Industrial Policy and Manufacturing Targeting in the US: New Methodological Tools for Strategic Policy-Making *

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Abstract

The economic crisis has pushed several countries to adopt selective industrial policies to promote manufacturing and some selected strategic sectors. Despite this new activism, the process of defining strategic targets risks being carried out with poor rigour on a political level, setting governments up for failure. This paper discusses the notion of *strategic sector* and proposes a new methodology to increase transparency and effectiveness in the identification of what can be defined as 'strategic.' Focusing on the analysis of the US manufacturing system, we develop a composite indicator – the Strategic Sector Index (SSI) – to rank manufacturing industries on the basis of their strategic significance. Furthermore, we apply an *uncertainty analysis* methodology to the SSI to evaluate the robustness of the ranking and to minimize the degree of policy-makers' discretionality in influencing the results.

Keywords: Policy-making, Industrial policy, Industry, Manufacturing, United States, Uncertainty analysis.
JEL classifications: L50, L60, O14.

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1. Introduction

Industrial policy has always been a contentious issue in the academic and policy-making debate[1]. Economic theory has traditionally emphasized the role played by markets in guiding industrial development and structural adjustment. Moreover, many scholars have

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[1] The debate about Industrial Policy has a long history and it refers to variety of definitions (Gerosky, 1989; Warwick 2013). The most literal and simple interpretation includes any policy that affects industry (Chang et al, 2013). For more sophisticated definitions, see: Warwick (2013), Chang *et al.* (2013), Di Tommaso and Schweitzer (2013); Cimoli *et al.* (2009), Sawyer (1981, 2000), Chang (1994), Geroski (1989, 1990).

continued to highlight how government interference in markets risks to be destined to failures. Today these positions continue to be powerful both in academic and policy maker circuits but it also true that we assist to some rethinking of the role of industrial policy and that many governments are clearly promoting actions targeting their national industries (Aghion *et al.* 2011; Cowling and Tomlinson 2011; Wade 2012). Two are the main reasons of what has been referred as industrial policy *rejuvenation* (Stiglitz and Lin 2013; Salazar-Xirinachs *et al.* 2014; Altenburg and Lütkenhorst, 2015) or *renaissance* (Mazzucato *et al.* 2015; European Commission 2014). First, there is an urgent need to find effective solutions to the dramatic economic and social problems caused by the prolonged international crisis. Second, there is the necessity to face some of the main challenges connected to globalisation: the value chain internationalisation process and its impact on domestic industries, the concerns associated with the process of manufacturing migration toward the *South* and the anxieties related to the rise of new emerging industrial powers, to mention only the most debated issues (Tregenna 2009, 2014; Bianchi and Labory 2011; Chang *et al.* 2013; Andreoni and Scazzieri 2014; Di Tommaso *et al.* 2013).

Moreover, after several decades in which policies were implemented mainly at a horizontal level, a new *selective* interventionist approach has gradually gained new unexpected popularity (Aiginger and Sieber 2006; Aghion *et al.* 2011; Birdsalland and Fukuyama 2011; Lin 2012). Both in Europe and in the US many politicians, observers and academics are today supporting the need to define industrial policy strategies targeting particular industries (but also networks or technologies) with the aim of promoting a wide spectrum of economic and societal goals (Bianchi and Labory 2011; Cowling and Tomlinson 2011; Lin 2012; Mazzucato 2013; Stiglitz and Lin 2013; Di Tommaso and Schweitzer 2013). In President Obama's words, our times require 'strategic decisions about strategic industries' (*The Economist* 2010).

However, this new wave of selective interventions has at the same time raised an old problem: how can strategic industries be properly identified? This question reopens an old debate on the existence of *strategic industries* (OECD 1991) as national sectors whose growth and competiveness is considered strategic for economic or societal reasons.

In fact, the correct identification of strategic targets depends on the democratic definition of specific political goals, and on the ability of the administration to pick the potential 'winners' with regards to these goals. However, in spite of the complexity of these processes, policy-makers often seem to select industrial policy targets in a discretionary way, without reliance on clear theoretical criteria capable of motivating their choices, or - perhaps even worse - led by short-run interests and rent-seeker pressures. In these cases, policy intervention runs the risk of being extremely ineffective and inefficient, calling for a substantial reduction of the public role in economic dynamics (Krueger 1990; Chang 1994; Lerner 2009; Di Tommaso and Schweitzer 2013; Schuck 2014).

In this context, *government failures* literature is the most popular theoretical justification for the exclusion of industrial policy (IP) from the political agenda. In particular, it has been widely suggested that the risk that selective industrial policy responds to particular interests, and not to more general public societal interest, is extremely high. Different industries tend to have different 'voices' in discussing with government counterparts. In other words, sectors might have different lobbying capacities and capabilities in demanding policy interventions and this is the source of potential severe *failures*. In addition, beyond the real 'intention' of the government to pursue the

general interest, this kind of selective intervention risks failing simply because of a lack of information on the targets.[2]

Which industries will be able to respond to the national interest in the future is a crucial industrial policy question that often discourages the use of this kind of intervention beyond its real potential.[3] As pointed out by Monga (2012): 'Many economists who agree with the general notion that the government intervention is an indispensable ingredient of structural transformation have maintained their opposition to industrial policy because of the lack of a general framework that can be used to guide policy-making' (Monga 2012, 160). Thus, a more efficient and effective industrial policy needs to look for new methodologies that can be used to identify the targets of its strategies.

