Debt financing, corporate investment and the productivity of capital invested: Evidence from biggest manufacturing countries

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Abstract: This study examines the impact of debt financing on the productivity of capital invested and the mediating role of corporate investment using data from manufacturing firms in China, Japan and the United States. We find that firms that use more debt capital are less likely to make overinvestment. It is found that overinvestment is more likely in firms that have high cash flow but low level of financial leverage. Our study also shows that companies with high debt and low cash flow have more probability of underinvestment. This is consistent with the view that financially constrained firms are more exposed to underinvestment problem. Furthermore, we documented that the use of debt financing has a positive impact on the productivity of the capital invested and that this effect is partly mediated by the investment of the manufacturing firms. This paper sheds light into the present understanding of how companies use debt financing decisions to boost their investment efficiencies. The study has important management implications for corporate financial decisions as it identifies the links among corporate debt financing, investment and capital productivity.

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PUBLIC INTEREST STATEMENT

The agency cost theory claims that more use of debt financing diminishes the possibility of unwarranted spending and over investment made by management. Thus, firms with high debt in their capital structure would be more likely to invest in better projects and, hence, achieve better performance than less leveraged ones. In this article, we examine the impact of debt financing on the productivity of capital invested and the mediating role of corporate investment using data from manufacturing firms in China, Japan and the United States. Our study indicates that overinvestment is more likely in firms that have high cash flow and low level of financial leverage. In contrary, it is found that that companies with high debt and low cash flow have more chance of underinvesting. Furthermore, we documented that the use of debt financing has a positive effect on the productivity of the capital invested and that this effect is partly mediated by corporate investment.
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Keywords: Corporate Financing; Corporate Investment; Capital Efficiency; Agency Cost Theory; Manufacturing Industry

1. Introduction

Agency conflict between shareholders and managers distorts a firm’s financial decisions (Lin, 2017) and causes inefficient investment. According to Koussis et al. (2017), managers may sub-optimally invest in growth options and lead their firms to high agency costs. Agency cost theory suggest that the use of debt capital is important to improve organizational efficiency since the restrictive covenants in debt contracts may monitor managers’ spending behaviors and forces companies to adopt more efficient managerial practices (Jensen, 1986). Constraining managers with high debt may reduce the inefficiency of marginal investments and wasteful spending managers made through asset diversion (Berger & Patti, 2006; Canarella et al., 2014; Kochhar, 2015). Mande et al. (2012) find that when corporate governance is strong, equity financing may become attractive for some firms but with decrease of corporate governance, debt financing is more desirable to mitigate agency problem. The threats caused by the managements’ failure to settle debt-financing requirements are also effective motivating forces to make organizations more efficient. Thus, we predict that the use of debt capital, which we consider as the main explanatory variable in our paper, enhances the productivity of capital invested. This is because the use of borrowed funds enables firms to effectively monitor the investment behaviors of managers and mitigates over-investment of capital.

On the other hand, debt overhanging may lead to under-investment problem and may result in another form of inefficiency (Stulz, 1990). When the interests of the debtholders and the shareholders are contradicting, managers sometimes act according to the interest of the creditors. In the circumstances of excessive indebtedness or debt overhanging, managers may be forced to reject profitable projects to follow the interest of the creditors. Hence, firms shall continue borrowing up to some optimum amount of debt, to the level of their debt capacity, in order to capitalize the benefits of financial leverage. Studies have reported that the use of financial leverage improves corporate performance due to the disciplinary role of debt (Jensen, 1986; Wruck, 2004) and that excess debt causes underinvestment that leads to inefficiency (Myers, 1977; Stulz, 1990). This leads to the prediction that although the application of debt capital is beneficial for mitigating overinvestment problem, it can also humper firm’s performance by inhibiting some good investments. Accordingly, this paper attempts to investigate (1) how the use of debt financing affects firm’s investment; (2) whether the level of debt financing relates to corporate over-investment and under-investment levels; and (3) whether corporate investment mediates the effect of financial leverage on the productivity of capital invested.

To this end, this paper examines how the use of debt financing affects the productivity of capital invested with the mediation role of corporate investment. Here, we apply the productivity of capital invested as a measure of (inverse) agency costs to empirically test the predictions of agency cost capital structure theory. We gauge the productivity of the capital invested following Stochastic Frontier Analysis (SFA), parametric model applied to measure efficiency. We find that firms that use more debt capital mitigate over-investment and are more exposed to under-investment problem. Our finding indicates that when manufacturing firms optimize the level of their investment, the efficiency of the capital improves. Putting differently, overinvestment and underinvestment decisions made by companies impair the efficiency of invested capital. In addition, we find that the increase in corporate borrowing has a positive impact on the efficiency of the capital invested and that the effect is partly mediated by the corporate investment. This applies mainly for subsample of Chinese firms. The mediation role does not apply for the firms in Japan and USA.

Our study contributes to the existing body of knowledge in different ways. First, it shades light to the existing literature through an empirical analysis of the nexus among debt financing, investment,
and capital productivity using data from firms in the biggest manufacturing countries. We focus on the companies in the three biggest manufacturing countries namely: China, Japan and the United States. We concentrate on the productivity of one major sector of the economy, manufacturing. Despite the decreased importance of manufacturing in advanced countries in shares of output and employment, its role in the economy remains important, because the sector generates most technological innovations with important spillover effects to the rest of the economy. Moreover, the countries considered in this paper continue to play a major role in world production and trade of manufactured products. They account for the lion's share of the trade in manufactured goods among market economies. Thus, the choice of the countries is motivated by their leading positions with regard to global industrial economy and their reputable manufacturing experiences with high concern for efficiency. Second, although there are well established theories explaining how the use of debt affects efficiency, the mediating effect of investment has not been appropriately tested with empirical data. We show the impacts of debt financing on investment and the mediating role of investment in the financial leverage-productivity nexus. Our study applies novel approach in testing the agency cost theory. We systematically measure productivity and over (under) investments, and examine how firms’ financing decisions affect their productivity with mediation effect of investment. 

