Emerald International Journal of Emerging Markets

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Journal:	*International Journal of Emerging Markets*
Manuscript ID	IJoEM-02-2018-0105.R1
Manuscript Type:	Research Article
Keywords:	Policy-making, Selective Industrial Policy, Manufacturing, China, Uncertainty Analysis

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Abstract

Purpose
China's experience of industrial growth is noteworthy for several reasons, not least because it has made a massive use of selective industrial policies. The industrial development guidelines set by the Five-Year Plans are extensively based on the choice of "strategic" or "pillar" industries to be promoted and supported. What remains unclear is the way in which such industries are identified among many. This paper proposes a debate on how to improve the government choice of strategic sectors and suggests a methodology to make this choice more transparent and rigorous.

Methodology
The methodology allows ranking the different industries according to their strategic importance in the Chinese economy. We employ an uncertainty analysis methodology to verify the robustness of the ranking.

Findings
The results point to a list of strategic sectors for China. Comparing the ranking of the strategic sectors to the list of strategic priorities described in the Twelfth Five Year Plan, we find that, by and large, our ranking coincides with the list of strategic sectors of the Chinese government.

Social implications
We argue that improving the transparency and the rigor of the choice of pillar industries can be crucial for the Chinese government to maintain social legitimization in the transition to a "market" economy.

Originality
Very little is known about the choice of strategic sectors in China in the international literature. By addressing the debate on the choice of pillar industries in China, the paper discusses a topic scarcely studied offering an unique and original contribute.

Keywords: Policy-making, Selective Industrial Policy, Manufacturing, China, Uncertainty Analysis.
JEL classifications: L50, L60, O14, M00

1. Introduction

The debate over the inefficiencies and risks of selective industrial policies has influenced the agenda of policy actions in many ways and for a long time (Gainsborough et al., 2009; Altenburg, 2011). It surely has influenced the way governments describe their policy interventions. "Horizontal policies", "enabling technologies", "getting the fundamentals right" are all terms inherited from that debate. Yet, in practice countries all over the world make use of active industrial policies and *selective* or *vertical* incentives (Lall and Teubal, 1998). They might not call it selective industrial policy, but that is what it is *de facto* (Mazzucato, 2013; Di Tommaso, Schweitzer 2013; Weiss, 2014; Di Tommaso and Tassinari 2014; Tassinari, 2014).

In this scenario, while the reasons for "government failures" have been extensively studied, theoretical and empirical reasoning on the ways to correct such failures are uncommon. The vast majority of the economic literature had renounced searching for remedies to government failures and supported the view of a minimal state. The only way to correct government failures was non-intervention. When the crisis called for a new wave of interventionism, governments that *needed* to use, or simply *wanted* to use industrial policy, relied on old practices to select key and strategic sectors, winning firms and industries, priority regions and so forth. Little or no contribution came from the economic literature on *how* to deal with such choices. And, in absence of clear and rigorous analytical tool, such decision became often arbitrary, discretionary and guided by partial interests.

The aim of this paper is twofold. *First*, it wants to suggest a methodology to prioritize industrial sectors and to support the choice of strategic industries. Such methodology does not aim at finding the *optimal* ranking of strategic sectors for any country. It aims at defining a tool to make the choice of what is strategic transparent and rigorous by inducing governments to state explicitly their priorities and long-term goals. *Second*, we want to apply the methodology to the case of China. Like it or not, the second largest economy in the world *does* make use of selective industrial policies, in particular by choosing specific strategic sectors to be targeted by policy initiatives. This on its own should be of interest to any country that wishes to compete in the international market. However, little, if any, is known about the way such sectors are chosen by the national government. With this exercise we wish to give burst to that debate.

Moreover, opening the black-box of *how* the sectors are chosen (priorities, targets and etc.) can be vital for the Chinese government itself. The transition to a "market" economy is posing difficult challenges to the "ruling class" that needs to find new ways to legitimize its intervention (Di Tommaso et al., 2013).

We apply the proposed methodology to China's industrial sectors and we compare the ranking of strategic industries to the policy guidelines included in the 12th plan. We find a great deal of overlapping between the top strategic sectors identified with our methodology and the definition of key industries of the Chinese government. We then test the robustness of the ranking and discuss the implications.

The paper is structured as follows. Section 2 briefly reviews the literature on government failures and selective policy intervention. Particular attention is given to the concept of *strategic sectors*. Section 3 recalls the main features of industrial policy in China since the beginning of the transition process, with particular emphasis on the recent policy guidelines of the 12th Five Year Plan. Section 4 explains the methodology to rank the Chinese industrial sectors, including the *uncertainty analysis* to confirm the robustness of the ranking. Section 5 applies the methodology to the manufacturing sectors of the Chinese economy and comments on the results. Section 6 Concludes.

2. Strategic sectors and *Government failures.*

2.1 Strategic 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, 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 industrialized 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). Examples of these strategic goals are improvements in competiveness, 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 (Lall and Teubal, 1998; Chang et al., 2013). Thus, 'targeting' can be consider 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. This 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; Lin and Chang, 2009). 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 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).

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 reorganisation 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.

