
China's strategic sectors. Trends in health-related manufacturing

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Abstract: This paper is a first attempt to understand how strategic the health industry is for the Chinese economy, with respect to other manufacturing sectors. We measure this by building a composite indicator able to monitor over time the contribution of the different manufacturing sectors to the overall economic performance of China. In particular we define the strategic significance of the different manufacturing sectors according to their ability to stimulate entrepreneurship, generate employment, generate capital accumulation, meet market demand, generate profits, and produce fiscal revenues. Results suggest a good and stable contribution of the health-industry *filiere* to the Chinese economy. They also point to a relevant and increasing contribution of specific sub-sectors, including traditional Chinese medicine and proprietary Chinese medicine.

Keywords: health industry; strategic sectors; manufacturing; composite indicator; China.

Reference to this paper should be made as follows: Barbieri, E. and Tassinari, M. (2017) 'China's strategic sectors. Trends in health-related manufacturing', *Int. J. Healthcare Technology and Management*, Vol. 16, Nos. 1/2, pp.6–28.

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1 Introduction

China's experience of structural change is noteworthy for several reasons, not least because it has made an extensive use of the notion of 'strategic sectors' and of selective policy tools to target them. The industrial development guidelines set by the Five-Year Plans are extensively based on the choice of *pillar industries*, as well as *strategic emerging industries*, to be promoted and supported (Communist Party of China Central Committee, 1995, 2000, 2005, 2010). The long term aim of industrial policy in China has long been the promotion of economic growth. Such a goal is still binding for the future of China, even though the target growth rates have been lowered as a consequence of the economic crisis. But more important, such growth targets have been better qualified in the latest policy discourses. Starting in particular from the 11th Year Plan, the stated aims of the Chinese government have highlighted the need to move towards a process of economic growth that is translated also in a higher quality of life, lower disparities and lower environmental damage (Communist Party of China Central Committee, 2005).

Thus we would expect to see the Chinese economy and its industrial structure gradually shift towards productions that are not only compatible with, but also functional to, the achievements of a better quality of life. In this sense we would expect the sectors related to such new long term goals to emerge as the new strategic emerging industries identified by the Chinese government. In this framework, given the social and demographic transition that China is experiencing, we find the sectors related to the *health industry* of particular interest (Di Tommaso and Schweitzer, 2005). When looking at the Five-Year Plans it is clear that the health industry is perceived as a strategic field for the future of China. However it is less clear the extent to which the contribution of health-related manufacturing to the economic growth of China actually increases over time, in line with what the plans would hope.

This paper is a first attempt to understand how strategic the health industry is with respect to other sectors of the Chinese economy. The research questions that motivate the analysis are: what is the weight of the health industry in the composition of the overall Chinese economic performance, compared to other manufacturing sectors? Has the relevance of the health industry changed during the last decades? And again, which specific segments of the health industry's value chain are more relevant in the Chinese economy? We attempt to provide an answer to these questions by monitoring over time the contribution to the overall economic performance of China of the sectors that compose the health-manufacturing *filiera*. If the manufacture of goods related to the provision of health services remained marginal over time we would suggest that there might be trade-offs across different policy goals, in particular between promoting the generation of economic value and the enlargement of the supply of health-related goods to the benefit of an increasing demand for health.

The methodology applied builds a composite indicator to rank the different manufacturing sectors according to their *strategic importance* in the Chinese economy. Then it analyses in detail the trends on the contribution to total manufacturing of the specific industrial sub-sectors related to health for the time span 2003–2013. In this way we are able to identify within the health industry the specific sectors, including a distinction of traditional vs. Western medicine, that are increasingly contributing to the growth of Chinese economy. The index tends to rank sectors according to their past performance. It does not capture the future potential of industries (i.e., for instance their distance from the technological frontier or similar aspects). However, our goal here is not to forecast the sectors that will be strategic in the *future*. On the contrary we want to observe how the Chinese economy and its industrial structure have gradually shifted towards productions that are consistent with ‘health’ as strategic goal. From another perspective, we want to evaluate (*ex-post*) the consistency between the goals stated by the government and the trend in health-related industries.

The health industry, irrespective of how the health system is organised, is everywhere composed of three main actors (Di Tommaso and Schweitzer, 2005):

- 1 health service suppliers
- 2 financing institutions
- 3 manufacturers of health products.

In the first category we include both personnel and structures that provide health services: that is physicians, technical and paramedical staff as well as hospitals, clinics and ambulatories. The second category can vary a lot across countries and medical systems. In some countries health services are mainly financed by the public National Health Systems (it is the case of many European countries), while in other cases private institutions, mainly insurance companies, have a leading role (such as in the USA). Finally the third component includes manufacturing companies producing pharmaceuticals, medical and diagnostic devices, biotechnologies, microelectronic machinery – such as RMI scanners – robots and so forth. In this latter case, private companies are the main actors, even though governments can play important roles in terms of regulation, financing and reimbursement mechanisms.

Of course the dynamics of the health industry could be analysed also by looking at the improvements in health services and health system performances. The government’s ambition to attain a better quality of life could be reflected in improvements in aspects such as health outcomes, worker productivity, decline in premature mortality, and prevention of premature death and disability. In this paper, however, we wish to specifically focus on the third component of the health industry – i.e., manufacturing producers. We want to understand the extent to which government’s desired goals are reflected in modifications in the structure of the manufacturing sector, and in the establishment of a domestic industry offering goods – and technologies – for the health sector.

The paper is structured as follows. The next section provides a discussion on selective industrial policy in China: the peculiarities of the Chinese case are examined with a particular focus on the health industry relevance. In Section 3 we focus on the literature

on *strategic sectors*. Section 4 describes the methodology that we are going to utilise in the empirical analysis. In Section 5 we build a composite indicator to rank the different manufacturing sectors and the specific industrial sub-sectors related to health, according to their strategic importance in the Chinese economy. Section 6 concludes.

