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Properties of Research and Development Costing under GAAP and International Accounting Standards

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Abstract

The objective of this paper is to compare accounting figures under International Accounting Standards (IAS) with those figures under U.S. GAAP. Foreign companies might follow IAS to issue securities in NYSE. It is important to analyze the accounting variables under both accounting rules on a comparable basis. Major results of this paper are as follows; Steady-state firms make the same incomes under either IAS or GAAP in the long-run. But the assets of steady-state firms under IAS are increased by the capitalized portion of development costs than the assets under GAAP. As a result, for steady-state firms, return on assets under IAS is smaller than return on assets under GAAP. On the other hand, debt to equity ratio under IAS is smaller than the ratio under GAAP. Variance of income of steady-state firms under IAS is smaller than variance of income under GAAP. Expanding firms make larger incomes under IAS than under GAAP. P/E ratio of expanding firms under IAS is smaller than the ratio under GAAP.

Key words

Research and development, U.S. Generally Accepted Accounting Principles、International Accounting Standards, capitalized expenses,

米国会計基準ならびに国際会計基準における研究開発費の特性に関する考察

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＜論文要旨＞

この論文の目的は米国会計基準（U.S.GAAP）と国際会計基準（IAS）における会計数値の違いを分析することにある。米国においても、ニューヨーク証券取引所において外国企業の国際会計基準の適用が例外として認められており、二つの会計基準による財務諸表の違いを理解することは、今後重要性を増すものと考えられる。

本稿では統計的モデルを用いて、研究開発費の会計数字の違いを理論的に明らかにしようと試みた。定常状態企業では、２つの会計基準のもとで、同一の利益を計上する。資産については、開発費の資産化により、IASにおける数値が大きくなる。このため、総資産利益率はIASでの数値が小さくなる。一方、負債比率は同様の理由でIASにおける数値が小さくなる。また、利益の分散はIASのもとでより大きくなる。成長企業については、IASのもとで、利益はより大きく表示される一方、株価収益率はより小さくなる。

＜キーワード＞

研究開発費、米国会計基準、国際会計基準、費用の資産化

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1. Introduction

There is a certain difference of accounting rules among several countries. From 1973 International Accounting Standards Committee (IASC) tried to harmonize accounting standards for the past two decades.

One of the accounting issues In IASC is the treatment of Research and Development (R&D) costs. For example, FASB requires that all R&D costs are immediately expensed with the exception in computer software. On the other hand, IASC requires that certain development costs are capitalized and depreciated for the life of the products.

"Accounting methods about non-cash items relatively ambiguous" (Ijiri 1980). Some argue the usefulness of the accounting information about intangibles. Cash recovery rate is described to overcome this problem (Ijiri 1978, 1979).

"Unusual commitment to research and development" makes difficult to measure the profitability of pharmaceutical industry (Baber and Kang 1996). In this context, difference in accounting disclosure about intangibles is worthwhile to examine.

Lev and Sougiannis (1996) estimates R&D capital using financial data. This paper follows the method of Sunder (1976) to analyze the difference in accounting figures under GAAP and IAS. A model is set up to understand the effect of different accounting rules, rather than picking up some examples to describe the difference of accounting disclosures (Imhof, Lipe and Wright, 1997).

The model in this paper follows basic assumptions in Sunder (1976). We analyze the difference in earnings and assets under two different accounting methods with no tax payment. Basic assumptions of the model is that the firm has same amount of research projects each period. And each research project is transformed into the development stage with a certain probability in the next period.

The model for accounting variables under IAS shows the comparable results in the analysis of Successful-Efforts-Costing in Sunder (1976). On the other hand, R&D costs are expensed under GAAP and the analysis of accounting variables under GAAP shows the different characteristics from those of Full-Costing in Sunder (1976). In this paper, the effect of parameters in different industries is discussed. And Dupont Composition and P/E ratio are also discussed. In addition, the granularity of research and development activities is considered in the model of this paper.

In the following section, accounting rules in IAS and GAAP are described right after this introduction. And then steady-state firms, new firms and expanding firms are analyzed using models.

2. Overview of accounting rules in GAAP and IAS

2.1. GAAP

SFAS 2 requires that all R&D investment should be expensed immediately. FASB make this pronouncement because there is uncertainty of future benefits with respect to research and development activities, and lack of causal relationship between expenditures and benefits. Furthermore, it insists that "no set of conditions that might be established for capitalization of costs could achieve the comparability among enterprises that proponents of selective capitalization cite as a primary objective of that approach", i.e. they did not find the appropriate standards to capitalize research and development costs selectively to keep comparability of financial statements.

