Intangible Investment by Industry in China

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Part I: Introduction:

Intangible assets are assets that cannot be physically touched or seen, and are key assets of today's "knowledge economy". Examples of intangible assets are as software, design, market research, R&D, training and business processes in various aspects.

Intangible assets are deemed especially important for China. The remarkable rapid growth over the past three decades has enormously enlarged Chinese manufacturing size relative to that of the US, but in terms of labor productivity China appears to be still far away from the US. By 2016, while the value added of China's manufacturing sector had reached a level that was about 160 percent of the US, its output per worker was only 14 percent of the US level. Facing continuously rising costs, especially in labor, land and environment, the Chinese government now seeks to shift the economy from extensive to more intensive growth through technological advancement and innovations to upgrade the Chinese manufacturing sector. Ambitious plans and strategies have been announced by the Xi-Li administration ever since their official term in 2012, such as "China Innovation 2020", "China Industry 2025", and "Global Innovation Leader 2030" according to the 13th Five Year Plan, laid out by the government.

Becoming truly innovative in manufacturing is a big challenge to Chinese manufacturing in the decades to come, and intangible investment is even more important than tangibles to that end. Advanced economies invest heavily in intangible assets. The U.S. business invested more in intangible assets than in tangible assets since the 1990s, and the rate of investment was 10.4 percent of GDP in 2015. Other advanced economy also invested heavily in intangibles. The list includes such countries as Germany, France, the UK, and Japan. It is a big question how China has performed in intangible investment, which may shed important light on China's potential in the near future. So far we know that based on a preliminary estimation by Hulten & Hao (2012), China invested 7.06 percent of GDP in intangibles in the market sector in 2006, indicating China might have indeed been catching up.

To achieve the grand goals of "China Innovation 2020", "Made in China 2025", and "Global Innovation Leader 2030", China needs spending in research and development (R&D) as well as spending in other types of intangible assets. Innovation requires much more than R&D—commercializing an invention requires, for example, design, brands, licenses, human capital, modern business models, management of supply chains, etc.. Investment in machines such as assembly lines may not bring high profit as is exemplified in the case of iPhones where the Chinese assembly factories gained merely about 2% of the revenues of each iPhone in 2010 while the US Apple headquarters captured about 60% of revenues of each iPhone. [1] The ability to capture high profit is related to intangible assets such as design, marketing, supply chain management.[2]

A comprehensive list of intangibles is provided by CHS (2005). There are three major categories of intangible assets—computerized information, innovative property and economic competencies. Computerized information includes software and databases; Innovative property includes research and development, mineral exploration, copyright and licenses, new product in financial services, and architectural and engineering design; Economic competency includes brand equity, on-the-job training and organizational structure. R&D is just one type of the intangible assets.

China invested 8.4 percent of GDP in intangibles in 2013, rising from 5.3 percent in 2006 (unpublished updates of Hulten and Hao, 2012). The level of investment is higher than that in Italy and Spain, comparable to that in Germany and France, and lower than that in the U.K. and the U.S.. Despite the relatively large investment in intangible investment, China still relies heavily on tangible investment, because intangible investment amounted to only one fifth of tangible investment. Moreover, about half of the intangible investment in China (investment in design and software) is driven by government policy.

In this study we propose a work that turns the estimation of intangible investment from the aggregate to industry level. It is deemed necessary to estimate intangibles at the industry level because, as studies show in the case of the UK manufacturing, ignoring intangible investment is missing three quarters of the total investment (Borgo et. al. 2011). Intangible estimates for the

[1] Kraemer, Kenneth, Greg Linden, and Jason Dedrick, 2011. Capturing value in global networks: Apple's iPad and iPhone. Available at http://pcic.merage.uci.edu/papers/2011/Value_iPad_iPhone.pdf

[2] The official statistics provides mostly R&D related data and miss many other types of intangibles data to track and evaluate the progress of China's efforts in becoming an innovative nation, and that is probably why the 13th Five-Year Plan uses mostly R&D related metrics to gauge the success of being an innovative nation. "Under the 13th FYP, by 2020 the government seeks to increase its global innovation ranking from 18 to 15, the share of research and development (R&D) spending as a percent of gross domestic product (GDP) from 2.1 to 2.5, the number of patents filed per 10,000 people from 6.3 to 12, and the number of personnel in R&D."

UK, Germany, Japan and Korea all show significant difference across industries (Borgo et. al. 2011, Hyunbae et. al. 2012, Crass et. al. 2014, Miyagawa et. al. 2013).

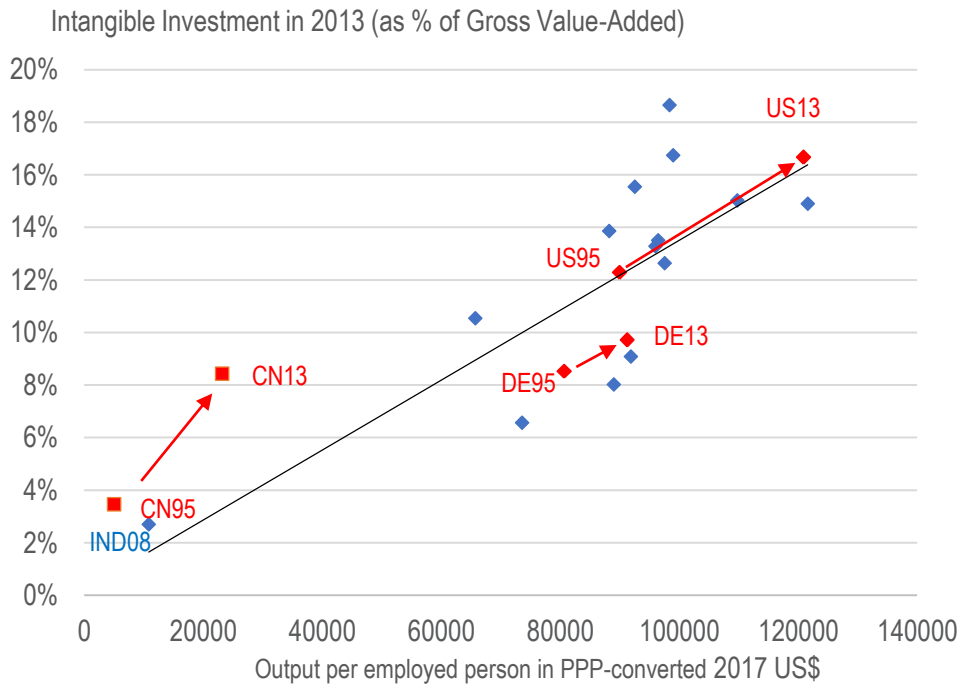
In this research, we aim to estimate Chinese intangible investment across 37 industries nationwide for about two decades from 1995 to 2013. We basically follow the method of Corrado et. al. (2005) to measure ten types of intangible assets. We take advantage of China KLEMS-type growth accounts at the industry level carried on by Wu and his associates (Wu 2016; Wu et al. 2015), which allows our work to be conducted in a coherent framework despite data deficiencies. Other data sources are diverse, ranging from China Statistical Yearbooks, Chinese Census and data from trade associations. Facing difficulties in data availability and especially data quality (most data on intangibles are not collected by national statistical offices even in the advanced economies), we resort to creative ways beyond the methods of Corrado et al. (2005).

