R&D value of Chinese manufacturing listed companies

Based on the financial market's valuation of corporate assets

An Tongliang
School of Economics, Nanjing University, Nanjing, China, and
Wang Wenyi
Shen Wan & Hong Yuan Securities, Shanghai, China

Received 14 October 2018
Accepted 14 October 2018

Abstract

Purpose – The way to measure the value of an enterprise's R&D investments remains elusive for theoretical and empirical study on innovation economics. The paper aims to discuss this issue.
Design/methodology/approach – This paper expands the asset-value model pioneered by Griliches (1981) and applies it for the first time to the Chinese stock market to calculate the value of R&D investment instilled by Chinese manufacturing listed companies (CMLCs) from 2003 to 2014.
Findings – The authors find that: the assets-value model can better explain the enterprise value composition of CMLCs; with equal input, the value of R&D is higher than that of tangible assets, and lower than that of organizational assets; compared with the developed countries, the R&D value of CMLCs is lower; and the R&D value of CMLCs saw a downward trend from 2007 to 2014.
Originality/value – Furthermore, by rationally estimating the value of organizational assets and non-tradable shares, and innovatively introducing semi-annual momentum indicators from the perspective of behavioral finance to control the influence of investor sentiment on enterprise value, this paper tries to develop the asset-value model and provides a feasible solution to the problem of measuring the value of Chinese enterprises' R&D investment.

Keywords Innovation, Investor sentiment, Market valuation, Asset-value model
Paper type Research paper

1. Introduction

As the key source and the inexhaustible driving force of economic growth, innovation primarily originates from the research and development (R&D) behavior of enterprises. Measuring the value of corporate R&D activities is of pivotal importance to corporate management, market investment, academic research and policy development, but the nature of innovation activities (high risk, inter-temporal revenue span and severe information asymmetry) makes such measurement a hard nut in both the theoretical and empirical study of innovation economics.

In this regard, there are three major research paths in academia, which estimate the R&D value of enterprises from three aspects: productivity, performance indicators and market value. The most common approach is the use of various production function models to measure the contribution of R&D inputs to total factor productivity (Mairesse and Mohnen, 1995), which is mainly guided by the theory of endogenous growth, and model estimates based upon Cobb Douglas functions, transcendental logarithmic functions, etc. However, this approach has the

This paper is funded by the National Special Support Program for High-Level Talents Recruitment (Ten Thousand Talents Program).

China Political Economy
Vol. 1 No. 2, 2018
pp. 241-262
Emerald Publishing Limited
2516-1652
DOI 10.1108/CPE-10-2018-012

following defects: R&D activity is highly uncertain, and even experienced industry experts can hardly estimate the final result in the R&D process; R&D activities are of a hysteretic nature that renders the current index very indirect and imperfect in terms of R&D value, and the lagging indicator often means that the data length is not enough to accurately estimate the overall effect; and the determination of the production function parameters is highly controversial and has undue influence on the final result. The second approach is to use performance indicators such as patents, technology licenses, profits or outputs to directly measure R&D value. This method also has certain defects: the number of patents is not comprehensive and sufficient. Because the value distribution of patents is extremely skewed, some patents are very valuable, and many are worthless (Harhoff *et al.*, 1999; Scherer *et al.*, 2000); the value of a technology license constitutes only a small part of the direct return of R&D, and most firms' innovations do not take the form of technology licenses to generate revenue; and the profit or output at the enterprise or industry level is affected by many other factors, from which the impact of R&D is difficult to be separated. Aside from the above two approaches, the market value method borrows a specific method in the commodity demand literature, namely, the hedonic price equation, to measure the values of knowledge assets formed by different corporate investments into R&D. The underlying assumption is that: a listed company is a combination of assets (usually including plant and equipment, inventory, intellectual property, trademarks and reputation), whose value is determined by the financial market every day, and the margin shadow value (total return) of knowledge assets in the market can be obtained from the regression coefficient. Estimating R&D value using market value method has its own advantages: perspectiveness (forward-looking): since the shadow price of the intellectual property formed by R&D contains all current information about the success or failure of the R&D investment, it relies on the valuation of corporate assets in the financial market, which is more concerned with expected returns than historical returns. Second is rationality: because asset prices are fair pricing formed by full transactions of the market, they are not easily manipulated by financial personnel. Third is feasibility: the public financial statement of listed companies form the basis for market investors to price the company, and can also be used to price different types of assets. Griliches (1981) first adopted this method to determine the marginal value of adding one unit of investment to R&D assets by regressing the assets of firms. Following this groundbreaking work, many studies have adopted hedonic price equation in the capital market, namely, an assets-value model to analyze relationships between R&D (in stock and in flow) and market value (Griliches, 1981; Hall, 1993a; Blundell *et al.*, 1999; Toivanens *et al.*, 2002; Munari and Oriani, 2005; Nagaoka, 2006; Greenhalgh and Rogers, 2006; Chadha and Oriani, 2010; Sandner and Block, 2011).

These early researches focus mostly on US-listed companies, and then gradually on other countries and regions, such as Europe, Australia, Japan, India, Chinese Taiwan and South Korea. However, these studies ignore the impact of market volatility and investor sentiment on enterprise value, and nor do they notice the impact of organizational assets on the firm's market value. In China, only Wang and An (2014) studied the impact of the size of Chinese manufacturing listed companies (CMLCs) on R&D investment performance in 2003–2011 with the assets-value model, but the research variables were relatively unitary. To this end, this paper introduces investor sentiment variables from the perspective of behavioral finance, estimates organizational assets, comprehensively expands the assets-value model pioneered by Griliches (1981), and uses the panel financial data of CMLCs in 2003–2014 to measure the value of their R&D investment and its changes.

2. Theoretical framework and econometric model

2.1 Theoretical framework

The basis for applying the hedonic price equation in the capital market is the Tobin's Q theory: the long-term equilibrium market value of a company's assets should equal the replacement value of these assets. When the market is in an unbalanced state, i.e. Tobin's

$Q \neq 1$, the firm has the incentive to increase or decrease the investment; otherwise there should be unmeasured assets or rents, rendering a difference between the market value and the book value. Firm value is seen as a dynamic optimization strategy for a given portfolio of assets to maximize the discounted value of future cash flows generated by that portfolio. Since asset adjustment is not cost-free, the current state of the company's capital determines the optimal value of the existing portfolio. This means that the company as a continuing entity can have its market value represented as a function of this group of assets. R&D inputs generate knowledge and experience, and their accumulation constitutes the company's technical knowledge stock, ultimately forming a knowledge asset whose value is equal to the present value of its future returns. Assuming that the intellectual assets created by R&D investment will generate profits in the future, and that these profits are capitalized by the stock market as part of the company's stock price, the contribution of intellectual assets should be reflected in the company's market value. It is thus possible and economically meaningful to use the company's market value as an indirect indicator of R&D's expected future returns.

The intellectual asset created by R&D investment has been the focus of many researches. However, as an important part of intangible assets, the impact of organizational assets on firms' market value has not received due attention. As an intangible asset that exists in corporate organization, organizational capital (assets) encompasses explicit or tacit knowledge of the organization's proprietary experience, rules and culture. Although organizational assets are not reflected in financial statements, they constitute an important part of intangible assets of firms, affecting the portfolio of physical capital, human capital and intellectual capital, enabling enterprises to smoothly produce products or provide services. Organizational assets include three aspects: the framework of rational allocation of power as a resource in an organization; the operational processes, regulations and unwritten practices formed by the organization; and the mechanisms for promoting knowledge creation, dissemination and communication in the organization (Liu and Chen, 2007). Studies outside China have shown that organizational assets have a significant contribution to market value (Brynjolfsson *et al.*, 2002; Hulten and Hao, 2008; Piekkola, 2016), but the author has not seen similar studies China. Therefore, this paper attempts to estimate the organizational assets of CMLCs and incorporate them into the assets-value model to control the impact of organizational assets on the company's market value.

