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INDUSTRIAL POLICY AND THE GREAT DIVERGENCE

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ABSTRACT

We discuss recent work evaluating the role of the government in shaping the economy during the long 19th century, a practice we refer to as industrial policy. States deployed a vast variety of different policies aimed at, primarily, but not exclusively, fostering industrialization. A thin, but growing literature has started to evaluate the economic effects of these policies, but many questions remain open for study.

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A fundamental question in economics is why some countries are rich, while others are poor. One controversial hypothesis is that in advanced economies, the state played a decisive role in fostering and shaping the path to industrialization and economic development. Thinkers from Friedrich List through Ha-Joon Chang have argued that these types of state interventions (which we will call industrial policy) were used to kickstart industrialization first in England, and later, in successful follower countries. In recent years, the economics profession has, for the most part, discounted this hypothesis. In this paper, we argue that this verdict is premature, as there is increasing evidence that industrial policy had substantial effects on the global economy.

We revisit the historical track record of industrial policy in the context of the 19th and early 20th century – a critical juncture in economic history. By the beginning of this time period, Britain had developed a set of key mechanized technologies and organizational forms in manufacturing that propelled first its textile industry, and later, other sectors to global dominance in export markets. In many parts of the world, a key aim for policymakers was acquiring these British technologies and building modern, competitive manufacturing industries. In practice, this meant trying to build a domestic, mechanized, factory based textile industry as a first step. Independent countries deployed wide-ranging policies to this end. By the eve of WWI, a small set of countries across the globe succeeded in catching-up, and in a few cases even surpassing British income per capita, but most did not. Thus, this period, often referred to as the Great Divergence, substantially widened differences in income per capita, much of which are sustained to this day. A key question then is what role did industrial policy play in the period of the Great Divergence?

In recent years, a thin but growing literature has emerged that sheds new light both on what states around the world did to foster development, and also, to a lesser extent, what effect these policies had on the economy. Informed by new work, we find that industrial policy was not only widely deployed across independent countries using a vast variety of tools, but also that many of these policies contributed to industrialization.[1]

In particular, while much attention in economics has been paid to the developmental effects (or lack thereof) of protective import tariffs in the 19th century, our review of recent work suggests that tariffs were neither the only, and perhaps not the most important policy lever in countries' industrial policy toolkit. Rather, many independent countries deployed a multitude of complementary policies that foreshadow modern industrial policy, such as state-led technology acquisition, human capital development, intellectual property rights protection, low industrial input tariffs, and subsidies for prioritized activities. We also highlight an aspect of the 19th century which cannot and should not be ignored; namely that colonial powers used colonies in the service of their own industrial development goals.

[1]The point that independent states used a variety of industrial policy tools to promote 19th century development has been made by Chang (2002); Allen (2011); Studwell (2013) and Helleiner (2021).

Recent work evaluating these interventions finds positive effects for many policies including infant industry promotion, domestic market integration, and technology policy. In other areas, such as the promotion of international sourcing and access to export markets, the literature is vastly underdeveloped. Beyond evaluation, however, a distinct issue is that the intention behind many policies was not always to shape the composition of economic activity (strictly speaking, we consider only the latter to be "intentional" industrial policy). While we can learn from careful policy evaluations even when the intention was another objective or it is unknown, to settle the question of how much states actively contributed to industrialization, we need more and deeper research into how much of government policy was shaped by the desire to actively shape economic activity.

The paper is structured as follows. In Section 1, we introduce our definition of industrial policy, discuss the rationales for implementing them in the 19th century setting and introduce our conceptual framework. This disciplines how we examine the wide-ranging policies we then cover. The remainder of the paper considers the different channels through which industrial policies affect the economy, one at a time. For each channel, we first outline which kind of industrial policy governments historically used to target the specific channel, and then discuss the empirical evidence we have that evaluates the policy. We conclude by pointing to promising avenues for future work.