2 Selective industrial policy in China and health industry relevance

With the *open-door policy* China has decided to gradually open most of its economic transactions to the international market and to remove the planning mechanism. However, what is now clear is that such opening has been taking place in a gradual way, with different sectors being liberalised to a different degree and at different times. Moreover, even when the shift towards a *free* market economy seemingly has taken place, it can be argued that it has led to a capitalism *with Chinese characteristics* (Peck and Zhang, 2012), where governments continue to importantly intervene to support Chinese economic development.

The tools that have been used by the government, particularly with the aim to promote specific manufacturing sectors and firms are numerous: special economic zones (Rubini et al., 2015; Yao and Whalley, 2015; Zheng et al., 2016); specialised industrial clusters (Bellandi and Di Tommaso, 2005; Barbieri et al., 2009a, 2009b; Rubini et al., 2015; Barbieri et al., 2010, 2012, 2013); infrastructural mega-projects (Di Tommaso et al., 2013), public procurement policies (USCBS, 2011), SOEs as a political means to *directly* control the dynamics of production (Rubini and Barbieri, 2013) and etc.

Both in the case of Special Economic Zones and other policy tools, a rooted characteristic of the Chinese public intervention has been a special attention to the sectoral component of industrial development, by targeting specific priority industries. This has led to an idea of the market for *strategic sectors* that allows the emergence of few state actors and limits de facto the competition (Pearson, 2005; Rubini and Barbieri, 2013; Ahrens, 2013).

What we find interesting is that the same tools have been used by the government over the decades, adapting them to changing long-term policy goals (Di Tommaso et al., 2013). So, in line with an increasing policy interest over health-related industries one can note the recent emergence of special economic zones targeting high-tech sectors, such as biotechnologies, or the birth of health-specialised towns.¹ Changing goals and adapting tools seem to remain one of the distinctive characteristics of government intervention in China (Rubini et al., 2015). The same meaning of *industrial growth*, at least ideally, has evolved considerably for policy-makers in recent years. Chinese government's rhetoric during the last decade has increasingly announced the perspective to push economic growth towards sectors and industries able to respond to complex societal goals, such as environment sustainability, equity, access to health care and to, more generally, a better quality of life. This change in policy goals is indeed widely supported by the official documents of the government and, above all, the *Five-year Plans*. The long-term *vision* of the leadership and policy goals expressed within the plans are (or should be) a crucial element to understand the control over specific state firms, the promotion of national champions, and the support for specific industrial sectors.

Five-year plans have been the main programming tool of the Chinese governments since the 1950s. Even though they now aim at providing *guidelines*, rather than defining binding targets, Five-year Plans always give precise indications the industries that have to be considered strategic (Ahrens, 2013). They are either defined, on the one hand, as *pillar* industries or *key* industries when they involve sectors in some way already present in the Chinese manufacturing context, and, on the other hand, as *strategic emerging sectors* looking at the industries that could become *pillars* in the future. Even when such definitions are not explicitly written, one can identify in the plans the paragraphs and indications specifically directed to selected sectors. Often the identification of what is strategic goes as far as to the detection of specific sub-sectors or products to be promoted (as in the case of the 12th Five-Year Plan, Table 1).² The identification of strategic sectors in the Five-year Plans goes hand in hand with the catalogues of the MOFCOM that identify, permitted, encouraged, restricted and prohibited investment projects (Davies, 2013). Table 1 summarises the main strategic sectors identified in the last four Five-year Plans.

As it is clear from the comparison of the four plans, some major strategic industries (pillar) have remained fixed. In particular machinery, electronics automotive, petrochemicals and construction/building materials are always in the list of key industries. Then, in recent plans new sectors have been identified, namely shipbuilding, metallurgical industry and packaging. Next to the pillar industries the plans identify a list of *emerging* sectors. They are the industries that set the path of the future economic development, since they are supposed, according to the *visions* of the government, to compose the forthcoming Chinese industrial structure. Emerging industries are normally connected with high-tech and high-value added productions (Petti et al., 2013), but, beyond their economic significance, they can be easily associated also with the purpose of the government to promote in some ways a number of *merit goods* (as indeed claimed by the administration). Most recent Five-year Plans identify as emerging sectors *broadband, digital devices, satellite; environmentally friendly vehicles; biotechnology; traditional Chinese medicine* (TCM). These would aim at promoting socially desirable objectives such as equity, environment sustainability and health. In particular, already in 1996 the medical and pharmaceutical industry, were considered as strategic emerging sector, as well as *biotechnology* which was specifically mentioned in the Ninth Five-year Plan and in the following ones. Interestingly *TCM*, which has always characterised the Chinese economy and society, has become a strategic emerging industry in which to invest according to the Chinese government's view of the last two Five-year Plans. This is in line with the general spirit of 'indigenous innovation' that has been promoted in China starting in particular from the Eleventh Year Plan (Di Tommaso et al., 2013).

Indeed, the inclusion of health-related industries into the list of the sectors that 'deserve to be promoted' is consistent with a wider plan of the government to increase the health status of the Chinese population. In this context in the last years the Chinese government has promoted several initiatives aimed at establishing rural health insurance, developing community health centres, and aspiring to universal basic healthcare coverage by 2020 (the so-called healthy China 2020 plan) (Ling et al., 2010).

Table 1 Pillar (P) and emerging (E) industries in China's Five-years Plans (1996–2015)

<i>Industries/Five-years Plans</i>	<i>IX (96-00)</i>	<i>X (01-05)</i>	<i>XI (06-10)</i>	<i>XII (11-15)</i>
Food production				
Beverage production				
Tobacco products processing				
Textiles	P	P	P	
Wood products				
Furniture manufacturing				
Papermaking and paper products				
Printing and record medium reproduction				
Petroleum and coal products	P		P	P
Raw chemical material and chemical products			P	
<i>Medical and pharmaceutical products</i>	E	E	E	E
<i>Biotechnology</i>	E	E	E	E
<i>Traditional Chinese medicine</i>			E	E
Chemical fiber				
Nonmetal mineral products	P	P	P	P
Non-ferrous metal manuf.			P	P
Ordinary machinery manufacturing	P			
Special equipment manufacturing		P	P	P
<i>Packaging</i>				P
<i>Mechatronics</i>		P		
Transportation equipment manufacturing	P	P		
<i>Automobile</i>	P	P	P	P
<i>Environmentally friendly vehicles</i>				E
<i>Aerospace</i>	E		E	
<i>Shipbuilding</i>			P	P
Electrical machinery and equipment manufacturing				
Computers, communications and other electronic equipment	P	P	P	P
<i>Broadband, digital devices, satellite</i>		E	E	E
<i>Optoelectronics</i>		E		

Source: Authors' elaboration on NPC (1996, 2001, 2006, 2011)

As an important stage of China's health care reform, The New Rural Co-operative Medical Care System (NRCMCS) was established in 2002 as a system of voluntary insurance, where population (especially rural residents) could voluntarily register. It was

funded by private contributions, local government and central government in equal measure (Dong and Torgler, 2013). By 2007 approximately 83% of total rural population has been covered by health insurance thanks to this plan (Ling et al., 2010).

