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Industrial policy and the future of manufacturing

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Abstract The paper aims at reconstructing the industrial policy debate by focusing on a number of theoretical issues, in particular the contested nature of industrial policy—its selectivity—also in relation to manufacturing and the different rationales for industrial policy making. The paper concludes by looking ahead into the future of manufacturing and focuses on the need for rethinking our understanding of global production and emerging technologies for increased prosperity.

Keywords Industrial policy · Manufacturing · Interdependencies · Capabilities · Uncertainty

JEL Classification L50 · L60 · O14 · O25 · O38

1 Introduction

The dramatic transformations in the global manufacturing landscape started in the mid-1990s, but have been reinforced by the financial crisis and the subsequent recession. During the first phase of the crisis (2008–2009), the *manufacturing loss* estimate reveals the collapse of industrial production worldwide with respect to both the zero growth scenario and the sustained growth rate scenario (based on the average annual growth rate achieved in the pre-crisis period between 2000 and 2007). Specifically world manufacturing loss was between US $361.32 billion (with

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respect to the zero growth rate scenario) and US $875.72 billion (if we compare it with the sustained growth rate scenario) (Andreoni 2015a).

However, the manufacturing loss was uneven across countries. Among the top 20 industrialised nations (see Table 1), Italy, followed by Spain and the UK has experienced the most dramatic manufacturing loss.

Against this background, the paper aims at reconstructing the industrial policy debate by focusing on a number of theoretical issues, in particular the contested nature of industrial policy—its selectivity—also in relation to manufacturing and the different rationales for industrial policy making. The paper concludes by looking ahead into the future of manufacturing and focuses on the need for rethinking our understanding of global production and emerging technologies for increased prosperity.

Table 1 The effect of the financial crisis on the top twenty industrialised countries ranked by total MVA for the period 2007–2012 and according to different growth and industrial indicators. Source: Authors based on World Bank and UNIDO

Ranking 2012 by total MVA	Country	MVA var (%)	MVApc var (%)	GDP var (%)	GDPpc var (%)	MVAsh var (%)	WMVAsh var (%)	WGDPsh var (%)
1	USA	−1.41	−5.63	3.01	−1.40	−0.61	−1.56	−1.19
2	China	60.45	56.64	55.63	51.94	1.03	5.90	2.60
3	Japan	−7.64	−7.58	−2.31	−2.25	−1.21	−1.62	−0.91
4	Germany	−8.57	−7.99	3.48	4.14	−2.49	−1.04	−0.24
5	Republic of Korea	25.22	22.42	15.94	13.34	2.07	0.52	0.14
6	France	−6.56	−9.08	0.42	−2.29	−0.80	−0.37	−0.31
7	Italy	−23.98	−25.81	−7.03	−9.27	−3.09	−1.05	−0.51
8	UK	−14.75	−17.33	−3.40	−6.33	−1.33	−0.64	−0.51
9	India	38.46	29.17	38.01	28.76	0.05	0.54	0.57
10	Mexico	6.47	0.12	8.28	1.82	−0.30	0.01	0.01
11	Brazil	3.83	−0.66	17.51	12.44	−1.75	−0.04	0.18
12	Russian Federation	−1.56	−1.15	9.48	9.94	−1.54	−0.12	0.03
13	Canada	−13.60	−17.83	5.48	0.32	−2.33	−0.34	−0.05
14	Spain	−20.82	−24.49	−4.13	−8.57	−2.35	−0.50	−0.27
15	Turkey	19.60	12.35	16.67	9.60	0.44	0.14	0.09
16	China, Taiwan Province	6.96	5.30	11.14	9.42	−0.99	0.01	0.02
17	Indonesia	26.73	20.36	32.97	26.29	−1.26	0.20	0.15
18	Poland	37.37	36.91	18.54	18.15	3.00	0.23	0.07
19	Australia	4.44	−3.76	12.20	3.39	−0.68	−0.01	0.07
20	Thailand	20.48	16.87	13.99	10.57	2.01	0.11	0.02