As shown by this literature review, the criteria for targeting particular industries could be numerous and controversial. And this is why we will argue that industrial policy should depend on the *transparent* definition of value-based societal goals.

2.2 Selective industrial policy and *government failures*: international debate and the case of China

In spite of the wide range of justifications for a strategic industrial policy, the common critique in this field has often been the one of considering government intervention as destined to failures (Wolf, 1989; Krueger, 1990; Le Grand, 1991; Chang, 1994; Lerner, 2009; Di Tommaso and Schweitzer, 2013; Schuck, 2014). A widespread literature has criticized the capacity of governments to intervene in the industry's dynamics. In some selected circumstances industrial policy can be considered crucial or legitimate, but in the end it has to be discouraged because government interventions are assumed to be inefficient and ineffective. The traditional *government failures* literature argument in this field points out that it is possible that the consequences of policy failures may be worse than the benefit of the intervention. Indeed, public institutions can fail to achieve their objectives for several reasons, or can divert them from true public interests to partial ones.

In particular, the specific case of *selective* industrial policies raises a risk of *government failures* particularly high regarding to the mechanism through which politics defines industrial policy goals, targets, and tools. The political arena is where various interests interact and contribute to the definition of general and specific policy goals. Different groups have different weight and capacity to express their demand for policy. Using Hirschman's powerful concepts, different social segments have different capacity to express their "voice" (Hirschman, 1970). These differences in influence interfere with the politically-driven activity of defining public interest goals. In this perspective industrial policy could fail because, in defining what societal goals are to be pursued, some partial interests might be too influential. In general governments tend to be too vulnerable to the pressure of "partial" interests and this is why industrial history (up to the present time) contains many examples of policies targeting specific industries, regions and companies where the linkages with wider societal goals have been vague and weak (Di Tommaso and Schweitzer 2013). This happens also because governments tend to be vulnerable to what well-organized special interests can offer. They might fail to define goals (and also fail to select targets and tools with adequate caution) because they see the opportunity of exchanging consensus (and political support) for their "special attention". Thus, industrial policy might fail because it is a very powerful instrument in the hand of politicians seeking to maximize the chances of winning the next election or maintaining power in other ways. In this scenario, the industrial policy debate, involving support and strategies for industries, regions and companies, become one of the most interesting fields of negotiation between politicians and groups of individuals with highly organized, narrow, economic interests, inducing a gradual shift from a "profit-seeking" society to a far less efficient 'rent-seeking' society (Buchanan J.,

Tollison R., Tullock G., 1980; Tollison R., 1982; Di Tommaso and Schweitzer, 2013). And the negotiation between "rent-suppliers" and "rent-demanders," the exchange between political consensus and policies in favour of specific industries, regions and companies may even further deteriorate encouraging practices of favouritism, nepotism and corruption.

Notwithstanding the differences in the political systems, China and western economies share the possible scenario of a government that fails to act in favour of the public interest, because captured by partial stances. Government failure is a potential threat in China, as it is anywhere else. According to the pessimist view the true threat to Chinese economy and society lies in the existence and pervasiveness of its government failures (Gong, 2014; Gillboy, Read 2008). Solving these could be a crucial part of maintaining the Chinese capitalism alive in the long run. Evidence suggest that government failure is a central issue in contemporary China.

First of all, lobbying exists in China, as it is documented by the specialized literature (Kennedy, 2009; Deng and Kennedy, 2010; Rugman *et al.*, 2014; Unger and Chan, 2015). Even though the Chinese political system is not governed by the electoral mechanism, it has been argued that other mechanisms, other than votes - and not necessarily involving corruption - can make governments responsive to outside influence (Kennedy, 2009). There are reasons for businesses to lobby the Chinese government and for the government to be willing to listen. In particular, the Chinese government needs information and commitment by businesses to make public policies effective and to achieve its long-term goals. Fast economic growth, as well as other goals such as a rapid shift to environment friendly productions or higher value added activities, cannot be achieved without the *collaboration* of firms. And in the end the ability of the Chinese government to maintain its legitimization, avoiding social unrest, rests on its capacity to achieve such goals.

Second, the government perceives government failures as a serious issue, and this is itself a sign that the threats of regulatory capture or widespread rent-seeking are concrete. The recent anti-corruption campaigns, both at the national and local level, show that the problem of extreme self-seeking bureaucrat is particularly widespread, as also suggested by some specialized literature (Dong and Torgler, 2013; Liu and Liu, 2017). Such campaigns also highlight another important aspect: the party is increasingly forced to build its legitimization on the "management of integrity" (Gong, 2014). Defeating extreme government failures becomes the ultimate challenge of the Chinese political system (Fan, 2006; Naughton, 2005; He, 2014).

In this scenario the focus on all the remedies that are directed to mitigate potential government failures is a crucial part of highly demanded (and opposed) industrial policy programs of the present and of the future. Therefore, theoretical and empirical reasoning must keep the pace with the interventionist practices. In other words, the debate on industrial policy has to include new rigorous discussions about possible remedies to government failures, in China as well as in other countries. Otherwise we are destined to see the same old failures of the past.

