

# *Intellectual Property Intensity (IPI)*

## *and the Value-Growth*

### *Effect*

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#### **Abstract**

Intellectual Property Intensity (IPI) measures the weight of IP in the firm's total market value. IPI has a positive (convex) functional relationship with Price to Book (P/B) ratio, and thus may provide additional economic insight to the empirical value-growth effect. Growth firms have higher IPI while value firms are characterized by lower IPI. The large (small) weight of IP in growth (value) firms can explain their higher (lower) profitability. This is due to: (i) the monopolistic power that results from IP and (ii) the higher risk associated with IP. Thus, the lower (higher) returns that characterize growth (value) stocks should be attributed to market inefficiency and mispricing and not to lower (higher) risk. The positive bias in growth stock prices is explained by the inability of investors to fully account for the risk associated with IP.

Using a sample of biotechnology companies I compare the forecasting ability of IPI versus P/B. I find that IPI has a superior forecasting ability over P/B.

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## 1. Introduction

Recent work and debate in the financial literature is focused on the value-growth effect and its sources. The value-growth effect, a widely observed empirical phenomena, states that the so-called growth (value) firms, distinguished by their high (low) Price to Book (P/B) ratio, tend to have higher (lower) future profitability, but their stocks tend to generate lower (higher) returns. The profitability superiority of growth firms versus value firms is reported by Fama & French (FF, 1995), Fairfield (1994), Bernard (1994) and Frankel & Lee (FL, 1997). The positive return differential between value and growth stocks is reported by FF (1992, 1996, 1997), Lakonishok, Shleifer & Vishney (LSV, 1994), Davis (1994), Chan, Hamao & Lakonishok (1992), Capaul, Rowley & Sharpe (1993) and FL (1997).

The evidence of the value-growth effect is conclusive, but there is an extensive debate about the economic explanation of this phenomena. One explanation is that the higher returns that characterize value stocks reflect higher risk associated with these companies. The main advocates of this view are FF (1992, 1993, 1996, 1997) and Daniel & Titman (1995). A second view, supported by LSV (1994) and FL (1997), is that the value-growth effect represents market inefficiency and specifically over optimistic (pessimistic) mispricing of growth (value) stocks.

The economic foundation of both theories is not straightforward since P/B, which is the metric used to distinguish between value and growth firms, does not represent any clear economic characteristic of the firm. FL (1997) use accounting based valuation model to represent a more interpretable formulation of P/B. Following their notation V/B, which is the theoretical value for P/B is:

$$(1) \quad (V/B)_t = 1 + B_t^{-1} \cdot \sum (1+r_e)^{-i} E_t [(ROE_{t+i}-r_e) \cdot B_{t+i-1}]$$

Where:

- B - Book value.
- ROE - Return on book equity.
- $r_e$  - Cost of equity capital.
- E - Expectations operator

This representation lends economic sense to the (theoretical) P/B ratio. P/B is a function of the discounted expected (infinite) sum of abnormal earnings, weighted by their respective book values. Growth firms are

expected to have ROE higher than their cost of equity capital, while value firms are expected to have ROE close to their cost of equity capital.

The FL representation associates the value-growth effect with future profitability. Investors can successfully identify which firms will have high (low) profits and are ready to pay higher (lower) prices for these firm's stocks. Explanation of the return aspect of the value-growth effect is less straightforward. FL suggest that the return effect is caused by mispricing and support this view by presenting empirical findings showing that the P/B ratio is positively correlated with higher than average forecasts for ROE: "*Specifically, we find that the consensus I/B/E/S forecasts is too high (too low) for low (high) B/P firm,...*" (FL, 1997 p. 24). According to this explanation investors can predict correctly whether a firm will have higher (lower) than normal future profits, but are over optimistic (pessimistic) about the size of such profits and thus positively (negatively) misprice the firm's stocks.