MVA manufacturing value addition, *GDP and GDPpc* gross domestic product total and per capita, *MVAsh* var change in the share of MVA in total GDP, *WMVAsh* var change in the World MVA share, *WGDPsh* var change in the World GDP share

2 The contested definition of industrial policy

The controversial nature of industrial policy is testified to by the fact that there is actually no universally agreed definition of the term (Chang 1994; Stiglitz and Lin 2013; Warwick 2013, Stigltiz and Greenwald 2014; Andreoni 2016a, b). The most literal interpretation of industrial policy would be to define it to include any policy that affects industry (usually interpreted as the manufacturing industry), in the same way in which we would define fiscal policy as policy that affects government revenue and spending, and monetary policy as policy that affects monetary variables. Indeed, some commentators who adopt this definition would include even infrastructure policy, education policy and tax policy as parts of industrial policy (Chang 1994; Andreoni 2016b; Noman and Stiglitz 2016).

The majority of the commentators on industrial policy, however, define industrial policy to mean 'selective' industrial policy, 'sectoral' industrial policy or 'targeting'—namely, a policy that deliberately favours particular industries/sectors (or even firms) over others, against market signals, usually (but not necessarily) to enhance efficiency and promote productivity growth, for the whole economy as well as for the targeted industries themselves.

Industrial policy thus defined has been even more controversial than more generally defined industrial policy. Many people believe that industrial policy should be of general (or functional or horizontal) kind, rather than of selective (or sectoral or vertical) kind. In this view, industrial policy should focus on 'public goods' that benefit all industries equally but are likely to be under-provided by the market—e.g., education, research and development (R&D), and infrastructure—and not involve 'picking winners'.

The fundamental problem with this view is that the distinction between selective and general industrial policies cannot take us very far. In a world with scarce resources, every policy choice you make, however general the policy involved may look, has discriminatory effects that amount to implicit targeting.

For example, many people believe that education is one of those general industrial policies, but beyond the basic level (say, the first 9 years), education becomes specialised. So, for example, when we produce engineers, we do not produce some generic engineers but engineers specialised in certain areas. Therefore, a government providing more funding to electronics engineering departments than to chemical engineering departments is implicitly favouring the electronics industry. Likewise, there is no such thing as generic physical infrastructure. Physical infrastructure is always location-specific, so it affects different industries differently. Moreover, different modes of transportation have different impacts on different industries—bulky goods (e.g., iron ore, wheat) will be helped more by developments of seaports and railways, while lighter goods, especially when they are perishable (e.g., flowers, fresh fish), will be helped more by developments of airports. Finally, if a government is giving out R&D subsidies, it is implicitly favouring the more R&D-intensive higher-tech sectors.

Thus seen, selectivity (targeting) is inevitable. Except the provision of basic education, calling which an 'industrial policy' is really stretching the term beyond credulity, there is really no policy that does not involve some degree of targeting.

Now, it may be said that, while targeting may be unavoidable, the less targeted a policy is, the better it is. However, this is not true. While less targeted policies may open themselves less to the possibilities of lobbying and 'regulatory capture', they are more costly to implement. Being less precise and thus more difficult to monitor, they have more 'leakages' than more targeted policies. Indeed, many mainstream economists have long argued that the welfare state should be more precisely targeted because there are simply too many leakages in the system of universal welfare. It is curious that this point is almost entirely ignored in relation to industrial policy.

Given all this, we have to admit that we cannot 'not target' and should try to attain the best possible degree of targeting, which may differ across industries and countries. We cannot assume that there is a linear relationship, positive or negative, between the degree of targeting and policy success. Some degree of targeting is inevitable, while some more of it may be desirable, but too much of it may not be good, although how much is too much is debatable (and one's position on it will depend on one's economic theories and political values).

3 The special role of manufacturing

Industrial policy, according to our definition, does not involve only manufacturing industries. However, those who are interested in selective industrial policy tend to put great emphasis on the need to promote the manufacturing sector. The reasons are many and diverse.