In particular, while a lot of discretional reasons might justify the favour of the government toward particular industries, we argue that the definition of the specific targets and goals has to rely on methodologies able to increase transparency, effectiveness and participation to the policy-making processes. In this perspective, this paper aims to propose a methodology to increase rigor and transparency in the identification of strategic sectors.

3. Selective Industrial Policy in China

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 liberalized 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*, where governments maintain an active role in pursuing strategic objectives (Yang and Stoltenberg, 2014; Lv and Spigarelli, 2016). In particular the *metavision* of the leadership is a crucial element to understand the control over specific state firms, the promotion of national champions and the focus on long term social and distributive goals. 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).

The strategic sector approach is dominant throughout the transition process. Since the 80s the Chinese government has always kept strict control on what was considered *strategic* in specific phases of the transition. When trade and investment were firstly and gradually liberalized, specific conditions were imposed to foreign investors, and investment in specific sectors was privileged (Di Tommaso et al., 2013). Other areas of the economy, such as capital flows, were maintained strictly under the control of the central government and did not experience any liberalization up to date. In a second phase, state-owned enterprises were reformed and "privatized". However, strict control was maintained on the majority of shares of those companies considered "strategic" (Rubini and Barbieri, 2013). Examples include for instance the automobile industry and the energy-related sectors where national state-owned champions were nurtured to be the leading actors of those sectors.

Policies specifically aimed at supporting the industrial development have always followed a strategic sector approach. This can be seen both in the definition of the policy objectives and in the specific tools used to promote industrial growth. Long-term policy goals are defined within the Five Year Plans, which have been the main programming tool of the Chinese governments since the 1950s. And even though they now aim at providing *guidelines*, rather than defining binding targets, five-year plans always give precise indications on the industries that are to be considered strategic. They are either defined as "pillar" industries or "key" industries, together with "strategic emerging sectors". 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, Tab 1.). 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 summarizes 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. The identification of these industries is often accompanied by indications on the actions to be taken, either in terms of production and growth targets or in terms of quality improvements to be promoted.

Next to the pillar industries the Plans normally identify a list of emerging sectors, that are normally connected with high-tech and high-value added productions.

Table 1. *Pillar Industries and Emerging strategic sectors. Five Year Plans (1996-2015)*

The guidelines of the Five Year Plans have been implemented through several policy tools. The first important one has been that of *experimenting* by means of Special Economic Zones. Throughout the transition process the national and provincial governments have been "experimenting" initial changes within bounded areas and then expanding the reforms if the results were satisfactory. Even nowadays Special Economic Zones are used as "laboratories" to observe new production mechanisms, while maintaining the ability to control and govern the change (Yao e Whalley, 2015). There are several types of economic zones in China, each one with its specific aim and each one promoting specific industries. Economic and Technology Development Zones are mainly directed at promoting growth in traditional strategic industries. High Tech Development Zones focus on the promotion of investment in high value added sectors. Export Processing Zones and Free Trade Zones are particularly aimed at promoting international trade. Most zones specifically identify encouraged industries (HKTDC, 2015, www.hktdc.org). Beyond special economic zones other tools have been used to promote industrial growth, with special attention to the sectoral component of industrial development. Among these tools is the promotion of specialized industrial clusters (Bellandi e Di Tommaso, 2005; Barbieri et al., 2009; Rubini et al, 2015), the use of public procurement policies (USCBS, 2011), the implementation of mega-prjects and the management of SOEs (Rubini and Barbieri, 2013) and etc.

There is little doubt that selective industrial policies, also by means of identification of strategic sectors, have been a pillar of the Chinese economic policy. However, very little is known about the processes that govern the choices made by the central (and local) governments. How does the Chinese government choose what is strategic? How are strategic sectors defined? Very little is known about the choice of strategic sectors in China in the international literature. A great deal of the Plans' content is formulated by the Development and Reform Commission (Ahrens, 2013) and there is no official document entering in the process of choosing what the strategic sectors are. Indubitably, the existing *western* literature is mainly focused on the mere description of the sectors as they appear in the plan.

Even in China little is known on the choice of sectors, although a recent debate is growing among Chinese scholars regarding the *pros* and *cons* of identifying strategic sectors at the national level. Some criticism is emerging on the failures of such choices. In particular there is an issue of sector convergence in policy support across the different Chinese provinces, that creates duplication and waste of resources, as well as excessive competition (Guo et al., 2013). There is an academic debate on how to make a better choice (Guo et al., 2013; Guo e Hiu, 2012). However, in our perception, this debate aims at substituting for the political decision of what is strategic, with algorithms able to find a "fit-for-all" solution.

In the methodology we propose in this paper, we stress that no "best solution" is to be found in the use of statistical tool. But rather that the statistical tool should force governments to define its objectives explicitly, to state clearly the relative importance placed on different aspects (e.g. employment, growth, productivity, environment etc.), and finally to test the robustness of the ranking of strategic sectors respect to opaque statistical manipulation.

