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Modern Industrial Policy and the World Trade Organization

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Abstract

This article surveys the economics of industrial policy as it relates to the World Trade Organization (WTO). Motivated by concern that the modern use of industrial policy is emerging in ways that threaten cooperation in the international trading system, the article begins with the basic historical economic framework for tying industrial policy to underlying market failures. It then introduces the dominant economic understanding of the role played by the WTO, examining the WTO's rules on subsidies (and thus industrial policy), the unease with the evolution of the trading system's subsidy rules, gaps in knowledge, and important data and measurement shortcomings. The main part of the article examines four areas in which modern industrial policy operates differently and has become especially important for the trading system: China, supply chain resilience, supply chain responsiveness, and climate change. The article identifies the evidence to date, open questions, and potential paths forward for economic research to help inform policymakers' efforts to restore international economic cooperation in trade and industrial policy.

1. INTRODUCTION

To remain relevant in the international trading system, the World Trade Organization (WTO) may need its members to engage directly over the issue of industrial policy. The staff at the major international organizations—the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), the World Bank, and the WTO—have put out an explicit plea for a renewed work program and policymaker engagement on the issue (see IMF et al. 2022). This article explains the renewed emphasis on industrial policy and explores priority areas for economic research to help inform policymakers at the front lines of the rules-based trading system.

For a number of overlapping reasons, today's industrial policy seems different from policy in the past. It is often forcefully pursued by major high-income industrial economies, including the United States, the European Union, and Japan, as opposed to emerging economies. China's use of industrial policy is both motivating these new users—sometimes to deploy industrial policy themselves, sometimes to defend their economies from China—and driving some of the associated WTO challenges. Moreover, today's industrial policy objective is often less about learning for the first time how to competitively produce a good or acquire the necessary technological absorptive capacity to do so, which is what often motivated infant industry policies for developing countries in the past. Instead, the objective appears aimed at returning parts of a supply chain for industries, ranging from semiconductors to personal protective equipment (PPE), that were once present but that have since been offshored.

Industrial policy today is also sometimes motivated by objectives other than increasing firm-level productivity or generating spillovers to other sectors and thus enhancing national economic growth. Instead, industrial policy is driven by diversification in the name of supply chain resilience, fear over the weaponization of exports by trading partners, the goal to maintain technological supremacy, or the desire to offer future policymakers more control over economic activity in response to expected shocks. In the presence of cross-border supply chains, some governments are seeking to coordinate their industrial policies with key partners, as opposed to implementing everything at the national level in an attempt at reshoring. Overlaying other considerations is the existential threat of climate change, an important driver behind many modern industrial policy initiatives.

To explore these interrelated motivations for today's industrial policy and its numerous implications for the WTO, this article is organized as follows. Section 2 briefly introduces the historical economic approach to industrial policy, borrowing from Harrison & Rodríguez-Clare (2010). The starting points of this literature are typically market failures, developing countries, and how industrial policy can improve firm-level productivity growth and possibly national economic growth.

Section 3 turns to the dominant economic framework motivating the WTO. It draws on work beginning with Bagwell & Staiger (1999, 2002) as well as key WTO rules and considers the role of enforcement. The WTO is interpreted as providing an institutional setting for large countries to coordinate policies and set rules on behavior to neutralize the international externality implications of their actions and solve a prisoner's dilemma problem. This section also explores the economic understanding of current subsidy rules that have implications for industrial policy. It describes unease with the evolution of those rules, gaps in knowledge, and important data and measurement shortcomings.

The subsequent two sections form the heart of the article. They introduce four areas in which modern industrial policy has emerged as a major issue for the WTO. Section 4 tackles the myriad challenges introduced by China. Section 5 examines supply chain resilience, supply chain

responsiveness, and climate change. The four issues are not cleanly separable; the last three are independent areas of concern, but China plays a critically important role in each. The last section concludes by motivating the need for further economic research.

2. INDUSTRIAL POLICY

Harrison & Rodríguez-Clare (2010) provide the core theoretical underpinnings for the economics of industrial policy, defined as deviations from policy neutrality.[1] Historically, much of the research on industrial policy has been conducted through the lens of economic development, with a focus on economic growth, improvements in firm-level productivity, and sometimes diversification to prevent excessive concentration in commodities associated with boom-bust cycles. This framework provides an important starting point, although it has limitations for understanding today's industrial policy for the reasons described below.

The primary economic motivation for government intervention is typically a local economic externality or market failure. One such reason are Marshallian, or intraindustry, externalities that are external to any firm; that is, it is not simply about a firm learning by doing or reducing its average costs as it expands output (Marshall 1920). These spillover benefits arise from the geographical agglomeration of an industry, perhaps tied to the emergence of a large pool of skilled labor from which multiple firms may be able to draw. Benefits can also occur because of local knowledge spillovers—that is, a worker at one firm learns something they transmit to a worker at another firm through local interaction. Such externalities may also arise because of geographical proximity of specialized input suppliers.

Examples of Marshallian externalities include the agglomeration of high-tech industries into the Silicon Valley in California or the Route 128 corridor outside Boston. They may also characterize the North American automotive supply chain—located around Detroit before expanding along a North American corridor nicknamed auto alley (Klier & Rubenstein 2008). These effects are not limited to high-tech goods. In China, for example, Qiaotou became the manufacturing location of 60% of the world's buttons, and Wenzhou ended up making 95% of the world's cigarette lighters (Krugman 2011).

A second type of local spillovers are interindustry externalities (sometimes referred to as vertical spillovers), whereby the expansion of one sector provides benefits to another. For example, a local financial or software industry—arguably an important input for other parts of the economy—might generate productivity gains for downstream sectors. Alternatively, the emergence of a downstream industry could help upstream input providers expand and enjoy productivity gains of their own. This issue may be increasingly important and complex in an era in which production processes become more fragmented, with more input-output links in a lengthening supply chain via both outsourcing and offshoring to a different country.

Other types of market failures include sector-specific coordination failures, such as the challenge to convince all local firms to adopt a similar standard so that they can jointly access a foreign market when that foreign market makes a nontariff barrier determination at the country level, such as after an animal disease outbreak.[2] Another is information spillovers, or the self-discovery of newly profitable activities (see, e.g., Hausmann & Rodrik 2003).

[1]This definition is loose, as policy neutrality does not necessarily mean free trade, nondiscriminatory tax treatment between multinational and domestic companies, or a uniform tax rate across sectors. Grossman (1990) provides a useful early articulation.

[2]Hausman et al. (2005) point to the foot-and-mouth disease (FMD) outbreak in Uruguay as a coordination failure that, once resolved, allowed for access to the US beef market. Similar examples of coordination failures

Given such market failures, Harrison & Rodríguez-Clare (2010) illustrate the conditions under which industrial policy can benefit a small, price-taking country. The first-best policy is often a Pigouvian subsidy, following the targeting principle (Bhagwati & Ramaswami 1963). An industrial policy can convert a country's latent comparative advantage into a realized one if the underlying conditions clear two hurdles. The first is the Mill test (named after John Stuart Mill), which requires that the sector benefiting from the industrial policy will eventually be able to survive on its own as a successful exporter once the policy is removed. The second is the more stringent Bastable test (named after Charles Bastable), which requires that the discounted future benefits exceed the costs of the industrial policy.[3]

There is emerging evidence that some episodes of industrial policy from recent history likely pass the Mill test.[4] For example, Manelici & Pantea (2021) find that tax breaks to workers in Romania's information technology (IT) sector beginning in 2001 contributed to the expansion of the country's software industry, with spillover benefits to downstream sectors that use software intensively. Lane (2024) revisits South Korea's Heavy and Chemical Industry (HCI) Drive of 1973–1979. He finds that, relative to firms in sectors that did not get access to subsidized credit, Korea's industrial policy affected the firms' input choices, productivity, output growth, output prices, and exports; shifted their comparative advantage; and spilled over to benefit downstream industries.[5] Few of these studies, however, examine whether the industrial policy passes a Bastable test.

For several reasons, including capture by special interest politics and corruption, some economists maintain a healthy skepticism about the ability of governments to implement industrial policy effectively (see Ades & Di Tella 1997). Furthermore, when industrial policy calls for subsidies, governments must levy additional taxes elsewhere in the economy, which may be distortive or put excess pressure on the state's administrative capacity. Finally, as will become clear in the examples cited below, targeting industrial policy successfully may require policymakers to have access to information—including input-output linkages up and down the supply chains, the nature of market failures, and the conditions of market competition—that is either unrealistically detailed or that require additional public investment in (and sharing of private-sector) data that have previously been unavailable to government officials.