First, it is widely recognised that the manufacturing sector is the main source of technology-driven productivity growth in modern economies. It is not much of an exaggeration to say that manufacturing is what has made the modern world. Thanks to the fact that the manufacturing activities lend themselves much more easily to mechanisation and chemical processing than do other types of economic activities, the manufacturing sector has been the main source of productivity growth throughout history. Productivity increase in agriculture is highly constrained by nature in terms of time, space, soil, and climate. By their very nature, many service activities are inherently impervious to productivity increases. In some cases, the very increase in productivity will destroy the product itself. If a string quartet trots through a 27-min piece in 9 min, we will not say that its productivity has trebled. For some other services, the apparently higher productivity may be due to the de-basement of the product. A lot of the increases in retail service productivity in countries like the US and the UK have been bought by lowering the quality of the retail service itself—fewer shop assistants, longer drives to the supermarket, lengthier waits for deliveries, etc. The 2008 global financial crisis has also revealed that much of the recent productivity growth in finance had been achieved through the de-basement of the products—that is, the creation of overly complex, riskier, and even fraudulent products.

Second, many argue that the manufacturing sector, especially the capital goods sector, has been the 'learning centre' of capitalism in technological terms (for a review see Chang 2010; Andreoni and Gregory 2013; Chang et al. 2013). Because of its ability to produce productive inputs (e.g., machines, chemicals), what happens in the manufacturing sector has been extremely important in the productivity growth of other sectors. The increases in agricultural productivity would not have been remotely possible without the developments of manufacturing industries producing agricultural machinery, chemical fertilizers, pesticides, and increasingly genetic engineering. The rapid increases in the productivity of services like logistics and retail in the last couple of decades were also made possible by manufacturing industries producing more efficient transport equipment, computers, and mechanised warehouses.

Third, the manufacturing sector has also been the source of organisational innovation. Productivity growth in the last two centuries has been driven not just by technological changes but also organizational changes, most of which originated in the manufacturing sector. For example, these days many fast food restaurants use 'factory' techniques, turning cooking into an assembly job and sometimes even delivering food on conveyor belts. For another example, large retail chains—be they supermarkets, clothes shop chains, or on-line retailers—apply modern inventory management techniques, developed in the manufacturing sector. Even in the agricultural sector, productivity has been raised in some countries through the application of manufacturing-style organisational knowledge, like computer-controlled feeding.

Fourth, the manufacturing sector has been the main source of demand for high-productivity activities in other industries. For example, most of the service activities that have high productivity and have seen high productivity growths recently (e.g., finance, transport, and business services) are 'producer' services, whose main customers are manufacturing firms. Of course, countries can specialise in those services, but their ability to export them cannot be maintained in the long run without a strong manufacturing sector. In those services, insights gained from the production process and the continuous interaction between the provider and the clients are crucial. Given this, a weakening manufacturing base will eventually lead to a decline in the quality, and exportability, of those services (Tassey 2010; Pisano and Shih 2012; Berger 2013).

Fifth, the manufacturing sector, producing physical and non-perishable products, has higher tradability than agriculture and, especially, services. At the root of the low tradability of services lies the fact that many services require their providers and consumers to be in the same location. No one has yet invented ways to provide haircut or house cleaning long-distance. Of course, this problem will be solved if the service provider (the hairdresser or the cleaner in the above examples) can move to the customer's country, but that in most cases means immigration, which most countries severely restrict. Given this, a rising share of services in the economy means that the country, other things being equal, will have lower export earnings. This, in turn, means that, unless the exports of manufactured goods rise disproportionately, the country will not be able to pay for the same amount of imports as before.

4 Theories of industrial policy

Unless we live in the fantasy world of perfect markets, industrial policy does not lack theoretical justifications (for reviews, see Chang and Andreoni 2016). This is not a place to review these theories in any detail, so let us just provide an overview of the key types of arguments.