4. Methodology.

The first part of our methodology we present in this paper is focused on the computation of composite indicators. Composite indicators (or summary indices) have been constructed first by sociologists with the aim at comparing social units like cities and nations with respect to multiple dimensions of social life. Composite indicators are very familiar in country performance comparison in globalization, competitiveness, education, health, human rights, ecological footprint, corruption, technology achievement, social cohesion and trust in public institutions (Fayers and Hand 2002, Arboretti *et al*. 2007, OECD 2008, Bonnini *et al.* 2009). Other fields where composite indicators have been successfully used are: quality assessment of industrial products, quality of work and customer satisfaction (Marozzi 2009).

The main intuition of this paper is to apply the notion of composite indicator to build a coherent methodology to define the strategic sectors of an economy. A rather general framework to compute composite indicators is reported in Marozzi (2014b). Here, we modify this framework to rank the J=28 Chinese

manufacturing industries on the base of X_1,.., X_K, K=5 variables that describe the strategic significance of the sectors.

The procedure to design the Strategic Sector Index is based on two steps:

1. normalisation
2. weighting and aggregation.

In the first step of the procedure, the variables are normalised. Let X_{jk} denote the value of X_k for sector j. X_{jk} is transformed into

$$\beta\left(X_{jk}\right)=\frac{X_{jk}-\min_j\left(X_{jk}, j=1,...,J\right)+1/J}{\max_j\left(X_{jk}, j=1,...,J\right)-\min_j\left(X_{jk}, j=1,...,J\right)+2/J},$$

corresponding to well-known linear scaling in the min-max range. Note that, to avoid $\beta(X_{jk})$ values equal to 0 or 1, which may cause computational inconsistencies in the aggregation step, correction factors $1/J$ and $2/J$ are added respectively to the numerator and denominator. Note that before performing the aggregation-weighting step, the variables should be normalized because they have different scales and dispersions.

In the second step of the procedure, the normalized data are weighted and aggregated to obtain the SSI value for sector j (j=1,...,J). In general, the SSI may be defined as

$${}_{dc}\delta\left(\beta\left(X_{jk}\right)_d w_k, k=1,...,K\right)={}_{dc}\psi_j,\ c=1,\ldots,C,\ d=1,\ldots,D$$

where δ_c denotes the aggregation rule and ${}_dw_k$ the weight assigned to the k-th sub-indicator according to a certain weighting scheme. In general, we may select the aggregation rule among C different rules, and the weighting scheme among D different schemes. In particular, we may consider the following four aggregation rules

- c=1, Additive rule

$${}_{d1}\delta\left(\beta\left(X_{jk}\right)_d w_k, k=1,...,K\right)=\sum_{k=1}^{K}\beta\left(X_{jk}\right)_d w_k={}_{d1}\psi_j;$$

- c=2, Fisher rule

$${}_{d2}\delta\left(\beta\left(X_{jk}\right)_d w_k, k=1,...,K\right)=-\sum_{k=1}^{K}\log\left(1-\beta\left(X_{jk}\right)\right)_d w_k={}_{d2}\psi_j;$$

- c=3, Logistic rule

$$ {}_{d3}\delta\left(\beta\left(X_{jk}\right)_d w_k, k=1,\ldots,K\right)=\sum_{k=1}^{K}\log\left(\frac{\beta\left(X_{jk}\right)}{1-\beta\left(X_{jk}\right)}\right)_d w_k={}_{d3}\psi_j\,; $$

- c=4, Liptak rule

$$ {}_{d4}\delta\left(\beta\left(X_{jk}\right)_d w_k, k=1,\ldots,K\right)=\sum_{k=1}^{K}\Phi^{-1}\left(\beta\left(X_{jk}\right)\right)_d w_k={}_{d4}\psi_j\,, $$

where Φ^{-1} denotes the quantile function of a standard normal distribution (see Arboretti *et al.*, 2007, and Bonnini *et al.*, 2009, for a deeper discussion on normalisation and aggregation functions).

The design of the SSI involves subjective decisions on which aggregation method and weighting scheme select. Each selection of (c,d) has its pros and cons, and leads to a different SSI and then potentially to a different ranking of sectors from the most to the least strategic one. As emphasized by the Organization for Economic Co-operation and Development (OECD, 2008) it is mandatory to assess the robustness of SSI ranking against its design. As suggested among others by Saisana *et al*. (2005), Marozzi (2014a), Luzzati and Gucciardi (2015), and Di Tommaso *et al.* (2017), this question is addressed by performing *uncertainty analysis*.

Uncertainty analysis is a Monte Carlo simulation-based procedure applied to the equations defining the composite indicator. The sources of uncertainty in the SSI are:

- aggregation;
- weighting.

Uncertainty analysis aims at testing whether the ranking of manufacturing sectors according to their different ability to promote the economic growth is robust or volatile with respect to the design of the index. More precisely, the aggregation source of uncertainty is modelled by scalar input factor U_1 and the weighting source of uncertainty is modelled by vectorial input factor U_2. According to general practice, uniform distributions are assigned to the input factors (Saisana *et al*. 2005). These distributions are sampled, ie aggregation and weighting are varied simultaneously to assess their effects on the SSI.

