \sum_{m=0}^{M} \pi(m) m \omega. \tag{9}
\]
The mean of $X$ is therefore simply the product of the mean of $m$ and the mean of $x$.

The $r$th moment about the mean of $X$ is defined as

\begin{equation}
\Omega_r = \int_0^{V_T} f(X) (X-\Omega)^r \, dX.
\end{equation}

Utilizing (6) we can rewrite (10) as

\begin{equation}
\Omega_r = \sum_{m=0}^M \pi(m) \left[ \int_0^{V_T} g^m(X) (X-\Omega)^r \, dX \right].
\end{equation}

Evaluating (11) for $r=2,3,4,5,$ and 6 leads to

\begin{equation}
\Omega_2 = \sum_{m=0}^M \pi(m) \left[ m \omega_2 + (m \omega - \Omega)^2 \right].
\end{equation}

\begin{equation}
\Omega_3 = \sum_{m=0}^M \pi(m) \left[ m \omega_3 + 3m \omega_2 (m \omega - \Omega) + (m \omega - \Omega)^3 \right],
\end{equation}

\begin{equation}
\Omega_4 = \sum_{m=0}^M \pi(m) \left[ m \omega_4 + 3(m^2 - m)(\omega_2)^2 + 4m \omega_3 (m \omega - \Omega) + 6m \omega_2 (m \omega - \Omega)^2 \right],
\end{equation}

\begin{equation}
\Omega_5 = \sum_{m=0}^M \pi(m) \left[ m \omega_5 + 10(m^2 - m) \omega_3 \omega_2 + 5m \omega_4 (m \omega - \Omega) + 15(m^2 - m)(\omega_2)^2 (m \omega - \Omega) + 10m \omega_3 (m \omega - \Omega)^2 + 10m \omega_2 (m \omega - \Omega)^3 \right],
\end{equation}

and

\begin{equation}
\Omega_6 = \sum_{m=0}^M \pi(m) \left[ m \omega_6 + 15(m^2 - m) \omega_4 \omega_2 + 10(m^2 - m)(\omega_3)^2 + 15(m^3 - 3m^2 + 2m)(\omega_2)^3 + 6m \omega_5 (m \omega - \Omega) + 60m \omega_3 \omega_2 (m^2 - m)(m \omega - \Omega) + 15m \omega_4 (m \omega - \Omega)^2 + 45(\omega_2)^2 (m^2 - m)(m \omega - \Omega)^2 + 20m \omega_3 (m \omega - \Omega)^3 + 15m \omega_2 (m \omega - \Omega)^4 \right].
\end{equation}
The process of deriving higher moments of $X$ and thus providing more information about $f(X)$ could be continued. For the purpose of this analysis, however, $r=6$ is considered to be sufficient for estimating the parameters of the distribution to represent $f(X)$. It should be noted that the moments $\Omega_r$ are expressed in terms $\pi(m)$ and the moments of $X$. Both pieces of information are either available or can be obtained through sampling. The problem remaining is to find a distribution which is consistent with the derived information about $f(X)$.

2.3 Finding a Distribution for $f(X)$

Various distributions can be used to represent $f(X)$. Estimating the parameters of the distribution selected to represent $f(X)$ can be done by various methods, among them the method of maximum likelihood and the method of moments. Although the method of maximum likelihood has certain desirable properties [4], it is not suggested here for the following reasons. For the multiparameter case the maximum likelihood estimates are determined by solving the equations obtained by setting the partially differentiated likelihood function equal to zero. Since explicit results can frequently not be obtained, the task must be carried out numerically. Furthermore, the information about $X$ is not a sample of $n$ observations but rather in form of the moments of $X$. This makes the method of moments particularly appropriate. In estimating the parameters with the method of moments, we equate the first $\ell$ ($\ell=1,2,...$) moments of $f(X)$ as derived above to the corresponding moments of the $\ell$ parameter distribution to be used. If for example, the Gamma distribution with parameter $\alpha$ and $\beta$ is to be used, the expressions $E(X)=\beta(\alpha+1)$ and $\text{Var}(X)=\beta^2(\alpha+1)$ are equated to (9) and (12) and solved for $\hat{\alpha}$ and $\hat{\beta}$, with $\hat{\alpha}$ and $\hat{\beta}$ being estimates of the unknown parameters $\alpha$ and $\beta$. 
Of course, the estimates will ordinarily not equal the quantities being estimated. As the estimates have probability distributions, confidence intervals can be determined [4].