Our preliminary estimates at this stage have shown that sectors differ greatly in their intensity of intangible investment. The industrial sector invested 15.4 percent of value added in intangibles in 2013, the sector of least investment in intangible assets is agricultural, only 1.0 percent of value added. Intangible investment was equivalent to about one fifth of the tangible investment in the industrial sector in China as well as in the total economy of China, implying that Chinese industries are still heavily relying on machines, equipment and structures, and still have a long way to go before they can operate in ways similar to their counterparts in advanced economies.

The structure of the paper is as follows. Part II gives an overview of the national level of intangible investment and puts China in comparison with advanced and developing economies. Part III lists the data and methodology of estimating each detailed type of intangible assets for 37 industries from 1995 to 2013. Part IV presents intangible investment at the level of 8 sectors. Part V discusses the implication of the intangibles estimates on the prospect of the Chinese economy. Part VI concludes.

Part II: Intangible investment in China—an overview

Chart 1



Sources: Corrado Carol, Jonathan Haskel, Cecilia Jona-Lasinio and Massimiliano Iommi (2016), Total Economy Database of The Conference Board, unpublished updates of Hulten & Hao (2012), and Hulten,

Chart 1 shows that China invested 8.4% of GDP on intangible assets in the total economy in 2013, a level comparable to that of Germany and France. China expanded aggressively on intangible investment compared to EU countries. When the output per employee in China increased from $4,994 in 1995 (PPP-converted 2017 US$) to $23,155 in 2013 (PPP-converted 2017 US$), intangible investment in China expanded from 3.5% of GDP to 8.4% of GDP. In contrast, EU countries investing 8% of GDP on intangibles typically have an output per employee of about $70,000 (PPP-converted 2017 US$).

While the level of China investment is relatively high, the ratio of intangible to tangible investment in China is only one fifth, implying that China still heavily relies on tangible capital. Capital formation (or investment) in China is alarmingly high. China invested over 40% of GDP since 2008, a level higher than Japan and Korea in their investment peaks. Over-investment leads to a series problem of over-capacity—an indication of overcapacity is that the PPI of the industrial sector decreased for 54 consecutive months from February 2012 to August 2016.[3] If the rapidly expanding intangible investment is driven by the wave of over-investment, we have reasons to question the efficiency of intangible investment. The same amount of intangible

[3] Data source is the National Bureau of Statistics of China. http://data.stats.gov.cn/index.htm

investment in China may not lead to the same amount of output as that in other countries such as the U.S..

Part III: Data and Methodology

We measure 3 categories and 8 detailed types of intangible investment from 1995 to 2013 for 8 sectors and 37 industries. We follow the CHS method of measuring intangible investment and collect data from the National Bureau of Statistics of China, ministries, and trade associations. When data on intangible investment at the industry level is not readily available, we resort to creative methods to come up with our own estimates, as a placeholder.

3.1 Years covered

This paper covers the time period is from 1995 to 2013. The period 1995 to 2013 covers three distinct periods of the Chinese economy—the pre-WTO period, the booming period due to expanding exports and later high investment, and the period after the global financial crisis in 2008. We chose not to cover years before 1995, because the data on many types of intangible investment is hard to find.[4]

3.2 Eight sectors and thirty-seven industries

Hulten and Hao (2012, updated) estimated intangible investment from 1995 to 2013, and this paper breaks down that investment into 8 sectors and 37 industries. Table 1 lists the 8 sectors and the 37 industries. The 8 sectors are Agriculture, Industrial, Construction, Wholesale & Retail, Hotels & Restaurants, Transport, Storage & Post, Finance & Real Estate, and Other Services[5], following the classification of sectors of the National Bureau of Statistics of China, partly because some key data, such as value added, is available only at the sector level in the official statistics. The 37 industries are the same industries as those in Wu (2016), to take advantage of the data on employment and value added by industry from Wu (2016). (why Harry classify industries into those 37 industries?)

[4] Moreover, because the intangible investment is relatively new compared to tangible investment, and grew fast in the past two decades, the level of intangible investment before 1995 is much smaller than that in 2013 (in the case of China, the 1995 investment is less than half of the 2013 investment).

[5] The sector of other services includes (1) ICT services, (2) leasing, technical, science & business services, (3) public administration & defense, (4) education services, (5) health & social security services, and (6) other services excluding the financial and real estate services.

Please note that we do have intangible estimates by 37 industries, but for the ease of presentation, we focus on results of 8 sectors for most of this paper. We estimate 8 detailed types of intangible investment for 37 industries, and then aggregate the results of industries into 8 sectors.

3.3 Data sources of value added, employment, and tangible investment

China has a serious problem of data availability. Some key data that are widely available for advanced economies are not available at the industry level in China. It might be surprising to some readers that Chinese official statistics (NBS) do not provide employment, value added or employment by industry[6], and the most detailed breakdown of value added is by 9 sectors.[7]

For industry-level data on investment, employment and value added, the data source is Wu (2016). (How did you estimate those variables?) Wu (2016) estimates investment

3.4 Measuring 8 detailed types of intangible assets

This paper covers three categories and eight detailed types of intangible assets (Table 2), following the structure of CHS (2005). The first category is Computerized Information, including software and databases. We measure software and drop database because no data is available for database investment in China. We expect that the omission of database has a very small impact on the estimates of Computerized Information. CHS (2005) measures that among the annual average investment of $155 billion in Computerized Information in the U.S. between 1998 and 2000, only $3 billion is from database. The second category is Innovative Property, including five detailed types of intangible assets—research and development (R&D), mineral exploration, copyright and license costs, architectural and engineering design, and new product development costs in the financial industry. We measure all five types of assets. The third category is Economic Competencies, including three detailed types of intangible assets—brand equity, training, and organizational capital. We measure all three types of assets.

Data on intangible investment in China are from various types of sources—China Statistical Yearbooks, Chinese Census, data from trade associations, and Wu (2016). In many cases, intangibles data are not at the detailed level of 37 industries, and we resort to creative methods to distribute the national aggregate of intangible investment to industries. As important as intangible assets are for the modern economy, most data on intangibles are not collected by

[6] NBS does provide some data for urban units by industries, but we are interested the total value added by industry (urban and rural), not just urban value added.
[7] We combine financial and real estate sectors and get 8 sectors in our research.

national statistical offices of even the advanced economies, not to say the former socialist China whose statistical system is still slowly shifting from the Soviet Union-style system to the Standard National Accounts adopted by most of the advanced economies.