A second important initiative has been the establishment of *Community Health Centres*. It started in 2005 as pilot program and rolled out countrywide in 2007. This reform has converted into Community Health Centres many community hospitals, favouring cutting cost and improving efficiency for health care in urban area.

Finally, in 2009 the Government launched the *Healthy China 2020* plan, aimed at achieving basic healthcare coverage for all residents living in urban and rural areas by 2020. The first phase of the plan was from 2009 to 2011, when the Government invested approximately US\$ 125 billion for medical services, public health services, medical insurance and drugs supply (Chi-Man Yip et al., 2012). More recently, Chinese government has implemented a new cycle of reform through the 12th Five-year Plan. Launched in 2011, it explicitly stated the government's goals for health care area. They are related to the strengthening of public healthcare infrastructure and healthcare service network, the development of comprehensive medical insurance system, the improvement of drug supply system, the reform of the public hospital system and the development of the *TCM* (KPMG China, 2011).

Since there is no doubt in this context that *health* is seen by the government as a 'strategic sector', focusing on the industrial growth dynamics we would expect to find health industry as increasingly relevant in the Chinese economy. Thus, the research questions we pointed out in this paper are: What is the weight of the health industry in the composition of the overall Chinese economic performance, compared to other manufacturing sectors? Has the relevance of the health industry changed during the last decades? And again, which specific segments of the health industry's value chain are more relevant in the Chinese economy?

But before entering these questions through our empirical analysis, it is important to recall the general framework in which selective industrial policy and the concept of *strategic sector* are defined, in order to contextualise *targeting* of a particular sector, such as health industry, within a wider spectrum of competing goals that can characterise Chinese government's action.

3 Industrial policy and rationales for targeting strategic industries

The industrial policy domain has been vividly discussed in academic and policy making circuits. The rationales of government intervention in this field have traditionally focused on market failures corrections (Pigou, 1929; Bator, 1958; Baumol, 1965; Stiglitz, 1988, 1989), but also on other arguments as the provision of merit goods or the need of governing industrial development with *strategic-economic* purposes (Amsden, 1989, 1994, 2003; Chang, 1994, 2002a, 2002b; Rodrik, 2008; Di Tommaso and Schweitzer, 2005, 2013; Stiglitz, 2001; Stiglitz and Lin, 2013).

We in particular focus our analysis on the latter field of intervention, that we identify as 'strategic industrial policy'. In this specific case, the rationale is that policy makers can have a role in guiding a country, just as much as entrepreneurs and managers do in the case of companies. Government responsibility may be viewed as defining strategies in the name of national interest and citizens' welfare.

In many established industrialised countries it is possible to find a debate about the role that government might play in defining and implementing the national strategy for industrial development. In all the industrial development experiences of the most successful countries governments have identified a set of goals that have been defined to be strategic for their economies and more generally for their countries (Chang, 2002b; Di Tommaso et al., forthcoming). Examples of these strategic goals are improvements in competitiveness, acceleration of growth, structural adjustments, industrial development, industrial and economic 'independence', export promotion and import substitution, innovation and technological upgrading, the definition of measures to contrast industrial decline or crises and recessions.

In most circumstances these goals are promoted through *selective* (or vertical) industrial policies, by targeting selected companies, regions and territories, or specific industries.³ Thus, 'targeting' can be considered the most traditional (and debated) feature of industrial policy.

Generally, the existing literature in this field has defined strategic sectors according to their ability to promote economic growth. Thus, competitiveness has been a first objective to evaluate how strategic a sector is.

According to several authors firms of a particular industry are exposed to a certain degree of uncertainty, given by the changes that take place in the competitive environment in which they operate. Technological upgrading, entry of new competitors, free-trade agreements, are examples of circumstances that can vary considerably the degree of threat from external competitors or the profit opportunities of a particular sector. In a dynamic perspective, the ability of the firms of the sector to answer to the changes and to improve their organisation of production over time, is crucial for their competitiveness (see, e.g., Malerba, 2002; Bianchi and Labory, 2006; Spender, 2012).

Similarly, some authors stress how the development of competitiveness involves the continuous acquisition of knowledge, as a crucial 'productive factor' for the sector's ability to innovate over time, creating new products or new productive processes (see, e.g., Bianchi and Labory, 2006). Libicki (1990, p.1), for example, defines strategic industries as 'those that best foster the systematic application of knowledge to generate more and better outputs from inputs'.

A dynamic perspective in defining strategic sectors has been recently supported also by Justin Lin, the World Bank's Chief Economist from 2008 to 2012. Consistent with the idea that different industries have different growth potential, the government should promote the structural adjustment of the economy by fostering the development of the technical and organisational capacities of enterprises operating in sectors with 'latent comparative advantages' (Lin, 2010, 2012).⁴

In general terms, having identified competitiveness as the relevant aspect of the strategic significance of a sector has made the academic debate focus on 'more dynamic' industries, which are capable of developing important economies of scale through learning by doing, characterised by high technological and capital content, high value added, and which are capable of gaining the highest profits and export performances (Krugman, 1987; Michalski, 1991; Soete, 1991; Stevens, 1991; Teece, 1991; Yoshitomi, 1991).