1 DEFINITION, RATIONALE AND CONCEPTUAL FRAMEWORK

1.1 Defining industrial policy in the 19th century context

We define industrial policy as "those government policies that explicitly target the transformation of the structure of economic activity in pursuit of some public goal." (borrowing from another paper in this volume; Juhász, Lane & Rodrik 2023, p. 4). We highlight two aspects of this definition. First, industrial policy is selective; i.e., it targets some prioritized activities at the expense of others. This distinguishes it from "horizontal" interventions that do not purposefully change the structure of the economy. Second, industrial policy is intentional, i.e., changing the structure of the economy is what the policy wants to do, *by design*. For example, an education policy may be industrial policy if its intention is to create the skillset necessary for a modern, industrial workforce.

Policymakers in the 19th century implemented a host of policies consistent with this modern definition as we will see below. The intellectual basis for this form of state activism was provided by neomercantilist thought, which was influential around the world.[2] The public goal of industrial policy at the time was typically modernization and fostering industrialization, often in response to the perceived geopolitical and economic threat of a powerful Britain. Though state capacity, and particularly fiscal and administrative capacity was limited, countries deployed a vast array of

[2]Helleiner (2021, p. 4) defines neomercantilism as "a belief in the need for strategic trade protectionism and other forms of economic activism to promote state wealth and power in the post-Smithian age."

industrial policy levers beyond trade policy – many that entailed fiscal spending.

When evaluating industrial policies, it is important to keep in mind the imperial context of this era. Our definition of industrial policy only truly applies to independent countries that had autonomy to determine what policies they deployed to shape the economy. Colonial markets and peoples were often used by imperial powers in the service of their own industrial policies, which nonetheless affected local economies. Where relevant, we will discuss work that examines the outcomes of these imperial industrial policies on local, colonial outcomes. Throughout, however, we should keep in mind that these effects are different by nature to those we find for independent countries.

1.2 The economic justification for 19th century industrial policies

Economic theory provides two broad justifications for industrial policy: market failures, and activity-specific public inputs.[3]

Market failures. In the presence of market failures, market forces alone do not deliver the socially desirable level of an activity, which provides states with the rationale to intervene. The 19th century context offers examples of at least four types of market failures. The first include *external economies of scale*, such as a learning-by-doing externality. These arise when a technological leader forges ahead, as in the case of Great Britain during the Industrial Revolution, and follower countries are not competitive, because they cannot reach the scale of the leader. However, a technological follower country that is not competitive in a sector today, can, under certain conditions, become competitive in the long-run if it is given temporary protection from trade – the classic infant industry argument (Harrison & Rodríguez-Clare, 2010).

Second, *cost-discovery externalities* as in Hausmann & Rodrik (2003) arise when early adopters produce valuable information for late adopters. Without intervention, no producer may have an incentive to be the early adopter, which holds back the adoption of new technologies in follower countries. A third example are *coordination failures*, which arise when it may be profitable for all producers to adopt modern technologies together, but it is not individually profitable for any, leaving the economy in a low-income equilibrium. These mechanisms are central to big-push theories of development and industrialization (Murphy, Shleifer & Vishny, 1989). Fourth, the market may *undersupply innovation* because the developer of a new technology cannot capture all the benefits.

Activity-specific public inputs. These inputs are public good type investments which are designed with a specific activity in mind. The clearest 19th century example is the provision of infrastructure, such as the railroad or telegraph. *If* the infrastructure was built or subsidized with the goal of fostering a particular type of activity – for example, modern industrial development, or, in the case of railroad development in colonies, securing access to critical industrial inputs,

[3]This part builds on Juhász et al. (2023).

that is industrial policy. Other examples include education policy designed to foster an industrial workforce, and technology policies designed to absorb technology and knowledge from abroad.

1.3 A conceptual framework to evaluate 19th century industrial policies

The main goal of this paper is to evaluate what we know about the use and efficacy of 19th century industrial policies at addressing market failures and providing public inputs. We propose a simple conceptual framework, illustrated in Figure 1 that examines the different ways in which producers in an economy are affected by their environment. This will allow us to evaluate mechanisms (e.g., what was the effect of output market integration policies?) rather than individual policies (e.g., what was the effect of state-led railroad development?).