3. THE GENERAL AGREEMENT ON TARIFFS AND TRADE, THE WTO, AND SUBSIDIES

To see how industrial policy fits into the WTO, this section introduces the dominant economic framework behind the rules-based multilateral system, its provisions on subsidies, how the rules

include the FMD outbreak in Argentina (Bown & Hillman 2017) and the melamine scandal that affected infant formula in the Chinese dairy industry (Bai et al. 2022).

[3]These tests can be further complicated if the externality (or part of the externality) is ongoing, in which case even in the long run the subsidy provides a benefit and the value of the policy does not depend on the industry being able to survive once the policy is removed. For other theoretical complications, readers are referred to the analysis by Melitz (2005).

[4]For episodes of industrial policy before the General Agreement on Tariffs and Trade (GATT), Juhász (2018) examines the impact of the Napoleonic blockade (1803–1815) on the long-run economic development of France's mechanized cotton spinning industry. Irwin (2000) investigates whether US tariffs in the nineteenth century provided effective infant industry protection for the tinplate industry. Mitrunen (2023) focuses on Finland's war reparations to the Soviet Union in 1944–1952, which forced the largely agrarian country to temporarily support Soviet-prioritized industries. Juhász & Steinwender (2024) and Juhász et al. (2024) provide recent surveys.

[5]Other recent explorations into the HCI Drive include work by Choi & Levchenko (2023) and Kim et al. (2022).

are enforced in practice, and what (little) is known empirically about the prevalence of subsidies across countries and over time.

3.1. The General Agreement on Tariffs and Trade and the WTO

The dominant economic framework for the WTO [and the General Agreement on Tariffs and Trade (GATT) before it] involves governments of large countries using the institutional setting to coordinate policies to reduce the negative externalities they would otherwise impose on one another (Bagwell & Staiger 1999, 2002).[6] Negotiations between governments have led to the reciprocal reduction of tariffs, allowing market access (trade volumes) to expand to levels closer to global efficiency and neutralizing what would have otherwise been negative terms-of-trade (price) impacts resulting from unilateral tariff reductions. Under this modeling approach, the WTO helps solve a prisoner's dilemma problem by coordinating policies to move from a noncooperative to a cooperative equilibrium among governments. This view of the WTO is sufficiently general that it can accommodate governments retaining considerable national sovereignty over their domestic policies, including the ability to respond to political pressures to use trade policy to redistribute between local interest groups. A growing body of empirical evidence, from a wide range of settings, broadly supports this interpretation of the WTO.[7]

This research also documents how certain WTO principles help governments negotiate and reciprocally sustain open trade in practice. For example, the nondiscrimination across trading partners implied by the most-favored-nation (MFN) principle can help a world of more than two countries—where free riding and other concerns emerge—to initiate and sustain efficient bargains. Nondiscrimination between foreign and domestically produced goods (once the foreign good has paid the tariff) implied by the national treatment principle contributes to preventing a government from taking away the market access implied by an earlier tariff reduction commitment through subsequent resort to domestic tax or regulatory policy that may otherwise shift the costs of such policies abroad (see Horn 2006, Staiger & Sykes 2011).

The GATT/WTO also has guidelines that apply when governments seek to change policies in response to shocks. Governments should expect to compensate trading partners; as such, many legal scholars view the GATT/WTO as having liability rules, some of which can promote efficient breach, which allow parties to break a contract when the costs of compliance (to the policy-changing country) exceed its benefits (to trading partners).[8]

For example, a government can raise a tariff above its WTO legal commitment without having to explain why. Under GATT Article XXVIII, the tariff increase must be notified to trading partners and is then subject to negotiation, in which the default compensation rule is for adversely affected partners to be permitted a limited tariff retaliation to rebalance market access reciprocally if no other form of compensation can be agreed on.

Countries can also change their domestic policies. In some cases, the WTO provides guidelines on how to do so in ways that do not run afoul of its rules. However, even if a new policy

[6]The other dominant motivation is the commitment theory (Maggi & Rodríguez-Clare 1998, 2007), whereby a government may benefit from external enforcement of trade policy to convince agents that it will not renege in the future even if it has a unilateral incentive to do so. For a commitment theory of agreements limiting subsidies, readers are referred to Brou & Ruta (2013).

[7]Readers are referred to Broda et al. (2008), Ludema & Mayda (2013), and Nicita et al. (2018) for tariffs; Bown & Crowley (2013) for triggering exceptions to tariffs under trade remedies; Bagwell & Staiger (2011) and Bagwell et al. (2020) for outcomes and bargaining under GATT/WTO negotiations; and Bown & Reynolds (2017) for outcomes under WTO dispute settlement. Bagwell et al. (2016) provide a survey.

[8]For a discussion, readers are referred to Staiger (2022, pp. 162–63), Schwartz & Sykes (2002), and Pauwelyn (2008). For a theory of the WTO as an incomplete contract, readers may consult Horn et al. (2010).

violates WTO rules, the government needs to be prepared to bear the consequences (after being challenged through formal dispute settlement proceedings) that stem from tariff retaliation only, which is typically limited to restoring a reciprocal balance of market access. In both instances, the WTO does not prevent countries from making changes to their policies, and the recourse it permits is not punitive (for an early modeling approach and empirical evidence, see Bown 2002, 2004). The WTO reduces uncertainty by helping to define the limits to the costs for policy changes, broadly ensuring that the government has designed the policy for the right reasons—such as to address market failures or local externalities—and not to shift its costs onto trading partners through international price movements, thereby creating new international externalities.

3.2. Evolving Subsidy Rules and Enforcement: From the GATT to the WTO

The approach described thus far broadly applied under the GATT period (1947–1994), as detailed by Sykes (2005). A government subsidy in place at the time of the many GATT negotiating rounds, for example, did not require removal (i.e., market access expectations that resulted from the round's new reciprocal tariff cuts took preexisting subsidies into account).

The GATT rules did seek to discipline the application of new subsidies. Consider the interactions among country 1 (the subsidizing country), country 2, and country 3. New subsidies could affect access in three markets, with different implications for available recourse.

First, suppose that country 1 has previously negotiated a market access concession (tariff binding) with country 2 and that, subsequent to these market access negotiations, country 1 introduces a new domestic production subsidy to its import-competing industry. The new subsidy reduces the export market access expected by country 2 on the basis of the previous tariff-binding commitment. GATT rules allowed country 2 to challenge such subsidies through a nonviolation nullification and impairment (NVNI) claim under dispute settlement. Simply put, NVNI involves arguing that a government action resulted in a harmful, unexpected loss of market access, even though no explicit trade rules may have been broken. The prospect of such an NVNI complaint (and compensation) dealt with the concern that, in the absence of facing the true costs of its action, country 1 would introduce new subsidies to frustrate the market access expectations implied by tariff concessions that have just been negotiated.[9]

Second, suppose country 1's production subsidy increases its exports to country 2's import market and that country 2 objects to the injury caused to its import-competing industry by that subsidy. GATT rules permit country 2 to use a countervailing duty (CVD)—a tariff set at the size of country 1's subsidy—to unilaterally restore the original conditions of competition between country 2's import-competing producers and country 1's (now subsidized) exporters, without need for a formal dispute adjudicated by a third party. Note that foreign subsidies that lower the price of imports provide static gains to importing countries, as the benefits to consumers are larger than the immediate losses to domestic producers. Thus, resort to CVDs needs to be motivated on other grounds, such as adjustment costs, the political importance of the competing industry in the government's objective function, or long-run market power concerns if the conditions are ripe for predation.

Third, suppose country 1's subsidy increases this country's exports to country 3's import market, to which country 2 also exports. Country 2 is made worse off, because the subsidy also lowers the price received by its exporters in country 3's market. Originally the GATT had no provisions to handle this case, as neither a formal trade dispute (and NVNI claim) nor the CVD approach could tackle the problem faced by country 2.

[9]Staiger & Sykes (2013, 2017) explore NVNI claims in general. Bagwell & Staiger (2001) examine NVNI combined with market failures and thus discuss a role for domestic policy.

The trading system's rules on subsidies were tightened significantly in 1995 with the inception of the WTO and its new Agreement on Subsidies and Countervailing Measures (SCM). One contribution was the introduction of the concept of serious prejudice—that is, economic harm arising from subsidies affecting competing exporters in third-country markets, which the NVNI doctrine under the GATT would not address (Sykes 2005).[10] By the time of the Uruguay round of negotiations, in the 1980s, subsidies affecting third-market competition, such as the competition between the United States and Europe (Boeing versus Airbus) in commercial aircraft, had become an area of concern. Farm subsidies in Europe, the United States, and elsewhere—sometimes leading to dumping in third-country markets—were worrisome enough that members introduced the separate WTO Agreement on Agriculture.