Let ε denote a continuous random variable uniformly distributed in the [0,1] interval. For input factor U_1 the general disposal rule is

$$ U_1=\begin{cases}1 & \text{ie select } {}_1\delta \text{ if } \varepsilon\in[0,1/4)\\ 2 & \text{ie select } {}_2\delta \text{ if } \varepsilon\in[1/4,1/2)\\ 3 & \text{ie select } {}_3\delta \text{ if } \varepsilon\in[1/2,3/4)\\ 4 & \text{ie select } {}_4\delta \text{ if } \varepsilon\in[3/4,1]\end{cases} $$

Input factor $U_2=(U_{21},...,U_{2K})$ is the vector of raw weights. We assign to each raw weight a continuous uniform distribution in the interval $[p,q]$ with $0<p<q$. Therefore the normalised weights $U'_k = U_{2k} \Big/ \sum_{k=1}^{K} U_{2k}$ are such that $U'_k \in \left(\frac{p}{p+(K-1)q}, \frac{q}{q+(K-1)p} \right)$. Marozzi (2014b) suggested to select p and q so that

$$\max\left(\frac{U'_{2\max}}{U'_{2\min}} \right) \leq \omega ,$$

with $\omega>1$, where for example $\omega=3$ (the value used in the next Section) means that the maximum theoretical normalised weight cannot exceed three times the minimum theoretical normalised weight. The raw weights are then rescaled as

$$w_k = \frac{U_{2k}}{\sum_{k=1}^{K} U_{2k}}, k = 1,..., K$$

so that the usual restrictions on weights apply: $w_k \geq 0$, $\forall k=1,...,K$ and $\sum_{k=1}^{K} w_k = 1$.
The rationale for assigning different weights to the variables is to reflect different importance as well as different perceptions of policy makers towards them.
The uncertainty input space is sampled L times, ie L combinations of the two sources of uncertainty are generated. Each combination corresponds to a different SSI: ${}_l\psi=({}_l\psi_j, j=1,\ldots,J)$ and then to a different ranking of the J sectors. Let ${}_lR=({}_lR_j, j=1,...,J)$ be the rank vector. Considering all L combinations of input factors we obtain for sector j a vector of L ranks ${}_jR=({}_lR_j, l=1,...,L)$, $j=1,\ldots,J$ which is an estimate of the uncertainty distribution of the rank of sector j. The median of ${}_jR$ is a summary measure of sector j rank uncertainty distribution and the interval defined by the 5th and 95th percentiles of the rank distribution reflects the robustness of it with respect to the design of the composite indicator. A wide uncertainty interval for sector j means that its ranking is volatile because it markedly depends on the selection of a particular aggregation method and a particular set of weights. Conversely, a narrow interval means that sector j ranking is robust because it slightly depends on the particular design of the SSI.

5. Application to Chinese industry

The strategic importance of a sector is a complex phenomenon to measure, since it depends on several aspects. By applying the methodology described in the previous section, we construct a composite indicator - the Strategic Sector Index (SSI) - able to order the sectors according to their degree of strategic importance.

As previously noted, there are several criteria that can potentially justify the promotion of particular industries. Therefore a clear specification of the policy priorities is necessary in order to assess the strategic importance of the sectors.
In this application we assume that the Chinese "economic growth" is the main policy objective that the government wants to achieve. We do so because promoting economic growth has been a constant commitment of Chinese governments since the open-door policy. It is true that in the 11th and 12th Year plan in particular, the government has declared other strategic objectives (among which indigenous innovation, environmental sustainability and reduction of income disparities), in addition to economic growth (Yip and McKern, 2014; Guo *et al.*, 2016). However, these new objectives are not to be achieved at the costs of a lower income growth: promoting sustained economic growth remains at the centre of the policy action. The recent lowering of target growth rates has to be considered an inevitable consequence of the economic crisis, rather than evidence that fast economic growth is no longer a priority in the policy agenda. Given this specific goal, we focus our analysis on *manufacturing* industries, because of the special role that they play in the dynamics of economic growth.[1]

The Strategic Sector Index (SSI) is used for studying the Chinese manufacturing system with particular regard to the years of the international crisis. The data, provided by China Statistical Yearbook 2012 and 2008, are related to 28 manufacturing industries.
The five variables used to construct the index - which are in the end the criteria we use to define a *strategic industry* – capture both the relevance of the sectors in static terms and the sector performance in a dynamic perspective. It is important to stress here that, when we conclude that a specific sector is "strategic" we are not claiming that it should be supported nor we identify specific tools to support it. We just highlight that, given its weight in the economy and its growth performances, it likely deserves particular attention by the government.

The variables that compose the SSI are:

1. *Employment (%) (2011)*: measured as the sector's employment as a percentage of the total employment. The higher the capacity of a sector to generate jobs, the more strategic that industry, not merely from an economic point of view, but also from a social and political perspective;

2. *Output Growth (2007 - 2011)*: measured as the growth of the sector's industrial output from 2007 to 2011. It aims at capturing how the sector has evolved during the crisis.

