Research on the construction of industrial R&D price index in China—taking large and medium-sized industry for example

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Abstract

R&D price index, as an important deflator to deduct current R&D value into real term, is quite necessary for empirical researches and the establishment of the R&D Satellite Account. This paper elaborates the theory and empirical work of constructing the R&D input and output prices indices for Chinese industry. According to the empirical result, 1998-2011, the R&D input price increased by 179.11 percentages, while the R&D output price increased by 190.82 percentages from the year of 1998 to 2009 for the whole industry. Meanwhile, along with ascending of input indices and output indices, industry R&D intensity rise firstly, and then come down. Compared to the R&D price indices we built in this paper, traditional price indices such as PPI, CPI and the GDP deflator as well as the deflators constructed upon them which are used by many Chinese scholars are likely to overestimate real industrial R&D expenditures.

Key words: input price index output price index R&D

R&D, as one of the core ingredients of economic growth, should be estimated appropriately and felicitously to assess its contribution. The primary problem is to get the real R&D value, so we need deflators. In addition, the System of National Account2008 (SNA2008) has recognized R&D as investment, which highlights the importance of constructing R&D price deflator.

In the paper, we will construct china's R&D input and output price deflator.The paper's framework is as follows: Section 1 is about the literature review, summarizing current practices and something that we can learn from them; Section 2 introduces our methods of constructing the price index and explains the sources and handling of the data and indicators; Section 3 concerns the result of the indices constructed and Section 4 is their comparisons with the other indices commonly used following which is our final conclusion.

1. Literature review

1.1 Literature review of R&D price deflator—in view of input

According to the data source, there are two kinds of approaches to construct input price deflator: questionnaire survey and alternative indicators.

Questionnaire investigation is for enterprise and institutions, to investigate their view and feelings about the rising prices and construct the price index based on the investigation data. Such as Edwin Mansfield, Anthony Romeo and lorne switzer (1982)[1], Edwin Mansfield (1987)[2]. Alternative index approach is a kind of method that build the R&D input price index through choosing a proxies for R&D input elements, such as Sidney A. Jaffe（1972）[3], the Jaffe-Griliches Index by Griliches (1984)[4], Schott（1976）[5], John E. Jankowski(1993)[6], John E. Jankowski ,Jr（1991）, DTI(1978,1980) and Gavin Cameron（1996）[8]. In addition, 2007 R&D Satellite Account of the U.S. also provides a R&D input price index. Chinese Domestic scholars generally use alternative index to construct R&D price deflator, for example, Zhu and Xu(2003), Wu (2008), Wang (2011), Dai (2012), Chen (2010), Li and Liu (2012) and Wang (2011) .

1.2 Literature review about R&D output price index

R&D activities can lead to the improvement of productivity, and the R&D price index constructed based on its output is able to reflect the productivity change .In theory, we should construct the price index according to the situation of R&D market .But many R&D outputs are for self-use and have no price information in market transactions. Therefore, we should measure R&D output index indirectly.

Adam Copeland，Dennis Fixler（2008，2009，2011）[10], Carol Corrado，Peter Goodridge，Jonathan Haskel（2011）[11]. 2007R&DSA of USA also introduced three kinds of R&D output price indices.

Throughout these papers, although there are still many inadequacies, the studies are still very meaningful to the exploration of building the R&D price index, laying solid foundation for completeness of the theory of constructing R&D price index. What's more, this work also has great practical significance for the promotion of China's statistical work in science and technology, governmental work on statistics.

2. The construction of R&D price index

2.1The construction of R&D input price index

R&D expenditures of China is according to its full cost which is mainly composed of three parts：Labor cost, capital expenditure and the other daily expenditures. As no price information related can be found in the present statistical data, we build the R&D input price index from the aspect of the constitution of R&D expenditures in this paper, that is, we construct the price index for R&D personnel (denoted as P_1)based on the average labor cost in intramural expenditure on R&D of each large and medium-sized industrial enterprise at first, then we use the purchasing price index for raw material, fuel and power provided by China Statistical Yearbook as the substitute index of the price index for other daily expenditures on R&D (denoted as P_2) as they are mostly in accordance in contents and choose the price index for the purchase of equipment and instrument as an alternative index of the price index for capital expenditures in R&D activities (denoted as P_3)because of their conceptual resemblance .Finally, we take the relative amount of the three parts of R&D expenditures mentioned above as the weight, and calculate our final R&D input price index with the formula :

$P = \sum \lambda_i P_i$, where λ_i refers to the weight and P_i is the price index for each part of R&D expenditure we built above.