3.4.1 Software

The software industry in China includes software products, information technology services, and embedded system software. Over 80% of software investment is not treated as investment in the national accounts, and embedded system software is the only category that is treated as capital in the national accounts. Only software purchased together with hardware is treated as investment in China national accounts, and other purchased software and own-account software are all considered intermediate inputs, not investment (Xu, 2008). Spending on embedded system software is part of the investment in GDP, while spending on other types of software products and services is expensed in the national accounts.

We use the estimate of total software investment from Hulten & Hao (2015), and distribute total investment among 37 industries using equipment investment as weights. This weight will give us the distribution of embedded system software, but not the distribution of software products or information technology services, and embedded system software only accounts for a small portion of the revenues of the software industry. Revenues from embedded system software are 0.7 trillion Yuan in 2015, compared with the total revenues of the software industry, 4.3 trillion Yuan (MIIT, 2016).[8] A problem with using this weight is that we cannot track the impact of, say, e-commerce on 37 industries. E-business platform services is part of information technology services.[9] If there were any data available on the software investment in Chinese industries, we would have used that data, but without any data available such as data on the number of IT related employees or the investment in ICT equipment, we use the equipment investment as weights.

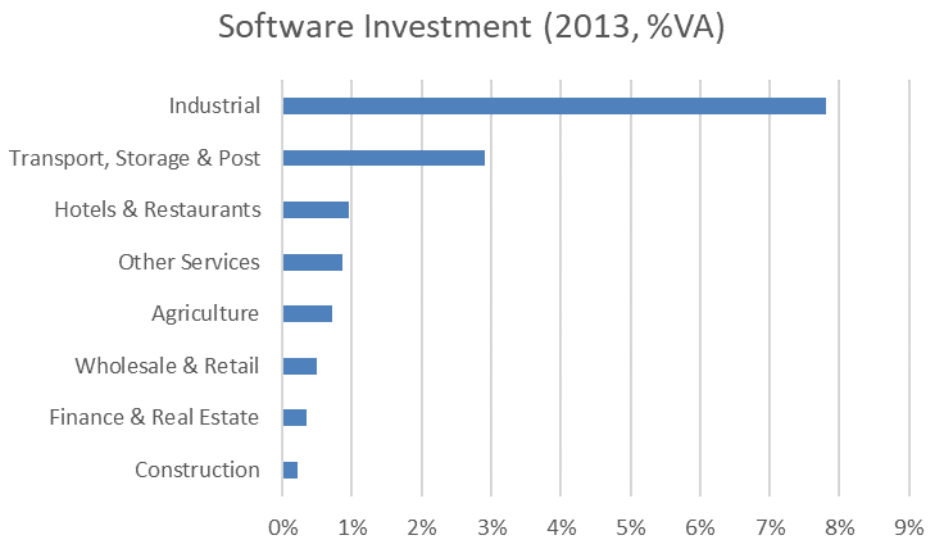
We estimate that software investment intensity is the highest in the industrial sector, 7.8% of value added in 2013, followed by the transport, storage & post sector, 2.9%, other services,

[8] 2015 年 1 - 12 月软件业经济运行快报.
http://www.miit.gov.cn/n1146312/n1146904/n1648374/c4624367/content.html

[9] Information technology services include operation services (operation services of online software, platform operation services, and infrastructure operation services), e-business platform services (online trade platform services and online trade support services), and integrated circuit design.

0.86%; and the sector with the least investment in software is the construction sector, 0.22% (Table 2).

Chart 2



Note: The sector of Other Services includes (1) ICT services, (2) leasing, technical, science & business services, (3) public administration & defense, (4) education services, (5) health & social security services, and (6) other services excluding the financial and real estate services.

3.4.2 Research and Development (R&D)

China has rapidly increased its spending on R&D from 0.57% of GDP in 1995 to 2.01% of GDP in 2013. China ranks the 2nd in total R&D spending in the world after the U.S. The Chinese government has set science and technology as a key growth strategy of China since 1978.[10]

The data source of national spending on R&D is the National Bureau of Statistic of China, and the data sources of the distribution of R&D spending by industry (2006-2013) are the China

[10] Xiaoping Deng said "Science and technology are primary productive forces" in the national science conference in 1978. (http://cpc.people.com.cn/GB/64156/64157/4418457.html) Since then, the Chinese leaders emphasized the importance of science and technology in different government documents, including the recent 13th Five Year Plan.

Statistical Yearbooks on Science and Technology[11] and the 2009 National Comprehensive Statistics on the R&D Census.[12] For years before 2006, we use the distribution of R&D in 2006.

The China Statistical Yearbooks on Science and Technology provides R&D spending by industry from 2006 to 2013. It lists R&D spending by about 40 industries covering three sectors (mining, manufacturing and utility) and that spending covers about 70% of total national R&D spending in 2013. To find out the industry distribution of the rest of the 30% of national R&D spending, we use R&D spending in service industries from 2009 National Comprehensive Statistics on the R&D Census.[13] The 2009 survey compliments the annual R&D survey because the 2009 survey covers the agricultural sector and 11 service industries. According to the 2009 survey, R&D spending is negligible in catering and hospitality, wholesales and retails, real estate and public administration.

R&D intensity is the highest in the Industrial sector, 4.6% of VA in 2013, followed by Other Services[14], 1.7% VA, and Construction sector, 0.3% VA (Table 2). Three sectors invest almost zero percent of VA on R&D—Finance & Real Estate, Hotels & Restaurants, and Wholesale & Retail. The fact that Wholesale & Retail has gone through major innovations such as ecommerce despite negligible spending on R&D implies that innovation does not necessarily need to be driven by R&D.

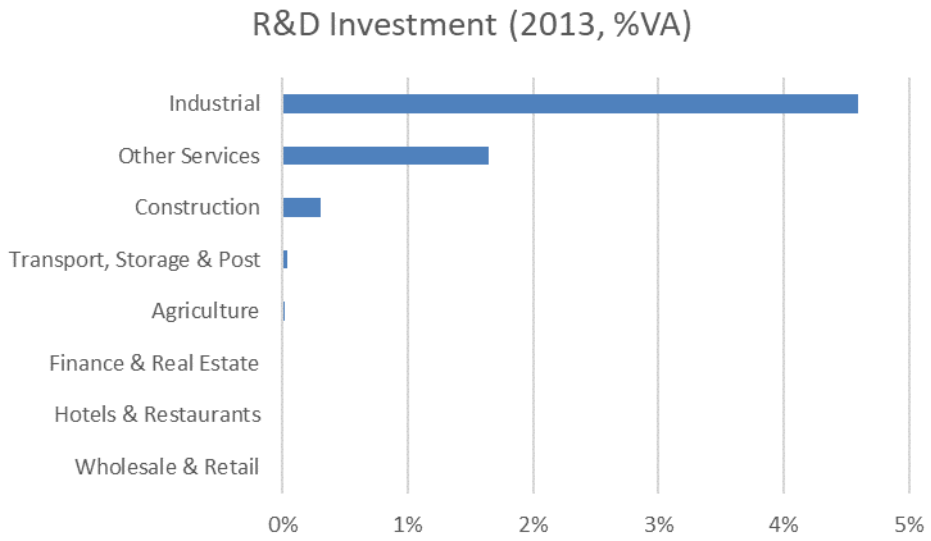
Chart 3

[11] 《中国科技统计年鉴》

[12] We do not have enough data at the detailed industry level to adjust estimates for double counting, to exclude R&D in software investment and R&D in mineral exploration from total R&D spending.