The main aim of this work is to propose a methodology that increases rigour and effectiveness in the selection of strategic industries, promoting a more transparent process of decision-making. We build on the idea of clearly identifying a policy priority and of fixing some of the criteria that are useful in supporting the identification of strategic industries given the selected goal.[4] In particular, we propose a composite indicator – the Strategic Sector Index (SSI) – which ranks manufacturing industries on the basis of their different abilities to promote long-run economic growth, identifying sectors with the best strategic potential. However, at a methodological level, the limits of composite indicators are related to the discretionality in choosing the formula and specifically in choosing the combining function and weights of the selected variables (see, for example, Saisana *et al.* [2005]; Luzzati and Gucciardi [2015]). In this work we therefore apply an *uncertainty analysis* methodology to the SSI in order to mitigate this kind of problem. In particular, this methodology is utilised to evaluate the policy-makers' discretionality and the robustness of the SSI ranking. We must specify that here the main focus of the analysis is about potential strategic *targets*, not the *tools* that the government should put into effect. From this perspective, some sectors could be considered strategic, even though the kind of public intervention they may require is not considered.

The remainder of the paper is set out as follows: the next section provides a discussion on industrial policy in the US: the distinctiveness of the American case and the most recent debate stimulated by the Crisis. In Section 3 we focus on selective industrial policies and the debate on *strategic sector*. Section 4 describes the *uncertainty analysis* methodology that we are going to utilize in the empirical analysis. In Section 5 we build the SSI and we apply the *uncertainty analysis* methodology to American manufacturing, in order to identify those industries that can be considered strategic for future economic growth in the US. Section 6 concludes.

2. Industrial Policy in the US

[2] On these topics see, e.g., Schultz (1983), Krueger (1990), Le Grand (1991), Chang (1994, 2011), Buigues and Sekkat (2009), Lerner (2009), Di Tommaso and Schweitzer (2013), Schuck (2014).

[3] See for example the interesting *debate between Justin Lin and Ha-Joon Chang* (Lin and Chang 2009).

[4] We are not assuming that just one political goal is enough to motivate each policy intervention and the strategic significance of each policy target. In fact, policy objectives could be different in space and time: for example, economic growth, employment, environmental protection and merit goods diffusion could all be reasonable political goals, and are sometimes even in conflict with each other, calling for a political definition of priorities. Thus, given the complexity of the democratic process, in this work we support the idea that policy goals should not taken for granted, but clearly explained. Indeed, a rigorous specification of the pursued goals, and of the criteria for selecting certain targets, could be extremely promising for policy-making effectiveness, because of an increase in *transparency* (see, for example, Bird, 2005).

2.1 The Peculiarities of the American Case

Any analysis focused on industrial policy in the US needs to highlight some specific factors that characterise the America context.

First, specific sociocultural aspects and the distinctive national psychology [5] have to be mentioned. As stated by Etzioni '[...] The American antipathy for government, and the corresponding belief in individualism, competition, and the marketplace, go back to the days of the founding.' (Etzioni, 1983, p. 47). In many periods of American history, this socio-cultural attitude has been strongly hostile to industrial policy interventions (Graham, 1992; Stiglitz and Lin, 2013; Di Tommaso and Schweitzer, 2013; Wade, 2014). Today the landscape remains largely unchanged: the influence of anti-government positions seems to be as profound as in the past and the resistance to industrial policy is still strong in the American public debate. There is no doubt that this national character has its effects on and makes implementation of industrial policies more difficult than in other countries (advanced capitalist economies or new emerging industrial powers) with established interventionist traditions (Wade 2014, Hall and Soskice, 2001).

Second, it is necessary to refer to the specific characteristics of the American politico-institutional system. As Wade recalls in his discussions about the peculiarities of US industrial policy, the institutional system is characterised by two fundamental features: (a) strong separation of powers between the executive, legislature, and judiciary; and (b) strong separation of powers between the federal, state, and local levels (Wade, 2014). Under these conditions industrial policy suffers some important problems of consistency and coordination (Mann, 1997; Ketels, 2007; Hall and Soskice, 2001). In this context, particularly important is the relationship between the president and Congress. At the federal level the president may establish a political agenda by identifying specific problems and he/she has a good chance of implementing policies only in a few areas deemed of high priority, investing the presidency with political capital. On the other hand, Congress is responsible for ensuring that the general actions of the administration meet the specific interests of voters, defining all of the remaining interventions on industry. This generates a set of uncoordinated differing interventions: a few key policies promoted by the president and many other small actions, favouring local industries and actors, decided upon by Congress (Ketels, 2007). [6]

Speaking more generally, the American political system is characterised by frequent elections (for the presidency, congressional seats, and at the state level) and long political campaigns that have the inevitable effect of shortening the horizon of all government policies. In this context, the American media leads to further constriction and an even shorter perspective for policy-makers because of the need to follow public opinion in the very short-run, reacting to polls, television programs, newspapers, social networks, blogs, etcetera. This is quite a difficult scenario for industrial policies with

[5] On the notion of national psychology see: Inkeles (1997). On the American case, see Low (2005); Rourke (2008).

[6] This risk of inconsistency is partially mitigated by other IP programs aimed at overcoming network failures and creating networks among the agents of the economic system (firms, scientists, engineers, and venture capitalists). Programs such as, for example, Manufacturing Extension Partnerships (MEPs) or Small Business Innovation Research (SBIR) foster cooperation and exchange of information among economic agents and, consequently, the diffusion of the benefits of different policies (Wade, 2012; Block, 2008; Schrank and Whitford, 2009).

ambitious and strategic goals: the need for short-run political consensus makes the implementation of any long-run intervention very difficult, if not impossible (Majone, 2003; Garrì, 2010; Marsh and McConnell, 2010; Evans, 2012).

