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Total Factor Productivity, Intangible Assets and Return

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# **TOTAL FACTOR PRODUCTIVITY, INTANGIBLE ASSETS AND RETURN**

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# Chapter 1: Introduction

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Empirical evidences documented many links between firm characteristics with stock returns. Even with the Fama-French three factor model in 1992, there are still a lot of abnormal returns cannot be explained by CAPM model or Fama-French model (Fama and French, 2009). While when researchers are focusing on specific financial proxies to explain the return, there are other researches that developed intuitively from the macro-economic, and in theory with appropriate proxy and estimation method, the empirical evidence can be found the micro-economic level. The Investment CAPM is one of these theories, instead of using the equilibrium condition from the relationship between supply and demand, it pursues the asset pricing from a different perspective than the behavioural finance.

Total Factor Productivity (TFP), on the other hand, is developed from macro-economic level for explain the growth of the country's GDP and defined as "the portion of output not explained by the amount of inputs used in production" (Diego Comin, 2006). Unlike the Investment CAPM, productivity is the key source for economic growth and productivity growth is the key economic indicator of innovation.

Economic growth can take place without innovation through replication of the established technologies (Jorgenson, 2009). While there are empirical evident about the link between the firm-level TFP and the stock returns, the traditional firm-level TFP focuses on the physical capital and labour. However, firms are investing big amounts into intangible assets such as R&D, software, brands ...etc "at a rate close to that of tangible assets" (Ellen R. McGrattan, 2017). Therefore, in this study, we incorporate the intangible capital and the investment in intangible capital into the firm-level TFP measurement.

This paper provides the evidences about the link between this new firm-level TFP with intangible capital and stock return. Chapter 2 is the literature review for the development of the TFP theory and the relevant estimation methods. Chapter 3 is

the data collection and estimation method. Chapter 4 is the data analysis and the robustness check. Chapter 5 is the conclusion.

## Chapter 2: Literature Review

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### 2.1 TOTAL FACTOR PRODUCTIVITY THEORY

The endeavor to understand the economic reasonings between firm inputs and the output started long ago. Since the Industrial Revolution in the United States, economists have developed a variety theories and models (Hulten, 2001). The Total Factor Productivity Theory, henceforth abbreviated as TFP, was introduced independently by George Stigler (1947) and it is intended to provide an explanation for economic growth based only on the production function and marginal productivity condition (Isaksson, 2007). In a sense, the TFP is the portion of the output not explained by the amount of input used in production (Comin, 2006).

The attempts to explain productivity with economic input has had several milestones in recent decades in theoretical aspect and in empirical aspect.

In the theoretical part, two of the main facets contributing to TFP are Marxian or Neoclassical theories, both of which argue that productivity improvement of an entity is driven by advanced technology and organization of production. Another facet are the New Growth Theory and the Theory of Capital and Investment which argue the entity that productivity improvement is driven by an increase in investments in human capital, knowledge, and fixed capital (Hulten, 2001). The growth of the TFP provides an opportunity to increase the welfare of the society.

The Neoclassical Model, as known as the Old Growth Model, proposed by Solow (1957), tied the aggregate production function to productivity in a simple yet elegant way. The Old Growth Model uses the growth accounting methodology, and its origins is national accounting, representing output per unit in the settings. It showed that in any economy, the long-run growth in income per capita, with the aggregate neoclassical production function as the link, must be driven by growth in the TFP. Typically, the productivity studies assume the output to be a function of inputs, employed by a firm or a country, and its productivity (Katayama, Lu, and Tybout, 2009). The measure of the TFP, obtained as the residual in the functional

relationship mentioned above, is then used to evaluate the impact of various policy measures, such as the extent of foreign ownership and trade (Van Beveren, 2010).

As elegant and intuitively as it can be, there are some drawbacks of this original theory, summarized by Hulten (2001); first, that GDP in the current level is not a satisfactory measurement. Second, even with constant price level, if a productivity improvement generates more output by a given amount of input, this measure is inaccurate. Third, this theory does not consider the possibility to convey the TFP into long-term welfare of the society. Many of the welfares of innovation comes from better goods, not from an increased quantity of the goods. As Hulten (2001) pointed out, the TFP residual does not consider this possibility. Meanwhile, one of the assumptions within the Solow model is that the technological progress, which is the driver of the productivity, is seen as given and is therefore exogenous. Intuitively, this does not fit reality in a convincing way. In 1967, Denison and Poullicher asked one of the main challenges to the Solow model. They measured the by growth rate with the national output and the capital stock, combine the new approach for the labour input. Although Solow stood by his measure of the labor input (Jorgenson, 2009).

In New Growth Theory, proposed by Romer (1986), assumes that technological progress is endogenous to the productivity. It implies that the technological progress of creating new ideas is a self-generating and self-feeding dynamic process, which allows for perpetual growth within the New Growth Model. Incorporated the endogenous in the theory provides the possibility that the continuous growth for the economy is driven and guaranteed by technological progress. Due to the fact that knowledge is intangible and therefore immeasurable, previous research uses investments in Research and Development (R&D) and patent data as proxies for the determinants of the TFP. Furthermore, not only does the amount of knowledge matter, but also the quantity and the people involved matter. The absorptive capacity for making use of the imported knowledge link to the quantity and the people with the knowledge affects the TFP in another channel. Human capital and R&D are also important means of increasing this capacity (Isaksson, 2007). The swiftly falling IT have provided a strong incentive in economically about the diffusion of the information technology through IT hardware and software (Jorgenson, 2009).



By focusing on capital embodied technical change, Jorgenson and Griliches (1967) made a significant improvement in the productivity theory: careful measurement of the relevant variables should cause the Solow measure of total factor productivity to disappear. One major contribution Jorgenson and Griliches to the TFP theory is precisely matching productivity theory with growth accounting and incorporating the neoclassical investment theory developed by Jorgenson (1963) into productivity analysis (Hulton, 2001). Jorgenson and Griliches recognized that the output must be measured with depreciation, based on the strict logic of production theory, while Griliches (1988) pointed out that direct R&D expense is essentially an internal investment, relevant assets and returns are not well observed by the market. Hence there is no real estimations for the quantity of knowledge or the corresponding weight in the TFP. The TFP theory has contradicting empirical microeconomic results and theories, and as such, there has been a lot of research conducted in order to figure out better proxies for the TFP.