In the assets-value model pioneered by Griliches (1981) and expanded by future generations, the company's market value is seen as a function of corporate assets consisting of tangible and intangible assets, and a series of control variables reflecting corporate risk-taking, market position and financial performance have been incorporated. However, this framework suffices not to explain the substantial fluctuations in corporate market value during the bull or bear capital markets, wherein the sharp rise and fall of the stock price of listed companies often embodies not the big changes in firms' own operating conditions, but those in the market environment. Environmental factors that affect all listed companies, such as macroeconomic conditions, can be controlled by using time dummy variables. In addition, investors who are both parties to the market are themselves part of the market environment and have a significant impact on company pricing. Since behavioral finance believes that investors are not "rational man" but "run-of-the-mill (ordinary normal) man," the existence of cognitive bias makes it impossible for investors to reflect and process information objectively, fairly and unbiasedly; hence, the market is not effective, the asset price is also irrational and the asset price is determined not only by the intrinsic value of the asset, but also by the psychological and emotional factors of the investors (Han Zexian, 2005). Many studies have shown that investor sentiment has an important impact on stock market returns and volatility (Shiller, 1980; Daniel *et al.*, 1998). Especially in the peak of the bull market and the trough of the bear market, the influence of investor sentiment on stock prices (accounting for about 60 percent) far exceeds that of the company's fundamental factors on prices (Darst, 2003). Therefore, this paper innovatively incorporates market sentiment factors in the assets-value model to represent the impact of investor sentiment on firms' market value. The model framework for this paper is shown in Figure 1.

2.2 Econometric model

The hedonic price equation describing firms' market value can be written as a function of the various assets that company i has at time t:

$$V_{it} = f(A_{it}, K_{it}), \tag{1}$$

where V_{it} denotes the market value of company i at time t (the value of all shareholders' equity plus long-term and short-term liabilities, minus cash). A_{it} denotes the book value of the company's tangible assets at time t, such as plant, equipment, inventory and financial assets, etc. K_{it} denotes the intangible asset of company i at time t, including intellectual assets, organizational assets, creditworthiness and brands, etc.

In Equation (1), labor and other inputs are ignored because this paper assumes that they can always adjust to the greatest value, so they are a function of various assets. This means that the correlation coefficient obtained in the study will cover the indirect effects of capital and knowledge stock through the adjustment of the variables used. Referring to the method of Hall (2000), Equation (1) can be written as:

$$V_{it} = q_{it}\left(A_{it} + \sum\nolimits_{n} \gamma_{nit} K_{nit}\right)^{\sigma}, \tag{2}$$

where Q_{it} denotes the multiplier of the total assets of company i at time t, reflecting the market investors' estimator coefficients of the operating conditions, future development prospects, bull or bear markets and other factors for the company's total assets. A_{it} denotes the company's tangible assets, K_{nit} represents the company's nth intangible asset, and γ_{nit} is the shadow value of the nth intangible asset for tangible assets. $q_{it}\gamma n_{it}$ denotes the absolute shadow value of the nth intangible asset. In practice, $q_{it}\gamma n_{it}$ reflects the valuation that investors expect the nth intangible asset to be discounted to the

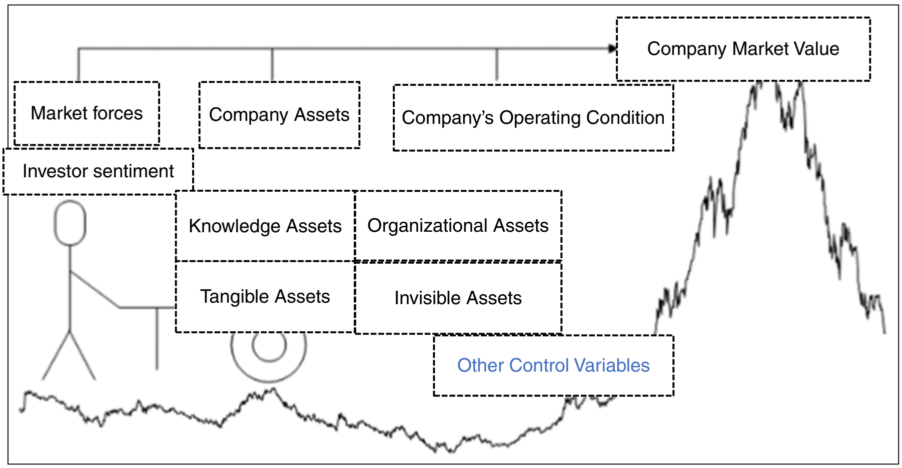


Figure 1.
Asset-value model framework

company's current and future returns. σ represents the scale effect of the asset, $\sigma > 1$ represents an increasing (returns of) scale effect, $\sigma < 1$ represents a diminishing scale effect and $\sigma = 1$ represents an invariant scale effect. Since the company investment in R&D activities forms intellectual assets, the intangible assets can be written as *RD+OC+K'*, where *RD* stands for intellectual assets, *OC* stands for organizational capital and *K'* stands for intangible assets other than intellectual assets and organizational capital. Therefore, Equation (2) can be written as:

$$V_{it} = q_{it}\left(A_{it} + \gamma_{1it}RD_{it} + \gamma_{2it}OC_{it} + \gamma'_{it}K'_{it}\right)^{\sigma}, \tag{3}$$

where γ_{1it}, γ_{2it}, and γ'_{it} are the shadow values of intellectual assets, organizational capital and other intangible assets for tangible assets, respectively. In principle, they should be allowed to fluctuate over time, but due to the small sample size and short time span, we refer to Hall (2000) and Toivanens *et al.* (2002) for estimates of the US and UK data, and assume γ_{1it}, γ_{2it} and γ'_{it} as time-invariant constants, i.e. γ_{1i}, γ_{2i} and γ'_{i}. A_{it} is extracted uniformly from the parentheses on the right side of the equation, and the natural logarithm is taken on both sides of the equation. Since the research object of this paper is manufacturing companies, assuming that the main part of their assets is tangible assets, the ratio of intellectual, organizational and other intangible assets to tangible assets is thus close to zero. According to the approximate equation $\lim_{x \to 0} \log(1+x) \approx x$, Equation (3) can be written as:

$$\log\ V_{it} = \sigma\left[\log\ A_{it} + \gamma_{1i}\left(\frac{RD_{it}}{A_{it}}\right) + \gamma_{2i}\left(\frac{OC_{it}}{A_{it}}\right) + \gamma'_{i}\left(\frac{K'_{it}}{A_{it}}\right)\right] + m_t + u_i + e_{it} + \varepsilon_{it}, \tag{4}$$

where m_t is a time dummy variable that represents the change in the stock market's overall price or industry sector price over time. It controls the effects of macroeconomic changes, including changes in overall economic growth expectations. u_i is a market-independent random error term that represents company-level factors. e_{it} represents the influence of market investor sentiment. When it is greater than 0, market investors tend to overestimate the company's value. When it is less than 0, investors tend to underestimate the company's value. ε_{it} is the error term.