Last, but not least, it is important to focus on the relationship between the American domestic industry and the globalised networks of production. The United States today is still a central part of the contemporary global value chain and its industry is strongly embedded in international nets of co-producers located all around the world. In this context, there is a great concern about the process of migration of American manufacturing that in the last decades has gradually taken many plants abroad (ERP 2014; Harrison and McMillan, 2011; Houseman et at, 2011; Baily and Bosworth, 2014). Not only is there concern about the transfer of standardised productions to low-wage countries that has characterised the past, but many observers are also alarmed by the possibility that more high value-added activities will follow similar trends. With this perspective in mind, industrial policy interventions that may decide to select some sectors and invest in them have to be evaluated (ex-ante and ex-post) according to their real impact on American soil (Reich, 1992; Dunning, 1994; Pack and Saggi, 2006) and with respect to their effects on American-owned companies.

2.2 The Present of Industrial Policy in the US

In the above described context, as in many other countries, the outbreak of the Crisis has rapidly pushed the American administration to react and promote urgent policy interventions. Since 2008, the American government has adopted a rather interventionist and selective approach in response to the problems of the Crisis (Wade 2012; Di Tommaso and Schweitzer 2013; Mazzucato 2013; Weiss 2014).[7] The first important act introduced by the Obama administration was the *American Recovery and Reinvestment Act* of 2009 (ARRA), a stimulus package worth $780 billion. The law allocated approximately one third of the total budget in direct government investment and tax credits for supporting and promoting selected sectors, such as energy and green industries, the automotive industry, nanotechnologies, broadband, the health industry, and the financial sector (ERP 2010).[8]

'Clean energy,' for example, was one of the most important fields of intervention, and it received approximately $90 billion. For renewable energy production (solar, wind, and geothermal), the investment was $23 billion. In the transport sector, including plug-in hybrid vehicles, electric vehicles and related infrastructures, the Obama administration has committed to invest $16 billion. With regard to the construction of a modern electric grid, which would give users the ability to schedule their use of electricity, the investment was $4 billion. Among other notable investments were $400 million for the establishment

[7] American industrial policy, although often 'hidden' by liberal rhetoric, seems to have a tradition that dates back to the time of Alexander Hamilton ([1791] 2001) and continues to the present day, with strong historical evidence. See Reich (1982), Eisinger (1990), Graham (1992), Dobbin (1994), Bingham and Sharpe (1998), Bailey and Cowling (2006), Chang (2007), Ketels (2007), Block (2008), Buigues and Sekkat (2009), Schrank and Whitford (2009), Block and Keller (2011), Wade (2012), Chang *et al.* (2013), Di Tommaso and Schweitzer (2013), Di Tommaso and Tassinari (2014), Mazzucato (2013), Tassinari (2014), Weiss (2014).

[8] The idea of a strategic approach to industrial development is clearly stated by President Obama: 'What we need is not a three-month plan, or even a three-year plan; we need a long-term American strategy, based on steady, persistent effort, to reverse the forces that have conspired against the middle class for decades. That has to be our project.' (Obama 2013).

of the *Advanced Research Projects Agency-Energy* (ARPA-E), an agency which invests in research for advanced energy technologies (ERP 2010; Di Tommaso and Schweitzer 2013).

For investment related to broadband diffusion, the ARRA allocated approximately $7 billion. In 2008, under the Bush administration, the *Troubled Asset Relief Program* (TARP) provided funds to bail out the American auto industry, and later the Obama administration continued these interventions. In order to save two big American automobile manufacturers from collapse, General Motors and Chrysler, $17.4 billion was provided by the government. Clearly the financial sector was also bailed-out. The government initially gave the United States Treasury authority to purchase $700 billion in mortgage-backed securities, and later the Financial Stability Plan of 2009 allocated $2 trillion to buy mortgages from the banks in order to assure supplemental liquidity in the banking system.[9]

In this context, one of the most important goals pursued by the US administration has been long-run growth and competiveness of advanced manufacturing, both fostering the development of American businesses and attracting industrial activities from abroad through 'go-back-to-manufacturing' policies (ERP 2014) in order to reverse the process of firm migration overseas. For example, in his State of the Union address in January 2014, President Obama stated: 'We know where to start: the best measure of opportunity is access to a good job. With the economy picking up speed, companies say they intend to hire more people this year. And over half of big manufacturers say they're thinking of in sourcing jobs from abroad. So let's make that decision easier for more companies' (Obama 2014).

As part of the *Make It In America* initiative, a *national manufacturing strategy* has been clearly defined and implemented (OSTP 2012; OSTP 2014).[10] This strategy aims to promote public-private partnerships, coordinating federal agency activities for accelerating and increasing investment in advanced manufacturing technology, especially by small and medium-sized enterprises. The federal programme also plans to expand public procurement in order to foster innovation in advanced manufacturing.[11]

Other areas where the US government's interest has been focused are the promotion of American exports, training of the workforce, and specific policies to bring manufacturing activities back from overseas. In this last field, the US Department of Commerce's *SelectUSA* programme, launched in 2011, provides additional incentives to encourage Foreign Direct Investment (FDI) in the United States (ERP 2014), by establishing a coordinated process to connect potential investors with senior American officials (Jackson 2013).

3. The Notion of S*trategic Sector*: A Tricky Debate

In the contemporary debate, strongly influenced by the Crisis and by the anxieties associated with the effects of globalisation and the rise of new industrial powers (Amsden, 2001; Di Tommaso et al., 2013; Warwick, 2013), there is growing discussion about strategic sectors. In particular, much of the work and of the discussion focuses on what

[9] For further details on these interventions see for example Di Tommaso and Schweitzer (2013).
[10] For details see, e.g., http://www.democraticwhip.gov/makeitinamerica (last accessed October 2014).
[11] For several examples of current Federal investments in advanced manufacturing R&D see OSTP (2012, Appendix F).

are supposed to be the industrial requisites to boost strategic sectors and on how it would be possible to finance them.

