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Measuring Intangible Assets in an Emerging Market Economy

An Application to Brazil

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Abstract

This paper measures intangible investment in Brazil. It estimates that during 2000–2008, annual business spending on intangible assets or knowledge-based capital in Brazil averaged about 4 percent of gross domestic product. While this is significantly lower than comparable rates for the United States, Japan and the United Kingdom, which hover around 11 percent, it is not too far below estimates for other developed countries such as Italy and Spain. Of the total expenditure on intangible assets in 2006, about 23 percent was spent on computer software and databases, 43 percent on innovative property (predominantly research and development and new product development in financial services), and 34 percent on economic competencies (which comprises branding, employee training and organization improvement). Brazil's share of spending on economic competencies is markedly lower than that observed in the United States and the United Kingdom, and the analysis finds it to be the slowest growing of the major intangible categories. Finally, having extended the intangible investment estimation methodology to produce more disaggregated (industry-level) estimates, the authors show that intangible investment is positively correlated with recent export growth and total factor productivity estimates across manufacturing industries. This suggests that intangible or knowledge-based capital, as measured here, can account for part of the hitherto unexplained component of productivity growth.

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Measuring intangible assets in an emerging market economy:

An application to Brazil

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1. INTRODUCTION

Firms invest in a range of knowledge-based or intangible resources such as computerized data and software, patents and trademarks, employee and management skills, or organizational improvements. Although they do not directly increase the level of physical assets, such knowledge-intensive expenditures resemble investment in traditional fixed capital such as machinery, equipment and buildings in that the benefits from them are not exhausted in a single year. Hence, it has been argued that such expenditures build 'intangible assets' or 'knowledge-based capital'. Increases in the stock of such knowledge-based capital are now increasingly recognized as an important driver of innovation and economic growth.

Intangible assets cannot be observed or quantified in the traditional sense. Some recent studies have proposed ways to deduce intangibles from observable tangibles using economic theory.[2] For example, one approach uses the value of securities to infer the quantity of intangible capital held by U.S. corporations (Hall 2000).[3] But the method which has become the most accepted in recent years estimates intangibles directly from observed expenditures. Building on previous studies that examined the undervaluation of US business investment in the late 1990s, Corrado, Hulten and Sichel (2005, 2009; henceforth CHS) proposed a comprehensive categorization of intangible investments, and quantified them by piecing together the corresponding expenditure data for the US.[4] The underlying principle is that any business outlay intended to increase future rather than current consumption should be treated as capital investment.

Spending on most intangibles is treated as intermediate expenditures in conventional national income accounting, which assumes that all their benefits are captured in the current output of tangible goods.[5] If one accepts the CHS framework, this causes an underestimation of total levels of investment and output.

[2] See OECD (2011) for a summary of recent work on measuring intangibles. Fereira and Hamilton (2010) compute 'intangible capital' as a residual by subtracting the values of physical capital, natural resources and net foreign financial assets from estimated total wealth (the present discounted value of future consumption). This broad definition includes human capital, institutional and social infrastructure, and resources omitted in the natural capital calculations such as subsoil water, diamonds, and fisheries. For Brazil, their average estimated value over 1995, 2000 and 2005 is 70 percent of total wealth, versus 85 percent for the US.

[3] Another indirect approach (Nakamura, 2001) is based on the insight that the ratio of consumption to GDP should be relatively stable if all investment (tangible and intangible) is properly counted. Hence, any rise in the consumption ratio will indicate the size of the unmeasured investments.

[4] The prior studies include OECD (1998), Nakamura (1999, 2001, 2003), Brynjolffson and Yang (1999), McGratten and Prescott (2000), and Brynjolffson, Hitt, and Yang (2002).

[5] National accounting treatment of intangibles has begun to change. In a number of countries, expenditures on software are now treated as a contribution to investment. And in the US, the Bureau of Economic Analysis will count expenditures on R&D as investment in its headline measure of GDP from 2013 onwards.

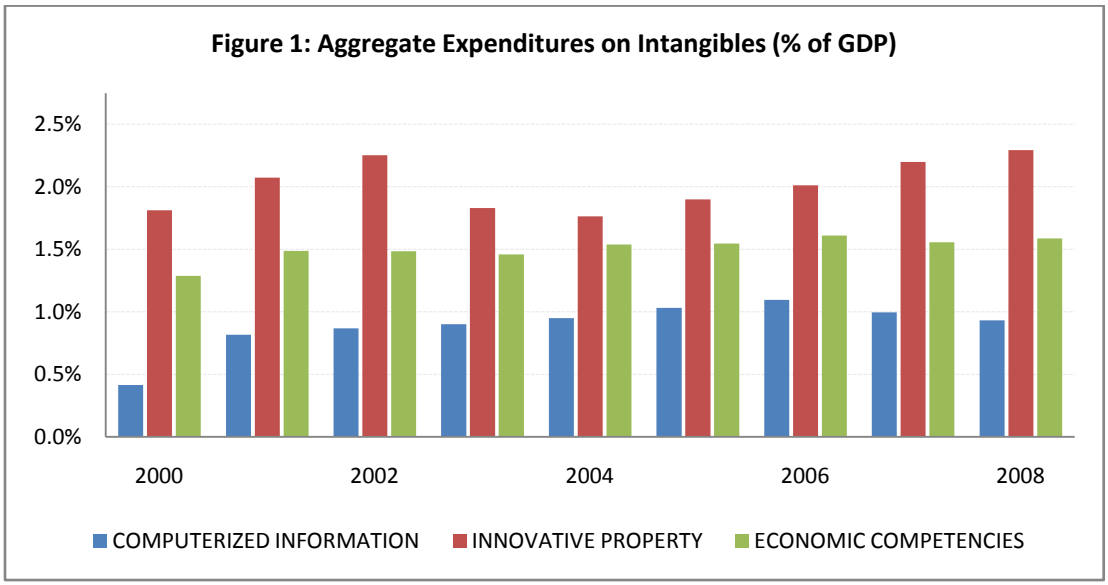
For instance, CHS (2009) estimate that US total business investment in intangibles was approximately one trillion dollars in 1999. Including intangible investment thus raises estimated US GDP in 1999 by roughly this amount, or 12 percent. Using the same methodology, Marrano and Haskell (2007) find that as a result of excluding intangibles, market sector gross value added in the UK was understated by 13 percent in 2004. Studies replicating the CHS methodology in other developed OECD countries also report large magnitudes in intangible investment, ranging from 5 to 12 percent of GDP.[6]

Another common finding is that since intangibles have become increasingly important over time, ignoring them distorts the *trends* in measured investment and output. For example, the share of intangible investment (or the extent of underestimation of GDP) in the US has risen from about 7 percent in 1970 to 14 percent in 2007 (Corrado and Hulten 2010). Between 1995 and 2005, business investment in intangibles increased faster than investment in tangibles in almost all countries of the EU (Jona-Lasinio et al. 2011). In the UK, intangible investment more than doubled as a share of market sector gross value added between 1970 and 2004, overtook fixed capital investment in the mid 1990s and is now roughly 50 percent bigger. In the US, Finland and Sweden, intangible investment is now also greater than tangible investment. And in Canada, Denmark, France, Germany and Japan, it comes close (OECD 2010).

Does intangible investment display similar magnitudes or trends in developing countries? This is difficult to answer because apart from a recent study on China (Hulten and Hao, 2011), there has been no systematic attempt to quantify intangible assets in low and middle income countries. Yet, the question is of interest to policy makers because intangible investment is arguably a key driver of innovation and growth for all countries, and likely is not promoted by the same policy instruments as tangible investment. Our study begins to redress this gap by adapting the CHS methodology to measuring intangible assets in Brazil. While this methodology is not without shortcomings, it has compelling advantages compared to the alternatives. For one, the resulting estimates can be meaningfully compared to existing ones for developed countries and for China. Moreover, the methodology explicitly identifies and measures the components of intangible investment, which is more useful for policy purposes than just backing out economy-wide aggregate intangible investment as a black-box residual from aggregate output and tangible investments.

[6] See Barnes and McLure (2009) for Australia, Belhocine (2009) for Canada, Hao et al. (2009) for Germany, France, Italy, and Spain, Fukao et al. (2009) for Japan, van Rooijen-Horsten et al. (2008) for the Netherlands, and Edquist (2009) for Sweden. OECD (2010) summarizes the results of various countries.

We estimate that during 2000-2008, annual private business spending on intangibles in Brazil averaged about 4 percent of GDP. While this is significantly lower than comparable rates for the US, Japan and the UK, which hover around 11 percent, and China at almost 8 percent, it is not too far below estimates for other developed countries such as Italy and Spain at around 5-6 percent. Also, Brazil's business investment in intangibles is only slightly lower than that in fixed assets (which ranged between 4-9 percent of GDP during this period). Thus, our results suggest that intangible investment is an important part of the Brazilian economy. We also find that total intangible investment is increasing, rising from about 3 percent of GDP in 2000 to 5 percent in 2008. However, in recent years, tangible investment appears to be growing even faster. It is too early to say if this signals a divergence between tangible and intangible investment, which would be contrary to the experience of advanced economies.



The CHS classification of intangibles consists of three main categories: computerized information, innovative property, and economic competencies. Of these, Brazil spends the most (2.3 percent of GDP in 2008) on innovative property, which comprises business research and development, copyrights, architectural and engineering designs, new financial products and mineral exploration. Next (at 1.6 percent of GDP) are economic competencies, which include brand equity development through advertizing and market research, employee training and organizational improvement.[7] Lastly, business computer software and database investments total about 1 percent of GDP. However, spending on

[7] This is an underestimate because of missing data on labor training expenditures in service sector firms.

computer software has more than doubled between 2000 and 2008, experiencing the fastest growth rate among all segments of intangible assets in Brazil.

Expressed as a percentage of GDP, the US spends more than Brazil on all types of intangibles. But the gap in their spending is particularly large in the case of economic competencies, especially employee training and organizational improvement. As a share of GDP, US spending on this category is roughly four times that of Brazil. Thus, there is a striking difference in the composition of their intangible expenditures, with economic competencies accounting for as much as 53 percent of all intangible asset expenditures in the US, as opposed to less than 35 percent in Brazil. This finding of relative underinvestment in training and management is consistent with a recent study which finds high and unexploited returns to organizational improvements in a sample of Indian firms (Bloom et al. 2012). It may be appropriate for policy makers in developing countries to be concerned about why firms appear to be under-investing in economic competencies.[8]

CHS and similar studies focused on measuring aggregate investment. Going a step further, we also provide industry-level estimates of intangible investment.[9] As expected, those manufacturing industries which broadly speaking are more technology-sophisticated on average (such as chemical products, machinery and equipment, electronics) invest a larger proportion of their revenue in computerized information and innovative property than relatively less technologically-sophisticated industries on average (such as food products or textiles). Interestingly, firms in less technologically-sophisticated manufacturing industries invest as much in economic competencies as more sophisticated manufacturing industries. But by the standards of advanced economies, both are investing very little in this area, and worryingly, there is sign of a slowdown in this spending. Further, the services sector invests even less than the manufacturing sector in economic competencies.

[8] Note that there is no presumption that U.S. levels of investment in intangible assets are optimal, either for the U.S. or for other countries. However, more systematic collection and compilation of these data facilitate more informed discussions on where returns to investment in different types of intangible assets are highest, and why such investments remain lower than desirable. Before jumping to policy implications, it would be important, among others, to identify true shortfalls in investment in particular types of intangible assets from low levels explained by other drivers of investment patterns, such as endowments, industrial structure, technological capabilities, and the broader business environment. See Maloney and Rodriguez-Clare (2007) on the kind of analysis that could be undertaken to determine whether the R&D investment in a particular country is lower than would be expected given its underlying pattern of specialization, and its investment in physical and human capital.

[9] Subject to limited availability of data disaggregated by industry for some types of intangible investments.

A key motivation behind the quantification of intangible capital is that it improves aggregate growth analytics, opening up the black box of traditional residual TFP (total factor productivity) by directly measuring key drivers of innovation. In general, estimates of the sources of growth undergo substantial revision once intangible investment is incorporated. In particular, the role of capital deepening in explaining growth increases, while that of the unexplained TFP component is correspondingly diminished.[10] Accounting for intangible capital can also lead to a reconsideration of trends in the unexplained component of productivity (that is, what remains after intangibles are incorporated). This is because besides adding a new class of inputs, it also requires revisions in output estimates. Interestingly, adjusting for intangible capital, some studies have revised the estimates of recent TFP growth in the US and UK *upwards*.[11]

While TFP is useful as a concept, the fact that it is composed of unknowns makes it difficult to devise policies to raise TFP. By reducing the unknowns, quantifying intangibles can improve the specificity of policies which target particular drivers of productivity. Given that by far the largest part of the gap in output per capita between Brazil and the United States is accounted for by differences in TFP (Duval and de la Maisonneuve 2009), this should be a priority area for Brazilian and other developing country policymakers.