According to the Theory of Capital and Investment, capital intensity is one of the main determinants of the TFP, alongside with education, openness, knowledge, and other aspects. Capital intensive investment will increase the TFP by allocating capital in more productive sectors or in high-quality investment projects (Isaksson, 2007). Miao and Wang (2011a) showed that a credit-driven stock price bubble can also be a determinant of the TFP; the loosening of credit leads to a bubble, more capital available to the economy, ultimately increasing the corresponding TFP in theory when it reaches the bubbly equilibrium, and decreasing the corresponding TFP when it reaches a Pareto-dominates bubble-less equilibrium.

As Romer (1990) pointed out, innovators recoup the cost of innovation through the profit margin by commercializing the patent. There are two channels to increase the TFP: the first is through R&D; when R&D expenses are higher, innovation rate increases, which leads to higher TFP. The second is through the combination of the size of firms and the market; the larger the size of the market, the higher ability to innovate, which leads to a higher TFP. Using patents as a proxy for knowledge has been associated with a positive long-run relationship with TFP, which is validated by Abdih and Joutz (2006). However, Hellwig and Irmen (2001) empirically show that patents are not necessary for innovators to recoup the cost of R&D. In 1995,

Baldwin and Diverty performed a survey of Canadian manufacturers firms, the results showed that both plant size and plant growth are closely relevant to the use of technology. While could it be the same pattern for the other industries are still waiting to be validated. Similar results can be found for the United States in research from McGuckin, Streitwieser and Doms (1998). They intend to investigate the TFP for different industries for focusing on the 1974 and 1975, while the different industries TFP is not all decreasing at the same time frame, such as agriculture and service, even the economy is slowing down.

There are researchers investigating the excess returns of the firms with R&D on a micro-economic level from point of view of risk and return. Chambers, Jennings and Thompson (2002) have shown that the returns are consistent with risk, explaining the R&D patterns. Lev and Sougiannis (1999) demonstrated that adjusted reported earnings and the book value of equity reflect the R&D level, and that the R&D can reflect on contemptuous returns and subsequent stock returns. The lag effect on the stock returns implies mispricing of the stock price by the equity investors. According to Donelson and Resutek (2012), however, the return patterns of R&D firms are not mispriced by investors but are essentially a transformation of the value or growth anomaly. They warn that because the R&D is jointly correlated with future returns and firm characteristic, as an accounting measure, researchers should carefully design the effectively control variables to deal these correlations. Recently, research conducted by Hou et al (2016), about the relationship between R&D and returns cross countries, empirically agree with Donelson and Resutek (2012) that the returns patterns are associated with innovation, rather than due to mispricing or market frictions.

Guellec (2001) investigated the long-run relationship between R&D and the TFP growth. The results show that among all three sources of R&D, foreign-sourced R&D has the largest effect, followed by domestic business research effects, and public research effects. It is worth noting that, as Isaksson (2007) argued, for different countries with different absorption capacity levels, imported technology is seldomly used immediately for lower absorption capacity (less developed) countries. This means that the order of importance in developing countries should be different, and that is can be more costly to exploit new technology for better

economic states. Ulku (2007) investigated the TFP among large OECD countries which showed that innovation leads only to short-term TFP growth.

In principle, the TFP should be positively correlated with the investment R&D, but in practice, empirical results are inconclusive. Comin and Mulani (2009) constructed a theory to address the relationship between R&D and the TFP cross. One reason for this is the incomplete measurements of the knowledge proxies (Isaksson, 2007). Similar results shown that the TFP impact are extremely low or lost in the R&D contribution by Jones and Williams (1998). These conflicts empirical result and various theories that intend to provide statistically proofs or intuitions on micro-economic level, even with improvements in quantity and quality of the data, making a universal agreement on the importance of R&D in the TFP theory is almost impossible.

In 2014, McGrattan and Prescott presented evidence that intangible investments are larger than researchers had previously thought. In their research, they include intangible investments such as software and organization capital to solve the discrepancy between the GDP of the United State measured by Bureau of Economic Analysis (BEA) and the theoretical prediction GDP from 2008 to 2009. The results revealed that the intangible investments are highly correlated with tangible investment such as plant and equipment in firm level and help to explain the real business cycle model. BEA updated their method by adding intellectual property products such as software, R&D, mineral exploration, and entertainments into their GDP measurement. At the same time, Corrado, Hulten, and Sichel (2005) estimated that intangible investments are same size as tangible investments in the business sector. In 2017, McGrattan expanded the model in his working paper with the data from the updated BEA model, adding computer design services, management consulting services, and advertising to the output estimation. They found that adding intangible assets improve the theory and the measurement of TFP, which provides a new benchmark model for the future research.

It is undeniable that the R&D is critical for innovation in the economic development, however, innovation does take place without some R&D activities, and are classified into three category by Arundel, Bordoy and Kanerva (2008): (1) minor modifications or incremental changes to products and process using existing

engineering knowledge; (2) imitations or the adoption of innovations developed by users; and (3) the combination of existing knowledge. Based on the results from Lopez-Rodriguez and Martinez-Lopez (2017), they found a negative impact from TFP when including non-R&D expense, which contradicted the positive and significant coefficient results done with the standard model implemented by Griffith Redding and Reenen (2004). Peter and Taylor (2016) investigated the relationship between intangible capital and the total Tobin's Q. Empirically, the q-slopes are significantly larger with intangible investments than without, which implies that a firm with more intangibles demonstrates more convex adjustment costs.

The economic growth puzzle says that relative earnings and personal income are not enough to explain the economic growth, since the ratio of all capital is declining. In 1962, after Kuznets and Jenks (1961) pointed out that the concept of capital should be broadened to include more investments in different aspect on the population, such as health, education. Schultz discussed the role of investment in human capital in economic growth. One of the main assumptions is that including human capital, the ratio of all capital is essentially constant, which could be the key solve the puzzle about economic growth. He also assumed the investment in human capital is the driver of social equality. The restricted concept of capital to structures, equipment, and inventories may distract in the search for critical understanding in long-term economic growth. Meanwhile, Schultz also points out that not all investments in human capital are for the future, making it difficult, in practice, to find the proper proxy. Maudos, Pastor and Serrano (1999) validate these findings with their empirical research on OECD countries. They also incorporate the inefficiency of agents in the economy as an improvement, and with empirical tests they prove that the efficiency is a source of variation in TFP, even more that technological progress.