The regression model established by Equation (4) is as follows (Table I):

$$\log\ V_{it} = \sigma\ \log\ A_{it} + \sigma\gamma_{1i}\left(\frac{RD_{it}}{A_{it}}\right) + \sigma\gamma_{2i}\left(\frac{OC_{it}}{A_{it}}\right) + \sigma\gamma'_{i}\left(\frac{K'_{it}}{A_{it}}\right) + \left[\alpha_1 Mo_{it} + \alpha_2 EPS_{it} + \alpha_3 Lev_{it} + \alpha_4 Growth_{it} + \alpha_5 CF_{it}\right] + \sum_{t=1}^{T-1} \delta_t YrDum_t + \varepsilon_{it}. \tag{5}$$

The description is as follows:

(1) The market value in the model is derived from the company's enterprise value defined by Tobin's Q theory, which can be regarded as the theoretical cost of acquiring a company, given that the acquirer must bear the company's liabilities.

(2) The R&D value discussed in this paper refers to the contribution of a unit R&D input to the logarithm of the company's market value, namely, $\sigma\gamma_{1i}$ in Equation (5). Among them, according to the assets-value model regression, the shadow value of the intellectual property of CMLCs relative to the tangible assets, i.e. γ_{1i}, can be regarded as the relative value of R&D investment. If $\gamma_{1i} = 1$, it means that the contribution of one unit of currency to the market value of the intellectual assets is equivalent to that of one unit of currency invested in the tangible assets. When γ_{1i} is greater than (or less than) 1, the stock market's valuation of intellectual assets is

Variable name	Symbol	Calculation equation
Dependent variable		
Logarithm of enterprise value	*LogV*	*V* (value) before the share reform: tradable shares + non-tradable shares + liabilities – cash *V* (value) after the share reform: tradable shares + liabilities − cash
Explanatory variables		
Tangible asset logarithm	*LogA*	*A*: tangible assets, i.e. the company's total assets − intangible assets[a]
Intangible asset strength[a]	*K'/A*	Company's intangible assets[a] divided by tangible assets
R&D flow strength	*RD/A*	Company's R&D investment divided by tangible assets
Organizational asset flow intensity	*OC/A*	Company's organizational assets investment divided by tangible assets
Control variable		
Investor sentiment	*Mo*	The cumulative monthly stock returns from July to December of the current year
Earnings per share	*EPS*	The current net profit attributable to ordinary shareholders divided by the weighted average of current outstanding ordinary shares
Asset-liability ratio	*Lev*	The company's total liabilities for the current year divided by the company's total assets
Growth prospects	*Growth*	Three-year average of annual growth rate of main business income
Cash flow-asset Ratio	*CF*	Cash flow divided by the two-year moving average of total assets

Note: [a]Intangible assets in the model refer to intangible assets in the financial report of the listed company, excluding intellectual and organizational assets

Table I.
Variable definition

greater than (or less than) that of the tangible assets. Note that γ_{1i} is a relative value that represents a multiple of the contribution of an intellectual asset to a market value relative to the contribution of a tangible asset to a market value. The higher the multiple, the higher the expected return of the intellectual asset relative to the tangible asset will be. It represents the economic benefits that the capital market expects the company to obtain from R&D investments, and also reflects the private rate of return on intellectual assets. Due to data limitations, the intellectual assets referred to here only include intellectual assets converted from R&D inputs. Similarly, the value of organizational assets refers to the contribution of unit organizational assets to the logarithm of the company's market value, namely, $\sigma\gamma_{2i}$, where γ_{2i} denotes the relative value of organizational assets.

(3) Our model selects R&D input to measure enterprise innovation without the use of common R&D personnel and patent data because of the following reasons: first, R&D input is more widely used and lasts longer in innovative research. Although it is often seen as one of the many indicators of innovation, the strength of R&D lies in its adequacy of data on time scale, given that many countries have detailed statistical classifications covering innovations in industries, universities and research institutions (Smith, 2004). It is the basis for companies to build knowledge absorption capacity (Cohen and Levinthal, 1990), and reflects the determination and intensity of the company's implementation of innovation strategy. Second, the number of R&D personnel is generally used to compare innovation ability, also used in innovation-related regression. The underlying assumption is that the number of R&D personnel is directly proportional to the ability to innovate, but it remains elusive that the process of linking innovation capabilities to the number of R&D personnel simplifies the inter-researchers and inter-organizations difference in innovation efficiency. Third, the drawback of patent numbers is that they only indicate new technologies, which do not equal to

commercial innovation. Many patents do not have significant technical and economic significance, and many types of inventions are not patentable (Kleinknecht and Mohnen, 2002). Fourth are data availability limits. Due to the express regulations of the regulatory authorities, the number of listed companies that disclose R&D investment is the highest, and because the number of R&D personnel and patent data are not within the scope of mandatory disclosure, only a few listed companies disclose this information.

(4) Our model uses the salary of the company's managers to estimate the company's organizational assets. The work of company managers in establishing or improving business models, corporate culture, organizational structure, institutional processes, operational practices and other implicit knowledge can be seen as investments in organizational assets. Therefore, this paper uses the salary of management staff to estimate the capital and intermediate expenses associated with the organization. This method was developed by Görzig *et al.* (2011) and improved by Rahko (2014), similar to the estimation at the national level by Corrado *et al.* (2005); it focuses on the company's own accounting investment in organizational assets. The above literature assumes that 20 percent of the company manager's work time is spent on investing in organizational assets. Based on this assumption, 20 percent of the salary of listed company managers is regarded as the company's investment in organizational assets.

(5) Our model's knowledge assets and organizational assets are, invariably, replaced by the current year's input flow, that is, the R&D input flow is used to replace the current year's intellectual asset stock, and the organizational asset input flow is used to replace the current year's organizational stock. Since the source of R&D investment stock is the company's current and previous R&D investment, it is difficult to determine the depreciation rate of previous R&D inputs into stocks. Therefore, this paper adopts the existing literature method to replace R&D stocks with R&D flows; Hall (1993a, b) showed that these two types of measures have very little difference in estimates, and that because R&D flows reflect higher depreciation rates and temporal randomness, they are more explanatory (Klette and Griliches, 2000). In the same way, organizational assets are treated as such.

(6) Since the samples are sourced from listed companies between 2003 and 2014, it is necessary to consider the calculation of the enterprise value before and after the Split Share Structural Reform started in 2005. Since most of the listed companies before the share reform have state-owned shares and legal person shares whose circulation is restricted, we can neither ignore the value of these restricted circulation stocks nor equate them with the value of fully-circulated stocks. According to the research of Yang *et al.* (2008), according to the completion time of the share reform of different sample companies, the price of the restricted shares before the share reform is regarded as a certain percentage of the price of the outstanding (circulating) shares, and the ratio is set to 0.43.

(7) Control variables: first, according to Polk and Sapienza (2004) and Hua *et al.* (2010, 2011), the Model uses the cumulative monthly stock returns of listed companies from July to December of the current year to control the impact of market investor sentiment on corporate valuation. Second, earnings per share, representing profitability, is the potential guarantee for R&D investmen.; Third, the asset-liability ratio can control company-level risks, and measure financing capabilities. Generally speaking, the higher the debt ratio, the higher the cost of corporate financing, and the less likely it is to invest in R&D. Fourth, the growth prospects

represent the growth potential of the company, and if the future investment will bring higher than average returns, this will make the decision makers of the enterprise more motivated to invest in innovation. Fifth, the cash flow asset ratio represents the market power and long-term profitability unrelated to R&D investment (Hall, 1993a).