Disaggregated estimates such as those presented in this study can also help explain within-country productivity differences. There is a growing body of work documenting large gaps in TFP across firms within developed and developing countries (Syverson 2011, Banerjee and Duflo 2005). Recent analyses by Ferraz and Monteiro (2009) for the Brazilian manufacturing sector and by Pages et al. (2010) for other Latin American countries indicate that within-country TFP differentials in the Latin America region are much greater than in the United States and Europe, with comparable studies highlighting similar patterns in other developing regions of the world.[12] Closing the gap between leading and lagging firms is therefore critical to raising aggregate productivity. The policy instruments for this purpose can be made more focused if these gaps can be attributed to differences in specific intangible assets along specific dimensions, such as across industries.

[10] For example, CHS (2009) suggest that the acceleration in TFP accounted for two-thirds of US growth in the mid-1990s when intangibles were excluded, but accounts for less than half when intangibles are included.
[11] Brynjolffson and Yang (2001) and Marrano et al. (2007).
[12] See for instance Dutz (2007) for India, and Hsieh and Klenow (2009) for China and India, who indicate that within disaggregated industries a plant at the 90th percentile of the productivity distribution makes on average 5 times as much output with the same measured tangible inputs as the 10th percentile plant, while this dispersion in the US has been estimated to be closer to 2:1 (Syverson 2004).

Using our disaggregated estimates, we make an opening contribution to this agenda by presenting evidence of a strong correlation between intangible investment across Brazilian manufacturing industries during 2000-08 and growth in their conventionally estimated TFP as well as exports, This suggests that the measurement of intangible investment can help quantify sources ofhitherto unexplained productivity growth.

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By showing that intangible investment in Brazil is of significant magnitude and that it is related to productivity changes, we expect that our study will spur efforts to improve data collection for this purpose, in Brazil as well as in other developing countries. Our work also serves to highlight key areas of data shortage, prominently data on firm-specific human capital investment, and on new product development in services (which is not captured in standard R&D measures).

The rest of the paper is organized as follow. Section 2 presents our methodology and available data for the Brazil estimation, and compares it to the CHS methodology. Section 3 presents our results, beginning with a comparison of intangible investment in Brazil relative to other available countries, and then examining the evolution of aggregate spending components over time, the composition of spending by industry group, the importance of tangible relative to intangible investment, and estimates of the intangible capital stock. Section 4 presents evidence on the impact of intangible investment (as estimated) on export growth and TFP. Section 5 concludes, and highlights areas for future work.

2. METHODOLOGY AND DATA

2.1 The CHS framework for measuring intangible assets

CHS (2005, 2009) classify firm spending on intangibles into three main categories: computerized information, innovative (scientific and creative) property, and economic competencies. They include the following sub-categories:

A. Computerized information

- Computer software: own use, purchased, and customized software
- Computerized databases

B. Scientific and creative property

- Research and Development (R&D) in science and technology (spending for the development of new products and production processes, usually leading to a patent or license)
- Mineral exploration (spending for the acquisition of new reserves)
- Copyright and license costs (spending for the development of entertainment and artistic originals, usually leading to a copyright or license); and development costs in the motion picture, radio and television, sound recording, and book publishing industries
- Other product development, design, and research expenses (not necessarily leading to a patent or copyright), such as new product development costs in the financial services industry, new architectural and engineering designs, and R&D in the social sciences and humanities

C. Economic competencies

- Brand equity (advertising expenditures and market research for the development of brands and trademarks)
- Firm-specific human capital (spending on developing workforce skills; for example, on-the-job training and tuition payments for job-related education)
- Organizational capital (costs of improvement in organizational structures).

In the US, the Income and Product Accounts (NIPA) already provide data on business expenditures on computer software (own account spending and purchases) and databases (own account spending). For other intangible expenditures, CHS estimations are based on a mixture of public data, private data, and derivative measures.

Official firm surveys are an important source of direct information for CHS. For example, the Census Bureau's Services Annual Survey (SAS) gives firm-level data on purchases of computer databases. Surveys conducted by the Bureau of Labor Statistics (BLS) collect data on firm expenses on workforce skills development (in-house trainers, outside trainers, tuition reimbursement, and outside training funds). R&D data are from firm R&D surveys conducted by the National Science Foundation (NSF).

But several intangible expenditures are not elicited in any firm survey in the US. In some cases, CHS use data on the revenue of the industry which produces the intangible asset to measure the expenditure on that asset. For example, spending on new architectural and engineering designs is estimated as half of the revenue of the architectural and engineering design industry as reported in SAS. Similarly, outlays on

market research are estimated as twice revenues of the market and consumer research industry as reported in SAS, and purchased "organizational" capital is estimated using SAS data on the revenues of the management consulting industry.

Finally, due to the absence of direct data, some intangible expenditures are "crudely" derived from the closest available proxy. For example, new product development costs in the financial services industry are assumed to be 20 percent of intermediate purchases in that industry. Spending on organizational change is also difficult to measure, because there is no broad consensus on the scope of these assets and little hard data on spending. A substantial portion of these activities are handled in-house and there are no available data on these activities; CHS propose a rudimentary estimate based on the value of executive time, estimated from BLS data on employment and wages in executive occupations.

In general, economic competencies, which is the largest category in the CHS framework, presents the most conceptual and measurement challenges (Aizcorbe et al. 2009). For instance, there are questions about whether brand equity should be treated as investment in a national account. Some argue that advertising and marketing expenditures are in some sense unproductive, because they are thought to affect the demand function instead of the production function. In contrast, spending on other intangibles directly affects the production function by either creating a better output or the same output using fewer inputs or better inputs.

Appropriate price deflators and depreciation rates are other outstanding questions in the measurement of intangible capital. CHS and some other recent studies use the goods price deflator associated with the final industry (that is, the industry purchasing the intangible asset) or the economy as a whole (CHS 2009, Marrano et al. 2007). The problem here is that this is not the price index for the intangible per se, but rather the price index for the good that used the intangible asset as an input. An alternative solution has been to develop a price index for the costs involved in producing the intangible asset. Since most intangible are produced in the services industry, the major component of these input price indices are wages, such as wages of engineers and scientists (van Rooijen-Horsten and others 2008). However, this ignores any productivity gains in the production of the asset. Unsurprisingly, there is no consensus yet on this issue.

Even for tangible assets, there is controversy and disagreement over the appropriate depreciation rates. The question becomes much more difficult for intangible assets, since there is no physical 'wear and tear' to be observed. CHS admit that the rates of depreciation they assume are based on limited information. For better or worse, these rates have since been used in a number of CHS-type studies. In general, they are significantly higher than commonly-used rates of depreciation of tangible assets, reflecting the view that knowledge-intensive capital becomes obsolete relatively fast.

2.2 Methodology and data sources for Brazil estimation

In measuring intangible investment in Brazil, we use the same categorization of intangibles as CHS, and to the extent possible, the closest Brazilian counterpart to the US data source originally used in CHS.[13] As in CHS, our preferred method is to build up the expenditure estimates from primary firm level survey data. The main surveys we use are the Annual Survey of Services (PAS), the Annual Survey of Industry (PIA), the Annual Survey of Commerce (PAC), the Annual Survey of Construction (PAIC) and the Survey of Technological Innovation (PINTEC), all conducted by the Brazilian Institute of Geography and Statistics (IBGE). Like CHS, in case firm survey data are not available, our preferred alternative is to use official data sources such as National Accounts data, and wage and employment data from the Ministry of Labor and Employment.

Since many of our estimates are based on firm surveys which do not capture the government and household sectors, for the sake of consistency we have excluded government and household investment when calculating aggregates for all investment categories. This is largely consistent with CHS, who focus on business intangible investment.

Reflecting differences in data availability across the US and Brazil, some of our sources differ significantly from the CHS original, though they attempt to measure the same underlying economic phenomenon. The Appendix lists our source for every intangible asset class and compares it to its CHS counterpart.

[13] In some cases where comparable data sources are simply not available for Brazil, we use the closest counterpart to the source used by Maranno et al. (2007) to estimate intangible assets in the UK. Since Maranno et al. also follow the CHS methodology, their departures from CHS are the second-best option and closest in sprit to the original.

As explained, CHS estimate purchased intangible investment directly whenever possible: that is, from the expenditure data of the industries purchasing the asset in question. When such direct data are not available, their strategy is to estimate purchased intangible investment using the revenue of the industries that produce the intangible investment in question. The availability of direct expenditure data is poorer in the case of Brazil, and as a result, we have to use the indirect approach – the revenue of the producing industry— more frequently. This is the most common difference between our sources and those in CHS. For example, we find no surveys in Brazil that estimate the amount spent by industries on computer software and databases, and have to resort to using the Net Operating Income (NOI) of computer software and database services industries from the Annual Survey on Services.

In cases where CHS use crude approximations to estimate something not captured in surveys or national accounts, we replicate their approximation using the closest Brazilian counterpart. Arguably, there are cases in which the CHS approximation could be considered unrealistic for Brazil. To give an example, assuming that as much as 20 percent of intermediate expenses in financial services industry go towards new product development could be too optimistic. But in the absence of any Brazil-specific or other developing country literature that could guide us towards a better approximation, we have chosen to use the number suggested to CHS by the US literature; this has the additional advantage of methodological comparability.

Most of the key surveys for our study are quite new to Brazil. For example PINTEC, our main source for R&D data, has been conducted in 2000, 2003, 2005 and 2008. This restricts us to estimating intangibles during 2000-2008, a much shorter time span than that examined in studies of intangible investment in developed countries, some of which go back to the 1970s. Future intangible asset studies on developing countries should expect a similar disadvantage in historical data availability.

Finally, while most existing studies of intangibles present only national aggregates, we present intangible investment estimates disaggregated to the industry level. This is a simple corollary of the CHS approach, since they take firm level spending as their starting point. For those intangibles for which we use firm level surveys, this is easily done by aggregating the firm level data to the industry level; the surveys are designed to be representative at the industry level. In cases where we use aggregate national accounts data, we estimate the amounts purchased by different industries by using the national accounts input

output tables.[14] Since some industries produce both tangibles and intangibles, the assumption is that input-output ratios are similar across both goods.[15]

In the following paragraphs, we describe our estimation approach in more detail, starting with our estimation of intangible asset categories, followed by our use of price deflators and the assumptions underlying the calculation of investment from expenditures.

(1) Estimation of intangible asset categories

A. Computerized information. We found no surveys in Brazil that present the amount spent by industries in computer software and databases. Therefore, we used the Net Operating Income of computer software and database services industries from the Annual Survey on Services (PAS), and distributed it over industries using sector coefficients from the input-output matrix. Thus, sector i expenditures X can be obtained by:

$$X_i = \left(NOI_j\right) \cdot \alpha_{ji}$$

where j is the "service purchased" (computer software or computer databases) and α_{ji} is the coefficient from the input-output matrix that represents the amount of the service/product j used as input by sector i.

B. Innovative property. This category can be divided into three components: scientific R&D, copyright and license costs, and other product development, design and research expenses.

The major category here is expenditures in scientific R&D, which includes science and engineering R&D, R&D in petroleum and natural gas exploration, as well as in mining industries. For R&D in mining industries, we use data provided by the National Department of Mineral Production for the period of 2008-2010. We apply the average expenditure observed in this period as a percentage of GDP in order to estimate a time series of expenditures for the previous years (assuming a constant ratio throughout the entire period).

[14] We use the same industry classification as that used in the system of national accounts, estimating investment for 55 industry groups.
[15] This approach cannot capture imports of intangibles.