In addition to competitiveness, another important criterion that literature has used to identify industries with a strategic potential is the level of interdependence between different economic activities. As described by several authors, a sector can be considered

as strategic because it produces positive externalities, having a high degree of upstream and downstream connections with other sectors (Hirschman, 1958; Krugman, 1987; Michalski, 1991; Soete, 1991; Stevens, 1991; Teece, 1991; Chang et al., 2013; Andreoni and Scazzieri, 2014).⁵

In other cases, the industrial policy practices common to many governments throughout history show how some sectors can be considered as strategic because of their weight in the economy, calling for a deep re-organisation of traditional and old industries. The relevance of the sector in terms of, for example, how much employment it creates, which is a crucial aspect of the wellbeing of a community, can per se give particular importance to an industry. This aspect is often associated with sectors that have been part of a society for a long time, have accumulated know-how, specific human capital, supply networks, and a reputation, so that transition to other sectors would be too costly from an economic and social point of view (see, e.g., Chang, 2003; Whitford, 2005).

Finally, another kind of literature suggests that strategic sectors can (or should) be identified by going beyond purely economic criteria and referring to the doings and beings of a society as a whole. In fact in many cases industrial policy has been called on to intervene to address issues of distribution of wealth among people or regions, access to merit goods, social or environmental sustainability and even foreign policy goals. In this perspective the processes of development and change of a country is evaluated going beyond the traditional variables of growth and economic performance (Sen, 1983, 1999; Arndt, 1987; Hirschman, 1981; Ingham, 1993; UNDP, 1990). When adopting this approach, governments might be called on to intervene in some specific industries even at the cost of economic efficiency (Musgrave, 1959; Musgrave and Musgrave, 1984; Chang, 1994; Ver Eecke, 2007). For example, government might encourage the production of education, research, energy, health care, or environmental protection industries. On the other hand, governments might be called upon to discourage the production of those goods and services that are deemed non-meritorious and perhaps over-provided, such as cigarettes, alcohol, gambling, and sales of weapons. Of course the identification of meritorious and non-meritorious goods and services is, by definition, normative and it is based on each government's specific vision about its nation's societal values.

It is clear that in the scenario above described there are *many* political goals that can justify a selective industrial policy and, more specifically, the promotion of particular industries. One of the problems in this context is therefore given by the existence of potential trade-offs between political objectives: for example, a *merit sector* could not be relevant for its economic performances.

In the next pages we build a composite indicator to rank manufacturing industries on the base of their *strategic significance*. In our specific case we have decided to define a *strategic sector* on the base of its economic performance and, in particular, of the *overall weight* of an industry in the economy.⁶ Of course, one could argue that being a merit good the health-industry should be considered as strategic even if did not create relevant economic value. Here however, we suggest that it is important to focus *also* on the capacity of the health-industry to generate good economic performances. If the manufacturing of health-related products does not display good economic performances there is a potentially binding trade-off that might discourage investing in health-related sectors, to the advantage of more economically efficient sectors. On the contrary if health-related manufacturing does contribute, in a relevant way, to the creation of economic value then such trade-off disappears.

4 A composite indicator for measuring strategic importance of manufacturing industries

The construction of a composite indicator is useful when it is necessary to study a complex phenomenon, in order to 'synthesise' the information provided by different variables in a single value. Thus, composite indicators are used, for example, to inform policy-makers, investors or citizens on trends and changes in countries' performance over time (in terms of market opening, development, security, education, health, human rights, environment, corruption, etc.) (OECD, 2008; Di Tommaso et al., forthcoming).

Composite indicators are particularly well-suited for our analysis since we aim to understand the degree of *strategic importance* – a complex phenomenon – of different manufacturing industries, and in particular the relative importance of health-related sectors. In this section a composite indicator is therefore developed in order to classify

- a 15 Chinese manufacturing industries
- b 19 Chinese health-related manufacturing industries on the basis of their economic performance and ability to create economic value.

The indicator, the *strategic sector index* (SSI), wishes to measure the strategic importance of health-related sectors according to their capacity to:

- 1 stimulate entrepreneurship
- 2 generate employment
- 3 generate capital accumulation
- 4 meet market demand
- 5 generate profits
- 6 produce fiscal revenues.

Each of these dimensions has been proxied by specific variables and in particular:

- 1 number of firms at the end of the year in the sector
- 2 number of employees at the end of the year in the sector
- 3 total value of fixed asset investment at the end of the year in the sector
- 4 total volume of sales at the end of the year in the sector
- 5 total volume of profits at the end of the year in the sector
- 6 total amount of payable income taxes at the end of the year in the sector.

Given the high correlation (see Table 2) between profits and sales, and between profits and taxes, we decided to keep only the variable related to fiscal income as a proxy of the ability to generate additional income for the whole economy.

This composite indicator places particular emphasis on the weight that each of the sectors has in the Chinese economy, rather than the growth dynamics of each sector.

Table 2 Pearson – R correlations

	<i>Number of enterprises (unit)</i>	<i>Number of employees (person)</i>	<i>Fixed assets (1,000 yuan)</i>	<i>Sales revenue of product (1,000 yuan)</i>	<i>Total profits (1,000 yuan)</i>	<i>Payable income taxes (1,000 yuan)</i>
Number of enterprises (unit)	1	0.75	0.75	0.35	0.43	0.40
Number of employees (person)	0.75	1	0.84	0.69	0.75	0.63
Fixed assets (1,000 yuan)	0.75	0.84	1	0.73	0.74	0.70
Sales revenue of product (1,000 yuan)	0.35	0.69	0.73	1	0.90	0.70
Total profits (1,000 yuan)	0.43	0.75	0.74	0.90	1	0.88
Payable income taxes (1,000 yuan)	0.40	0.63	0.69	0.66	0.88	1

Source: Authors' elaborations on data provided by National Bureau of Statistics of China (NBS) (2014)

Once the variables composing the index are chosen, the method for calculating a composite indicator is divided in two steps:

- 1 transformation of the original variables (in order to allow comparability between them)
- 2 combination of variables to obtain a composite measure of the phenomenon that is of interest.⁷

In the first step, each of the original variables is normalised in the interval (0, 1) so that a transformed value tending to 1 is assigned to the best of the sectors, while a transformed value tending to 0 identifies the worst of them. For all other sectors the transformed value is a number between 0 and 1.

