Revista de Economia Contemporânea

REC

Revista de Economia Contemporânea (2023) 27: p. 1-32
(Journal of Contemporary Economics)
ISSN 1980-5527
http://dx.doi.org/10.1590/198055272723
elocation - e232723
https://revistas.ufrj.br/index.php/rec | www.scielo.br/rec

Seção Especial em Homenagem a David Kupfer

THE RENEWAL OF THE DEBATE ON INDUSTRIAL POLICY: LIMITATIONS AND SUGGESTION FOR A NORMATIVE TYPOLOGY BASED ON THE DIALOGUE BETWEEN NEO-SCHUMPETERIANS AND DEVELOPMENTALISTS

Antonio Carlos Diegues[a]
José Eduardo Roselino[b]
Marcos José Barbieri Ferreira[c]
Renato de Castro Garcia[d]

[a] Associate Professor at the Institute of Economics, State University of Campinas. Campinas, SP, Brazil.
ORCID: https://orcid.org/0000-0002-4124-666X.

[b] Associate Professor at the Federal University of São Carlos. Sorocaba, SP, Brazil.
ORCID: https://orcid.org/0000-0001-8066-8024.

[c] Professor at the State University of Campinas. Campinas, SP, Brazil.
ORCID: http://orcid.org/0000-0001-5792-2231.

[d] Associate Professor at the Institute of Economics, State University of Campinas. Campinas, SP, Brazil.
ORCID: https://orcid.org/0000-0001-9739-1658.

Received on: 2021/11/30
Accepted on: 2023/1/18
Recebido em: 30/11/2021
Aceito em: 18/01/2023

ABSTRACT: The aim of this paper is to propose a typology of industrial policy based on the dialogue between neo-Schumpeterian and developmentalist frameworks that incorporates in its normative guidelines the transformations in the techno-productive paradigm in recent decades and their consequent impacts on the competitive, innovative and accumulation dynamics of industrial activities. The article proposes a theoretical discussion with normative implications based on the analysis of the literature on the transformations in the nature of two objects: the changes in the techno-productive

Correspondência para: Antonio Carlos Diegues
Contato: diegues@unicamp.br

Todo o conteúdo deste periódico, salvo indicação em contrário, está licenciado sob os termos da Creative Commons Attribution License.

paradigm from the 2000s to the efforts towards the promotion of Industry 4.0. As a result, an attempt is made to theoretically justify the design of industrial policies that shift from overly general normative guidelines towards the ones based on the simultaneous understanding of the combination of three specificities of activities supported: (i) levels of capabilities of agents—technological, productive and organizational, (ii) the analysis of the potential degree of effectiveness of industrial policies and (iii) the degree of transversality of the promoted activities.

KEYWORDS: Industrial policy; development; productive structure; innovation; industry 4.0.

JEL CODES: O25; L52; O38.

A RETOMADA DO DEBATE SOBRE POLÍTICA INDUSTRIAL: LIMITAÇÕES E UMA SUGESTÃO DE TIPOLOGIA NORMATIVA A PARTIR DO DIÁLOGO ENTRE AS CORRENTES NEOSCHUMPETERIANA E DESENVOLVIMENTISTA

RESUMO: O objetivo deste artigo é a proposição de uma tipologia de política industrial a partir do diálogo entre as correntes neoschumpeteriana e desenvolvimentista que incorpore em suas diretrizes normativas as transformações no paradigma tecnoprodutivo nas últimas décadas e seus conseguintes impactos na dinâmica concorrencial, inovativa e de acumulação das atividades industriais. O artigo se propõe a realizar um esforço de natureza teórica com implicações normativas a partir da análise da literatura sobre as transformações da natureza de dois objetos: as transformações no paradigma tecnoprodutivo desde os anos 2000 até os esforços rumo ao fomento ao que se convencionou denominar de Indústria 4.0. Como resultado procura-se justificar teoricamente o desenho de políticas industriais que transitem de orientações normativas demasiadamente generalistas em direção a orientações fundamentadas na compreensão simultânea de especificidades das atividades incentivadas a partir dos (i) níveis de capacitações — tecnológicas, produtivas e organizacionais — dos agentes locais, (ii) da análise do potencial grau de efetividade das políticas industriais e (iii) do grau de transversalidade das atividades fomentadas.

PALAVRAS-CHAVE: Política industrial; desenvolvimento; estrutura produtiva; inovação; indústria 4.0.

INTRODUCTION

The goal of this article is to propose a typology of industrial policy based on the dialogue between the neo-Schumpeterian and developmentalist approaches that incorporates in its normative guidance the changes in the techno-productive paradigm in recent decades and their consequent impacts on the competitive dynamics of industrial activities.

The viewpoint of this paper is that the gaps in the normative guidance of industrial policies originated in these two approaches stem mainly from the limited dialogue between the two interpretations. In other words, the gaps are not due to conceptual issues and serious deficiencies in the fundamentals of the respective frameworks. This article thus seeks to contribute to the literature by establishing a dialogue between these approaches, proposing a typology of industrial policy that is capable of supporting a normative guidance that considers the specificities of the stimulated activities and the respective production and institutional structures to which they belong.

Methodologically, this paper undertakes a theoretical effort with normative implications based on the analysis of the literature on the transformations of the techno-productive paradigm from the 2000s to the emergence of the so-called Industry 4.0.

Based on this context and the dialogue between complementary analytical currents, the typology proposed in this article seeks to contribute with elements to theoretically support the design of industrial policies that evolve from overly general normative guidance to guidelines grounded in the simultaneous understanding of the specificities of the encouraged activities based on (i) local agents' capability level—technological, productive and organizational (COHEN; LEVINTHAL, 1989; KHAN, 2019; PISANO, 2017; TEECE; PISANO; SHUEN, 1997); (ii) the degree of effectiveness of industrial policies (AMSDEN, 2001; ANDREONI; CHANG, 2019; BEST, 2018; EVANS, 1995; KATTEL et al., 2022); and (iii) the degree of transversality of the stimulated activities (ANDREONI, 2020; FAGERBERG, 2017; FREEMAN, 1995; HIRSCHMAN, 1958; KALDOR, 1966; KENNEY ; BEARSON; ZYZMAN, 2021; LUNDVALL, 1992, 2016; NELSON, 1993; PÉREZ, 2010).

To this end, this paper revives the centrality of the relationship between industrial structure and its heterogeneity and the constraints of the catching-up process, from the developmentalists perspective. The levels of technology and innovation capability are then incorporated to those constraints as main variables for competitive dynamics in a context of transition of the techno-productive paradigm, as suggested by the neo-Schumpeterian interpretations based on the suggestion of "smart policies."[1] Lastly,

[1] According to Andreoni and Chang (2019), these are understood as policies that aim mainly to focus industrial policy efforts on furthering knowledge through investment in education and R&D, in contrast to traditional industrial policies, based on subsidies and protectionism.

as a further effort to establish a dialogue between these approaches, this paper analyzes the capacity for permanent institutional transformation as a guiding element for the applicability, coordination and enforcement of industrial policies, as suggested by the interpretation based on mission-oriented policies.

For this purpose, this article is structured into three sections, besides this introduction. The first presents the context of the renewed debate on industrial policy after the 2008 crisis and analyzes the main contributions of developmentalists and neo-Schumpeterians to the subject, as well as some of their limitations. In section two the typology is developed and illustrated. Last, the conclusions are presented.

1. THE RENEWED DEBATE ON INDUSTRIAL POLICY AFTER THE 2008 CRISIS: INTERPRETATIONS AND LIMITATIONS

The main role of industry in the process of accumulation and, consequently, of economic development is observed still in its embryonic stage in the emblematic "pin factory" example of Adam Smith's classic work (1776). The unique character of industrial activities in furthering development is evidenced by the increasing returns derived from greater production scale and the incorporation of technical progress, resulting in greater productivity and also greater income elasticity of demand for their products (KALDOR, 1966). This importance of industry has been reinforced over time by the growing efforts made by other countries—through active State participation—to achieve the level of productive development of the British economy. In this sense, works by Hamilton (2007 [1791]) and List (1989 [1841]) clearly outline the need for public policies to promote industrialization.

Industrial policy instruments were widely used in the first half of the 20th century, not only to further the new industrial pattern but especially within broader public policies aimed at the recovery of economic activities after the 1929 crisis and the war efforts to face the long, devastating world conflicts (BEST, 2018; CHICK, 2018), particularly during World War II, when a widespread process of industrial reconversion and great technological achievements took place (BONVILLIAN, 2021). In the post-war period, there was a consensus that industrialization was an essential condition for development, whether for the reconstruction of war-torn core countries or the catching-up of peripheral ones (FURTADO, 1961; MYRDAL, 2012 [1968]; NISHIJIMA, 2012; PREBISCH, 2000 [1949]). In this context, industrial policy established itself as the main means to achieve such development, taking on a key role in the political and economic debate of the period, although its meaning, scope and instruments varied significantly (ANDREONI; CHANG, 2019; OQUBAY et al., 2020).