For the other two items, we use data from the Survey of Technological Innovation (PINTEC). However, this survey was conducted only for the years 2000, 2003, 2005 and 2008. We extrapolated our estimates to the other years by using a previous finding (Araujo, Cavalcante and Alves, 2009) that the PINTEC data on R&D spending is strongly correlated (correlation coefficient above 0.8) to the number of scientific-technical personnel, on which data is available for the intervening years. For example, to obtain the expenditures for year 2001 $R\&D_{2001}$, we use data from the closest years available (2000 and 2003) in the following extrapolation:

$$R\&D_{2001} = STP_{2001} \cdot \left\{ \beta_{2000} + (2001 - 2000) \cdot \left[\frac{(\beta_{2003} - \beta_{2000})}{(2003 - 2000)} \right] \right\}$$

where β_i is the ratio of spending on R&D from PINTEC per scientific-technical personnel (STP) for year i. Employment data comes from RAIS (a survey of the Ministry of Labour and Employment, roughly translated as Annual Registry of Social Information). Since PINTEC is only available for industrial and mining sectors, we are missing estimates on R&D expenditures for services, commerce and construction industries.

Copyright and license costs mainly include R&D in information-sector industries such as radio, television, sound recording, book publishing and the motion picture industry, usually leading to a copyright or license. Following an admittedly arbitrary choice in CHS, the development costs of new products in the entertainment and artistic industries are estimated as 20% of their employment and operating costs. To this we add estimates of industrial and mining sectors spending on royalties from the Annual Survey of Industry (PIA).

The third item – other product development, design and research expenses – is composed of new product development costs in financial services industries, new architectural and engineering design, and R&D in social sciences and humanities. The first is estimated as 20% of intermediate purchases of financial services, obtained from the Make and Use Tables of the National Accounts System. New financial products development is assumed to be wholly own-account intangible investment in the financial services industry.

The estimates for new architectural and engineering designs are calculated as half of the architectural and engineering services industry Net Operating Revenue; these are then distributed over purchasing industries using sector coefficients from the input-output matrix.

Finally, the expenditure on R&D in social sciences and humanities is estimated by the same method used for science and engineering R&D, except that we replace the number of scientific-technical personnel by the number of social sciences and humanities researchers employed by each industry.[16]

C. Economic competencies. Three basic asset types are included in economic competencies: 'brand equity', firm-specific human capital, and organizational structure.

Brand equity expenditures consist of advertising expenditures and market research. For industrial sectors, the information on advertising expenditures is obtained directly from the Annual Survey of Industry; as for other industries such as services, commerce and construction, the values are estimated by distributing the net operating revenue of the advertising industry using sector coefficients from the input-output matrix. Outlays on market research are estimated as twice the industry net operating revenue and also distributed using the input-output matrix.

Measuring firm-specific human capital in Brazil is a major challenge because unlike countries such as the US and UK, there is no regular official survey in Brazil collecting information on worker training expenditures or on the wage and salary costs of employee time in formal and informal training. To obtain estimates for this item, we used a survey conducted by the National Confederation of Industry (CNI) that estimates the percentage of gross revenue spent in training programs in 2007. We use another survey from CNI, the Brazilian Service of Support for Micro and Small Enterprises (SEBRAE), and the Unions Department of Statistics and Socioeconomic Studies (DIEESE) which estimate the percentage of workers that participated in training and the distribution of the hours spent in training in 2003 in manufacturing firms. We combine this estimate of hours in training with wage data to estimate the wage and salary cost of employee time in formal training. Because these surveys were conducted only in the industrial sector, we do not have estimates for training expenditures for services. Therefore, when comparing our aggregate estimate of training investment to that from other countries, it is important to keep in mind that ours is an

[16] As one would expect, this method suggests that business R&D in social sciences and humanities is insignificant.

underestimate.[17] When presenting our estimates and comparing them to those from other countries, we will show that our conclusions are robust to adjusting for this underestimation by assuming a reasonable range of values for the missing services expenditures.

The last item, organizational structure is composed of a purchased and an own-account portion. The purchased part is estimated as the revenue of the management consulting services industry, multiplied by the sector coefficients from the input-output matrix. The own-account portion is estimated as one-fifth of wages of persons employed in executive occupations.

(2) Price deflators

Unlike CHS, who use industry output deflators, we use the Consumer Price Index (calculated by IBGE) to deflate intangible expenditure. As discussed, the use of final output deflators is controversial because it is not the price index for the intangible, but that for the good that uses the intangible asset as an input. Since the major input into the production of intangibles is labor, and since the cost of labor (wages) should track the CPI, the CPI could in principle do a better job in capturing the changing price of intangibles. We stress that this issue is far from settled even in developed countries, and that there are ongoing initiatives to design better price deflators for intangibles (Aizcorbe et al. 2009).

(3) From expenditure to investment

As discussed in CHS, not all expenditure on intangible items should be classified as investment in long-lasting knowledge capital. For some intangibles, economic research suggests that only a portion of the spending on an intangible pays off in a future year (or years). For example, although the marketing literature finds that the effects of advertising are generally short-lived, some advertising has an effect well beyond its first year. In contrast, economic research suggests that all R&D spending has long-term benefits. We follow previous studies in assuming that only certain percentages of the expenditures estimated are to be treated as investment: 60% of expenditures on brand equity, 80% of own-account organizational structure expenditures and 100% of all other assets. These percentages from CHS are

[17] Two alternate approximations based on the available spending on training in manufacturing that we explore in the results section are to assume that Brazilian spending on training in services is either in proportion to the ratio of value added in manufacturing and services, or that the ratio of labor training spending to that on brand equity and organizational improvement in services is the same as that in a comparator country.

largely based on prior economic research. For those intangibles for which there is little indication in the literature of what share of the spending has long-term effects, the choice is admittedly more arbitrary.

3. RESULTS

This section begins with a comparison of intangible expenditures in Brazil relative to other available countries. Brazil's expenditure pattern in intangibles is then explored in greater detail, by examining the evolution of aggregate spending components over time, the composition of spending by industry group, the importance of tangible relative to intangible investment, and estimates of the intangible capital stock.

For reasons of comparability with the estimates presented in CHS (2005, 2009), most of the estimates presented in this section are of *expenditures* on intangibles, rather than of investment in intangibles. For most components of intangible assets, investment equals expenditures. The exceptions are brand equity and own-account organizational structure for which investment equals 60 and 80 percent of expenditures, respectively. Hence, total investment in intangibles is less than total expenditures on them.

3.1 A comparison of intangible expenditures across countries

We estimate that in 2006, annual private business expenditures on intangibles in Brazil averaged 4.72 percent of GDP. While this is significantly lower than comparable rates for the US, Japan and the UK, which are in the order of 11 percent, and China at roughly 8 percent, it is not too far below estimates for other developed countries such as Italy and Spain at around 5-6 percent.

Moreover, our estimate for Brazil does not include firm specific human capital (employee training) expenditures in services firms due to data limitations. We have avoided adjusting for it by extrapolating blindly from manufacturing to services. But for the sake of illustration, suppose we do just that, assuming that as a share of gross value added (GVA), service sector firms spend the same as manufacturing firms on employee training. Since GVA in the services sector is about thrice that in manufacturing, this would quadruple our estimate of firm specific human capital expenditure to about 1.2 percent of GDP, and increase our estimate of total intangible expenditures in Brazil to 5.6 percent of GDP, placing it squarely in the neighborhood of Italy and Spain.

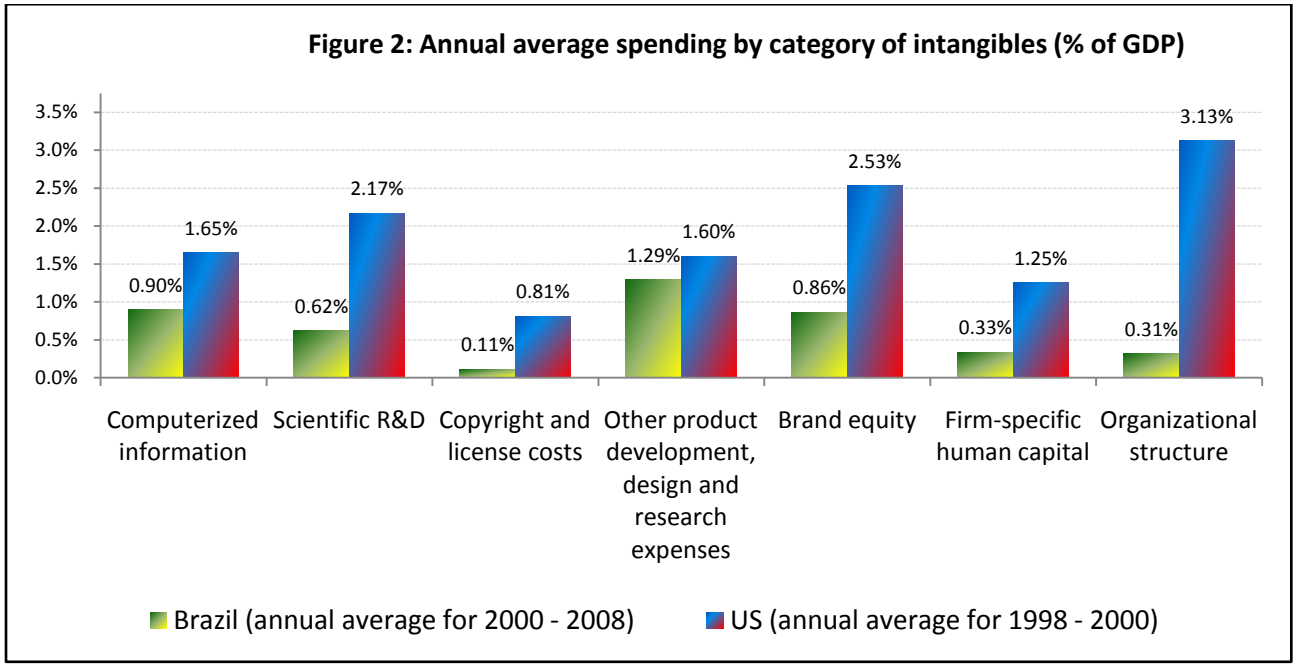
Table 1 compares intangible expenditures in a given year (2006) for Brazil relative to other available countries.

Table 1: Cross-country Comparison of Aggregate Intangible Expenditures (% of GDP)									
	Germany	France	Italy	Spain	UK	US	Japan	China	Brazil
	2006	2006	2006	2006	2006	2000	2000-05	2006	2006
1. Computerized info.	**0.69**	**1.33**	**0.61**	**0.75**	**1.42**	**1.24**	**2.03**	**1.88**	**1.10**
2. Innovative property	**3.38**	**2.98**	**2.13**	**2.66**	**2.88**	**4.07**	**5.42**	**3.40**	**2.01**
a) R&D, including social sciences and humanities	1.62	1.22	0.56	0.60	0.98	1.69	2.57	1.02	0.56
b) Mineral exploration and evaluation	0.01	0.04	0.09	0.04	0.04	0.78	-	0.21	0.03
c) Copyright and license costs	0.20	0.29	0.10	0.17	0.20	0.55	1.01	0.08	0.11
d) Development costs in financial industry	0.70	0.56	0.56	0.50	0.06	0.55	1.84	0.47	1.10
e) New architectural and engineering designs	0.85	0.87	0.82	1.35	1.60	0.50	-	1.62	0.21
3. Economic competencies	**3.14**	**3.84**	**2.63**	**2.19**	**6.44**	**5.94**	**3.39**	**2.34**	**1.61**
a) Brand equity	0.88	1.55	1.13	0.67	1.77	2.25	1.83	0.63	0.93
Of which:- Advertising expenditure	*0.65*	*1.15*	*0.75*	*0.30*	*1.40*	*2.07*	-	*0.63*	*0.84*
- Market research	*0.23*	*0.40*	*0.38*	*0.37*	*0.37*	*0.18*	-	-	*0.09*
b) Firm-specific human capital	1.21	1.41	0.99	0.78	2.33	1.05	0.46	0.29	0.34
Of which: - Continuing vocational training	*0.61*	*1.17*	*0.68*	*0.68*	-	-	-	*0.29*	-
- Apprentice training	*0.60*	*0.24*	*0.31*	*0.10*	-	-	-	-	-
c) Organizational capital	1.05	0.88	0.50	0.75	2.35	2.64	1.10	1.41	0.34
Of which: - Purchased	*0.51*	*0.30*	*0.14*	*0.26*	*0.47*	-	-	-	*0.04*
- Own account	*0.54*	*0.58*	*0.36*	*0.49*	*1.88*	-	-	*1.41*	*0.30*
Total Expenditures	**7.21**	**8.15**	**5.37**	**5.60**	**10.74**	**11.25**	**10.84**	**7.62**	**4.72**

Notes: (1) US estimate is an average for 1998-2000. (2) Japan R&D excludes social science, and social science R&D is in the 2.0 percent of the residual term of innovative property. (3) Brazil firm-specific human capital excludes services.