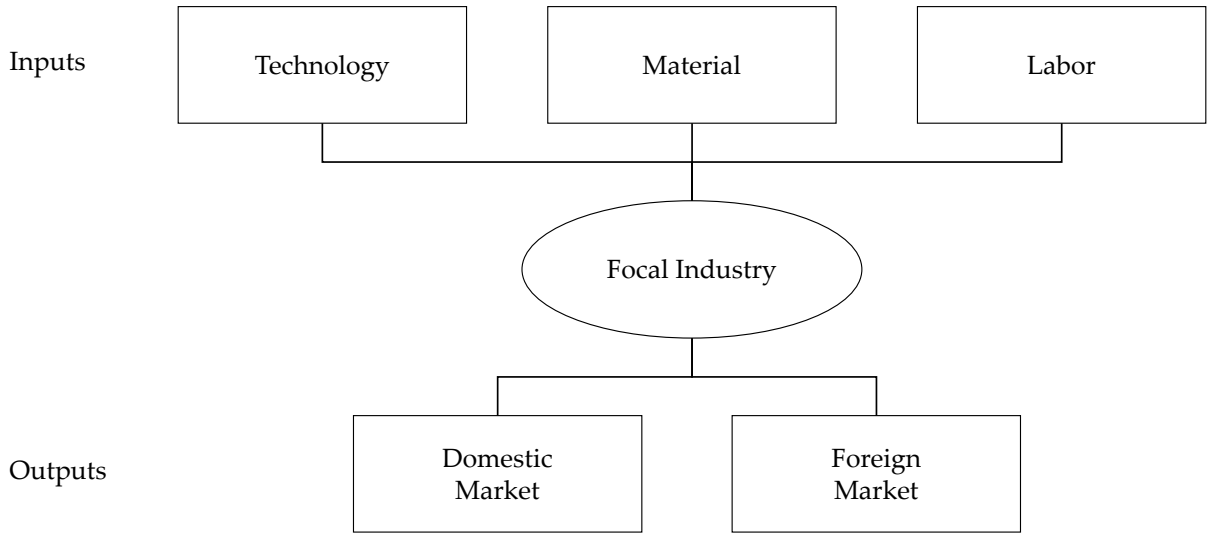

Figure 1: Conceptual framework

We distinguish between two, often complementary, ways in which industrial policies affect domestic producers' incentives: on the output and input side. On the output side, one set of policies was targeted at increasing a firm's domestic sales: i) policies that protected domestic producers from foreign competition; ii) policies that increased the *size* of the domestic market by increasing domestic market integration; and iii) policies that increased the *share* of the domestic market that individual firms captured through domestic competition policy. A second set of policies were targeted at enabling access to foreign markets. On the input side, the production function suggests that producers will benefit: i) when they have access to more productive technology; ii) when they can source material at low cost, both domestically and from abroad; and iii) when they have access to cheap labor.

These economic channels may interact with one another. For example, protection from foreign

producers may improve the technology available to all domestic firms if external economies of scale are present (as in infant industry models). Similarly, limiting domestic competition in the industry may create domestic profits that can be used to finance entry into foreign markets. Moreover, the same policy can affect multiple channels. For example, railroads affected output market integration, led to better access to material inputs, export markets, technology and ideas.

2 SHAPING DOMESTIC MARKETS

We begin by examining the three channels that operate through domestic markets: protection of domestic producers; domestic market integration; and competition structure.

2.1 Protection from foreign competition

Much-discussed policy tools used to promote infant industry in the 19th century are protective import tariffs, or even prohibition. These and similar instruments incentivize local production by raising the domestic price for the targeted industry. Strategic protectionism of this form was central to Friedrich List's thought and neomercantilist thought more generally (Helleiner, 2021). Protection is strategic, as it is not applied across the board, but rather, it is applied to a selective set of (infant) industries.