[13] 《第二次全国 R&D 资源清查资料汇编》

[14] The sector of Other Services includes (1) ICT services, (2) leasing, technical, science & business services, (3) public administration & defense, (4) education services, (5) health & social security services, and (6) other services excluding the financial and real estate services.



Note: The sector of Other Services includes (1) ICT services, (2) leasing, technical, science & business services, (3) public administration & defense, (4) education services, (5) health & social security services, and (6) other services excluding the financial and real estate services.

3.4.3 Mineral exploration

National total spending is from the China Mining Yearbooks[15] which provide total spending on mineral exploration over the years. Mineral exploration is relevant for the mining sector only. To break down spending into 4 mining industries, we use the provide the spending on different types of minerals in 1996, 1997, 2002 and 2003 from the China Mining Yearbooks. We use the breakdown of 1996 for years before 1996, 2003 for years after 2003, and for the other years between 1996 and 2003 we use the interpolation of two closest years with data available. Total mineral exploration decreased from 0.41% of GDP in 1995 to 0.21% of GDP in 2013. Among the total spending in 2013, 65% of the spending is on oil and gas, 22% is on metal mining, 7% is on non-metallic minerals mining, and 5% is on coal mining. Mineral exploration investment amounted to 0.56% of VA in the Industrial sector in 2013, and other sectors did not invest in mineral exploration.

3.4.4 Copyright & Licenses

We use a slightly different method from CHS (2005) to estimate copyright and license fees. CHS (2005)used three times the development costs of movies to estimate this type of intangibles, while we estimate copyright fees as royalty costs of the publishing industry and transfer or

[15] 《中国矿业年鉴》

license fees from patents. Our data sources are the National Overview of the News and Publishing Industry [16]and China Statistical Yearbooks on Science and Technology[17].

We estimate copyright fees using the royalty costs of books, magazines, newspapers, audios and videos published in China. Then we assign the royalty of textbooks to the industry of education services and assign the royalty of the rest types of publications to the industry of information and communications. We estimate royalty costs as 7% of the list prices, using data on royalty of books in the U.S.[18]

Data source of license revenues from patents is the 2009 National Comprehensive Statistics on the R&D Census[19]. Most of transfer and license costs are in the manufacturing sector, the education sector and the industry of R&D and technical services and mineral exploration. For years other than 2009, we use ratios of license revenues to R&D spending by industry in 2009, to estimate license revenues in all years.

National spending on copyright and license fees remained between 0.05% and 0.07% of GDP from 1995 to 2013. The spending is allocated to two sectors in our estimation—the Industrial sector (which includes the R&D intensive manufacturing industries), 0.08% of value added, and the Other Services sector (which includes the education sector (for publishing) and the industry of R&D and technical services and mineral exploration (for R&D)), 0.16% of value added.

3.4.5 Architectural designs

CHS (2005) measures architectural and engineering designs, but there is no data available for engineering designs in China, so we measure architectural designs only. There has been a large spending on architectural designs, thanks to the booming and bubbled real estate sector in China. Floor space completed per year increased from 1.5 billion square meters in 1995 to 3.5 billion square meters in 2013 (NBS, 2014). The increase in investment in structures is huge, compared with the relatively stable number of the population. In 2013 alone, China completed over 2 square meters of structures for each person in the 1.3 billion population. The booming investment in structures pushes up the demand for architectural design.

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[16] 《全国新闻出版业基本情况》

[17] 《中国科技统计年鉴》

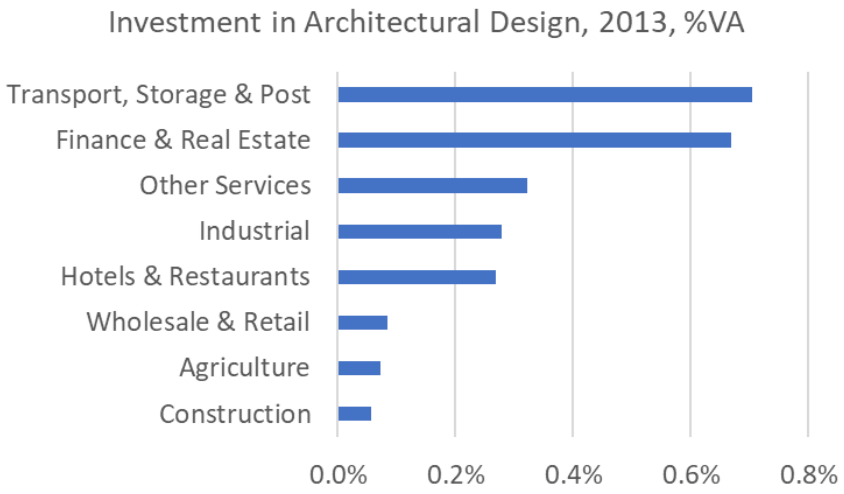
[18] 2005 Annual report of HM Publishing Corporation shows that royalties is about 7% of listing prices of books. HM Publishing Corporation, 2005. Annual Report (Form 10-K). Available at http://www.sec.gov/Archives/edgar/data/48638/000119312505060772/d10k.htm

[19] 《第二次全国 R&D 资源清查资料汇编》

Data sources are the National Bureau of Statistics of China and the National Yearbooks of Engineering Survey and Design Companies[20]. The Yearbooks provide total revenues of "Companies and institutes of engineering survey and design". Their revenues from 0.33% to 0.56% of GDP from 2003 to 2014. Then we allocate the total revenues on architectural designs into industries using weights which are Fixed Asset Investment (FAI, 2003-2011) in structures. All industries invested some shares of value added in architectural design, because each industry build structures for business, and some companies, still following the old socialist welfare way, hire construction teams to build residential structures for their employees. Not surprisingly, the sectors that have the most investment in architectural design are Finance & Real Estate, 0.67% of VA, and Transport and Storage and Post, 0.70% of VA in 2013 (Table 2). The real estate industry invested heavily in residential and non-residential structures, and the transport sector invested heavily in transport infrastructure due to many railway and highway projects funded by the government.

A problem is that the data is on structure-related designs, not product designs. So we cannot interpret the investment in architectural design as investment in product innovation or moving-up the value chain. Too much investment in structures is harmful for the economy, creating real estate bubbles.

Chart 4



Note: The sector of Other Services includes (1) ICT services, (2) leasing, technical, science & business services, (3) public administration & defense, (4) education services, (5) health & social security services, and (6) other services excluding the financial and real estate services.