The SCM Agreement tightened subsidy disciplines in other ways. Bagwell & Staiger (2006) stress that subsidies suddenly became delinked from the market access implications of tariff negotiating rounds, because the SCM Agreement did not distinguish between new subsidies and subsidies that existed at the time of tariff negotiations or that applied to industries in which no tariff commitment had been made.[11]

Furthermore, only "specific" subsidies would be subject to WTO constraints; funding that is generally available to all firms would not. Specificity creates a tension with the notion of a Pigouvian subsidy to correct a particular externality that might arise only for certain industries or firms (and which might be first best, from the perspective of economic welfare).

The SCM Agreement also prohibits subsidies contingent on exports and local content (i.e., domestic as opposed to imported inputs).[12] Banning certain subsidies and making others actionable—and thus subject to trading partner recourse—may have been prompted by the practical challenges to prosecute NVNI claims and thus enforcement under dispute settlement. By 1995, it would have been increasingly difficult to link a new subsidy to a change in market access implied by a tariff concession made decades earlier, in an early GATT round, given that so much else had changed (affecting supply and demand) in the interim. Furthermore, NVNI cases rely intensively on data, models, and economic evidence; WTO arbitrators have subsequently struggled when forced to credibly estimate the amount of lost market access in order to determine levels of authorized retaliation in the few disputes reaching that stage of the process.[13]

Subsidy policies became different from other policies challenged in formal WTO disputes along two additional dimensions. First, in principle, the dispute could reach the recourse (cost-imposing) phase sooner than other types of disputes. Second, for prohibited subsidies, the language for compensation is for the complainant to adopt "appropriate countermeasures," which, in principle, could be larger than the authorization for nonsubsidy disputes.[14]

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[10] Serious prejudice could also apply to a loss of exports from the complaining country to the subsidizing country market (where previously the NVNI doctrine would have applied).

[11] Bagwell & Staiger (2006) suggest that the stringency of the new rules has efficiency costs for the system relative to the GATT, as it makes it more difficult for governments to negotiate and sustain low tariffs.

[12] Sykes (2005) notes that local content subsidies are prohibited, but the content could be subsidized directly by the government through a slightly different approach, to equivalent effect, and not be prohibited. For example, under the WTO, a government may be prohibited from offering subsidies to an automaker contingent on its using locally produced steel. However, the WTO does not prohibit a government from offering an equivalent scheme in which it subsidizes production of local steel.

[13] Bown & Brewster (2017), for example, find that the estimates of lost market access and thus the tariff retaliation authorized in the *US–COOL* dispute seemed implausibly large, as they failed to control for factors affecting trade growth other than the policy during the period of interest, such as the macroeconomic fundamentals of the 2008 trade collapse.

[14] Some subsidy disputes have authorized tariffs equivalent to the size of the subsidy (Bown & Ruta 2010; see also Grossman & Sykes 2011).

Although the WTO cannot stop any government action, its authorization of quicker and/or larger trading partner retaliation could shape policymaking behavior. This authorization could be beneficial if it halted subsidization that was inefficient or pushed the form of subsidies into those that do not generate international spillovers. It could also prove costly, however, if the rules inadvertently discouraged governments from first-best subsidies to address market failures or pushed them toward less efficient policy instruments simply because those other policies (e.g., tariffs or export restrictions) have weaker disciplines or no discipline at all. For example, GATT Article XI limits the use of quantitative restrictions on exports, but it does not constrain export taxes. Although China was required to take on commitments to limit its use of export taxes as part of its protocol of accession to the WTO, efforts to enforce limits on China's deployment of export restrictions have often proven ineffective, as described below.

3.3. Industrial Policy Theory in the WTO Framework

The discussion so far has defined the country imposing the industrial policy as small, meaning that its policies have no impact on world prices and no discernible adverse effect on trading partners. For WTO purposes, this assumption can be interpreted in two ways. First, it makes little sense—at least under the terms-of-trade theory of trade agreements—for WTO rules to constrain small countries' policies, raising the question of who would have negotiated them in the first place. Second, if the subsidizing country were small, trading partners would also not be concerned with its use of industrial policy; any such rules would be superfluous, as there would be no one to lodge a dispute settlement challenge anyway.[15]

Now assume that the countries are not small.[16] Harrison & Rodríguez-Clare (2010) explore the conditions under which the country imposing the industrial policy has the potential to affect world prices and therefore impose costs on trading partners. They show that sometimes this ability can result in negative international externalities—i.e., a deterioration of the other country's terms-of-trade—which could lead to a reduction in its export market access. For this reason, the other country should be concerned and potentially want to resort to its rights under the WTO.[17]

In this case, the Bastable test—which considers only the financing and efficiency costs of imposing the industrial policy—would seem to be insufficient under fully enforceable WTO rules. If the industrial policy has adverse effects, trading partners could demand compensation that might involve lost export market access for a different good as a result of a trading partner being authorized to retaliate with higher tariffs.[18] Put differently, if the benefits to a country of an industrial policy just outweigh the costs, so that from a national perspective the Bastable test is passed, but some of the costs of the industrial policy are being passed onto trading partners through

[15]There may be alternative motivations for the government to want to tie its own hands, such as under the commitment theory (Brou & Ruta 2013). However, Bown & Hoekman (2008) note that, even in such settings, small countries require the credible external enforcement that is unlikely to emerge in the current WTO dispute settlement system.

[16]This discussion considers only local market failures and externalities. The article later examines how industrial policy is being used to tackle climate change, a particularly important global (cross-border) externality.

[17]This research has parallels with the literature on strategic trade policy, in which the market is zero sum and the policy mainly shifts rents (or profits) from firms in one country to firms in another (for a survey, see Brander 1995).

[18]A handful of disputes resulted in respondent countries agreeing to cash transfers in lieu of suffering tariff retaliation. In *United States–Section 110(5) of the US Copyright Act* (DS160), the United States paid the European Union a lump sum of $3.3 million; in *United States–Subsidies on Upland Cotton* (DS267), the United States paid Brazil $147.3 million a year for a number of years.

terms-of-trade movements, from an international perspective the policy would not pass the Bastable test.

3.4. Measurement Challenges to Subsidies, Industrial Policy, and Inference

For interconnected reasons, surprisingly little is known about the prevalence and importance of industrial subsidies across sectors and countries or their impacts on trading partners. Assembling such data is not impossible, given that the OECD has been providing estimates of support for the farm sector for many countries for decades.[19]

One challenge, however, is definitional. The SCM Agreement defines a subsidy as a financial contribution, by a government or any public body within the territory of a member, that confers a benefit. However, economically impactful subsidies can emerge outside of this definition. Suppose, for example, that there are two countries, Home and Foreign (the latter indicated by an asterisk), each with two firms A and B: Firms A and A* produce inputs, and firms B and B* produce outputs from those inputs. The equivalent economic effect of an input subsidy to B (hurting B*) could emerge under each of the following scenarios:

- The Home country imposes an export restriction on firm A.
- The Home country fails to enforce the intellectual property of the foreign firm A*.
- Firm A is a state-owned enterprise (SOE), with a welfare function that includes social objectives (e.g., employment, national security, maximization of market share, maximization of exports, etc.) that differ markedly from those of firm A*, a profit-maximizing firm.

One important US complaint at the WTO has been definitional. China has argued that its SOEs are not public bodies and thus cannot confer subsidies to downstream firms. The United States has argued that SOEs are public bodies; as a result, since 2007 it has imposed countervailing duties on imports from China benefiting from subsidized inputs from those SOEs.[20] China's SOEs are pervasive across a variety of sectors providing inputs to the economy (e.g., banking, energy, other upstream industries) and have grown over time. However, the definitional challenges posed by China are not limited to SOEs. The Chinese state controls access to land, another critical input, and the Chinese Communist Party may place members on the boards of companies or otherwise influence firm decisions away from profit maximization and toward other objectives (Wu 2016). A related definitional issue for policymakers is whether, for the purposes of the often substitutable trade remedy of antidumping, China is a nonmarket economy.[21]

Yet, stepping back from the China case, these definitional issues surrounding input subsidies are nontrivial and raise a number of thorny questions. For example, when it comes to subsidizing critical inputs, many governments in high-income economies prioritize the funding of education. Suppose one country prioritizes vocational training and apprenticeships—which may disproportionately affect manufacturing—whereas another funds research universities that affect R&D and innovation. Public funding to lower the costs of education can be expected to benefit some sectors

[19]Data can be accessed on the OECD's website, at **https://data.oecd.org/agrpolicy/agricultural-support.htm**.

[20]The US government began to grapple with this issue when it faced requests to reverse a 1986 decision [*Georgetown Steel Corp. v. United States* (1986)] that had ruled against using CVDs to address imports from nonmarket economies such as the Soviet Union and China. In 2007, the United States reversed the decision and developed methodologies to assess when Chinese firms were benefiting from subsidies and thus began to impose CVDs (see US Dep. Commer. 2006a,b, 2007).

