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Regional heterogeneity among non-operating earnings quality, stock returns, and firm value in biotech industry

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Abstract: This paper analyses regional heterogeneity under the discretionary measures of non-operating earnings quality and stock returns on firm value in Taiwan's biotech industry during 2008–2015. An econometric framework based on panel smooth transition regression models is employed in a non-linear panel data model. The results show that biotech firms near the bottom threshold for operating income have low-quality non-operating earnings and those near the upper threshold demonstrate the opposite. Investors who exclusively focus on stock returns are thus likely to miss important information about the quality of earnings.

Keywords: biotech industry; firm value; non-operating earnings; panel smooth transition regression (PSTR) models; regional heterogeneity; stock returns

The biotech industry is forecasted to experience explosive growth in the chronic disease market, driven by population growth, increased longevity, the economic and political ascent of highly populous nations, and attendant global redistributions of wealth. This development provides numerous opportunities across the biotech industry, including in the pharmaceutical, medical device, and diagnostics sectors, that will be shaped by a variety of distinct forces. Among these are the need for specialisation in a complex capital structure, a formidable regulatory approval process, financial quality, scientific risks, and concerns related to earnings management and capital market incentives. This study believes that the mission of the biotech industry is important, but it brings about abnormal stock price volatility and non-operating earnings quality in Taiwan.

Taiwan's domestic market for biotechnology services has grown rapidly in recent years. It has comprehensive intellectual property protection, an excellent industry development framework, and rich sources of capital. With a deep pool of highly-skilled bioscientists, a low-cost R&D environment, and a renowned capability for precision manufacturing, Taiwan provides global companies with a sound investment environment as well as numerous business opportunities. Biotechnology is viewed by the Taiwan government as an industry of particular importance to the country's future. The government has therefore taken a proactive policy stance toward the industry's research and development, which refers to innovative activities undertaken by firms, R&D, manufacturing, and production capacity. For this reason, law and policy makers have over the years drafted and implemented supervisory and promotion policies with the aim of guiding the biotechnology industry to a position of prominence.

The adaptation of the biotech industry to a new, more sustainable economy may seem an overwhelming and unclear task. However, it is worthwhile to question the industry's performance in the contemporary marketplace, which is characterised by economic uncertainty, reform-driven pricing pressures, rising demand for innovation and value, increasing focus on stock engagement, and ever-changing earnings management. In particular, investors often overlook business value and quality when buying high-priced shares of biotechnology firms.

A sudden spike or decline in a company's non-operating earnings within the previous few years

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is likely to be caused by earnings management quality because core operating income tends to be relatively unstable over time. With the influx of hot money into the biotechnology industry, the amount of private investment has grown annually, but unfortunately, this has been accompanied by instances of share prices plummeting or skyrocketing. The main contribution of this article is to examine the relevance of firm value and earnings management in biotech companies, and taking into account non-operating earnings and stock market remuneration, to analyse the relevance of firm value and the incentive for stock returns. According to this study's observations, under high operating income and solid profitability, non-operating earnings are positively related to firm value. By contrast, for biotech firms with low operating income, their stock returns are usually positively related to firm value. Therefore, investors are recommended to closely observe the operational quality of biotech companies.

LITERATURE REVIEW

Previous studies on the relationship of returns to earning quality have found evidence that high-quality firms earn more and have higher operational value than others. According to Healy and Wahlen (1999), earnings management involves managers using personal judgment in financial reporting and structuring transactions in order to alter financial reports that mislead some of their stakeholders about the underlying economic performance of the company. Rajgopal and Venkatachalam (2011) showed that reduced earnings quality is associated with increased firm-level volatility. According to Graham et al. (2005), financial executives are more willing to manipulate earnings through real activities rather than accruals; they defined real activities' manipulation as a departure from normal operational practices, as motivated by managers' desire to mislead at least some stakeholders into believing certain financial reporting goals have been met in the normal course of operations. Jian and Wong (2004) argued that large Chinese listed firms tend to have an extensive network of related parties, thus making it comparatively easier for them to manipulate their earnings through non-operating transactions.

Houge and Loughran (2000) found that stocks with high accruals, which signify that earnings are high relative to cash flows, have lower returns and performance than stocks with low accruals. Firms with growth opportunities are penalised more than others by the stock market when they miss earnings thresholds (Skinner and Sloan 2002). Lambert and Verrecchia (2011) argued that the adverse consequences of information asymmetry are inversely related to the degree of investor competition in stock.