## **2.2 TOTAL FACTOR PRODUCTIVITY ESTIMATION**

As the first part of the TFP theory mentioned, the origin of the TFP can be traced to Solow (1957), and the recent increased interest are driven by the increasing availability of the firm level data, allowing for estimation of TFP at individual level (Van Beveren, 2012). At first, the estimation method of TFP is the traditional

methods, the Ordinary Least Squares (OLS) to a panel data. Because of the correlation of the inputs, the OLS estimation faced simultaneity, selection bias and endogeneity problems (Wedervang, 1965). Then the proxy for firm-level price is being challenged by Katayama (2009).

For the estimation method, there are four estimators that stand out in Van Beveren's review: (1) fixed effects, (2) instrumental variables and Generalized Method of Moment (GMM), (3) the semi-parametric estimation algorithm developed by Olley and Pakes (1996) and (4) the semi-parametric estimation algorithm developed by Lebinsohn and Petrin. Van Beveren performs a simple evaluation exercise and finds that the differences between the different estimators are very small, while the correlations between the different TFP are high, especially for the results from GMM, OLS and Olley-Pakes (Van Beveren, 2012).

The TFP is assumed to be firm specific while simultaneously time-invariant. Using Pavcnik's (2002) modified fixed effects estimator, it is possible to get estimators that are simultaneously unbiased. The fixed effect does not perform well in practice (Ackerberg et al, 2007). Olley and Pakes (1996) and Wooldridge (2009) pointed out more serious underlying problems of the estimation method, such as impose strict exogeneity of the input which make it extremely easily to be violated in practice (Van Beveren, 2012). The alternative to deal with the endogeneity is using Instrumental Variables (IV) and GMM. Unlike the fixed effect estimator, the IV method does not have the strict exogeneity assumption (Wooldridge, 2009). Even with these attractive characteristics, the IV method has its own drawbacks. First, input or output prices may be used in the productive function, which are not endogenous in an imperfect market when the participants have the ability to affect the prices. Second, the underlying assumption that productivity evolves exogenously over time is problematic (Ackerberg et al, 2007).

Olley and Pakes (1996) developed a consistent semi-parametric estimator, a method that deals with the simultaneity problem and soled selection issues with an exit rule added in the model. That method is adopted in this paper, therefore more details on this will be included in our methodology section. Although Olley and Pakes use the investment decision as a proxy for unobserved productivity, the monotonic condition required the investment is strictly increasing with the productivity (Van

Beveren, 2012). Levinsohn and Petrin (2003) use intermediate inputs as a proxy with GMM in the later estimation function, in order to deal with irregular reporting of investments quantities that violate this assumption. While with the empirical test by Van Beveren in 2012, the estimated TFP has significantly lower correlation with the fixed effect OLS regression compared to the estimated TFP by the GMM or the LP estimator.

# Chapter 3: Methodology and Research Design

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## 3.1 METHODOLOGY

### 3.1.1 Data Collection

Our data are collected from WRDS in *Compustat* and for detail name of variable corresponding in our ratio calculations, see the appendix. We use the CRSP Monthly Stock on *Compustat* or the monthly return (RET in WRDS). Moreover, we take the *PERMNO* link to *Compustat* Record.

#### Part 1: TFP Data

The main data source for estimation of the firm level productivity is the *Compustat* on the database WRDS and the research target is in US market in firm level. All the following used variables and their abbreviations in *Compustat* are summarized in the table in Appendix. Since 1975, the firms have been required to report the R&D by the Federal Accounting Standards Board (FASB) (Peter and Taylor, 2016). We give the firm 10 years to comply with the FASB requirement. Moreover, the first Windows was introduced on the end of 1985, it is very clear that personal computer has strong impact to the development of knowledge capital and organization capital, in another word – intangible capital. Hence, 1986-2017 is a suitable time period. It requires 2 years to estimate the TFP with intangible capital so the TFP estimation will be from 1987.

Roughly modifying the data, we exclude the financial firms, the SIC code is between 6000 and 6999, and the utilities firms, the SIC code is between 4900 and 4999, because the high leverage that is normal for the financial firms but does not have the same meaning as for nonfinancial firms (Fama and French, 1992), and the utilities firms are excluded due to their highly regulated nature. The key data for our TFP with intangible capital is, the firm level value added, employment, physical capital and intangible capital.

The main problem is the expenses for intangible asset are often in income statement and almost never been on the balance sheet. As the firm can acquire the intangible asset by purchasing it (external) or create it internally, the total intangible capital is the sum of external intangible asset and internal intangible asset. We use the Intangible Asset as a measure of external intangible asset. In the case that missing value, we set the Intangible Asset equal 0. The internal intangible capital is expressed by two parts: Knowledge Capital and Organization Capital. Knowledge is defined by the spending in R&D and the organization capital is a fraction of past Selling, General and Administration expense. We use the measurements from ‘Peter and Taylor Total Q’ on knowledge capital and Organization Capital in WRDS.

We define that the firm’s total capital investment as the sum of its investment in physical capital and intangible capital. The investment in physical capital is the capital expenditure. The investment in intangible capital is defined as the sum of the investment on knowledge capital (R&D spending) and organization capital (fraction of spending on Selling, General and Administration). Following Hulten and Hao (2008), Eisfeldt and Papanikoloau (2014), and Zhang (2014), we make a strong assumption that 30% of spending on SG&A would be an investment in organization capital.

Collecting and Calculating of used variables:

- The Value Added ( $y_{it}$ ):

$$y_{it} = Sales - Materials$$

where *Sales* is the net sales value deflated with the GDP deflator,

$$Materials = Total Expense - Labor Expense$$

*Total Expense = Sales - Operating Income before Depreciation and Amortization*

$$Labor expense = number\ of\ employees \times average\ wage$$

where average wage is the average wage from Social Security Administration.

- The Capital Stock ( $k_{it}$ ):

$k_{it}$  is gross property, plant and equipment, and we need to deflate this factor by the price deflator for investment with Hall’s approach (1990).