[21]For a discussion of the issues surrounding China's nonmarket economy status, readers are referred to Bown (2016).

more than others. Is the public provision of human capital acquisition also a subsidy that WTO rules should consider?

Going back to China, another concern involves the country's explicit use of state-led industrial policy. China continues to deploy five-year plans, including the highly controversial Made in China 2025 policy rolled out in 2015. Its subsidies can arise through additional policy instruments. Its export restrictions on inputs subsidize downstream parts of a supply chain, including by selectively targeting rebates of value-added taxes in sectors like aluminum (OECD 2019a). State-banked financial capital funds have been deployed for strategic sectors like semiconductors (OECD 2019b). Trading partners have accused China of actively forcing the transfer of foreign technology through joint ventures with local, state-owned firms, as highlighted in the US government's Section 301 reports motivating the trade war (USTR 2018a,b).

The combination of Chinese policies and state-centric objectives exacerbates existing challenges for the standard WTO dispute settlement to tackle the enforcement of subsidy disciplines. China's interventions may be more difficult than other countries' subsidies to detect. Furthermore, a Chinese subsidy may hurt a trading partner, but without any observable transfer of funds between the government and the agents engaging in economic transactions, it is difficult to measure the size of that subsidy and link it to the harm experienced in the other country.

These features of the Chinese economy matter for at least three reasons. First, China may be more likely—relative to other countries or to itself under a different system—to subsidize. Second, the pervasiveness of and uncertainty over China's subsidies may lead trading partners (like the United States) to impose trade remedies on more products and at higher rates in response, because they are provided additional institutional flexibility to do so. (Allowing China to be treated as a nonmarket economy, for example, provides government officials discretion to turn to third-country cost data to represent Chinese industry.) Third, given how trade remedies work, the first two reasons combine to make it more likely that third-country exporters will be caught up in other countries' trade restrictions imposed on China, putting additional stress on their trade relations as well as the trading system.

3.5. Limited Information on Subsidies, Industrial Policy, and Which Inferences to Draw

Surprisingly little is known about the size and prevalence of subsidies or their impact on trading partners. However, at least three potential sources of data—use of trade remedies, the subsidies themselves, and formal WTO disputes—provide a starting point.

First, a telling sign about the importance of China's industrial policy and the ability of its economic system to generate conflict comes from other countries' use of trade remedies to address those subsidies. By 2019, more than 7% of China's exports to the Group of 20 (G-20) economies had become subject to CVDs or to one of the other trade remedies, and the share has been growing (**Figure 1*a***). Despite differences in the remedies' legal criteria, the nature of the Chinese economy has allowed foreign governments to substitute across trade remedy instruments. The most common instrument is antidumping, though for many countries, CVDs are growing in use, following the US lead described earlier (**Figure 1*b***).

There is evidence consistent with the negative spillover identified above: Exporters in third countries increasingly face trade restrictions over the same product as China's exporters (**Figure 2**). Thus, China's subsidies may cause not only a Chinese exporter to get caught up in a foreign trade remedy, but third-country exporters too (which lower their prices in that foreign market to compete with China) can be accused of dumping (antidumping) or at least of causing injury (safeguards) and can face trade restrictions. It is these trade restrictions—imposed on third-country exporters but traced back to China—that have generated some of the most

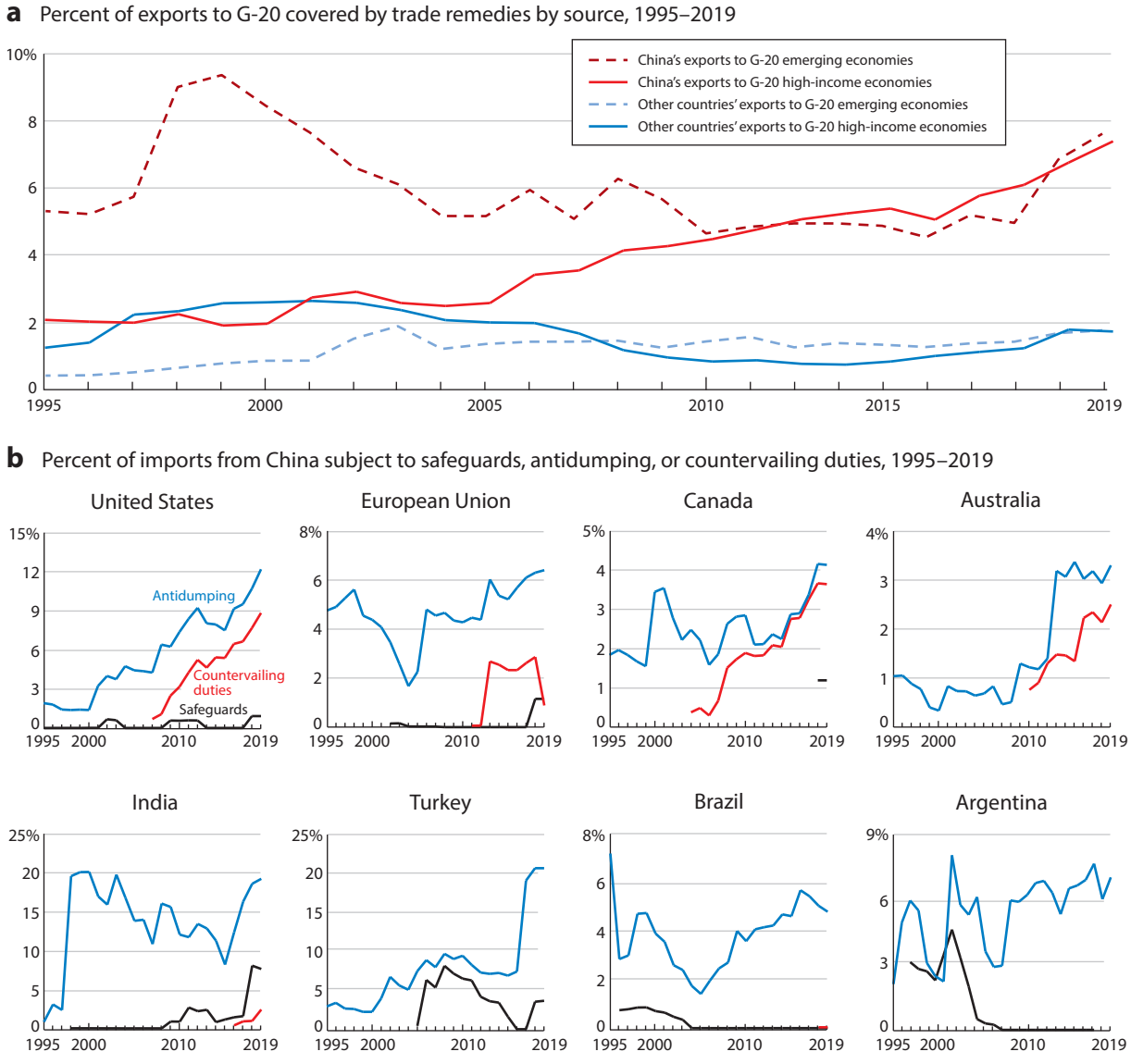

Figure 1

Trade remedies have increasingly targeted China's exports since 2010. Trade remedies include safeguards, antidumping, and countervailing duties. Saudi Arabia is omitted because its data were not available. Data do not capture the US–China trade war tariffs, the US steel and aluminum (national security) tariffs, or the counter-tariffs imposed in retaliation in 2018–2019. Abbreviation: G-20, Group of Twenty. Image adapted from Bown (2022c, figures 2 and 3).

contentious disputes in the WTO system to date. For example, the US tariffs that were imposed on third-country exports of steel and aluminum beginning in 2018 resulted both in immediate, extra-WTO retaliation by US allies and in formal WTO disputes with contentious legal rulings (Bown 2021b, 2023c). (**Figure 2** does not capture those tariffs because they were imposed under a national security law rather than as a trade remedy; **Figure 2** therefore provides a lower bound on the empirical importance of this phenomenon.)