2. Review of literature

Berle and Means (1932) first recognized the inefficient use of funds by management in excess of profitable investment opportunities. When there is abundant free cash flow, managers have the tendency to invest it in size-increasing but unprofitable projects (D’Mello & Miranda, 2010; Deangelo et al., 2006; Denis & Osobov, 2008; GY. Wang, 2010). Moreover, Koussis et al. (2017) proved that managers may choose cash-holding policies, sub-optimally investing in growth options and leading to high agency costs. The agency cost theory suggests that firms should use more debt financing and commit part of their operating cash flows for periodic debt service payments in order to prevent managers from building unnecessary empires in their own narrow interests (Harris & Raviv, 1991; Jensen, 1986; Myers & Majluf, 1984). Constraining managers with high debt may reduce the inefficiency of marginal investments as well as the wasteful spending managers made through asset diversion, even holding the investment policy constant. The threat caused by failure to make debt service payments serves as an effective motivating force to make organizations more efficient. An increase in financial leverage reduces the free cash flow available to the managers thereby mitigates the agency cost of the firm. The funds remaining after financing all positive net present value projects cause conflicts of interest between managers and shareholders. Dividend and debt interest payments decrease the free cash flow available at discretion of managers to invest in nonvalue adding projects and to spend for perquisite consumptions. 

However, with excessive level of debt, bankruptcy become chronic and financial distress costs exceeds the advantages of additional leverage (Brealey & Myers, 2011). Theories have both argued that high level of debt increases financial distress costs (Andrade & Kaplan, 1998; Warner, 1977) and that it can improve corporate performance due to the disciplinary role of debt (Jensen, 1986; Wruck, 2004). Furthermore, while debt may prevent firms from making bad investments, it may also prevent them from making good ones. Stulz (1990) predicts that firm efficiency initially increases as the level of debt increases and starts to decline after it reach the maximum point. Dube (2013) found that debt financing had a positive effect on SMEs’ efficiency, noting that businesses that obtained sufficient funding from banks increased their performance. Small and medium-sized companies (SMEs) are considered to have more trouble accessing external funding than large corporations. Dube (2013) had several limitations, including mechanical correlations in its baseline model due to measurement issues, a limited scope, and weak regression analysis. Prior studies that examined the relationship between debt financing and corporate efficiency found both positive (Berger & Patti, 2006; Cai & Zhang, 2011; Margaritis & Psillaki, 2010) and negative (González, 2013; Le & Phan et al., 2017; Xu, 2012) associations between the two variables. These contrasting outcomes may be because the use of debt can have both positive and negative effects on firm performance. In our study, we focus on the link between debt financing decisions and capital efficiency with mediating role of corporate investment using data from biggest economies.
3. Hypothesis development
The agency cost theory argues that increasing the level of financial leverage reduces the possibility of unwarranted spending and mitigates overinvestment made by management. More use of debt finance may also mean more reliance on external capital that involves more scrutiny by fund providers, with less tolerance for unproductive investment activity and excess perquisite consumption. Thus, firms that have high debt in their capital structure would be more likely to invest in better projects and, hence, perform better than less leveraged ones. However, agency costs can also emanate from conflicts of interest between creditors and owners. According to Myers (1977), these conflicts usually occur when there is a risk of default and such conflicts create “under-investment” or “debt overhang” problems. Under debt overhanging situation, additional use of debt capital will have a negative effect on firm performance. Stulz (1990) also states that debt financing mitigates overinvestment problems but can aggravate the underinvestment problem. Thus, in light of the above points, we predict that the level of debt financing determines the amount of investment that firms make; it normally reduces overinvestment but can also cause underinvestment when it is too much.

**Hypothesis 1**: Citrus paribus, the amount of investment that firms undertake depends on their level of debt financing

**Hypothesis 2a**: Firms that use more debt financing are less likely to make over-investment

**Hypothesis 2b**: Firms that use more debt financing are more likely to make under-investment

Agency conflicts are likely in cases where managers have the opportunities to take advantage of maximizing their private interests. According to the free cash flow theory, agency conflicts are more probable in situations where free cash flows are high. Managers tend to overinvest when firm holds high liquid assets readily available at the managers’ discretion. Cash holdings offer an interesting context to study the implication of agency problems (Xuan Vinh, 2015). Generally, it is probable that firms with high cash flow make overinvestment and exhibit inefficiency in their investment performance. Constraining managers with high debt may reduce the inefficiency of marginal investments and wasteful spending managers made through asset diversion (Berger & Patti, 2006; Canarella et al., 2014; Kochhar, 2015). Thus, use of debt financing monitors managers spending behaviors and can play an important role for mitigating excess investments.

There is evidence that long-term investments made by cash rich firms suffer from abnormal declines in operating performance attributable to overinvestment (Lamont, 1997). Some studies (Opler & Titman, 1994) also proved that companies with excess financial resources involve in more capital investments, and spend more on acquisitions, although their investment opportunities appear to be poor. Agency problems lead to investing cash flows on unprofitable projects or consuming it on organizational inefficiencies. One of the remedies, suggested by agency cost theory, is systematically increasing the level of debt capital used by the firm to constrain the manager’s investment behaviors. The use of debt financing entails reinforcing that discourage managerial financial resources wastages and it avoids over-investment (Jensen, 1986). Moreover, the use of debt capital allows the firm’s creditors to monitor firm’s investment activities more closely and systematically.

Generally, the tendency of management to carry out over-investment can be constrained by the availability of free cash flow, and debt financing can further tighten this constraint. The application of debt capital pre-commits the corporation to pay cash as interest and principal, requiring managers to meet those obligations with funds that would otherwise have been allocated to poor projects or negative NPV projects. Thus, the use of financial leverage is one of the strategies for addressing the issue of overinvestment. Companies with poor growth opportunities are expected to show a negative association between the level of debt and over-investment. On the other hand, when managers fear that investments may not produce enough cash to pay the interest and debt principle needed to
financ e investment, they may underinvest. In similar view, we predict the following relationship among financial leverage, cash flows, investment, and the efficiency of capital invested.

Hypothesis 2a: Citrus paribus, the efficiency of capital invested is determined by the investment decisions of the firm. Both over-investment and under-investment decisions negatively relates to the productivity of capital invested.

Hypothesis 2b: Corporate investment mediate the effects of debt financing on the productivity of capital invested.

4. Data & methods

4.1. Data
The study uses data of manufacturing companies of China, Japan and USA for the years 2007–2017. The study attempts to covers year 2007–2017 to incorporate most recent data in the analysis. The focus on the recent phenomena in the area of study makes the paper up to date and more relevant. We extracted the data from WRDS (Wharton Research Data Service), COMPUSTAT Capital IQ Global database. The firms included in the study are those with global manufacturing operations. To filter the manufacturing firms from the rest of other companies in the database, we referred their global industry code (GIC). The firms under our study are categorized in to ten subindustry sectors based on their global industrial classification. We winorized the variables, at top 99% and bottom 1%, to avoid the effects of extreme values. Finally, our sample data contains 56,842 firm-year observations that we included in our empirical analysis. Table 1 summarizes the sample data that we applied for the analysis in the current study.