2.2 The construction of R&D output price index

Following the residual intangible asset price index introduced in the 2007R&DSA of USA, we approximate the value of the residual intangible assets as the revenue from the principle business minus cost from the principle bushiness minus the cost to sustain the capital they have at present, meanwhile, to eliminate the effects of greater R&D inputs and outputs brought about by the ever-growing scale of R&D activities in China since 1978 on our price index, the residual intangible assets calculated is averaged by the number of R&D personnel in this paper. In the situations when the R&D output price relative doesn't exist, we complement the price relatives using the method of moving average or trend extrapolation. Upon the above adjustment, we arrive at our new formula to calculate China's R&D output price index,

$$\frac{P_{R\&D}(t)}{P_{R\&D}(t-1)}=\frac{\overline{\Pi}_{5yr}(t)}{\overline{\Pi}_{5yr}(t-1)}=\frac{\sum_{t}^{t-4}[TR_y-M_y-[P^t(\bar{r}+\delta)]*K]/Q(t)}{\sum_{t-1}^{t-5}[TR_y-M_y-[P^t(\bar{r}+\delta)]*K]/Q(t)} \quad (1)$$

Where TR_y and M_y refer to he revenue and the cost from the principle business of the downstream firm respectively, $\bar{r}$ is the average short-term benchmark lending rate announced by People's Bank of China, δ is the denotation of the deprecation rate for physical capital, $P^t K$ is the capital stock in current price, $Q(t)$ represents the number of R&D personnel in the period of t ,and $\overline{\Pi}_{5yr}(t)$ is the amount of residual intangible assets after the adjustment by the number of R&D personnel . In addition, unless specially stated, all the data are from China Statistical Yearbook on Science and Technology and China Statistical Yearbook.

3. The estimates of R&D price indices

According to the method mentioned above, this paper estimated Chinese large and medium-sized industrial enterprises' R&D input index and R&D output index by industry, and the result see appendix table4 and table5.

We group industry R&D intensity by input index. The result is presented in table1, from which we can see that along with ascending of input indices, industry R&D intensity rising, and then coming down.

Table1 range of input index and R&D intensity

Range of input indices（%）	R&D intensity（%）	Industry number
Below 200	0.18-1.38	4
200-250	0.19-1.8	10
250-300	0.25-2.16	13
Above 300	0.12-0.82	9

We also group output indices and R&D intensity. As can be seen from table4, along with ascending of output indices, industry R&D intensity rise firstly, and then come down.

Table2 range of output indices and industry R&D intensity

Range of input index（%）	R&D intensity（%）	Industry number
Below 100	0.09-1.56	11
100-200	0.25-1.79	7
200-300	0.47-2.04	9
Above 300	0.11-1.31	9

4. Comparison with the other indices

Deflators are often used by scholars is GDP deflator, CPI, PPI and even the price index of investment in fixed assets. In order to display the price index built in this paper intuitively, we compare R&D input index and output index with the GDP deflator, CPI and PPI, seeFigure1.

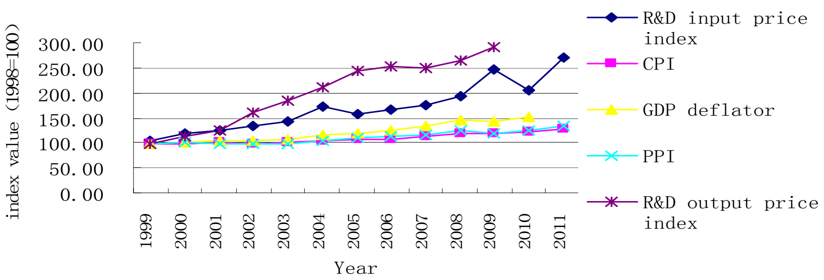

Figure1. The comparison of different price indices

Figure 1 shows that R&D input price indices and output price indices are higher than the other three indices from the year of 1999 to 2009 which resembles the results of the researches by foreign scholars such as Mansfield(1987) and John E. Jankowski，Jr（1991，1993）.The distinction between the R&D input price index constructed in this paper and the three traditional price indices (GDP deflator, CPI and PPI) suggests that the traditional price indices are not proper representatives for R&D price index because their statistical measurement are not R&D oriented . It also implies that using GDP deflator, CPI, PPI or some other deflators combined with them to deflate R&D expenditures as most domestic scholars do at present will overestimate the actual R&D expenses.