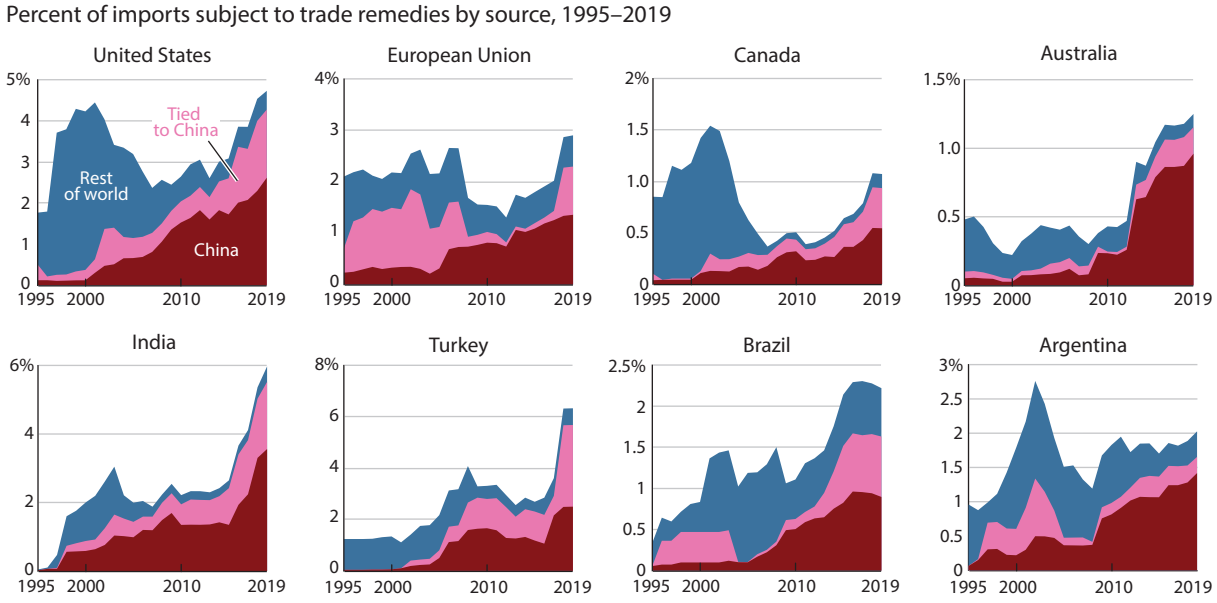

Figure 2

China's exports are the main target of all the major Group of Twenty (G-20) users of trade remedies, but third-country exports may increasingly face trade remedy spillovers. Trade remedies include antidumping, countervailing duties, and safeguards. Tied to China refers to products from other countries subject to trade remedies that targeted China's exports at the same time or had targeted them earlier. Figure adapted from Bown (2022c, figure 4).

Second, in theory, many sources of data could be combined to provide useful information about the prevalence of subsidies. For example, the Global Trade Alert (GTA) has created a database of changes to government measures since 2008 (Evenett 2009).[22] The GTA is only a gateway to an improved empirical accounting of subsidies, however, especially when seeking to draw inferences from aggregate data across countries or over time. One challenge is definitional (as described earlier, US policy is distinct in its transparency; Chinese subsidies lie at the other extreme). Another is that evidence of more subsidies could be associated with policymaking improvements—e.g., shifting from a third-best import tariff to a second-best instrument—or even with governments deploying first-best policies that target externalities or market failures. For example, the large government subsidies supporting the acceleration and capacity enhancement of COVID-19 vaccine supply chains in 2020–2021 was a positive signal; if anything, governments significantly undersubsidized relative to the size of the coronavirus externality (Athey et al. 2022a).

Third, only limited inference can be drawn from formal WTO dispute settlement activity involving subsidies.[23] Between 1995 and 2019, WTO members filed a total of 593 disputes against one another. Of those, 129 involved subsidies, with the complaining country referring to the SCM Agreement. However, fewer than 80 of those disputes challenged the underlying subsidy. The rest challenged the trade remedy—that is, an importing government's response to the subsidy.

[22] Juhász et al. (2023) use machine learning to draw inferences regarding GTA data for policymakers intent on using industrial policy.

[23] Maggi & Staiger (2018) provide a theory of trade disputes that shows the difficulty of drawing inferences from the existence of WTO disputes more generally.

WTO members requested dispute settlement consultations with China over its subsidies only 16 times between 2001 and 2019. Over this period, trading partners brought over 60 disputes against US trade remedies, with China alone bringing 10 of them.

Very few subsidies have been challenged at the WTO for several reasons. First, the dispute settlement system requires state-to-state enforcement but demands that evidence be made available by private-sector interests. Governments often lack subpoena power, and multinational companies with investment interests in the subsidizing country may be making a large enough profit on those other interests to be loath to complain.

Second, the free-rider problem means that the system may underinvest in dispute settlement cases to keep subsidy use in check. Suppose a government with limited resources to spend on WTO litigation must choose which of two foreign market access violations to litigate. One is an MFN-violating policy that hurts only its exporters; the other is a national treatment violation (like a subsidy), which hurts multiple countries' exporters (see, e.g., Bown 2005, Bown & Reynolds 2015). Disputes of the latter type will be less likely to arise, because the benefits of the removal of such policies spill over and are not fully captured by any one complainant.

Third, such WTO disputes are data intensive; by the time the evidence showing that there were adverse effects materializes, it is too late to matter: The foreign subsidized industry is established (the subsidy has done its job), and even a dispute the complainant wins allows only for retaliation until the subsidy is removed (as WTO recourse is prospective and not retrospective in nature).

4. CHINA, INDUSTRIAL POLICY, AND THE WTO

The size and role of the state in the Chinese economy have increased over the last decade, especially under President Xi Jinping, after initially declining after the country's accession to the WTO in 2001 (Lardy 2014, 2019). This reversal has dispelled any notion that China would transition into a market-oriented economy and that the associated challenges for the trading system of its nonmarket system would dissipate organically over time. China's economy is now so large and intertwined with others through buying and selling (imports and exports) and supply chains that even its domestic policies can impose considerable externalities on trading partners.

4.1. Economic Research into China's Industrial Policy

Economists have begun to grapple with China's use of industrial policy and its implications for trading partners and the rules-based trading system.

Consider the illustrative case study of Chinese shipbuilding. At the turn of the century, China was responsible for only about 10% of global shipbuilding, which was dominated by firms in Japan and Korea. As part of its eleventh (2006–2010) and twelfth (2011–2015) national five-year plans, China implemented a series of industrial policies to promote the sector. By 2009, it had become the largest shipbuilder in the world, with roughly 50% of global market share.

Kalouptsidi (2018) and Barwick et al. (2024) present novel approaches to detect the existence of the Chinese subsidies, estimate their size, and begin to assess their impact. Lacking access to detailed information on the exact policy instruments but knowing their timing, the research approach relies on a structural model of the global shipbuilding industry that recovers the size of the subsidies by estimating the cost structure of Chinese firms before and after policy implementation and then uses that information, along with the model, to examine the subsidies' impact.

Barwick et al. (2024) find that Chinese industrial policy between 2006 and 2013 was effective, more than doubling China's domestic investment and firm entry. However, the policy resulted in

only a slight increase in Chinese firm profitability and worldwide consumer surplus gains through lower prices. Interestingly, the policy introduced global inefficiency, with excessive fragmentation of the industry and low levels of capacity utilization. There was also no evidence of learning by doing, calling into question one important potential motivation behind the policy in the first place. (The authors find that marginal costs tended to increase, rather than decrease, in past production, as measured at both the firm and industry levels.)

From the potential perspective of the WTO, the evidence is consistent with China being a large country, whose industrial policy has ramifications for its trading partners. Although China's policy had a positive, albeit small, impact on the world's consumers, by lowering freight rates, its major impact arose through the global reallocation of production, as China's market share in shipbuilding increased by 42% between 2006 and 2013. Only 30% of China's expansion translated into higher world output, however; 70% was business stealing from Japan and South Korea. Chinese subsidies caused market share to fall from 48% to 39% in South Korea and from 23% to 20% in Japan, with significant reductions in their firms' profits. Third-market competition was also important, as export shares of domestic ship production in 2016 were over 80% for China, 90% for South Korea, and over 50% for Japan (Gourdon 2019).

Batteries for electric vehicles (EVs) are a second important example of China's industrial policy. Between 2010 and 2020, battery prices for EVs fell by nearly 90%. Barwick et al. (2023) model the global EV and battery industry supply chains. They find strong evidence of firm-level learning by doing, with production costs falling as a company gains manufacturing experience. Because many governments—including in China, the United States, Japan, and countries in Europe—during this period implemented nondiscriminatory consumer subsidies for EVs to incentivize potential buyers to switch over from internal combustion engine vehicles, such subsidies could potentially accelerate learning by doing.

In 2016, China also implemented a discriminatory local content policy, through a whitelist, that made its EV subsidies contingent on the vehicle's battery being provided by a small set of only (it would turn out) Chinese firms, such as BYD and CATL. This policy remained in place until mid-2019 (see S&P Glob. Mark. Intell. 2019, Hu 2022). Barwick et al. (2023) estimate that the Chinese whitelist policy increased sales of Chinese battery firms considerably, mostly through business stealing at the cost of non-Chinese firms, with Korean battery companies (including LG Energy Solution, SK On, and Samsung SDI) suffering the most.