There is an exception for this general rule. SFAS 86 permits firms to capitalize the certain computer software costs. SFAS 86 requires the technical feasibility such as detailed program design or completed working model for the capitalization. This rule only applies to the costs of computer software to be sold, leased, or otherwise-marketed.

2.2. IAS 9

International Accounting Standards, IAS 9 requires that certain development costs be capitalized. The research costs are expensed even under IAS 9.

IAS 9 defines research as original investigation undertaken to gain new scientific or technical knowledge and understanding. It also defines development as the application of knowledge to a plan or design for the production of new or substantially improved products, services. IAS 9 requires the capitalization of development costs if the following criteria are satisfied; (1) the product/process is technically feasible、(2) the product/process is clearly differentiable、(3) the market exists for the product/process、(4) resources are available to complete the project.

In other words, if the development activities almost surely provide future benefits, the development costs are capitalized and depreciated for the useful lives. As in SFAS 2, all the research investments are expensed immediately.

In summary, GAAP permits no capitalization except internally developed computer software costs. On the other hand, International Accounting Standards requires the capitalization of the development costs, if the development activities almost surely make the revenues.

In the following chapter, the difference in financial reporting between two accounting rules is analyzed using a simple model. The model deals with the research and development activities in industries other than computer software, because of the existence of SFAS 86. Both rules expense research costs immediately and as a result a major focus is in the treatment of development costs.

3. Model Development and Analysis

3.1. Steady-State Firm

In this section, expected incomes of steady-state firms under IAS and GAAP are examined. Steady-state firms are defined as firms investing same amount of money into research and development projects every year. The variances of incomes under two accounting methods are also examined. Variance of income is important, because in the framework of this analysis, the accounting variables are treated as probabilistic variables. Even if the two accounting variables have the same expected value, the different variances provide the different processes. After analyzing the expected value and variance of incomes, the return on assets and P/E ratios under two accounting methods are compared. The purpose of these analyses is to clarify the difference in characteristics of accounting variables under IAS and GAAP.

Consider a firm that conducts research and development activities with \$M million for N research projects for each period. One research project with \$1 millions project transforms into capitalizable development stage in the next period with probability θ. The unrecoverable portion of research and development activity is c and d, respectively. Each product produces a net operating revenue of x per period for K periods. Denote the amount of capitalizable development costs in IAS in period t as S_t. S_t is a random variable with binomial distribution and parameters θ and M. Then

$$E(S_t)=M\theta \tag{1}$$

$$Var(S_t)=\frac{M\theta(1-\theta)}{N} \tag{2}$$

If the firm invests a sufficiently large amount of money in research activities for each period, the distribution of capitalizable development projects can be approximated by a normal distribution with the same mean and variance.

If one research project transforms into a development project in period i, it makes cash flow $S_i x$ in the following period. So, the firm invests \$M in N research activities in t-1 period, and it has \$$S_t$ capitalizable development costs in t period and it has xS_t cash flow in t+1 period. S_t is known at the beginning of t period and at the same time xS_t is known with certainty. It does not necessarily assume that it takes one period for a research project to become development project. It just means that the research investment produces development projects with probability θ no matter how long that research project is kept in the firm.

The net cash flow in period t , Y_t, is

$$Y_t = -Mc - S_t d + (S_{t-1} + S_{t-2} + \cdots + S_{t-K})x \tag{3}$$

The mean of the net cash flow τ years into the future is

$$E(Yt/\overline{S_{t-\tau-1}}) = \begin{cases} M\{\theta((\tau-1)x-d)-c\} + (S_{t-\tau} + \cdots + S_{t-K})x & for \tau \le K \\ -Mc - M.\theta.d + MKx\theta & for \tau > K \end{cases} \tag{4}$$

Then the variance of the net cash flow τ years into the future is

$$Var(Y_t/\overline{S_{t-\tau-1}}) = \begin{cases} \dfrac{M\theta(1-\theta)(d^2 + x^2(\tau-1))}{N} & for \tau \le K \\ \dfrac{M\theta(1-\theta)(d^2 + x^2 K)}{N} & for \tau > K \end{cases} \tag{5}$$

Larger the variance of the cash flow, longer the prediction interval (for τ<K). When the prediction interval is increased to K, then the variance levels off. The variance of the cash flow becomes constant for prediction intervals larger than K.

In formula (5), the minimum variance is obtained at θ=0.5. So, if the probability of successful development is between 0 and 50%, then, the rate of change of variance of cash flow with probability θ is

$$\frac{dVar(Y_t/\overline{S_{t-\tau-1}})}{d\theta} = (d^2 + x^2 K)(1-2\theta)\frac{M}{N} > 0 \tag{6}$$

The variance of cash flow increases with the increased probability of successful development in the research activities.