These studies in the literature show that managers are keenly interested in maintaining growth in earnings because their compensation is often tied to their firms' earnings. Earnings management has a negative effect on the quality of earnings if it distorts information in a way that reduces its usefulness for predicting future cash flows. The term "quality of earnings" refers to the credibility of the earnings number reported. Earnings management in effect reduces income reliability. The investing public does not necessarily view minor earnings management as unethical but as a common and necessary practice in the everyday business world. It is only when the impact of earnings management is great enough to affect investors' portfolios that they feel fraud has been committed. We have looked at the related literature to study the impact of non-operating earnings and stock returns on firm value, and we also consider the threshold effect of non-linear relationships for different operating incomes.

ILLUSTRATIVE MODEL

Model basics

The model by Lindenberg and Ross (1981)[1] is derived from conventional theory and uses the panel data model to estimate mutual fund cash holdings, where the dependent variable is monthly cash holdings. This study's analysis relies on data from a variety of standard sources that are matched to create panels on yearly frequencies. Our main estimates rely on data from Taiwan Economic Journal (TEJ) sources (TEJ 2018):

$$\ln Q_{it} = \beta_{1i} \ln LEV_{it} + \beta_{2i} \ln OPM_{it} + \beta_{3i} \ln NOE_{it} + \beta_{4i} \ln OPI_{it} + \beta_{5i} \ln ST_{it} + \varepsilon_{it} \quad (1)$$

where Q_{it} is *Tobin's Q*; LEV_{it} is leverage ratio; OPM_{it} is operating income margin; NOE_{it} is non-operating earnings, and OPI_{it} is operating income. All of these

[1]This paper examines the relationship between accounting and financial market data to determine the extent, distribution, and history of monopoly and quasi-rents in the industrial sector. The basic idea uses *Tobin's Q* ratio.

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$$\ln Q_{it} = \beta_{1i} \ln LEV_{it} + \beta_{2i} \ln OPM_{it} + \beta_{3i} \ln NOE_{it} + \beta_{4i} \ln OPI_{it} + \beta_{5i} \ln ST_{it} + \varepsilon_{it} + \\ + [\beta_{1i} \ln LEV_{it} + \beta_{2i} \ln OPM_{it} + \beta_{3i} \ln NOE_{it} + \beta_{4i} \ln OPI_{it} + \beta_{5i} \ln ST_{it}]\ g(q_{it};\gamma,c) + \varepsilon_{it} \quad (2)$$

are independent variables and ST_{it} represents the firm's stock returns (main variables description in Table 1).

To explore whether or not many biotech technology companies may be operating in the form of sail under false colours while doing business properly, this paper observes the structural changes in the non-operating earnings quality, stock returns, and firm value under low-operating income and high-operating income of biotech firms, which allows for estimating the parameters of a Panel Smooth Transition Regression (PSTR) model and for defining the number of location parameters for more details and the maximum number of transition function) (Hansen 1999; Gonzalez et al. 2005). The model automatically determines the optimal number of transition functions. The slope parameters and location parameters of the transition function and the slope parameters in each regime for all the explicative variables are estimated by Non-linear Least Squares (NLS). Finally, the individual elasticities for each explicative variable are computed. Therefore, we use the excess return for the operating income (OPI_{it}) as the threshold variable. The model implies that the two extreme regimes are associated with the low-operating income and high-operating income variables while allowing for considerable heterogeneity in the timing of regime changes across series.

PSTR model

We first model a non-linear relationship between operating income and *Tobin's Q*, leverage ratio, operating income margin, non-operating earnings, operating income, and stock returns, expressing the log equation as follows in Equation 2.

We estimate Equation 2 using the panel approach that considers both biotech industry i and year t, with ε_{it} representing the fixed effects, deterministic trends, and error terms, respectively.

The transition function $g(q_{it};\gamma, c)$ is a continuous function of the observable variable q_{it} and is normalised to be bounded between 0 and 1. These extreme values are associated with regression coefficients β_0 and $\beta_0 + \beta_1$. More generally, the value of q_{it} determines the value of $g(q_{it};\gamma, c)$ and thus the effective regression coefficients $\beta_0 + \beta_1\, g(q_{it};\gamma, c)$ for individual i at time t. The transition function is a logistic specification, shown as:

$$g(q_{it};\gamma,c) = \left(1 + \exp\left(-\gamma \prod_{j=1}^{m} (q_{it} - c_j)\right)\right)^{-1} \quad (3)$$

The transition function $g(q_{it};\gamma, c)$ is a continuous function bounded between 0 and 1 associated with the