Sources: The original data source of the US is CHS (2005), of Japan is Fukao et al. (2009), and of the UK, Germany, France, Italy and Spain is van Ark et al. (2009). The source of China estimates is Hulten and Hao (2011). This table is based on their Table 2, which contains downward revisions of the non-China data to be consistent with the results of another EU-funded project. GDP in this table is the sum of conventional GDP plus new intangibles. Estimates of investment have been converted to estimates of expenditures using CHS formulae.

Figure 2 presents in greater detail comparative results regarding intangible spending for two countries, Brazil and the US (with the US data here based on the original CHS 2005 figures). Not surprisingly, as a share of GDP, US firms spend considerably more than Brazilian ones in nearly all types of intangible assets. Overall, at about 13 percent of GDP, US intangible expenditures are nearly thrice those in Brazil. Moreover, since the US estimates correspond to an earlier period (1998-2000), the current gap between the US and Brazil is likely to be even larger.



Looking at major categories of intangibles, the US lead over Brazil is largest in two areas: scientific R&D, and economic competencies. The CHS methodology suggests that as a share of GDP, the US spends about 10 times as much as Brazil on organizational capital, three times as much on brand equity, and about 4 times as much on scientific R&D. The cost of employee time spent in training in Brazilian manufacturing is 0.1 percent of GDP; even if one quadruples this to account for missing data for services (in proportion to the ratio of value added in manufacturing and services), it would be less than half that spent in the US (1 percent).

As a result, the composition of intangible expenditures differs markedly across Brazil and more advanced economies like the US and the UK. Brand equity, organizational capital and firm specific human capital comprise more than half of all intangible expenditures in the US and the UK, in contrast to about 35

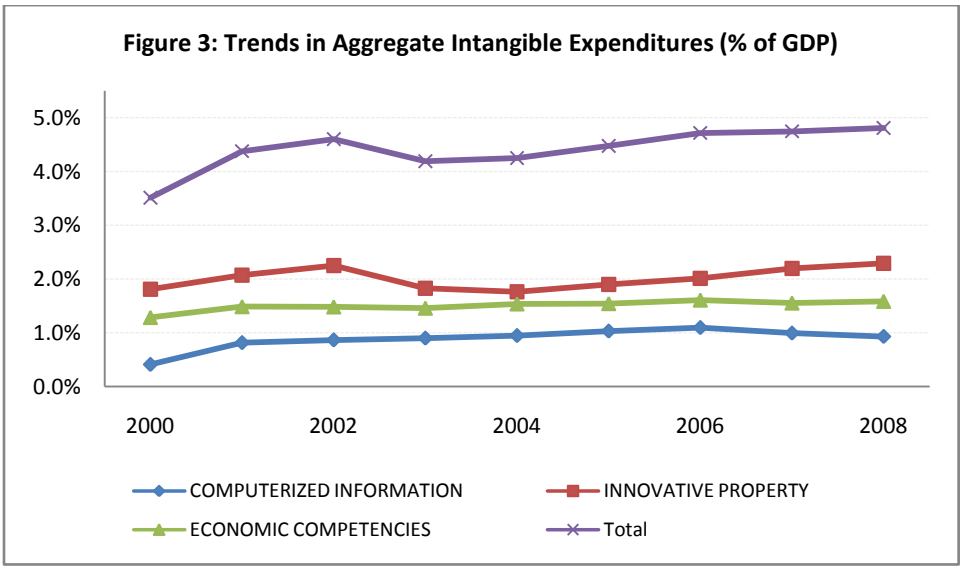
percent in Brazil.[18] Relative to these economies, Brazilian spending is tilted towards computerized information and product development (other than scientific R&D).

Interestingly, Table 1 suggests that relative to more advanced economies like the US and the UK, Brazil and China have similar profiles of intangible expenditures. In both Brazil and China, computerized information accounts for 20-25 percent of all intangible expenditures, as opposed to only about 10 percent in the US. Economic competencies account for 30-40 percent of all intangible expenditures in the former, in contrast to as much as 53 percent in the latter.

3.2 Aggregate expenditures in intangible assets over time

Figure 3 presents our estimate of total expenditures in intangibles assets by Brazilian firms during 2000-2008. The estimates are adjusted for inflation and expressed in year 2000 prices.

There is a clear positive trend in intangible investment, with total expenditure rising from 3.5 percent of GDP in 2000 to 4.8 percent in 2008. Innovative property (which includes R&D and other product development) is the largest among the three major intangible asset categories and spending on it has risen from 1.8 percent of GDP in 2000 to 2.3 percent in 2008. In comparison, total spending on the next largest category – economic competencies (which includes firm human capital, brand equity and organizational improvements) – has been slow to increase, rising from 1.3 to 1.6 percent of GDP during this period.



[18] Or 40 percent, if one crudely adjusts for missing services data on employee training.

We next examine spending on the three main categories in greater detail. Computer software and databases is the smallest category, but it is the fastest growing, having risen from 0.4 percent of GDP in 2000 to 1 percent in 2008. Further, as shown in Figure 4, this trend is driven by a near tripling of expenditures on software.

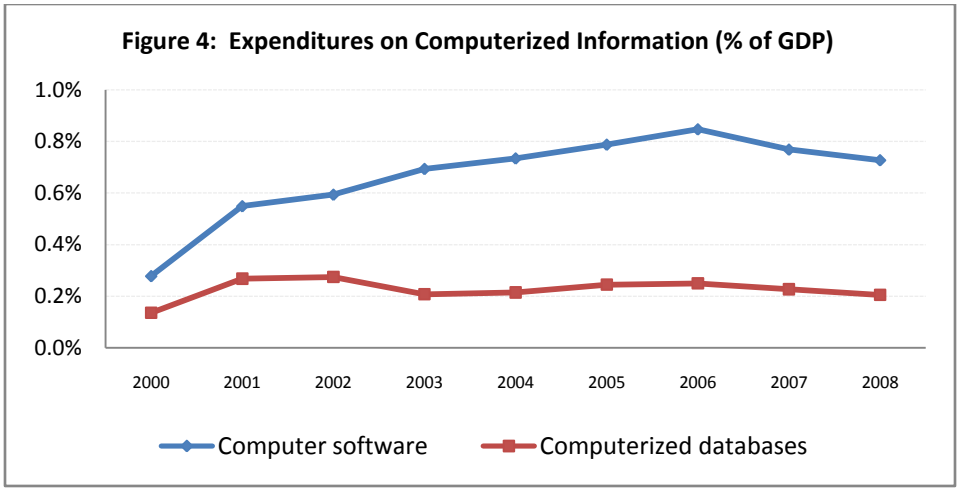
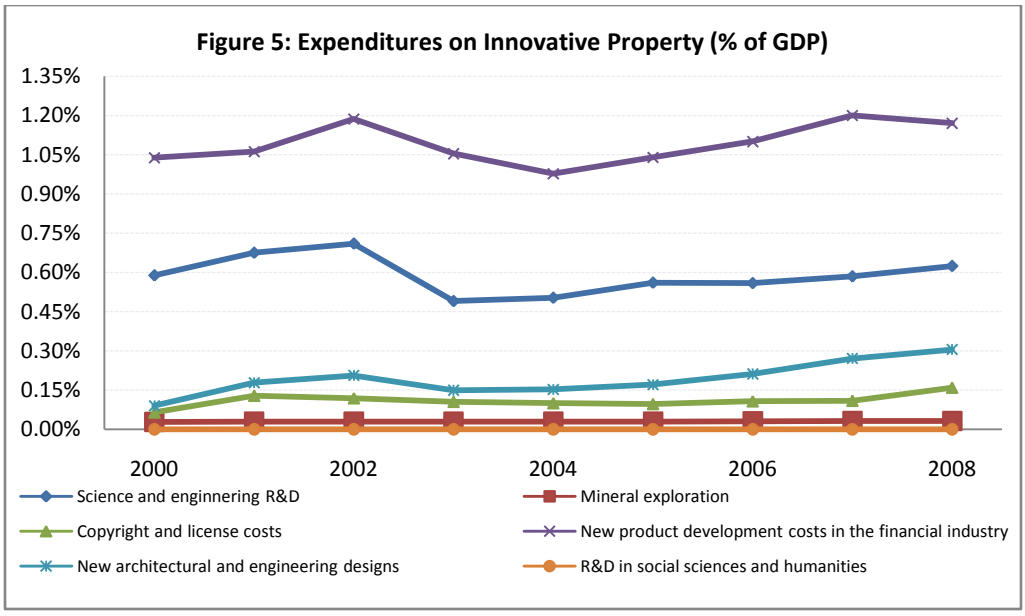


Figure 5 breaks down expenditures on innovative property into its components. The two major constituents of innovative property expenditure by Brazilian firms are new product development in the financial industry, and science and engineering R&D. It may come as a surprise that Brazil's private sector spends considerably more on new product development in financial industry than on in-house R&D. However, this could in part be an artifact of the CHS methodology, which assumes that 20 percent of intermediate expenses in the financial services industry go towards new product development. As discussed in Section 2.2, there is no research that can guide us towards finding a more appropriate ratio for Brazil, and we have decided to use 20 percent in order to maintain comparability with CHS.

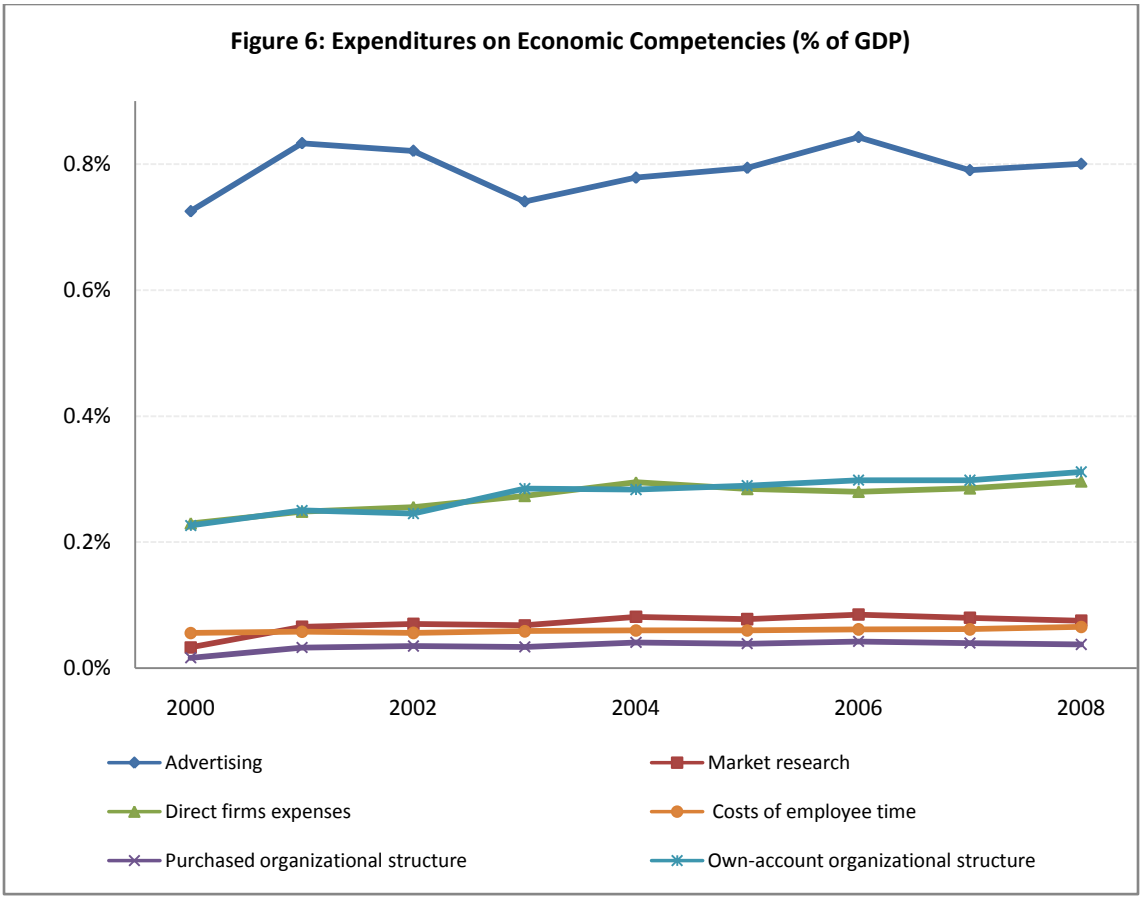


Nonetheless, it is striking that even if we assume that Brazil's financial services industries spend only half as much as their US counterpart on product development (that is, only 10 percent of costs), total Brazilian spending on new financial products would still be as high as expenditure on R&D across all industries. Further, it is unlikely that we are underestimating R&D given that our data source for R&D expenditures, the PINTEC surveys, are comparable to the innovation surveys used to estimate R&D expenditures in the US and EU. Thus, compared to those advanced economies, R&D in the traditional sense –conducted largely by manufacturing firms – is a smaller component of innovation-related spending in Brazil. For instance, even though manufacturing has a smaller share in GVA in the US[19] (13 percent for US versus 17 percent for Brazil in 2008), total business spending on R&D in the US is considerably larger than that on new financial product development (CHS 2005).