It is also interesting to look at the relationship between variance of cash flow and the cost of development and the expected cash flow for each project. If we make the reasonable assumption that $x^2 K$ is much larger than d^2, i.e. expected cashflow is much larger than development cost, the variance of cash flow increases with the increase of squared cash flow per year and/or the useful lives of products.

The parameters in (6) are also useful to compare the variance of cash flow in different companies. Suppose that x and K are identical in the same industry. Then, variance of cash flow is the function of probability of conversion to development θ. Holding other parameters in different companies constant, larger the probability θ, larger the variance of cash flow.

Income under SFAS 2 is the same as cash flow in a steady state firm, because research and development costs are expensed immediately. Then, the expected income under SFAS 2 τ years into the future is

$E(I_t^G/\overline{S_{t-\tau-1}}) = E(Y_t/\overline{S_{t-\tau-1}})=$

$$=\begin{cases} -Mc - M.\theta.d + \left\{ \sum_{i=t-K}^{t-\tau} S_i + (\tau-1)M.\theta \right\}x & for \tau \le K \\ -Mc - M\theta.d + MKx\theta & for \tau > K \end{cases} \quad (7)$$

Variance of income under SFAS 2 τ years into the future is

$Var.(I_t^G/\overline{S_{t-\tau-1}}) = Var.(Yt/\overline{S_{t-\tau-1}})=$

$$\begin{cases} \frac{M}{N}\theta(1-\theta)\{d^2+x^2(\tau-1)\} & for \tau \le K \\ \frac{M}{N}\theta(1-\theta)(d^2+x^2K) & for \tau > K \end{cases} \quad (8)$$

The accounting variables in International Accounting Standards are examined next. The income under IAS 9 is denoted as I_t^S. Then,

I_t^S = - research costs + net cash flow - amortization charge of capitalized development costs

$$= -Mc + (x-\frac{d}{K})\sum_{i=t-K}^{t-1} S_i \quad (9)$$

Expected income τ period into the future is

$E(I_t^S/\overline{S_{t-\tau-1}})=$

$$\begin{cases} -Mc + (x-\frac{d}{K})\{\sum_{i=t-K}^{t-\tau} S_i + M\theta(\tau-1)\} & for \tau \le K \\ M\{-c+(Kx-d)\theta\} & for \tau > K \end{cases} \quad (10)$$

Larger the amount of investment to research, larger the absolute value of expected income under IAS. Note that to have a positive income for $K \le \tau$ under IAS 9, it should hold that

$$\theta > \frac{c}{Kx-d} \quad (11)$$

It is reasonably assumed that $Kx-d$ is positive. Otherwise the firm does not incur the development costs to make profits. Suppose K, the useful lives of products, varies with the firm's quality of research and development and the firm's marketing efforts. Then, higher the quality of R&D is and/or more efficient the firm's marketing activities is, larger the expected income under IAS.

The variance of income τ years into the future is

$$Var(I_t^S/\overline{S_{t-\tau-1}}) = \begin{cases} \frac{M}{N}\theta(1-\theta)\left\{(\tau-1)(x-\frac{d}{K})^2\right\} & for \tau \le K \\ \frac{M}{N}\theta(1-\theta)\left\{K(x-\frac{d}{K})^2\right\} & for \tau > K \end{cases} \quad (12)$$

As in the case of the cash flow and the income under GAAP, the variance of income under IAS increases with the prediction intervals upto K and then remains constant. Suppose that the unrecoverable portion of development cost d, the useful life of the product K and x, the cash flow of the product per year, are identical in the same industry. Then, the variance of income under IAS is the function of M, N and θ in a particular industry. Larger the amount of investment to research in a company, larger the variance of income. In general, its minimum is achieved at θ=0.5 given that other parameters are same.

Suppose that the unrecoverable portion of development costs d is variable in different companies in the same industry. Holding other parameters constant, smaller the development costs (i.e. more efficient in the development activities given that cash flow for each year is larger than d/K.), larger the variance of income.

The rate of change of variance of cash flow with useful life of the product K is

$$\frac{dVar(I_t^S/\overline{S_{t-\tau-1}})}{dK}=\frac{M}{N}\theta(1-\theta)(x-\frac{d}{K})(x+\frac{d}{K}) \tag{13}$$

Expression (13) is positive, because it could be reasonably assumed that cash flow for each year is larger than d/K. And variance of cash flow increases with useful lives of the products.