Any method of estimation presumes a specific distribution to represent \( f(X) \). An indication of the error introduced in representing \( f(X) \) by a given distribution can be obtained by comparing the moments of \( X \) not used in the estimation of parameters to the corresponding moments of the chosen distribution. For ease of presentation, we will work with moment coefficients which are defined by \( \Omega_r/\sqrt{\Omega_2} \). Thus, a test quantity \( B(r) \) for \( r=3,4,... \) can be defined and is given in

\[
B(r) = \frac{\hat{\Omega}_r}{\sqrt{\Omega_2}^r}
\]

(17)

where \( \hat{\Omega}_r/\sqrt{\Omega_2}^r \) is the \( r \)th moment coefficient of the fitted distribution. The closer \( B(r) \) to 1 the better is the fit.

3. SAMPLE PROBLEM

Assume a portfolio of 500 accounts receivable at a given point in time characterized by the information given in Exhibit 1 with \( K_j \) representing the number of accounts in age category \( j \). It is assumed that according to company policy accounts receivable older than 180 days are considered as uncollectible.
EXHIBIT 1

Description of Portfolio of Accounts Receivable

<table>
<thead>
<tr>
<th>Age Category (in days)</th>
<th>j</th>
<th>K_j</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30</td>
<td>1</td>
<td>335</td>
</tr>
<tr>
<td>31-60</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>61-90</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>91-120</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>121-150</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>151-180</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

Based on information obtained through sampling, the aging of accounts receivable takes place as indicated in Exhibit 2 with q_j being the percentage of accounts receivable unpaid in age category j. An estimate of the probability of an account receivable of age category j becoming uncollectible is defined by p_j, determined by

$$p_j = \prod_{i=j}^{6} q_i$$

for all j

and is given in Exhibit 2.

EXHIBIT 2

Aging of Accounts Receivable

<table>
<thead>
<tr>
<th>Aging (j to j+1)</th>
<th>q_j</th>
<th>p_j</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 2</td>
<td>.2</td>
<td>.00756</td>
</tr>
<tr>
<td>2 to 3</td>
<td>.3</td>
<td>.03788</td>
</tr>
<tr>
<td>3 to 4</td>
<td>.4</td>
<td>.126</td>
</tr>
<tr>
<td>4 to 5</td>
<td>.5</td>
<td>.315</td>
</tr>
<tr>
<td>5 to 6</td>
<td>.7</td>
<td>.63</td>
</tr>
<tr>
<td>6 to&gt;6</td>
<td>.9</td>
<td>.9</td>
</tr>
</tbody>
</table>

The distribution of the amount lost given a defaulted account, q(x), can be obtained through sampling from company records. For the
sample problem $g(x)$ is assumed to be a Gamma distribution with parameters $\alpha=-.75$ and $\beta=400$. In order to derive the probability distribution of the aggregate amount of accounts receivable which cannot be collected, $f(X)$, we must specify $\pi(m)$ and the moments of $g(x)$.

$\pi(m)$ represents the probability distribution of defaults for the entire portfolio of accounts receivable. For a given age category, however, the number of defaults can be represented by the binomial distribution with parameters $K_j$ and $p_j$. $\pi(m)$ would also be binomial if the $p_j$'s are constant for all $j$ which is unrealistic. The exact values of $\pi(m)$ can be derived by convolving the binomial distributions of the various age categories and are given in Exhibit 3.