Industrial policies started to lose momentum during the economic crises of the mid-1970s, but it was the advance of neoliberal ideas and policies in the 1980s and

1990s—commanded by the US—that was responsible for the decline of active industrial policies. According to Labrunie, Penna and Kupfer (2020), during this period, government action was limited to setting the "rules of the game," besides sponsoring deregulation and privatization policies. In the academic debate, the prevailing trend turned against industrial policies, associating them with government failures and the predominance of rent-seeking behaviors (NAUDÉ, 2010; RODRIK, 2007). Only horizontal policies aimed at improving overall industrial quality and competitiveness were considered by academia and policy makers.

Albeit enfeebled and ousted from the main economic debate, academic production on industrial policy advances in this period, seeking to understand the dynamics of the profound transformations underway in the world economy. On the one hand, the advance of the third industrial revolution, centered on the spread of information technologies in the 1980s and communications in the 1990s, enabled not only the creation of new products and sectors but also a major change in the productive structure, which became centered on global value chains (GVCs) (GEREFFI; HUMPHEY; STURGEON, 2005; HUMPHREY, 2004). On the other hand, new and efficient models of industrial policy—centered on a process of technological learning—were implemented, in some countries of East and Southeast Asia, for example, which enabled active insertion in GVCs. Prominent in this period are the works by Evans (1995), Chang (1994) and Amsden (2001).

In the first two decades of the 21st century, this process of reorganizing production on a global scale, based on technological transformations combined with commercial and financial liberalization, brought about a disruption in the existing relationships between accumulation, innovation, and development within developed countries. Conversely, the same period witnessed the emergence of the vigorous Chinese economy, the result of continuous industrial policies implemented by the State within a comprehensive and bold national development plan (DIEGUES; ROSELINO, 2020). However, due to its territorial, demographic, and geopolitical dimensions, China's exceptional economic progress starts threatening the leadership of developed countries.

Moreover, the first decades of the 21st century also shed light on major long-term challenges that can be summarized in the megatrends presented by multilateral institutions and consulting firms (PRICEWATERHOUSECOOPERS, 2021; UNITED NATIONS, 2020): (i) demographic changes, marked by global imbalances; (ii) accelerated urbanization, straining the infrastructure and social fabric of cities; (iii) climate change and nature degradation, with serious consequences for populations and ecosystems; (iv) the shift in global economic power from the North Atlantic to the Asia-Pacific region resulting from the advance of Asian economies as presented above; (v) technological advances.

Technological advances have brought about the rise of a new techno-productive paradigm, characterized by a large and diversified set of disruptive innovations,

with profound economic and social effects, as listed by the McKinsey Global Institute report (MANYIKA et al., 2013) and the OECD (2017). According to Coutinho et al. (2018), these technologies can be arranged into eight large groups: three of them related to information and communication technologies (artificial intelligence, communications networks, and internet of things); smart factories (innovations directly linked to production); new materials; new energy sources and storage; and biotechnology.

Despite the different analyses, this new techno-productive paradigm has become known as Industry 4.0, a concept originated in Germany in 2011[2] and that served to compile a set of recommendations for the German government and entrepreneurs, aiming to restructure production comprehensively and profoundly. In this sense, the concept is conflated with a Fourth Industrial Revolution. It is worth emphasizing that this process of change does not originate outside the productive structure nor are the technologies freely available in the market to be acquired and incorporated (DAUDT; WILLCOX, 2016). On the contrary, as Diegues and Roselino (2020) note, all these technological transformations have been driven in developed countries by mobilizing initiatives—public and business-oriented—and are aimed at offsetting the advances of the Chinese economy and responding to the challenges posed by the abovementioned megatrends.

In this context of profound structural change, the turning point is the economic crisis of 2008, which marks the end of almost three decades of hegemony of neoliberal thought and policy. From this point on there is a progressive return to explicit industrial policy initiatives, which once again play a key role in the economic policy of developed countries, aiming to reconfigure the determinants of competitiveness and thus regain technological superiority and restore the previous international hierarchy between the productive structures. For example, the emblematic American Recovery and Reinvestment Act, approved in the US in 2009. Labrunie, Penna and Kupfer (2020) also highlight the industrial policies issued in Germany in 2014, named the New High-Tech Strategy – Innovations for Germany, and the United Kingdom in 2017, Industrial Strategy. However, it should be noted that China also seeks to exploit the opportunities provided by changes in the techno-productive paradigm to advance and conclude its catching-up process, especially with the Made in China 2025 and China Standard 2035 policies (CHEN; NAUGHTON, 2016; LEE; 2019).

Industrial policy thus regains a prominent place in the academic debate, resulting in a wide range of approaches seeking to understand how industrial policy strategies contribute to or even determine economic development.

---

[2] This concept was formulated in 2011 by Henning Kagermann, head of the German Academy of Sciences and Engineering (Acatech), and is one of the most used worldwide to refer to the wide range of technological changes that have impacted the world's productive structure (KAGERMANN et al., 2016).

Within the mainstream, the main industrial policy propositions relate to the Market Failures Approach, to the effect that public policy interventions should privilege knowledge-intensive sectors (AIGINGER; RODRIK, 2020; STIGLITZ; GREENWALD, 2015). In turn, Lin (2012) advances within the mainstream approach by proposing the Growth Identification and Facilitation (GIF) strategy, i.e., basing the catching-up process on an industrial policy that stimulates areas related to those that already have clear comparative advantages. Along the same lines, Hidalgo and Hausmann (2009) present the strategy of industrial diversification based on similarity with exported products, the Space Product Approach. Despite making significant contributions to the academic debate, the strategies lack the boldness observed in the case of the "Asian Tigers" (Singapore, Hong Kong, South Korea, and Taiwan), in which competitive advantages were developed in a dynamic and non-linear manner (CHANG; ANDREONI, 2016).

The context discussed in the previous paragraphs gives rise to a renewed debate—political and academic—on industrial policy as a key element to forge the transition from the techno-productive paradigm to Industry 4.0 and partially circumvent the inherent tensions of the dynamics of capital accumulation that were heightened after the 2008 crisis. However, despite the important contributions previously mentioned, there is a relevant gap in the literature: the lack of dialogue and complementarity between the principal non-mainstream analytical trends—neo-Schumpeterian and developmentalist.

It is precisely from this viewpoint that this paper seeks to contribute to the debate by proposing a typology that, based on the establishment of a dialogue between these two analytical trends, circumvents certain limitations associated with each of them. The proposed approach theoretically supports the design of industrial policies that move from overly general normative guidance to guidelines grounded in the simultaneous understanding of the specificities of encouraged activities based on (i) the degree of effectiveness of industrial policies, (ii) the level of technological and innovation capability of agents, and (iii) the degree of transversality of those activities.

To this end, like in Chang (1994), this paper starts out from a strict definition of industrial policy, understood as well-defined initiatives with clear and measurable goals, aimed at specific sectors and activities, that seek to encourage efficiency and structural change. This definition, still in line with that proposed by Chang (1994), emphasizes the particular character of industrial policy. Thus, it excludes "policies designed to affect industry in general (for example educational investment, infrastructural development," and also "policies aimed principally at categories other than industry (for example regional policy, 'group-oriented' policy) from the domain of industrial policy" (CHANG, 1994, p. 60-61). Although these policies have indirect impacts on industrial dynamics, like in Chang (1994), this paper understands that they should not be conflated

with actual industrial policies. Additionally, as suggested by the neo-Schumpeterian approach, the definition of industrial policy used in this work argues that the search for efficiency must be intrinsically associated with the encouragement of innovative learning and creative destruction processes. In other words, what Cimoli et al. (2007) call innovation or Schumpeterian efficiency.

Having presented the definition used by this paper to justify the proposition of a normative typology based on the dialogue between neo-Schumpeterians and developmentalists, a discussion is in order on some of the limitations of those interpretations when taken in isolation, starting with developmentalism. In this work, it is understood as contributions derived from the analytical matrix named Developmental State (AMSDEN, 1989; CHANG, 1994; EVANS, 1995; JOHNSON, 1982; WADE, 1990)

Its main contributions are based on the analysis of catching-up processes in Japan, South Korea, Taiwan, and China. Among the main common traits of the industrial policies that enabled those processes, the Developmental State trend suggests: (a) the presence of a vigorous public bureaucracy, with autonomy and effectiveness for policy making and socio-political embeddedness (EVANS, 1995); (b) a high level of direct and indirect State control over the economy's accumulation dynamics; (c) a reasonable degree of previous social homogeneity; (d) strong State/private sector cooperation, coordinated by the former and subordinated to the logic of national development; (e) low penetration of international capital in the domestic economic structure; (f) direct and indirect State control over the financial system, subordinating it to production; and (g) the existence of an international scenario/geopolitical context reasonably conducive to national catching-up strategies.

Prominent among recent contributions of developmentalism to international literature are works by Ha Joon-Chang and Antonio Andreoni, as mentioned above. In Chang and Andreoni (2016), specifically, the authors aim to "[…] after reviewing three centuries of economic debate on industrial policy […] develop a new theory of industrial policy, incorporating some issues neglected in the debate so far and taking into account the recent changes in economic reality" (CHANG; ANDREONI, 2016, p. 1). Generally speaking, the great effort made by the authors—in both this and countless other works—seems to focus mainly on what they call "bringing production back" (ANDREONI; CHANG, 2017). That is, to revive the centrality of production as a subject of analysis for industrial policy (ANDREONI; TREGENNA, 2019).