The difference of income between GAAP and IAS is

$$I_t^G-I_t^S=-S_td+\frac{d}{K}\sum_{i=t-K}^{t-1}S_i \tag{14}$$

The difference is caused by the capitalization (delayed expense) of development costs incurred on the project in the capitalizable development stage.

The difference of expected income between GAAP and IAS τ years into the future is

$$E(\quad I_t^G-I_t^S\quad)=\begin{cases}\{\sum_{i=t-K}^{t-\tau}S_i+(\tau-1)M\theta\}\frac{d}{K}-dM\theta & for \tau\le K\\ 0 & for \tau>K\end{cases}$$

(15*a*)

(15*b*)

The expected incomes in two accounting methods are the same in the long-run. Income under GAAP is expected to be larger, if the recent research activities produced more development projects than the average. But in average the two terms in expression (15a) cancels out.

$$\mathrm{Var.}(I_t^G/\overline{S_{t-\tau-1}})-\mathrm{Var}(I_t^S/\overline{S_{t-\tau-1}})$$

$$=\begin{cases}\frac{M}{N}\theta(1-\theta)\{d^2+\frac{(\tau-1)d}{K}(2x-\frac{d}{K})\} & for \tau\le K\\ \frac{M}{N}\theta(1-\theta)\{d^2+d(2x-\frac{d}{K})\} & for \tau>K\end{cases} \tag{16}$$

It is reasonably assumed that cash flow for each year is larger than one-year development costs divided by useful years. And the variance of income under GAAP is larger than that under IAS.

Stock variables under two accounting rules are examined next. The difference in two accounting rules also influences the asset structure in addition to income.

Under IAS, the capitalized value of assets at the beginning of period t is

$$A_t^S=\mathrm{d}(S_{t-1}+\cdots+S_{t-K})-\frac{d}{K}(S_{t-2}+2S_{t-3}+\cdots+(K-1)S_{t-K}) \tag{17}$$

The expected value of capitalized assets τ years into the future is

$$E(A_t^S/\overline{S_{t-\tau-1}})=\begin{cases}dM\theta\frac{(\tau-1)}{K}\frac{2K+2-\tau}{2}+d\sum_{i=\tau}^{K}S_{t-i}(\frac{K-i+1}{K}) & for \tau\le K\\ dM\theta(\frac{K+1}{2}) & for \tau>K\end{cases} \tag{18}$$

The variance of capitalized assets τ years into the future is

$$\mathrm{Var}(A_t^S/\overline{S_{t-\tau-1}})=\begin{cases}\dfrac{d^2}{K^2}\dfrac{M}{N}\theta(1-\theta)\sum_{i=1}^{\tau-1}(K-i+1)^2 & for\tau\le K\\ \dfrac{M\theta(1-\theta)}{N}\dfrac{d^2(K+1)(2K+1)}{6K} & for\tau>K\end{cases} \tag{19}$$

Uncertainty in capitalized value of assets under IAS depends on how much research projects are converted into the development stage. On the other hand, there is no capitalized assets with respect to R&D activities under GAAP.

$$A_t^G=0 \tag{20}$$

Then, under GAAP there is no uncertainty about the assets. Holding other variables constant, the assets under IAS is larger than the assets under GAAP, of course. The difference depends on parameters M, θ and K for prediction intervals longer than K. Larger each parameter, larger the difference.

The effect of two accounting rules on returns is analyzed next. Denote the assets of the firm other than capitalized development costs as B_t. Then the total assets in period t are (A_t+B_t) and return on assets is

$$R_t=\frac{I_t}{A_t+B_t} \tag{21}$$

Under IAS, return is $R_t^S=\dfrac{I_t^S}{A_t^S+B_t}=\dfrac{-Mc+(x-\frac{d}{K})\sum_{i=t-K}^{t-1}S_i}{B_t+d\sum_{i=t-K}^{t-1}S_i-\frac{d}{K}\sum_{i=t-K}^{t-1}(t-i-1)S_i}$ (22)

$$\mathrm{E}(R_t^S)=\frac{M\{-c+(Kx-d)\theta\}}{B_t+dM\theta(\frac{K+1}{2})} \tag{23}$$

Under GAAP, return is

$$R_t^G=\frac{I_t^G}{B_t}=\frac{-Mc-S_td+x\sum_{i=t-1}^{t-K}S_i}{B_t} \tag{24}$$

$$\mathrm{E}(R_t^G)=\frac{M\{-c+(Kx-d)\theta\}}{B_t} \tag{25}$$

Comparing (23) and (25), it is found that the latter is always larger than the former. The assumption of steady-state firm makes incomes under two different accounting rules the same.