**EXHIBIT 3**

**Probability Distribution of Defaults**

<table>
<thead>
<tr>
<th>$m$</th>
<th>$\pi(m)$</th>
<th>$m$</th>
<th>$\pi(m)$</th>
<th>$m$</th>
<th>$\pi(m)$</th>
<th>$m$</th>
<th>$\pi(m)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.000000</td>
<td>13</td>
<td>0.000002</td>
<td>26</td>
<td>0.065572</td>
<td>39</td>
<td>0.008051</td>
</tr>
<tr>
<td>1</td>
<td>0.000000</td>
<td>14</td>
<td>0.000009</td>
<td>27</td>
<td>0.080322</td>
<td>40</td>
<td>0.004711</td>
</tr>
<tr>
<td>2</td>
<td>0.000034</td>
<td>15</td>
<td>0.000034</td>
<td>28</td>
<td>0.091932</td>
<td>41</td>
<td>0.002631</td>
</tr>
<tr>
<td>3</td>
<td>0.001100</td>
<td>16</td>
<td>0.000110</td>
<td>29</td>
<td>0.098134</td>
<td>42</td>
<td>0.001404</td>
</tr>
<tr>
<td>4</td>
<td>0.00314</td>
<td>17</td>
<td>0.000314</td>
<td>30</td>
<td>0.099110</td>
<td>43</td>
<td>0.000717</td>
</tr>
<tr>
<td>5</td>
<td>0.000000</td>
<td>18</td>
<td>0.000000</td>
<td>31</td>
<td>0.093741</td>
<td>44</td>
<td>0.000350</td>
</tr>
<tr>
<td>6</td>
<td>0.000000</td>
<td>19</td>
<td>0.000000</td>
<td>32</td>
<td>0.083529</td>
<td>45</td>
<td>0.000164</td>
</tr>
<tr>
<td>7</td>
<td>0.000000</td>
<td>20</td>
<td>0.000000</td>
<td>33</td>
<td>0.070245</td>
<td>46</td>
<td>0.000073</td>
</tr>
<tr>
<td>8</td>
<td>0.000000</td>
<td>21</td>
<td>0.000000</td>
<td>34</td>
<td>0.055846</td>
<td>47</td>
<td>0.000031</td>
</tr>
<tr>
<td>9</td>
<td>0.000000</td>
<td>22</td>
<td>0.000000</td>
<td>35</td>
<td>0.042039</td>
<td>48</td>
<td>0.000013</td>
</tr>
<tr>
<td>10</td>
<td>0.000000</td>
<td>23</td>
<td>0.000000</td>
<td>36</td>
<td>0.030010</td>
<td>49</td>
<td>0.000005</td>
</tr>
<tr>
<td>11</td>
<td>0.000000</td>
<td>24</td>
<td>0.000000</td>
<td>37</td>
<td>0.020344</td>
<td>50</td>
<td>0.000002</td>
</tr>
<tr>
<td>12</td>
<td>0.000000</td>
<td>25</td>
<td>0.049896</td>
<td>38</td>
<td>0.013115</td>
<td>51</td>
<td>0.000000</td>
</tr>
</tbody>
</table>

In order to determine the moments of $X$, the moments of $g(x)$, the distribution of the amount lost given a defaulted account, are required. While mean and standard deviation for a Gamma distribution with the given parameters are
\[
\omega = 100.00 \\
\sqrt{\omega} = 200.00
\]

Higher moments coefficients can easily be derived and are for the sample problem:

\[
\begin{align*}
\frac{\omega_3}{\sqrt{\omega}_2}^3 &= 4.00 \\
\frac{\omega_4}{\sqrt{\omega}_2}^4 &= 27.00 \\
\frac{\omega_5}{\sqrt{\omega}_2}^5 &= 232.00 \\
\frac{\omega_6}{\sqrt{\omega}_2}^6 &= 2,455.00.
\end{align*}
\]