4.2. Estimating the productivity of capital
To estimate capital productivity, our study applies stochastic frontier true random effect (SF TRE) model of (Greene, 2005). We represent the inputs variable by the natural logarithm of the total capital invested as reported in the balance sheet of the respective firms. The outputs variable is the natural logarithm value of gross profit generated plus the depreciation and amortization. We added back depreciation and amortization to above double counting of the input side because these items relates to capital investment. To check whether the data is normally distributed, we employee skewness/kurtosis tests for normality of both input and output factors. The result shows that there is normal distribution in the data applied for the analysis, with significant p-value for both skewness and kurtosis test. Our specification follows trans-log frontier function. We also made inflation adjustment on the value of input and output by taking year 2007 as base year and converted the values of variables to a common currency of denomination, USD. We estimated the productivity of capital invested with the equation below:

\[
\ln Y_{it} = \alpha_i + \beta_1 K_{it} + \beta_2 K_{it}^2 + U_{it} + V_{it}
\]

(1)

\[V_{it} \sim \mathcal{N}(0, \sigma^2_i), U_{it} \sim \mathcal{N}^+(0, \sigma^2_u)\]

Where, \(Y_{it}\) is gross profit plus depreciation and amortization of firm \(i\) at time \(t\). \(K_{it}\) is the capital invested in firm \(i\) at time \(t\). \(\beta\) is unknown parameters to be estimated, \(\alpha_i\) is firm-specific time-invariant heterogeneity, \(\nu_{it}\) = two-sided normal error, and \(U_{it}\) is one-sided non-negative inefficiency.

Greene’s model assumes a two-sided normal error \(V_{it}\) and a half-normal random term \(U_{it}\) that represents a one-sided non-negative inefficiency term \((U_{it} \geq 0)\). We estimate the model by the maximum likelihood method. Within the stochastic frontier framework and the above function, we define efficiency as follows.
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Table 1. Summary of sample data

|                          | Observation |
|--------------------------|-------------|
|                          | No. of Firms | China  | Japan  | USA    | Total  |
| Material                 | 1,273       | 5,625  | 2,859  | 2,956  | 11,440 |
| Capital Goods            | 1,693       | 6,075  | 4,918  | 4,292  | 15,285 |
| Auto Industry            | 341         | 1,287  | 1,291  | 569    | 3,147  |
| Household Durable        | 587         | 1,870  | 1,508  | 1,642  | 5,020  |
| Food & Bev.              | 463         | 1,585  | 1,249  | 1,285  | 4,119  |
| Household Personal       | 136         | 155    | 306    | 600    | 1,061  |
| Health Equip.            | 482         | 284    | 283    | 2,849  | 3,416  |
| Pharmaceutical           | 205         | 1,960  | 0      | 0      | 1,960  |
| Techno Hardware          | 1009        | 3,002  | 2,451  | 3,281  | 8,734  |
| Semi-Conductor           | 326         | 564    | 501    | 1,595  | 2,660  |
| Total                    | 6,515       | 22,407 | 15,366 | 19,069 | 56,842 |

\[ Y_k = \text{Exp}(f(K, it)) = \text{Exp}(V_k) \]  \tag{2}

Theoretically,

\[ \text{Eff} = \frac{\text{Observed Output}/\text{Potential Output}}{\text{Eff}} = \frac{\text{Exp}(f(K, it)) \times \text{Exp}(V_k) \times \text{Exp}(-U_k)}{\text{Exp}(f(K, it)) \times \text{Exp}(V_k)} \]  \tag{4}

\[ \text{Eff} = \text{Exp}(-U_k) \]  \tag{5}

Table 2 presents the parameter estimates obtained from SF TRE model regression conducted for gauging the efficiency of capital. In panel B, the table also reports the average productivity of capital in the three countries for each industrial subsector. The values of input and output variables are transformed into their natural logarithm value. Hence, it is possible to interpret the first-order coefficients in the model as elasticity of the output for changes occurred in the capital invested. The estimated second-order coefficients of the input, capital invested, is positive and significant at the 1% significance level in all industries except household and personal products industries. This indicates the sensitivity of profit generated for the change of capital invested. Output elasticity of a given input is computed from the partial derivative of the logged value of output with respect to the logged value of the input. Thus, the partial derivative of the output function in our model with respect to capital, \( K \), gives the elasticity of the gross profit generated for change in capital invested. To check for normality of the variables included in the efficiency model, we apply skewness and kurtosis tests. Such tests can be used as an alternative to the Jarque–Bera test in panel-data models. The result, as shown in annex B, indicates that there is normality within the data. In additional to capital productivity, there are different explanatory variable included in our study. Annex A describes measurements applied for the other variables used in the current study.
### Table 2. Estimated parameters from true random-effects model