- The Stock of Labor ( $l_{it}$ ):



$l_{it}$  is the number labor, proxy by the number of employees

- The Intangible Capital ( $t_{it}$ )

$t_{it} = \text{Intangible assets} + \text{Knowledge Capital} + \text{Organizational Capital}$

- The Invested Capital ( $t_{it}$ ):

$$t_{it} = CAPEX + \text{Investment in Intangible Assets}$$

, where the *CAPEX* is the investment in physical assets, proxied by CAPEX

$$\text{Investment in Intangible Assets} = R\&D + 30\% \times SG\&A$$

$$SG\&A = XSGA - XRD - RDIP$$

If Research and Development Expense (XRD) is greater than Selling, General and Administration Expense (XSGA) but is smaller than Cost of Goods Sold (COGS), then the *SG&A* is equal to the Research and Development Expense with no further adjustment. If the Research and Development Expense is missing, we set *SG&A* equal 0.

#### Relevant adjustments on used variables:

For more reasonable estimated TFP, we make some suitable adjustments for the data we collected, the difficult part among there is choosing the deflator. With the data and analysis from Bureau of Economic Analysis, we decide the GDP deflator (NIPA Table 1.1.9, line 1) to be the Deflator of value output, price index for non-residential private fixed investment (NIPA Table 5.3.4, line 2) to be the deflator of investment, physical capital and intangible capital (Moore, 1983).

Another adjustment is the average age of capital is computed at every year for every company following the methods of Hall (1989) and Brynjolfsson & Hitt (2003). The capital age is equal to the ratio of Accumulated Depreciation, Depletion and Amortization divided by Depreciation and Amortization. We smooth the capital age by using 3 years moving average. In the case that the firm has less than 3 years data, we calculate the average year with the available year of capital age. If the firm has over 2 years data but not continuing, we take the average of the first year and the third year of capital age. In order to compute the available stock at the beginning period, we will lag one year in capital stock and intangible stock.

To collect all data at the firm level on WRDS, we will use SAS Studio on WRDS. Detail codes are in Appendix.

## Part 2: Other data

First, we collect the risk-free rate, name as the RF in Fama-French 3 Factor data. It is used for calculating excess returns for portfolio analysis later.

Second, to define the business cycle with contraction and expansion, the US Business Cycle Expansions and Contractions of the National Bureau of Economic Research is used.

Third, we collected data for relevant financial ratios and firm characteristics. As it is well known and documented, there are several firm characteristics are linked to stock returns. Banz (1981) found out that the low market capitalized companies displayed abnormal higher returns than average. Firms with higher book to market ratios also has higher returns than average that it is not explained by CAPM (Rosenberg, Reid and Lanstein, 1985). To observe this, we learn the method of relevant variables used by Fama and French (2008) with other financial ratios from Koller, Goedhart and Wessels (2010).

*MarketCap*: the nominal value of market capitalization is defined as the product of the close market price at the fiscal year end times the common shares outstanding.

*MC (size)*: the natural log of market cap

*B/M*: the natural log of the ratio of book equity divided by market equity

*NS*: the nominal value of split-adjusted shares outstanding

*RD/PPE*: the ratio of Research and Development Expense divided by total PP&E

*Leverage*: the ratio of long-term debt in total divided by the sum of long-term debt in total with market equity value

*ROE*: the ratio of income before extraordinary items divided by the value of book equity

*ROA*: the ratio of income adjusted with dividends and tax divided by total assets

*GRP*: the ratio of gross profit divided by the total assets

*I/K*: the ratio of adjusted fixed capital expenditure divided by the natural log of capital

*Age\_Cap*: the age of capital used in TFP estimation

*Age*: the number of years since the firm first show up in *Compustat*

### 3.1.2 Estimation Methodology Construct the TFP with Intangible Assets

The main estimation method in this paper is the estimation of the TFP with Olley-Pakes Estimators.

#### Part 1:

There are some different methods to construct the TFP such as Olley and Pakes (1996), Levinsohn-Petrin (2003). As Van Beveren (2010) demonstrated in his research, for different TFP estimators, with or without make special treatments of dealing with unbalance panel data, the results for different TFP estimators are quiet similar, all roughly significant around 0.115 in the test. Mainly reason Van Beveren (2012) offered is that the estimations by different TFP estimators are highly correlated. Based the availability of data and the characteristics of each method, we decide to follow the Olley and Pakes (1996) to estimate the TFP with the labor, physical capital and the new added factor intangible capital  $t_t$  as the input. We use Matlab in the beginning of this part to organize and to select the data, but in running the regression with unbalanced panel data, Stata is used because of its strength in solving regression.

#### 1 Estimate $\beta_l$ and $\phi_t(\cdot)$

We have the production function:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_t t_{it} + \omega_{it} + \eta_{it} \quad (1)$$

Where:

$y_{it}$ : log value of output (value added) for firm  $i$  at time  $t$

$k_{it}$ : log value of capital for firm  $i$  at time  $t$

$l_{it}$ : log value of labor for firm  $i$  at time  $t$

$t_{it}$ : log value of intangible capital for firm  $i$  at time  $t$

$\omega_{it}$ : the productivity of firm  $i$  at time  $t$

$\eta_{it}$ : measurement error not known by the firm or the econometrician

The labor ( $l_{it}$ ) is the only variable input, that can be affected by current productivity  $\omega_{it}$ . The capital and intangible capital are fixed input, that can be affected by the conditional distribution of  $\omega_{it}$  at time  $t - 1$  and past value of  $\omega$ . The productivity ( $\omega_{it}$ ) is the state variable that can affect firm's decision.

- Estimate the Exit Probability ( $\hat{P}_{survival,t}$ )

Follow Olley and Pakes (1996), in the beginning of each period, the firm will make a perspective of the market structure based on the current information and then it can decide whether to stay or exit the market: Firms compares the sell-off value of its business to the expected discounted returns of staying. If the current state variables indicate continuing in operation is not worthwhile, the firm closes down the business and receive the sell-off value. If no, the firm choose the labor variable, optimal investment level with physical capital stock and intangible capital.

This generates an exit rule and an investment demand function, define:

$X_t$  is the survival indicator,

, where,  $X_t = 0$  if the firm exit.

, and  $X_t = 1$  if the firm stays in the market:

$$\omega_{it} \geq \underline{\omega}_{it}(k_{it}, t_{it}) \text{ and } i_{it} = i(\omega_{it}, k_{it}, t_{it})$$

The Exit Probability  $\hat{P}_{survival,t}$  can be estimated by a probit of a survival indicator  $X_t$  on a polynomial regression containing physical capital, intangible capital and investment.