Although it is an important contribution, largely in agreement with the interpretation of this work, for the authors of this paper its analyses still seem fairly restricted to the framework present in Chang (1994), who is an important exponent of the classic readings of the Developmental State, typical of the techno-productive pattern of the transition from the Second to the Third Industrial Revolution in the last quarter of the 20th century.

In pointing out the limitations of these interpretations, there is absolutely no intention to question their premises and fundamentals. Quite the contrary, given that this paper supports the same analytical trend. What is intended is precisely to point out a few gaps with regard to the feasibility of reproducing these strategies in the current context of changes of the techno-productive paradigm, among which we can mention: (a) fragmentation of production, (b) emergence of GVCs, (c) servitization of industrial activities, (d) advanced digitization of production, (e) blurred boundaries between sectors, and (f) the effort to develop Industry 4.0, among others. Some of these gaps, in turn, seem to derive, to some extent, from the lack of dialogue with the contributions of neo-Schumpeterian literature.

The first gap concerns the fact that recent contributions of developmentalism have, at least partially, neglected the dynamics of technology learning through encouragement to build "dynamic capabilities" (KHAN, 2019; PISANO, 2017; TEECE; PISANO; SHUEN, 1997)[3], whether within organizations or national or sectoral innovation systems (FREEMAN, 1995; LUNDVALL, 1992; NELSON, 1993). Despite stressing the accelerated changes stemming from the digitization of the economy, Chang and Andreoni (2016) and Andreoni and Chang (2019) analyze learning almost as a by-product of the logic of concentration of investment in large companies in order to enable increase in economies of scale, as is quite typical of the works of the Developmental State in the last quarter of the 20th century. More than that, they seem quite skeptical of neo-Schumpeterian smart policy suggestions. According to the authors,

> the above discussion about learning in production has some important implications for industrial policy design. In the last couple of decades, much emphasis has been put on 'smart' industrial policies that encourage knowledge generation (investments in education and R&D), against those clumsy, traditional ones that provide protection and subsidies. However, once we recognise the importance of learning in production, we begin to see that no amount of 'smart' policies will generate innovation without those 'dumb' policies that keep firms in business and help them expand their production. (ANDREONI; CHANG, 2019, p. 24)

This limitation is further intensified in a setting of increasing integration between knowledge-intensive services and manufacturing, since the dynamics of competition and learning in these activities is quite different compared to the typical industrial

[3] "We define dynamic capabilities as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. Dynamic capabilities thus reflect an organization's ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions" (TEECE; PISANO; SHUEN, 1997).

pattern of the techno-productive paradigm in which the Asian countries developed their catching-up strategy.

Finally, the recent discussion of developmentalist studies still seems to be basically centered on large, State-owned (or very close to the State) groups, typical of Asian configurations. Thus, given the centrality of this agent as a seemingly *causa causans* of structural transformation, gaps are observed in the systemic understanding of the logic of competition and innovation in the current context of transition of the techno-productive paradigm. This would require, as the neo-Schumpeterians show, an analysis that incorporates a higher level of transversality and a greater number of agents, as well as of their interactions.

Once again, it is necessary to stress that this work in no way underestimates the importance of large conglomerates and State-owned companies as instruments for the operationalization of industrial policy. On the contrary, their essentiality in this regard is totally acknowledged, especially in developing countries and contexts of increased inter-capitalist and inter-State competition, such as those that mark the transition of techno-productive paradigms. However, this article aims to highlight the need to understand the dynamics of competition and innovation from a broader outlook of the economic spectrum, capable of incorporating recent changes in these dynamics from a systemic perspective. Also worth noting are the difficulties of reproducing the strategy of full coordination in a context of weakening investment capacity of nation states and consolidation of an international institutionality that restricts industrial policy's room for maneuver (CHANG; ANDREONI, 2016).

Despite these limitations, recent contributions by developmentalists emphasize two important guidelines for formulating industrial policies in the current context of paradigmatic transition that are also key to the typology proposed by this article. The first states that, despite the limitations mentioned above, industrial policies should consider the prior assessment of their capacity to be truly effective (accounting for the global dynamics of accumulation, competition and innovation in each area of activity) (ANDREONI; CHANG, 2019). To this end, it suggests that both policies and institutions should undergo constant transformation to adapt to the changes of the targets of encouragement (ANDREONI, 2020; KATTEL; DRESCHSLER; KARO, 2022).

The understanding of institutional change as an element to enable learning and the building of dynamic capabilities, in turn, is a fundamental element in the analysis of the neo-Schumpeterian trend. Development is understood here as an evolutionary process of change aimed at increasing Schumpeterian efficiency.[4] To this end, according

[4] Schumpeterian efficiency opposes the static perspective of Ricardian allocative efficiency by highlighting its structural dimension since it is associated with diversification towards sectors of greater appropriability and innovation dynamism (Schumpeterian efficiency). See Dosi, Pavitt and Soete (1990).

to authors such as Nelson and Sampat (2001) and Nelson (2008), the institutionality and transformations of the selection environment are key elements to create feedback flows of interaction and knowledge exchange, thus stimulating the emergence of the creative destruction process.

By understanding this process basically from a systemic perspective, neo-Schumpeterian authors circumvent the limitation previously suggested as a characteristic of developmentalism. However, in yet another symptom of the lack of dialogue between the two trends, these authors seem to at least partially neglect important aspects related to the dynamics of investment and production presented by developmentalists.

In other words, the normative guidance based on so-called smart policies seems to focus on dimensions that are excessively intangible, general, and disconnected from the specificities associated with the market structure in each economic sector. Thus, suggestions such as stepping up innovation efforts and fostering interactions between different agents of innovation systems, for example, often emerge as a comprehensive normative corollary that dispenses with the analysis of important factors derived from the market structure, such as investment dynamics, company size and profile, funding structure and adherence of the innovation effort to the productive structure and pattern of local demand.

Briefly speaking, company specificities seem to be understood based solely on their different levels of technological capabilities, disconnected from the dynamics of accumulation that characterize their areas of activity. It is precisely because of these traits that the authors of the developmentalist approach are skeptical about smart policies and suggest the need for "bringing production back" as a main subject of analysis to understand structural transformation and development.

Once again one can observe that this paper admits the centrality of industrial policy to encourage learning efforts towards building dynamic capabilities, even more so in a setting of transition of the techno-productive paradigm. In no way is such normative guidance contested here. On the contrary, the typology proposed by this work aims to contribute to the understanding of this phenomenon in a more comprehensive way by also ascribing importance to the market structure as a subject of analysis, based on the dialogue with the contributions of developmentalist authors.

Lastly, also prominent in the neo-Schumpeterian approach are the contributions associated with mission-oriented policies, especially works by Mariana Mazzucato. Based on a viewpoint highly suggestive of a normative corollary, Mazzucato, Kattel and Ryan-Collins (2020) summarize the guidelines of what would be required to develop a new paradigm of innovation policy. To this end, they suggest that such guidelines should be directed towards missions invariably associated with the great challenges imposed on society (such as population aging, global warming, energy transition, reduction of inequality, among others). These require permanent transformations within public

organizations to encourage the creation of dynamic capabilities, enabling them to meet and adapt to the new challenges imposed on public policies.

In turn, the effectiveness of these policies based on the entrepreneurial state require, in the long term, the construction of a symbiotic relationship between the State and the private sector, comprising a process of socialization of the positive results of innovation rather than a relationship that the author calls dysfunctional and parasitic, in which the private sector benefits from the public sector's long-term efforts to encourage potentially disruptive innovations in their budding stages (MAZZUCATO, 2013).

Although this article supports this perception of reorganizing policies and institutions in order to encourage the construction of a symbiotic innovation system, the interpretation based on mission-oriented policies also presents some gaps that suggest caution in the quest for its widespread replication in different economic and political contexts.

The first of them is especially important for the purpose of this article and concerns the very understanding of industrial policy. Indeed, the normative corollary proposed in Mariana Mazzucato's works is more closely related to an economic policy that fosters growth based on innovation than to conventional definitions of industrial policy. That is because, according to the author herself, this policy should simultaneously comprise (i) encouragement of general-purpose technologies, (ii) structural transformation, (iii) incentive to new growth vectors and (iv) transition to a new framework of development. All this in a context in which "financial and accounting reforms should be regarded as a prerequisite for any successful smart and inclusive growth plan" (MAZZUCATO; KATTEL; RYAN-COLLINS, 2020, p. 433). In other words, the scope of the policy framework transcends stricter definitions of industrial policy, such as the one suggested by Chang (1994) and on which this article is based.

Another limitation of mission-oriented policies is the fact that they seem to focus excessively on the goal of encouraging major transformations, often revolutionary in nature, given their breadth, pervasiveness, and direction towards reorganizing founding elements of the economic system. Therefore, they seem to be associated with policy goals more closely related to countries that are already on the technological frontier.

This fact, in turn, raises questions about the feasibility of reproducing the policies in developing countries, given that their main goal is catching-up. The difficulties of organizing the institutional framework and mobilizing political and economic efforts in those countries for such comprehensive action is also noteworthy. That would require an enormous amount of resources, extremely complex coordination, and a long maturation period.