[20] 《全国工程勘察设计企业年报》

3.4.6 Brand equity

We measure spending on brand equity using the turnover of the advertising industry in China. CHS (2005) measures spending on both advertisement and market research for spending on brand equity. We do not measure spending on market research because data is unavailable, and because the spending on market research is less than 0.03% of GDP (Hao & Hulten, 2012). CHS (2005) treats 60% of advertising spending as investment in brand equity.

The data sources are the National Bureau of Statistics of China for national total advertising spending, the China Advertising Yearbooks[21] for advertising spending on 19 aggregate groups of products and services, and the National Bureau of Statistics of China for marketing costs and sales, general and administrative costs (SG&A) by industries.[22]

We allocate the advertising spending on 19 types of products & services into their corresponding industries. The allocation is far from prefect, because most aggregate groups of products or services belong to a relatively small number of industries and the spending on "other services" covers multiple service industries. Then we break down the spending into more detailed industries in the industrial sector using the sales and distribution costs, and in the service sector using total SG&A costs (because sales and distribution costs are unavailable). We have no data on advertisement spending of the government, while the government heavily influences the content of news and movies and TV programs. Then we estimate investment in brand equity as 60% of advertising spending, following CHS (2005).

Investment in brand equity in China increased from 0.27% of GDP in 1995 to 0.53% of GDP in 2013. The investment is the highest in the Industrial sector, 0.99% of value added, followed by Hotels and Restaurants, 0.66% of value added, Finance and Real Estate, 0.48% of value added, and the sector that invested the least in brand equity is the agricultural sector, 0.0015% of value added (Table 2). The Industrial sector is the largest spender of advertisement, because most of the heavily advertised products are from that sector. Automobile accounted for 14.2% of national advertising spending in 2013, food products and food supplement, 15.7%, cosmetics, 10.7%, and medicines, 5.5%, just to name a few. The most heavily advertised service among different services is real estate services, accounting for 13.8% of national advertising spending, followed by information services, 4.1%, and financial and insurance services, 3.5%.

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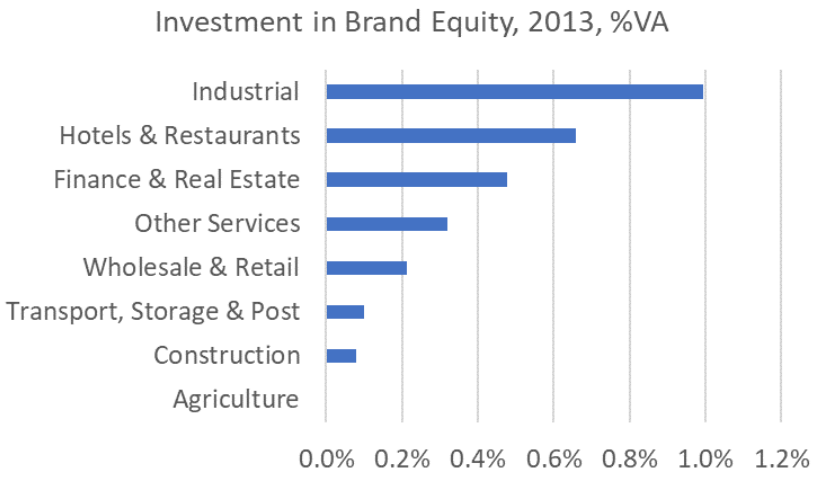
[21] 《中国广告年鉴》

[22] Advertisement spending by 19 types of products, provided by the Table of National Advertising Revenues by Major Industries in the China Advertising Yearbooks.中国广告年鉴，表：全国主要行业广告营业额统计表. Sales and distribution costs in industries of the agricultural and industrial sectors, provided by CEIC. For industries in the service sectors: the sum of management costs, financial costs and sales and distribution costs provided by the Second National Economic Census of China. (三项费用合计)，来源于第二次经济普查 2008.

Chart 5



Note: The sector of Other Services includes (1) ICT services, (2) leasing, technical, science & business services, (3) public administration & defense, (4) education services, (5) health & social security services, and (6) other services excluding the financial and real estate services.

3.4.7 Firm-specific human capital (training)

Data sources are the General Principles of Corporate Finance (Ministry of Finance Order No. 41)[23], 2010 Continuing Vocational Training Survey provided by OECD, and compensation data from Wu (2016), and the 2004 Economic Census (unpublished detailed data provided by the National Bureau of Statistics of China).

The Ministry of Finance of China states in the General Principles of Corporate Finance that companies should allocate fund amounting to 1.5% of wages for education and training of employees. If companies fail to do so, the government will confiscate that fund.[24] There is a

[23] 《企业财务通则》（财政部令第 41 号）

[24] 《国务院关于大力推进职业教育改革与发展的决定》 The Decision of the State Council on Strongly Promote the Reform and Development of Vocational Education
http://www.gov.cn/gongbao/content/2002/content_61755.htm
"一般企业按照职工工资总额的 1.5%足额提取教育培训经费,从业人员技术素质要求高、培训任务重、经济效益较好的企业可按 2.5%提取,列入成本开支。要保证经费专项用于职工特别是一线职工的教育和培训,严禁挪作他用。"
财政部《关于职工教育经费管理和开支范围的暂行规定》的补充通知 Supplement Notice on the Interim Provisions on the Management and Allocation of Employee Education Expenses
http://www.mca.gov.cn/article/zwgk/fvfg/zh/200711/20071100003778.shtml

possibility that companies will choose not to obey the regulations, but we would not know how serious that problem is because firms will not disclose that in public information, so we assume that all companies obey that regulation on allocating funds to the education and training of employees.

We estimate that total spending on on-the-job training is 2.8% of wage in the urban units of industries.[25] Total spending on firm-specific human capital is the sum of direct training costs and personal absence costs. Among the 2.8% of wage, direct training costs equals 1.5% of wage in each industry, and indirect costs as 1.3% of wage. The indirect costs are estimated as personal absence costs which are 0.89 times direct training costs in the European Union in 2010. We use this ratio for China.

We estimate that total spending on on-the-job training is 1.5% of compensation. We do not have data on wage payment at the industry level, but we have data on compensation from 2004 Economic Census. We estimate wage by multiplying compensation with the ratio of wage to compensation at the country level.

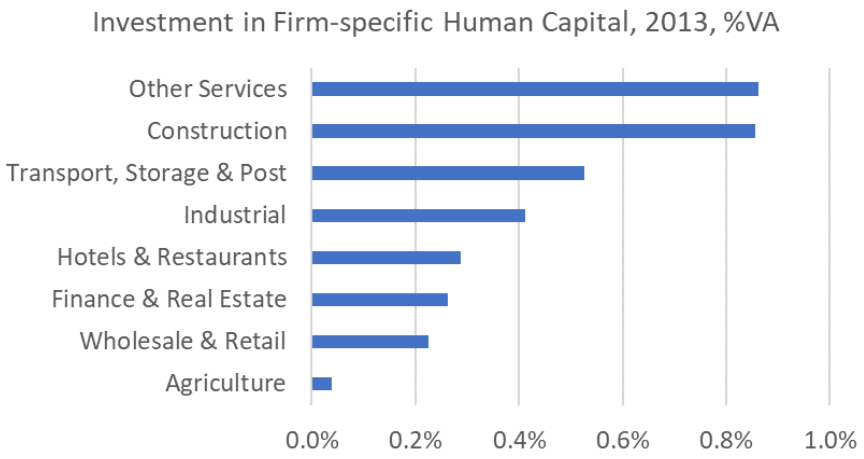
Sectors are estimated to invest between 0.2% and 1.0% of value added in training, depending on how labor intensive a sector is. (wholesale and Retail is not labor intensive?) The sectors that invested the most in on-the-job training are Construction, Other Services[26], and Transport, Storage & Post, while the sectors that invested the least in on-the-job training are Agriculture, Wholesale & Retail and Finance & Real Estate.