## 2 Estimate $\beta_t$ and $\phi_t(\cdot)$

A positive productivity shock in period  $t$  will lead to a higher investment on physical capital/ intangible capital ( $i_{it}$ ) and the firm will hire more labor,  $l_{it}$  in that period. Therefore, the solution of the firm's optimization problem results in the equation of investment:

$$i_{it} = i(\omega_{it}, k_{it}, t_{it})$$

From the Pakes theorem (1994, Theorem 27) the  $i_t > 0$ , so the equation of investment is strictly increasing in  $\omega_{it}$  with all the subset  $(\omega_{it}, k_{it}, t_{it})$ . We have the inverse function:

$$\omega_{it} = h(i_{it}, k_{it}, t_{it}) \quad (2)$$

where  $h(i_{it}, k_{it}, t_{it})$  is strictly increasing in  $i_{it}$ .

Substituting (2) into (1) we have:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_t t_{it} + h(i_{it}, k_{it}, t_{it}) + \eta_{it}$$

Define:

$$\phi_t(i_{it}, k_{it}, t_{it}) = \beta_0 + \beta_k k_{it} + \beta_t t_{it} + h(i_{it}, k_{it}, t_{it})$$

Then:

$$y_{it} = \beta_l l_{it} + \phi_t(i_{it}, k_{it}, t_{it}) + \eta_{it} \quad (3)$$

Following Imrohoroglu and Tuzel (2014), Olley and Pakes (1996), we use a second order polynomial series in investment, physical capital and intangible capital to estimate the  $\beta_l$  and  $\phi_t(i_{it}, k_{it}, t_{it})$ . In order to eliminate the effect of industrial level or aggregate TFP in any years, the industry-specific time dummy is used, and the dummy is in the form of “Financial year and 3-digit SIC code”.

### 3 Estimate $\beta_k$ and $\beta_t$ , end with productivity $P_{it}$

This step is more complex as the effect of capital and technology on investment decision and on output are still not separately in the equation (3). In order to estimate  $\beta_k$  and  $\beta_t$ , we have to estimate the survival probability. With the estimation in first step, we have the expectation, of  $y_{i,t+1} - \beta_l l_{i,t+1}$  on information at time  $t$  and survival probability of the firm:

$$\begin{aligned} & E_t(y_{i,t+1} - \beta_l l_{i,t+1}) \\ &= \beta_0 + \beta_k k_{i,t+1} + \beta_t t_{i,t+1} + E_t(\omega_{i,t+1} | \omega_{it}, survival) \\ &= \beta_0 + \beta_k k_{i,t+1} + \beta_t t_{i,t+1} + g(\omega_{it}, \hat{P}_{survival,t}) \end{aligned}$$

Where  $\hat{P}_{survival,t}$  is the probability of survival of the firm from time  $t$  to time  $t + 1$

We fit the following equation by using nonlinear least square:

$$(y_{i,t+1} - \beta_l l_{i,t+1}) = \beta_k k_{i,t+1} + \beta_t t_{i,t+1} + \rho \omega_{it} + \tau \hat{P}_{survival,t} + \eta_{i,t+1}$$

With  $\omega_{it} = \phi_t(i_{it}, k_{it}, t_{it}) - \beta_0 - \beta_k k_{it} - \beta_t t_{it}$ : we assumed this is a ARMA(1,1).

At the end of this process, we find out the  $\beta_k$  and  $\beta_t$ .

The productivity is:  $P_{it} = \exp(y_{it} - \beta_0 - \beta_k k_{it} - \beta_l l_{it} - \beta_t t_{it})$ .

### 3.2 RESEARCH DESIGN

In this thesis, we are going to estimate the TFP with all the data we collected in the first part of data collection, with estimated firm level TFP, we intend to investigate the relationship between the estimated TFP with the contemporaneous and future return with different states of business cycle, the expansion and the recession.

For the asset pricing implication analysis part, we following Fama and French (2008), there is a potential problem in the returns on equal weighted portfolios that using all stocks can be dominated by stocks that are tiny – microcaps firm (which we define as stocks with market cap below the 20<sup>th</sup> percentile for NYSE), not just small. Therefore, the stocks in our samples are sorted into 10 portfolios based on their TFP level at time  $t$  from Low to High. Moreover, the portfolio breakpoint is set based on the sample of NYSE firms removing the microcap because including these microcap stocks can lead to few small or big stocks in the extreme portfolio. By this way, the portfolios will be more stable and balance. Note that these exclusions are for the computation of the breakpoint only. We keep using all firms in all computation. Note that we need to sort portfolio by using TFP for every year.

We investigate the relationship between our firm-level TFPs with the contemporaneous annualized excess return and future annualized excess returns (excess of the risk-free rate). We annualize the monthly return by using the formation:

$$\begin{aligned} \text{Annual Return } r_a &= (1 + r_1) \times (1 + r_2) \times (1 + r_3) \times \dots \times (1 + r_{12}) - 1 \\ &= \exp[\ln(1 + r_1) + \ln(1 + r_2) + \ln(1 + r_3) + \dots + \ln(1 + r_{12})] - 1 \end{aligned}$$

Where the excess return ( $r_e$ ) is calculated as

$$\text{Excess return } r_e = r_a - r_f \text{ with } r_f \text{ is the risk free rate}$$

The contemporaneous excess return at time  $t$  is computed from January of year  $t$  to December of year  $t$ . For each portfolio, we need to measure the contemporaneous excess return in each year and then take average over the year to identify the average contemporaneous excess return.

We follow İmrohoroğlu, Tüzel (2014) to determine the future annualized excess return. The future return at time  $t$  is computed from July of year  $t + 1$  to June of

year  $t + 2$  and then annualized. We also need compute the future risk-free rate with the same method. For each portfolio, we need to measure the contemporaneous excess return in each year and then take average over the year to identify the average contemporaneous excess return.

Moreover, to understand the relationship between TFP and future excess returns over the business cycles, the sample is divided into 2 periods: expansion and contraction periods around the portfolio formation time. We use the business cycle from the National Bureau of Economic Research to designate the expansion/contraction periods in June of each year and test the returns of TFP-sorted Portfolios over the following 12 months. The contraction periods are in 4 years: 1990, 2001, 2007, 2008 and it has 48 months. The expansion is the left years. The excess returns of each periods are estimated by the similar method for future and contemporaneous returns.