3. Data source and description

3.1 Data source

China's current sources of innovative information can be divided into three categories: innovation data published by official agencies such as the National Bureau of Statistics, the Ministry of Science and Technology or the National Development and Reform Commission; innovation data of small sample surveys conducted by universities and research institutes based on innovation at the enterprise level; and innovation data disclosed by listed companies in the annual reports. At the beginning, the listed companies in China were not required to disclose the innovation data; only a small fraction of companies voluntarily did so. This situation remain unchanged until February 2007, when the China Securities Regulatory Commission (CSRC) issued the "Regulation No. 15 on the Information Disclosure and Reporting of the Publicly Issued Securities – General Provisions on Financial Reporting" and explicitly required that listed companies must disclose relevant innovation information such as R&D. The innovation data obtained from the annual report combine the advantages of the first two types of data: it can be refined to the company level, and it can be easily obtained via public access. Therefore, this paper selects the innovation data of listed companies for 12 consecutive years from 2003 to 2014 as a sample based on the annual reports of listed companies. The selected sample companies must meet the following conditions:

(1) Manufacturing as the main business: the stock market has different valuations for intellectual capitals of the manufacturing and service industry, given the big difference between the two: manufacturing innovation mainly focuses on technological innovation, including product innovation and process innovation, while industry innovation is mainly based on model innovation and process innovation. The innovation of manufacturing industry is mainly reflected in the introduction of new products, and the improvement of the productivity and technical parameters of existing products. The innovation of service industry is more reflected in the innovation of business model, organization and management.

(2) Financial health: the research object of this paper is the enterprises of normal production and operation. Therefore, in the sample companies, we excluded those with net assets, less than 30 employees, ST (special treatment) labels, backdoor listings during the inspection period and annual reports issued by the accounting firm with reservations or no signatures, and those have been disclosed by the media with frauds, investigated or penalized by the CSRC for financial data problems.

(3) No abnormality in the R&D input data: some companies disclose excessive R&D investment in some years, even higher than 20 percent of their total assets, which is obviously unreasonable. To avoid the impact of individual outliers on the overall analysis, the R&D capital intensity was used as an indicator to remove the highest and lowest 0.5 percent samples.

As of December 31, 2014, China's A-shares (RMB ordinary shares) contained 2,587 listed companies. After eliminating companies that did not meet the above criteria, a total of 946 sample companies were selected. The financial data of all listed companies are sourced from their annual report and the Wind Stock Financial Database. The List of Back Door Listing companies, ST (special treatment) companies and delisted companies are from the

Flush Stock Financial Database. The List of special ST (SST) companies, listed companies' violations and illegal activities data are from the CSMAR Database. The accounting firm's opinion on the annual report comes from the Wind Financial Stock Database. Table II lists the descriptive statistics for the regression variables.

3.2 Basic situation of innovation of sample companies

(1) Huge gaps in R&D investment: as shown in Table II, the coefficient of variation reached 3.7573, but after the R&D inputs were divided by company's tangible assets, the difference in R&D capital intensity was much smaller. Moreover, the average and median R&D capital intensity of the sample companies exceeds the internationally recognized level of 2 percent.

(2) The number of companies that disclose R&D and the average input of individual firm's R&D increased year by year. No listed companies disclosed R&D investment before 1999 (Xue and Wang, 2001). In 2003, there emerged listed companies who disclosed their R&D investment. It is not until 2006 that the Ministry of Finance issued the "Accounting Standards for Business Enterprises" to set clear standards for the accounting treatment of corporate R&D investment. In February 2007, the CSRC issued regulations requiring listed companies to publicly disclose R&D in the 2006 annual report. Therefore, as shown in Table III, the number of companies that disclose R&D has grown rapidly since 2006.

(3) After 2012, the sample companies' R&D input intensity is higher than the national average. As shown in Table IV, listed companies, as representatives of the national manufacturing industry, have an R&D investment intensity roughly equivalent to the national average, showing no special lead before 2012. Since 2012, the R&D input intensity of CMLCs started to outpace the national average.

4. R&D value of CMLCs

4.1 Empirical premise

To study the R&D value of CMLCs with an assets-value model, it is important to note the conditions under which the model can be established: it can only be applied to public companies trade in a well-functioning financial market (Hall, 1999) – only when the market is effective, can Investors identify the company's intellectual capital and organizational capital as the basis for the company's valuation. Nonetheless, the use of capital market valuations can take advantage of market fair pricing for future-oriented valuations and avoid cost-benefit intertemporal issues, which have baffled the traditional productivity methods and indirect indicator methods. However, researchers have always believed that the Chinese stock market is of a serious speculative nature. Its policy-dependent and message-dependent characteristics have further roused the speculative psychology of ordinary investors. Most investors will not use the financial statements of listed companies as the basis for company valuation, if this view holds, then the assets-value model cannot be applied to the Chinese stock market.

Although scholars have long believed that the stock performance signals of Chinese listed companies are distorted, and the market is not effective, fortunately, this situation has improved with the gradual development of China's securities market. Zhang and Li (2003) used the AR(2) autoregressive model of time-varying coefficients, and considered the influence of heteroscedasticity of "volatility clustering" to determine that China's stock market has manifested a weak form efficiency since 1997. Wang and Yang (2006) conducted a panel data unit root test on the price indices of the various components of the Shanghai and Shenzhen Stock Exchanges from June 2000 to February 2005. The results

Table II. Descriptive statistical results of the regression variables

	Variable	Sample size	Mean	SD	Coefficient of variation	Minimum value	Quantile 0.25	Quantile Median	Quantile 0.75	Maximum value
Enterprise value (100m yuan)	*V*	6,629	93.7291	220.1989	2.3493	3.2729	23.4794	40.9352	80.1073	4,665.9051
Natural logarithm of enterprise value (yuan)	*LogV*	6,629	22.2595	1.0153	0.0456	19.6063	21.5768	22.1327	22.8040	26.8687
Tangible assets (100m yuan)	*A*	8,928	44.1297	153.5159	3.4787	0.1898	6.2542	13.5082	29.4749	4,083.9287
Natural logarithm of tangible assets (yuan)	*LogA*	8,928	21.0792	1.3088	0.0621	16.7591	20.2539	21.0240	21.8042	26.7355
Intangible assets (100m yuan)	*K'*	8,683	1.6927	5.7270	3.3833	0.0000	0.1835	0.4988	1.2251	127.1548
Intangible assets/assets	*K'/A*	8,918	0.0462	0.0447	0.9667	0.0000	0.0190	0.0360	0.0600	0.8269
Asset–liability ratio	*Lev*	8,930	0.4163	0.1938	0.4657	0.0075	0.2646	0.4254	0.5665	0.9569
Growth prospects	*Growth*	8,930	0.2640	2.2513	8.5261	−0.3464	0.0739	0.1866	0.3119	181.2022
Cash flow–asset Ratio	*EPS*	8,930	0.0669	0.0747	1.1168	−0.3749	0.0211	0.0583	0.1034	0.8420
Earnings per share (yuan)	*CF*	8,929	0.4625	0.4802	1.0382	−2.6500	0.1800	0.3900	0.6453	9.3300
Semiannual momentum	*Mo*	6,625	0.0854	0.3637	4.2603	−0.7795	−0.1634	0.0378	0.2804	3.1087
R&D investment (100m yuan)	*RDinv*	7,139	0.7937	2.9821	3.7573	0.0009	0.1045	0.2281	0.5480	68.6451
R&D intensity	*RD/A*	7,026	0.0246	0.0184	0.7472	0.0003	0.0110	0.0210	0.0335	0.1024
Organizational assets investment (100m yuan)	*OCinv*	8,934	0.1218	0.4014	3.2971	0.0001	0.0177	0.0395	0.0940	12.6998
Organizational asset strength	*OC/A*	8,934	0.0037	0.0024	0.6572	0.0000	0.0020	0.0031	0.0048	0.0328

Note: The sample size of the assets is greater than that of the company value because these companies disclosed the assets before listing, but there is no market value at this time