[1] In fact, according to several authors manufacturing plays a central role in the dynamics of growth thanks to features such as high labour productivity, economies of scale, positive externalities, frequent technological change, and innovation (see, for example, Tregenna, 2009, 2014; Chang *et al.*, 2013).

3. *Fixed assets Growth (2007 - 2011)*: measured as the growth in the value of a sector's fixed assets from 2007 to 2011. It aims at measuring the capital intensity and the propensity of private businesses to invest in the sector.

4. *Total profits Growth (2007 - 2011)*: the sector's growth of profits wants to approximate the ability to attract new entrants in the future and generate new investment.

5. *Value added tax payable Growth (2007- 2011)*: the sector's growth in value added from 2007 to 2011 approximates the presence of high technologies and knowledge content in the production processes. Together with profits it captures the ability of a sector to generate income in the years of the economic crisis.

Summarizing, according to these variables strategic sectors are those with a remarkable and growing weight in the manufacturing system in terms of employment, with growing industrial output, capital intensity, profits, and value added.
Before building the index we have calculated the Pearson correlation coefficient between all the different possible pairs of variables, in order to assess the degree of correlation. When building composite indicators it is important that the variables display a positive correlation, a negative correlation between the variables would in fact imply that there are trade-offs between the criteria that we have defined. As shown by the Pearson coefficient matrix below, the chosen variables are all positively correlated.

Table 2. *Pearson coefficient between the SSI variables*.

After normalization of the five variables, in order to assess the robustness of the SSI ranking, we perform the uncertainty analysis presented in the previous section. The following graph summarises the result of the uncertainty analysis computed, considering L=20000 different combinations of input factors – combination functions and variable weighting schemes – in the composite indicator equation.

Figure 1. *Result of the uncertainty analysis for the SSI*.

The graph shows the ranking of strategic industries according to the SSI for Chinese manufacturing (where sector 1 is the best and sector 28 the worst for strategic importance).

By applying the uncertainty analysis, for each sector we obtain a distribution of values of the SSI that are transformed in the corresponding ranks. Therefore the position of each sector is not given by a single value but by a distribution of values corresponding to a large number of different combinations of inputs in the index equation. This is graphically represented by an uncertainty interval (bands) for each rank (position). In particular, the ranking is built on the basis of the median rank for each sector, which is represented in the graph by the dot, whereas the band goes from the 5th to the 95th percentile of the rank uncertainty distribution. The median can be considered reasonably independent with respect to the computing assumptions of the index (see Section 4). The wider the band, the higher the influence of index computing choices (i.e. selection of combining function and of the weights assigned to the variables) on the ranking. In other words, the wider the bands, the less sure the result of the ranking for that specific sectors: by changing weights to the single variables or by changing the combining function, the position of the sector in the ordering of strategic sectors can vary significantly.

When this is the case, the discretional power of the policy maker and the possibility of manipulating the ranking are higher. In practice, by giving more importance to profits or to employment, or by changing the way the different criteria are put together the policy maker could easily *push up* in the rank the sectors he or she *cares* about. While this is not necessarily a bad thing – it might be legitimate for a government to give more importance, for instance, to value added or employment and to act accordingly - it can give space to government failures when the policy priorities are not set and communicated in a transparent way to the public.

The SSI and the uncertainty analysis provide a powerful tool to both *inform* the government and to *watch* the government. When bands are very narrow it means that a sector unambiguously contributes – much or little, depending on its position - to *all* the priorities specified in the indicator. On the other hand, when bands are very large, the contribution is more ambiguous.

In the specific case of China, the uncertainty analysis shows that the SSI based ranking of industries is sufficiently robust. In fact, the bands tend to be generally narrow (with some exceptions). As it can be noted, industries near to the head and to the tail of the ranking have generally shorter bands, and results tend to be more robust for these sectors. In certain cases the median is located at the extremity of the band because its value coincides with the maximum or minimum of the range, this is another indication of the robustness of the median ranking.

At a general level, the analysis shows a different capacity of economic sectors to promote the growth of the Chinese economy, providing a ranking of strategic industries.

In the top ten positions we find: transport equipments, chemicals, computers and electronics, smelting and processing of ferrous metals, non-metallic mineral

products, machinery (general and special purpose and electric), textiles. The only sectors with relatively large bands is smelting and processing of ferrous metals, whose band however remain always within the first ten positions. The other top ten sectors show a very robust positioning. It is interesting to note that, with the only exception of chemicals, all of the top ten sectors of our ranking are included in the list of the key industries of the Chinese government in the 12th Year Plan[2]. This result is coherent with our assumption that strategic sectors in China are being defined by their ability to generate economic growth. However, further research is needed to verify also how well this ranking would fit different and more recent policy objectives (for example environmental sustainability). In the list of key industries identified by the Chinese government petrochemicals has always been present, since 1996. Our ranking suggests that its contribution is not so clear-cut. It enters the first 10 positions only in some simulations, according to the specific weight and combining function used to compute the index.