In this part, we want to check whether asset pricing models such as CAPM and Fama - French three factors model capture the variation in excess returns of TFP sorted porfolios. There are some duplicated data in our dataset because of the non-unique property of firm's *PREMO*, we need to remove the duplicated data before running the regression.

Stata is used with the pooled OLS regression for panel data with firm-ID is the *GVKEY*, time is *fyear* and cluster is *GVKEY*.

## Chapter 4: Analysis and Discussion

### 4.1 DESCRIPTIVE STATISTICS OF TFP & FIRM CHARACTERISTICS

First, we look into the general descriptive statistics:

Table 1 Descriptive Statistics 1986 - 2017

	Low	2	3	4	5	6	7	8	9	High	High-Low
TFP	0.43	0.60	0.66	0.71	0.75	0.80	0.87	0.96	1.14	1.82	1.39
MC	4.56	5.28	5.68	6.05	6.27	6.55	6.71	6.92	7.22	7.71	3.16
B/M	-0.36	-0.42	-0.52	-0.62	-0.72	-0.80	-0.90	-0.96	-1.04	-1.16	-0.80
RD/PPE	0.18	0.10	0.09	0.09	0.11	0.12	0.14	0.18	0.24	0.36	0.18
NS	0.20	0.23	0.21	0.20	0.19	0.17	0.16	0.15	0.13	0.12	-0.08
Leverage	-0.48	-0.04	0.04	0.10	0.12	0.12	0.07	0.15	0.30	0.20	0.68
ROE	-0.05	0.02	0.03	0.05	0.05	0.06	0.07	0.08	0.08	0.10	0.15
ROA	0.39	0.42	0.43	0.44	0.45	0.45	0.45	0.44	0.43	0.43	0.04
GPR	0.22	0.26	0.39	0.30	0.42	0.58	-0.09	1.06	1.19	1.66	1.44
I/K	6.88	6.33	5.82	5.57	5.18	4.82	4.75	4.43	4.27	3.76	-3.12
Age	25.94	29.10	29.42	29.99	29.38	29.49	28.84	28.48	27.15	24.84	-1.10
Age_Cap	6.88	6.33	5.82	5.57	5.18	4.82	4.75	4.43	4.27	3.76	-3.12

As mentioned in the research design, we first sort the firm into different portfolios base on their TFP level, as the monotonic increasing trend of the TFP-sorted portfolios, the monotonic trend of the Size (MC), Book-to-Market ratio (B/M) and Return of Assets (ROA) are stable and consistent with the TFP-sorted portfolio. Meanwhile the Capital Age (Age\_Cap) shows consistent decreasing trend with the increasing with the TFP, while we think it is consistent with the TFP trend, the newer capital including physical and intangible will give better productivity as new technology than the existed old ones.

Second, we investigate into the correlation:

Table 2 Correlation

	TFP	MC	B/M	RD/PPE	NS	Leverage	ROE	ROA	GPR	I/K	Age	Age_Cap
TFP												
MC	0.39											
B/M	-0.24	-0.41										
RD/PPE	0.13	0.03	-0.18									
NS	0.25	0.44	-0.11	0.00								
Leverage	-0.09	-0.15	0.36	-0.23	-0.03							
ROE	0.02	0.02	0.01	0.00	0.01	-0.01						
ROA	0.35	0.27	-0.20	-0.07	0.09	-0.18	0.07					
GPR	0.03	-0.17	-0.24	0.10	-0.05	-0.28	0.00	0.13				
I/K	0.03	0.06	0.00	-0.01	0.07	0.01	0.00	0.00	-0.02			
Age	-0.20	-0.03	0.10	-0.18	0.00	-0.01	0.00	0.07	-0.06	0.01		
Age_Cap	-0.02	0.29	0.00	-0.17	0.17	0.03	0.01	0.13	-0.06	0.02	0.31	

From table above we observed the consistent monotonic pattern between the TFP with Size, Book-to-Market ratio, which is also have relatively large correlation coefficient. For the Size and the Book-to-Market ratio, it is consistent with our theory and the monotonic trend shown in the general descriptive statistics. It is intuitively that bigger the size, more capital to be used as R&D or purchase patents, which leads to a higher TFP, similar for Book-to-Market ratio, the higher value for the market value of equity comparing to the book value of the equity, the



expectation of the firm is more positive, implied the growth is at least not declining significantly in basic valuation theory. It is consistent with the TFP theory implied. While the ROA is not shown monotonic pattern in the general descriptive statistics, it has high and positive correlation with the estimated TFP. It is also can be explained as that the firm with higher return on assets will be more capable of supporting innovation and keeping up with new developed technology, which leads to higher TFP.

In the end, based on the general descriptive statistics and correlation coefficients, we investigated the relationship among industrial level of TFP and the Size, the Book-to-Market ratio and the ROA.

Table 3 Industrial Descriptive Statistics

Economic Sector	n	TFP	Size	B/M	ROA
Transportation	158	0.760	5.483	-0.486	0.023
Consulting/Accounting	17	0.896	6.717	-0.864	0.076
Health Care	768	0.769	5.436	-1.009	0.019
Capital Goods	1063	0.675	4.666	-0.472	0.018
Energy	273	0.921	6.565	-0.501	0.031
Technology	1935	0.761	5.039	-0.844	-0.015
Basic Materials	494	0.726	5.881	-0.438	0.023
Communication Services	208	0.897	6.599	-1.026	-0.018
Consumer Cyclical	1663	0.719	4.772	-0.476	0.011
Consumer Staples	868	0.740	5.166	-0.706	0.003

There are three of the industries that have the average TFP higher around 0.9, while for consulting or accounting have obviously few observations than other industries to be comparable with other industries, so we excluded from the top 3 industries. The left two highest TFP industries are Energy and Communication Service. The interesting fact from this industrial level table is that the Communication Service has higher Size and more negative Book-to-Market ratio, but the second lowest ROA. While on the contrary, the Energy section has higher Size but with average level of the Book-to-Market ratio and the ROA.