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sample size	3	36	48	294	533	722	868	900	916	939	940	940
RDinv average (100m yuan)	0.0846	0.2158	0.1596	0.1347	0.2345	0.3217	0.4061	0.5603	0.7657	1.1716	1.2899	1.4712
RD/A average	0.0068	0.0105	0.0089	0.0228	0.0274	0.0315	0.0284	0.0234	0.0217	0.0229	0.0237	0.0230

Table III.
Distribution of R&D indicators

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total expenditure on science and technology activities in the China (100m yuan)	1,540	1,966	2,450	3,003	3,710	4,616	5,802	7,063	8,687	10,298	11,846	13,015.6
Proportion in GDP (%)	1.31	1.23	1.34	1.42	1.49	1.54	1.70	1.76	1.84	1.98	2.08	2.05
Total R&D investment of sample companies (100m yuan)	0.25	7.78	7.66	41.69	171.87	247.61	366	509.23	707.6	1,106.54	1,222.68	1,396.84
Proportion in main business income (%)	1.38	1.15	0.90	1.15	1.93	1.87	1.71	1.53	1.66	2.39	2.37	2.57

Table IV.
R&D investment of sample companies and national expenditure on science and technology activities

show that the major dependent panel price indexes of China's securities market are subject to the panel data unit root process: this conclusion implies that the market has microcosmic weak efficiency during the study period. Konglai and Jingjing (2013) studied the daily closing price and daily yield of the Shanghai Composite Index (000001) and the Shenzhen Composite Index (399106) from January 4, 2000 to April 1, 2011. According to the Random Walk Hypothesis, the logarithmic dynamic autoregressive model, runs test and unit root test are used to test the market efficiency of the Shanghai Stock Exchange and the Shenzhen Stock Exchange, respectively. The results show that, basically, the two markets both have weak efficiency. Furthermore, the author also excluded companies with unhealthy financial status and serious speculativeness in the sample screening process. Therefore, it can be considered that the sample of our research basically satisfies the assumption of the assets-value model.

4.2 Pre-regression inspection

(1) Correlation coefficient test: if there is a high correlation between multiple explanatory variables in the regression model, it means that the information contained in these variables to explain the change of the dependent variable overlaps, and it is therefore not appropriate to incorporate them into the model regression, otherwise it will lead to severe multicollinearity. The direct consequences are that the standard error of the regression coefficient parameter estimation becomes larger, the confidence interval becomes wider, the stability of the estimated value decreases, the probability of accepting the error of alternative hypothesis increases, the probability that the coefficient cannot pass the *t*-test increases and that the correctly estimated value of the coefficient is often unattainable. Therefore, the correlation coefficient between the explanatory variable and the dependent variable must be calculated before regression (see Table V). The results show that the collinearity problem between the explanatory variables is not serious. The correlation coefficient between the asset-liability ratio Lev and the enterprise scale *LogA*, as well as between earnings per share EPS and growth prospects, and cash flow-asset Ratio CF, is rather large. In practice, these control variables are included separately in the model regression, and the regression results that contain all the control variables need to be carefully explained.

(2) Unit root and cointegration test: the unit root test is to check whether the variables are in a stationary sequence. If the stationarity of the sequence is not checked, direct linear regression can easily lead to spurious regression. With unit root test for regression variables, we found that *LogA, K'/A, RD/A, OC/A, Mo, EPS, Lev, Growth* and *CF* are free with unit roots, and are therefore stationary sequences that can be included in model regression (the test results are omitted and available from the author upon request).

4.3 General regression results

The regression results show that:

(1) After incorporating a number of factors related to R&D values, i.e. the $\sigma\gamma_{1i}$ values, they are invariably greater than 1 and significant. This shows that R&D investment will bring about an increase in market value, and the Chinese capital market has a higher evaluation of the R&D investment of CMLCs. Although the inclusion of more control variables causes the regression coefficient of RD/A to fluctuate up and down, the significance and symbols do not change drastically, which indicates that the above conclusions are robust. This is consistent with the results obtained by foreign researchers in the same way to measure the R&D value of listed companies in other countries. Czarnitzki *et al.* (2006) compiled a total of

Table V.
Correlation coefficients between explaining variables and dependent variables

		1	2	3	4	5	6	7	8	9	10
LogV	1		0.8465	−0.0253[a]	−0.0678	−0.1029	0.2133	0.2073	0.3978	0.0717	0.1360
LogA	2	0.8917		−0.0416	−0.1538	−0.1299	0.0344[a]	0.0501	0.5663	−0.0131[a]	0.0040[a]
K'/A	3	−0.0261[a]	−0.0578		0.0644	0.1984	0.0290[a]	−0.0973	0.0682	−0.0731	−0.0482
RD/A	4	−0.0384	−0.1159	0.0267[a]		0.2323	0.0249[a]	0.1459	−0.2003	0.0539	0.0639
OC/A	5	−0.1062	−0.1405	0.1542	0.2110		0.0356	−0.0678	0.0309[a]	−0.0661	0.1067
Mo	6	0.1909	0.0307[a]	0.0107[a]	0.0248[a]	0.0248[a]		0.0274[a]	0.0665	−0.1415	0.0921
EPS	7	0.2390	0.0866	−0.1017	0.0807	−0.0733	0.0309[a]		−0.2718	0.4154	0.3609
Lev	8	0.4294	0.5818	0.0588	−0.1431	0.0160	0.0648	−0.2350		−0.0032[a]	−0.1642
Growth	9	0.0916	0.0208[a]	−0.0498	0.0205[a]	−0.0674[a]	−0.1028	0.3135	0.0186[a]		0.0455
CF	10	0.1438	0.0101[a]	−0.0163[a]	0.0653	0.0983	0.0761	0.3713	−0.1848	0.0297[a]	

Notes: The upper right part of the table shows the Spearman correlation coefficient between the variables, and the lower left part is the Pearson correlation coefficient between the variables. The correlation coefficient without [a]indicates that 1 percent significance has been reached. Shaded cells indicate that there may be a high degree of collinearity (⩾0.3) between the two variables

16 studies using the assets-value model to estimate the R&D value of listed companies between 1981 and 2005. It was found that the R&D values obtained in the assets-value model were basically all positive and significant for companies listed on the USA, the UK, continental Europe and Australia. This shows that in the well-functioning capital market, the listed company's investment in R&D will increase the company's market value.

(2) Organizational asset investment has a higher valuation in the capital market. The regression coefficient $\sigma\gamma_{2i}$ of the organizational asset strength (OC/A) is much higher than the regression coefficient $\sigma\gamma_{1i}$ of the R&D capital intensity (RD/A), and in models incorporated with different control variables, they are all statistically significant. The reasons may be that: first, organizational assets are more difficult to replicate than technological innovation is. It is the implicit knowledge of information, experience internalized in individuals, teams and organizations through socialization, externalization and integration. Investment that solely relies on tangible assets, human capital, organizational structure and other intangibles is impossible to completely replicate the organization assets. Second, under the system of determining the listing of enterprises by examination and approval, the listing itself is a proof of the company's management ability. Once listed, the capital market will award higher premium to its organization assets. Third, most Chinese companies still rely on the "rule by man"; the founders of the company have a vital influence on business operations, and professional managers are difficult to replace the original management team. The high valuation of organizational assets represents the capital market's emphasis on the management team.

(3) The R&D value of CMLCs is rather low. The regression coefficient $\sigma\gamma_{1i}$ of the R&D capital intensity (RD/A) that incorporates all control variables is lower than the coefficient of 3.10 (Hall, 1993b) of the US manufacturing companies between 1973 and 1990, and lower than that (3.51) of the British manufacturing companies between 1989 and 2002 (Greenhalgh and Rogers, 2006), and also the coefficient of 3.83 and 8.80 of Taiwan and Korean electronics companies, respectively, in 2000–2008 (Chen, 2010). The reasons may be twofold: first, the development path of technological capabilities of developing countries and regional enterprises is different from that of developed countries. The technological development of late-starter countries like China is mostly derived from the selection, acquisition, assimilation, absorption and improvement of foreign technology (An, 2003). Second, China's protection of intellectual property rights is insufficient. Even if enterprises invest a lot of resources in R&D, the technological innovations obtained will be quickly copied, and the plagiarists will not be severely sanctioned.