The third limitation concerns the fact that the corollary of mission-oriented policies is based on the US national innovation system, which means that efforts to replicate the guidelines in developing countries is limited by the frailty of their national innovation systems.

Last but not least, even in the case of developed countries, such policies place little emphasis on elements that are key to their effectiveness and to the dynamics of innovative

learning, namely the characteristics of business structures (such as type of company, capital origin, etc.) and markets (productive structure profile, previous levels of production and technology capabilities, heterogeneity, among others). In short, there seems to be no mediation between the initial picking-up process of the technologies to be encouraged, the future materialization of those technologies in leading companies and the great structural transformations desired.

Despite the critical interpretation presented in this section, generally speaking, the viewpoint of this article is that the gaps suggested in the developmentalist and neo-Schumpeterian analytical approaches basically stem from the lack of dialogue between them. In other words, they are not derived from conceptual issues and serious gaps in the fundamentals of the respective trends. In this sense, this article seeks to contribute to the literature by establishing a dialogue between these analytical currents and thus proposing a typology of industrial policy capable of supporting a normative guidance that considers the specificities of the encouraged activities and the respective production and institutional structures to which they belong.

2. SUGGESTION FOR A NORMATIVE TYPOLOGY BASED ON THE DIALOGUE BETWEEN NEO-SCHUMPETERIANS AND DEVELOPMENTALISTS

Based on the analysis of the gaps in the principal non-mainstream approaches to industrial policy—neo-Schumpeterian and developmentalist—this section aims to develop a typology based on the dialogue between them. Thus, there is the intention to revive the centrality of the relationship between industrial structure and its heterogeneity and the requirements of the catching-up process, in the manner of the developmentalists. However, there is also the intention to incorporate to those constraints the levels of technology and innovation capability as main variables for competitive dynamics in a context of transition of the techno-productive paradigm, as suggested by the neo-Schumpeterian interpretations based on 'smart policies.' Finally, as a further effort to establish a dialogue between these approaches, the article aims to analyze the capacity for permanent institutional transformation as a guiding element for the applicability, coordination, and enforcement of industrial policies, as suggested by the interpretation based on mission-oriented policies.

The construction of this typology and of the ensuing policy proposals is based on three logical steps, as shown in Figure 1. Roughly speaking, a first requirement is to understand the competitive dynamics—in the broad sense, including the innovation and accumulation spheres—of the target to be encouraged through industrial policy. This target must be understood based on different forms of materialization, such as activities, sectors, links in GVCs, among others.

In this context, it is worth highlighting the understanding of how these materializations are determined by the direct and indirect influences stemming from their relationship with GVCs. In other words, the encouragement of activities inserted in GVCs as low-skilled work-intensive assembly activities imposes substantially different constraints from those observed in an industrial activity whose main sources of revenue and technological dynamism are endogenous (GEREFFI, 2014; GEREFFI; HUMPHEY; STURGEON, 2005) or which are inserted in GVCs as suppliers of highly specialized and value-added inputs, even if subordinated to companies controlling the chains (DURAND; MILBERG, 2019).

The second logical step in building the typology proposed by the article is to understand the industrial policy constraints (based on the technological and institutional dimensions, the level of development of the business structure and the local systemic competitiveness).

Finally, the third logical step, based on the understanding of those constraints, comprises the construction of a typology that combines local agents' capability level—technological, productive and organizational, the degree of effectiveness of industrial policies and the degree of transversality of the stimulated activities.

Figure 1 – Conceptual framework for the construction of the Industrial Policy typology

Steps	Analyzed elements
1. Analysis of characteristics / competitive, innovation and accumulation dynamics in the activities / sectors / links in value chains	**1.** Systemic determinants of competitiveness Business determinants of competitiveness Value chain structure Kinds of activities performed Value generation and appropriation strategy
2. Analysis of Industrial Policy constraints	**2.** Technological Institutional Level of development of the business structure Local systemic competitiveness
3. Construction of the typology and policy guidelines	**3.** Levels of capability—technological, productive and organizational—of local agents Degree of effectiveness of industrial policies Degree of transversality of encouraged activities

Source: Authors' elaboration.

The first logical step starts from the observation that the various forms of materialization of the industrial policy target—activities, sectors and their links with GVCs—must be understood from the viewpoint of a broad segmentation that admits competitive, innovation and accumulation dynamics essentially distinct. Therefore, for each of the different forms of materialization, the effort to build an industrial policy must analyze a number of traits, such as: business determinants of competitiveness,

systemic determinants of competitiveness, structure of the GVC, types of activities undertaken and value generation and appropriation strategy. Thus, by way of illustration, when the competitive dynamics of the activity is strongly influenced by its insertion in a GVC, it will be possible to understand the qualitative differences between links based on geographic/regional aspects—such as the position of car manufacturers in the Brazilian market—or on certain technological capabilities—such as Taiwanese companies that are leaders in specific segments of the global semiconductor chip production chain, among others. And, as suggested by Durand and Milberg (2019), to understand how susceptible these links are to national industrial policy instruments.

Still at this stage, it is suggested that the understanding of the activities targeted by industrial policy must go beyond the well-defined and crystallized borders between industry and services, as typical of the production paradigm of the 2nd Industrial Revolution, which is based on a logic of vertical integration and roughly underpins the main analyses and derivations of industrial policies of the developmentalist approach. That is because one of the characteristics, and at the same time one of the empowering elements of the transformations underway in the current techno-productive paradigm, is the growing penetration of knowledge-intensive services in manufacturing activities, whose definitive expression seems to be so-called Industry 4.0 (ANDREONI, 2020).

Thus, a consequence of the imperative to reassess the relationship between industrial density and development is the need to understand the role played by technology services in the competitive dynamics of industrial activities. As Andreoni (2020) emphasizes, as a result of these transformations, "industrial policy targeting requires a focus on key parts of modern industrial ecosystems. New heuristics are critical to reveal opportunities and challenges within sectoral value chains and those nested at the interstices of industrial ecosystems" (ANDREONI, 2020, p. 389).

From the analysis of competitive dynamics and its relationship with industrial policy, the second logical step of the approach suggested by this work analyzes the constraints of industrial policy based on four dimensions.

In the *technological dimension*, one of the main constraints to be observed is the degree of horizontality and standardization of the technologies in question. As reminded by Borrus and Zysman (1997), the higher this degree, the greater tend to be the network externalities derived from the use of this technology and, therefore, the greater the lock-in effects. This fact, very typical of technologies with a high degree of generality, also called general-purpose technologies (GPT), invariably leads to a predominant trend of few technological platforms and the consequent concentration of market structures in a reduced number of global scale agents (KENNEY; ZYSMAN, 2016).

In contexts where such characteristics predominate, it is assumed that the possibilities of implementing industrial policies are fairly restricted (such as supporting specific national telecommunications standards opposed to those prevailing in the European

and US markets, derived from the evolution of CDMA and GSM). In turn, in cases where there is a low degree of generality of the technical base, low network externalities and reduced lock-in effects, market structures tend to be less concentrated. Therefore, industrial policies tend to be more effective (such as encouraging startups to develop specific software for healthcare systems and other public services heavily influenced by local and/or national contexts). Numerous other constraints are also present in the technological dimension, such as the cumulative character of learning, the absorption capacity of agents (COHEN; LEVINTHAL, 1989), the systemic nature of learning (FREEMAN, 1995; LUNDVALL, 1992; NELSON, 1993), the high degree of uncertainty and high financial costs for the development of disruptive innovations (MAZZUCATO, 2013) and the need for minimum scales of efficiency to make the budding technologies economically competitive. All these elements, to a greater or lesser extent, can be seen in the barriers to the current Chinese effort to stimulate the capabilities required for the development and manufacture of semiconductor chips at the technological frontier and thus circumvent the restrictions imposed by the US on access to machines and equipment of the semiconductor production chain that have US on-board technologies (DIEGUES; ROSELINO, 2023).

In the *institutional dimension*, it is suggested that the constraints for the elaboration of policies are based on two prerequisites. First, the capabilities related to the conception, design and implementation of policies. Then, as Cimoli et al. (2007) and Andreoni and Chang (2019) argue, given that the development process is marked by continuous imbalances, the institutional infrastructure must be able to undergo transformation and adapt permanently to the new conditions imposed by this process. Thus, according to the authors, in this viewpoint one may even say that industrial policy is a process of "political economy of institutional change." In line with this interpretation, the studies by Diegues and Roselino (2023), Naughton (2021) and Chen and Naughton (2016) illustrate the different processes of institutional change that characterized the evolution of industrial policies in China and show that the co-evolution of institutions and policies is one of the elements that explain the virtuous character of its catching-up strategy. In turn, Edquist (2019) presents advances in Swedish industrial policy based on the adoption of a new and integrated institutional model.

Along the same lines, Suzigan and Furtado (2010) stress that the institutional dimension must be able to adapt to the characteristics of a logic of accumulation that is quite different from the typical production pattern. This, in turn, is key to increasing the effectiveness of industrial policy in a context of transformations in the techno-productive paradigm marked by the digitization and servitization of production. It is worth noting, however, that despite the need to adapt the institutional infrastructure, the policy formulation strategy must always consider its effective capacity to influence the decisions of economic agents.