Table 1. Main variables description

Variable	Description	Calculation
Tobin's Q (*Q*)	ratio of the firm's market value to its asset replacement costs	*Tobin's Q* = (total market value/total asset value) × 100%
Leverage ratio (*LEV*)	ratio used to determine companies' financing methods	*LEV* = {total liabilities/total assets} × 100%
Operating income margin (*OPM*)	ratio important to both creditors and investors (it helps to show how strong and profitable a company's operations are)	*OPM* = (operating income/net sales) × 100%
Non-operating earnings (*NOE*)	non-operating earnings are any profit or loss generated by activities outside a business' core operating activities	*NOE* = (non-operating earnings/net operating income) × 100%
Operating income (*OPI*)	indirect measure of efficiency (the higher operating income is, the more profitable a company's core business is)	*OPI* = {(net operating income – operating cost)/total assets} × 100%
(*ST*)	profits of companies' rate of return on stock	*ST* = {(ending of stock price – beginning of stock price)/beginning of stock price} × 100%

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database

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$$\ln Q_{it} = \beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it} + \varepsilon_{it} + \\ + \sum_{j=1}^{r}[\beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it}]\, g(q_{it}^{(j)};\gamma,c) + \varepsilon_{it} \quad (5)$$

transition variable (q_{it}), the threshold parameter (c_j), and the slope of transition function (γ). The slope parameter γ is an indicator of the speed of transition from one regime to another. The threshold variable is sample-specific and time-varying, allowing the regression coefficients to change for each of the biotech firms in the panel with the passage of time. It is the same as the vertical and horizontal threshold model described by Hensen (1999) as follows:

$$Q_{it} = u_{it} + \beta_0^{'} x_{it} + \beta_1^{'} x_{it}\vartheta(q_{it};c) + \varepsilon_{it}$$

$$\vartheta(q_{it};c) = \begin{cases} 1 & \text{if} \quad q_{it} \geq c \\ 0 & \text{if} \quad q_{it} \leq c \end{cases} \quad (4)$$

Because of their heterogeneous beliefs, different biotech firms may not take instant and identical actions at the same time. Thus, directly interpreting the values of these regression coefficients is difficult. For this purpose, we utilise the increase or decrease in operating income (OPI_{it}), depending on whether it is a threshold variable.

The additive model is a generalisation of the PSTR model to allow for more than two different regimes (Equation 5).

In Equation 5, the transition functions $g(q_{it}^{(j)};\gamma,c)$, $j = 1, \dots, r$, depend on the slope parameter γ_j and the location parameter c_j. The shape of these transform functions g (·) is determined by Equation 3, where $j = 1, \dots, r$ represents the existence of r smooth transfer functions so that the model exists at 2^r different influence intervals.

The transfer function is in general set to $m = 1$ or $m = 2$. When $m = 1$, it is called the logistic model; it divides the data into two intervals according to the conversion threshold. According to Equation 6, when g is a large c, the g (·) conversion function is equal to 1; when $q = c$, the g (·) the transfer function is equal to 0.5; when q is much smaller than c, the g (·) conversion function is equal to 0.

$$\vartheta(q_{it};c) = \begin{cases} 1 & \text{if} \quad q_{it} >> c \\ 0.5 & \text{if} \quad q_{it} = c \\ 0 & \text{if} \quad q_{it} << c \end{cases} \quad (6)$$

If the transfer function is $m = 2$, also known as the exponential model, then the conversion function will have a different $m = 1$ conversion process. The conversion interval is divided into three intervals by Equation 6; when q is positive, or when infinity is constant, the g (·) conversion function is equal to 1. When $q = c_1$ or c_2, the g (·) conversion function is equal to 0.5; when q is between c_1 and c_2, g (·) shows a smooth transition from 0 to both ends of the phenomenon.

$$\vartheta(q_{it};c) = \begin{cases} 1 & \text{if} \quad q_{it} << c_1 \ \text{or} \ q_{it} >> c_2 \\ 0.5 & \text{if} \quad q_{it} = c_1 \ \text{or} \ q_{it} = c_2 \\ 0 & \text{if} \quad q_{it} < c_1 \ \text{or} \ q_{it} < c_2 \end{cases} \quad (7)$$

The linearity or equivalently homogeneity hypothesis in a PSTR model (Equation 3) can be tested by H_0: $\gamma = 0$ or H_0: $\beta_0 = \beta_1 = 0$. However, the test statistics have a non-standard distribution, because the PSTR model contains unidentified nuisance parameters under the null hypothesis, which is also called the Davies problem. It replaces the transition function (q_{it}; γ, c) with its first-order Taylor expansion around $\gamma = 0$ and performs the test of linearity through the auxiliary regression in Equation 8 below.