Chart 6

职工教育经费：不按规定提取和使用将被统筹 Employee Education Expenses: The Government will Take Over the Funding for the Expenses if Companies Do not Set aside and Allocate the Funding Following the Government Regulations
http://blog.sina.com.cn/s/blog_88a4e7250101yyf7.html

[25] Rural population in the agricultural industry often do not organize as companies and have little organizational structure.

[26] Other Service sector includes (1) Information and communications, (2) Leasing, technical, science & business services, (3) Public administration and defense, (4) Education services, and (5) Health and social security services.



Note: The sector of Other Services includes (1) ICT services, (2) leasing, technical, science & business services, (3) public administration & defense, (4) education services, (5) health & social security services, and (6) other services excluding the financial and real estate services.

3.4.8 Organizational structure

Spending on organizational structure is measured with 20% of manager's compensation in CHS (2005), and 80% of that is treated as investment. Hulten and Hao (2012, unpublished updated) estimated that China invested 0.66 percent of valued added in organizational structure in the total economy in 2013. We allocate the national total investment into 37 industries using weights which are urban employment of industries.[27] (Data is unavailable on the compensation by occupations at the industry level in China.)

Data sources are Corrado & Hao (2015) on the employment and compensation by occupation and industry in the U.S.. China data sources are equipment investment provided by Wu (2016), and education and employment data estimated from various years of Population Census and Chinese Statistical Yearbooks.

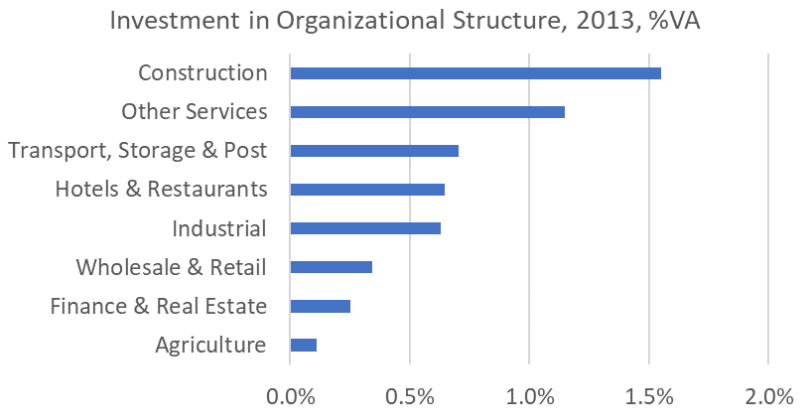
All 8 sectors invested heavily in organizational structures in 2013. The sector of Construction invested the most in organizational structures, 1.55% of value added, followed by Other Services[28], 1.15% of value added, followed by the sector of Transport, Storage & Post, 0.70%. The Agricultural sector invested the least in organizational structures, 0.55% and 0.57% of value

[27] Rural population in the agricultural industry often do not organize as companies and have little organizational structure.

[28] Other Service sector includes (1) Information and communications, (2) Leasing, technical, science & business services, (3) Public administration and defense, (4) Education services, and (5) Health and social security services.

added, respectively. The implication on the relatively small spending on organizational capital is that the Chinese companies do not have a structure as complex as their U.S. counterparts.

Chart 7



Note: The sector of Other Services includes (1) ICT services, (2) leasing, technical, science & business services, (3) public administration & defense, (4) education services, (5) health & social security services, and (6) other services excluding the financial and real estate services.

Part V: Intangible investment at the sector level

Intangible investment as a share of value added is the highest, 15.4%, in the industrial sector in 2013, followed by Other Services sector[29], 5.32%, and Transport, Storage & Post, 4.98%. The agricultural sector is the sector that invested the least intangibles, only 0.96% of value added.

Intangible investment accounted for the largest share of total investment (tangible and intangible investment) in the construction sector, 48%, in 2013, followed by the industrial sector, 19%, and wholesale & retail sector, 17%. Without measuring intangible investment, we would miss all that investment. That bias is especially serious when a lot of the tangible investment is policy or stimulus driven and leads to over-capacity, while intangible investment is closed related to investment in innovations and innovation is a key growth strategy pointed

[29] Other Service sector includes (1) Information and communications, (2) Leasing, technical, science & business services, (3) Public administration and defense, (4) Education services, and (5) Health and social security services.

by the Chinese government.

Intangible investment grew the most rapidly in the Industrial sector, from 4.2% of VA in 1995 to 15.4% of VA in 2013, followed by the Transport, Storage & Post sector, from 2.0% of VA in 1995 to 5.0% of VA in 2013. The sectors that grew the least in intangible investment is the Agricultural sector from 0.25% of VA in 1995 to 0.98% of VA in 2013, and the Finance & Real Estate sector, from 1.4% of VA in 1995 to 2.0% of VA in 2013. The sector of Other Services even decreased its intangible investment from 6.9% to 5.3% of VA during the same period, due to the decrease in investment in organizational structure, on-the-job training, copyright and licenses, and architectural design. Other Service sector includes (1) Information and communications, (2) Leasing, technical, science & business services, (3) Public administration and defense, (4) Education services, and (5) Health and social security services.

Part V: implication of the intangibles estimates on the prospect of the Chinese economy

We do not attempt to comprehensively evaluate the future of the Chinese Industrial and service sectors. Rather, we look at those sectors through the lens of intangible investment to provide some new evidence about their prospect.

Investment in today's intangible capital is an indicator of the power of innovation in the future. Investment delays consumption and builds capital that will lead to output in the future. A small investment in intangible assets implies a weak capital stock in innovation and in moving the Chinese sectors up the global value chain. More specifically, the capacity of companies of R&D, design, marketing and supply chain management are all related to intangibles. The production of goods may require many machines but may not capture much revenues. For example, although China assembled all of the iPhones in 2010, China only captured 2 percent of revenues of iPhones. In contrast, Apple captures about 60 percent of revenues of iPhones. [30]

We compare China with Japan, the UK and the U.S., both for 3 categories of intangible investment and for detailed types of intangible investment. Table 3 lists the 3 categories of intangible investment in China, Japan, the UK and the U.S., for the industrial sector and the sum of the 4 service sectors (Wholesale & Retail; Hotels & Restaurants; Transport, Storage & Post;

[30] Kraemer, Kenneth, Greg Linden, and Jason Dedrick, 2011. Capturing value in global networks: Apple's iPad and iPhone. Available at http://pcic.merage.uci.edu/papers/2011/Value_iPad_iPhone.pdf

Finance & Real Estate). Table 2 reports total detailed intangible investment, total intangible investment and adjusted intangible investment which is a sum of software & databases, R&D, mineral exploration, copyright & licenses, and branding in China, Japan, the UK and the U.S.