In the downstream industry, EV companies with BYD and CATL batteries experienced faster price reductions than other automakers—suggesting that the whitelist policy for batteries may have worked like an implicit subsidy to EVs—as EV companies were able to pass on much of the battery cost reduction (the result of learning by doing) onto car buyers. However, the authors also find that China's whitelist policy negatively affected global EV sales and efficiency, as it shifted EV automaker sourcing from battery firms that were initially low cost to higher-cost suppliers.

4.2. Implications for WTO Enforcement of Subsidy Rules

Evidence of business stealing for shipbuilding and EV batteries means that Japan and South Korea may have had their WTO market access rights violated by China's industrial policy. Puzzlingly, neither pursued a WTO dispute against China over either issue. These decisions were not simply domestic collective action problems: Japan initiated formal WTO disputes against Korea's shipbuilding industry in 2018 and 2020, and the South Korean battery companies were part of *chaebols*—giant multinational conglomerates—and were politically organized enough to engage the implementation of the US industrial policymaking process for EV supply chains shortly

thereafter.[24] Furthermore, there have been other high-profile disputes over use of industrial policy at the WTO, most notably the lengthy and costly US–EU disputes over subsidies to Boeing and Airbus.[25]

Why countries other than the United States were mostly unwilling to use WTO dispute settlement to challenge China's domestic policies, including its discriminatory subsidies and industrial policy, has long been a puzzle (Bown & Keynes 2020). Possible explanations include the fact that the WTO system's demand for economic evidence implies the participation of business interests. Multinational companies with a presence in China may have been fearful to engage, given China's history of using economic coercion and its acts of extra-WTO retaliation, including against Japanese and Korean firms. In its 2010 response to Japan's detention of a shipping trawler over disputed territorial waters, for example, China restricted exports of rare earth metals needed for EVs and other high-tech products. At the height of the China batteries policy period, in 2017, China separately began using acts of economic coercion against Korean companies following the Korean government's decision to implement the THAAD missile system (see Bradsher 2023, Lim & Ferguson 2019). In 2023, when the European Union self-initiated a CVD investigation into subsidized Chinese EVs that could result in tariffs, China immediately retaliated by announcing export restrictions on graphite, a material critical for battery manufacturing (see Hancock et al. 2023, White et al. 2023).

The explanation may be even more complicated for China's subsidies. For prohibited subsidies (e.g., local content and export subsidies), there is less of an evidentiary burden, so the dispute resolution process may be quicker. Yet, for other subsidies, it is often necessary to show economic effects. It can take years for the effects to turn up in the data, with evidence arriving only with a lag. By then, the capacity has been installed, and it may be too late to stop (or reverse) the economic effects. Thus, although multiple studies find evidence of serious market access implications of discriminatory subsidies, such cases may have been too difficult to prosecute under the WTO, as the evidence relies heavily on (*a*) structural economic models that may not be amenable to litigation between sovereign states and (*b*) a legal process that is short on economic expertise and dispute settlement panels that may not be adept at handling complex economic fact patterns (for a discussion, see Bown 2010).

Nevertheless, these new research approaches to study industrial policy provide an important starting point for understanding the challenges facing the WTO, given the China problem.[26] A fruitful research agenda would be to examine other sectors—including steel, aluminum, and solar panels—in which policymakers have raised similar concerns that Chinese industrial policy resulted in sizable, negative international externalities with implications for other WTO members, in which Chinese firms are allegedly benefiting from industrial policy and where the responses from trading partners to date have been limited to tariffs. Of course, tariffs do not tackle the source

[24]These companies publicly responded to requests for information by the fall of 2022, when the US Treasury was seeking stakeholder feedback to inform the regulations to implement the Inflation Reduction Act (Bown 2024).

[25]In simulation results, Irwin & Pavcnik (2004) find that EU subsidies to develop the Airbus A-380 lowered prices to consumers but with a negative impact on Boeing's sales, thus motivating a dispute.

[26]In an alternative approach, Branstetter & Li (2022) and Branstetter et al. (2022) provide formal econometric analysis of China's industrial policy since 2007, particularly its Made in China 2025 policy. They find no evidence that firms targeted by such policies performed better than nontargeted firms on several standard economic criteria. Aghion et al. (2015) examine the impact of industrial policy on Chinese medium-size and large firms in an earlier era (1998–2007). They find productivity growth associated with industrial policies that targeted sectors that were competitive or that fostered competition. These analyses do not formally examine the international implications of such policies in terms of their impact on trading partners.

of the problem associated with China's industrial policy, leaving trading partners with additional concerns in both the Chinese domestic market and in third-country markets in which they are competing exporters. Furthermore, the partner's tariff response has often generated new trade conflicts when it also hit third-country exports (see **Figure 2**).

Another politically and technologically important sector is semiconductors. OECD (2019b) used creative data collection techniques to back out the size of subsidies received by firms by examining firm balance sheets and income statements.[27] Advanced economies other than China are now targeting the semiconductor industry with industrial policies of their own (see below); where Chinese firms have struggled is to manufacture the most sophisticated chips at the technological frontier.

4.3. Motivations for WTO Engagement

The WTO will need to grapple with China's industrial policy for multiple reasons. On the positive side are potential development lessons for poorer countries. Having seen China lift hundreds of millions of people from extreme poverty to middle-income status in under four decades, many countries want to adopt aspects of the Chinese model for their own development strategies. WTO rules may need to be adapted to accommodate (or even facilitate) elements of such policies on development grounds. Research could help rule designers better understand which parts of the Chinese approach drove that success and which did not and should therefore be avoided. Studies like the one by Barwick et al. (2024) provide a useful template, as their formal modeling also helps sort through the effectiveness of different industrial policy instruments, such as entry, investment, and production subsidies.

The second and more imminent threat to the WTO system, however, is the conflict with the rules that China's approach has provoked, most notably (but not exclusively) in the United States. The US tariffs on steel, aluminum, and solar panels, as well as the US–China tariff escalation of 2018–19 and the new status quo codified into the Phase One agreement (and failure to deescalate hostilities since), have led to a situation in which both sides are imposing tariffs in a manner that is inconsistent with the WTO's MFN principle of nondiscrimination (Bown 2021a). The trade war was at least partially caused by the United States' dissatisfaction with the multilateral system's ability to curtail the externalities that China was imposing.[28]

The system was showing signs of stress before the trade war, however, including for many of China's other trading partners (see **Figures 1** and **2**). Furthermore, the US decision to end WTO dispute settlement was driven in part by its view that the problem was worsening and that the system was increasingly unable to constrain Chinese policy (which led to the need for US trade remedies) and at the same time was keen on constraining the US ability to defend itself from Chinese imports through trade remedies (Bown & Keynes 2020). WTO legal decisions announced well into the US–China trade war illustrate the challenge: In the *US–Anti-Dumping Methodologies (China)* (WT/DS471/ARB) and *US–Countervailing Measures (China)* (WT/DS437/ARB) decisions, WTO arbitrators authorized China to retaliate against US exports annually for $3.6 billion and $645 million, respectively, because of what it decided was US misuse of trade remedies affecting Chinese exports.[29] There have been no recent WTO disputes effectively challenging China's subsidies.

[27] Thurk (2022) provides a dynamic oligopoly model of the global semiconductor industry.

[28] Mattoo & Staiger (2020) provide an alternative interpretation of the trade war, arguing that the US targeting of countries with which it runs a bilateral trade deficit is a shift from working within a rules-based approach to tariff bargaining to one based on power.

[29] These WTO retaliation authorization decisions may have made little practical difference, as they were announced in November 2019 and January 2022, respectively—that is, long after China had likely exhausted its

Another argument is that some of the industrial policies that other major economies are pursuing today—which may also challenge the bounds of WTO rules—are a noncooperative policy response to China. For example, the United States has motivated its use of industrial policy—and designed its details, described in more depth below—in sectors ranging from semiconductors to EVs partially as a reaction to China's policies (see, e.g., White House 2022a,b).

This argument raises two related questions. First, are the countries imposing these new industrial policies acting rationally? Even if China's industrial policy is not making its firms more productive, other countries can still be negatively affected, as the evidence found by Barwick et al. (2024) shows for shipbuilding. Does this perception that China is acting noncooperatively explain the industrial policy reaction? Put differently, to what extent are countries simply shifting from a cooperative to a noncooperative policy?[30]

Second, if these countries are acting rationally, can the trading system's rules be adjusted to both accommodate an economy like China and restore cooperation among governments in policymaking? If so, how?

At one extreme have been proposals to add even more specificity to the WTO disciplines in an attempt to better address the international externality concerns raised by China's industrial policy, subsidies, and SOEs.[31] At the other extreme is the proposal by Staiger (2022), who suggests engaging with China directly over its market access commitments, with less emphasis on its policy behavior. The argument is that, under the terms-of-trade framework for the WTO, what matters for any country, including China, is reciprocity for its changes to imports and exports and the securitization of market access to prevent externalities from being imposed on trading partners.