In terms of industrial requisites there is a wide literature on the role that infrastructure plays in the development of strategic sectors. Here it is interesting to mention the work on sector-specific physical industrial infrastructure that has always been at the centre of the literature on industrial development, as well as the crucial importance of other requisites including social, relational, and reputational capital which are important factors that explain why companies belonging to different sectors or territories may react to industrial policies in different ways (Petrick et al., 1999; Helliwell, 2001). From this perspective, there is no doubt that the presence of relevant actors (universities, labs, research centres, local intermediate institutions) in specific industries or territories is a crucial element that has appropriately attracted the interest of many observers working on industrial policies and development (Lundvall,1992; Cooke et al., 1997; Malerba, 2002; Di Tommaso and Schweitzer, 2005).

How industrial investments in strategic sectors can be financed is also a topic that has been widely discussed. Here recent work has focused on the problems related to how adequate funding can be secured to support industries during times of austerity (Crotty, 2011; Brancaccio e Passarella, 2012; Blyth, 2013; Peck, 2013). The issue is of course real, but at the same time it is also true that in this field there are many misunderstandings. Industrial policy is not just about dispensing money to companies, sectors or regions. Some interventions do entail financial support, but many do not. Industrial policy is basically about changing individual and collective behaviours and this can be achieved with or without the distribution of money. New laws and regulations, public procurement programs, antitrust measures, mechanisms for helping markets perform better for "buyers" and "sellers," or other policies that might be applied to targets to induce change, may be examples of industrial policies with low impact on government spending. (Di Tommaso and Schweitzer, 2013).

Having said this, the financing issue is important and it deserves attention. However, it is also true that it has often been utilised only as anti-intervention general argument. On the contrary, costs of government intervention should be discussed with reference to *how* specific policies are implemented and to the benefits they produce. In this perspective, in the case of selective industrial policies one of the crucial open questions is: how can sectors be rigorously identified as 'strategic'? Failures and mistakes in this process of selection have a clear impact on the policies' net benefits. And this paper is devoted exactly to the discussion of this central point.

With this goal in mind, the analysis has to start from what can be meant by "strategic sectors". Intuitively, they could be perceived as those sectors which contribute in a relevant way to the national interest and to societal wellbeing and which therefore might deserve some special attention from governments. However, beyond this common sense, in dominant economic literature the existence of strategic sectors is quite a controversial issue. In fact, the notion of strategic sector is based on the idea that there are *differences* in economic sectors in terms of how much they contribute to the achievement of economic and societal goals and that it is therefore possible in this perspective to define a hierarchy among sectors. This has not been a widely shared idea so far: many economists have generally been quite sceptical in suggesting that '[...] there is a difference in economic significance between an industry that produces a dollar's worth of silicon chips and one that produces a dollar's worth of potato chips' (Teece 1991,

49). And these words will not surprise us if we do not challenge the assumptions on which they are based. The distinction between different kinds of 'chips' is meaningless if we do not accept the idea that there can also be societal normative goals defined outside the economic mechanism of markets. In other words, the normative component behind the idea of 'strategic sector' is such that one can define a strategic sector only by answering the question of what the societal objectives are and what we intend to pursue through policies that favour those sectors. The notion of strategic sector is therefore inherently related to the value judgments that we adopt and to the analyser's perception of societal goals and needs.

In this paragraph we offer a literature review that attempts to capture the criteria by which strategic sectors can be defined.

In most cases, within the existing literature, a strategic sector is defined according to strictly economic objectives and, in particular, by considering the different capacities of industries to foster *economic growth*.

In this framework, an important criterion to evaluate the strategic significance of a sector is its *competiveness* over time. According to several authors, enterprises operating in an industry are subject to a certain degree of uncertainty, given by changes in the international competitive environment, such as the adoption of a new technology, or the emergence of a new competitor. Thus, each industry is characterised by a different level of threat and profit opportunities for domestic enterprises, on the basis of the ability of the national enterprises of the sector to develop their organisation of production towards new products or productive processes over time, and to operate in a changing competitive environment (see, i.e., Malerba [2002]; Bianchi and Labory [2006]; Spender [2012]). In general terms, having identified competitiveness as the relevant aspect of the strategic significance of a sector has led the academic debate to 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).

Similarly, some authors emphasise how the development of competitiveness involves the continuous acquisition of *knowledge* by sector, as a key factor of the industry's capacity to innovate through new products or new production processes. Libicki (1990), for example, defines strategic industries as 'those that best foster the systematic application of knowledge to generate more and better outputs from inputs' (Libicki 1990, 1).

A dynamic perspective in defining strategic sectors has also been recently supported 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 selected sectors. However a crucial point, which distinguishes Lin's approach from a traditional 'picking-the-winner' industrial policy, is that the government should choose strategic industries consistent with the economy's *comparative advantage* (Lin 2010, 2012). In particular Lin (2012) and Monga (2012) define strategic industries as those with *latent comparative advantages*: 'Industrial policies implemented by governments in developed and developing countries usually fall into one of two broad categories: (i) they attempt to

facilitate the development of new industries that are either too advanced and thus far from the comparative advantage of the economy, or are too old and have lost the comparative advantage; or (ii) they try to facilitate the development of new industries that are consistent with the latent comparative advantage of the economy. Only the latter type of policy is likely to succeed.' (Monga 2012, 161). Clearly, in this context, how it is possible to identify industries with *latent* comparative advantage is still a crucial question. Indeed, as stated by Wade (2012), '[Lin] has been reluctant to identify criteria for distinguishing investments within and without the economy's existing comparative advantage' (Wade 2012, 235) and this shows that in IP the risk of mistakes in the identification of the industries that will be able to improve their competiveness in the future is inevitable (Lin and Chang 2009; Chang *et al.* 2013).