The adjusted investment excludes the estimates of spending on design, training and organizational structures, to account for the difficulty of accurately measuring those items by sector in China. We decide to exclude design, training and organizational structures for the different problems involved in measuring the three types of intangible assets. First, the investment in design measured for China is architectural design, unlike the U.S. estimate which includes both architectural design and industrial design. Considering that China has been undergoing a prolonged real estate bubble with many sold but unoccupied apartments, if we measure investment architectural design, we are mostly measuring the real estate bubble and the over-investment in architectural design including that for empty apartments. Second, as to training costs, although the Chinese government regulation states that all employers must set aside 1.5% of wage as training costs, we are not sure how well the regulation is enforced. Also given the wide-spread of creative accounting in Chinese companies, we consider it safer to exclude training in the comparison. Third, as to investment in organizational structures, the CHS (2005) treat their estimate (20% of managers' time) as a placeholder. And the placeholder has a problem of lack of employment data on managers, and different management tradition and organizational structures in Chinese and U.S. companies, and we think the estimates of organizational structure would not be accurate for China following the method of CHS (2005).

Another caveat is that about half of the intangible investment is on software and the software estimates is largely determined by investment in machines and equipment, and overinvestment in the Chinese industrial sector was a serious problem, which means that the software investment might need to be discounted for the factor of over-investment and thus waste. We still include software in the comparison but just need to keep in mind of the caveat.

5.1 The upgrading of the Industrial sector of China

The Industrial sector of China is the sum of the manufacturing sector, the mining sector and the utilities sector. The Industrial sector accounted for 37 percent of value added and 21 percent of employment in the total economy in 2013. The Chinese government outlines the plan to upgrade the Industrial sector in *Made in China 2025*, where innovation is at the core of the development of the Industrial sector.[31]

[31] Made in China 2025. 中国制造 2025. Available at http://www.miit.gov.cn/n973401/n1234620/n1234622/c4409653/content.html

Intangible investment can help us evaluate the commitment of the Chinese industrial sector to upgrade the sector through innovation. China invests 15.4% of value added in intangible investment in the industrial sector, imply that the Industrial sector of China commits a significant amount of resources into building the innovation capacity and moving up the global value chain. The Chinese level of investment is about 80% of the investment in the industrial sectors of the U.S. and the U.K.. The U.S. invested 19.9% in the industrial sector in 2013, and the U.K. invested 19.7% in the manufacturing sector in 2011.

Comparing the investment in the 3 categories of intangibles in China, Japan, the U.K. and the U.S., we find that the Chinese industrial sector invests much less in economic competencies than the U.K. and the U.S., and much less in innovative competencies, implying ***** (Please revise the writing here, Harry.)

The China industrial sector emphasizes on different types of intangibles than the U.S. and U.K. counterparts (Table 2). The U.S. and U.K. industrial sectors invest more on R&D and branding than the China industrial sector, while the China industrial sector invests more heavily on software (a co-investment of machines and equipment) than both the U.S. and U.K. counterparts. Investment in machines and equipment leads to serious overcapacity in the Chinese economy. The comparison shows that the Chinese intangible investment needs more emphasis on advances and applications of science and technology (R&D) and the building of influential brands, rather than building intangibles as a co-investment as the heavy tangible investment.

5.2 The prospect of the service sector driving the China economic growth

The Chinese government expects the service sector to play an important role in Chinese economy moving up the value chain.[32] The National Bureau of Statistics stated that the service sector had become a new driver of economic growth in 2014, because the GDP share of service sector surpassed that of the industrial sector.[33] The 13th Five Year Plan states that the government plans to make the service sector of higher quality. Here we use the service sector of the U.S. as a benchmark, and compare the investment in intangible assets with that in the

[32] 服务业已成我国就业最大容器. 国家发展和改革委员会。
http://www.ndrc.gov.cn/fzgggz/jyysr/jqyw/201604/t20160429_800555.html
中国经济能否靠服务业力挽狂澜？德媒：专家看法相左。 参考消息网
http://m.cankaoxiaoxi.com/finance/20160926/1315631.shtml
服务业是中国经济的大救星？ 德国之声 Deutsche Welle. www.dw.com

[33] 服务业：中国经济增长新动力 ——解读《2014 年国民经济和社会发展统计公报》
http://www.stats.gov.cn/tjsj/sjjd/201503/t20150305_689566.html

Chinese service sector. Intangible investment indicates the resources for innovation and moving up the value chain in the service sector.

The service sectors of China do not show much commitment of resources into upgrading the sectors (Table 3)—intangible investment in the service sectors is much less than that in the U.K. and the U.S.., despite the Chinese government's plan to use the service sectors as a new driver of economic growth. The small intangible investment in Chinese service sectors imply that China still need more intangible investment to move its services sectors up the value chain and to facilitate innovations in the service sectors. (Please revise the writing here, Harry.)

Table 2 shows that the four Chinese service sectors all invest much less in intangible assets than their U.S. counterparts. Brand equity is the major reason of the gap between U.S. and China intangible investment in sectors including Wholesale& Retail, Hotels & Restaurants, Finance & Real Estate, and Transport, Storage & Post. For example, while the U.S. wholesale and retail sector spends 7.1% of value added in the 5 types of intangible assets listed as adjusted intangible investment, the Chinese wholesale & retail sector spends only 1.35% of value added, and the gap is mostly from the investment in brand equity (5.1% VA in the U.S. v.s. 0.2% VA in China). Brand equity helps service sectors to move up the value chain in that good brands could allow premium pricing which transform the competition among companies from competition through low prices (thus low costs) to competition of high quality, product differentiation and so on. In addition, brand equity facilitates product innovation in that new products under a good known brand are more likely to be welcomed by the market during the launch of new products. The comparison between China and U.S. shows that the Chinese service sectors would need to invest heavily in building strong brands to catch up with the U.S. service sector.

Part VI: Conclusion.