Although certainly not on the scale of China, there is historical precedent for an approach focused more on multilateral trade outcomes than on policy behavior. When Poland and Romania, for example, entered the GATT in the late 1960s, there was no expectation that they would become market economies. Instead, they took on quantitative commitments to expand their imports (Haus 1991). Poland agreed to grow imports by the same 7% a year that it anticipated would be the growth of its exports to the rest of the GATT countries (Douglass 1972). An open question is whether a similar approach could provide a useful starting point for restoring some form of cooperation between China and its key trading partners in a modern trading system.

5. OTHER MODERN INDUSTRIAL POLICY MOTIVATIONS FOR THE WTO

This section examines three additional areas where industrial policy is emerging as a policy issue for the WTO: supply chain resilience, supply chain responsiveness and control, and climate change.

5.1. Supply Chain Resilience in the Face of Shocks

Resilience is often defined as the ability of markets to adapt once a shock occurs. National policymakers are now concerned that the current pattern of supply chains is not resilient. The WTO

capacity for optimal retaliation by raising tariffs on nearly $100 billion of US exports, or roughly 60% of its total imports from the United States (Bown 2021a).

[30]Ferrari & Ossa (2023) explore related questions regarding noncooperative versus cooperative subsidy behaviors in a quantitative model across localities within one country—i.e., the United States. For quantitative models of noncooperative versus cooperative tariff behavior internationally, readers are referred to Ossa (2011, 2012, 2014) and Lashkaripour & Lugovskyy (2023).

[31]On proposals to add legal specificity, readers are referred to Bown & Hillman (2019) and Mavroidis & Sapir (2021).

recognizes the salience of the issue, devoting two recent World Trade Reports to it (WTO 2021, 2023; see also the survey in Baldwin & Freeman 2022).

Supply chain resilience has arisen as a policy question in part because of the success of the multilateral trading system at lowering trade barriers. As a result of innovations in transportation technology and information and communications technology (ICT), production fragmented, leading to the creation of global supply chains. Parts of global production processes, however, sometimes concentrated geographically, potentially taking advantage of agglomeration and scale economies. (Industrial policy by China and other countries may have contributed to the concentration.) This equilibrium may have resulted in an efficient allocation of resources and sufficient resilience for the distribution of shocks expected at the time. Nevertheless, given evidence that economic shocks can propagate from one country to another along supply chains,[32] if the world changed, a new distribution of climate, health, and geopolitical shocks could mean that the existing pattern of geographic concentration would be suddenly problematic. Three examples highlight how the world may have changed.

Climate shocks have increased the frequency and intensity of severe storms, leading to flood and wind damage, as well as periods of less precipitation, leading to droughts and wildfires. Much of high-end semiconductor production is concentrated at TSMC in Taiwan, an island off the coast of mainland China that is subject to typhoons and has been hit with water shortages (Bown 2020).

The COVID-19 pandemic suggested a future of more serious public health shocks. The initial epicenter of that public health emergency was China, where production of medical supplies like PPE was geographically concentrated, creating a perfect storm of negative shocks to supply (and exports) and positive shocks to demand (and imports). Supplies were taken off the global markets just as import demand for PPE from the rest of world increased (Bown 2022b).

Geopolitical conflict and tensions reemerged more recently with Russia's invasion of Ukraine, China's threatened takeover of Taiwan after the political capture of Hong Kong, and China's increased military activity (including along trade routes) in the East and South China Seas. The fear of China's monopoly power over inputs into the EV battery supply chain, for example, has shaped US industrial policy in the Inflation Reduction Act (Bown 2023a, 2024) and is contributing to concerns over semiconductors.

What if the geographic footprint of these supply chains was not sufficiently resilient even from a global social planner's perspective, let alone from the perspective of any individual country? If it was not, an adjustment of supply chains could improve global welfare. (Of course, an important empirical question is also whether the distribution of shocks has really changed.)

Supportive of this possibility are numerous examples of today's industrial policy being different from simply (national) reshoring. Sometimes countries are coordinating their industrial policies with others, as governments seek to retain at least some of the benefits of fragmentation and comparative advantage. Japan, for example, recently budgeted nearly $160 million of "China exit" subsidies for firms moving from China to Southeast Asia (see Nikkei Staff Writ. 2020). For semiconductors, US subsidies under the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and the Science Act of 2022 may also fund new assembly, packaging, and testing plants (a separate, labor-intensive element of the supply chain) in Costa Rica, Panama, or Vietnam (see US Dep. State 2023a,b,c). With a common goal of diversifying semiconductor manufacturing away from certain parts of Asia, the United States, Japan, and the European Union have sought to coordinate their subsidization. Information sharing and cooperation may help prevent

[32] Boehm et al. (2019) find that following the 2011 Tōhoku earthquake, output of Japanese affiliates in the United States fell roughly one-for-one with declines in US imports.

redundancy across semiconductor nodes and excess industry-level capacity (see Hayashi 2022, Kelly et al. 2023, Nagao 2023). Finally, to qualify for a $3,750 tax credit under the US Inflation Reduction Act, South Korean companies must source their inputs for EV batteries from countries with which the United States has a critical minerals agreement. This requirement led the South Korean government to lobby the US government to sign such critical minerals agreements with Indonesia and Argentina, countries from which Korean battery companies source inputs (see Oh 2023).

Are such policies necessary? Consider the evidence on supply chain resilience based on firm behavior in the absence of policy interventions. Khanna et al. (2022) examine Indian firm responses to COVID-19-related lockdowns, measuring resilience in three ways: whether input usage and output drop, whether supplier links are maintained, and whether it is easy to find new suppliers to replace existing suppliers if links are broken. Their first findings confirm what theory would predict: More exposed firms are more likely to break links with their suppliers, have difficulty finding new suppliers when links are broken, and therefore experience declines in their total input purchases and output. The second part of their research explores which features of supply chains make them more resilient. Their evidence suggests that the most resilient supply chains arise when suppliers are larger, the inputs purchased are more differentiated, and the number of alternative suppliers is low. Perhaps surprisingly, they find that more complex supply chains are not less resilient to shocks. Firms involved in complex supply chains may understand their exposure and thus be more likely to invest in resilience ex ante.

In research designed to draw inferences about climate change, Castro-Vincenzi (2022) studies how the global auto industry responded to historical flood events. The evidence also suggests that auto companies invest in resilience. Multiplant firms respond to a flood at one plant by reallocating some production to another plant making the same model. Over time, firms have constructed more (but smaller) plants and hold some capacity idle so that it can be deployed in response to a negative shock hurting production elsewhere. Their efforts at increasing resilience allow automakers to produce more output in the aftermath of a shock, but these supply chain adjustments are costly, as firms are less productive (with more and smaller plants operating at lower levels of capacity utilization). As a result, consumers pay higher prices.

Firms respond to incentives about resilience; qualitatively, they are adjusting in the right direction. However, open policy questions include whether firms face sufficient incentives. If not, what is the role for government, and what are the appropriate policy instruments?

New theoretical work by Grossman et al. (2023a,b) has begun to explore industrial policy designed to achieve the optimal level of resilience. A complete assessment of the still emerging theory is beyond the scope of this article, but one message is that the answer is likely to be nuanced and to depend on supply chain details.[33] An important effort is being made to identify where firm-level and social incentives about resilience may be misaligned and why. The answer is not trivial: Consumers are hurt (through lost consumer surplus) when a supply chain disruption makes a good unavailable, but firms also often lose producer surplus or profits, which should incentivize them to invest to avoid such scenarios.[34] A key question is under what conditions they fail to do so at the socially desirable level.

[33]The evolution of the strategic trade policy literature in the 1980s warrants some caution, as it shows that in oligopoly models where firms were competing on quantities (Cournot) the optimal policy was a subsidy (Brander & Spencer 1985), whereas competition on prices (Bertrand) led to the optimal policy being a tax (Eaton & Grossman 1986). Readers may also consult Maggi (1996).

[34]In some models, counterintuitively, firms may overinvest in resilience to take advantage of potential business-stealing opportunities when such negative shocks hit. In these cases, the optimal policy may be an optimal

For the WTO, this literature will also need to explore conditions under which nationally optimal resilience policy diverges from globally optimal resilience policy and why. Do countries acting unilaterally impose (negative) externalities on one another in ways that create a role for the WTO? If so, should the role involve international rule-making efforts to discipline subsidies or to coordinate subsidies?

5.2. Supply Chain Responsiveness and Control in the Face of Shocks

If supply chain resilience is the ability to re-achieve the status quo after a shock, responsiveness involves the ability to do more and/or to act more quickly in response to an emergency. This responsiveness includes speedy and sizable production of new goods and may sometimes involve policymakers exerting control over a supply chain.