The third constraint for the elaboration of industrial policies proposed by this typology concerns *company capital control*, given its relevance to the degree of effectiveness of these policies. The greater the autonomy, level and learning capacity of these agents, the greater tend to be the possibilities for implementing policies (COHEN; LEVINTHAL, 1989) and their effects on the building of dynamic capabilities (TEECE; PISANO; SHUEN, 1997). This is illustrated by sectors with a historically strong presence of national companies and solid trajectories of building capabilities (technological, productive and organizational), such as the long-term Brazilian industrial policy aimed at increasing the technological capability of Embraer in the aeronautical sector (FERREIRA, 2021).

Conversely, in segments financially and technologically dominated by multinational companies, in which the market and domestic capabilities are hardly relevant to their global strategies, industrial policies tend to not be as effective. As illustrative cases we can mention the difficulties faced by Brazil and India to enable the development of high value-added sectors in the electronics industry—mainly semiconductor chips—despite decades of efforts (ERNST, 2014; SALLES FILHO et al. (2012).

Finally, understanding the *systemic constraints* also proves to be essential for the effectiveness of industrial policies, especially in a context characterized by the widespread presence of global production and innovation chains (COUTINHO et al, 2015; FREEMAN, 1995; LUNDVALL, 1992; NELSON, 1993). The main point to be highlighted is that, given the logic of the chains, systemic constraints should be evaluated from an international comparison perspective. In other words, levels of cost, productivity, accumulation, growth potential, innovation, etc., are permanently reassessed by economic agents in the continuous renewal of their business strategies.

In this context, the design of industrial policies should consider such analyses from a comparison perspective and seek to build different strategies for different materializations of global value chain links. By way of illustration, countries with complex innovation systems would have greater scope to formulate a strategy that seeks to stimulate the development of local technological solutions, as can be seen in the German initiatives systematized in *Plattform Industrie 4.0* to position their main companies—such as Siemens, Bosch, BMW, etc.—as leaders in establishing technological standards related to the emerging Industry 4.0 (HORST; SANTIAGO, 2018).

On the other hand, those countries in which the most relevant systemic features are related to a domestic consumer market with high growth potential would have relative advantages for the development of local production compared to countries with less thriving consumer markets and lacking minimum efficient scale. Thus, they could direct their strategies towards the development of increasingly complex local production alongside market growth—as is the recent case of both production and technology development of the electric vehicle sector in China, according to Teece (2019).

Based on the understanding of these industrial policy constraints from an international comparison perspective, the third logical step of the approach suggested by this work seeks to present industrial policy guidelines based on the combination of three variables (as briefly mentioned previously):

(i) local agents' capability level—technological, productive and organizational (COHEN; LEVINTHAL, 1989; KHAN, 2019; PISANO, 2017; TEECE; PISANO; SHUEN, 1997);
(ii) the degree of effectiveness of industrial policies (AMSDEN, 2001; ANDREONI; CHANG, 2019; BEST, 2018; EVANS, 1995; KATTEL; DRESCSHLER; KARO, 2022); and
(iii) the degree of transversality of the stimulated activities (ANDREONI, 2020; FAGERBERG, 2017; FREEMAN, 1995; HIRSCHMAN, 1958; KALDOR, 1966; KENNEY; BEARSON; ZYZMAN, 2021; LUNDVALL, 1992, 2016; NELSON, 1993; PÉREZ, 2010).

The analysis of the levels of production and technological capability as a guiding element for the definition of industrial policies relates to neo-Schumpeterian contributions. It is assumed that the learning process of companies have cumulative effects, which conditions their future trajectories of reinforcement of this process and, consequently, the potential effects of the industrial policy. In turn, the interaction between this learning process and the policy effects shapes the way in which the company's dynamic capabilities are built (COHEN; LEVINTHAL, 1989; KHAN, 2019; PISANO, 2017; TEECE; PISANO; SHUEN, 1997). Thus, they are responsible for defining the level of production and technological capabilities of the agents targeted by the industrial policy.

As indicators capable of measuring the efforts to foster production and technological capability, one can cite (always in an international comparison perspective): innovation efforts focused on R&D expenditures, the number of staff occupied in STEM areas (Science, Technology, Engineering and Mathematics), capital expenditure (acquisition of machinery and equipment, etc).

As indicators that could directly or indirectly measure these efforts results the paper suggests: number of patents, productivity level, revenues from intellectual property, level of revealed comparative advantage, percentage of exports in relation to net revenues, rate of innovation, among others.

The understanding of the second variable that guides the construction of the typology—industrial policies—benefits mainly from interpretations of developmentalist contributions. As stated in Evans (1995), greater effectiveness is conditioned by the degree of autonomy and embeddedness of policy makers. Amsden (2001), Chang (1994), Andreoni and Chang (2019) and Best (2018) also emphasize, as important elements for the effectiveness of policies aimed at structural transformation and catching-up, the power of direct and indirect State control over the accumulation dynamics of the economy—based

on key macroeconomic prices—and strong State/private sector cooperation, coordinated by the former and subordinated to the logic of national development.

In the empirical dimension, one can list some indicators that are correlated with a greater potential for policy effectiveness: the existence of solid institutional infrastructure for designing, applying and evaluating the policy, high capacity for institutional enforcement of the imposed constraints, a relevant role of national companies—particularly of State-owned ones—in the market structure of the sectors/activities targeted by the policy, high relevance of the local market for the stimulated businesses, relevant impact of public procurement and development bank funding on the dynamics of learning and accumulation of the stimulated activity/sector, among others.

However, it is worth mentioning that, as is well-known, the effectiveness of industrial policies involves a high degree of uncertainty, given their intrinsic characteristics of fostering structural transformation. Thus, the elements introduced in the previous paragraph are indicators rather than a priori definers of potential effectiveness since, as Schumpeter (1934) reminds us, structural transformation is essentially a process marked by permanent imbalances.

The third variable for the construction of the typology—degree of transversality of stimulated activities. The transversality concept adopted by this paper is based on an assumption that some activities present higher potential of spreading technical progress diffusion and enabling endogenous and sustainable economic growth, contributing to fostering productivity and efficiency among several sectors. So, the paper concept dialogues with classic structuralist literature (HIRSCHMAN, 1958; KALDOR, 1966) that identifies these transversality effects as an intrinsic characteristic of manufacturing activities. In a broader sense, the present paper emphasizes that these pervasive effects are also strongly observed in modern services (RODRIK, 2014; STOJKOLKI; UTKOVSKI; KOCAREV, 2016), especially in knowledge-intensive ones. As Andreoni (2020) and Roselino and Diegues (2020) point out, fostering these transversality effects in order to reconfigure competition and innovation dynamics is one of the main expected results of the tech-paradigm transition to smart manufacturing or Industry 4.0.

In sum, the transversality concept adopted by this paper benefits from elements stemming from both the neo-Schumpeterian and developmentalist approaches. Classical works by the latter stress the importance of the effects of inter- and intra-sectoral linking and demand of industrial activities (HIRSCHMAN, 1958) and their potential as vectors for the transmission of technical progress and increased productivity in other economic sectors (KALDOR, 1966). Recent literature emphasizes the complementarity among manufacturing and knowledge-intensive services and the emergence of platforms as key elements to analyze competition and innovation (ANDREONI, 2020; KENNEY et al, 2021; PÉREZ, 2010). Neo-Schumpeterian interpretations, in turn, stress the essentially systemic nature of competitiveness and the dynamics of technological

and innovative learning. Thus, traits such as fostering interaction as an instrument for the spread of tacit knowledge among the various agents of the national innovation system are critical to enhancing the effects of industrial policy (FAGERBERG, 2017; FREEMAN, 1995; LUNDVALL, 1992, 2016; NELSON, 1993).

In the empirical dimension, in order to identify the degree of the transversality of encouraged activities and sectors, potential indicators include those of Rasmussen-Hirschman and others related to the analysis of interaction networks between activities, stimulated technologies and/or patent families, among others.

To better visualize the combination of these variables, Chart 1 features the overall normative guidelines suggested by the typology. These will be complemented with the inclusion of the three-dimensional axis of the analysis related to the degree of the transversality of activities to produce the final version of the typology, analyzed in greater detail in terms of design and policy implementation.

Chart 1 – Industrial policy guidelines according to degree of policy effectiveness and level of agent capability

		Degree of IP effectiveness	
		High	**Low**
Level of capabilities—technological, productive and organizational—of local agents	**High**	Local technological development	Encouragement of systemic competitiveness and funding of technology-based companies
	Low	Encouragement of medium value-added activities, linked to domestic productive structure	Incorporation of technologies and encouragement of their diffusion to increase productivity in the productive structure

Source: Authors' elaboration.

It is worth mentioning that this typology is presented in the same format for analyzing industrial policy guidelines for both developed and developing countries, regardless of the country's level of technological development and productive structure. As demonstrated earlier, its logical and theoretical construction has exactly as a prerequisite—through the empirical observation of suggested indicators—to contemplate the heterogeneity of productive structure and the need for the coexistence of different strategies according to technological complexities in different countries and regions.