In Equation 8, the parameter vectors $\theta_1, \dots, \theta_n$ are proportional to the slope parameter γ, and

$$\mu_{it} = \varepsilon_{it} + Rm\theta_1 [\beta_{1i} \ln LEV_{it} + \beta_{2i} \ln OPM_{it} + \\ + \beta_{3i} \ln NOE_{it} + \beta_{4i} \ln OPI_{it} + \beta_{5i} \ln ST_{it}], \text{ and}$$

$$\ln Q_{it} = \beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it} + \\ + Rm\,\theta_0[\beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it}] + \\ + Rm\,\theta_1 q_{it}[\beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it}] + \\ + Rm\,\theta_n q_{it}[\beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it}] + \mu_{it} \quad (8)$$

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$$SSR_0 = \sum U_{it}^2 = \sum (\beta_{1i}\ln LEV_{it} - \beta_{2i}\ln OPM_{it} - \beta_{3i}\ln NOE_{it} - \beta_{4i}\ln OPI_{it} - \beta_{5i}\ln ST_{it} - \\ - \theta_0[\beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it}])^2 \quad (9)$$

$$SSR_0 = \sum U_{it}^2 = \sum (\beta_{1i}\ln LEV_{it} - \beta_{2i}\ln OPM_{it} - \beta_{3i}\ln NOE_{it} - \beta_{4i}\ln OPI_{it} - \beta_{5i}\ln ST_{it} - \\ - \theta_0[\beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it}] - \\ - \theta_1 q_{it}[\beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it}] - \\ - \theta_n q_{it}^n[\beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it}])^2 \quad (10)$$

$$\ln Q_{it} = \beta_{1i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{3i}\ln NOE_{it} + \beta_{4i}\ln OPI_{it} + \beta_{5i}\ln ST_{it} + \\ + \sum_{j=1}^{r}[\beta_{1i}\ln LEV_{it} + \beta_{1i}\ln OPM_{it} + \beta_{1i}\ln NOE_{it} + \beta_{1i}\ln OPI_{it} + \beta_{1i}\ln ST_{it}]\, g_1(q_{it}^{(j)};\gamma_1, c_1) + \\ + \theta_0[\beta_{2i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{2i}\ln NOE_{it} + \beta_{2i}\ln OPI_{it} + \beta_{2i}\ln ST_{it}] - \\ - \theta_1 q_{it}[\beta_{2i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{2i}\ln NOE_{it} + \beta_{2i}\ln OPI_{it} + \beta_{2i}\ln ST_{it}] - \\ - \theta_n q_{it}^n[\beta_{2i}\ln LEV_{it} + \beta_{2i}\ln OPM_{it} + \beta_{2i}\ln NOE_{it} + \beta_{2i}\ln OPI_{it} + \beta_{2i}\ln ST_{it}] + \varepsilon_{it} \quad (11)$$

Rm is the remainder of the Taylor expression. Consequently, the linearity hypothesis can be tested as H_0: $\theta_1 = , \dots , = \theta_n = 0$ versus H_1: $\theta_1 \neq , \dots , \neq \theta_n \neq 0$ in this first-order Taylor expansion.

For the purpose above, we can apply general restriction tests such as the Wald LM test (*LMW*), the Fisher LM test (*LMF*), and the likelihood ratio test (*LRT*), where *N* is the total number of biotech firms, *T* is the size of the sample period, and *K* represents the number of explanatory variables. Based on the null hypothesis, the *LMW* and *LRT* statistics are distributed as $X^2(ML)$, whereas *LMF* has an approximate *F*(*ML*, *T-N-ML*) distribution. Moreover, SSR_0 and SSR_1 can be obtained through the sum of squared residuals under the H_0 and H_1 hypotheses, respectively, in Equations 9 and 10.

The null hypothesis of no remaining non-linearity can be defined as $\gamma = 0$. The problem of unidentified nuisance parameters under the null hypothesis can be identified and circumvented using a first-order Taylor approximation of second transition function, which subsequently becomes the auxiliary regression in Equation 11.