2.1.1 Strategic tariff protectionism

Though prominent in neomercantilist thinking and beyond, it is unclear to what extent states in the 19th century deployed strategic protectionism. Tariffs may be deployed for a variety of reasons, only one of which is infant industry promotion. An important competing objective in this period was deploying tariffs to raise revenue, which, in the US, made up 90% of government revenue until the Civil War (Irwin, 2017). In fact, there is emerging evidence that the fiscal needs of the state were an important determinant of tariff policy, perhaps dominating infant industry promotion and other objectives (Chuchko, 2019; Lampe, 2020).

We take a different approach and ask to what extent the structure of tariffs was conducive to shifting relative prices in favor of infant industries in manufacturing, regardless of the underlying policy objective. In Figure 2, we examine the average level of tariffs in agriculture and manufacturing for a sample of ten countries every five years between 1877-1912. Overall, tariffs in core, industrialized economies seem slightly biased towards agriculture, while in periphery economies the opposite is the case, suggestive of infant industry protection in these countries. Yet these patterns are weak, and, on average, the difference between agricultural and manufacturing tariffs are fairly small.

Figure 3 provides a further breakdown of manufacturing tariffs for one single year where data have been digitized, distinguishing tariffs for machinery, industrial intermediates such as yarn or chemicals, and manufacturing final products such as cotton cloth. For this dataset, we are also

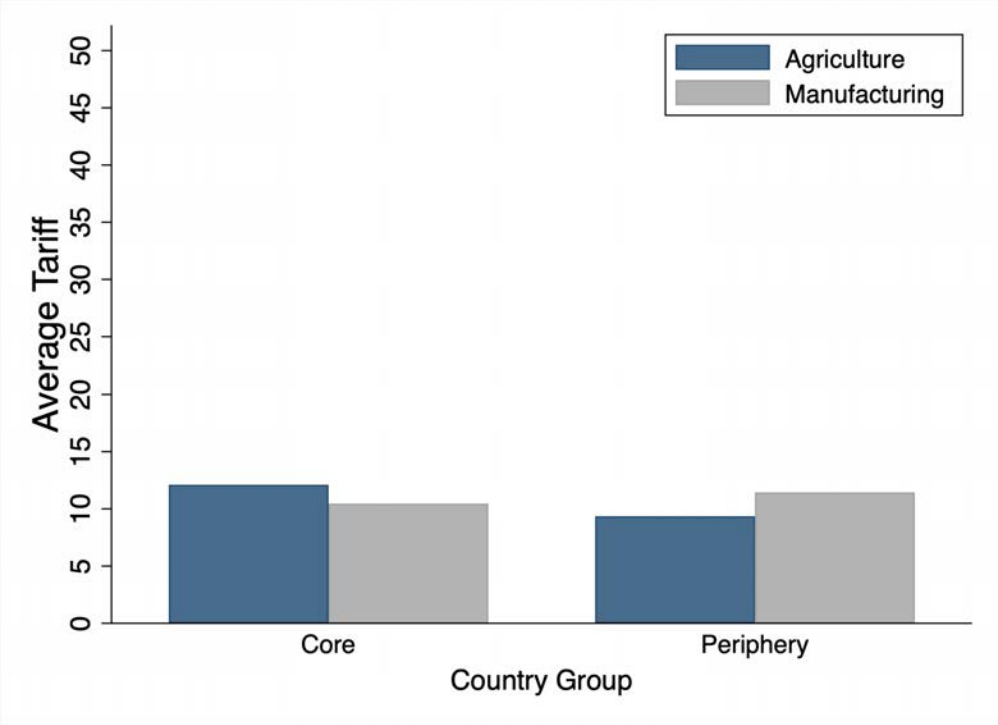

Figure 2: Structure of tariffs: agriculture vs. manufacturing, 1877-1912

Notes: Data are from Lehmann & O'Rourke (2011). Core economies are Britain, France, Germany, and the US; periphery economies are Australia, Canada, Denmark, Italy, Norway, and Sweden.

able to separately examine colonies (in particular, British India and the Union of South Africa). The patterns within manufacturing paint a picture that is strikingly consistent with infant industry protection, as output tariffs are consistently higher than material input tariffs and capital input tariffs. This is particularly true for periphery economies.[4] In light of these findings, there is some evidence that the structure of tariffs was conducive to shifting prices in favor of light manufactures such as textiles in some periphery economies.