Our estimates suggest that Brazilian firm expenditures on R&D have risen in the initial years, dropped significantly, and then have been rising relatively constantly. Between 2000 and 2008, total expenditures on science and engineering R&D ended up remaining fairly constant at roughly 0.6 percent of GDP.

[19] Source: World Development Indicators.

Figure 6 examines spending on economic competencies in greater detail. The single largest component of this type of intangible investment is expenditure on brand equity, specifically on advertizing. Next, firm expenses on labor training and own-account spending on organizational improvement are also major components.



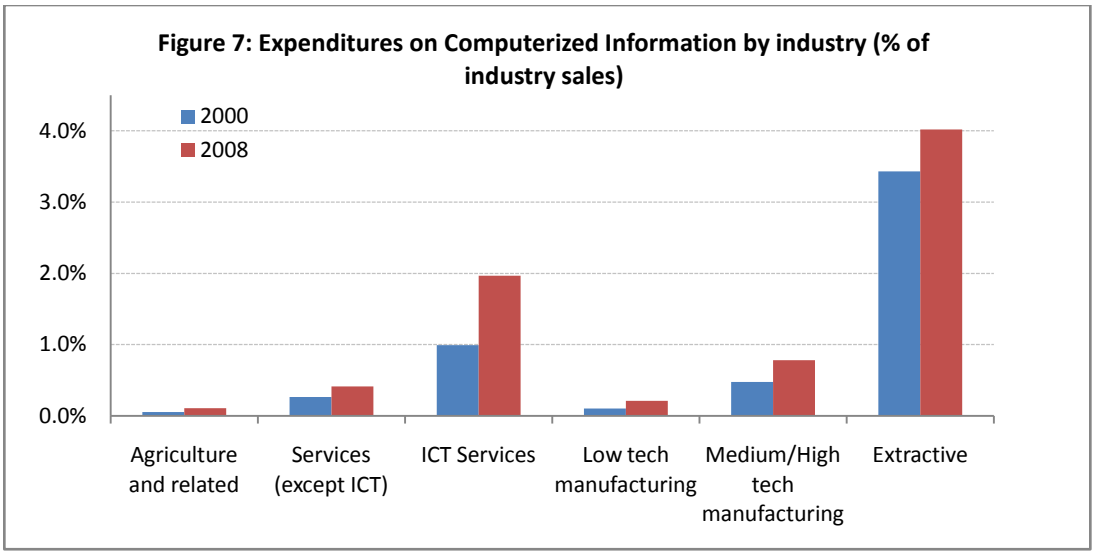
Note that compared to CHS, the labor training estimate we show is an underestimate since it does not include training in services firms. In general, as discussed in Section 2, spending on economic competencies is more difficult to measure than other types of intangible investment, and there is also some controversy about whether advertizing should be included at all. However, with the exception of labor training in services, all our estimates are methodologically comparable to CHS estimates. And unless trends in services differ from those in manufacturing, we are still estimating overall trends without any obvious bias, if not levels. Hence, the key message of Figure 6 is sobering: there is little sign of a positive trend in Brazilian spending on economic competencies.

3.3 The composition of intangible expenditures by industry group

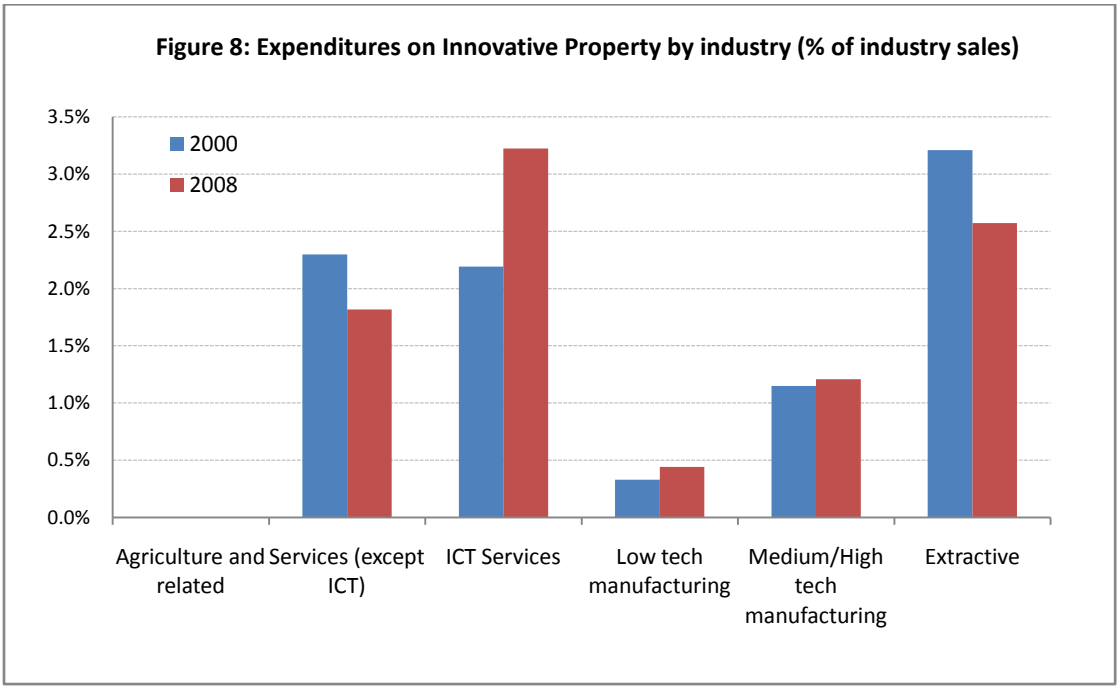
This section discusses our industry-wise estimates of intangible expenditures in Brazil. As explained in Section 2, we obtained these estimates by aggregating firm-level data to the level of industries, or if this was not possible, by using the sector input-output coefficients in the national accounts tables. Specifically, among major categories, industry-level spending estimates for computerized information, other product development and organizational improvement are based on input-output tables and are therefore less precise than other bottom-up estimates.

We give an overview of our industry level findings again by categories of intangibles, grouping our 55 industries (as classified in the Brazilian national accounts) into six broad categories: agriculture, extractive industries (including petroleum), low tech manufacturing, medium/high tech manufacturing, ICT services (which includes R&D services) and all other services (including construction). Our division of manufacturing into just two groups is admittedly crude but quite effective at capturing key inter-industry differences in intangible investment. The category called 'medium/high tech manufacturing' includes industries generally considered to be more technologically sophisticated *on average*, such as chemical and pharmaceuticals, machinery and equipment, electronics, instruments, motor vehicles and other transport equipment, basic metals and metal products. The category called 'low tech manufacturing' includes industries like food products, textiles, leather, wood, paper, which are considered technologically less sophisticated on average.

As indicated by the share of computer software and database spending in total industry sales, the extractive industries and (unsurprisingly) ICT are by far the most IT-intensive industries in Brazil (Figure 7). All other sectors spend less than 0.75 percent of sales on computerized information, which is quite low by US standards. As expected, firms in low tech manufacturing spend even less than those in medium/high tech manufacturing. However, manufacturing is also seeing considerable growth in computerized information expenditures, with its share in industry sales doubling in the case of low tech manufacturing.

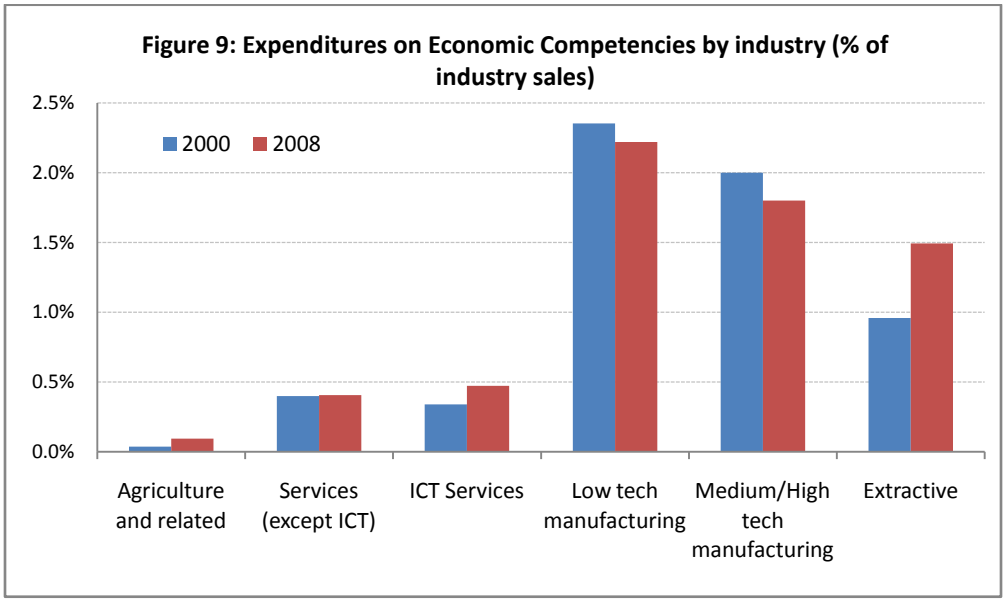


In the case of innovative property, services in general spend more than manufacturing (as a share of industry sales). This is driven by product development in the financial industry. Low tech manufacturing spends less than medium/high tech manufacturing and extractive industries. Worryingly, R&D expenditures have not increased much in recent years (except in ICT firms, which have a small share in total R&D spending in the economy).



When comparing aggregate spending on economic competencies, we know that the US-Brazil gap is overstated because of the omission of Brazilian expenditures on labor training in the services sector. Figure 9, in which this spending is disaggregated by industry, suggests that a considerable gap would remain even after adjusting for the omission. Since labor training data are included in the case of manufacturing and extractive industries, estimates for these sectors are comparable to US estimates. In Brazil, manufacturing industries spend about 2 percent of sales on brand equity, firm-specific human capital and organizational improvement. In comparison, the US spends as much as 7 percent of GDP on these intangibles.[20] Another source of concern identified in Figure 9 is the apparent decline in the manufacturing sector's spending on economic competencies.

Figure 9 also suggests that compared to its manufacturing sector, the Brazilian service sector spends very little on economic competencies. To make them more comparable, suppose that we make a crude adjustment for missing labor training expenditures in services by assuming that the ratio of labor training expenditures to those on brand equity and organizational improvement is the same as that in the US (about one-fifth). Then, our estimates suggests that non-ICT service sector spending on economic competencies is about 0.6 percent of sales, in contrast to about 2 percent in manufacturing. Another interesting pattern in Figure 9 is that low tech manufacturing industries spend slightly more on economic competencies than medium/high tech industries.



Note: Service sector estimate excludes labor training expenses.

[20] Note that we do not have US estimates disaggregated by manufacturing and services.

3.4 Tangible versus intangible investment in Brazil

Figure 10 compares tangible and intangible investment in Brazil.[21] Compared to gross fixed capital formation (GFCF) in Brazil, which has ranged between 15-18 percent of GDP during 2000-2008, intangible investment is a small share of GDP. However, GFCF includes non-business tangible investment (such as government and household investment, and a part of infrastructural investment), so it is strictly speaking comparable to our estimate of intangible investment.[22] So we have also presented an estimate of business tangible investment, estimated from IBGE's surveys on Industry, Services, Commerce and Construction Industry using data on acquisitions and improvements to the firms' permanent assets. Our estimates indicate that the ratio of tangible to intangible investment in Brazil's firms is close to 1, which is lower than that reported for for the US and the UK, but comparable to that reported for some other advanced economies like France and Germany(CHS, 2004; Marrano and Haskel, 2006). It is, however, markedly higher than China's ratio, which is estimated to be 0.2 (Hulten and Hao, 2011).