Formally, indicating with X_{jk} the value of the k -th variable for the sector j , with Y_{jk} the corresponding normalised value, and $T_k(\cdot)$ the function for normalising the k -th variable:

$$Y_{jk} = T_k(X_{jk}) = \frac{X_{jk} - \min(X_{1k}, \dots, X_{Jk}) + \frac{1}{J}}{\max(X_{1k}, \dots, X_{Jk}) - \min(X_{1k}, \dots, X_{Jk}) + \frac{2}{J}}$$

where $\frac{1}{J}$ and $\frac{2}{J}$, respectively added to the numerator and to the denominator, allow to obtain normalised values strictly included between 0 and 1, to avoid infinite values or impossible forms of indeterminacy in the aggregation phase.

In the second step, the normalised variables are aggregated by applying an appropriate combination function. This phase implies the choice of the combination function and the weight to assign to each variable, in order to incorporate their different degree of importance in the indicator.

In our case the variables have the same weight and are combined by applying the *Fisher* function,⁸ obtaining for each sector j the values of the SSI:

$$SSI_j = \sum_{k=1}^K w_k \ln(1 - Y_{jk})$$

where K is equal to 6 (number of variables); Y_{jk} is the normalised value of the k -th variable for the j -th sector; and W_k is the weight given to the k -th variable.

The final values of the indicator are normalised in the interval (0, 1): industries with values of the SSI tending to 1 have a high degree of strategic importance, while those with values tending to 0 have a low degree of strategic importance.

As already mentioned, the SSI tends to rank sectors according to their past performance. It does not capture the future potential of industries (i.e., for instance their distance from the technological frontier or similar aspects). Similarly, the SSI is computed on sectors that already exist in the economy: industries that are absent from a country's economy are not included. Furthermore, sectors that are still small (because in the initial stages of development) tend to be ranked low by the index. These could be viewed as the major limitations of the index. However, as already explained we are mainly interested in observing if and how the manufacturing structure of China is evolving towards health-related productions. Having clarified this, the SSI could indeed be useful to get some information on the strategic *potential* of an industry. Given that the SSI ranks sectors relative to one another and it is computed over a relatively large time span one would expect industries with a high potential to display, at some point, a higher growth rate of some of the variables. If the position of a sector in the rank over time is stable, one can infer that its growth rates (in the various variables) are not different from those of other sectors. It is clear however that this 'predictive' function of the index could be improved by including more appropriate variables in the composite indicator. Further steps of this research line could better address this or other informative goals.⁹

5 Application to Chinese manufacturing industries

This section presents the results obtained by calculating the SSI in the case of Chinese manufacturing. Our data source is the National Bureau of Statistics (various years).

As a first step we have calculated the indicator, according to the availability data, for 15 manufacturing sectors of the Chinese economy (equivalent to the 2 digit of the conventional SITC/NACE classifications) and for 19 health-related manufacturing industries (equivalent to the 4 digit of the conventional SITC/NACE classifications) in both cases for different years from 2003 and 2013. The 2 digit analysis allows to highlight the importance of the medical and pharmaceutical sectors with respect to other sectors of the economy (see Appendix). The 2 digit analysis, however, provides only a partial view of the evolution of health-related manufacturing since several health-related productions do not belong to the 'medical and pharmaceutical' sectors, but to other categories.

Given that the aim of the paper is to gain a better understanding of the strategic importance of the health-industry as a whole, as a second step we have also re-classified the sectors in order to highlight the contribution of the health-manufacturing *filiere*. Table 3 shows the results of the ranking after such re-classification, where the health-industry includes all the 4 digit sectors related to the manufacturing of health product for which we could find data.¹⁰ We then analyse these sub-sectors in detail in Table 4.

Position 1 of Table 3 corresponds to the industry with the highest degree of strategic importance, as defined by our composite indicator.

Table 3 shows that the health industry is placed sixth in the ranking of the 15 manufacturing sectors analysed for China. Such position is stable throughout the whole considered period. The sector contributed in 2013 on average to 6.8% of the overall economic performance displayed by the 15 manufacturing sectors (7.2% in 2003). The relative contribution to the different dimensions considered has actually deteriorated slightly overtime: entrepreneurship (from 8.16% in 2003 to 7.01% in 2013), employment (from 6.63% to 6.27%), investment (from 6.35% to 5.53) and taxes (from 8.34% to 8.25%). The only increasing trend is that of sales (from 5.11% to 5.16%). These slight variations in the contribution to the different dimensions did not translate in major changes of the relative position of the sector. In other words, when we consider the weight of the sector on the overall economy, according to our pre-defined dimensions, the health-industry does not seem to acquire an increasingly strategic role in the Chinese industrial system. Its contribution has basically remained the same in the last ten years.¹¹

As a second step, we analysed in more detail the sub-sectors (4 digit), across the different manufacturing industries, that can be referred to the health industry, including for instance medical equipments, special machinery, optical tools and the like.

Table 4 represents the ranking of different health-related manufacturing sectors according to the same SSI index presented in paragraph 4.

As a first sight reveals, Table 3 shows a stable ranking of sectors. Changes in the position of each sector, that reflect changes in the ability to contribute to the overall economic performance of China, are only marginal and leave the basic structure of this *filiere* unmodified. As a results, sectors that mainly contributed to economic performance in 2003, as emphasised by the top five positions, are still the same in 2013. It is interesting to note that TCM¹² that was no longer in the top five in 2005, regained positions in 2013. Similarly proprietary Chinese medicine¹³ improved its positioning already in 2011. We could speculate that these might be the results of the *indigenous innovation* policies of the latest policy guidelines. However further empirical verification would be needed to confirm this hypothesis.

Table 3 also reveals a relative specialisation towards the production of final goods and services. Most sectors related to the production of machinery and equipment are in fact positioned at the bottom of our ranking.