2.1.2 Economic effects of tariff protection

In the 19th century context, the main place to look for infant industry mechanisms are new industries in technological follower countries. Specifically, in mechanized, factory-based manufacturing, particularly textiles. Assessing the growth effects of (average, country-level) import tariffs was the main way in which an earlier literature engaged with the question of infant industry and industrial policy more generally. The identification and interpretability problems in this literature have been extensively discussed elsewhere (see Rodriguez & Rodrik 2000; Harrison & Rodríguez-

[4]This sample includes a wider set of countries, which is why it cannot easily be compared with Figure 2.

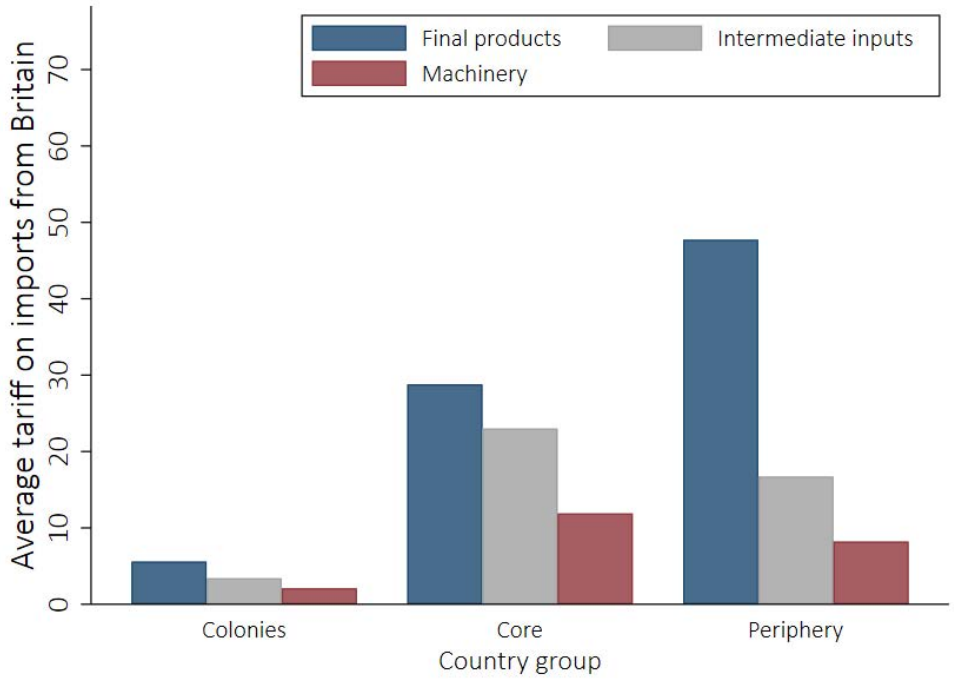

Figure 3: Structure of tariffs: Manufacturing by product type, 1905

Notes: Data are from Varian (2023) and denote average tariffs that countries impose on imports from Great Britain in 1905. Colonies are British India, and the Union of South Africa; core economies are Belgium, France, Germany, Holland, Switzerland, and the US; periphery economies are Argentina, Australia, Austria-Hungary, Canada, Denmark, Greece, Italy, Japan, New Zealand, Norway, Portugal, Roumania, Russia, Spain, and Sweden.

Clare 2010; Juhász et al. 2023).[5] Here, we simply highlight that in light of the preceding section, average country-wide tariffs are unlikely to be informative about the extent to which domestic relative prices were favorable to infant industries.[6]

The literature in recent years has made important strides both in terms of developing careful identification strategies to deal with the inherent endogeneity of tariffs, and to better isolate the infant industry mechanism. In terms of identification, this new literature leverages quasi-random time variation in effective protection driven by technological shocks, as well as wars and blockades.