The test for no remaining non-linearity can then be defined as H_0: $\theta_1 = , \dots , = \theta_n = 0$ against H_1: $\theta_1 \neq , \dots , \neq \theta_n \neq 0$ in this auxiliary regression. To this end, the statistical values *LMW*, *LMF*, and *LRT* can be calculated as mentioned previously. Here, SSR_0 denotes the panel sum of squared residuals under H_0 and refers to the PSTR model with one transition function, while SSR_1 denotes the sum of squared residuals of the transformed model and refers to Equation 11. If the null hypothesis is not rejected, then the procedures end; otherwise, the existence of a third transition function must be determined. The testing procedure continues until the hypothesis is accepted with no remaining heterogeneity.

EMPIRICAL RESULTS

Descriptive statistics

Table 2 indicates that the gap between the maximum (139.560) and minimum (–41.920) non-operating earnings implies a large performance gap in the earnings management standards of biotech operations. A firm, as noted beforehand, might attempt to use non-operating earnings to mask poor operational results.

Earnings management is closely related to a company's business strategy; non-operating earnings are also a crucial element of any earnings operations. Companies often invest in additional business realms to earn additional benefits; this choice relates to whether the company itself has such professional competence. Therefore, the company's business ability is the focus of many actors, including those with an indirect relationship to the company. Many companies are concerned about outside business operations, including stocks and other investment projects. The afore mentioned direct or indirect non-operating earn-

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Table 2. Descriptive statistics

Variable	Mean	Median	Minimum	Maximum	Std. dev.	CV	Skewness	Ex. kurtosis
Tobin's Q	1.774	1.505	0.480	7.660	1.026	0.578	2.107	6.342
LEV	3.288	3.474	0.615	4.245	0.651	0.197	–1.673	3.056
OPM	4.830	4.895	–59.120	45.360	13.9200	2.881	–0.965	3.909
ST	9.573	6.110	–128.987	235.337	46.933	4.902	0.448	1.940
NOE	3.157	1.190	–41.920	139.560	12.463	3.947	5.424	50.588
OPI	24.60	21.735	–5.771	107.651	16.387	0.665	1.669	5.624

CV – coefficient of variation; Ex. kurtosis – excess kurtosis; Std. dev. – standard deviation; for explanation of variables see Table 1

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database (TEJ 2018)

ings are often related to the company's own business capacity and development.

For operating earnings, the maximum is 107.651, the minimum is –5.771, and the standard deviation is 16.387. A company's greatest value lies in creating shareholder returns, but according to statistical analysis, the operational ability of companies in the biotechnology industry has become polarised over the years. Whether favourable business operations are positively correlated to non-operating earnings is thus worthy of further analysis.

The standard deviation of stock returns is large relative to the other variables, showing that stock prices are highly volatile in the biotech industry. Biotechnology companies with stock price changes are shown to be more concerned about minimum (–128.987) and maximum (235.337) stock returns than investors are. The large gap in stock price performance deserves further exploration, as is the question of whether biotechnology companies with high stock returns also have outstanding performance in operating income and non-operating earnings. Other variables such as the standard deviation (1.026) of *Tobin's Q* and the standard deviation (0.651) of *LEV* are relatively stable. In addition, most of the variables by skewness statistics belong to symmetry, most of the variables by excess kurtosis statistics belong to high narrow peak, and most of the variables have a coefficient of variation between 0 and 5.

The results in Table 3 show that stock returns are highly correlated with *Tobin's Q* and non-operating earnings are negatively correlated with firm value. In addition, the debt ratio is negatively correlated with outside profits but positively correlated with operating income. This implies that an enterprise's performance can benefit if the debt is located in operating income, but cannot when it is located in business income.

We also observe a negative correlation between non-operating earnings, operating income margin, and stock compensation, showing that non-operating earnings are not conducive to the development of enterprise value in the biotechnology industry. Therefore, non-operating earnings may affect the biotech industry, and it is especially important to determine whether business profits and losses differ in biotech firms with high versus low operating income.