Going beyond sectoral competitiveness, another important criterion that economic literature has used to identify sectors that are strategic for their ability to foster economic growth is the level of *interdependence* between different activities. Under this perspective, several authors suggest that strategic sectors are those that bear a high level of positive externalities, or high upstream and downstream connections with other sectors (Hirschman 1958; Krugman 1987; Michalski 1991; Soete 1991; Stevens 1991; Teece 1991; Yang 1993; Chang *et al.* 2013; Andreoni and Scazzieri 2014). According to Hirschman (1958), sectors with strong upstream connections, which buy inputs from many other sectors, are capable of increasing overall economic production by stimulating demand for the related sectors. On the other hand, sectors with downstream connections can increase the offer by selling output to other sectors, and therefore push overall consumption. To this end, several empirical analyses have investigated these upstream and downstream connections through input-output tables (see, for example, Laumas 1975; Schultz 1977; Meller and Marfán 1981; Hewings 1982; Cella 1984; Oosterhaven 1988; Dietzenbacher and Van Der Linden 1997; Los 2001).[12]

In other cases, the industrial policy practices common to many governments throughout history show how some sectors can be considered 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 transitioning 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 defined as going beyond purely economic criteria, which refer to the *doings and beings* of a society as a whole. A wide range of interesting literature has tried to evaluate countries' 'processes of development and change from perspectives that go beyond the traditional variables of growth and economic performance (see, for example, Sen 1983,

[12] 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. The prevailing idea of market liberalisation gave the government the primary role of regulator of national and international dynamics, and the ability of domestic firms to enter the global networks of suppliers and customers became crucial at the expense of the overall development of the national industrial system (Pack and Saggi 2006). On this topic see also Gereffi *et al.* (2005), Gibbon *et al.* (2008), Pietrobelli and Rabellotti (2011), Elms and Low (2013).

1999; Arndt 1987; Hirschman 1981; Ingham 1993; UNDP 1990). Without going into the details of such a fascinating debate, from this perspective sectors are considered different because they might meet a people-centred national strategic interest in different ways. Frequently quoted examples in this framework are health and green industries, or education and cultural sectors. These *merit industries* reflect a model of development that is widely accepted in the political debate of several countries and within international institutions. For instance, according to the UNDP definition of Human Development (UNDP 1990), the promotion of health or education becomes fundamental for social development and therefore fundamental in defining what sectors are strategic for a society. From this point of view, a particular sector is different from others not just because it produces economic growth, but because it can influence people's quality of life by offering specific merit goods and fundamental capabilities for increasing people's participation in economic and political processes (Sen 1999).

This brief review shows that there are several criteria and goals that might justify a sectoral policy and the promotion of specific industries. This is why – in the current context of an Industrial Policy Renaissance – on-going practices require clear and transparent specification of political priorities and rationales, in view of possible trade-offs between different goals.

4. Methodology

Composite indicators can be used to assess variables that are difficult to observe or measure (Fayers and Hand 2012; Marozzi 2009). Composite indicators are very often used in country performance comparison in economic openness, globalisation, competitiveness, development, security, education, health, human rights, environment, corruption and financial risk (OECD 2008). In these cases, the aim is to rank countries according to complex phenomena, inform policy makers, international commitments, investors, and citizens about trends and changes in country rankings across time. They are designed by public institutions as well as by profit and non-profit private organisations.

The intuition of this paper is to apply the notion of composite indicators 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).

We use a similar framework to rank J=19 American manufacturing industries on the base of K=7 variables that describe the strategic significance of the sectors (see next section).

Strategic significance variables are combined using composite indicators. The procedure, similar to that described in Arboretti *et al.* (2007) and Bonnini *et al.* (2009), is based on two steps:

1. normalisation
2. weighting and aggregation

In the first step of the procedure (before performing the aggregation step), the variables are normalised since they have different scales and dispersions. Let X_{jk} denote the value of X_k for sector j. X_{jk} is transformed into

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

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.

In the second step of the procedure, the normalised data are weighted and aggregated to obtain the SSI value for sector j (j=1,...,J), according to c-th aggregation rule and the d-th weighting scheme, 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 C denotes the number of aggregation methods, $_{d}w_k$ denotes the weight assigned to the k-th sub-indicator with $_{d}w_k \geq 0$, $\forall k=1,...,K$ and $\sum_{k=1}^{K} {}_{d} w_k = 1$, D is the number of weighting schemes. We consider four rules of aggregation

- 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

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

- c=4, Liptak rule

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

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 selection of the weighting scheme is highly debated as well as the selection of the aggregation method. 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. Therefore the robustness of the SSI ranking should be analysed. The question is: are SSI rankings robust with respect to the selection of aggregation and weighting rules? As suggested, among others by Saisana *et al.* (2005), Marozzi (2014a) and Luzzati and Gucciardi (2015), 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 are:

- aggregation;
- weighting.

The aim is to test whether the ranking is robust or volatile with respect to plausible changes in the sources of uncertainty. The uncertainties are translated in input factors U_1, which is scalar, and U_2, which is vectorial. U_1 and U_2 are sampled from the distributions, discrete for the scalar input factor and continuous for the vectorial input factor, assigned to them. In uncertainty analysis, aggregation and weighting are varied simultaneously to assess their effects on the composite indicator. 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 weighting vector. We assign to each weight a continuous distribution, more precisely an uniform distribution in the interval $[p,q]$ with $0<p<q$. Therefore the normalised weights are restricted to take values between

$$U_{2\min} = \frac{p}{p+(K-1)q}$$

when one weight is equal to p and the other ones are equal to q and

$$U_{2\max} = \frac{q}{q+(K-1)p}$$

when one weight is equal to q and the other ones are equal to p. Following Marozzi (2014b) we 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 Section 4) means that the maximum normalised weight cannot exceed three times the minimum normalised weight. The corresponding values of p and q are given by Theorem 1 and Table 1 in Marozzi (2014b). The weights are then rescaled as

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

so that their sum is 1. We assign different weights to the variables to reflect different importances as well as different perceptions of policy makers towards them.