And capitalized development costs increase assets under IAS. The ratio of expected returns under the two different accounting rules is

$$\frac{E(R_t^S)}{E(R_t^G)}=\frac{B_t}{B_t+dM\theta(\frac{K+1}{2})} \tag{26}$$

The ratio is always smaller than 1, because parameters d, M, θ and K are positive. When the firm's R&D activities are efficient (i.e. Mθ is larger), the ratio of returns under two accounting rules is smaller. And if the competitiveness of the product is sustained for longer time and/or the quality of marketing is higher (i.e. K is larger), the ratio becomes smaller. And if the size of B_t is dominant with respect to capitalized development costs, expression (26) moves toward 1.

Next Dupont Decomposition is considered. Denote sales of the firm for period t as S_t. Then, Dupont Decomposition is

$$R_t = \frac{I_t}{S_t} \times \frac{S_t}{A_t + B_t} \tag{27}$$

Profit margin, the first part of expression (27), is same under two different accounting rules. But, the second part, asset turnover, is different under two rules. Asset turnover under GAAP is higher than asset turnover under IAS, because of the capitalized development costs.

The next issue is the capital structure under two different accounting rules. Denote

$D_t \equiv$ debt of the firm at time t

$E_t \equiv$ owner's equity at time t under GAAP

Then, the owner's equity at time t under IAS is

$$E_t + \ dM\theta(\frac{K+1}{2}) \tag{28}$$

And the debt to equity ratio under IAS, F_t^S is

$$E(F_t^S) = \frac{D_t}{E_t + dM\theta(\frac{K+1}{2})} \tag{29}$$

The debt to equity ratio under GAAP, F_t^G is

$$F_t^G = \frac{D_t}{E_t} \tag{30}$$

The higher return under GAAP is achieved with the costs of lower debt to equity ratio. There is trade-off of benefits in financial disclosure between accounting variables under two accounting rules.

The ratio of the debt-to-equity ratios under two accounting rules is

$$E(\frac{F_t^S}{F_t^G}) = \frac{E_t}{E_t + dM\theta(\frac{K+1}{2})} \tag{31}$$

As in the case of return of assets, the ratio depends on the parameters d, M, θ and K. If

$$E_t >> dM\theta(\frac{K+1}{2}) \tag{32}$$

then, expression (30) is close to 1. In the industry where the research activities are less intensive and/or the probability of successful research is low, Mθ will be relatively small, the difference of debt-to-equity ratio is not significant. (Beverage manufacturers might fall into this category, for example.) On the other hand, in the industry where the research costs is large and/or the probability of successful research is high and then Mθ is dominant in the assets of firms, the difference of debt-to-equity ratio is, relatively speaking, significant. The ratio is useful to convert the debt-to-equity ratio under GAAP into the ratio under IAS.

Finally, P/E ratio is considered for a steady-state firm. Denote the stock price for period t as P_t, and the number of outstanding shares as H_t. Then, the P/E ratio for period t is

$$PE_t = \frac{P_t}{(\frac{I_t}{H_t})} = \frac{P_t H_t}{I_t} \tag{33}$$

The P/E ratio under GAAP and IAS are the same, because income under two accounting rules is the same. The ratio under either of GAAP and IAS is

$$PE_t = \frac{P_t H_t}{M\left\{c + (Kx - d)\theta\right\}} \tag{34}$$

Now the accounting variables for the changing firms are examined in the next section.

Dynamic Models for Changing Firms

The previous analysis for the steady-state firm is based on the assumption that the firm conducts the same amount of R&D investments. This assumption is relaxed in this section.

3.2. New Firms

First, new firms are examined. New firms are defined as firms investing the same amount of money into R&D projects but not reaching the steady-state. Expected income and return on assets under two accounting rules are compared.

Consider new firms that conduct research and development activities with $M for each period. At t=K, the firms R&D activities reached the steady state. After K≤ t, the previous analysis applies to the firm and no longer a new firm in terms of research and development activities. The definition of parameters is same as before.

$$Y_t = -Mc - S_t d + (S_1 + S_2 + \cdots + S_{t-1})x \tag{35}$$

Expectation and variance of cash flow τ periods into the future is

$$E(Y_t/\overline{S_{t-\tau-1}}) = -Mc - M\theta.d + x\sum_{i=1}^{t-\tau} S_i + (\tau - 1)M\theta.x \quad for \tau < t \le K \tag{36}$$

$$Var(Y_t/\overline{S_{t-\tau-1}}) = \frac{\left\{d^2 + (\tau-1)x^2\right\}M\theta(1-\theta)}{N} \quad for \tau < t \le K \tag{37}$$