A helpful place to start is Pascali (2017), which exploits the exogenous, time-varying change in trade openness caused by the introduction of steamships. The author finds, on average, a negative impact of trade openness on various measures of economic development. While this is not an infant industry paper *per se*, its findings are consistent with strong infant industry forces at

[5]Irwin (2019) provides a recent discussion of advances in literature assessing the effects of trade reform on growth.

[6]This point was first made by Lehmann & O'Rourke 2011 who distinguished between agricultural and industrial tariffs.

play in the late 19th century, as countries that experienced less opening to trade experienced more growth. This is in line with infant industry models featuring external economies of scale, which would predict that countries which were more open witnessed slower income growth due to remaining specialized in "low-growth" agriculture (as in Matsuyama 1992). In contrast, neoclassical trade theory predicts that increased trade will lead to higher income through specialization effects. While infant industry models are not the only lens through which one can interpret these empirical patterns (others being the inclusiveness of political institutions, or the imperial context of the 19th century), this interpretation is striking: It implies, that, at this critical juncture, the gains from increased specialization according to static comparative advantage may have been outweighed by developing dynamic comparative advantage in modern manufacturing.

A different approach is taken by Juhász (2018) who studies the development of mechanized cotton spinning in France during the period of the Napoleonic Blockade. The setting is one that closely corresponds to textbook infant industry. France had a similar (cottage industry-based) cotton textile industry to Britain's before mechanization. Thus, Britain arguably had a first-mover advantage once it forged ahead. Consistent with infant industry mechanisms at work, the author finds that French regions exogenously better protected from trade with Britain during the blockade expanded their mechanized spinning capacity. Moreover, temporary protection changed the long-term profitability of the industry and industrial development more generally.

It is interesting to contrast these findings to Liu (2020) who studies the effect of trade disruptions during WW1 on the development of cotton textile manufacturing in China. In contrast to the Napoleonic period, the paper finds little evidence of increased activity in more protected Chinese areas until after the war ended. The key to reconciling the findings between the French and Chinese context seems to be firms' access to technology, and in particular, capital equipment. While WW1 gave Chinese entrepreneurs, particularly those around ports, a chance at import-substituting industrial development, they also cut off a critical input: the necessary technology.

This point highlights two key takeaways. One is that the different mechanisms we examine do not exist in isolation. Infant industry protection may be insufficient without providing access to critical inputs such as technology (which we discuss in Section 4). Second, context matters. Mechanized cotton spinning was sufficiently new everywhere, and France was sufficiently similar in terms of fundamentals and geographic proximity, that based on limited access to technology (mostly blueprints and a handful of British engineers), the French were able to domestically produce the simple "first generation" machines relatively quickly. A century later, machine building was so developed that Chinese firms did not stand a chance without access to British capital equipment.

Given France's ability to adopt and utilize the new technology so quickly during the blockade, we may wonder what market failure impeded them from adopting the technology in the first place?

In follow-up work, Juhász, Squicciarini & Voigtländer (2023b) show evidence that French cotton spinners faced important organizational challenges in running modern, factory-based production. This suggests that an important component of the externality was a cost-discovery channel a la Hausmann & Rodrik (2003). Early, inefficient plants may have produced important externalities to later entrants by discovering how to optimally run factories in the French setting. This suggests that part of the tacit knowledge an industry needs to develop to thrive cannot be imported from anywhere, and must be developed locally, potentially at substantial cost to the industry.

The preceding discussion presents a somewhat mixed picture of tariff protection as an important and effective industrial policy tool for 19th century industrial development. On the one hand, recent work based on careful identification suggests that infant industry mechanisms, particularly in modern (textile) manufacturing were present, and potentially highly important for development trajectories. One reading of this line of work suggests that countries or regions more protected from trade stood a better chance of developing a modern, factory-based manufacturing system. On the other hand, it is not clear how important or widespread strategic tariff policy was relative to competing uses of tariffs. Our results suggest that some economies did have a tariff structure in place which favored infant industries in manufacturing (textiles), though more work is needed to understand how consistent or widespread this pattern was; to what extent it was intentional industrial policy; and whether it was as effective in fostering infant industry development as the shocks the current literature has evaluated.