## 4.2 ASSET PRICING IMPLICATIONS – PORTFOLIOS’ RETURNS

### 4.2.1 Contemporaneous Returns

	Contemporaneous Return									
	Low	2	3	4	5	6	7	8	9	High
Excess Returns	1.240	10.325	13.786	15.792	17.904	20.686	18.657	23.013	23.261	26.557
T Statistic - Newey West Standard Deviations	0.230	2.329	2.617	3.482	3.767	4.210	4.281	4.895	4.900	5.423
Sharpe Ratio	30.068	24.679	29.332	25.254	26.463	27.355	24.264	26.177	26.430	27.266
	0.041	0.418	0.470	0.625	0.677	0.756	0.769	0.879	0.880	0.974

Table 4 Contemporaneous Excess Returns for TFP-Sorted Portfolios (%)

Our result in Table 4 shows that the TFP with intangible capital is positive monotonically related to contemporaneous return. The spread between High and Low is also high with 25.3% and most of portfolios are significant statistic, the Newey West t-statistic is corresponding to the null hypothesis that the mean of this time-series is zero. This mean that the high TFP with intangible capital Portfolio on average can earn an annual premium of 25.3% over the low TFP with intangible capital Portfolio.

The Sharpe Ratio is also positive monotonically trend with the TFP. The higher a portfolio's Sharpe ratio, the better its returns have been relative to the amount of investment risk it has taken. As the High portfolio get the highest Sharpe Ratio, It indicates that the High portfolio took on less risk to achieve the same return. We interpret this is due to the property of TFP as its level refers to “how efficiently and intensely inputs are used in the production process” by Comin (2006).

	Future Returns									
	Low	2	3	4	5	6	7	8	9	High
Excess Returns	12.08	10.94	10.36	10.96	10.93	10.86	8.24	8.76	9.34	8.12
T Statistic - Newey West Standard Deviations	2.91	3.37	2.97	3.46	3.41	3.83	3.00	3.40	3.37	2.47
Sharp Ratio	23.12	18.07	19.39	17.65	17.83	15.80	15.28	14.33	15.45	18.34
	0.52	0.61	0.53	0.62	0.61	0.69	0.54	0.61	0.60	0.44
	Future Returns - Recession									
	Low	2	3	4	5	6	7	8	9	High
Excess Returns	15.94	4.68	5.37	10.73	4.65	3.09	4.25	2.27	5.64	2.02
T Statistic - Newey West Standard Deviations	0.86	0.33	0.37	0.73	0.38	0.33	0.44	0.26	0.53	0.18
Sharp Ratio	37.20	28.16	28.71	29.46	24.56	18.98	19.53	17.51	21.16	22.92
	0.43	0.17	0.19	0.36	0.19	0.16	0.22	0.13	0.27	0.09
	Future Returns - Expansion									
	Low	2	3	4	5	6	7	8	9	High
Excess Returns	11.51	11.87	11.09	10.99	11.86	12.01	8.84	9.72	9.89	9.03
T Statistic - Newey West Standard Deviations	2.80	3.69	3.15	3.55	3.62	4.06	3.08	3.62	3.45	2.62
Sharp Ratio	21.32	16.69	18.29	16.10	17.03	15.36	14.91	13.93	14.88	17.91
	0.54	0.71	0.61	0.68	0.70	0.78	0.59	0.70	0.66	0.50

Table 5 Future Excess Returns for TFP-Sorted Portfolios (%)

From Table 5, the future excess return has the negative monotonically with the TFP. The low TFP-sorted portfolio on average earn a premium 3.9% annually compare to the high TFP-sorted portfolio in the following year. In both periods' expansion and contraction, the future excess returns in low TFP-sorted portfolio is higher than in high TFP-sorted portfolio and both periods share the same negative monotonically relationship with TFP – similar with the future excess return in TFP-sorted portfolios in all states. From the descriptive table, the firms that receive repeated bad shocks (the low TFP firms) end up being the small firms and have low investment, high leverage, low return on equity and high B/M ratio. The high TFP firms are large firms with high investment, low leverage, high return on equity and low B/M ratio. As a result, the low TFP stocks are riskier than the high TFP stocks.

Hence, we interpret the negative monotonically of the future excess returns and the TFP due to the reward to the risk that associated with the low productivity. Our interpretation is fitted with the expansion/recession period. For low TFP-sorted portfolio, the future excess returns in recession is higher than in expansion (15.94% vs 11.51%), which is because during recession, the low TFP firms have higher risk than they have during expansion. Moreover, the spread between high and low TFP firms in recession is also much higher than in expansion (13.92% vs 2.48%), this

difference in spread of return is the evidence that low TFP firms are riskier than high TFP firm, especially during Recession.

On the other hand, we made the average contemporaneous return and future return for TFP-sorted portfolios with Non-Intangible TFP (Imrohoroglu and Tuzel, 2014). The Non-Intangible TFP is estimated by the same methodology of Imrohoroglu and Tuzel (2014).

Comparing the excess returns in Table 4, Table 5 with Table 6 (Intangible TFP-sorted portfolios vs Non- Intangible TFP-sorted portfolios), spreads of all different types of excess returns in Intangible TFP-sorted portfolios is higher than they are in Non-Intangible TFP-sorted portfolios. For example: in average contemporaneous return, the spread of Intangible TFP-sorted portfolios is 25.317% and the spread of Non-Intangible TFP-sorted portfolios is 22.121%. We can interpret that Intangible capital TFP-sorted is more sensitive and stronger relationship to excess returns than the Non-Intangible TFP-sorted portfolios.

Contemporaneous Return - Tuzel TFP										
	Low	2	3	4	5	6	7	8	9	High
Excess Returns	2.821	11.512	13.533	16.630	17.527	20.377	21.453	21.539	22.323	24.942
T Statistic - Newey West Standard Deviations	0.507	2.415	2.785	3.716	3.739	4.420	4.740	4.721	5.341	5.301
Sharp Ratio	30.997	26.538	27.053	24.919	26.096	25.667	25.198	25.404	23.271	26.199
	0.091	0.434	0.500	0.667	0.672	0.794	0.851	0.848	0.959	0.952
Future Returns - Tuzel TFP										
	Low	2	3	4	5	6	7	8	9	High
Excess Returns	11.69	11.32	10.81	10.13	9.64	10.10	9.54	7.15	8.90	9.55
T Statistic - Newey West Standard Deviations	3.03	3.16	3.36	3.19	3.10	3.82	3.86	2.68	3.18	2.84
Sharp Ratio	21.49	19.91	17.90	17.69	17.31	14.73	13.76	14.86	15.57	18.73
	0.54	0.57	0.60	0.57	0.56	0.69	0.69	0.48	0.57	0.51
Future Returns - Recession - Tuzel TFP										
	Low	2	3	4	5	6	7	8	9	High
Excess Returns	12.79	9.62	5.85	2.73	5.47	4.89	3.73	3.01	2.65	3.67
T Statistic - Newey West Standard Deviations	0.80	0.61	0.43	0.26	0.42	0.42	0.43	0.31	0.24	0.33
Sharp Ratio	32.11	31.54	27.34	21.23	25.76	23.13	17.45	19.56	22.18	22.06
	0.40	0.30	0.21	0.13	0.21	0.21	0.21	0.15	0.12	0.17
Future Returns - Expansion - Tuzel TFP										
	Low	2	3	4	5	6	7	8	9	High
Excess Returns	11.52	11.57	11.55	11.22	10.25	10.87	10.40	7.76	9.83	10.42
T Statistic - Newey West Standard Deviations	2.94	3.25	3.59	3.37	3.27	4.17	4.06	2.80	3.48	2.93
Sharp Ratio	20.33	18.50	16.71	17.30	16.31	13.56	13.32	14.41	14.70	18.50
	0.57	0.63	0.69	0.65	0.63	0.80	0.78	0.54	0.67	0.56