Income under IAS is

$$I_t^S = -Mc + (x - \frac{d}{K})\sum_{i=1}^{t-1} S_i \quad for t \le K \tag{38}$$

Income under GAAP is

$$I_t^G = -Mc - S_t d + x\sum_{i=1}^{t-1} S_i \quad for t \le K \tag{39}$$

The difference of expected income under two accounting rules is

$$I_t^G - I_t^S = \frac{d}{K}\sum_{i=1}^{t-1} S_i - S_t d \quad for t \le K \tag{40}$$

$$E(I_t^G - I_t^S) = dM\theta(\frac{t-1-K}{K}) \quad for t \le K \tag{41}$$

In expression (40), (t-1-K) is negative for a new firm (t ≤ K). And the expected income under GAAP is smaller than that under IAS.

The capitalized development costs under IAS is

$$A_t^S = d(S_1 + S_2 + \cdots + S_{t-1}) - \frac{d}{K}(S_{t-2} + 2S_{t-3} + \cdots + (t-2)S_1) \tag{42}$$

$$E(A_t^S) = dM\theta(t-1)\left\{1 - \frac{1}{K}(\frac{t}{2} - 1)\right\} \tag{43}$$

Note that there is no explicit condition whether the last part of expression (43) is positive or negative. And the rate of return under IAS is

$$\mathrm{E}(R_t^S)=\frac{-Mc+(x-\frac{d}{K})M\theta(t-1)}{B_t+dM\theta(t-1)\left\{1-\frac{1}{K}(\frac{t}{2}-1)\right\}} \tag{44}$$

On the other hand, the rate of return under GAAP is

$$\mathrm{E}(R_t^G)=\frac{-Mc-dM\theta+xM\theta(t-1)}{B_t} \tag{45}$$

As already mentioned, the numerator of (45) is smaller than the numerator of (44) for new firms. But the size of denominators depends on parameters.

3.3. Expanding Firms

Next, the expanding firms are examined. The expanding firms are defined as those which are increasing their research and development activities. Expected income and P/E ratios under two accounting rules are compared.

Denote M_t as the amount of money invested into research activities in period t. In the expanding firms, the M_t increases as follows;

$$M_t = a + bt \tag{46}$$

Then, the amount of costs for research activities increases \$b million from period t-1 to period t. The net cash flow for expanding firms is

$$Y_t = -M_{t+1}c-S_t d+(S_{t-1}+S_{t-2}+\cdots+S_{t-k})x \tag{47}$$

Here, S_t has binomial distribution with parameters θ and M_t.

$$\begin{aligned}\mathrm{E}(Y_t)&=-M_{t+1}c-M_t.\theta.d+x\theta(\sum_{i=t-K}^{t-1}M_i)\\&=-M_t(c+d\theta)-bc+M_tKx\theta-x\theta.b\frac{K(K+1)}{2}\end{aligned} \tag{48}$$

The net cash flow from expanding firm is $bc+x\theta b\frac{K(K+1)}{2}$ smaller than steady-state firm given $M_t=M$. It indicates the extra cash need of expanding firms. Suppose that the increased R&D amount b, unrecoverable portion of research costs c and the development costs d are constant. Then, expression (48) is the function of θ, x and K. Larger each parameter, larger the cash shortage. The variance of the net cash flow is

$$\mathrm{Var}(Y_t)=\theta(1-\theta)\left\{M_t(d^2+kx^2)-\frac{K(K+1)}{2}bx^2\right\} \tag{49}$$

Income under IAS for period t is

$$I_t^S=-M_{t+1}c+(x-\frac{d}{K})\sum_{i=t-K}^{t-1}S_i \tag{50}$$

$$\mathrm{E}(I_t^S)=-M_tc-bc+KM_t\theta.x-d\theta.M_t-b\theta(x-\frac{d}{K})\frac{K(K+1)}{2} \tag{51}$$

Income under GAAP for period t (t.2) is

$$I_t^G=-M_{t+1}c-S_td+x\sum_{i=t-K}^{t-1}S_i \tag{52}$$

$$\mathrm{E}(I_t^G)=-(M_t+b)c-M_t\theta.d+x\theta\left\{KM_t-b\frac{K(K+1)}{2}\right\} \tag{53}$$

The expected difference between incomes under IAS and GAAP is $E(I_t^S - I_t^G) = bd\theta \frac{K+1}{2}$

(54)

Here, all the parameters are positive for expanding firms. And the expression (54) is always positive for expanding firms. In other words, the expected income under IAS is always larger than the expected income under GAAP for expanding firms. The amount of expensed development costs under GAAP is always larger than the charge of depreciation for the capitalized development cost under IAS for the expanding firm. Note that the difference of expected income between two accounting rules does not depend on the unrecoverable portion of the research costs c.