The extraordinary use of industrial policy to accelerate and scale up vaccine production in response to COVID-19 provides one example.[35] As new goods, COVID-19 vaccines could not have been stockpiled in advance. There was a societal (human health) objective to achieve scale and speed of production under tremendous uncertainty, creating a divergence between firm-level and social incentives. As expected, without an advanced global arrangement on vaccine sharing, it was difficult to implement one during the ongoing pandemic. Governments wanted access to locally produced vaccines to treat their citizens first; promises to share the vaccine internationally became a time-inconsistent policy. The predictable result was vaccine nationalism (Bollyky & Bown 2020).

At the same time, new supply chains emerged in short order, international trade played a complex role in those supply chains, and government policy interventions were rampant (Bown & Bollyky 2022). The US government, for example, acted as a social planner through novel, priority-rated contracting and industrial policy implemented through emergency powers under the Defense Production Act (DPA). Among other features, priority-rated contracting provided policymakers with unusual informational insights into supply chains, allowing the government to compel economic activity up and down those chains and even to force firms to temporarily act against their private interests (Bown 2022a). In theory, such powers could also have allowed policymakers to allocate scarce inputs to their most productive social use—e.g., expanding production for an effective vaccine about to be authorized for public use—which may not have happened if the input allocation had been left to the market.

The vaccine experience raises at least two overarching questions for policy and the WTO.[36] First, what are the trade-offs to having cross-border as opposed to purely local supply chains in the face of such an emergency? Did the benefits associated with the fact that the (pre-emergency) backbone of the supply chain was local, which allowed for a greater responsiveness, outweigh the cost reduction associated with a cross-border supply chain? If, for example, price signals cannot be transmitted upstream to input suppliers when supply chains cross borders, subsidies to the end output producer may have more rapid (or more efficient) effects when supply chains are local.[37]

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diversification tax to correct for the business-stealing externality and to prevent excessive investment in diversification that would be socially wasteful. Readers are also referred to Elliott et al. (2022) for a network theory approach.

[35] Vaccines are not the only example. During a pandemic, novel tests and treatments are another. Other emergencies motivating this research include military responsiveness (production of armaments) and climate change (see Athey et al. 2022b).

[36] Bown et al. (2022) explore some of these formally.

[37] To explore one reason that price signals may not fully cross borders along a supply chain to upstream input providers, readers are referred to the contracting difficulties analyzed by Antràs & Staiger (2012).

Governments may also undersubsidize if they anticipate that the benefits of those subsidies will leak to firms operating abroad. Given the US government's experience under the DPA, another rationale may be the reduction of asymmetric information in terms of identifying which input makers to subsidize and how to subsidize them when the supply chain is local rather than cross-border (Bown 2022a). Finally, policymakers can compel firms in their own legal jurisdiction to act against their own private interest in an emergency in ways that may not be possible if the firms are located abroad.

Second, is there a role for cooperation (and thus the WTO) in such emergencies? Balancing the advantages of lower costs of production (abroad) with the need to maintain control over the supply chain to quickly expand the speed and scale of output production after an emergency, governments may need to cooperate over different instruments, such as the triggering of expansionary subsidy policies and the prevention of export restrictions. To date, the WTO has sought only to discipline subsidy policies, not necessarily to coordinate their deployment across countries (Bown 2023b).

PPE is a second example of how policy responsiveness and control emerged during COVID-19.[38] Before the pandemic, relatively simple-to-manufacture products like hospital gloves and N-95 respirators were mostly made abroad, for cost-saving reasons. US policymakers could thus not accelerate their domestic production by triggering surge clauses in contracts with local firms (as one US official put it, "You can't surge zero") (see Bown & Keynes 2021).

The tragic shortages of PPE that emerged in early 2020 resulted in a novel combination of industrial policies seeking to gain access to emergency supplies. The US government ended up providing over $1 billion to ultimately create a US manufacturing industry and domestic supply chain for PPE. In the short term, it turned to other policy instruments, imposing export controls to keep the small quantity of PPE that was produced domestically from leaving the country. Furthermore, under a different part of the DPA, the United States compelled 3M, a US-headquartered multinational, to supply the United States from its Chinese plants under the threat that 3M would not otherwise be allowed to export to long-time hospital customers in Canada and Mexico from its US plants.[39] These policies could have turned out quite costly if trading partners had responded in an escalatory fashion. These experiences—driven by the lack of policymaker insight into and control over a supply chain—raise a number of questions about information sharing, stockpiling, and international policy cooperation that are relevant for the WTO, given the possibility of international (economic) externalities.

5.3. Climate Change Mitigation

Climate change is another important impetus behind modern industrial policy. It differs from the motivations for market intervention considered thus far because it involves a global externality.

The United States is using industrial policy to subsidize a number of clean energy industries through the Inflation Reduction Act. There may be learning-by-doing externalities (see Bistline et al. 2023 for estimates). Other major economies are putting a price on carbon directly, however, which may be more economically efficient if the industry-wide learning-by-doing effects are small. For the WTO, trade conflicts may emerge that will need to be managed, because of some of the secondary outcomes resulting from these different policy approaches.

[38]Bown (2022b) provides a more detailed discussion.

[39]The United States was not alone. For example, France and Germany stopped exports to other EU member states until the European Commission intervened by imposing an extra-EU set of export policy controls (Bown 2022b).

One concern is that the two policy approaches have divergent competitiveness impacts on downstream, energy-intensive sectors like steel, aluminum, chemical, fertilizers, and cement (Bown & Clausing 2023, Clausing & Wolfram 2023). Investment or production subsidies to clean energy may move energy use toward clean energy, which provides a social benefit. However, subsidies tend to lower the price of energy overall, providing a competitive benefit to local energy-intensive industries downstream. (There is no externality associated with energy, so lowering the price of energy encourages excessive energy consumption.) In contrast, a carbon tax tends to raise the price of energy, hurting the competitiveness of the local downstream industry, all else equal.

For WTO purposes, a key issue is that a country using a second-best policy (e.g., industrial policy to subsidize clean energy) may be imposing negative externalities on trading partners in terms of loss of market access in such tradable, downstream industries, especially in countries using a first-best policy (e.g., a tax on dirty energy). Addressing the trade-related externalities, without disrupting the pro-climate policies that may be creating them, is another important area for trade rules to tackle.

6. CONCLUSION

This article describes why the WTO should be tasked with coming to grips with modern industrial policy. Nevertheless, numerous proposals for major new issue areas have come (and sometimes gone) from the WTO's agenda. They include multilateralism in the face of rising preferential trade agreements, deep integration of those agreements, regulatory convergence, trade in services, digital trade, and more.[40]

Modern industrial policy does seem different. This article illustrates some of those differences as well as key international externality concerns that industrial policies can generate that are most relevant for the WTO system. It raises more questions than it answers, however, indicating that more research is needed to help policymakers clamoring to deal with today's pressing challenges.

One demand is for measurement—perhaps akin to what the OECD did for agricultural subsidies beginning in the 1980s. Another is for research to help understand the size of externalities (where they exist) relative to the size of the subsidies, as well as the size of the impacts of industrial policy on domestic economic activity and on the market access of trading partners.

More also needs to be learned to inform institutional design. In the currently fractured environment of multilateral trade relations, restoring sustainable cooperation over trade policy may require additional cooperation and understanding of industrial policy as well as of the particular challenges to enforcement.

Governments seem intent on using industrial policy to tackle the world's most pressing market failures and externalities and to at least tweak the footprint of global supply chains. Researchers can help by identifying the size and shape of policies and the role of international cooperation—where it calls to discipline subsidies or where it calls for coordinated policies to jointly expand subsidies—so that the world can continue to benefit from the efficiency gains of trade and the international fragmentation of production, competition, and comparative advantage.

The original impetus behind the GATT in 1947 was to coordinate reciprocal tariff reductions in light of the beggar-thy-neighbor and globally inefficient trade restrictions of the

[40]Readers are referred to Limão (2006) and Freund & Ornelas (2010) for early research on preferential trade agreements, Mattoo et al. (2020) and Maggi & Ossa (2021) for deep trade agreements, Grossman et al. (2021) for regulatory convergence, Staiger & Sykes (2021) for trade in services, and Staiger (2022) for digital trade agreements.

1930s. Any industrial policy excesses of today may someday trigger governments to agree to develop new international rules on which subsidies to coordinate, which to greenlight, and which to limit. As was the case in the 1940s during the GATT's development, policymakers would benefit from well-informed economic research to help them sort through the most important trade-offs.[41]

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[41] Readers are referred to Irwin et al. (2008) on the role of economists in the 1940s in shaping the GATT.

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