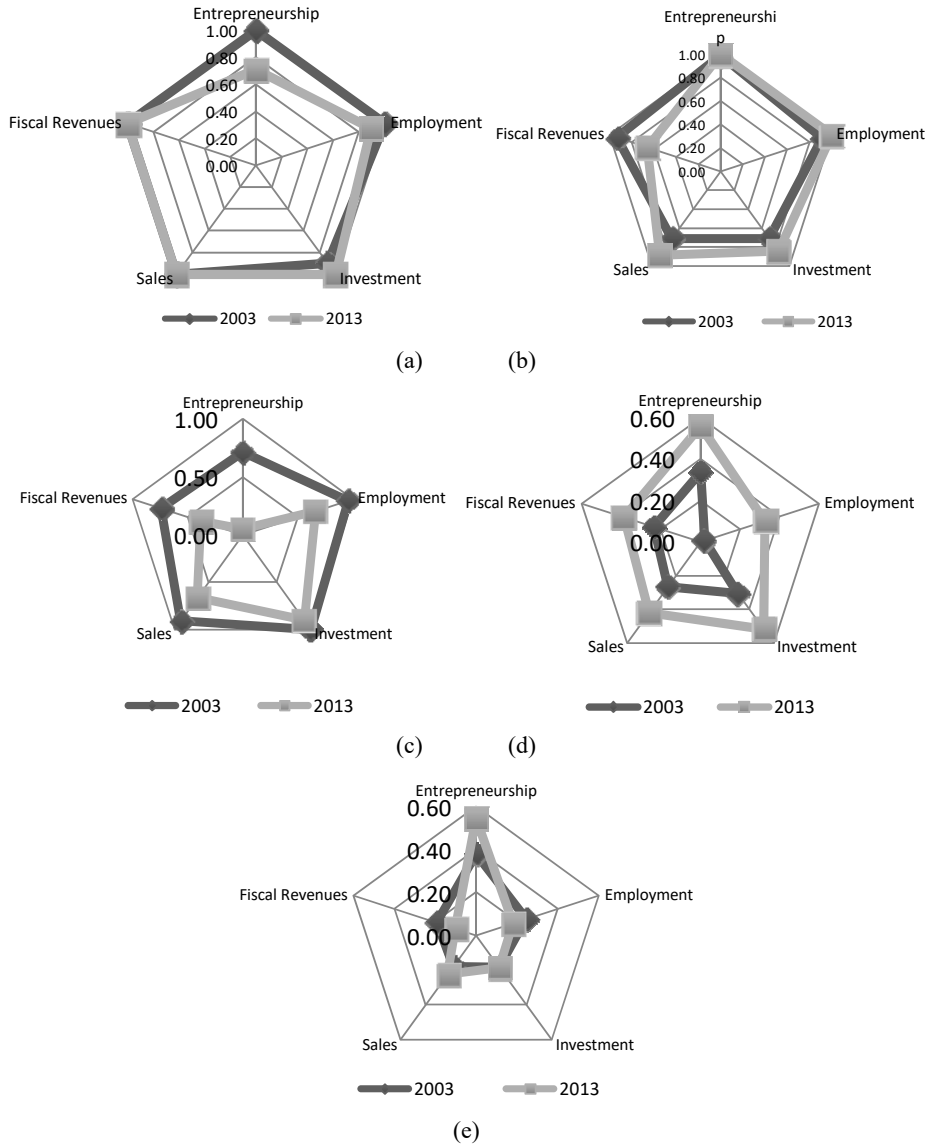
Below we provide a further zooming-in on the top five positions of our strategic sector ranking. Figure 1 shows the evolution of each sub-sectors' contribution to the different dimensions that we used to measure economic performance.

Table 3 Rankings of China's strategic health-related industries (years 2003, 2005, 2007, 2009, 2011, 2013)

Rank	2003	2005	2007	2009	2011	2013
1	Chemical medicine dose	Chemical medicine dose	Chemical medicine dose	Chemical medicine dose	Chemical medicine dose	Chemical medicine dose
2	Chemical medicine mat.	Chemical medicine mat.	Chemical medicine mat.	Chemical medicine mat.	Chemical medicine mat.	Proprietary Chinese med.
3	Proprietary Chinese med.	Chemical medicine mat.	Proprietary Chinese med.	Proprietary Chinese med.	Chemical medicine mat.	Chemical medicine mat.
4	Biopharmaceuticals	Biopharmaceuticals	Biopharmaceuticals	Biopharmaceuticals	Biopharmaceuticals	Biopharmaceuticals
5	Traditional Chinese med.	Optical instruments	Sanitation materials	Sanitation materials	Sanitation materials	Traditional Chinese med.
6	Optical instruments	Sanitation materials	Traditional Chinese med.	Traditional Chinese med.	Traditional Chinese med.	Sanitation materials
7	Sanitation materials	Traditional Chinese med.	Animal medicines	Animal medicines	Animal medicines	Animal medicines
8	Glasses	Glasses	Sanitation materials	Optical instruments	Optical instruments	Medical, surgical and vet. eq.
9	Animal medicines	Animal medicines	Medical diagnosis and eq.	Medical, surgical and vet. eq.	Optical instruments	Optical instruments
10	Medical diagnosis and eq.	Medical rubber products	Medical, surgical and vet. eq.	Medical, surgical and vet. eq.	Medical, surgical and vet. eq.	Medical diagnosis and eq.
11	Medical rubber products	Medical, surgical and vet. eq.	Glasses	Glasses	Optical glass	Optical glass
12	Medical, surgical and vet. eq.	Medical diagnosis and eq.	Medical rubber products	Medical diagnosis and eq.	Medical diagnosis and eq.	Optical glass
13	Optical glass	Medical diagnosis and eq.	Optical glass	Medical rubber products	Glasses	Glasses
14	Medicine production eq.	Other medical cure eq.	Other medical cure eq.	Other medical cure eq.	Medical rubber products	Medical rubber products
15	Other medical cure eq.	Medicine production eq.	Medicine production eq.	Medicine production eq.	Other medical cure eq.	Other medical cure eq.
16	Artificial limb and transplan. M.	Mechanical cure and nurs. eq.	Artificial limb and transplan. M.	Mechanical cure and nurs. eq.	Artificial limb and transplan. M.	Medicine production eq.
17	Mechanical cure and nurs. eq.	Artificial limb and transplan. M.	Mechanical cure and nurs. eq.	Mechanical cure and nurs. eq.	Mechanical cure and nurs. eq.	Mechanical cure and nurs. eq.
18	Med. lab. and med. disinfec. eq.	Artificial limb and transplan. M.	Mechanical cure and nurs. eq.	Artificial limb and transplan. M.	Mechanical cure and nurs. eq.	Artificial limb and transplan. M.
19	Oral cavity treatment eq.	Med. lab. and med. disinfec. eq.	Med. lab. and med. disinfec. eq.	Med. lab. and med. disinfec. eq.	Med. lab. and med. disinfec. eq.	Med. lab. and med. disinfec. eq.
		Oral cavity treatment eq.	Oral cavity treatment eq.	Oral cavity treatment eq.	Oral cavity treatment eq.	Oral cavity treatment eq.