#### Panel A: Parameter estimates

| Frontier | Material | Capital Goods | Auto Industry | Household Durable | Food & Bev. | Household Personal | Health Equip. | Pharmaceutical | Techno Hardware | Semi-Conductor |
|----------|----------|---------------|---------------|-------------------|-------------|-------------------|---------------|----------------|----------------|----------------|
| ln(K)    | -0.574***| -0.350***     | -0.359***     | -0.737***         | -0.540***   | -0.544***         | -0.685***     | -0.880***      | -0.371***      | -0.887***      |
|          | (0.067)  | (0.036)       | (0.062)       | (0.070)           | (0.051)     | (0.041)           | (0.034)       | (0.191)        | (0.149)        | (0.054)        |
| ln^2 (K) | 0.061*** | 0.050***      | 0.049***      | 0.069***          | 0.061***    | 0.059***          | 0.071***      | 0.082***       | 0.057***       | 0.081***       |
|          | (0.004)  | (0.002)       | (0.003)       | (0.006)           | (0.003)     | (0.002)           | (0.002)       | (0.010)        | (0.008)        | (0.003)        |
| Intercept| 17.819***| 15.916***     | 16.652***     | 20.158***         | 17.658***   | 17.709***         | 18.241***     | 20.221***      | 15.213***      | 20.472***      |
|          | (0.587)  | (0.332)       | (0.580)       | (0.655)           | (0.481)     | (0.378)           | (0.296)       | (1.770)        | (1.373)        | (0.491)        |
| σ_u      | 0.417*** | 0.315***      | 0.275***      | 0.316***          | 0.330***    | 0.298***          | 0.400***      | 0.311***       | 0.424***       | 0.305***       |
|          | (0.006)  | (0.004)       | (0.008)       | (0.007)           | (0.008)     | (0.013)           | (0.008)       | (0.014)        | (0.012)        | (0.006)        |
| σ_v      | 0.121*** | 0.124***      | 0.108***      | 0.095***          | 0.090***    | 0.100***          | 0.057***      | 0.200***       | 0.128***       | 0.151***       |
|          | (0.004)  | (0.003)       | (0.005)       | (0.005)           | (0.006)     | (0.008)           | (0.006)       | (0.010)        | (0.008)        | (0.004)        |
| λ        | 3.445*** | 2.539***      | 2.548***      | 3.331***          | 3.672***    | 2.980***          | 6.994***      | 1.556***       | 3.311***       | 2.015***       |
|          | (0.009)  | (0.006)       | (0.011)       | (0.011)           | (0.013)     | (0.018)           | (0.012)       | (0.022)        | (0.017)        | (0.009)        |
| Wald χ^2 | 11.382.840 | 27.069.110  | 52.883.77    | 6576.31           | 5670.20     | 19.348.77         | 4042.81       | 3204.18        | 12.344.28      |

#### Panel B: Mean Eff

|          | China     | Japan      | USA        | Obs.      | Firm      |
|----------|-----------|------------|------------|-----------|-----------|
| Mean Eff | 0.583     | 0.667      | 0.506      | 11.440    | 1.273     |
|          | 0.677     | 0.735      | 0.650      | 15.285    | 1.693     |
|          | 0.712     | 0.741      | 0.640      | 3.147     | 341       |
|          | 0.674     | 0.658      | 0.620      | 5.020     | 587       |
|          | 0.627     | 0.698      | 0.605      | 4.119     | 463       |
|          | 0.656     | 0.603      | 0.536      | 1.061     | 136       |
|          | 0.613     | 0.610      | 0.521      | 3.416     | 482       |
|          | 0.751     | 0.763      | 0.700      | 1.960     | 205       |
|          | 0.719     | 0.763      | 0.700      | 8.734     | 1009      |
|          | 0.664     | 0.685      | 0.651      | 2.660     | 326       |
The average estimated capital efficiency in the entire sample is about 0.6598 (65.98%). TRE usually provides low inefficiency estimate since it does not confound heterogeneity with inefficiency (Hailu & Tanaka, 2015) and our finding suggests the same. The result also indicates that among the companies covered by our analysis, there is more variability (standard deviation of about 0.2292) in capital efficiency levels. The potential for performance enhancement is very strong in some businesses and the management should optimize the amount of capital invested in such companies. The result shows that, relative to the best practice frontier, a company that reached the average productivity level has made over (under) investment by around 34.02%. This means that the sample’s average degree of inefficiency is around 34.02%. In each of the countries in the current analysis, manufacturers of technical hardware generally look relatively successful.

5. Results
In this study, we are particularly interested in analyzing the effects of debt financing on the efficiency of capital with mediating role of investment. First, we embark on examining the determinants of firm’s investment amount. Then, we investigate how increase of debt capital affects overinvestment and underinvestment. Last, our study tests the mediating effects of the investment decisions for the debt-efficiency nexus.

5.1. Determinants of firm investment
The current study follows the framework of Richardson (2006) to determine the expected level of investment. According to his model, the amount of firm’s investment depends on investment in the prior period (Invt-1), firm size (Sizet-1), the level of cash holding (Casht-1), investment opportunity or revenue growth (Growth), market return (ROAt-1), and firm age. We also consider these variables in the baseline model that we applied to predict the normal level of investment. However, an attempt to include firm age variable can result in loss of large data that we use for the analysis. Thus, we excluded it from the model. In addition, because firms’ investments in projects are often assigned to more than one accounting period, we include the lag of investments. Accordingly, we estimated the model below to identify the determinants of investment and the nature of their effect.

\[
\text{Inv}_{it} = \beta_0 + \beta_1 \text{Inv}_{i,t-1} + \beta_2 \text{Debt}_{i,t-1} + \beta_3 \text{ROA}_{i,t-1} + \beta_4 \text{Cash}_{i,t-1} + \beta_5 \text{Size}_{i,t-1} + \beta_6 \text{Growth}_i + \epsilon_{it}
\]

In the current study, we define the normal investment level as investment level predicted by the above baseline model. Researchers commonly apply Tobin’s Q value (Zhong et al., 2010) and sales growth (Y. Wang, 2009; Yang & Hu, 2007) as a proxy for corporate investment opportunities. We applied the sales growth in our study. The definitions and measurements of the other variables are shown in appendix A. The results in Table 3 show a significant positive relation between new investment expenditures and prior new investments, which could be understood in the light of continued firm investment behavior and the adjustment costs of new investments (Liu & Bredin, 2010; López-de-foronda et al., 2019). The coefficients of the prior investment, growth opportunities (measured with sales growth), corporate cash holding (CF), and investment return (ROA) are positive and significant consistent with Richardson (2006). The coefficient of Size is negative and significant suggesting that the highest investments are made by firms in the fastest growing sectors that are not so intensive in fixed assets. Results under all columns of Table 3 report a negative and significant coefficient of the debt financing. This is consistent to the paper by Richardson (2006) and in line with the expectations under the current study. Increase of debt financing should lead to reduction of overinvestment according to the prediction of agency cost theory. We also performed additional estimation with GMM regression and checked that there is no problem of second order autocorrelating. To this end, the result shows that the effect of debt financing on the investment is negative under different estimations and with robustness tests.