Based on the framework developed in this work, the typology suggests that the adoption of policies aimed mainly at **local technology development** should be characteristic of segments and activities (whether traditionally understood as industry or services) with high levels of policy effectiveness and capability of local agents. In this quadrant, when such activities show high transversality across other economic sectors, traditional neo-Schumpeterian policies stand out, such as encouragement and organization of the National Innovation System, widespread funding for innovative activities, encouragement to employ staff in technological functions as compensation for funding, use of public procurement instruments, technology orders, establishment of pilot

initiatives to foster the spread of technology—such as the German and Chinese initiatives to create demonstration units of smart factories—and even setting specific standards as a means to encourage local technology development (see Figure 2).

Figure 2 – Typology of industrial policy based on degree of policy effectiveness, level of capability of domestic agents and degree of transversality of stimulated activities

A – High effectiveness and high capability Local technology development

High transversality	Low transversality
Encouragement of National Innovation System, widespread funding of innovation activities, encouragement to employ staff in technological functions, public procurement, technology orders, pilot initiatives to foster the spread of technology, encouragement of local technology standards.	Widespread support for technology-based companies and encouragement of startups

B – High effectiveness and low capability
Encouragement of medium added-value industry and service activities linked to domestic productive structure demand

High transversality	Low transversality
Encouragement of medium value-added activities through instruments based on domestic content requirements (linked to activities with the highest level of technology complexity)	Encouragement of activities linked to niches associated with future structural changes in the current techno-productive paradigm

C – Low effectiveness and high capability
Encouragement of systemic competitiveness and funding of technology-based companies

High transversality	Low transversality
High capacity building of human resources, permanent incentive to improve production techniques through extension programs, offer of loans with adequate terms, cost and volume, overall improvements to physical infrastructure	Horizontal policies to reinforce the operation of the institutional system regulating national markets

D – Low effectiveness and low capability
Incorporation of technologies and knowledge-intensive services and encouragement of their diffusion to increase productivity in the productive structure

High transversality	Low transversality
Easy access to imported inputs with potential to increase domestic productivity. Establishment of regulatory stockpiles of raw materials and components considered strategic	No targets

Source: Authors' elaboration.

A set of recent industrial policies that clearly illustrates the situation described in this quadrant of the typology is the US effort to speed up the development of key technologies for Industry 4.0. Such efforts materialized in a number of systemic initiatives to stimulate innovation. Prominent among them are increased funding for research via the National Science Foundation (through The Endless Frontier Act), for training human resources in STEM areas and for the development of semiconductor chips at the technology frontier (with an estimated US$ 52 billion through the CHIPS for America Act) in order to allow the US companies to reduce the gap vis-à-vis TSMC of Taiwan and Samsung of Korea in the production of 5 nm and future-generation chips. In addition, the US government has set up a national network of laboratories and research institutes (National Network for Manufacturing Innovation) aimed mainly at developing smart manufacturing applications and then transferring them to the US productive structure through formal partnership relationships and demonstration effect. In the specific case of semiconductors, the first results have appeared with the subsidies to be used for the construction of two new Intel foundries in the state of Arizona (totaling US$ 20 billion).

Overall, the situation described in this quadrant of the typology is the closest to the ideal for the formulation of industrial policies. However, by highlighting the diversity of constraints present in the formulation of these policies, this typology indirectly illustrates the relative exceptionality of the situations observed in this quadrant. Thus, it evokes one of the limitations pointed out in Section 1, namely that the normative guidance understood as *causa causans* of the virtuous nature of industrial policies is the encouragement of technological development—for both the developmentalists and, especially, neo-Schumpterians. In other words, the analytical effort of this work includes—and supports—the perception that encouragement of technology learning must be pervasive across all industrial policy initiatives. However, the aim is to undertake a more complex analysis of situations to enhance the effects of this guidance by designing policies adapted to the constraints and which take into consideration their level of effectiveness and the degree of capability of local agents.

In summary, although encouragement of learning is key to all initiatives, only in specific cases can local agents be placed in leadership positions in national and international technology development in their respective areas/sectors of activity.

Still in the same quadrant, when the degree of transversality is low, it is generally suggested that policies focus both on widespread support for large technology-based companies and encouragement of startups. An example is the French conglomerate Alstom, which has been working since the 1970s—with decisive support of French industrial policy—on the development and production of high-speed trains (TGV) and is the leader in this market (AUSSILLOUX et al., 2020). On the other hand, an illustrative

case of industrial policy for encouraging startups is found in the policies of the Israel Innovation Authority, which seek to characterize the country as a Startup Nation (WONGLIMPIYARAT, 2016). Given the size of the Israeli economy and the consequent inability to reach minimum efficient scales capable of making local companies leaders in key sectors and activities of the international productive structure, such initiatives seem to be the most appropriate given the level of local technological capabilities.

In cases combining high effectiveness and low capability of local agents, the strategy suggested is to encourage **industry and service activities of medium added value** linked to the demands of the domestic productive structure and the benefits derived from their knowledge of the specifics of local business models. In a context of high transversality, such activities could be encouraged through instruments based on national content requirements (particularly linked to activities with the highest degree possible of technological complexity rather than strict physical metrics only).

This seem to be precisely the case of the main Brazilian industrial policy initiatives, especially those indirectly coordinated by the Brazilian Development Bank (BNDES). In general, in metalworking sectors—given the high scales of production and consequent importance of funding as a competitive instrument—there is a high effectiveness of policies requiring local compensation for access to subsidized BNDES loans. However, given that these sectors are dominated by multinational companies, national ones are inserted in less prominent links of the production chains. Thus, on the one hand, the industrial policies are relatively successful in encouraging local production as a result of domestic demand—cases in point are the automobile and agricultural machinery and equipment industries. On the other hand, however, given the deficiencies in capacity building of local agents, they are limited in terms of addressing the limitation of generalist local content goals and moving towards the demand for gradual compensation related to increased domestic learning (SUZIGAN; FURTADO, 2010). Despite these difficulties, an example of a well-evaluated initiative in this industrial policy quadrant was BNDES' strategy of gradually encouraging the development of a production chain in the wind power segment, formed by local companies such as WEG and Tecsis and transnational companies such as German Wobben (ARAÚJO; WILLCOX, 2017).

Still in the quadrant suggesting encouragement to medium added-value industry and service activities in low-transversality sectors and activities, it is suggested that policies should focus on stimulating activities linked to niches associated with future structural changes in the current techno-productive paradigm. An illustrative program of these guidelines is America's seed fund based on Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR). About these programs, Andreoni (2016) states:

> Some of today's most successful industrial policy measures in the United States have been introduced and continuously supported along various transformation cycles […] This is the case of two programs run by the Small Business Administration (SBA), namely, the Small Business Investment Company (SBIC) and the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR). These programs combine loans, R&D grants, and precommercial public procurement to support small businesses, original equipment manufacturers (OEMs), and specialist manufacturing contractors engaged in the development and scale-up of technological systems or components (sometimes for niche segments). (ANDREONI, 2016, p. 263)

When there is low effectiveness of industrial policies but high level of technological, productive or organizational capability of local agents, the most appropriate guidelines seem to be those aimed at **supporting systemic competitiveness and funding technology-based companies**, both industrial and of knowledge-intensive services. For activities with high transversality, it is suggested that policies focus on measures such as encouraging the development of highly skilled human resources, providing continuous incentive to improve production techniques through extension programs, offering adequate loans in terms, cost and volume, and supporting improvements in overall physical infrastructure. Interesting examples of initiatives in this direction are the US production extension programs (Manufacturing Extension Partnership, created in the 1980s and coordinated by the National Institute of Standards and Technology) and the work of the Fraunhofer institutes in encouraging and transferring technology between agents in the German manufacturing sector. As for activities characterized by low transversality, since policy effectiveness is already low and capability is high, the best measures seem to be horizontal initiatives merely to reinforce the operation of the institutional system regulating national markets.

Lastly, this typology also suggests that there are situations in which the most appropriate industrial policy strategy is based on the incorporation *of technologies and knowledge-intensive services and the encouragement of their diffusion aimed at increasing the productivity of the productive structure* when low policy effectiveness is combined with a low level of capability of local actors. When these activities present high transversality, easy access to imported inputs seems to be an adequate instrument to increase domestic productivity. Once again, the semiconductor chip sector offers important evidence to illustrate the suggestions of this typology. On the one hand, as discussed above, this segment invariably benefits from vigorous industrial policy programs, including in countries on the technological frontier such as the USA and Japan. On the other hand, even in those countries, such policies to encourage local technology development coexist with low import tariffs on these chips. The reason is that due to

the specific characteristics of the segment, such as extremely high minimum efficiency scale and an international market highly concentrated in a restricted number of agents when it comes to next-generation processor chips—Taiwanese TSMC and, to a lesser extent, Korean Samsung—a policy that restricted imports would negatively impact the productivity and competitiveness of other sectors of the economy by reducing their access to products on the technological frontier, even in countries like the USA and Japan.

However, this strategy can be complemented by building strategic stockpiles such as the US National Defense Stockpile (NDS) and China's State Reserve Bureau. Both have a strategic and comprehensive outlook, seeking to ensure the supply of raw materials and essential components for national defense and the functioning of the economy (THE WHITE HOUSE, 2021). It should be noted that, contrary to what is being proposed in this work, the Chinese agency goes beyond strategic issues in some cases and has also been used as an instrument to offset price volatility in some sectors.