Although the FL representation is economically plausible the mispricing issue is still puzzling. Examination of the empirical results of FL shows that the cross-sectional average ROE in their sample ranges between 8% to 18%, and the intertemporal average (over 18 years covered by their data set) is 13%. These figures coincide with the commonly used cost of equity capital in the U.S.A. which is in the range of 10% to 15%, as shown by Palepu, Bernard & Healy (PBH, 1996). Moreover, PBH show that ROE, in U.S. industrial firms, tends to revert to 13% in a period of 3 to 5 years. However, if we look at the P/B series in the FL study we see that the cross-sectional average P/B ranges between 1.38 and 2.96 and the intertemporal average is 2.18. Thus, there is a discrepancy between the observed average long-run ROE and P/B. Since the average long-run ROE is very close to the cost of equity capital, we should expect that the average long-run P/B will be close to 1, otherwise we must conclude that investor's expectations are irrational. Instead we find an average premium, amounting to 118%, of market value over book value. It is peculiar why, over long period of time, investors are consistently wrong in their expectations. FL account the discrepancy between the observed ROE and P/B to conservative accounting policies, however the extent of the difference seems too high to be explained in such manner.

In a previous article (Malki, 1997) I have suggested a measure for the Intellectual Property Intensity (IPI) of a firm, and have shown some desirable properties of this measure. This article examines the theoretical and empirical functional relationship between IPI and P/B. The

identification of positive functional relationship between IPI and P/B suggests that the value-growth effect can be understood within the framework of IP analysis. Furthermore, the forecasting ability of IPI relative to P/B is examined and is found to be superior.

Section 2 describes the data set used for the empirical analysis; section 3 explains the concept of IPI and shows its functional relationship with P/B; section 4 analyzes the value-growth effect in IP framework; section 5 compares the forecasting ability of IPI relative to P/B; and section 6 concludes the article.

## **2. The Data**

For the empirical analysis I have used financial and market data for 47 biotechnology public companies which comprise the Genetic Engineering News Index (GEN-DEX). As I have previously shown the biotechnology sector has different IPI distribution than the U.S. industrial norm (Malki, 1997). Moreover, being a sector that derives most of its value from IP we might expect that IPI will be more uniform across biotechnology companies.

Data were available to the years 1991-1996 through the Wall Street Research Net (WSRN). Some companies were not publicly traded in 1991-1992, and I have also excluded anomalies such as negative book values and extremely high P/B values. The last column of Table 1 lists the number of observations available for each year. definitions of the variables in the data set are available via WSRN and may be found at <http://www.wsrn.com>.

## **3. The concept of IPI.**

A similar concept to IPI is described by Smith & Parr (SP, 1993); the following analysis is taken from Malki (1997). The IPI concept is based on the observation that a firm's value is the sum of its tangible and intangible asset values. Tangible assets include current assets (such as cash, securities, inventories and receivables) and fixed assets (such as buildings, machinery and vehicles). Intangible assets include on-the-job training, know-how, brands, trademarks, copyrights and patents. Although financial statements can reflect only the tangible portion of the firm's value, markets evaluate firms according to the full scope of their

assets worth. Thus, we can estimate the value of intangible assets by combining market data with fundamentals.

A significant insight, initially presented by Modigliani & Miller (MM, 1958), is that the value of a firm is the sum of its equity market value and its debt market value. Debt market value is usually assumed to equal the respective book value, and thus we can calculate the firm's market value as the sum of its market capitalization and the book value of its current liabilities and long term debt. The difference between the firm's market value and its assets book value is a fair estimate of its intangible assets worth.

The ratio of intangible assets worth to the total firm's market value is the Intellectual Property Intensity (IPI). IPI has some desirable properties making it a good mean for comparison between different companies. Since the tangible assets value is always positive, IPI must be, by definition, less than one. Intangible assets value can be negative, usually when the market is extremely pessimistic about the firm's prospects, however, when this anomaly is discarded IPI will vary between 0 and 1. Firms with IPI close to zero derive most of their value from their tangible assets, while values close to one characterize firms that use intellectual property as their main source of value creation.

The mathematical representation of IPI is fairly straightforward:

By definition:

$$(2) \quad ABV = CA + NFA = B + D$$

Where:

ABV - Assets book value  
CA - Current assets  
NFA - Net fixed assets  
B - Equity book value  
D - Debt book value

The definition of the firm's value proposed by MM is:

$$(3) \quad AMV = EMV + DMV$$

Where:

- AMV- Assets market value which, according to MM, is equal to the discounted sum of future net operating income (income before interest payments minus tax).
- EMV - Equity market value.
- DMV - Debt market value.

Assuming that debt's market value (which is usually not observable) can be fairly estimated by debt book value we get:

$$(4) \quad AMV = D + EMV$$

Equation (4) defines AMV as a combination of balance sheet figures and market data.