4.1 Interdependences

There are various arguments that justify industrial policy, especially of selective type, on the basis of the existence of interdependence between different activities. The best-known of this type of argument are those based on demand complementarities and increasing returns (to scale) in manufacturing industries, which were prominent in Classical Economics and in early Development Economics (Andreoni and Scazzieri 2014). The first variety of these is the so-called Big Push argument—or the balanced growth model—of Paul Rosenstein-Rodan and Ragnar Nurkse, which argues that there needs to be a coordination of investment between interdependent activities, as their returns depend on there being all the complementary investments. Using a similar insight, the so-called linkages argument of Albert Hirschman advocates industrial policy that first promotes industries with particularly strong interdependences with other sectors, whether as suppliers of inputs into other industries (forward linkages) or as purchasers of outputs of other industries (backward linkages), thus setting off chain reactions in different directions.

Second, there are less well-known justifications for industrial policy based on interdependences between competing—rather than complementary—activities. In oligopolistic industries with lumpy investments, simultaneous investments by competing firms may result in excess capacity, which may push some firms into bankruptcy, which in turn means that the resources invested in them will have been wasted—unless the machines and skills involved are of very general nature and can be redeployed elsewhere easily, which rarely is the case in modern industries. In order to prevent such 'wasteful competition', countries, especially Japan and Korea, have used entry restrictions and government-approved investment cartels so that investments are staggered at suitable intervals (Chang 1994).

Coordination problems among competing investments may be related not only to investment but also to situations of temporary disinvestment or structural change in the industrial sector. Recession cartels and mechanisms of negotiated exit have been widely used to face periods of economic crisis or accompany structural transformation (Dore 1986). In these situations, industrial policies introduce "a 'protective' element—that is 'helping losers' by temporarily shielding them from the full forces of the market" (Chang 2003, p. 262). More generally, support for declining sectors may be seen as an attempt to socialise risk, in order to encourage and sustain the process of structural change and productivity growth, from which economic development derives.

Third, there is the externality argument, in which industrial policy is deployed to compensate for under-investment in (and thus under-production of) certain activities due to the fact that their providers do not reap the full benefits from their efforts. Supports for basic R&D or worker training are classic cases. More recently, some commentators have developed an argument for industrial policy based on 'information externality'. The argument is that investments are not made in industries because the potential 'pioneer' firm is afraid of providing 'free experiment' to competitors, who may then imitate it and deprive it of what Schumpeter would have called 'entrepreneurial profit' (Hausmann and Rodrik 2003; for a critique see Chang and Andreoni 2016).

4.2 Capabilities

Another important set of arguments for industrial policy is based on the time-consuming and costly nature of the process of accumulating productive capabilities (Chang 1994; Andreoni 2014). Productive capabilities are personal and collective skills, productive knowledge and experience that are embedded in physical agents and organisations.

The most famous argument along this line is the infant industry argument. This is based on the understanding that productive capabilities can be accumulated only over time and in an unpredictable way. Given this, new producers need a period of protection—through tariffs, subsidies (related to equipment investments, R&D, and worker training), regulation on foreign direct investment (FDI), and other measures—from competitive forces coming from abroad, in the same way in which children need protection before they can go out and compete in the labour market unassisted. This argument applies to the catching-up economies particularly strongly, but can hold for all countries, insofar as their producers in certain sectors are trying to catch up with superior producers abroad. The ultimate example of the latter case is the development of Airbus by the European governments against what looked like an insurmountable US dominance in the civilian aircraft market.

Another capabilities-related justification for industrial policy is based on policies providing support for small producers—such as small and medium-sized enterprises (SMEs) in the manufacturing sector and small farms. The problem is that capability accumulation needs some indivisible inputs that small producers cannot provide on their own—R&D, machinery, or worker training. There are many industrial policy measures intended to solve this problem. The government can directly provide these inputs through public R&D, training of workers in public universities and training institutes, and the provision of 'extension service' for SMEs and small farmers. It may subsidise those inputs through the provision of R&D subsidies, credit guarantees (which will promote physical investments, among other things), or training subsidies. On top of all these, the government may provide legal and other backings for voluntary cooperative arrangements among small producers—such as tax advantages for cooperatives among small producers or subsidies for particular joint activities among firms (e.g., R&D, processing, export marketing).