5.2. Debt financing and over (under) investment
Overinvestment represents the extent that corporate investments are beyond a reasonable level and can be measured as the amount by which the actual corporate investment level deviates from
a normal level. Likewise, the portion that is greater than the normal level is considered as underinvestment. We follow Richardson’s model to measure the over (under) investment. Based on economic determinants, we compute an expected (new) investment level or capital expenditures for each firm year. Specifically, we adopt the regression shown in column (4) of Table 3 to estimate the over (under) investment level for the empirical analysis. The residual of regressing a firm’s actual investment level, capital expenditures deflated by lag of total assets, on these economic determinants is the measure for over (under) investment. A positive residual implies that the firm invested more than expected in that year, whereas a negative residual implies that the firm invested less than expected. The model determines the optimum investment needed by assuming that the investment amount is a function of these explanatory variables. Once we determined over (under) investment level by the value of the residual, we examined whether financial leverage explains the variation in these residuals. First, we arranged the residual into three quartiles based on their values where residuals with the extreme negative values are underinvestment and those with the extreme positive value are overinvestment. We considered residuals that are not that far from zero in both sides as normal. After grouping the residual based on the above procedures, we estimate the model represented by Equation (7) using panel Tobit regression. This model is used to analyze the effects of debt financing on over (under) investment levels in the firms.

\[
\text{Investment}_{i,t} = \beta_0 + \gamma \text{Investment}_{i,t-1} + \beta_1 \text{Debt}_{i,t-1} + \beta_2 \text{CF}_{i,t-1} + \beta_k \sum \text{Country} + \beta_m \sum \text{Industry} + \beta_n \sum \text{Year} + \epsilon_{it} \tag{7}
\]

Where Investment_{it} refers to the level of overinvestment or underinvestment in firm “i” in the period “t”.

In the model indicated by the Equation (7), Lag of debt level (Debt_{it-1}) and Cash flow (CF_{it-1}) are used as regressors. The results in Table 4 provide interesting insights into the dual role of leverage. For firms that have underinvested, there is a positive relationship between the level of underinvestment and the level of debt although it is not statistically significant. This implies that the higher the use of debt capital the higher is the likelihood of underinvestment. The effect of excess debt on underinvestment is more pronounced in firms with low cash flow. Firms with high debt and low cash flow are more likely to make underinvestment. This is logical because such firms are expected to be financially constrained and may not have enough cash for investment. Thus, support the argument that excess use of debt capital curtails investment even under circumstances that firms have good investment opportunities (Stulz, 1990). Conversely, we document that high debt is negatively relates to the overinvestment variable suggesting that debt financing can play meaningful role in mitigating managers’ overinvestment behavior. The result also shows that firms are more likely to overinvest when they have higher cash flows and low level of debt. In general, firms with high levels of free cash flow tend to overinvest when they apply less debt than otherwise. This complies with the Jensen’s free cash flow hypothesis.

The dependent variable is represented by the regression residuals obtained from investment model shown in Table 3. Accordingly, the residuals in FE regression, Column 4 of Table 3, are applied to identify overinvestment and underinvestment conditions in the firms. We arranged the residual into three quartiles based on their values where residuals with the extreme negative values are underinvestment and those with the extreme positive value are overinvestment. We considered residuals that are not that far from zero in both sides as normal. After grouping the residuals into three quartiles, we created three dummy variables namely: Underinvestment _ dummy, Normal investment dummy and Overinvestment _ Dummy. Then, the absolute value of the residual is multiplied by the respective dummy variable values to determine the level of underinvestment and overinvestment.

5.3. Debt financing, corporate investment and productivity of capital

Finally, we investigate how debt financing affects the efficiency of capital and whether investment decisions plays the mediation role. We apply three steps to test the mediation effect following the
### Table 3. Determinants of investment

|                  | Expected sign of Coefficient | China (1) | Japan (2) | USA (3) | Full Data (4) | Full Data (5) | Full Data (6) |
|------------------|------------------------------|-----------|-----------|---------|---------------|---------------|---------------|
| Dependent Var.   | Investment                   |           |           |         |               |               |               |
| **Investment t-1** | (+)                          | 0.234***  | 0.173***  | 0.176***| 0.233***      | 0.523***      | 0.278***      |
|                  |                              | (0.010)   | (0.022)   | (0.024) | (0.009)       | (0.007)       | (0.013)       |
| Debt t-1         | (-)                          | -0.029*** | -0.019*   | -0.009**| -0.014***     | -0.004***     | -0.023***     |
|                  |                              | (0.007)   | (0.011)   | (0.005) | (0.004)       | (0.001)       | (0.007)       |
| Cash t-1         | (+)                          | 0.078***  | 0.035***  | 0.033***| 0.061***      | 0.001         | 0.088***      |
|                  |                              | (0.008)   | (0.008)   | (0.007) | (0.005)       | (0.002)       | (0.007)       |
| ROA t-1          | (+)                          | 0.121***  | 0.047***  | 0.054***| 0.084***      | 0.060***      | 0.067***      |
|                  |                              | (0.008)   | (0.005)   | (0.006) | (0.004)       | (0.003)       | (0.005)       |
| Firm Size t-1    | (-)                          | -0.031*** | -0.006**  | -0.013***| -0.027***     | -0.002***     | -0.062***     |
|                  |                              | (0.002)   | (0.002)   | (0.001) | (0.001)       | (0.001)       | (0.002)       |
| Growth Opp. t-1  | (+)                          | 0.032***  | 0.010***  | 0.016***| 0.024***      | 0.029***      | 0.019***      |
|                  |                              | (0.002)   | (0.002)   | (0.002) | (0.002)       | (0.002)       | (0.002)       |
| \( \beta_0 \)    |                              | 0.668     | 0.139***  | 0.296***| 0.564***      | 0.070***      | 1.263***      |
|                  |                              | (0.035)   | (0.047)   | (0.029) | (0.021)       | (0.004)       | (0.043)       |
| **Firm effect**  | Yes                          | Yes       | Yes       | Yes     | Yes           | No            | No            |
| **Year effect**  | Yes                          | Yes       | Yes       | Yes     | Yes           | Yes           | Yes           |
| **Country effect** | Yes                          | Yes       | Yes       | Yes     | No            | Yes           | Yes           |
| **Industry effect** | No                           | No        | No        | No      | Yes           | No            | Yes           |
| \( R^2 \)        |                              | 0.226     | 0.077     | 0.109   | 0.184         | 0.471         |               |
| **F-test (\( \chi^2 \))** | 148.999     | 25.647   | 35.720   | 169.665 | 616.048       | 2687.752      | (Continued)    |
| **AR test1**     |                              | 0.000     |           |         |               |               |               |
| Expected sign of Coefficient | Fixed Effect Model | OLS | System GMM |
|------------------------------|--------------------|-----|------------|
|                              | China (1)          | (2) | (3)        | (4)        | (5) | (6) |
| AR test2                     |                    | 0.182 |            |            |     |     |
| Sargan test                  |                    | 0.267 |            |            |     |     |
| Firm                         | 2,353              | 1,609 | 2,298      | 6,258      | 6,258 | 6,258 |
| Obs.                         | 17,576             | 12,127 | 13,610     | 43,313     | 43,313 | 43,313 |