Intellectual Property Intensity (IPI) is defined as:

$$(5) \quad IPI = (AMV - ABV)/AMV$$

Combining (2), (4) and (5) leads to another representation:

$$(6) \quad IPI = (EMV - B)/(EMV + D)$$

Dividing the numerator and the denominator by B represents IPI as a function of P/B:

$$(7) \quad IPI = (P/B - 1)/(P/B + D/B)$$

Where:

D/B is the financial leverage.

Inverting (7) leads to the representation of P/B in terms of IPI:

$$(8) \quad P/B = (1 + IPI(D/B))/(1 - IPI)$$

#### **4. IPI and the value-growth effect.**

Equation (8) defines the functional relationship between IPI and P/B. When IPI equals zero P/B equals one, suggesting that firms with no IP have market value that is equal to their book value. When IPI is close to one, meaning that the firm derives most of its value from IP, P/B will tend to be very high. This observation can explain the fact that the

average long-run P/B is higher than one. Since most firms use IP in their business activities, at least to some extent, we should expect that the average P/B will be higher than one.

Further insight can be gained from the partial derivatives of P/B in respect to IPI.

The first derivative is:

$$(9) \quad d^1(P/B)/d(IPI) = (D/B + 1)/(1 - IPI)^2$$

which is always positive (excluding negative book values as anomalies).

The second derivative is:

$$(10) \quad d^2(P/B)/d(IPI) = 2/(1 - IPI)^3$$

and is also positive since IPI is by definition smaller than 1.

The signs of the partial derivatives suggest a positive convex functional relationship between P/B and IPI. Diagrams 1-a to 1-c present P/B versus IPI in our sample of biotechnology companies for the years 1994-1996. The positive convex functional relationship is very apparent.

The functional relationship between P/B and IPI sheds new light on the value-growth effect. Growth (value) firms are characterized by high (low) IPI, but unlike P/B, IPI lends itself to economic interpretation. The two aspects of the value-growth effect can be explained in the framework of IP characteristics. High future profitability is a result of higher use of IP. SP (1993) examine a large sample of firms from various industries and show that high IPI (defined there slightly different) is positively correlated with net income and gross profit margins. Moreover, there is a plausible theoretical explanation to such abnormal profits. IP is expected to generate higher profits due to two main reasons:

1. IP usually enables firms to exercise certain monopolistic power over their competitors. The most explicit form of such monopolistic power is patent protection, however trademarks, copyrights and trade secrets are also means to limit competition.
2. IP is riskier than tangible assets and thus firms will invest in IP only if it generates higher than normal returns. The higher risk of IP is attributed to the following factors:

- One) *Lack of marketability*: Most tangible assets have markets where they can be sold and, at least partially, be liquidated. Such markets include the very liquid bonds and money market, and the less liquid real estate market, used vehicles market and used machinery market. In general firms that need to liquidate their tangible assets will usually find markets for a significant portion of these assets. Moreover, these markets are usually monitored and information about prices is widely available. IP often lacks marketability at all, but even if such markets exist, IP's pricing is very complicated (see Malki 1997) and thus IP prices are less observable.
- Two) *Difficult redeployment*: Tangible assets can be redeployed whether by other firms, in case of liquidation, or by the same firm for different uses. IP is usually much more specific and thus is harder to redeploy.
- Three) *Unpredicted obsolescence*: Tangible assets life span can be fairly projected since unpredicted obsolescence is rare. Moreover, the risk of such unpredicted obsolescence can usually be completely insured. IP on the other hand is subject to frequent unpredicted obsolescence and its life span is usually unknown. Such unpredicted obsolescence can result from failure of the R&D activity to develop a product, failure of the advertising campaign to establish a viable brand, shifts in technology and shifts in public attitude. The common effect of all these events is that they instantly make the investment in the said IP obsolete.

The above analysis suggests that the low (high) returns on growth (value) stocks cannot be explained by *lower (higher) risk*, since growth (value) firms, with higher (lower) IPI, are exposed to *higher (lower) risk*. IP-based analysis leads to the conclusion that the value-growth effect must be attributed to market inefficiency and mispricing.