The third capability-based justification for industrial policy rationale is known as the 'industrial commons' argument. The argument is rooted in the fact that

productive capabilities have a fundamental collective nature, that is, their development and application is very much the result of interdependent processes of learning and production, each of which involves a variety of actors (Richardson 1972; Andreoni et al. 2016). Given this, the effective coordination of actors endowed with different capabilities becomes a key determinant of competitiveness. A representative study in this line of argument is Pisano and Shih (2012). Using information from the semiconductor, electronics, pharmaceutical and biotech industries, the study shows how the production and innovation capacities of a given economic system depend on the presence of multiple resources, such as R&D know-how, engineering skills, technological capabilities, and specific manufacturing and prototyping competences.

The industrial commons literature stresses that even the development of high-tech cutting-edge products often depends (amongst other factors) on the commons of a mature manufacturing industry. The maintenance of industrial commons necessitates not only the maintenance of a manufacturing base of a certain size and diversity but also various forms of what we call in this paper 'intermediate institutions'—industry associations, trade unions, research institutes, and educational institutions. (Andreoni et al. 2016; Chang and Andreoni 2016).

4.3 Risk and uncertainty

There are a lot of justifications for industrial policy that are based on the recognition that there are inherent discrepancies in the ability to deal with risk and uncertainty between individual producers (whether they are corporations or individual workers) and the society as a whole—often expressed somewhat misleadingly as 'capital market failure' (implying, implausibly, that a 'perfect' capital market will finance any project that is viable) (Chang and Andreoni 2016).

One classic argument of this kind is based on the observation that the government often has the 'deepest pocket' in the country and thus the strongest ability to deal with risk. This is why many ambitious, high-risk projects have had to be subsidised by the government—as in the case of Airbus—especially when the country's capital market is of 'impatient' variety, like the UK one. When it comes to backward economies entering technologically most demanding industries, the risk is incalculable and thus turns into uncertainty. In such cases, establishing state-owned enterprises (SOEs) may be the only solution. Korea's steel-maker (POSCO), established in the late 1960s when the country's income was only 4 % of the US income, and Brazil's aircraft manufacturer (EMBRAER), established in the late 1950s when the country's income was only 8 % of the US income, are the supreme examples of this kind.

Second, governments have often deployed industrial policy to restructure companies in trouble on the recognition that a major corporate restructuring—or even restructuring of an entire industry (like the shipbuilding industry in Japan in the 1980s or the automobile industry in the US after 2008)—involves risk of scales that private sector investors are simply not interested in taking. Policies include government taking of an equity stake (which often results in majority control), state-

mediated mergers, coordinated capacity scrapping, provision of loan guarantees, public subsidisation of severance payments, and transitional subsidies.

Third, some governments, especially those in Scandinavia, have taken cognisance of the fact that, in a fast-changing world, workers are exposed to levels of risk that they cannot simply bear on an individual basis. On this recognition, these governments have provided a comprehensive welfare state—especially strong unemployment insurance, job search services, subsidised retraining, and even subsidies for re-location (e.g., government providing bridging loans to workers who have to sell their house to move to their new jobs) (Chang 1994). These are not 'industrial policies' in the sense we have defined in this paper, but they help industrial developments by promoting smoother structural change.

5 Looking ahead into the future of manufacturing and policy

The continued loss of manufacturing capabilities in advanced industrial countries, in particular the UK, Italy and Spain (if we focus on the European context) necessarily disadvantages these economies over the long-term because the manufacturing sector boosts technologically-driven productivity growth and has strong interdependences with other high-value sectors, especially high-value-added services, in the economy (Chang and Andreoni 2014; Mazzuccato et al. 2015; Andreoni 2015b; Pianta and Zanfei 2016). Although exactly what would be high-value industries in 20, not to speak of 50, years' time is difficult to predict, what is certain is that the potential of these advanced economies to tap into the most profitable supply chains of the future and capture value will largely depend on the industrial capabilities that they build and retain today.