There is some hint that in recent years, growth in intangibles has fallen behind that in tangibles. A caveat to this observation is that that the particularly sharp increase in business tangible investment after 2007 appears to be associated with a revision of IBGE's methodology for their surveys on Industry, Services, Commerce and Construction Industry. However, even the GFCF series – which should not have been affected by this methodological revision –shows a markedly higher post-2005 rate of growth than intangible investment.

[21] Note that for reasons of comparability with tangible investment, the chart shows estimates of intangible *investment*, and not expenditure. CHS and similar papers also present the same comparison of business tangible and intangible investment.

[22] Source of GFCF Data: National Accounts

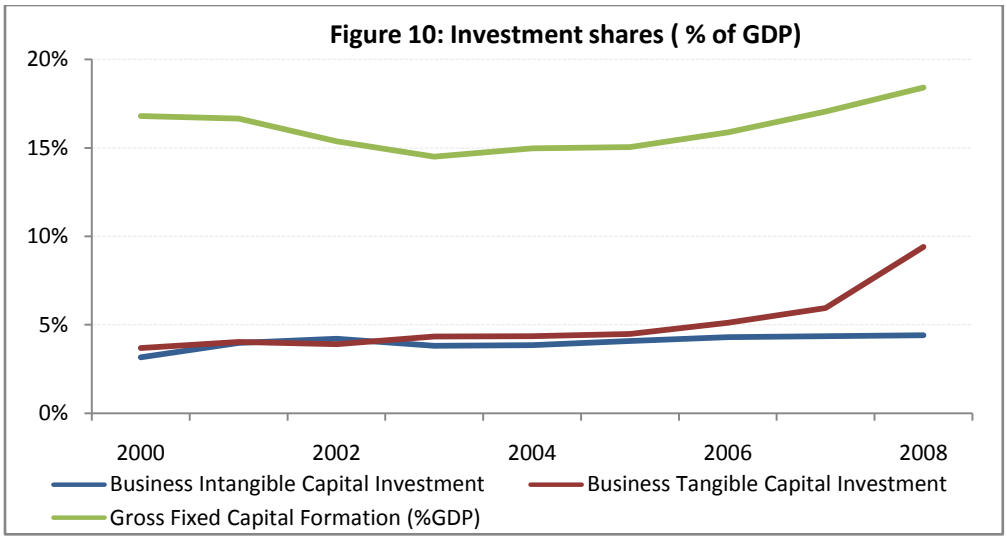
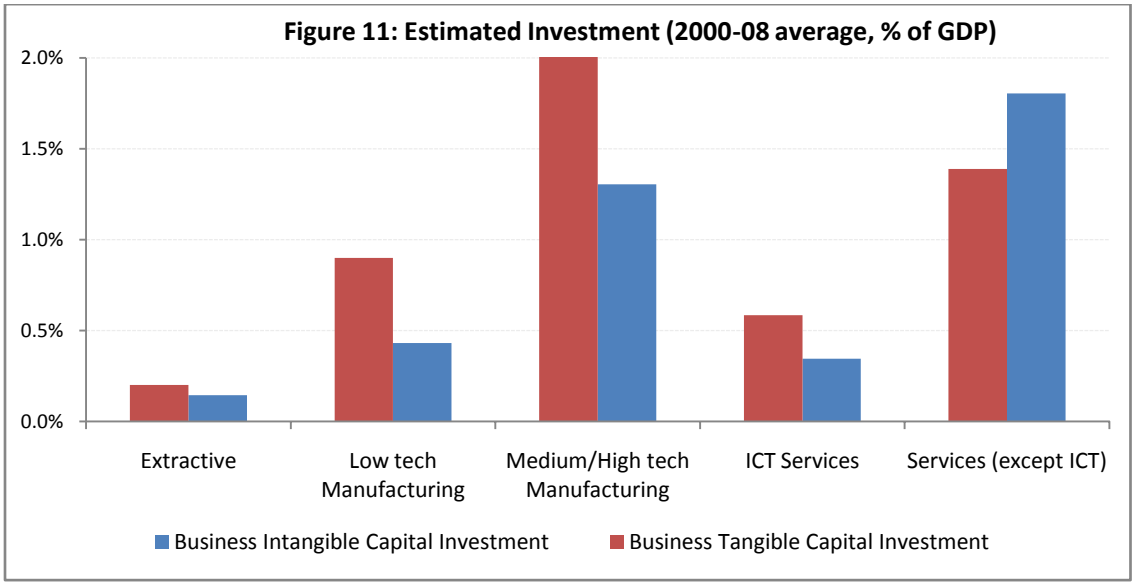


Figure 11 compares tangible and intangible investment by industry. There is a hint here that the ratio of intangible to tangible investment is lower in more 'low tech' industries, or that in other words, knowledge-related capital matters more in industries which are technologically more sophisticated on average. But in general, Brazilian manufacturing firms still spend more on tangible capital. In contrast, the service sector is already spending more on intangible assets than on tangible assets (and this pattern would be even stronger if we could account for omission of labor training expenditure). Given that services account for a rising share of the economy, this finding may have important implications for policies for encouraging innovation and growth.



3.5 Estimates of the intangible capital stock in Brazil

If expenditures on intangibles truly are an investment, then as with fixed assets, the accumulated 'stock' of intangible assets is a determinant of Brazil's current GDP levels. Moreover, growth in the stock of intangible assets should help explain GDP growth. Hence, estimating the size of Brazil's intangible capital stock is a key objective of our study.

To obtain intangible capital stocks, we apply the following accumulation identity:

$$K_t = I_t + (1 - \delta)K_{t-1}$$

where I_t is our estimates of the real investment series and δ is the depreciation rate. We use the same depreciation rates as those assumed by CHS and similar studies:

Category	Depreciation Rate (%)
Computerized Information	33
Innovative Property	20
Brand equity	60
Firm-specific resources (human capital and organizational structure)	40

The main challenge is that we do not have data on the starting stock of capital. Fortunately, with the assumed depreciation rates being as high as 20-60 percent per annum, the starting value of the capital stock becomes markedly less significant in determining capital stock estimates with distance from the starting year. In the case of CHS (2005), whose expenditure series starts in the 1980s, estimates of capital stock in the early years vary markedly with the assumed starting value, but converge in later years.

Our estimates of intangible assets start in 2000, which is quite recent compared to previous studies. However, we have tested that estimated stock in 2008 is still robust to a reasonable range of starting values for 2000. To illustrate this, we estimate capital stock series under the following assumptions for the initial capital stock:

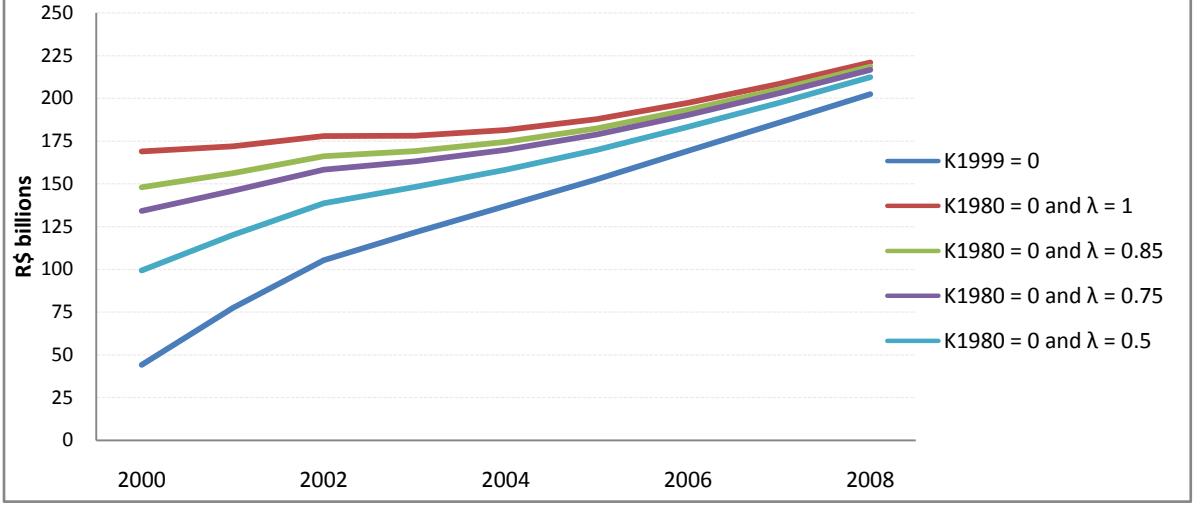
a. $K_0 = K_{1999} = 0$ (Extreme lower bound: capital stock set to zero in 1999)

b. $K_0 = K_{1980} = 0$ and $I_t = \lambda . I_{2000}$, for $t = 1981, \dots, 1999$ and $\lambda = 1, 0.85, 0.75$ or 0.5.

In (b), we set the capital stock to zero in 1980 and assume the investment in the following years was equal to a percentage λ of the investment in the first year we had available for each asset (2000 or 2001). The $\lambda = 1$ version is the most optimistic, assuming that Brazil invested as much in intangible assets annually during 1980-1999 as it did in 2000.

As shown in Figure 12, our estimate of the stock in 2008 is robust to a wide range of starting values, even one as extremely conservative as zero in 1999.[23] It is in a range of 200-225 billion R$, which is about 8 percent of its business tangible capital stock. Thus, even though Brazil has been spending as much on intangible assets as on tangible assets in recent years, higher depreciation rates imply markedly less accumulation of the former. However, even in comparison to the US, this 8 percent is not a trivial ratio. In 2003, business intangible capital stock in the US was about 27 percent of the tangible capital stock.[24]

Figure 12: Estimated Intangible Capital Stock under different assumptions



This exercise also serves to highlight a policy implication of the relatively short life of intangible assets. Compared to fixed assets, an increase in intangible investment can have a large impact on the intangible

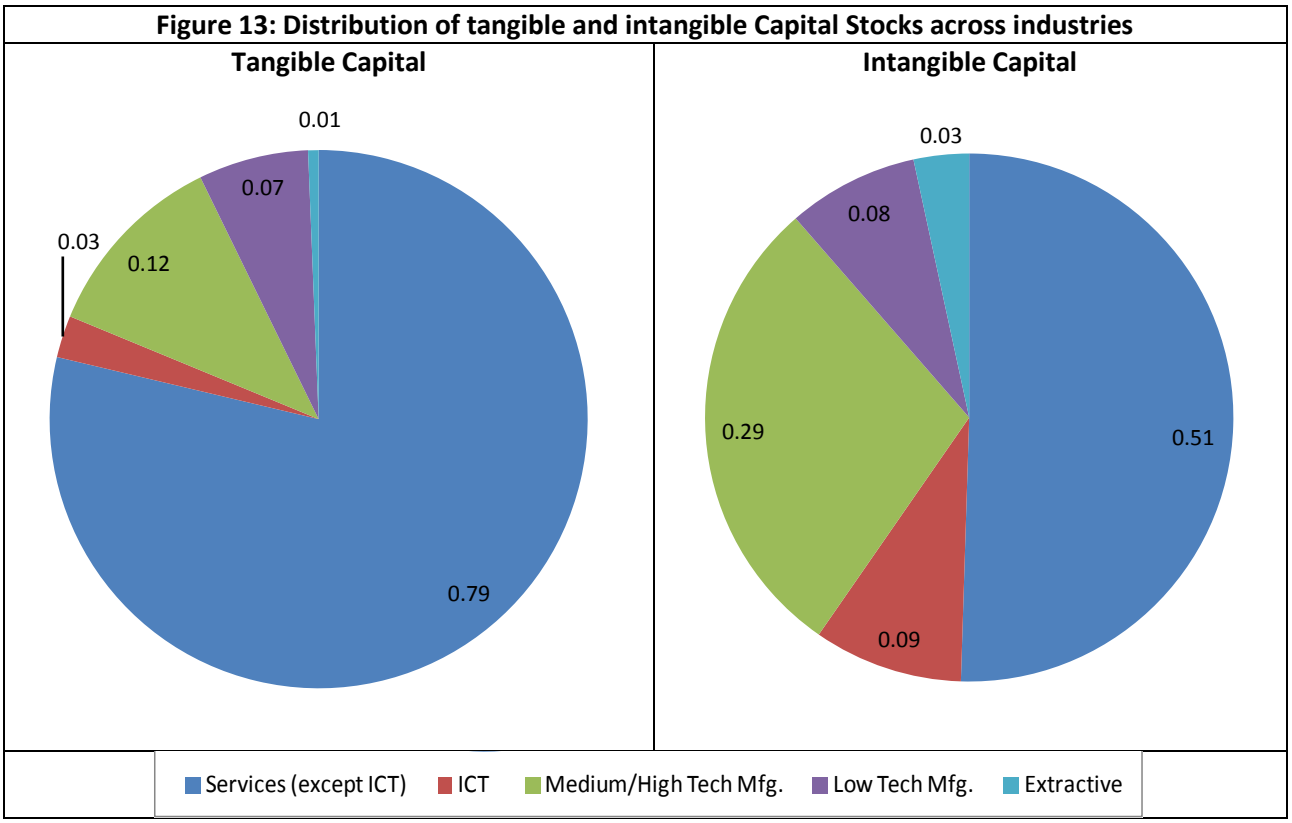
[23] This also shows that setting an arbitrary 'zero date' for the capital stock (such as 1980) should not really make a difference.