(4) The regression coefficients of the investor sentiment index are all greater than 0 and significant. This proves that investor sentiment will affect the market's estimation of the value of listed companies' assets. To compare the relative size of R&D values of listed companies in the bull or bear markets, the impact of investor sentiment on enterprise value should be controlled in the assets-value model.

(5) Discussion of model endogeneity.

In the basic regression mentioned above, it is necessary to consider the problem of endogeneity. There reasons may also bifurcate: First, if there is a correlation between R&D input, organizational capital and random perturbation terms, the estimates for $\sigma\gamma_{1i}$ and $\sigma\gamma_{2i}$ are biased. In order to deal with this problem, Model (6) is used as the test model, and the current term of R&D input, organizational capital and control variables in the model is replaced with the corresponding lag phase (T−1) terms, and Model (6) is re-estimated by still using the fixed effect model. The main estimates are shown in column (7) of Table VI.

Table VI. Least squares estimation results of panel data and endogeneity test results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C	5.4216 (0.3409)	6.8076 (0.3445)	5.9197 (0.3769)	6.9833 (0.3626)	6.0977 (0.3531)	6.0354 (0.3510)	13.9092 (0.6280)	4.5720*** (3.2307)
LogA	0.7802 (0.0156)	0.7127 (0.0158)	0.7611 (0.0176)	0.7070 (0.0167)	0.7484 (0.0162)	0.7485(0.0164)	0.3845 (0.0292)	0.8100 (0.1368)
K'/A	0.4315 (0.1280)	0.5847 (0.1367)	0.4403 (0.1310)	0.4406 (0.1423)	0.4331 (0.1281)	0.6418 (0.1508)	0.9302 (0.1973)	0.2368*** (0.5587)
RD/A	1.8386 (0.3930)	1.2079 (0.3924)	1.7442 (0.4149)	1.6705 (0.4086)	1.7546 (0.4125)	1.2125 (0.3658)	0.2409*** (0.5488)	1.4120*** (3.8569)
OC/A	16.3336 (3.6835)	18.1262 (3.7374)	18.3460 (3.9148)	13.4628 (3.8306)	16.1646 (3.7959)	16.2073 (3.5079)	25.4655 (5.1813)	72.6161*** (87.6821)
Mo	0.2049 (0.0117)					0.1985 (0.0113)	0.1535 (0.0180)	0.2042 (0.0138)
EPS		0.2085 (0.0115)				0.1572 (0.0117)	0.0921 (0.0173)	0.1491 (0.0137)
Lev			−0.1945 (0.0511)			−0.1232 (0.0475)	0.1244* (0.0708)	−0.2307*** (0.1537)
Growth				0.2465 (0.0254)		0.1906 (0.0246)	0.0676** (0.0331)	0.2214 (0.0486)
CF					0.6647 (0.0871)	0.2758 (0.0830)	0.0580*** (0.1118)	0.1820** (0.0924)
SZ	5,259	5,264	5,264	5,264	5,264	5,259	4,258	4,823
Firms	946	946	946	946	946	946	944	946
	0.2098	0.2085	0.2180	0.2150	0.2169	0.1986	0.2392	0.1977
Ad R^2	0.9522	0.9528	0.9484	0.9499	0.9490	0.9572	0.9378	0.9564
Prob(F)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
D-W	1.3441	1.5492	1.4754	1.4905	1.4706	1.4293	1.8080	1.5589
γ_{1i}	2.3566	1.6948	2.2917	2.3628	2.3445	1.6199	0.6265	1.7432
γ_{2i}	20.935	25.433	24.104	19.042	21.598	21.653	66.2302	89.6495

Notes: SZ, sample size; Firms, number of firms; Ad R^2, adjusted R^2. The Regressions have, without exception, controlled the time and firm fixed effects. *,**Significant at the 10 and 5 percent levels, respectively; ***indicates "not significant." All other results were significant at the 1 percent level

Since the variable of the lag ($T-1$) phase is correlated to the current term, the endogenous problem caused by the correlation between the current variable and the current residual term is effectively avoided. The estimated results are basically consistent with the Model (6). The relative value of the R&D input is still greater than 0, only that the absolute value is slightly lower than Model (6), but not significant enough; the relative valuation of the organizational capital is still positive, and slightly higher than the result of Model (6).

The second possible reason for the endogeneity is that the size of enterprise value will also affect the investment on R&D and organizational capital. Listed companies with higher enterprise value may invest more R&D and organizational capital, that is, there may be a reverse causal relationship between enterprise value and investment on R&D and organizational capital. The standard approach to dealing with this endogenous problem is to find instrumental variables that are correlated to endogenous explanatory variables but not affected by firm value. In practice, most empirical literature usually chooses the $T-1$ lag phase variable of the explanatory variable; see Wang (2005). This paper also considers the $T-1$ lag phase of R&D and organizational capital as an instrumental variable for R&D and organizational capital. Model (6) is estimated using the two-stage least squares method. The main estimation results are shown in column (8) of Table VI. Compared with the estimates of Model (6), the estimated coefficients of R&D and organizational capital are also positive, and the absolute values are relatively close, but not so significant as the former estimates. It can be seen that there is a certain endogeneity between enterprise value and R&D and organizational capital investment, but it does not affect the estimation result.

4.4 Time-phased regression results

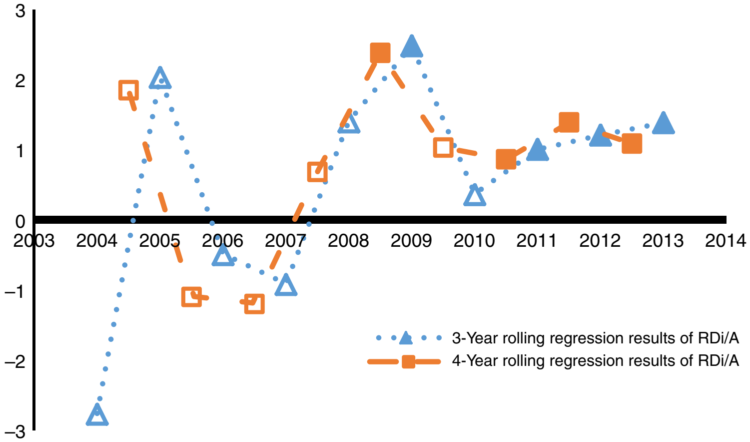
The previous result is the R&D value obtained from all samples from 2003 to 2014, representing the market valuation of R&D of CMLCs during this time period. Then, has the R&D value of listed companies in the manufacturing industry changed during this time span, and what is the trend of change? Since the section fixed effect model must be calculated in a certain period of time, if the time period is too short, the regression result will be unattainable. In order to observe the change of the R&D value of Chinese listed companies in time, the author segmented the 2003–2014 samples into smaller time periods. Considering that the time of segmentation shall be neither too short nor too long, the time period for segmented regression is set to three or four years. In order to prevent the regression bias caused by simple halving, starting from 2003, this paper calculated once every year with the time period moves forward until the end of the time period arrives in 2014. The results thus obtained are as follows (see Table VII, Figure 2).