We observe by contrast that *Tobin's Q* is highly correlated with the rate of return on a stock and is higher than operating income, which seems to imply that the value of a biotech company has a significant impact

Table 3. Correlations

Variables	*Tobin's Q*	*LEV*	*NOE*	*OPI*	*OPM*	*ST*
Tobin's Q	1	–0.2889	0.0216	0.1426	0.2220	0.4292
LEV	–	1	–0.3353	0.3644	0.3373	0.0771
NOE	–	–	1	–0.1960	–0.1108	–0.0431
OPI	–	–	–	1	0.6370	0.1938
OPM	–	–	–	–	1	0.2752
ST	–	–	–	–	–	1

For explanation of variables see Table 1

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database (TEJ 2018)

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Table 4. Panel regression model results (observations = 1 920)

Variables	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Intercept	3.492***	0.0000	3.882***	0.0000	3.772***	0.0000
LEV	–0.648***	0.0000	–0.714***	0.0000	–0.688***	0.0000
NOE	–0.005	0.2642	–0.006	0.1489	–0.005	0.1615
OPI	0.0175***	0.0000	0.006	0.1360	0.005	0.1390
OPM	–	–	0.022***	0.0001	0.014***	0.0000
ST	–	–	–	–	0.008***	0.0000
Adjusted R^2	0.157	–	0.210	–	0.347	–

*, **, and *** denote 10, 5, and 1% significance levels, respectively; for explanation of variables see Table 1

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database (TEJ 2018)

on the rate of return on its stock price. However, we are more interested in whether biotech firms have the same stock remuneration regardless of operating income and whether stock prices are more favourable for companies with low operating income than those with high operating income. To discuss these structural phenomena, we extend the PSTR model.

Panel regression results

As shown in Table 4, non-operating earnings were negatively related to firm value and did not benefit firm operations. Non-operating earnings in the biotechnology industry seem to be non-professional, and biotech companies may seek to gain foreign investment by expanding operations and revenue, but ultimately cannot obtain substantial income. Therefore, non-operating earnings performance can be used as an early warning assessment; namely, if the external surplus in a biotech company is very large, then investors should be cautious. However, whether there is a structural change in the relationship between operating income and non-operating earning remains undetermined.

We next observe that when the stock price is accounted for, the relationship between operating income and firm value becomes non-significant and the stock price has a significant positive relationship with firm value. More importantly, stock price returns seem to be highly important to the biotech industry, exceeding the impact of operating income. We also note that the margin of return on operating income is positively related to firm value. The practice of earnings management damages the perceived quality of reported earnings over the entire market, resulting in the belief that reported earnings do not reflect economic reality and eventually leading to unnecessary stock price fluctuation. This uncertainty ultimately has the potential to undermine the efficient flow of capital and thereby damage the market as a whole.

We finally have strong evidence that investors in the biotech industry must be more cautious than they presently are, because a large part of their motivation for supporting the industry may be related to stock prices. From the perspective of business enterprises, however, operating income is still the main focus. We also observe that leverage is negatively related to firm value. We thus further analyse the relationship between the different threshold effects, enterprise value, non-operating earnings, and stock price remuneration, with operating income as the threshold variable.

PSTR model test

The first step in specifying the model is meant to test the null hypothesis of linearity against the alternative PSTR model. We use the excess return for the operating income (OPI_{it}) as the transition variable. The results are shown in Table 5. For a single location parameter (m = 1), we can reject the null hypothesis of linearity. For two and three location parameters (m = 2 or 3), the *LRT* tests support a non-linear relationship between cash holdings and the size of returns.

Table 5. Linearity tests

	Wald test	Fisher test	LRT test
Statistic	50.305*** (0.000)	4.165*** (0.000)	54.808*** (0.000)

*, **, and *** denote 10, 5, and 1% significance levels, respectively; p-values are in parentheses; LRT – likelihood ratio test

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database (TEJ 2018)

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Table 6. Constancy tests (H_0: $r = 1$ versus H_1: $r = 2$)

Statistic	Wald test	Fisher test	LRT test
Wald test	15.538 (0.001)***	3.412 (0.001)***	15.935 (0.001)***

*, **, and *** denote 10, 5, and 1% significance levels, respectively; p-values are in parentheses; LRT – likelihood ratio test; r – regime

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database (TEJ 2018)

To determine the non-linearity, we test the hypothesis of no remaining non-linearity, with the results reported in Table 6. The null hypothesis of $r = 1$ is rejected, and that of $r = 2$ is not rejected at the 5% significance level. In this case, we have two transition functions. Whenever $m = 2$ or $m = 3$, we have one transition function.

Two criteria for comparing the goodness of fit of various specifications are the Akaike information criterion and the Schwarz criterion. Determination of the number of regimes ($r + 1$) is shown in Table 7 and Figure 1. Two location parameters are present; in other words, it is a two-regime PSTR model.