(to be written)

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(to be written)

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Table 1: Intangible investment by 8 sectors and 37 industries (million RMB, current prices)

Industry & Sector	1995	2000	2008	2013
Agricultural Sector	**2,978**	**5,599**	**21,091**	**54,961**
Industrial Sector	**105,118**	**195,675**	**1,025,257**	**3,340,344**
coal mining	3,684	6,815	42,440	129,843
oil & gas excavation	24,705	26,133	90,753	158,077
metal mining	1,823	1,522	19,420	63,770
non-metallic minerals mining	1,043	1,027	6,968	20,228
Food and kindred products	5,755	12,065	51,247	177,236
Tobacco products	581	1,377	4,091	10,040
Textile mill products	3,830	6,125	25,563	79,096
Apparel and other textile products	1,496	2,905	10,468	29,412
Leather and leather products	689	1,208	5,319	17,547
Saw mill products, furniture, fixtures	657	1,345	8,813	34,007
Paper products, printing & publishing	1,875	4,407	16,419	59,882
Petroleum and coal products	1,304	3,260	26,025	97,399
Chemicals and allied products	11,563	21,966	101,093	378,211
Rubber and plastics products	1,844	4,497	15,886	52,011
Stone, clay, and glass products	4,135	5,728	35,784	144,192
Primary & fabricated metal industries	6,219	13,466	118,333	391,602
Metal products (excluding rolling products)	1,722	3,070	13,949	56,142
Industrial machinery and equipment	8,111	13,819	80,636	289,978
Electric equipment	5,088	12,854	58,875	193,231
Electronic and telecommunication equipment	5,226	17,998	91,825	298,250
Instruments and office equipment	824	2,052	8,829	36,269
Motor vehicles & other transportation equipment	6,144	12,772	81,690	285,322
Misc. manufacturing industries	1,137	1,323	5,919	16,157
Power, steam, gas and tap water supply	5,663	17,942	104,909	322,443
Construction Sector	**6,262**	**10,739**	**38,210**	**124,933**
Wholesale & Retail Sector	**4,350**	**8,170**	**25,037**	**76,154**
Hotels & Restaurants Sector	**1,420**	**2,658**	**11,823**	**28,714**
Transport, storage & post services sector	**6,417**	**11,971**	**47,333**	**129,585**
Financial & real estate sector	**46,812**	**72,232**	**288,400**	**654,455**
Financial intermediations	41,876	63,425	239,558	539,550
Real estate services	4,936	8,807	48,842	114,905
Other Services sector	**38,423**	**76,777**	**314,851**	**549,365**
Information and communications	4,741	9,412	31,238	54,264
Leasing, technical, science & business services	5,657	16,629	107,757	167,772
Public administration and defense	7,672	12,214	47,877	106,061
Education services	12,739	24,820	77,784	117,355
Health and social security services	3,914	8,193	28,402	56,015
Other	3,700	5,509	21,793	47,899
Total	211,780	383,822	1,772,002	4,958,509

Table 2: Intangible Investment in 8 Sectors of China, 2013, % value added.

China2013 %Value Added	*Agri-culture*	*Industrial*	*Con-struction*	*Wholesale & Retail*	*Hotels & Restaurants*	*Transport, Storage & Post*	*Finance & Real estate*	*Other services**
Computerized Information								
Software	0.72	7.82	0.22	0.49	0.95	2.91	0.34	0.86
Innovative Property								
R&D	0.02	4.60	0.30	0.00	0.00	0.04	0.00	1.65
Mineral Exploration	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00
Copyright & Licenses	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.16
Design	0.07	0.28	0.06	0.08	0.27	0.70	0.67	0.32
Economic Competencies								
Brand Equity	0.00	0.99	0.08	0.21	0.66	0.10	0.48	0.32
On-the-job Training	0.04	0.41	0.86	0.22	0.29	0.53	0.26	0.86
Organizational Structures	0.11	0.63	1.55	0.34	0.64	0.70	0.25	1.15
Total-China	**0.96**	**15.37**	**3.06**	**1.35**	**2.81**	**4.98**	**2.00**	**5.32**
Adjust-China	**0.74**	**14.06**	**0.60**	**0.70**	**1.61**	**3.04**	**0.82**	**2.99**
Total-US2013	**0.70**	**21.4**	**2.5**	**12.2**	**11.4**	**7.3**	**16.7**	**20.7**
Adjust-US2013	**0.17**	**15.2**	**0.5**	**6.5**	**3.4**	**2.0**	**9.1**	**11.0**
Total-UK2011		**19.7**	**7.4**	**11.0**		**8.9**	**14.2**	**11.3**
Adjust-UK2011		**13.1**	**0.9**	**3.7**		**4.1**	**6.0**	**3.9**

Note: Adjust-China, Adjust-US and Adjust-UK include investment in software, R&D, mineral exploration, copyright & licenses and brand equity only.

Table 3: Cross-country Comparison of Intangible Investment in Selected Sectors, % Value Added

Sectors & Countries	Computerized Information	Innovative Property	Economic Competencies	Total Inv, % VA
Industrial				
China2013	7.82	5.52	2.03	15.37
Japan2008	3.36	12.01	2.30	17.66
UK2011(manu)	2.55	11.26	5.91	19.70
US2013	1.53	14.49	5.40	21.43
Service*				
China2013	0.64	3.37	1.03	5.04
Japan2008	2.47	2.27	1.93	6.67
UK2011(manu)	2.74	2.61	7.28	12.63
US2013	2.36	1.91	8.52	12.79

Note: Service* includes 4 sectors: (1) Wholesale & Retail, (2) Hotels & Restaurants, (3) Transport, Storage & Post, and (4) Finance & Real Estate.

Table 4: Intangible Investment by Sector, % Value Added, 1995-2013

	agriculture	industrial	construction	wholesale & retail	hotels & restaurants	transport, storage & post	finance & real estate	other services*
1995	0.25	4.22	1.68	0.91	1.18	1.98	1.41	6.87
1996	0.25	3.88	1.67	0.93	1.24	1.97	1.41	6.82
1997	0.28	4.10	1.77	0.94	1.20	2.06	1.43	6.33
1998	0.30	4.30	1.78	0.95	1.17	2.02	1.40	5.83
1999	0.33	4.63	1.86	0.96	1.19	2.02	1.48	5.64
2000	0.37	4.90	1.94	1.00	1.24	1.94	1.50	5.51
2001	0.40	5.18	2.01	0.97	1.26	1.98	1.53	5.22
2002	0.43	5.76	2.05	0.97	1.27	2.07	1.71	5.24
2003	0.49	6.19	1.98	0.98	1.17	2.35	1.95	5.29
2004	0.46	6.82	1.94	0.98	1.31	2.52	2.01	5.53
2005	0.51	7.29	2.02	0.98	1.49	2.68	2.09	5.72
2006	0.55	7.39	2.05	0.94	1.58	2.72	2.03	6.05
2007	0.59	7.44	2.01	0.94	1.71	2.72	1.82	5.91
2008	0.63	7.89	2.04	0.96	1.79	2.89	2.00	6.03
2009	0.70	9.02	2.13	1.02	1.99	3.52	1.79	6.76
2010	0.76	9.54	2.11	0.96	2.10	3.57	1.66	6.76
2011	0.80	11.30	2.22	1.10	2.39	3.84	1.87	5.47
2012	0.88	13.34	2.45	1.24	2.55	4.29	1.99	5.32
2013	0.96	15.37	3.06	1.35	2.81	4.98	2.00	5.32
2013 investment intangible/tangible	0.07	0.21	0.32	0.09	0.07	0.05	0.09	0.11