Compare the RD/A regression coefficients for different time periods. The period from 2003 to 2014 can be roughly divided into three periods: the regression results in the first (earliest) period are not significant and will not be discussed; however, it can be found that the R&D value of the second period is always higher than that of the latter period, that is to say, in 2007–2010, the R&D value of CMLCs was higher, and, subsequently, it declined. R&D value represents the expected return of intellectual capital relative to tangible assets. The decline in its value represents a decrease in the relative contribution of R&D investment to enterprise value, leading in return to listed companies' relatively lower R&D investment. Hall (1993a) conducted a study on the valuation of R&D investment stocks of 2,500 manufacturing companies in the USA from 1973 to 1990. It is also found that between 1986 and 1990, its stock market valuation showed a sharp decline of 20–30 percent as compared with the period of 1973–1982. For this phenomenon, Hall construed as such: the return on R&D investment has indeed decreased; the rate of R&D capital depreciation has been greatly accelerated; and the capital market has become more short-sighted and underestimated the future cash flow that R&D investment may bring. For the time being, this paper shall not discuss the intrinsic reasons for these findings in depth, and the more exact answers await further research.

Table VII.
Regression results for different time-segmented scenarios

Time segments: three years	2003–2005	2004–2006	2005–2007	2006–2008	2007–2009	2008–2010	2009–2011	2010–2012	2011–2013	2012–2014
RD/A	−2.7601	2.0397	−0.4857	−0.9113	1.4061	2.4789***	0.3694	1.0023*	1.2061**	1.3833**
	(5.7759)	(6.0000)	(2.7006)	(1.3697)	(1.0726)	(0.9172)	(0.8133)	(0.5809)	(0.5150)	(0.6826)
Sample Size	79	184	324	511	794	1,263	1,853	2,400	2,697	2,816
Number of firms	45	110	191	265	404	652	833	942	944	946
Adjusted R^2	0.9436	0.9386	0.9624	0.9617	0.9678	0.9678	0.9708	0.9749	0.9735	0.9678
γ_{1i}	−2.0721	1.6431	−0.6712	−1.4220	2.1259	3.3999	0.4943	1.3919	1.3776	1.9051
Time segments: four years	2003–2006	2004–2007	2005–2008	2006–2009	2007–2010	2008–2011	2009–2012	2010–2013	2011–2014	
RD/A	1.8466	−1.0993	−1.1999	0.6824	2.3788***	1.0302	0.8614*	1.3882***	1.0859**	
	(5.5436)	(2.3680)	(1.3135)	(1.0475)	(0.8253)	(0.7187)	(0.5204)	(0.4680)	(0.4756)	
Sample Size	187	357	554	902	1,436	2,083	2,791	3,339	3,636	
Number of firms	110	192	265	406	656	836	942	944	946	
Adjusted R^2	0.9398	0.9609	0.9614	0.9619	0.9626	0.9684	0.9713	0.9676	0.9667	
γ_{1i}	1.4924	−1.3392	−1.6604	0.9950	3.4813	1.4157	1.1394	1.7292	1.4232	

Notes: The regression also controlled the time and fixed effects of firms. The segmented (subsection) regression and the common regression model (6) used the same model, but to save space, only the regression coefficients of *RD/A* are reported. *,**,***Significant at 10, 5 and 1 percent levels, respectively



Note: Soild and hollow icons represent, respectively, that the results are statistically significantand and insignificant

Figure 2. Time-segmented rolling regression results

5. Conclusions and implications

The way to measure the value of an enterprise's R&D investments remains a major challenge for the theoretical and empirical study on innovation economics. By reasonably estimating the value of organizational assets, this paper innovatively introduces semi-annual momentum indicators from the perspective of behavioral finance to control the impact of investor sentiment on enterprise value in the market, and expands the assets-value model pioneered by Griliches (1981) to apply it to China's securities market. The relative value of R&D investment in China's manufacturing listed companies from 2003 to 2014 was measured, and the characteristics of R&D value evolution over time were expounded. In the past, the research on R&D value in China has focused on the fields of enterprise productivity, financial performance and output indicators. It remains infrequent to see literature analyzing R&D from the perspective of market pricing. However, the expected benefits of R&D can be measured through the pricing of listed companies in the capital market, thus avoiding the bias that human estimates may bring; therefore, this research has innovative theoretical and practical significance. This paper provides a feasible solution to the problem of measuring the R&D value of Chinese enterprises. Our research shows that the following:

(1) The assets-value model better explains the enterprise value composition of CMLCs. The model was applied to CMLCs in 2003–2014, and the results were robust. The empirical results show that tangible assets, intellectual assets, organizational assets and other intangible assets are the main components of the market value of CMLCs, while market investor sentiment, earnings per share, corporate debt risk, the growth prospects of successful companies and long-term profitability unrelated to R&D investment are also effective control variables.

(2) The results of the model regression show that the R&D value is greater than 1 and significant. R&D investment will raise the market value of listed companies by folds, that is, the capital market's recognition of R&D investment will increase the company's knowledge stock, and its shadow price will be higher than the equivalent investment in tangible assets. This fully demonstrates that the capital market regards R&D investment as a powerful means for companies to gain competitive edge, and encourages listed companies to innovate. Listed companies should invest heavily in R&D. On the one hand, R&D activities should be regarded as investment

in the development of business. On the other hand, R&D activities should be recognized as an incentive to win trust from both the investors and the capital market. In fact, in mature capital markets, the more R&D investments a listed company invests in, the higher valuations a company can receive.

(3) Compared with developed countries, CMLCs have lower R&D values. The reason lies in that the path of China's technological innovation generally starts from imitation (An, 2003). If we aim at maximizing short-term profits, in terms of technology choice, enterprises with limited rationality in a technologically less advanced country will naturally choose the strategy of copinism, given the highest success rate, and then absorb foreign advanced technology through replicative imitation, turning into the company's own technical capabilities. Then the enterprise will improve foreign advanced technology through innovative imitation, finally, and, gradually, it moves toward independent innovation. To this end, the lower R&D value of CMLCs should be a natural mapping of technical imitation. It should be noted that in the early stage of reform and opening up, China's manufacturing technology base was weak, so enterprises are therefore encouraged to vigorously introduce foreign advanced technology for imitation and absorption, and the loose intellectual property protection policy was in line with the national conditions at that time. But after more than 30 years since reform and opening up, there are already a considerable number of domestic enterprises that have established their own technological innovation systems and embarked on the road of independent innovation. At this time, the government should beef up the protection of intellectual property rights to encourage Chinese enterprises to gain new competitive edge through independent innovation.

(4) The R&D value of CMLCs saw a declining trend from 2007 to 2014, but the listed companies beefed up the relative investment of R&D in the same period. A similar phenomenon of declining R&D value also appeared in the USA during 1986–1990. There may be many explanations for this, but it is more important to first confirm this surprising phenomenon from more angles. This provides a new perspective on the future evolution of China's manufacturing industry, and an important orientation for scholars' further study as well.

References

An, T. (2003), "The technology choices of Chinese enterprises", *Economic Research*, Vol. 38 No. 7, pp. 76-84.

Blundell, R., Griffiths, R. and Van Reenen, J. (1999), "Market share, market value and innovation in a panel of British manufacturing firms", *The Review of Economic Studies*, Vol. 66 No. 3, pp. 529-554.

Brynjolfsson, E., Hitt, L.M. and Yang, S. (2002), "Intangible assets: computers and organizational capital", *Brookings Papers on Economic Activity*, Vol. 33 No. 1, pp. 137-198.

Chadha, A. and Oriani, R. (2010), "R&D market value under weak intellectual property rights protection: the case of India", *Scientomerics*, Vol. 82 No. 1, pp. 59-74.

Chen, H. (2010), "Innovative activities and market value: case studies of Taiwan and South Korea's electronics industry", master's thesis, National Central University.