After we have defined the sample input space, L combinations of the two sources of uncertainty are generated. Each combination corresponds to a SSI: ${}_l\boldsymbol{\psi}=({}_l\psi_j, j=1,\ldots,J)$. The J sectors may be ranked from the first to the last one according to ${}_l\boldsymbol{\psi}$. Let ${}_l\boldsymbol{R}=({}_lR_j, j=1,...,J)$ be the rank vector. Considering all L combinations of input factors we obtain for sector j a vector of L ranks ${}_j\boldsymbol{R}=({}_lR_j, l=1,...,L)$, $j=1,\ldots,J$ which is an estimate of the uncertainty distribution of the rank of sector j. The median of ${}_j\boldsymbol{R}$ 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. By looking at the uncertainty interval corresponding to each j, we can understand whether the selection of a particular aggregation method and a particular set of weights may or may not provide a misleading measure of how sector j is strategic. In fact, the wider the uncertainty interval for sector j, the less robust sector j SSI rank against the design of the composite indicator.

5. The Strategic Sector Index (SSI) and Application to American Manufacturing

The *strategic* significance of a sector is a complex phenomenon that can be analysed by considering several aspects and synthesised in a composite indicator, the Strategic Sector Index (SSI). As we pointed out in Section 2, there are several economic and societal motivations that can potentially justify the promotion of particular industries, making a clear specification of political priorities necessary, in view of possible trade-offs between different goals. Now we are going to select *national economic growth* as a 'hypothetical' policy priority, in order to apply the methodology we proposed in the previous paragraph to a concrete case. Having assumed this specific goal, we decided to focus the strategic sectors' analysis on *manufacturing* [13] industries because of their peculiar role in economic growth dynamics.

The Strategic Sector Index (SSI) is employed to study the American case. The analysis is conducted using data from 19 manufacturing industries collected by the United States Census Bureau, US Department of Commerce, according to the classification of productive sectors of the 2012 North American Industry Classification System (NAICS).

The 7 variables used for building the index – which act as the criteria defining what a strategic industry is – are consistent with the idea of considering the existing production structure (e.g. the weight of the sectors in the economy and the industries' capabilities in producing economic wealth already present in the country) and of moving the system towards sectors with higher economic performance at a national and international level

[13] The economic literature has recently shown a renewed interest toward manufacturing as engine of economic growth. Many scholars (among the others Tregenna 2009, 2014; Bianchi and Labory 2011; Chang et al. 2013; Andreoni and Scazzieri 2014) have recently shown a renewed interest toward manufacturing for the following main reasons: high productivity of labour, dynamic economies of scale, rapid technological change and innovation, and positive externalities toward other sectors. Moreover, in the American political debate there is a clear concern about the decline of manufacturing. Specific plans implemented by the Obama Administration have targeted manufacturing industries with the explicit aim of fighting the deindustrialization processes (see for example the US Government Office of Science and Technology Policy 2012 and 2014). In this scenario, we decided to limit our study to manufacturing industries. This choice has also one methodological advantage: we can test our exercise on a more homogeneous group of sectors.

(higher productivity, export, and capital intensity). Furthermore, they tend to consider both the static dimension and the dynamic one.

In particular, the variables making up the Strategic Sector Index (SSI) are specified as follows:

1. *VA as % of GDP (2012)*: is the sector value added as a percentage of the total national GDP in 2012. This variable aims to consider the weight of the industry in the economy.
2. *Growth rate VA (2012-2007)*: is the growth rate of sector value added (VA) from 2007 to 2012. It describes how the total VA of the sector has evolved over time and, in particular, during the crisis.
3. *Growth rate full-time equivalent employees (2012-2007)*: is the growth rate of full-time equivalent employees of a sector from 2007 to 2012. Similarly to the previous variable, it describes how the sector has evolved during the crisis with regard to employment.
4. *VA/Full-time equivalent employees (2012)*: is the sector productivity of labour in 2012. It shows the intrinsic capacities of a sector to produce economic wealth, regardless of the total volume of sector production (thus differentiating it from the previous three variables).
5. *Growth rate compensation of employees/Full-time equivalent employees (2012-2007)*: is the growth rate of the sector compensation per employee from 2007 to 2012. Since sector compensation per employee is part of sector value added per employee, the variable aims to consider the evolution of sectoral productivity performance over time, with particular regard to the industry's ability to compensate the workforce.
6. *Net export/Full-time equivalent employees (2012)*: is the value of net exports per employee in 2012. This variable is used as a proxy to evaluate sector performance in international markets.
7. *Investment in private fixed assets/Full-time equivalent employees (2012)*: is the value of investment in private fixed assets per employee in 2012. It aims to measure capital intensity and the propensity of private businesses to invest in the sector.