We consider the individual-specific fixed-effect non-dynamic PSTR model. As Table 7 shows, one form of the PSTR model is as follows:

$$Q_{it} = \beta_0 m_{it} + \beta_1 m_{it} g(q_{it}; \gamma, c) + \varepsilon_{it} \qquad (12)$$

β_0 and β_1 are estimated parameters to the slope parameter of transition function. The model is estimated using non-linear least squares. Parameter estimates are shown in Table 8. The threshold value is 8.3105, and the PSTR model is very smooth. Through empirical analysis, we find that low operating income, whether in non-operating earnings or operating income margin, is negatively related to firm value, and so the quality of earnings management must be improved.

In firms with low operating income, however, stock returns have a significantly positive relationship with firm value. Hence, it is clear that stock returns are an important source of support for these firms. However, it is worrying that the firms are not supported by high operating income and must rely on their stock prices to create firm value.

We also find that the overall value of firms with high operating income has a significant positive relationship with non-operating earnings, operating income margin, and stock returns. These firms are able to professionally manage their non-operating earnings and thereby create business value in addition to stock price compensation.

The preceding analysis confirms that the biotech industry has higher non-operating earnings, and firms are more likely than speculative firms to have high operating incomes. Stock rewards increase firm value, but operating income must be further investigated, because the high stock prices of firms may not be beneficial for business operations. We believe that the biotechnology industry should incorporate professional management, rather than only focusing on the performance of stock price compensation. Fi-

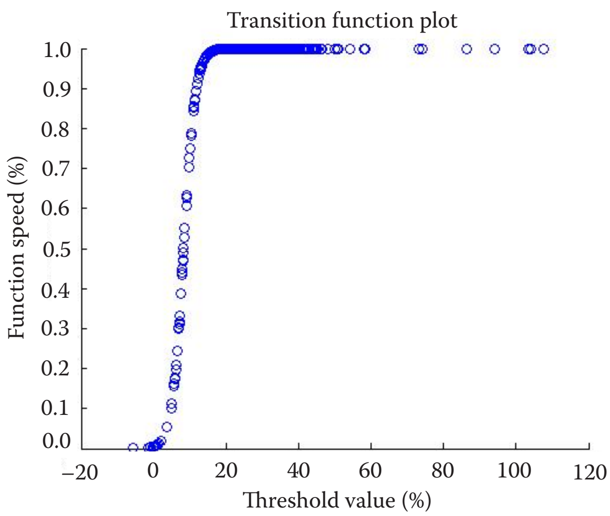

Figure 1. Conversion of non-operating earnings (NOE) to firm's value

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database (TEJ 2018)

Table 7. Determination of the number of thresholds

	H_3: $\beta_3 = 0$	H_2: $\beta_2 = 0 \mid \beta_3 = 0$	H_1: $\beta_1 = 0 \mid \beta_2 = \beta_3 = 0$
Statistic	0.551	0.808	2.714
Number of threshold r (m)	1	–	–

β – slope parameter of transition function; r – regime; m – threshold parameters

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database (TEJ 2018)

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Table 8. Panel smooth transition regression (PSTR) model estimation results

Variables	Low operating income		High operating income	
LEV	–0.0968	(0.1565)	–0.0341	(0.0795)
NOE	–0.0021	(0.0028)	0.007*	(0.0055)
OPM	–0.0183*	(0.0116)	0.0314***	(0.0151)
ST	0.0157***	(0.0026)	0.0068***	(0.0028)

*, **, and *** denote 10, 5, and 1% significance levels, respectively; for explanation of variables see Table 1

Source: authors' own calculations based on data provided by the Taiwan Economic Journal (TEJ) database (TEJ 2018)

nally, investors should target operating income in the biotech industry in order to reduce risk.

The stock prices of Taiwanese biotechnology companies have become increasingly inflated in recent years. We believe that many investors are too optimistic about share prices in the biotechnology industry and lack an understanding of the operations in the industry. Investors should observe the key indicators of a company's operating income rather than relying on preconceptions of its stock price. We also recommend that biotech firms strive for professional business performance and do not rely on stock price to support the value of their operations or deviate from core business development. By relying on stock price expansion, a firm will continue to attract investors in the short term but will be unable to attain its potential value in the industry.

Many biotech firms have non-operating earnings, but our findings are a strong proof that companies with outstanding earnings performance can maintain operating income, and that professional business performance is the most important core value. The biotech industry is a technology-intensive, high value-added, and high-risk sector requiring long product development periods and high levels of R&D investment. The industry, therefore, requires strong support from government policies, ample financing, and high-calibre R&D and management talents to ensure successful development, in addition to observation of stock returns.