Cohen, W.M. and Levinthal, D.A. (1990), "Absorptive capacity: a new perspective on learning and innovation", *Administrative Science Quarterly*, Vol. 35 No. 1, pp. 128-152.

Corrado, C., Hulten, C. and Sichel, D. (2005), "Measuring capital and technology: an expanded framework", in Corrado, C., Haltiwanger, J. and Sichel, D. (Eds), *Studies in Income and Wealth*, University Chicago Press, Chicago, IL, pp. 11-46.

Czarnitzki, D., Hall, B.H. and Oriani, R. (2006), "The market valuation of knowledge assets in us and european firms", in Bosworth, D. (Ed.), *The Management of Intellectual Property*, Edward Elgar Publishing, Northampton, MA, pp. 269-284.

Daniel, K., Hirshleifer, D. and Subrahmanyam, A. (1998), "Investor psychology and security market under- and overreactions", *The Journal of Finance*, Vol. 53 No. 6, pp. 1839-1885.

Darst, D.M. (2003), *The Art of Asset Allocation: Asset Allocation Principles and Investment Strategies for Any Market*, McGraw-Hill, New York, NY.

Görzig, B., Piekkola, H. and Riley, R. (2011), "Production of intangible investment and growth: methodology in innodrive", INNODRIVE Working Paper No 1.

Greenhalgh, C. and Rogers, M. (2006), "The value of innovation: the interaction of competition, R&D and IP", *Research Policy*, Vol. 35 No. 4, pp. 562-580.

Griliches, Z. (1981), "Market value, R&D, and patents", *Economic Letters*, Vol. 7 No. 2, pp. 183-187.

Hall, B.H. (1993a), "The stock market's valuation of R&D investment during the 1980s", *American Economic Review*, Vol. 83 No. 2, pp. 259-264.

Hall, B.H. (1993b), "Industrial research during the 1980s: did the rate of return fall?", *Brookings Papers: Microeconomics*, Vol. 1993 No. 2, pp. 289-343.

Hall, B.H. (1999), "Innovation and market value", National Bureau of Economic Research Working Paper No. w6984, National Bureau of Economic Research, Cambridge.

Hall, B.H. (2000), "Innovation and market value", in Ray, B., Mason, G. and Mahoney, M.O. (Eds), *Productivity, Innovation and Economic Performance*, Cambridge University Press, Cambridge, pp. 487-492.

Harhoff, D., Narin, F., Scherer, F.M. and Vopel, K. (1999), "Citation frequency and the value of patented inventions", *Review of Economics and statistics*, Vol. 81 No. 3, pp. 511-515.

Hua, G., Liu, Z. and Xu, Q. (2010), "Investor sentiment, corporate investment and resource allocation efficiency", *Accounting Research*, Vol. 31 No. 11, pp. 49-55.

Hua, G., Liu, Z. and Xu, Q. (2011), "Investor sentiment, managerial optimism and corporate investment", *Financial Research*, Vol. 40 No. 9, pp. 178-191.

Hulten, C.R. and Hao, X. (2008), "What is a company really worth? Intangible capital and the 'market to book value' puzzle", National Bureau of Economic Research Working Paper No. 14548, National Bureau of Economic Research, Cambridge.

Kleinknecht, A.H. and Mohnen, P.A. (2002), *Innovation and Firm Performance: Econometric Explorations of Survey Data*, Palgrave, Basingstoke.

Klette, T.J. and Griliches, Z. (2000), "Empirical patterns of firm growth and R&D investment: a quality latter model interpretation", *The Economic Journal*, Vol. 110 No. 463, pp. 363-387.

Konglai, Z. and Jingjing, Li (2013), "An empirical study on the validity of China stock markets", *Journal of Applied Statistics and Management*, Vol. 32 No. 1, p. 145154.

Liu, H. and Chen, C. (2007), "Enterprise organizational capital, strategic perspectiveness and corporate performance: an empirical study based on Chinese enterprises", *Management World*, Vol. 23 No. 5, pp. 83-93.

Mairesse, J. and Mohnen, P. (1995), "R&D and productivity: a reexamination in light of the innovation surveys", *The EUNETICS Conference on Evolutionary Economics of Technological Change: Assessment of Results and New Frontiers*, *Strasbourg*, *October 1994*.

Munari, F. and Oriani, R. (2005), "Privatization and economic returns to R&D investments", *Industrial and Corporate Change*, Vol. 14 No. 1, pp. 61-91.

Nagaoka, S. (2006), "R&D and market value of Japanese firms in the 1990s", *Journal of the Japanese and International Economies*, Vol. 20 No. 2, pp. 155-176.

Piekkola, H. (2016), "Intangible investment and market valuation", *Review of Income and Wealth*, Vol. 62 No. 1, pp. 28-51.

Polk, C. and Sapienza, P. (2004), "The real effect of investor sentiment", National Bureau of Economic Research Working Paper No. 10563, National Bureau of Economic Research, Cambridge.

Rahko, J. (2014), "Market value of R&D, patents, and organizational capital: finnish evidence", *Economics of Innovation and New Technology*, Vol. 23 No. 4, pp. 353-377.

Sandner, P.G. and Block, J. (2011), "The market value of R&D, patents, and trademarks", *Research Policy*, Vol. 40 No. 7, pp. 969-985.

Scherer, F.M., Harhoff, D. and Kukies, J. (2000), "Uncertainty and the size distribution of rewards from technological innovation", *Journal of Evolutionary Economics*, Vol. 10 Nos 1/2, pp. 175-200.

Shiller, R.J. (1980), "Do stock prices move too much to be justified by subsequent changes in dividends?", National Bureau of Economic Research Working Paper No. 456, National Bureau of Economic Research, Cambridge.

Smith, K. (2004), "Measuring innovation", in Fagerberberg, J., Mowery, D.C. and Nelson, R.R. (Eds), *The Oxford Handbook of Innovation*, Oxford University Press, pp. 159-197.

Toivanens, O., Stoneman, P. and Bosworth, D. (2002), "Innovation and the market value of UK firms, 1989-1995", *Oxford Bulletin of Economics and Statistics*, Vol. 64 No. 1, pp. 39-61.

Wang, S. and Yang, J. (2006), "Expansion of joint p-value panel data unit root test for weak efficiency of Chinese stock market", *Statistical Research*, Vol. 23 No. 4, pp. 69-72.

Wang, Y. (2005), "North-South technology diffusion: how important are trade, FDI and international telecommunications!", working paper, Carleton University, Ottawa.

Wang, Y. and An, T. (2014), "Firm size and R&D performance of Chinese manufacturing listed companies", *Forum on Science and Technology in China*, Vol. 30 No. 5, pp. 62-67.

Xue, Y. and Wang, Z. (2001), "The importance of R&D and the improvement of its disclosure", *Accounting Research*, Vol. 22 No. 3, pp. 20-26.

Yang, D., Wei, X. and Ye, J. (2008), "The effects of split share structure on the empirical capital market research in china and the corrections", *Economic Research Journal*, Vol. 43 No. 3, pp. 73-85.

Zexian, H. (2005), "A study on investor sentiment of Chinese financial market", PhD thesis, Tianjin University, Tianjin.

Zhang, B. and Li, X. (2003), "An evolving market efficiency test on Chinese stock market", *Economic Research Journal*, Vol. 38 No. 1, pp. 54-61.

Further reading

Fagerberg, J. *et al.* (2004), *The Oxford Handbook of Innovation* (translated by Liu Xielin *et al.*), Intellectual Property Publishing House, Beijing.

Corresponding author
An Tongliang can be contacted at: atliang@nju.edu.cn