In a setting of low transversality of activities, in turn, given the low capacity level of agents and low policy effectiveness, this typology suggests that such activities should not be targeted by industrial policy.

Before concluding, a brief comment is in order. It is worth mentioning that none of the policy suggestions presented by this typology derive from fundamentals that guide the liberal interpretation on the subject, nor do the suggestions presented in the previous paragraph derive from a priori conceptions of the superiority of horizontal policies. In other words, they emerge only a posteriori, from the execution of all the logical steps of the methodology (explained in Figure 1) and from the analysis of the variables that combine to support the construction of the guidelines (explained in Figure 2). The latter, in turn, are theoretically based on the developmentalist and neo-Schumpeterian interpretations of the determinants of competitive dynamics in the activities to be encouraged.

CONCLUSIONS

The acceleration of transformations of the techno-productive paradigm and the intensification of interstate and intercapitalist competition emerge as key elements to understand the renewed debate—theoretical and political—on industrial policy.

This revitalization of the subject occurs in an international context that is substantially different and more complex from the one used to support the formulation of the normative corollaries in the period in which industrial policies reached their peak as key instruments for economic development—between the end of World War II and the rise of neoliberalism.

Thus, the approach proposed in this article aimed to identify gaps related to reproducing traditionally successful industrial policy strategies in the current context of changes in the techno-productive paradigm, marked by (a) fragmentation of production, (b) emergence of GVCs, (c) servitization of industrial activities, (d) advancement in the digitalization of production, (e) dilution of sectoral boundaries, (f) search for the accelerated gestation of Industry 4.0, etc. In other words, the contextualized theoretical analysis on industrial policy expressed in this article, as well as the proposed typology, seeks to contribute to the debate by bringing elements that make it possible to reflect on the design of more effective policies in a context of great transformation of the morphology of global scale production.

By presenting policy suggestions that vary widely in degree and in qualitative terms (including in settings in which they would not be effective), this typology also aimed to include elements that would allow it to go beyond antagonistic (and sometimes binary) interpretations that have historically characterized the debate on industrial policy, including by economists not aligned with the mainstream.

Thus, based on the strategy segmentation presented above, this paper also sought to contribute to the construction of industrial policy guidelines with a greater degree of effectiveness, more suited to the specific characteristics of different national productive structures and based on a systemic understanding of the constraints of production development in a context of increasing international competitive pressures and transition to a new techno-productive paradigm, so-called Industry 4.0.

REFERENCES

AIGINGER, K.; RODRIK, D. Rebirth of Industrial Policy and an Agenda for the Twenty-First Century. *Journal of Industry, Competition and Trade*, v. 20, p. 189-207, 2020.

AMSDEN, A. H. *Asia's Next Giant*: South Korea and Late Industrialization. New York: Oxford University Press, 1989.

AMSDEN, A. H. *et al. The Rise of "The Rest"*: Challenges to the West from Late-Industrializing Economies. Oxford University Press, USA, 2001.

ANDREONI, A. Technical Change: The Shifting Terrain of the 'Industrial' and Digital Industrial Policy. *In*: CHANG, H-J. *et al*. (Eds.). *The Oxford Handbook of Industrial Policy*. Oxford: Oxford University Press, 2020. p. 369-393.

ANDREONI, A. Varieties of Industrial Policy: Models, Packages and Transformation Cycles. *In*: NOMAN, A.; STIGLITZ, J. E. (Eds.). *Efficiency, Finance, and Varieties of Industrial Policy*. New York: Columbia University Press, 2016. p. 245-305.

ANDREONI, A.; CHANG, H. Bringing Production and Employment Back into Development. *Cambridge Journal of Regions, Economy and Society*, v. 10, n. 1, p. 173-187, 2017.

ANDREONI A.; CHANG, H.-J. The Political Economy of Industrial Policy: Structural Interdependencies, Policy Alignment and Conflict Management. *Structural Change and Economic Dynamics*, v. 48 (Special Issue: Frontiers of Industrial Policy: Structures, Institutions and Policies), p. 136-150. 2019.

ANDREONI, A.; TREGENNA, F. Beyond the Inverted U: The Changing Nature and Structural Heterogeneity of Premature Deindustrialisation. *In*: INTERNATIONAL WORKSHOP: THE FUTURE OF INDUSTRIAL WORK: NEW PATHWAYS AND POLICIES OF STRUCTURAL TRANSFORMATION? UNIDO, Vienna, 19-20 Sept. 2019. *Proceedings* [...]. Vienna: UNIDO, 2019.

ARAÚJO, B. P.; WILLCOX, L. D. Reflexões críticas sobre a experiência brasileira de política Industrial no setor eólico. *BNDES Setorial*, v. 47, p. 163-220, 2017.

AUSSILLOUX, V. *et al. Industrial Policies in France Developments and International Comparisons. Note de synthèse*, p. 1-12, déc. 2020.

BEST, M. H. *How Growth Really Happens*: The Making of Economic Miracles through Production, Governance, and Skills. Princeton: Princeton University Press. 2018.

BONVILLIAN, W. B. Emerging Industrial Policy Approaches in the United States. *Information Technology and Innovation Foundation*, p. 1-36, Oct. 2021.

BORRUS, M.; ZYSMAN, J. Wintelism and the Changing Terms of Global Competition: Prototype of the Future? *BRIE Working Paper 96B*, p. 1-23, 1997.

CHANG, H.-J. *The Political Economy of Industrial Policy*. London: Macmillan. 1994.

CHANG, H-J; ANDREONI, A. Industrial policy in a changing world: basic principles, neglected issues and new challenges. *Cambridge Journal of Economics*, v. 40, 2016.

CHEN, L; NAUGHTON, B. An Institutionalized Policy-Making Mechanism: China's Return to Techno-Industrial Policy, *Research Policy*, v. 45, n. 10, p. 2138-2152, 2016.

CHICK, V. Industrial Policy, Then and Now. *Real-World Economics Review*, n. 84, p. 178-188, 19 June 2018. Disponível em: http://www.paecon.net/PAEReview/issue84/Chick84.pdf. Acesso em: out. 2021.

CIMOLI, M. *et al*. Instituições e políticas moldando o desenvolvimento industrial: Uma nota introdutória. *Revista Brasileira de Inovação*, v. 6, n. 1, jan./jun. 2007.

COHEN, Wesley M.; LEVINTHAL, Daniel A. Innovation and Learning: The Two Faces of R & D. *The Economic Journal*, v. 99, n. 397, p. 569-596, 1989.

COUTINHO, L. G. *et al*. (Coord.). *Mapa de clusters tecnológicos e tecnologias relevantes para a competitividade de sistemas produtivos*. Documento Interno de Trabalho. Rio de Janeiro: IE-UFRJ; Campinas: IE-Unicamp, 2018.

COUTINHO, L.; KUPFER, D.; DE TONI, J. DEZ anos de política industrial: balanços e perspectivas (2004-2014). Brasília, DF: ABDI, 2015.

DAUDT, G. M.; WILLCOX, L. D. Reflexões críticas a partir das experiências dos Estados Unidos e da Alemanha em manufatura avançada. *BNDES Setorial*, n. 44, p. 5-45, set. 2016.

DIEGUES, A. C.; ROSELINO, J. E. Editorial: Política industrial e Indústria 4.0: A retomada do debate em um cenário de transformações no paradigma tecnoprodutivo. *Revista Brasileira de Inovação*, v. 19, p. e0200032, 2020. DOI: https://doi.org/10.20396/rbi.v19i0.8661724.

DIEGUES, A. C.; ROSELINO, J. E. Industrial Policy, Techno-Nationalism and Industry 4.0: China-USA Technology War. *Brazilian Journal of Political Economy*, v. 43, n. 1, p. 5-25, 2023.

DOSI, G., PAVITT, K.; SOETE, L. *The Economics of Technical Change and International Trade*. New York: New York University Press, 1990.

DURAND, C.; MILBERG, W. Intellectual Monopoly in Global Value Chains. *Review of International Political Economy*, v. 27, n. 2, p. 1-26, 2019.

EDQUIST, C. Towards a Holistic Innovation Policy: Can the Swedish National Innovation Council (NIC) be a Role Model? *Research Policy*, v. 48, n. 4, p. 869-879, 2019. DOI: https://doi.org/10.1016/j.respol.2018.10.008.

ERNST, D. *Upgrading India's Electronics Manufacturing Industry*: Regulatory Reform and Industrial Policy. East-West Center: Honolulu, 2014.

EVANS, P. B. Embedded Autonomy: States and Industrial Transformation. Princeton: University Press, 1995.

FAGERBERG, J. Innovation Policy: Rationales, Lessons and Challenges. *Journal of Economic Surveys*, v. 31, n. 2, p. 497-512, 2017.

FERREIRA, M. J. B. Indústria aeronáutica brasileira: As especificidades de um modelo nacional de inserção global. *In*.: DIEGUES, A. C.; SARTI, F. (Orgs.) Brasil: indústria e desenvolvimento em um cenário de transformação do paradigma tecnoprodutivo. Curitiba: CRV; Campinas: IE-Unicamp, 2021. p. 219-239.

FREEMAN, C. The "National System of Innovation" in Historical Perspective. *Cambridge Journal of Economics*, v. 19, n. 1, 1995.