*** p < 0.01, ** p < 0.05, * p < 0.1
procedure suggested by (Baron and Kenny, 1986). First, we test whether and how corporate investment is affected by the firms' level of debt financing. We have already shown the analysis concerning this in the previous discussions with results obtained in Tables 3 and 4. Next, we conduct analysis concerning the direct effect of financial leverage on the productivity of capital invested. A regression on Equation (8) is performed to examine how the level of debt financing affects and the capital efficiency. This model does not include the mediator variable.

\[
\text{EFF}_t = \alpha_0 + \gamma \text{EFF}_{t-1} + \beta_1 \text{Debt}_t + \beta_2 \text{Cash}_t + \beta_3 \text{Size}_t + \beta_4 \text{CapInt}_{t-1} + \beta_5 \sum^\text{Year} + \epsilon_t
\]  

(8)

Table 5 illustrates how the amount of corporate debt affects capital efficiency and shows that there is a positive relationship between the two. The coefficients are positive and significant for countries' sub-samples and for the entire sample. In short, the use of debt funding has been positively linked to the efficiency of capital invested in all countries. According to agency cost theory, employing debt financing decreases the likelihood of unjustified expenditures and over-investment by management. More use of debt capital also requires more reliance on external capital, which involves greater scrutiny by fund providers, less tolerance for unproductive investment operations and excessive spending of resources. Companies that use more borrowed capital in their capital structure are more likely to use funds for better investments and hence achieve higher productivity than companies that use less borrowed capital. This is because debt contracts may require more rigorous investment screening processes and decisions.

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Last, we perform regression analysis of investment and corporate debt financing on capital efficiency to study whether the investment activities plays a mediation role in the agency cost theory of capital structure. The regression model for identifying the mediating effect is shown in Equation (9). If the coefficient of debt is not significant when estimating the last Equation (9), it implies that there is a complete mediation effect. If the coefficient is significant, it is necessary to judge whether there is partial mediation effect according to the coefficient values of the debt financing variable.

\[
\text{EFF}_t = \alpha_0 + \gamma \text{EFF}_{t-1} + \beta_1 \text{Investment}_t + \beta_2 \text{Investment}^2_t + \beta_3 \text{Debt}_t + \beta_4 \text{Cash}_t + \beta_5 \text{Size}_t + \beta_6 \text{CapInt}_{t-1} + \beta_7 \sum^\text{Year} + \epsilon_t
\]  

(9)

Both Table 5 and 6 present the regression results regarding the mediation effects of investment for the link between debt financing and capital productivity. We mainly estimate the baseline models represented by Equation (9) and Equation (8) using dynamic panel data regression, system GMM estimator. Our models use efficiency scores, calculated by the SF TRE model, as a dependent variable. The set of control variables includes cash holding (Cash.), firm size (size), and capital intensity (CapInt.). We also attempt to control the year effects and firm's heterogeneity using the fixed effect regression in some of the models.

Using system GMM estimator, first, we estimate the baseline models on subsample data of each country and the results have been reported in Table 5. Our findings indicate that the investment level partially mediates the effects of corporate debt on the productivity of capital for firms in China. There is no observed mediation effect and corporate investment has no significant relationship with capital efficiency in the subsample of Japanese firms. The mediating effect of corporate investment is no valid for the subsample of companies in USA. It appears that corporate investment is related to capital productivity in non-linear manner and this is more pronounced for companies in USA. The result suggests that, initially, capital efficiency increases with increase of corporate investment; but above a certain investment level, the efficiency starts to decrease with additional investment. Thus, firms should conduct optimal level of investment to achieve efficient use of capital. Figure 1 depicts firm capital efficiency as curvilinear function of the level of corporate investment. More specifically, the figure explain the quadratic fitted value of capital efficiency as function of the level of investment. It appears that the firms' capital productivity level
increases with increase of investment until the investment reaches an optimum level. This, implies that both underinvestment and overinvestment impair efficiency.

The results in Table 6 indicate that corporate investment has a partial mediation effect for the link between debt financing and capital efficiency in the aggregate data. However, the mediation role lacks consistency under different estimations, specifically fixed effect model and system GMM. With the system GMM estimation on the full data (in Table 6 column 6–10) the coefficients of debt capital are lower in the models where investment variables are inserted indicating that there is a partial mediation effect for the link between the debt level and capital efficiency of the manufacturing firms. This explains how debt financing minimizes the excess investment that would have adverse

| Dependent Variable = | Underinvestment | Overinvestment |
|----------------------|-----------------|---------------|
|                      | (1)             | (2)           | (3)           | (4)           |
| Underinvestment $i_{t-1}$ | $-0.196^{***}$  | $-0.198^{***}$ |                |               |
|                        | (0.015)         | (0.015)       |               |               |
| Overinvestment $i_{t-1}$ |                | $-0.109^{***}$ | $-0.106^{***}$ |               |
|                        | (0.015)         | (0.015)       |               |               |
| Dummy_ High Debt $i_{t-1}$ | 0.009           |               | $-0.138^{***}$ |               |
|                        | (0.017)         |               | (0.015)       |               |
| Dummy_ High CF $i_{t-1}$ | $-0.198^{***}$  | $-0.008$      |               |               |
|                        | (0.015)         |               | (0.013)       |               |
| Dummy_ High Debt $i_{t-1}$ X Low CF $i_{t-1}$ | 0.211^{***} |               | $-0.001$      |               |
|                        | (0.023)         |               | (0.023)       |               |
| Dummy_ Low Debt $i_{t-1}$ X High CF $i_{t-1}$ | $-0.064^{***}$  |               | 0.067^{***}   |               |
|                        | (0.020)         |               | (0.018)       |               |
| $\beta_0$             | $-0.233^{***}$  | $-0.321^{***}$ | $-0.217^{***}$ | $-0.282^{***}$ |
|                        | (0.030)         | (0.029)       | (0.028)       | (0.027)       |
| Sigma—u               | 0.464^{***}     | 0.469^{***}   | 0.258^{***}   | 0.260^{***}   |
|                        | (0.011)         | (0.011)       | (0.012)       | (0.012)       |
| Sigma—e               | 1.023^{***}     | 1.023^{***}   | 1.023^{***}   | 1.024^{***}   |
|                        | (0.007)         | (0.007)       | (0.007)       | (0.007)       |
| **Controls:**         |                 |               |               |               |
| **Year effect**       | Yes             | Yes           | Yes           | Yes           |
| **Industry effect**   | Yes             | Yes           | Yes           | Yes           |
| **Country effect**    | Yes             | Yes           | Yes           | Yes           |
| Wald $\chi^2$         | 1,325.715       | 1240.501      | 1,329.042     | 1263.685      |
| Right censored obs.   | 0               | 0             | 0             | 0             |
| Left censored obs.    | 28,184          | 28,184        | 28,676        | 28,676        |
| Uncensored obs.       | 14,371          | 14,371        | 13,879        | 13,879        |
| Firms                 | 6,213           | 6,213         | 6,213         | 6,213         |
| Obs.                  | 42,555          | 42,555        | 42,555        | 42,555        |
Table 5. Corporate debt financing and the productivity of capital invested: mediated by corporate investment