P/E ratio of the expanding firm under IAS is

$$PE_t^S = \frac{P_t H_t}{-M_t c - bc + KM_t \theta . x - d\theta . M_t - b\theta (x - \frac{d}{K}) \frac{K(K+1)}{2}} \quad (55)$$

The comparison of (34) and (55) reveals that P/E ratio of a steady-state-firm under IAS is smaller than the P/E ratio of an expanding firm with the same amount of R&D activities under the same accounting rule. The denominator of (55) is smaller than the denominator of (34) by $b\left\{c + \theta . (x - \frac{d}{K}) \frac{K(K+1)}{2}\right\}$. This expression is always positive for expanding firms.

P/E ratio of the expanding firm under GAAP is

$$PE_t^G = \frac{P_t H_t}{-(M_t + b)c - M_t d\theta + x\theta \left\{KM_t - b\frac{K(K+1)}{2}\right\}} \quad (56)$$

The denominator of (56) is smaller that the denominator of (34) with the amount of

$$b\left\{c + x\theta \frac{K(K+1)}{2}\right\} \quad (57)$$

This expression is negative for the expanding firms. Holding other parameters constant, the P/E ratio of expanding firm under GAAP is smaller than that of a steady-state firm.

Expression (54) shows the denominator of (55) is larger than that of (56). And P/E ratio for expanding firms under IAS is smaller than P/E ratio under GAAP.

3.4. Shrinking Firms

The same analysis applies for the shrinking firms. In the case of shrinking firms, parameter b in expression (46) is negative. A firm shrinks with a linear rate until M_t moves close to zero. Net cash flow from a shrinking firm is

$$-b\left\{c + x\theta \frac{K(K+1)}{2}\right\} \quad (58)$$

larger than the net cash flow of a steady-state firm. (Given b is negative in a shrinking firm, the expression is positive.) Under the reasonable assumption that the second item is much larger than the first item, larger parameters b, x, θ and K are, larger the difference is.

P/E ratio of the shrinking firm under IAS is described as expression (55). Contrary to the case of the expanding firm, P/E ratio of the shrinking firm is smaller than that of a steady-state firm under IAS. The comparison between (34) and (56) reveals the similar issue for P/E ratio under

GAAP. The above analysis reveals that P/E ratio for an expanding firm is the highest and ratio of a shrinking firm is lowest in three stages of the firm.

4.Conclusions

This paper deals with the different accounting variables under GAAP and IAS. The models are set up using some simple assumptions. Without these models, it is difficult to compare accounting variables under two different accounting rules. In this regard, this paper makes progress to understand and compare those different accounting variables on a comparable basis. Expressions in this paper are also useful to convert the accounting numbers under one accounting rule to those under another accounting rule.

I started the analysis with steady-state firms. Steady-state firms make the same incomes under either IAS and GAAP in the long-run. Variance of income either under GAAP or under IAS increases with the amount of R&D and decreases with the number of R&D projects. This characteristics of accounting variables is interesting and useful, because we have to consider variance as well as expected value of variables to forecast them.

The asset of steady-state firms under IAS is increased by the capitalized portion of development costs than the assets under GAAP. As a result, for steady-state firms, return on assets under IAS is smaller than return on assets under GAAP. On the other hand, debt to equity ratio under IAS is smaller than the ratio under GAAP. These characteristics are important to compare a company under IAS and another company under GAAP.

New firms are defined as firms investing the same amount in R&D but not reaching the steady-state. New firms make larger income under IAS than under GAAP.

Expanding firms are defined as firms increasing the amount of R&D every year. Expanding firms make larger incomes under IAS than under GAAP. P/E ratio of expanding firms under IAS is smaller than the ratio under GAAP.

Shrinking firms are defined as firms as firms decreasing the amount of R&D. Holding parameters constant, shrinking firms make larger cash flow than steady-state firms do. P/E ratio of expanding firms under IAS is larger than the ratio under GAAP.

When more firms engage in business globally, it is often necessary to analyze and compare financial information under different accounting rules. For this purpose, the models in this paper provide the basic tools for the analysis. Furthermore, the models are also useful to expect the theoretical difference of accounting figures among companies whose parameters of R&D activities are different.