FURTADO, C. *Desenvolvimento e subdesenvolvimento*. Rio de Janeiro: Fundo de Cultura, 1961.

GEREFFI, G. Global Value Chains in a Post-Washington Consensus World. *Review of International Political Economy*, v. 21, n. 1, p. 9-37, 2014.

GEREFFI, G. HUMPHEY, J.; STURGEON, T. The Governance of Global Value Chains, *Review of International Political Economy*, v. 12, n. 1, p. 78-104, 2005.

HAMILTON, Alexander. *Report on the Subject of Manufactures*. United States: Cosimo, Inc., 2007 [1791].

HIDALGO, C. A.; HAUSMANN, R. The Building Blocks of Economic Complexity. *Proceedings of the National Academy of Sciences*, v. 106, n. 26, p. 10570-10575, 2009.

HIRSCHMAN, A. The Strategy of Economic Development. New Haven: Yale University Press, 1958. v. 10.

HORST, J.; SANTIAGO, F. *What Can Policy Makers Learn from Germany's Industrie 4.0 Development Strategy?* Vienna: UNIDO, 2018. (Working Paper, 22).

HUMPHREY, J. *Upgrading in Global Value Chains*. Geneva: ILO, 2004.

JOHNSON, C. *MITI and the Japanese Miracle*. Stanford: Stanford University Press, 1982.

KAGERMANN, H. *et al*. *Industrie 4.0 in a Global Context*: Strategies for Cooperating with International Partners. Munich: Herbert Utz, 2016.

KALDOR, N. *Causes of the Slow Rate of Economic Growth of the United Kingdom*. Cambridge: Cambridge University Press, 1966.

KATTEL, R.; DRESCHSLER, W.; KARO, E. *How to Make an Entrepreneurial State*: Why Innovation Needs Bureaucracy. New Haven: Yale University Press, 2022.

KENNEY, M. *et al*. Platforms and Industrial Change. *Industry and Innovation*, v. 26, n. 8, p. 871-879, 2019.

KENNEY, M.; BEARSON, D.; ZYZMAN, J. The Platform Economy Matures: Measuring Pervasiveness and Exploring Power. *Socio-economic Review*, v. 19, n. 4, p. 1451-1483, 2021.

KENNEY, M.; ZYSMAN, J. The Rise of the Platform Economy. *Issues in Science and Technology*, v. 32, n. 3, p. 61-69, 2016.

KHAN, M. Knowledge, Skills and Organizational Capabilities for Structural Transformation. *Structural Change and Economic Dynamics*, v. 48, p. 42-52, 2019.

LABRUNIE, M. L.; PENNA, C. C. R.; KUPFER, D. The Resurgence of Industrial Policies in the Age of Advanced Manufacturing: An International Comparison of Industrial Policy documents. *Revista Brasileira de Inovação*, v. 19, p. e0200020, 2020.

LEE, K. *The Art of Economic Catch-Up*: Barriers, Detours and Leapfrogging. Cambridge: Cambridge University Press, 2019.

LIN, J. Y. *New Structural Economics*: A Framework for Rethinking Development. Washington, DC: The World Bank, 2012.

LIST, G. F. Sistema Nacional de Economia Política. São Paulo: Nova Cultural, 1989 [1841].

LUNDVALL, B. Å. *Innovation System Research and Policy*: Where It Came from and Where It Might go. Oslo: CAS Seminar, Oslo, 2007.

LUNDVALL, B. Å. *National Systems of Innovation*: Toward a Theory of Innovation and Interactive Learning. London: Pinter, 1992.

LUNDVALL, B. Å. *The Learning Economy and the Economics of Hope*. London: Anthem, 2016.

MANYIKA, J. *et al*. *Disruptive Technologies*: Advances that Will Transform Life, Business, and the Global Economy. San Francisco: McKinsey Global Institute, 2013.

MAZZUCATO, M. *The Entrepreneurial State*: Debunking the Public vs. Private Myths in Risk and Innovation.London: Anthem, 2013.

MAZZUCATO, M.; KATTEL, R.; RYAN-COLLINS, J. Challenge-Driven Innovation Policy: Towards a New Policy Toolkit. *Journal of Industry, Competition and Trade*, v. 20, p. 421-437, 2020.

MYRDAL, G. *Asian Drama*: An Inquiry into the Poverty of Nations. New York: Pantheon, 2012 [1968].

NAUDÉ, W. *Industrial Policy*: Old and New Issues. Helsinki: UNU-WIDER, 2010. (Working Paper, 2010/106).

NAUGHTON, B. *The Rise of China's Industrial Policy, 1978-2020*. Ciudad de México: Universidad Nacional Autónoma de México, 2021.

NELSON R. R. What Enables Rapid Economic Progress?: What are the Needed Institutions? *Research Policy*, v. 37, n. 1, p. 1-11, 2008.

NELSON, R. R. (Ed.). *National Innovation Systems*: A Comparative Analysis. New York: Oxford University Press, 1993.

NELSON, R. R.; SAMPAT, B. Making Sense of Institutions as a Factor Shaping Economic Performance. *Journal of Economic Behavior and Organization*, v. 44, p. 31-54, 2001.

NISHIJIMA, S. Japanese Industrial Policy. *Perspective of the World*, v. 4, n. 3, dec. 2012.

OQUBAY, A. *et al*. Introduction to Industrial Policy and Development. *In*: OQUBAY, A. *et al*. (Eds.). *The Oxford Handbook of Industrial Policy*. Oxford: Oxford University Press, 2020.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD). *The Next Production Revolution*: Implications for Governments and Business. Paris: OECD, 2017.

PÉREZ, C. Technological Revolutions and Techno-economic Paradigms. *Cambridge Journal of Economics*, v. 34, n. 1, p. 185–202, 2010.

PISANO, G. Towards a Prescriptive Theory of Dynamic Capabilities: Connecting Strategic Choice, Learning and Competition. *Industrial and Corporate Change*, v. 26, n. 5, p. 747-762, 2017.

PREBISCH, R. O desenvolvimento econômico da América Latina e alguns de seus principais problemas. *In*: BIELSCHOWSKY, R. (Org.). *Cinquenta anos de pensamento na CEPAL*. Rio de Janeiro: Cofecon-Cepal; Record, 2000 [1949]. v. 1.

PRICEWATERHOUSECOOPERS (PwC). Megatrends: 5 Global Shifts Changing the Way We Live and Do Business. *PwC*, London, 2021. Disponível em: https://www.pwc.co.uk/issues/megatrends.html. Acesso em: out. 2021.

RODRIK, D. *Normalizing Industrial Policy*. Washington, DC: The World Bank, Sept. 2007. (Working Paper, 3).

RODRIK, D. The Past, Present, and Future of Economic Growth. *Challenge*, v. 57, n. 3, p. 5-39, 2014.

ROSELINO, J. E.; DIEGUES, A. C. Limites do arcabouço tradicional de política industrial para o Brasil: Elementos para uma abordagem alternativa em um mundo de estruturas fluidas. Campinas: IE-Unicamp, 2020. (Texto para Discussão, 375).

SALLES FILHO, S. *et al*. Avaliação de impactos da Lei de Informática: Uma análise da política industrial e de incentivo à inovação no setor de TICs brasileiro. *Revista Brasileira de Inovação*, v. 11, p. 191-218, 2012. DOI: https://doi.org/10.20396/rbi.v11i0.8649041.

SCHUMPETER, J. *Theory of Economic Development*. Cambridge, MA: Harvard University Press, 1934.

SMITH, A. *Investigação sobre a natureza e as causas da riqueza das nações*. São Paulo: Abril Cultural, 1984 [1776].

STIGLITZ, J.; GREENWALD, B. *Creating a Learning Society*: A New Approach to Growth, Development, and Social Progress. New York: Columbia University Press, 2015.

STOJKOSKI, V.; UTKOVSKI, Z.; KOCAREV, L. The Impact of Services on Economic Complexity: Service Sophistication as Route for Economic Growth. *PLOS One*, v. 11, n. 8, p. e0161633, 2016.

SUZIGAN, W.; FURTADO, J. Instituições e políticas industriais e tecnológicas: reflexões a partir da experiência brasileira. *Estudos Econômicos (São Paulo)*, v. 40, n. 1, p. 7-41, mar. 2010.

SUZIGAN, W.; VILLELA, A. V. *Industrial Policy in Brazil*. Campinas: IE-Unicamp, 1997.

TEECE, D. China and the Reshaping of the Auto Industry: A Dynamic Capabilities Perspective. *Management and Organization Review*, v. 15, n. 1, p. 177-199, 2019.

TEECE, D.; PISANO, G.; SHUEN, A. Dynamic Capabilities and Strategic Management. *Strategic Management Journal*, v. 18, n. 7, p. 509-533, 1997.

UNITED NATIONS (UN). Report of the UN Economist Network for the UN 75th Anniversary: Shaping the Trends of Our Time. New York: UN, Sept. 2020.

WADE, R. *Governing the Market*. Princeton: Princeton University Press, 1990.

WHITE HOUSE. Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100-Day Reviews under Executive Order 14017. Washington, DC: The White House, June 2021.

WONGLIMPIYARAT, J. Government Policies Towards Israel's High-Tech Powerhouse. *Technovation*, v. 52, p. 18-27, 2016.