Table 6 Excess Return for Tuzel TFP-sorted Portfolio

### 4.3 ASSET PRICING IMPLICATIONS – CAPM AND FAMA FRENCH THREE FACTOR MODEL

CAPM										
	Low	2	3	4	5	6	7	8	9	High
Alpha	-11.35	0.42	2.92	5.25	8.3	11.23	9.17	13.36	11.80	17.55
	(-17.01)	(0.46)	(3.38)	(5.22)	(8.11)	(8.69)	(8.52)	(11.16)	(9.51)	(14.00)
MKT	1.22	0.97	1.19	1.12	1.1	1.08	1.16	1.19	1.22	1.24
	(32.15)	(21.40)	(11.51)	(19.31)	(17.68)	(14.54)	(22.05)	(19.25)	(19.00)	(21.34)
FF										
	Low	2	3	4	5	6	7	8	9	High
Alpha	-10.85	-0.10	1.78	5.64	7.4	10.48	9.24	14.67	13.38	20.35
	(-12.78)	(-0.11)	(1.92)	(4.97)	(6.84)	(7.68)	(7.8)	(10.13)	(10.16)	(13.16)
MKT	1.15	0.97	1.15	1.04	1.06	1.04	1.09	1.06	1.13	1.09
	(34.77)	(22.97)	(13.32)	(19.94)	(19.16)	(16.03)	(22.25)	(19.18)	(18.87)	(22.24)
HML	-0.04	0.33	0.27	0.078	0.18	0.25	0.083	-0.14	-0.19	-0.41
	(0.64)	(4.61)	(3.15)	(0.92)	(2.56)	(2.50)	(0.98)	(-2.99)	(-2.21)	(-3.59)
SMB	1.60	1.22	1.19	1.30	1.38	1.46	1.15	1.25	1.06	0.96
	(22.35)	(14.83)	(10.72)	(12.20)	(12.48)	(9.0)	(11.39)	(9.13)	(8.95)	(7.59)

Table 7 Alphas and Betas of Portfolios Sorted on TFP (% Annualized)—Dependent Variable: Excess Returns

The table 7 present the alphas and betas TFP-sorted portfolios for the of CAPM and Fama - French 3 factors models. Alphas are the intercept from regression, betas are the coefficients of the factors which are estimated from regression.

From the table we find that the MKT in both CAPM and FF, The HML in FF are nonmonotonic. However, the HML have higher loading in low portfolio than in high portfolio. The SMB has heavier loading in low portfolio rather than in high portfolio. From these results, we can interpret that TFP have systematically related to SMB.

# Chapter 5: Conclusions

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## 5.1 CONCLUSIONS

From the results and analysis above, we investigated the relationship between the returns with the firm level of the TFP with intangible. First of all, the estimated TFP combine with the intangible is proper correlated and share consistent monotonical trend cross 10 TFP-sorted portfolio with classical firm characteristics, the Size and the Book-to-Market ratio, the Return of Asset. Meanwhile, even though the Capital Age shares trend with the TFP shares, there is no proper correlation between these two. While the industrial level of the TFP does not display obvious pattern.

We use the TFP-sorted portfolio investment strategy, the contemporaneous returns of the TFP-sorted portfolio are increasing with TFP increase, while the future returns decreasing with the TFP increasing. To have reasonable comparison for the estimated TFP without intangible assets and with intangible asset, we compare the portfolios' returns and spread with Imrohoroglu and Tuzel (2014) while keep everything else same. Empirically, the TFP with intangible assets (estimated by us) are stronger relationship with return. For Fama-French approach, we conclude the TFP is more related to the SMB factor.

## 5.2 LIMITATIONS

First, we use NBER Business Cycle to determine the Expansionary and Contractionary period. However, NBER business cycle are often published after the start of Expansion or Contraction. Therefore, in real time, the investors should use Industrial Production from the Board of Governors of the Federal Reserve System to predict the expansionary/contractionary period.

Second, based on previous study, we assume that 30% of spending on SG&A would be an investment in organization capital. This is a strong assumption. Due to the limitation of this report, we did not do the sensitivity analysis for the investment in intangible asset

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# Appendices

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## Appendix A

Names	Abbreviations
Adjustment Factor (Company) - Cumulative by Ex-Date	AJEX
Assets - Total	AT
Cost of Good Sold	COGS
Common Shares Outstanding	CSHO
Long-Term Debt - Total	DLTT
Depreciation and Amortization	DP
Accumulated Depreciation, Depletion and Amortization	DPACT
Dividends - Preferred/Preference	DVP
Numbers of Employees	EMP
Gross Profit (Loss)	GP
Income Before Extraordinary Items	IB
Intangible Asset - Total	INTAN
Liabilities - Total	LT
Net Income (Loss)	NI
Property, Plant and Equipment - Total (Gross)	PPEGT
Preferred/Preference Stock (Capital) - Total	PSTK
Preferred Stock - Liquidating Value	PSTKL
Preferred Stock - Redemption Value	PSTKRV
Sales	SALE
Income Taxes - Deferred	TXDI
Deferred Taxes and Investment Tax Credit	TXDITC
Research and Development Expense	RXD
Price Close - Annual - Fiscal	PRCC_F
Selling, General and Administration Expense	SXGA