|                | China | Japan | USA  |
|----------------|-------|-------|------|
| Dependent Var. | Efficiency of Capital Invested (Eff) |       |      |
| Eff\(_{i,t-1}\) | 0.547*** | 0.565*** | 0.411*** |
|                | (0.015) | (0.014) | (0.021) |
| Eff\(_{i,t-2}\) | -0.045*** | -0.044*** | -0.173*** |
|                | (0.011) | (0.011) | (0.009) |
| Investment     | -0.251*** | 0.106 | 0.011 |
|                | (0.057) | (0.181) | (0.010) |
| Investment\(^2\) | -0.871* | -0.566 | -0.310 |
|                | (0.511) | (2.730) | (0.076) |
| Debt           | 0.241*** | 0.212*** | 0.397*** |
|                | (0.037) | (0.035) | (0.056) |
| Cash           | -0.310*** | -0.302*** | -0.480*** |
|                | (0.040) | (0.039) | (0.081) |
| Firm Size      | 0.011 | 0.017** | -0.002 |
|                | (0.009) | (0.008) | (0.010) |
| Capital Intensity | -0.173*** | -0.157*** | -0.480*** |
|                | (0.011) | (0.010) | (0.0048) |
| Constant       | 0.183 | 0.507** | 0.638*** |
|                | (0.176) | (0.164) | (0.200) |
| Wald\(\chi^2\) | 4470.682 | 4837.526 | 1362.449 |
| AR test 1      | 0.000 | 0.000 | 0.000 |
| AR test 2      | 0.636 | 0.563 | 0.609 |
| Firm           | 2.353 | 2.353 | 2.555 |
| Obs.           | 17,591 | 17,591 | 16,245 |

*** p < 0.01, ** p < 0.05, * p < 0.1

Legesse et al., Cogent Economics & Finance (2021), 9: 1936369
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Table 6. Corporate debt financing, investment and the productivity of capital invested: mediated—moderated model

|                | Fixed Effect Model | System GMM |
|----------------|--------------------|------------|
|                | (1)                | (2)        | (3)    | (4) | (5) | (6)    | (7)   | (8) | (9) | (10) |
| Eff_{t-1}      | 0.407***           | 0.406***   | 0.404*** | 0.407*** | 0.405*** | 0.506*** | 0.513*** | 0.508*** | 0.512*** | 0.506*** |
|                | 0.008              | 0.008      | 0.008   | 0.008 | 0.008 | 0.011   | 0.011   | 0.011 | 0.011 | 0.011 |
| Eff_{t-2}      | -0.052***          | -0.052***  | -0.053*** | -0.052*** | -0.052*** | -0.025*** | -0.033*** | -0.033*** | -0.034*** | -0.034*** |
|                | 0.007              | 0.007      | 0.007   | 0.007 | 0.007 | 0.008   | 0.008   | 0.008 | 0.008 | 0.008 |
| Investment     | 0.022              | 0.335***   | -0.097** | 0.333*** | -0.227*** | 0.468*** | 0.234***  | 0.497***  |
|                | (0.020)            | (0.044)    | (0.040) | (0.044) | (0.053) | (0.158) | (0.100)  | (0.156)  |
| Investment^2   | -0.888***          | -1.281***  | -1.956*** | -2.115*** |
|                | (0.113)            | (0.144)    | (0.466) | (0.554) |
| Debt X Investment | 0.291***  |                       | 0.070 |
|                | (0.089)            |                       | (0.225) |
| Debt X Investment^2 | 0.972*** |                        | 0.314 |
| Debt           | 0.285***           | 0.285***   | 0.287*** | 0.284*** | 0.276*** | 0.225*** | 0.190*** | 0.202*** | 0.165*** | 0.189*** |
|                | 0.015              | 0.015      | 0.015   | 0.015 | 0.015 | 0.027   | 0.026   | 0.026 | 0.025 | 0.027 |
| Cash           | -0.346***          | -0.346***  | -0.344*** | -0.343*** | -0.341*** | -0.352*** | -0.325*** | -0.338*** | -0.341*** | -0.346*** |
|                | 0.014              | 0.014      | 0.014   | 0.014 | 0.014 | 0.034   | 0.033   | 0.033 | 0.033 | 0.033 |
| Firm Size      | 0.036***           | 0.036***   | 0.036*** | 0.036*** | 0.036*** | 0.003   | 0.001   | 0.003 | 0.001 | 0.003 |
|                | 0.004              | 0.004      | 0.004   | 0.004 | 0.004 | 0.007   | 0.007   | 0.007 | 0.007 | 0.006 |
| Capital Intensity | -0.162***      | -0.162***  | -0.163*** | -0.162*** | -0.163*** | -0.183*** | -0.167*** | -0.164*** | -0.165*** | -0.162*** |
|                | 0.007              | 0.007      | 0.007   | 0.007 | 0.007 | 0.009   | 0.008   | 0.008 | 0.008 | 0.008 |
| Constant       | -0.287***          | -0.288***  | -0.290*** | -0.273*** | -0.278*** | 0.462*** | 0.425*** | 0.347*** | 0.451*** | 0.351*** |