[24] CHS (2009) estimate a US business intangible capital stock of 3636 billion USD in 2003. The US current-cost net stock of private fixed assets (excluding households) was to the tune of USD 13,225 billion in 2003 (Source: BEA).

capital stock – and hence on output – in the near future. But this impact will die down if the new levels of investment are not sustained.

Figure 13 compares the sector distribution of Brazil's business tangible and intangible capital stocks. Service sector firms account for the predominant share of fixed assets, by far. The distribution of intangible capital is relatively more even, with manufacturing accounting for a sizable share (about 40 percent), especially medium/high tech industries. While it is not clear if this signals that knowledge capital is more relevant to manufacturing, or that there are greater constraints to its accumulation in services, it certainly suggests that policies targeting intangibles will have different sector-wise impacts than those targeting fixed assets.

Figure 13: Distribution of tangible and intangible Capital Stocks across industries



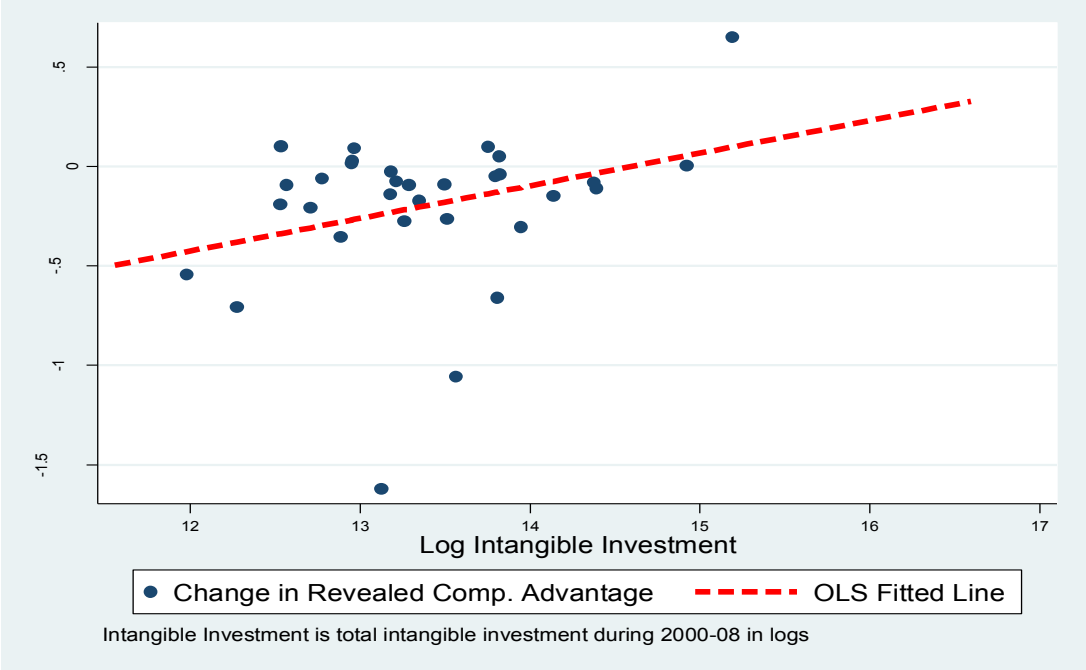
Note: In figure 13, the distribution of intangible capital across industries is based on a capital stock constructed according to assumption (b) $K_0 = K_{1980} = 0$ and $I_t = \lambda . I_{2000}$, for $t = 1981, \ldots, 1999$ and $\lambda = 0.5$.

4. THE IMPACT OF INTANGIBLE INVESTMENT: EVIDENCE FROM EXPORT GROWTH AND TFP PATTERNS

Ultimately, the case for better measurement of intangibles rests on its potential to quantify knowledge-based sources of growth which are largely consigned to the black-box of TFP in current growth analytics. Although CHS (2009) and similar studies have shown that growth accounting calculations which include the intangible capital stock as an input indicate a sizable role of intangibles as a source of growth, these are still essentially accounting exercises which take the asset nature of intangibles as a given. There is, of course, micro-economic research which supports this assumption for specific types of intangibles, such as the research measuring the impact of R&D expenditures, or the relatively recent work on the impact of management consulting on Indian textile firms (Bloom et al., 2012). But the impact of aggregate intangible expenditures on future output is yet to be systematically tested, particularly in the context of developing countries.

4.1 Evidence from export growth patterns

Figure 14: Intangible investment and export growth across manufacturing industries in Brazil



Note: Revealed Comparative Advantage (RCA) of an industry *i* in year *t* is calculated as the share of industry *i* in Brazil's total exports in year *t* divided by the share of industry *i* in total world exports in year *t*. This graph plots the change in RCA between 2000 and 2008 against intangible investment in 32 2-digit manufacturing industries. The fitted line is the linear prediction from an OLS regression of change in RCA on log intangible investment. The coefficient on intangible investment is statistically significant at the 10 percent level.

Disaggregated estimates of intangible capital (such as our industry-level estimates) are essential to such research. Here, we present evidence that our estimates of intangible investment are meaningful, in the sense that they are empirically related to 'productivity' growth – first presenting the correlation with export growth with a larger set of sectors, and then presenting evidence with TFP but with a more restricted set of sectors.

Taking export growth as a proxy for traditional TFP growth, we show that intangible investment is significantly correlated with export growth in Brazilian manufacturing industries between 2000 and 2008. Specifically, our proxy for TFP growth is the industry level growth in the index of revealed comparative advantage (RCA). RCA of an industry i in year t is calculated as the share of industry i in Brazil's total exports in year t divided by the share of industry i in total world exports in year t. An increase in RCA of an industry during 2000-08 indicates Brazil's rising comparative advantage in that industry, which in turn suggests rising productivity in that industry. Figure 14 below shows that industry-level growth in RCA during 2000-08 is positively related to industry-level intangible investment during this period. This relationship is statistically significant.

4.2 Evidence from TFP patterns

We rely on parametric estimates of traditional TFP from residuals of the regression of production values against labor and tangible capital based on a Cobb Douglas production function. The estimates are at a broad industry level, using 2-digit industrial data for 22 manufacturing sectors over the years 2000-08 [25]. We present results for two different estimates of TFP, based on two different assumptions for calculating the values of the initial capital stock. [26]

Table 2 reports results from regressing our intangible capital measure against both TFP estimates. Results are shown for models with and without industry fixed effects (which allow for unobserved sources of

[25] We had to restrict the number of sectors to only 22 manufacturing sectors due to the available data for capital investment.

[26] The estimates for initial capital stock are based on the equation, $K_j(0) = I_j(0)/(g_j + \delta_j)$ where g is the average growth of investments in the first 5 years of the series and δ is the depreciation rate for the j[th] good (De Mello 2003). For TFP1, we let the sum (gj + δj) vary for each sector, either 10, 15 or 20% depending on which produces a more stable capital/product ratio. For TFP2, we set the sum (gj + δj) to be equal to 10% for all sectors.

productivity differences across industries which are fixed over time) and with and without year fixed effects (which allow for unobserved time-varying determinants of TFP which are common across industries). Intangible capital is statistically significantly correlated with both measures of TFP, for all models except for the industry fixed effects model without controls for time (for TFP1).

Table 2: Intangible investment and TFP across manufacturing industries in Brazil

Dependent variable	TFP1	TFP1	TFP1	TFP1	TFP2	TFP2	TFP2	TFP2
Industry FEs	No	No	Yes	Yes	No	No	Yes	Yes
Year FEs	No	Yes	No	Yes	No	Yes	No	Yes
Intangible capital	**0.190***	**0.416****	**0.175**	**0.585****	**0.206****	**0.420****	**0.191***	**0.574****
	(1.810)	**(2.390)**	**(1.640)**	**(2.130)**	**(1.960)**	**(2.390)**	**(1.800)**	**(2.090)**
Constant	-0.077	-0.095	-0.070	-0.162	-0.083	-0.100	-0.077	-0.161
	(-1.570)	(-1.070)	(-1.530)	(-1.360)	(-1.710)	(-1.110)	(-1.670)	(-1.340)
R-squared – within			0.012	0.218				0.208
- between			0.091	0.091				0.101
- overall	0.016	0.206	0.016	0.202	0.019	0.198		0.195

Note: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels; t-statistics are in parentheses.

We stress that these correlations with exports and traditional TFP are only suggestive evidence. Intangible investment could be correlated with other unobserved sources of revenue or productivity growth. Similarly, it is also possible that the correlation observed in Figure 14 is driven by unobserved shocks that affected both export growth and intangible expenditures. Moreover, other determinants of comparative advantage, such as fixed capital accumulation, have not been controlled for in Figure 14. But at the very least, we hope that this serves to motivate more rigorous future work.

5. CONCLUSION

The key message of our study is that there is significant intangible investment in the Brazilian business sector, comparable in levels (as a share of GDP) to that estimated for EU countries like Italy and Spain using the same methodology. As a share of GDP, it is about one-third of the investment level in the US, Japan and the UK, the countries which are leading in this area. This finding leads us to two broad conclusions about future work in this area.

Firstly, what does this finding imply for Brazil's innovation and growth policies? Instead of focusing on traditional instruments like the R&D tax credit, should Brazil consider widening this instrument to an 'innovation tax credit' that covers a wider range of measured intangible assets where there are sufficient market failures to warrant public support, or consider a broader mix of policies targeting different types of intangible expenditures? If we were to extrapolate from growth analytics conducted for the US and UK using methodologically comparable estimates of intangible assets, then our results suggest that intangible investment has become a significant source of output growth in Brazil, implying that such polices should at least be considered. But it is possible that results from advanced economies do not translate readily to middle and low income countries. As a first step, it is therefore necessary to test the basic premise of this exercise more directly; that is, to see if measured 'intangible investment' does have a statistically significant and quantifiably important impact on future productivity. We presented some positive preliminary evidence on this question in our paper. With better data, it should be possible to see how the relationship with productivity varies by type of intangible asset, which is important for policy specificity – together with considerations such as the extent of positive spillovers for different types of intangibles, and implementation challenges of specific policies, including focus, design and governance structures to mitigate rent-seeking.

The second main message of our findings is that if intangibles are so sizable in Brazil (and in China, as another recent study suggests), then their measurement should get more attention in other developing countries as well. Our work has identified two challenges in this area. The first is data availability. For instance, finding primary survey data on worker training is far more difficult in Brazil than in the US. The second issue is whether it is correct to make the same assumptions as CHS do about expenditures not observed directly. For example, new product development in finance is a major component of our intangible estimates, but what if this is an overestimate due to the crude assumption that 20 percent of costs in this industry go towards product development? Interestingly, a recent firm-level survey conducted in the UK (Marrano and Haskel 2010) attempts to measure this item directly, and the results suggest that the 20 percent assumption is optimistic even for the UK.

One important way forward is to start incorporating questions on different types of intangible expenditures in firm surveys already conducted by official agencies. A desirable end-goal would be to have all firms report their investment in specific categories of globally-recognized intangible assets as

part of annual industrial census and survey collection efforts, so that the appropriate policy response can be better attuned to the needs of particular types of firms within industries.[27] Further, in cases where such expenditures are not formally recorded by firms (such as spending on product development), we can at least improve the accuracy of methodological assumptions by collecting basic information on spending patterns through small, targeted surveys. Given the potentially huge significance of intangible investment, there are high returns from spending resources on such data collection.

[27] As an illustration of already-ongoing efforts to collect intangible asset data at the firm level, the Brazilian development bank BNDES has begun to collect and evaluate measures on intangible asset investment by its borrowing firms as part of an initiative to improve credit analysis. See Almeida and Braga (2011) and Mendes and Braga (2011).