Source: Author's elaboration

Figure 1 Top five health-related sub-sectors: contribution to the different dimensions of the SSI
 (a) chemical medicine dose (b) proprietary Chinese medicine (c) chemical medicine material (d) biopharmaceuticals (e) TCM



Source: Authors' elaboration

In particular, it is interesting to note the increasing contribution of TCM in terms of entrepreneurship and sales; the improvement of biopharmaceuticals in all the considered dimensions; the improvement of proprietary Chinese medicine in particular in terms of employment, investment and sales. On the other hand, despite remaining in the top five positions, chemical medicine materials has worsened its values in all the considered dimensions.

6 Concluding remarks

In this paper we have focused on the strategic importance of Chinese manufacturing sectors, with particular attention to the health-industry.

Our analysis recalls the efforts done by the Chinese government to target specific pillar and emerging industries. In this scenario the health-related sectors have been considered as a priority for industrial policy interventions since the 9th Five-year Plan and even more prominently in the most recent plans.

The empirical analysis we carried out is a first attempt to clarify the extent to which health-related industrial sectors can be considered strategic for the Chinese economy, according to their capacity to contribute to the overall economic performance of China. We also investigated how such contribution has evolved over time.

Our results highlight first of all that the health-industry displays an overall good economic performance, which is reflected in a relatively high positioning in the ranking of Chinese manufacturing industries. However, the results also highlight that the contribution of the *filiere* in terms of economic performance has remained unchanged since 2003, compared to other manufacturing sector. There seems to be no evident shifting, or structural adjustment, of the Chinese industrial system towards health-related production. Of course this is not to conclude that policy action has been ineffective (a complex and rigorous causal analysis would be needed to this purpose). Some government intervention promoting the health-sector are indeed very recent and they might take time to show some results. Furthermore, one should also take into account the effect of the economic crisis, that is having a different impact across sectors. In this case a stable positioning of the health-industry might be a sign of its resilience to the crisis. The analysis has also clarified the relative contribution of specific sub-sectors of the health-industry. The results seem to point to an important, and increasing, contribution of the TCM and of proprietary Chinese medicine to the economic performance of the sector. This is an interesting trend, in line with the recent policy direction, that would deserve further attention in future researches.

More generally, the paper has presented a methodology to analyse the evolution of industries' strategic significance over time. To this purpose we built a composite indicator (the SSI). Although we believe that this methodology is appropriate to study this kind of informative problems, the application of the index presented in the paper could suffer from two main limitations. First, as already highlighted, the SSI tends to rank sectors according to their past performance and it only marginally captures the future potential of industries. This 'predictive' function of the index could be improved in future research lines by including more appropriate variables in the composite indicator.

Second, the final ranking of industries that we obtain as a result of the analysis could be affected by changes in the weights assigned to the variables and in the choice of the combining function of the index. Thus, future steps of the research could focus more on the robustness of the ranking. With this purpose, for example, an uncertainty analysis could be applied (see, e.g., Saisana et al., 2005; Marozzi, 2014; Tassinari et al., 2014).

Acknowledgements

The research leading to these results has received funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme fp7/2007-2013/ under the grant agreement no 612589. The publication does not necessarily reflect the opinion of the EU.

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Notes

- 1 See for instance the Guangzhou International Bio-Island, funded in 2010 by Administrative Committee of Guangzhou Development District, to name one (<http://www.bio-island.com>)
- 2 "New-generation IT industry: focus on the development of new-generation mobile communication, new-generation internet, three-network convergence, internet of things, cloud computing, IC, new displays, high-end software, high-end servers and information services. In the biological industry, focus on the development of biopharmaceuticals, biomedical engineering products, bio-agriculture and bio-manufacturing. In the high-end equipment manufacturing industry, focus on the development of aviation equipment, satellites and application, rail traffic equipment and intelligent manufacturing equipment. In the new energy industry, focus on the development of new-generation nuclear energy and solar energy utilization, photovoltaic and photo-thermal power generation, and wind power technological equipment, intelligent power grids and biomass energy. In the new material industry, focus on the development of new functional materials, advanced structural materials, high-performance fibers and compound materials, and common basic materials. In the new energy automobile industry, focus on the development of plug-in hybrid electric vehicles, pure electric develop new strategic industries energetically, such as energy-saving and biopharmaceuticals, biomedical engineering products, bio-agriculture and bio-manufacturing vehicles and fuel cell automobile technologies. The proportion of the added value of new strategic industries to GDP should attain about 8%." [Ahrens, (2013), p.38].
- 3 On the debate about the difference between vertical and horizontal industrial policy see, e.g., Lall and Teubal (1998) and Chang et al. (2013).
- 4 Clearly, also in this context, how it is possible to identify industries with latent comparative advantage is still a crucial question, and this shows that in IP the risk of mistakes in the identification of the industries that will be able to improve their competitiveness in the future is inevitable. On this point see in particular Lin and Chang (2009), Chang et al. (2013) and Wade (2012).
- 5 However, since the early '90s, the industrial policy approach based on the relevance of upstream and downstream linkages of an industry seems to have been questioned by a large part of economic literature. In fact, while in a closed economy the upstream and downstream linkages between productive sectors could have an important impact on the overall development of the national economy, the markets liberalisation has encouraged domestic firms to enter the global networks of suppliers and customers. These dynamics have made less relevant the vertical integration of one sector in the domestic industry (Pack and Saggi, 2006). On this topic see also Gereffi et al. (2005), Gibbon et al. (2008), Pietrobelli and Rabellotti (2011) and Elms and Low (2013).
- 6 We do not take into account the downstream and upstream linkages following the recent literature that suggest that global value chains make these linkages less relevant for the development of the domestic industry (Pack and Saggi, 2006; Gereffi et al., 2005; Gibbon et al., 2008; Pietrobelli and Rabellotti, 2011; Elms and Low, 2013).
- 7 For further details on methodological aspects related to composite indicators see, for example, Arboretti et al. (2007), Bonnini et al. (2009), Marozzi (2009), Fayers and Hand (2002).