Summarising, according to these variables, strategic sectors are those with a remarkable and growing weight in the economy in terms of value added and employment, with high and rising productivity of labour and high capital intensity, and with the best competitiveness.[14] The index ranks sectors according to their strategic relevance based on present and past performance of the selected variables included in the index. From this point of view the SSI considers the current strategic significance of the sectors and does not pretend to predict, with *certainty*, the strategic relevance of the industries in the future. For example, the SSI is computed on sectors that already exist in the economy: industries that are absent from a country's economy are not included. Similarly, sectors that are still infant (because in the initial stages of development) tend by definition to be ranked lower

[14] Referring to literature on strategic sectors (see Section 2), these variables exclude dimensions related to the backward and forward linkages between different sectors. Although these dimensions played a traditional role in the theoretical analysis of strategic industries, we decided to exclude them from the SSI. 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 liberalization of markets of the 90s 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.

by the index. In other words, in our exercise uncertainty about the future is not meant to be reduced by *Uncertainty Analysis* and it has to be clear that the relationship between what is strategic today and what it will be tomorrow cannot be taken for granted. *Uncertainty analysis* it is a quite sophisticated technique that we use for another goal: it foster decision-making processes making the sectors' ranking more robust and less influenced by the way in which combining function and weights of the variables are chosen.[15]

Before building the index we calculated the Pearson correlation coefficient between all the different possible pairs of variables in order to assess the degree of correlation. A negative correlation between the variables would imply that different sectors respond to different political *goals*, consequently, different sectors would have similar levels of strategic importance based on their contribution to different goals, distorting the analysis. On the contrary, a high level of correlation provides a duplication of information given by a variable. As shown by the Pearson coefficient matrix below, the chosen variables are all positively correlated. The degree of correlation is generally moderate (with very few exceptions).

Table 1. *Pearson coefficient between the SSI variables*.

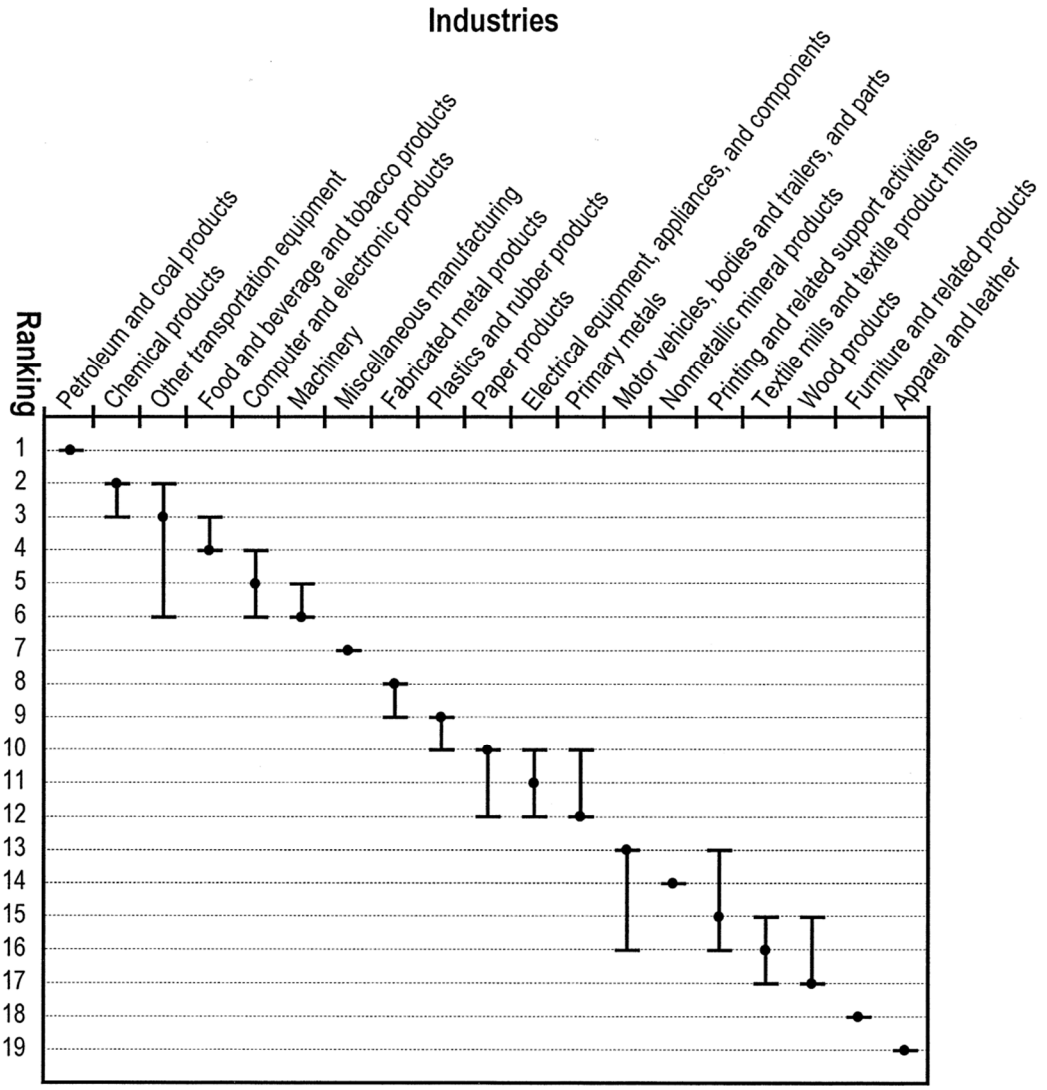
Pearson coefficient between variables	VA as % of GDP (2012)	Growth rate VA (2012-2007)	Growth rate full-time equivalent employees (2012-2007)	VA/Full-time equivalent employees (2012)	Growth rate compensation of employees/Full-time	Net export/Full-time equivalent employees (2012)	Investment in private fixed assets/Full-time equivalent employees
VA as % of GDP (2012)	1.0000	0.8130	0.6698	0.3972	0.3552	0.2226	0.7732
Growth rate VA (2012-2007)	0.8130	1.0000	0.8698	0.4008	0.5538	0.1602	0.6400
Growth rate full-time equivalent	0.6698	0.8698	1.0000	0.4403	0.5483	0.3383	0.4917