Using this information and the expressions (9) and (12) through (16), the mean, variance and higher moment coefficients of \(X\) are:

\[
\begin{align*}
\Omega &= 2,984.58 \\
\sqrt{\Omega}_2 &= 1,163.82 \\
\frac{\Omega_3}{\sqrt{\Omega}_2}^3 &= .7338 \\
\frac{\Omega_4}{\sqrt{\Omega}_2}^4 &= 3.7904 \\
\frac{\Omega_5}{\sqrt{\Omega}_2}^5 &= 8.4588 \\
\frac{\Omega_6}{\sqrt{\Omega}_2}^6 &= 34.2149.
\end{align*}
\]

Various distributions have been used to represent \(f(X)\). An indication of the closeness of the representation is provided by the test quantities \(B(r)\) which are given in Exhibit 4.
EXHIBIT 4

Error Analysis

<table>
<thead>
<tr>
<th></th>
<th>B(3)</th>
<th>B(4)</th>
<th>B(5)</th>
<th>B(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0.0</td>
<td>0.7915</td>
<td>0.0</td>
<td>0.4380</td>
</tr>
<tr>
<td>Gamma</td>
<td>1.0628</td>
<td>1.0322</td>
<td>1.0902</td>
<td>1.0972</td>
</tr>
<tr>
<td>Beta - 3*</td>
<td>--</td>
<td>0.9906</td>
<td>0.9803</td>
<td>0.9663</td>
</tr>
<tr>
<td>Beta - 4*</td>
<td>--</td>
<td>--</td>
<td>0.9986</td>
<td>0.9978</td>
</tr>
</tbody>
</table>

*Beta-3 and Beta-4 represent a Beta distribution using three moments and a known start and four moments respectively to estimate the parameters.

As indicated in Exhibit 4 the Beta distribution appears to be the appropriate choice, a result not surprising as more information about f(X) is utilized. f(X) is given in Exhibit 5.

EXHIBIT 5

Probability Distribution of Bad Debt Losses
It is now possible to use \( f(X) \) to determine mean, mode or median of \( X \). Furthermore, it is possible to quantify risk in terms of possible variation of actual bad debt losses from its expected value or to specify the probability that actual bad debt losses will exceed \( k \) times its most likely value. These pieces of information provide better insights into the stochastic variable \( X \) and facilitate any discussion about it on a more objective basis.

For comparison purposes the moments of \( X \) for a portfolio of 100 and 1000 accounts are given in Exhibit 6. As can be expected, with a larger portfolio, \( f(X) \) tends towards normality.

**EXHIBIT 6**

Moments of \( X \) With Varying Size of Portfolio

<table>
<thead>
<tr>
<th>Moment Coefficients</th>
<th>Size of Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td>( \Omega )</td>
<td>602.34</td>
</tr>
<tr>
<td>( \sqrt{\Omega_2} )</td>
<td>522.28</td>
</tr>
<tr>
<td>( \Omega_3/\sqrt{\Omega_2} )</td>
<td>1.6327</td>
</tr>
<tr>
<td>( \Omega_4/\sqrt{\Omega_2} )</td>
<td>6.9159</td>
</tr>
<tr>
<td>( \Omega_5/\sqrt{\Omega_2} )</td>
<td>28.7176</td>
</tr>
<tr>
<td>( \Omega_6/\sqrt{\Omega_2} )</td>
<td>149.0923</td>
</tr>
</tbody>
</table>
4. CONCLUSION

The purpose of this paper was to derive the probability distribution of future bad losses for a given portfolio of accounts receivable. As shown, the distribution is a compound distribution and methods developed in risk theory can be used in its derivation. It should be noted that the data required for the approach suggested can be obtained from company records and is the same as used in current procedures which only give a point estimate. The usefulness of the information provided by the probability distribution for various internal and external purposes is discussed and illustrated. Furthermore, the approach suggested may prove useful in assessing probability distributions in related settings.
1) The results for moments of $X$ can be greatly simplified if the moments about the mean are replaced by the moments about the origin and further reduced if $p(m)$ is Poisson. The interested reader is referred [8].

2) Geary and Pearson [7] have developed tests for normality based on $\Omega_3/\sqrt{\Omega_2^3}$ and $\Omega_4/\sqrt{\Omega_2^4}$ only.
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