Such market inefficiency and mispricing can also be explained in the framework of IP analysis. When investors shape their expectations about the firm's value they basically sum the values of the various components of the firm's assets base. Since prices of IP are usually not observable, due to the lack of marketability, we should expect higher pricing errors in relation to stocks of high IPI firms. This, however, does not explain why the mispricing of high IPI firms is positively biased (e.g. high IPI firm's stocks tend to have too high prices and thus generate lower than average

returns). The reason for such positive mispricing bias can be attributed to the unpredicted obsolescence risk associated with IP. Conventional capital budgeting theory suggests that, facing uncertainty, investors can make rational decisions about their investment if they know (or can fairly estimate) the probabilities of the different outcomes. I suggest that the probabilities of unpredicted obsolescence cannot be estimated by investors. Estimating probabilities is possible when events are reoccurring and thus frequencies of past events can be used to estimate the probabilities of future events. While the probability of R&D failure or failure of advertising campaign may be predicted from past experience, shifts in technology or shifts in public attitude cannot be predicted. Who could predict that PCs will become so effective and cheap driving other types of mini-computers out of the market, or that the internet will explode with free information threatening the solvency of on-line information companies, or that ecological awareness will force car makers to focus on low-emission cars. At the time when these events occurred there was no relevant past experience and thus the probability for there occurrence was not predictable. Thus, due to the unique characteristics of IP, it is possible for investors to systematically underestimate the risk associate with investing in IP, and thus create overoptimistic expectations regarding high IPI firms and overvalue their stocks.

## **5. The forecasting performance of IPI versus P/B.**

Certain properties of IPI makes it a useful metric for determining stock values. Unlike the V metric, proposed by FL, IPI is objective since it is made of financial and market data, without subjective estimates such as the cost of equity capital and the expected future earnings. Compared with P/B, which is also an objective metric, IPI has superior forecasting performance.

Table 1 presents descriptive statistics of P/B and IPI in the sample of biotechnology companies. The average biotechnology company in the sample had P/B in the range of 4 to 7, and IPI in the range of 56% to 74%. Excluding the year 1994, which was unfavorable for the biotechnology sector, the average P/B ranges between 4.5 to 7, and the average IPI ranges between 65% to 74%. IPI is more concentrated around its mean than P/B as demonstrated by the coefficient of variation (the standard deviation divided by the mean) which is substantially

smaller for IPI than for P/B. This suggests that the cross-sectional average IPI may be an efficient forecasting estimator.

An important feature of value metrics is their ability to forecast future stock prices. I have compared the ex-post forecasting ability of P/B versus IPI. For each metric I have constructed one-period-ahead forecasts using: (i) the average value of the metric, for each company in the sample, over the period prior to the forecast year (time-series model); (ii) the cross-sectional average of the metric one year prior to the forecast year (cross-section model). Using the time-series model I have computed forecasts for 1996, 1995 and 1994, by averaging the values of each company's metric for 1991-1995, 1991-1994, and 1991-1993 respectively. Using the cross-section model I have computed forecasts for 1992-1996 using the metric cross-sectional averages for 1991-1995 respectively. The forecasts are calculated ex-post using the fundamental values (e.g. the equity and debt book values) of the forecast period.

Forecasts are generated using the following equations:

$$(11) \quad EMV_{t+1} = B_{t+1} \cdot \overline{(P/B)}$$

$$(12) \quad EMV_{t+1} = (B_{t+1} + \overline{IPI} D_{t+1}) / (1 - \overline{IPI})$$

The forecasting errors for each model and each metric were computed using RMSE (root mean square error) and MAE (mean absolute error), and the results are shown in Table 2.

In general forecasts generated by IPI are superior to those generated by P/B, in both models, for all forecast periods. In the time-series model the reduction in the forecast error, due to the use of IPI instead of P/B, is significant by the RMSE criterion, but marginal by the MAE criterion (RMSE penalizes for large forecast errors while MAE does not). In the cross-section model the reduction in the forecast error, due to the use of IPI instead of P/B, is much more substantial and significant by both RMSE and MAE. The superiority of forecasts based on IPI, relative to those based on P/B, is conclusive in this sample.

## 6. Conclusions

Intellectual Property Intensity (IPI) is positively related to P/B. This functional relationship between the two metrics enables me to suggest a

plausible explanation to the value-growth effect in the framework of IP analysis.

I suggest that the high future profitability observed in growth firms is a result of (i) the monopolistic power gained by using more IP; and (ii) the higher risk associated with IP which means that firms will invest in IP only if profits are expected to be superior.