There is heterogeneity in different biotech firms, such as the need for long-term recovery issues, a company's level of profitability and business operating income margin. However, it is worthwhile to question the industry's performance in the contemporary marketplace, which is characterised by technology uncertainty, reform-driven profit pressures, rising demand for innovation and value, increasing focus on stock engagement, and ever-changing earnings management. In particular, investors often overlook business value and quality when searching for high stock returns in biotech firms. However, empirical results have shown that the stock returns and the values of biotech firms have a significant positive relationship, and both in biotech industry have a high operating income (0.0157) or low operating income (0.0068) for biotech firms. Taiwan's biotech industry in recent years has had such a problem, as new drugs' unblind failure have not only caused a great challenge to companies' stocks but also greatly impacted stock price fluctuations in the overall biotechnology industry.

Biotechnology stocks overall generate abnormal returns with negative motility of the subjects' stock price after new drugs' unblind failure. For example, new drugs' unblind failure at Medigen Biotechnology Corp. on July 27, 2014, and new drugs' unblind failure at OBI Pharma on February 21, 2016, resulted in abnormal returns of Taiwan's overall biotechnology stocks. The two new drugs unblind failures caused different influences on the weighted index number and fluctuation of biotechnology indices.

The biotech industry exhibits different heterogeneity from other industries. For example, biotech firms make up a technology-intensive and high-risk sector requiring long product development periods and high levels of R&D investment. In addition to relying on the long-term financial support of major shareholders in the early stage of product development, the time required for the recovery period last a lot longer.

These diversities belonging to biotech firms also exist among individual companies. As a result, many biotech firms operate through regular operations of non-operating earnings and expenditure activities and try to increase biotech-related earnings. However, my empirical results show that low-operating income biotech firms have a significant negative relationship between their operating income margin and firm value (–0.083). This implies that the operating income margin of these biotech firms is not good, and that there is also a loss in biotech firms' value and a negative relationship between non-operating earnings and firm value (–0.0021). On the other hand, the empirical results herein show that high-operating income biotech firms have a significant positive relationship between their non-operating earnings and firm's value (0.007), implying that these biotech firms positively contribute to the firm's value and there is a

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significantly positive relationship between operating income margin and the firm's value (0.0314).

Finally, we recommend that Taiwan's biotech industry should focus on developing their own operating income, instead of focusing on stock remuneration. At the same time, biotech firms should clearly tell the investing public about the actual progress of their R&D and what could be achieved. This would provide investors with sufficient information to judge biotech firms' operating capabilities and their problems.

CONCLUSION

This paper examines earnings quality, stock returns, and firm value, employing a panel of 40 Taiwanese biotechnology firms during 2008–2015. The results of the panel regression model indicate that the non-operating earnings of the biotech industry are not uniformly positive. If a given biotech firm does not have the capacity for professional earnings management, then non-operating earnings are not helpful for increasing the firm's value. We observe a significant relationship between stock returns and firm value, but operating income has a limited impact on the latter.

According to the results of the PSTR models, the relationship between firm value and operating income in the biotech industry is non-linear. In particular, we find that operating income has a threshold effect on firm value. Our results, therefore, provide evidence that for firms with low operating income, regardless of non-operating earnings, operating income margin and firm value have a negative relationship. This implies that biotech firms with low operating income have insufficient professional management performance, including inadequate earnings management capacity. However, stock returns have a greater impact on firm value, meaning that companies with low operating income can have high stock price remuneration. By contrast, a significantly positive relationship is found between operating income and corporate value. These results indicate that investors must observe the indicators of firm value in detail and not solely focus on stock prices.

Regarding advice that can be given to investors, almost all of them believe biotech stock returns are attractive. However, there is heterogeneity among different biotech firms, such as the need for a long recovery period, and a biotech firm's levels of profitability and operating income margin are not generally understandable. The empirical results herein indeed show that stock returns have a significantly positive effect on a firm's value, including the low-operating income of biotech firms. While these biotech present poor operating income performance, their stock returns still perform well. Such biotech firms are ubiquitous. However, it seems that these biotech firms are already confronting a big business crisis. Investors should consider this issue more cautiously, especially when they may have high expectations for biotechnology results and stock returns. It is thus necessary to observe the actual performances of these biotech firms from the lenses of management expertise and capabilities, especially on the actual earnings performance of their own professional operating income, rather than just from the performance of non-operating earnings. Investors, therefore, should pay more attention to a company's constitutional quality. This phenomenon concerns not just stock returns. Because of the differences in the operating characteristics of biotech firms, it is more important to pay attention to the sound financial ability of biotech firms.

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