6. Discussion and Conclusion

In China as well as in many other countries the choice of strategic sectors does not seem supported by a transparent debate on what defines how strategic an industry is. By and large the choice of strategic sectors seems to be taken for granted: some sectors are simply *assumed* to be strategic. But the specific political priorities that respond to a country's definition of strategic sectors are not openly debated and too often there is no scientific validation of the relationship between specific political priorities and the definition of strategic sectors. Nor do we see any attempt to test the robustness of the choices that identify the list of a country's strategic sectors.

Before the financial crisis, the economic literature had largely abandoned the debate over strategic sectors, in the belief that horizontal policies could be more effective than sectoral ones. However, in recent time a new interest has emerged over the definition of strategic sectors. This interest goes hand in hand with the *renaissance* of industrial policy called by the economic crisis.

In the present paper we offer a methodology to support the choice of strategic sectors. The methodology has two main advantages. First, it is built on the construction of a simple composite indicator (SSI) that includes the variables defining the political priorities that a country wishes to promote when choosing its strategic sectors. In this sense, the methodology can be used by governments as an easy way to communicate to the public their strategic priorities (e.g. employment, investment, value added, environment and so forth). Moreover, by applying such methodology governments are *forced* to clarify - to themselves and to the public - the relative importance they apply to each political priority. Second, the methodology employs an *uncertainty analysis* to verify the robustness of the ranking of strategic sectors. This aspect is crucial. The uncertainty analysis allows distinguishing the sectors that undoubtedly contribute to *all* the strategic priorities

[2] Equipment manufacturing, automotive, shipbuilding are classified as transport equipment by the NBS (2014), packaging is classified as special purpose machinery.

- irrespectively of the relative weights assigned and the specific combining function used to calculate the SSI - from those whose contribution is more partial or ambiguous. In this latter case the discretion of government to push specific sectors is higher and potentially more vulnerable to government failures. By verifying the ranking of strategic sectors, the government, as well as the public, are better informed on the choice of strategic sectors. Moreover, by communicating the robustness of its choice, by increasing the transparency in this sense, the government is less vulnerable to potential capture by partial stances not representing the public interest.

In this work, the uncertainty analysis has been applied to a case-study deliberately circumscribed and simplified. No need to recall here the reasons that make China more than just one case-study. Studying China is vital to understand the international contemporary manufacturing (Di Tommaso et al., 2013).

In our exercise, we have narrowed the range of the possible policy priorities to promotion of economic growth and we have applied the methodology to the manufacturing sector. Of course we are conscious that there are many other political priorities that could be analysed beyond economic growth, and to which the identified pillar industries might *de facto* contribute. This is left for future research, what here we want to stress is the need to discuss and develop tools able to enter the complex process of choice of strategic sectors. By making the linkage between declared social goals and choice of strategic sectors more transparent, we believe we can offer support to effective industrial policies, in China and elsewhere. From this point of view, one of the main strengths of the analysis is the clear evaluation of the robustness of the ranking obtained from our composite indicator, and, consequently, the possibility for policy-makers to discretionally condition the result. Our results suggest for China that the ranking of strategic sectors is sufficiently robust and overlaps by and large the choice of strategic sectors of the 12th Year Plan. In other words, the definition of pillar industries of the Chinese government appears coherent with the priority goal of promoting economic growth. Further research, as said, could be done with the same methodology to test the ranking and its robustness against different political priorities.

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Table 1. Pillar Industries and Emerging strategic sectors. Five Year Plans (1996-2015)