This proposition rejects the theory that growth (value) firms have lower (higher) risk associated with their activities, and thus indirectly supports the theory that the lower (higher) returns observed in growth (value) stocks are the result of market inefficiency and mispricing.

I further suggest that the positively-biased mispricing of growth stocks is a result of unique characteristics of the risk associates with IP, and specifically the unpredictability of obsolescence. Investors are unable to account for this risk, since past experience is not available, and thus consistently overprice high IPI (growth) firms.

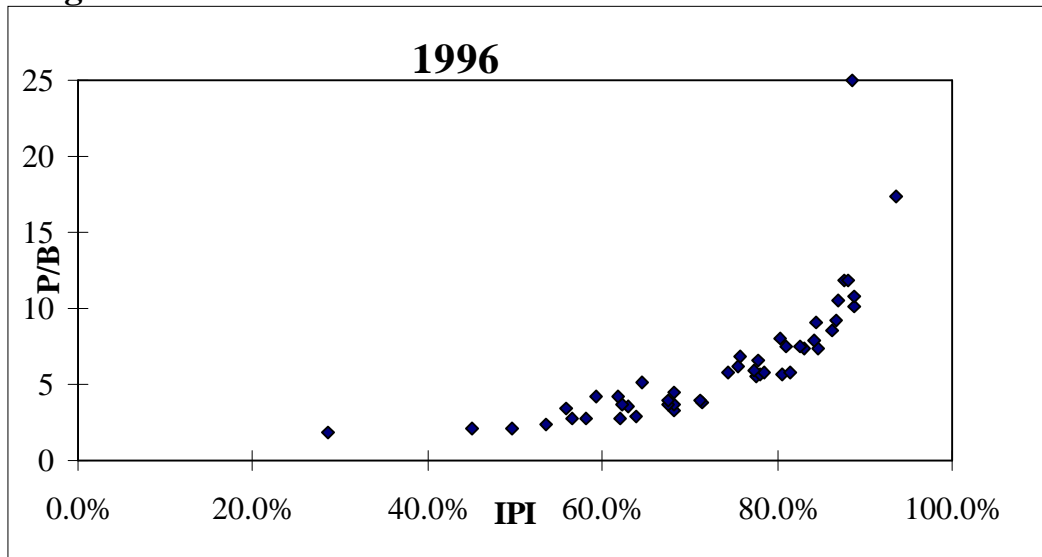
IPI, like P/B, belongs to the family of objective value metrics, since it is derived solely from financial and market data. I compare the ex-post forecasting performance of these two metrics and find that IPI provides more accurate forecasts than P/B.