References

Aizcorbe, Ana, Carol Moylan and Carol Robbins. 2009. "Toward Better Measurement of Innovation and Intangibles", Bureau of Economic Analysis, mimeo.

Almeida, Helena Tenorio Veiga de and Joao Paulo Braga. 2011. "Evaluating Competencies and Intangible Assets in Brazilian Firms: The BNDES' Approach to Credit Analysis", Presentation to World Conference on Intellectual Capital for Communities Seventh Edition, May 26-27, Paris.

Araujo, Bruno, Luiz Cavalcante and Patrick Alves. 2009. "Impacts of the Brazilian science and technology sectoral funds on the industrial firms' R&D inputs and outputs", mimeo.

Banerjee, Abhijit and Esther Duflo. 2005. "Growth theory through the lens of development economics" In Philippe Aghion and Steven Durlauf, eds., *Handbook of Economic Growth*, Vol 1A, pp. 473–552. North Holland: Elsevier Academic Press.

Barnes, Paula and Andrew McClure. 2009. "Investments in Intangible Assets and Australia's Productivity Growth". Productivity Commission Staff Working Paper, Canberra, Australia.

Belhocine, Nazim. 2009. "Treating Intangible Inputs as Investment Goods: The Impact on Canadian GDP", mimeo.

Bloom, Nick, and John Van Reenen. 2007. "Measuring and Explaining Management Practices Across Firms and Countries". *Quarterly Journal of Economics.* 122 (4): 1351-1408.

Bloom, N., B. Eifert, A. Mahajan, D. McKenzie and J. Roberts. 2012. "Does Management Matter? Evidence from India." mimeo, Stanford, CA: Stanford University.

Brynjolfsson, Erik and Shinkyu Yang. 1999. "The Intangible Costs and Benefits of Computer Investments: Evidence from the Financial Markets", *Proceedings of the International Conference on Information Systems,* Atlanta, GA.

Brynjolfsson, Erik, Lorin Hitt and Shinkyu Yang. 2002. "Intangible Assets: Computers and Organizational Capital", *Brookings Papers on Economic Activity,* 1, 137-98.

Corrado, Carol and Charles Hulten. 2010. "How do you measure a 'Technological Revolution'?" *American Economic Review* 100 (5): 99-104.

Corrado, Carol, Charles Hulten and Daniel Sichel. 2005. "Measuring Capital and Technology: An Expanded Framework", In Corrado, D., Haltiwanger, J. and Sichel D. (eds.), *Measuring Capital in the New Economy, Studies in Income and Wealth*. Vol 65, 11-45. Chicago: The University of Chicago Press.

Corrado, Carol, Charles Hulten and Daniel Sichel. 2009. "Intangible Capital and U.S. Economic Growth". *Review of Income and Wealth.* 55 (3): 661-85.

De Mello, Euler P. G. 2003. "Produtividade total dos fatores, mudança técnica, eficiência técnica e eficiência de escala na indústria brasileira, 1996-2000." Dissertação de mestrado, CEDEPLAR-UFMG

Duval, Romain and Christine de la Maisonneuve. 2009. "Long-run Growth Framework and Scenarios for the World Economy". Economics Department Working Paper No. 6635, February. Paris: OECD.

Dutz, Mark A. 2007. *Unleashing India's Innovation: Toward Sustainable and Inclusive Growth*. Washington, DC: The World Bank.

Edquist , Harald. (2009) "Can Investment in Intangibles Explain the Swedish Productivity Boom in the 1990s?" IFN Working Paper No. 809, Research Institute of Industrial Economics, Stockholm.

Ferraz, Claudio and Joana Monteiro. 2009. "Misallocation and Manufacturing TFP in Brazil." Mimeo.

Ferreira, Susana and Kirk Hamilton. 2010. "Comprehensive Wealth, Intangible Capital and Development". Policy Research Working Paper No 5452, October. Washington, DC: The World Bank.

Fukao, Kyoji, T. Miyagawa, K. Mukai, Y. Shinoda and K. Tonogi. 2009. "Intangible Investment in Japan: New Estimates and Contribution to Economic Growth". *Review of Income and Wealth.* 55 (3): 717-36.

Hall, Robert E. 2000. "e-Capital: The Link between the Stock market and the Labor Market in the 1990s." *Brookings Papers on Economic Activity* 2000 (2): 73-118.

Hulten, Charles R. and Janet Hao. 2011. "The Role of Intangible Capital in the Transformation and Growth of the Chinese Economy". Mimeo, University of Maryland.

Hao, Janet. X. ,Vlad Manole and Bart van Ark. 2009. " Intangible Capital and Growth – an International Comparison." The Conference Board, May.

Hsieh, Chang-Tai and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India", *Quarterly Journal of Economics*, 124(4): 1403-48.

Jona-Lasinio, C., M. Iommi and S. Manzocchi. 2011. "Intangible Capital and Productivity Growth in European Countries", INNODRIVE Working Paper No. 10.

Maloney, William and Andres Rodriguez-Clare. 2007. "Innovation Shortfalls". *Review of Development Economics.* 11 (4). 665-84.

Marrano, Mauro, Jonathan Haskel and Gavin Wallis. 2007. "What Happened to the Knowledge Economy? ICT, Intangible Investment and Britain's Productivity Record Revisited". *Review of Income and Wealth,* 55 (3): 686-716.

Marrano, Mauro and Jonathan Haskel. 2006. "How Much Does The UK Invest In Intangible Assets".

CEPR Discussion Paper No. 6287. London: CEPR.

Marrano, Mauro and Jonathan Haskel. 2010. "Measuring investment in intangible assets in the UK: results from a new survey." *Economic & Labour Market Review | Vol 4 | No 7*

McGratten, Ellen and Edward C. Prescott. 2000. "Is the Stock Market Overvalued?" *Federal Reserve Bank of Minneapolis Quarterly Review*. 24(4): 20-40.

Mendes, Adriano Dias and Joao Paulo Braga. 2011. "Assessment methodology for companies: A system to evaluate intangible assets and competitiveness based on the standard of competition", mimeo, BNDES, Rio de Janeiro, Brazil.

Nakamura, Leonard. 1999. "Intangibles: What Put the New in the New Economy?" Federal Reserve Bank of Philadelphia *Business Review*, July/August, 3-16.

Nakamura, Leonard. 2001. "What Is The U.S. Gross Investment In Intangibles? (At Least) One Trillion Dollars A Year!" Federal Reserve Bank of Philadelphia Working Paper No. 01–15.

Nakamura, Leonard. 2003. "The Rise in Gross Private Investment in Intangible Assets Since 1978", Mimeo, Federal Reserve Bank of Philadelphia.

OECD. 1998. "Measuring Intangible Investment: Selected Bibliography." Available at http://www1.oecd.org/dsti/sti/industry/indcomp/prod/paper16.pdf

OECD. 2010. *Measuring Innovation. A New Perspective*. Paris: OECD. Available at: www.oecd.org/innovation/strategy/measuring

OECD 2011. "New Sources of Growth: Intangible Assets", DSTI/IND (2011)2, Directorate for Science, Technology and Industry, March.

Pages, Carmen et al. 2010. *The Age of Productivity, Transforming Economies from the Bottom Up*. Wasington, DC: Inter-American Development Bank.

Syverson, Chad. 2011. "What Determines Productivity", *Journal of Economic Literature*, 49(2): 326–65.

Syverson, Chad. 2004. "Product Substitutability and Productivity Dispersion", *Review of Economics and Statistics*, 86 (2): 534-550.

van Ark, B., J.X. Hao, C. Corrado and C. Hulten. 2009. "Measuring Intangible Capital and its Contribution to Economic Growth in Europe", *EIB Papers* 14 (1).

van Rooijen-Horsten, Miryam, Dirk van den Bergen and Murat Tanriseven. 2008. "Intangible capital in the Netherlands: A benchmark". Discussion Paper No 08001. Voorburg/Heerlen: Statistics Netherlands.

Appendix: Brazil methodology and comparison with CHS methodology

Type of asset or spending	CHS method and sources	Current paper method and sources*	Details of estimation
Computerized Information			
1. Computer software	Based on NIPA data that include 3 components: own-use purchased, and custom.	Revenue of Computer Software industry, from PAS.	Distributed across industries using the input-output matrix.
2. Computerized databases	Own use captured in NIPA software measures and purchased portion estimated from SAS.	Revenue of Computer Database services industries from PAS.	Distributed across industries using the input-output matrix.
Innovative Property			
3. Science and engineering R&D	Mainly R&D in manufacturing, software publishing, and telecom industries. The census collects data on behalf of the National Science Foundation (NSF).	Industrial sectors spending in R&D from PINTEC (Survey of Technological Innovation) and employment data from RAIS (Annual Registry of Social Information - Ministry of Labour and Employment).	A study by IPEA proved that the data from PINTEC is strongly correlated (above 0,8) to the number of scientific-technical personnel (engineers, researchers, biologists, etc). Since PINTEC is only available for some years, we use the average spending in R&D per number of scientific-technical employees and apply this ratio to the number of scientific-technical employees in the other years. Not available for non-industrial sectors.
4. Mineral exploration	Mineral exploration and other geophysical and geological exploration R&D in mining industries, Census of Mineral Industries and NIPAs.	Mining industries (known as "Industrias Extrativas" in Brazil) spending in R&D.	For Petroleum and Natural Gas industries, we applied the same method applied to science and engineering R&D. For other mining industries we use data provided by the National Department of Mineral Production (DNPM) for 2008-2010, applying the observed average percentage of GDP spent to estimate expenditure values for the previous years.
5. Copyright &	a. Development costs in the motion picture industry, using data from the	20% of employment and operating costs of the Motion Picture industry,	

license costs	Motion Picture Association of America.	from PAS.	
	b.Development costs in the radio and television, sound recording, and book publishing industries: double the new product development costs for motion pictures.	20% of employment and operating costs of Information sector, from PAS; plus Industrial sectors spending in Royalties, from PIA.	
6. Other product development, design and research expenses	a. New product development costs in financial services industries: 20% of intermediate purchases, from BEA's GDP-by-industry.	20% of intermediate consumption of Financial Services, from the System of National Accounts - Make and Use tables.	
	b. New architectural and engineering designs: half of industry revenues, from SAS.	50% of revenue of Architectural and Engineering services industry, from PAS.	Distributed across industries using the input-output matrix.
	c. R&D in social sciences and humanities: twice industry revenues, from SAS.	Industrial sectors spending in R&D, from PINTEC, and employment data from RAIS.	Same method applied to sci. and eng. R&D, but using only data of social sciences and humanities researchers.
Economic Competencies			
7. Brand equity (advertising expenditures and market research for the development of brands and trademarks).	a. Purchases of advertising services; advertising expenditures, from Bob Coen's *Insider's Report*, by Universal McCann.	For Services industries: revenue of Advertising services industry, from PAS.	Distributed across industries using the input-output matrix.
		For Industrial sectors: spending on Advertising, from PIA.	
	b. Outlays on market research, estimated as twice industry revenues from SAS.	Twice the revenue of Market Research services industry, from PAS.	Distributed across industries using the input-output matrix.
8. Firm-specific human capital (costs of developing workforce skills, i.e. on-the-job training and tuition payments for job-related education).	a. Direct firm expenses (in-house trainers, outside trainers, tuition reimbursement, and outside training funds), from BLS surveys.	From PIA/IBGE and a especial survey by CNI (National Confederation of Industry).	The survey presents the percentage of gross revenue (from PIA) spent in training programs in 2007. We apply these percentages to the industries annual gross revenue to obtain a series of training expenses.
	b. Wage and salary costs of employee time in formal and informal training.	From PIA/IBGE and a especial survey by CNI, SEBRAE (The Brazilian Service of Support for Micro and Small Enterprises) and	The survey presents the percentage of workers that participated in a determined number of hours of training in 2003. We apply these

		DIEESE (Unions Department of Statistics and Socioeconomic Studies).	percentages and their respective number of hours to the annual wage and salary costs.
9. Organizational structure (costs of organizational change and development; company formation expense)	a. Purchased organizational or structural capital: revenue of the management consulting industry, from SAS.	Revenue of Management Consulting services industry, from PAS.	Distributed across industries using the input-output matrix.
	b. Own-account component, estimated as value of executive time using BLS data on employment and wages in executive occupations.	One-fifth of wages of directors and managers, from RAIS.	
*Surveys are available from 2000-2008, except for the Annual Survey on Services, which starts in 2001; PINTEC, only for 2000, 2003, 2005 and 2008; and, data on training, available only for 2003 and 2007.			