Appendix

Explanation of expression (4)

The mean of the net cash flow τ years into the future is the expected value of cash flow for year t forecasted at time of t-τ. When we expect cash flow at this time, we make expense for development cost for $dS_{t-\tau}$. We do have cash flow for this development activity with certainty. But we do not have cash inflow for development activity $S_{t-(\tau-1)}$ with certainty. The same is true for the cash inflows for the following development activities upto S_{t-1}. If we have $\tau \leq K$, then we have expected cash inflow Mθ(τ-1)x for development activities $S_{t-(\tau-1)}$ through S_{t-1}. For remaining development activities $S_{t-\tau}$ through S_{t-K}, we already know the cash inflow for certainty. Thus, we leave the expression $(S_{t-\tau}+\cdots+S_{t-K})x$ as described in (4). If we have $\tau > K$, then we do not have cash inflow for certainty for S_{t-1} through S_{t-K}. Thus, we have the expected cash inflow of MKxθ for the entire development activities.

Explanation of expression (5)

If the firm invests $M in one research activity each year, the variance of the cash flow is Mθ(1-θ)x^2. But the firm invests $M in N research each year and we have to consider granularity. The variance of expected cash inflow for each year is $\frac{M\theta(1-\theta)x^2}{N}$. If we $\tau \le K$, then we have the expected cash inflow for τ-1 research activities. The variance of expected cash inflow is $\frac{M\theta(1-\theta)x^2(\tau-1)}{N}$. We have a granularity for cash outflow of development activity for each year too. The variance of this expected cash outflow is $\frac{M\theta(1-\theta)d^2}{N}$. If we have $\tau > K$, then we estimate the expected cash inflow for entire research activities. The variance of the expected cash inflow is $\frac{M\theta(1-\theta)x^2K}{N}$.

Derivation of expression (18)

As in the explanation of expression (4), we derive the expression for estimated capitalized costs and capitalized costs with certainty separately. The capitalized portion for $S_{t-\tau-1}$ through S_{t-1} is estimated with uncertainty:

$$E\left[\, d(S_{t-1}+S_{t-2}+\cdots+S_{t-(\tau-1)})-\frac{d}{K}\left\{S_{t-2}+2S_{t-3}+\cdots+(\tau-2)S_{t-(\tau-1)}\right\}\right]$$

$$=dM\theta\left\{1+\frac{K-1}{K}+\frac{K-2}{K}+\cdots+\frac{K-(\tau-2)}{K}\right\}=dM\theta\frac{(\tau-1)\left\{K-\frac{1}{2}(\tau-2)\right\}}{K}$$

The capitalized portion for $S_{t-\tau-1}$ through S_{t-K} with certainty:

$$dS_{t-\tau}\frac{K-(\tau-1)}{K}+dS_{t-(\tau+1)}\frac{K-\tau}{K}+\cdots+dS_{t-K}\frac{K-(K-1)}{K}=d\sum_{i=\tau}^{K}S_{t-i}\frac{K-i+1}{K}$$

Derivation of expression (19)

Since we have variance of capitalized costs only in the uncertain projects, we only consider the capitalized portion for $S_{t-\tau-1}$ through S_{t-1}.

$$Var\left[\, d(S_{t-1}+S_{t-2}+\cdots+S_{t-(\tau-1)})-\frac{d}{K}\left\{S_{t-2}+2S_{t-3}+\cdots+(\tau-2)S_{t-(\tau-1)}\right\}\right]$$

$$=d^2\frac{M\theta(1-\theta)}{N}\left[\left(\frac{K}{K}\right)^2+\left(\frac{K-1}{K}\right)^2+\left(\frac{K-2}{K}\right)^2+\cdots+\left\{\frac{K-(\tau-2)}{K}\right\}^2\right]$$

$$=\frac{d^2}{K^2}\frac{M}{N}\theta(1-\theta)\sum_{i=1}^{\tau-1}(K-i+1)^2$$

If we have $\tau > K$, then

$$Var\left[d(S_{t-1} + S_{t-2} + \cdots + S_{t-K}) - \frac{d}{K}\left\{ S_{t-2} + 2S_{t-3} + \cdots + (K-1)S_{t-K} \right\} \right]$$

$$= d^2 \frac{M\theta(1-\theta)}{N}\left[\left(\frac{K}{K}\right)^2 + \left(\frac{K-1}{K}\right)^2 + \left(\frac{K-2}{K}\right)^2 + \cdots + \left\{ \frac{K-(K-1)}{K} \right\}^2 \right]$$

$$= \frac{M\theta(1-\theta)}{N} \frac{d^2(K+1)(2K+1)}{6K}$$

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