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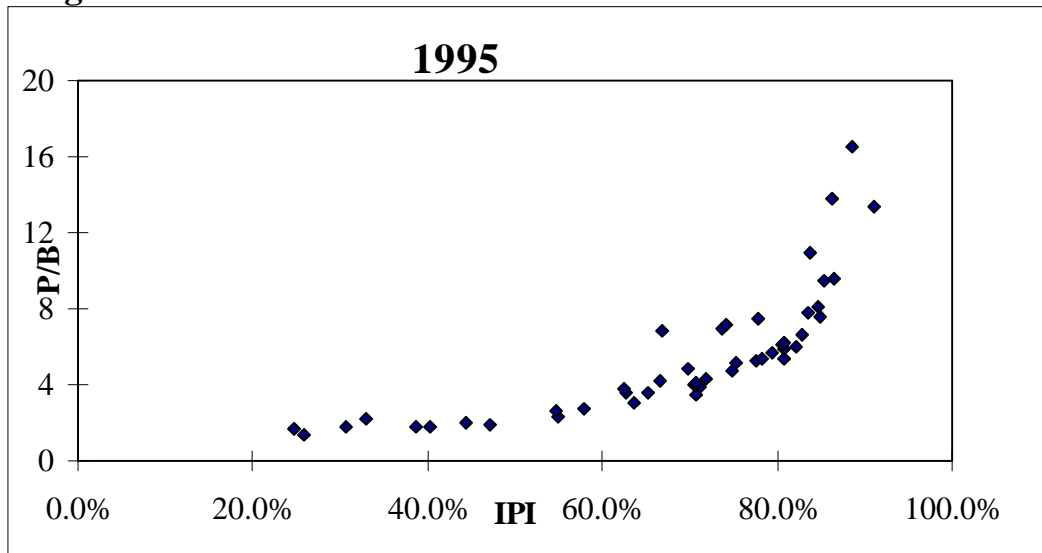
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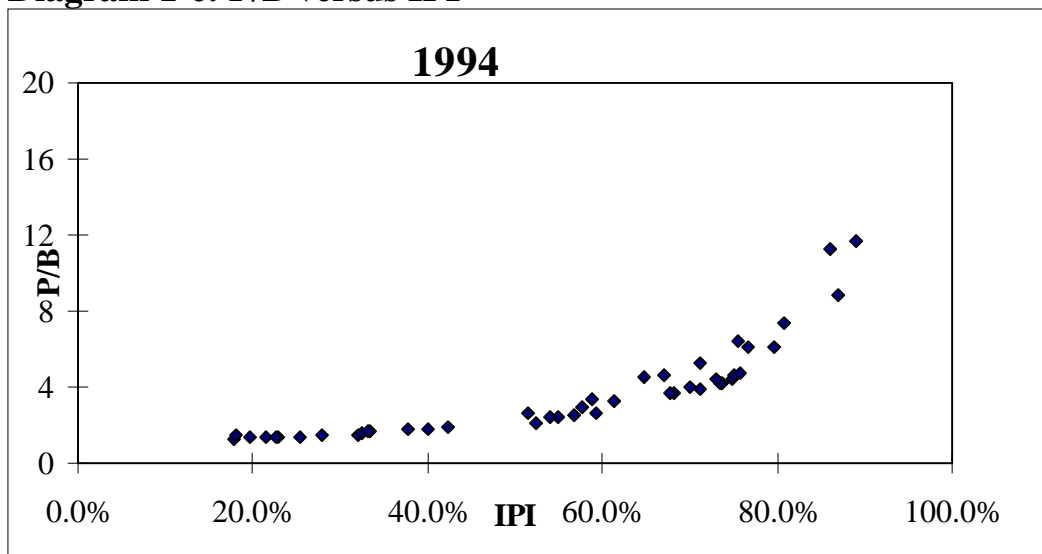
**Diagram 1-a: P/B versus IPI**



**Diagram 1-b: P/B versus IPI**



**Diagram 1-c: P/B versus IPI**



**Table 1: Statistical Properties of the Sample**

	Mean	Median	Standard Deviation	Coefficient of Variation	Observations
<i>Price to Book</i>					
<b>1996</b>	6.39	5.66	4.22	66.0%	47
<b>1995</b>	5.51	5.03	3.36	61.1%	46
<b>1994</b>	4.09	3.29	3.75	91.7%	45
<b>1993</b>	4.54	3.93	3.68	81.1%	45
<b>1992</b>	5.09	3.97	3.79	74.6%	43
<b>1991</b>	7.09	5.15	5.41	76.3%	41
<i>IPI</i>					
<b>1996</b>	72.7%	75.8%	13.6%	18.7%	47
<b>1995</b>	68.2%	72.8%	17.7%	26.0%	46
<b>1994</b>	56.0%	59.2%	22.1%	39.4%	45
<b>1993</b>	64.6%	69.8%	17.8%	27.5%	45
<b>1992</b>	68.8%	71.3%	13.8%	20.1%	43
<b>1991</b>	73.7%	73.7%	15.6%	21.2%	41

**Table 2: Forecast Accuracy of IPI versus P/B.****Forecast Accuracy of Time Series Model:**

	P/B		IPI	
	<i>MAE</i>	<i>RMSE</i>	<i>MAE</i>	<i>RMSE</i>
<b>1996</b>	50.8%	78.9%	49.7%	63.8%
<b>1995</b>	50.4%	68.1%	48.5%	63.9%
<b>1994</b>	80.2%	118.3%	70.3%	112.9%

**Forecast Accuracy of Cross Section Model:**

	P/B		IPI	
	<i>MAE</i>	<i>RMSE</i>	<i>MAE</i>	<i>RMSE</i>
<b>1996</b>	50.2%	67.1%	41.2%	51.7%
<b>1995</b>	50.9%	66.3%	48.9%	54.4%
<b>1994</b>	99.7%	138.7%	66.9%	91.9%
<b>1993</b>	75.5%	107.4%	47.1%	63.3%
<b>1992</b>	103.7%	134.4%	44.6%	59.6%