[15] As specified, in this paper SSI does not intend to serve to predictive purposes. However, this is a promising and interesting line for future research. In this perspective, the SSI index could be developed by considering other variables, related for example to technological development (such as R&D investments or patents), ranking sectors according to their innovation potential (Libicki 1990). The SSI could in this way abandon its emphasis on the present and it could include new important information on sectors' future performances. At any rate, these two different perspectives - the present and the future strategic significances - respond to different informative goals that the index can perform, namely to a different poll of variables of interest, that have not to be confused in economic terms. (Methodologically, as we argue in the rest of the paper, this means that the variables of the index need to be positively correlated each others). For this reason, in this paper we decided to not include in the SSI variables related to technological development, that are by definition connected to the *future* strategic significance of the sectors, in favour of a notion that mainly considers the *present* strategic relevance of the industries.

employees (2012-2007)							
VA/Full-time equivalent employees (2012)	0.3972	0.4008	0.4403	1.0000	0.6808	0.1839	0.7876
Growth rate compensation of employees/Full-time equivalent employees (2012-2007)	0.3552	0.5538	0.5483	0.6808	1.0000	0.2239	0.5606
Net export/Full-time equivalent employees (2012)	0.2226	0.1602	0.3383	0.1839	0.2239	1.0000	0.1506
Investment in private fixed assets/ Full-time equivalent employees (2012)	0.7732	0.6400	0.4917	0.7876	0.5606	0.1506	1.0000

After normalising the 7 variables, in order to test the robustness of the Strategic Sector Index (SSI), we performed the *uncertainty analysis* presented in the previous section. The following graph summarises the results of the *uncertainty analysis* computed, considering L=20000 different combinations of input factors – combination functions and variable weighting schemes – in the composite indicator equation.

Fig. 1. *Results of the uncertainty analysis for the SSI.*



The chart shows the ranking of strategic industries according to the Strategic Sector Index (SSI), where sector 1 is the best and sector 19 the worst for strategic importance. By applying the *uncertainty analysis* we got a distribution of values of the SSI for each sector that were transformed into 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 graphically represented as rank (position) uncertainty interval. 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 5^{th} to the 95^{th} percentile of the rank uncertainty distribution. The median can be considered reasonably independent with respect to the computing assumptions of the index (see Methodological Section). 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 higher the discretionality of the policy maker and the possibility of manipulating the ranking by changing the equation of the SSI index and the weights assigned to the variables.

The *uncertainty analysis* shows that the SSI based ranking of industries is sufficiently robust. In fact, the bands generally tend to be narrow: the widest one is for 'other transportation equipment' and covers just five positions (from rank 2 to rank 6). As can be noted, industries near the head and tail of the ranking have generally narrower 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 national economic growth, providing a ranking of strategic industries. In particular, the most strategic sectors for the US economy, which can, for example, be associated with the first five positions of the ranking (first quartile), are petroleum and coal products, chemical products, other transportation equipment, food and beverage and tobacco products, and computer and electronic products. These are the sectors that, on the basis of the variables of the SSI, have achieved the best performance. This result 'turns the spotlight' onto certain manufacturing sectors and must be interpreted as useful preliminary information in the process of defining an industrial policy. In fact, our analysis shows the potential strategic IP *targets*, without investigating what kind of intervention is appropriate for a particular strategic sector.

However, the main strength of this analysis is the ability to highlight the political priority. The choice of the variables (and of their weights) is an explicit identification of the goals that a government wishes to pursue. In this way the use of the SSI in strategic policy-making decisions may improve transparency of political objectives, limiting the degree of politicians' discretionality thus discouraging non-virtuous political behaviour.

6. Final Remarks

Looking for pragmatic remedies capable of mitigating *government failures*, this paper offers a contribution in the field of strategic policy-making decisions and industrial policy.

We presented this work in times of an industrial policy and a go-back-to-manufacturing renaissance, where selective interventions are back on the political agenda in both industrialised and emerging countries. We discussed the specific issue of how governments might define and select national strategic sectors through the use of an innovative methodology. From this perspective, bridging the theoretical debate on industrial policy and government failures with contemporary policy-making needs, we have elaborated an original framework that might prove useful in strategic sector selection processes that aim to be more certain, more transparent, and for these reasons more immune to lobbying pressures, partial interests, or policy-makers' discretionality.

We have built on the idea of clearly identifying a policy priority and of fixing some criteria that are useful in supporting the identification of strategic industries given the definition of selected national and societal goals. We proposed a composite indicator, which, by synthesising the value of different variables for the sectors of one economy, provides a strategic sector ranking. Finally, we decided to adopt an *uncertainty analysis* methodology in order to further minimise policy maker discretionality and vulnerability in this process of strategic sector rating and selection.

We applied this methodology to American manufacturing and we provided a ranking of what might be defined as strategic industries. The analysis highlighted how different industries might have different capacities in contributing to national economic growth.

The methodology for the identification of strategic sectors presented in this work can be developed and adapted to other interesting cases. Future applications can be elaborated in order to analyse the strategic significance of different industries with reference to other political and economic goals - such as for example those related to environmental protection, social equity, territorial disparities, economic dependency from abroad, or *merit goods and services* promotion.

Beyond the ability of this methodology to provide preliminary and specific information on nations' strategic industries, this work has intended to take steps to address broader issues that need further research and academic attention. The development of new policy-making tools capable of increasing rigour and transparency in strategic government decisions seems necessary to improve the effectiveness, strength, and evaluation of public intervention. From this perspective, the development of a solid framework that is able to guide and support strategic industrial policy decisions is not a mere matter of providing better technicalities for government intervention. On the contrary, it is a very promising research path for economic studies openly interested in improving the capacity of the government to react to contemporary demands for policy actions. Better internal government information management and transparency in the face of citizens are crucial aspects for policies that really aim to be effective, participatory, and genuinely driven by long-term public interests.

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