This means that industrial policy have to take full account of the fast-technological changes and the 'genetic mutation' of manufacturing industries (Andreoni 2015b). As eloquently documented in Tassey (2010, p. 6): "Most modern technologies are systems, which means interdependencies exist among a set of industries that contribute advanced materials, various components, subsystems, manufacturing systems and eventually service systems based on sets of manufactured hardware and software. The modern global economy is therefore constructed around supply chains, whose tiers (industries) interact in complex ways". The effectiveness of industrial policy increasingly depends on the capacity of policy makers to deal with these emerging complexities in local and global manufacturing systems, as well as their sub-systems and interdependencies. These 'global' manufacturing systems are composed of sectoral value chains organised both vertically (towards the final markets) and horizontally (across different chains of sub-contracting and supply, including providers of knowledge-intensive services). They also involve heterogeneous organisations performing distinctive productive and technological functions. According to their positions in the value chains, these organisations contribute differently to value addition and can capture different shares of the value generated by their chains (Milberg and Winkler 2013; Chang and Andreoni 2016).

The complex architecture of modern (and future) manufacturing systems largely stems from the fact that they increasingly rely on cross-cutting technology systems, including different 'types' of technology. There are 'proprietary technologies' generally associated to specific products and whose functioning rely on a certain 'platform technologies' emerging from the science base. But there are also 'production technologies' used for transforming materials in new products and whose deployment often require the access to 'infra-technologies' like measurement and test equipment (Tassey 2010; Andreoni 2015b, 2016b). These different technologies enable multiple production activities (also processes and tasks as their components) in different manufacturing industries. In the European context, this recognition has repositioned the industrial policy debate around the pervasive role played by key enabling technologies (KETs), that is, advanced materials, biotechnologies, photonics, micro and nanotechnologies, microelectronics and advanced manufacturing technologies. Given these recent 'genetic mutations' in manufacturing and technology systems, the selectivity of industrial policy is no more reducible to the sectoral distinction in the traditional sense. Industrial policy selectivity will be increasingly centred around the strategic targeting of specific activities and productive organisations within these sectoral value chains and around the underpinning mix of enabling technologies. This means that the traditional sectoral axis of interventions will have to be (and already is in a few countries) gradually replaced by a policy matrix combining sectoral value chains and different enabling technologies. Industrial and technology policies will increasingly have to operate within the matrix of sectoral value chain—technology system (Andreoni 2015b, 2016b).

In those industrialised economies affected by fast de-industrialisation, selective industrial policies must also help the transformation of mature industrial systems and shape, jointly with the private sector initiatives, new diversification trajectories towards higher-value product segments (Best 1990; Berger 2013; Pisano and Shih 2012; Andreoni et al. 2016). This requires selective reductions in the risks involved in critical technology investments, rebuilding of domestic manufacturing capabilities, and re-scaling of existing production capacity to suit the needs of the new technologies. These different, although complementary, goals can be achieved only with integrated packages of policy instruments. Their alignment and synchronisation is critical in shaping the development of the industrial ecosystems of the future.

Despite what the opponents of industrial policy may have us believe, industrial policy has always been around, even though some countries have called it with just another name, like the US has done throughout its history, and even though others have had it without realising that it had one, thus failing to properly organise it in a selective manner. Given this, it is better to accept that targeted industrial policy is necessary and try to get the targeting right, rather than pretending that there is no targeting and making a mess of the policy.

And industrial policy is here to stay. Countries like China are going to step up their industrial policies, as they try to break into the premier league of world industry. Whatever the big rhetoric at the central government is, a lot of industrial policy is going to chug along in countries like Germany, as their industrial policies are deeply rooted in local structures. The US will keep at its industrial policy

through federal R&D funding, and perhaps keep denying that it has any industrial policy. Singapore may continue its emphasis on free trade, but it will keep targeting strategic industries and setting explicit goals, in order to maintain its manufacturing base. Countries like Japan and Korea, having toned down their industrial policies since the 1990s for various good and bad reasons, are now trying to revive at least some of their industrial policy measures, especially in high-technology industries. Finland has successfully restructured its industrial policy by putting great emphasis on funding innovation and will press on with that strategy (for a review see Chang et al. 2013).

By constantly being in denial about the need for better industrial policy, today's de-industrialising advanced countries are going to fall further and further behind in manufacturing industries.

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