- 8 The Fisher function compared to other possible functions assigns a high value of the index to those sectors that present particularly high performances even just in a few variables. We have no priors on the relative importance of each variable, for this exercise we take all of them as equally important. Therefore is a sector displays excellent performance even only in one or few dimensions we want the index to emphasise this aspect. For further details see Arboretti et al. (2007) and Bonnini et al. (2009).
- 9 It is commonly acknowledged that getting empirical data on the strategic potential of an industry is but a first step towards a better understanding of the future performance of a sector. As argued by the industrial policy literature such a projection requires a permanent dialogue between the policy authority and the main actors who compose the economic system (see, e.g., Hausmann and Rodrik, 2006).
- 10 These include specifically: nutritious foods (1,491), health care foods (1,492), chemical medicine materials (2,710), chemical medicine dose (2,720), traditional Chinese medical tablets processing (2,730), proprietary Chinese medicines production (2,740), animal medicines (2,750), biopharmaceuticals manufacturing (2,760), sanitation materials and medical articles (2,770), dialy and medical rubber products (2,915), optical glass (3,052), medicine production equipment (3,544), medical diagnosis, supervision and cure equipment (3,581), oral cavity treatment equipment and devices (3,582), medical laboratory and medical disinfection equipment and devices (3,583), medical treatment, surgical and veterinary apparatuses (3,584), mechanical cure and ward nursing apparatuses (3,585), artificial limb and organs and transplanting machines (3,586), other medical cure equipment and apparatuses (3,589), optical instruments (4,041), glasses (4,042). Some of these have then been excluded in the analysis due to missing data.
- 11 In a different paper (Barbieri et al., 2015) we took into account also the growth dynamics of the different sectors, suggesting that a strategic sector might be defined by its growth rates rather than by its static contribution to an economy. We considered in particular the growth trends of value added taxes, output, investment and profits and the results remain confirmed, with medical and pharmaceutical manufacturing placed in the middle of the ranking of strategic sectors.
- 12 TCM is primarily used as a complementary alternative medicine approach and it is a broad range of medicine practices coming from long lasting Chinese tradition, including various forms of herbal medicine, acupuncture, massage, exercise, and dietary therapy (see National Center for Complementary and Integrative Health, <https://nccih.nih.gov/>, last accessed 29 Feb 2016)
- 13 Proprietary Chinese medicine refers to any proprietary product composed solely of Chinese herbal medicines, or any materials of herbal, animal or mineral origin customarily used by the Chinese as active ingredients, formulated in a finished dose form and known or claimed to be used for diagnosis, treatment, prevention or alleviation of any disease or any symptom of a disease in human beings, or for the regulation of the functional stated of the human body (see Chinese Medicine Division, Department of Health, on <http://www.cmd.gov.hk/>, last accessed 29 Feb 2016).

Appendix*Classification of main manufacturing sectors according to the SSI index*

<i>Rank</i>	<i>2003</i>	<i>2005</i>	<i>2007</i>	<i>2009</i>	<i>2011</i>	<i>2013</i>
1	Computers and other elec. eq.	Raw chemical and chemical pr.	Raw chemical and chemical pr.	Raw chemical and chemical pr.	Raw chemical and chemical pr.	Raw chemical and chemical pr.
2	Raw chemical and chemical pr.	Computers and other elec. eq.	Computers and other elec. eq.	Computers and other elec. eq.	Computers and other elec. eq.	Computers and other elec. eq.
3	Non-metal mineral products	Non-metal mineral products	Non-metal mineral products	Non-metal mineral products	Electrical machin. and equip.	Non-metal mineral products
4	Electrical machin. and equip.	Electrical machin. and equip.	Electrical machin. and equip.	Electrical machin. and equip.	Non-metal mineral products	Electrical machin. and equip.
5	Tobacco products processing	Non-ferrous metal manuf.	Non-ferrous metal manuf.	Non-ferrous metal manuf.	Non-ferrous metal manuf.	Non-ferrous metal manuf.
6	Medical and pharmaceutical	Medical and pharmaceutical	Petroleum and coal products	Petroleum and coal products	Petroleum and coal products	Medical and pharmaceutical
7	Non-ferrous metal manuf.	Tobacco products processing	Tobacco products processing	Medical and pharmaceutical	Medical and pharmaceutical	Beverage production
8	Petroleum and coal products	Papermaking and paper pr.	Medical and pharmaceutical	Food production	Beverage production	Food production
9	Beverage production	Petroleum and coal products	Papermaking and paper pr.	Beverage production	Papermaking and paper pr.	Petroleum and coal products
10	Food production	Food production	Food production	Papermaking and paper pr.	Food production	Papermaking and paper pr.
11	Papermaking and paper pr.	Beverage production	Beverage production	Tobacco products processing	Wood products	Wood products
12	Printing and record medium	Wood products	Wood products	Wood products	Tobacco products processing	Tobacco products processing
13	Wood products	Printing and record medium	Printing and record medium	Printing and record medium	Printing and record medium	Furniture manufacturing
14	Chemical fibre	Chemical fibre	Chemical fibre	Furniture manufacturing	Furniture manufacturing	Chemical fibre
15	Furniture manufacturing	Furniture manufacturing	Furniture manufacturing	Chemical fibre	Chemical fibre	Printing and record medium

Source: Author's elaboration