As the R&D input price index can neither reflect the changes of productivity nor the changes in profit brought about by R&D activities compared with the R&D output price index in theory, the difference between R&D input price index and output price index will be a good explanation for the shortcoming of R&D input price index .We can also see from Figure 1 that since the year of 2001, the R&D output price indices have been higher than the input price indices, which illustrates that R&D have great effects on our industrial products in recent years, not only having been promoting the continual upgrading of industrial products, but also leading to the substantive increase of industrial profits. In many industries, the effect of R&D activity on the increase of profits is stronger than that on labor productivity and this phenomenon result in the rapid increase of their residual intangible assets, leading to the rise of R&D output price index, which is in line with the reality. In addition, the empirical result also demonstrates the theory that there is some distinction between the input R&D price index and output R&D price index because of the non-complete market and the spillover effects of R&D activities .Meanwhile the comparison also illustrates the importance of building R&D input and output price index. What should be pointed out is that if the sub-industry transaction data in R&D market can be accessible and used in the construction of R&D output price index, the reliability of the index will be largely enhanced , which is of vital importance in the improvement work.

We use five indices to deflate R&D expenditure in 1998-2009, and calculate the growth rate of R&D expenditure with various constant prices, table 3 shows the result.

Table3 the growth rate of R&D expenditures and real value

	Average annual growth rate of actual R&D expenditures (%)	Real R&D expenditures in 2009(100 million Yuan)	Real R&D expenditures in 2010(100 million Yuan)	Real R&D expenditures in 2011（100 million Yuan)
current prices	125.52	3210.2	4015.4	4039.2
R&D input index	115.44	1300.9	1968.0	1490.5
R&D out index	113.56	1448.9	——	——
GDP deflator	121.53	2241.9	2636.7	——
CPI	123.64	2711.2	3283.6	3134.1
PPI	123.63	2710.9	3213.4	3049.1

Table 4 shows that the growth rate among those use GDP deflator CPI and PPI to deflate R&D expenditures are similar, and are also similar to the growth rate of R&D expenditures with the current price. The growth rate of actual R&D expenditures deflated by R&D input index and R&D output index are relatively low. Viewed from the absolute amount, the actual R&D expenditures calculated with the R&D price indices constructed in this paper all tend to be smaller than those deflated with the other indices in the years of 2009, 2010 and 2011 respectively. in 2009, among the actual R&D expenditures deflated by GDP deflator CPI and PPI, the largest value is 271.1 billion Yuan, and the minimum value is 224.2 billion Yuan, above the actual expenditures deflated by R&D input index 141.04 billion Yuan and 94.11 billion Yuan respectively, and also above the actual expenditures deflated by R&D output index 141.04 billion Yuan and 113.81 billion Yuan respectively.

5. Conclusion

In the empirical analysis of R&D, the R&D price index is an important tool to convert the current price into constant price, it is also indispensable in the establishment of R&D satellite account. This paper introduces the method of building R&D input price index and output price index in detail, and their concrete empirical results. Overall, we get the following conclusions:

Firstly, both the R&D input price index and the output price index constructed in this paper are higher than the traditional price indices such as the GDP deflator, CPI and PPI, thus the real R&D expenditures will be overestimated no matter deflated by these three indices or the combined ones based on them as most domestic scholars do at present. The maximum difference can be achieved 141.04 billion Yuan in estimation of real R&D expenditure in the year of 2009 when it is deflated by the traditional price indices and the ones we constructed in this paper.

Secondly, from the year 1998 to 2009, R&D input price index of the whole industry rose146.77 percentage points, the corresponding R&D output price index rose 190.92 percentage points, and each year’s output price index tends to be higher than the input price index since the year of 2001. The empirical result not only reflects the pheromone of the increasing profits brought about by R&D outputs in recent years, but also demonstrates the theory that there is some distinction between the input R&D price index and output R&D price index because of the non-complete market and the spillover effects of R&D activities.

Finally, along with ascending of input indices and output indices, industry R&D intensity rise firstly, and then come down.

It should be noted that, although the paper gives the introduction in detail in constructing R&D input and output price indices, some specific details, such as how to separate the R&D output gains accurately and how to scientifically choose the number of the years to do the average moving according to the specialty of each industry and so on, need further research, and are also the direction of future efforts.

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