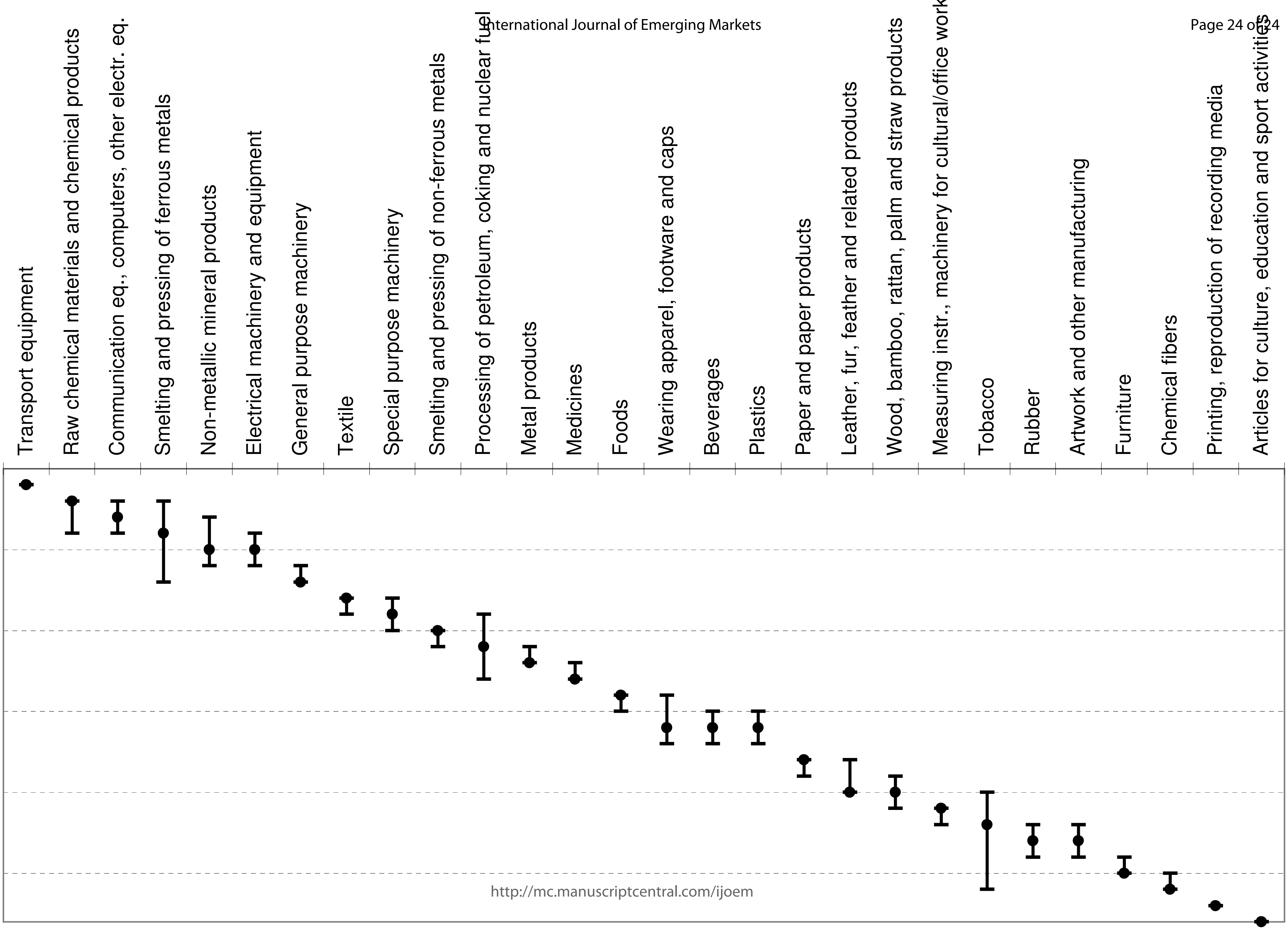
Settori/Piani Quinquennali	IX (96-00)	X (01-05)	XI (06-10)	XII (11-15)
Food				
Drinks				
Tobacco				
Textiles	**P**	**P**	**P**	
Wearing Apparels				
Leather				
Wood				
Furnitures				
Paper making				
Printing				
Sports and culture products				
Petroleum, coke and nuclear f.	**P**		**P**	**P**
Petro-chemicals	**P**		**P**	**P**
Nuclear fuels	E			
Chemicals			P	
Medicines and Pharmaceuticals				
Biotech	E	E	E	E
Traditional Chinese Medicine			E	E
Rubber				
Plastics				
Non mineral metals	**P**	**P**	**P**	**P**
Smelting of ferrous materials			P	P
Metal products				
General purpose machinery	**P**			
Special purpose machinery		**P**	**P**	**P**
Packaging				P
Meccatronics		P		
Transport veichles and equip.	P	P		
Automobiles	**P**	**P**	**P**	**P**
Ecological vehicles				E
Aerospace	E		E	
Shipbuilding			P	P
Electric equipment				
Computer and electronics	**P**	**P**	**P**	**P**
Boradband, digital devices, satellites		E	E	E
Optoelectronics		E		
Measurmnet instruments				
Other manufacturing industries				

Source: our elaboration on National Five Year Plans

Table 2. *Pearson coefficient between the SSI variables*.

Pearson coefficient between variables	Employed persons/Total national employed persons (%) (2011)	Gross industrial output Growth (2007 - 2011)	Fixed assets Growth (2007 - 2011)	Total profits Growth (2007 - 2011)	Value added tax payable Growth (2007-2011)
Employed persons/Total national employed persons (%) (2011)	1,0000	0,7566	0,6544	0,7389	0,7471
Gross industrial output Growth (2007 - 2011)	0,7566	1,0000	0,9620	0,7897	0,8203
Fixed assets Growth (2007 - 2011)	0,6544	0,9620	1,0000	0,6524	0,6786
Total profits Growth (2007 - 2011)	0,7389	0,7897	0,6524	1,0000	0,8689
Value added tax payable Growth (2007- 2011)	0,7471	0,8203	0,6786	0,8689	1,0000

Source: authors' elaboration


Transport equipment
Raw chemical materials and chemical products
Communication eq., computers, other electr. eq.
Smelting and pressing of ferrous metals
Non-metallic mineral products
Electrical machinery and equipment
General purpose machinery
Textile
Special purpose machinery
Smelting and pressing of non-ferrous metals
Processing of petroleum, coking and nuclear fuel
Metal products
Medicines
Foods
Wearing apparel, footware and caps
Beverages
Plastics
Paper and paper products
Leather, fur, feather and related products
Wood, bamboo, rattan, palm and straw products
Measuring instr., machinery for cultural/office work
Tobacco
Rubber
Artwork and other manufacturing
Furniture
Chemical fibers
Printing, reproduction of recording media
Articles for culture, education and sport activities
0
5
10
15
20
25