(Continued)
### Table 6. (Continued)

|                      | Dependent Var. = Efficiency of Capital Invested |                      |
|----------------------|-------------------------------------------------|----------------------|
|                      | Fixed Effect Model                               | System GMM           |
|                      | (1)     | (2)     | (3)     | (4)     | (5)     | (6)     | (7)     | (8)     | (9)     | (10)    |
|                      | (0.073) | (0.073) | (0.073) | (0.073) | (0.073) | (0.134) | (0.133) | (0.131) | (0.131) | (0.129) |
| $R^2$                | 0.341   | 0.341   | 0.343   | 0.341   | 0.343   |          |          |          |          |          |
| F-test/Wald $\chi^2$ | 585.861 | 546.928 | 515.677 | 513.551 | 484.629 | 5597.591 | 5645.914 | 5661.764 | 5653.422 | 5666.556 |
| AR test 1            | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   |
| AR test 2            | 0.893   | 0.415   | 0.588   | 0.539   |          |          |          |          |          |          |
| Firm                 | 6,256   | 6,256   | 6,256   | 6,256   | 6,256   | 6,256   | 6,256   | 6,256   | 6,256   | 6,256   |
| Obs.                 | 43,330  | 43,330  | 43,330  | 43,330  | 43,330  | 43,330  | 43,330  | 43,330  | 43,330  | 43,330  |

*** $p < .01$, ** $p < .05$, * $p < .1$
impact on efficiency. However, the mediating role of investment is mainly attributable to firms in China, as documented in Table 5. According to Vo (2018), companies in emerging markets are subject to precautionary motive and agency motive of holding more cash. Their study also suggests that companies in emerging economy have more exposure for agency problems because managers might subsequently use the cash reserve for their own advantages.

Generally, the results suggest that debt financing has the potential of minimizing inefficiency attributing to overinvestment. This is consistent with the prediction of agency cost theory. The availability of financial resources motivates managers to undertake unprofitable investment projects. High financial leverage can reduce agency costs since it entails restrictive monitoring of managers investment undertakings. When projects are financed by borrowed capital, the managers' tendency of overinvestment declines. This has the potential to reduce extravagant investment spending and enhances the productivity of capital invested. On the other hand, high debt financing may also cause underinvestment. This occurs when managers surrender value-adding projects due to the restriction imposed by debt contracts. Thus, leverage determines both overinvestment and underinvestment which in turn affects the efficiency of capital invested in one way or another.

6. Conclusion
This study investigated how the use of debt financing affects the productivity of capital invested and the mediating role of corporate investment. We gauge the productivity of the capital invested by employing Stochastic Frontier Analysis (SFA), parametric model to estimate productivity. We find that firms that use more debt capital are less likely to make overinvestment but are more likely to make underinvestment when their cash flows are low. Our findings suggest that the productivity of capital invested becomes high when the manufacturing firms optimize the level of their investment. Besides, the study shows that debt financing positively affect the productivity of capital invested and that the effect is partially mediated by the investment of the manufacturing firms. Generally, our study suggests that the use of borrowed funds has the potential of minimizing agency costs attributable to investment activities. The findings also indicate that high level of debt coupled with shortage of financial resources increase the firms' chance of underinvestment. The agency cost theory suggests that the use of borrowed funds improves capital efficiency since the restrictive covenants in debt contracts may monitor managers' spending behaviors and forces companies to make more efficient investment. Our study also indicates that debt financing
increases the efficiency of capital invested by mitigating problem of overinvestment. Therefore, the results in our study are consistent with the prediction of the agency cost theory.

Our investigation focuses on companies in the three biggest economies namely China, Japan and USA. The countries considered in this paper account for the lion’s share of the trade in manufactured goods among market economies. We concentrate on the productivity of capital invested in one of the major sector of the economy, manufacturing. Despite the decreased importance of manufacturing in advanced countries in shares of output and employment, its role in the economy remains important, because the sector generates most technological innovations with important spillover effects to the rest of the economy. However, our analysis lacks the data of the other sectors of the economy and the international evidence including the firms from the rest of the countries. This can be taken as the limitations of our study and future research direction. That said, this paper provides important management implication in the area of corporate finance since it explains the importance of corporate financing decisions for efficiency. We show the impacts of debt financing on corporate investment and the mediating role of investment in the financial leverage-productivity nexus. To this end, the study provides direct firm-level evidence on the interaction among debt financing, corporate investment and the level of efficiency firms achieve.

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Annex A: Definition and measurement of variables

| Variable | Meaning | Definition |
|----------|---------|------------|
| Debt     | Level of Debt Financing | Long-term debt plus debt in current liabilities deflated by total assets as of the balance sheet date |
| CF       | Net cash flow | Net operating cash flow deflated by lagged total assets |
| Investment | Investment amount | Capital expenditures deflated by lag of total assets |
| Size     | Firm size | The natural logarithm of total assets |
| Cash     | Cash holding | Cash balance deflated by total assets |
| CapInt.  | Capital intensity | Net PPE over total revenue |
| ROA      | Return on assets | EBIT divided by total assets |
| Growth   | Sales growth | Sales growth rate (change in sales over lag of sales) |
| Over Investment | Investment amount exceeding the expected level | The absolute value of the residual in the investment model multiplied by overinvestment dummy value. The overinvestment dummy value becomes 1 if the residual of an observation is in the third quartile and zero otherwise. |
| Under Investment | Investment amount less that the expected level | The absolute value of the residual in the investment model multiplied by underinvestment dummy value. The underinvestment dummy value becomes 1 if the residual of an observation is in the first quartile and zero otherwise. |

To check for normality, we applied skewness and kurtosis test, with xtsktest Stata command, on the variables included in the model applied to estimate efficiency. This can be used as an alternative to the Jarque–Bera test in panel-data models. The result shows that there is normality within the data. We have shown the test result in the table shown below.

Annex B: Normality test for data variables used in estimating efficiency

|                  | Observed | Bootstrap | Normal-based |
|------------------|----------|-----------|--------------|
|                  | Coef.    | Std.Err.  | z            | P > z | 95%Conf. | Interval |
| Skewness_e       | -0.055   | 0.020     | -2.780       | 0.005 | -0.093   | -0.016   |
| Kurtosis_e       | 1.039    | 0.161     | 6.360        | 0.000 | 0.719    | 1.359    |
| Skewness_u       | -0.158   | 0.025     | -6.380       | 0.000 | -0.207   | -0.110   |
| Kurtosis_u       | 0.669    | 0.083     | 8.060        | 0.000 | 0.507    | 0.832    |

Joint test for Normality on e: chi2(2) = 48.18 Prob > chi2 = 0.0000 Joint test for Normality on u: chi2(2) = 105.76 Prob > chi2 = 0.0000