2.2 Domestic market integration

At the turn of the 19th century, domestic markets were highly fragmented almost everywhere. Overland transportation was slow and expensive. Internal customs, tolls and other restrictions made it costly to trade across regions within the same state. Local economies, particularly those far from navigable waterways, existed in a state of near-autarky across much of the globe. The result of these man-made and natural barriers to trade was "a balkanized system of local monopolies that impeded the workings of the national economy, protecting niches of inefficiency from competition" (Mokyr & John, 2007, p.53).

2.2.1 Policies to foster domestic market integration

The creation of a unified, national market was a prominent policy objective for thinkers and policymakers through the nineteenth century. New technologies, most prominently the railroad and telegraph, made the creation of large, integrated markets possible. A national market, it was argued, would increase efficiency, promote regional specialization and make possible a finer division of labor. By creating a large internal market, producers would reap the benefits of economies of scale and invest in new technologies (Horn, 2006, p.48).

In independent countries, the state shaped domestic market integration through both its policies

and direct infrastructure investment. There was often an explicit developmental goal in promoting the railroad, particularly in latecomer countries such as Sweden and Japan. Berger (2019, p.74) quotes the Swedish Minister of Finance on the matter: "If one wants to extend a helping hand to our industry [...] the State cannot support the improvement of the country in a more efficient, appropriate, impartial and magnificent way, than by a firm action to bring about railways."[7]

State policy and public financing affected railroad development differently in different countries. At one extreme, Britain and Prussia initially opted for a policy of complete laissez-faire, leaving both the design and construction of the railway to the private sector (Shaw-Taylor & You, 2018; Hornung, 2015). In many other countries, however, the state played a role with some combination of granting concessions (the right to construct a particular railway line), subsidies or profit guarantees, regulation and public financing. Due to the large and lumpy financing required there was often also substantial private sector involvement. In the global periphery, the lack of developed capital markets meant that foreign firms often undertook the bulk of railroad construction. For example, British firms were heavily involved in railroad development in South America, and the state provided subsidies to attract the necessary capital (Summerhill, 2003; Diaz, 2017).

Much like the railroad, government involvement in the construction of telegraph networks varied substantially. In countries such as Britain and the US, domestic networks were initially privately developed in response to business interests, while the French and Chinese networks were developed with substantial government involvement (Huurdeman, 2003; Gao & Lei, 2021).

Despite its evident benefits, removing man-made barriers to internal trade such as internal tariffs was often difficult to achieve even in independent countries. The political economy problems associated with such radical reform delayed implementation. Special interests, and the state's need for revenue blocked efforts at removing internal customs and tolls in politically unified France for centuries until the French Revolution (Bosher, 1964). Across German states, rulers were concerned with market integration led by Prussia, which was seen as politically undesirable (Keller & Shiue, 2014).

In colonies, domestic market integration, chiefly railroad construction, was typically an accidental byproduct of colonial policies that served the goals of the metropole: military security (Donaldson, 2018); geopolitical power (Jedwab, Kerby & Moradi, 2015)); and the transport of raw materials from the interior to the ports for export (Jedwab & Moradi, 2016).

2.2.2 Economic effects of domestic market integration

The past decade has seen a proliferation of high quality work evaluating the effects of domestic market integration. The literature has pushed the frontier forward along a number of dimensions. First, new data has allowed researchers to examine outcomes across finer spatial units and along

[7] In countries where the state was involved in the development of the railroad, military and political considerations, as well as the efficient delivery of mail were other important considerations.

a variety of different margins. This new body of work speaks to how domestic market integration affected agricultural and industrial development, the market for ideas (which we discuss in Section 4), the distribution of economic activity across space, and its persistence.

Second, researchers have examined these questions in many different settings. New empirical work informs the experience not just of Western economies, but also colonies and peripheral countries where the objectives and context of domestic market integration were different. Third, the new body of work deals carefully with two prominent challenges that make evaluating the effects of market integration difficult: the inherent endogeneity that these policies and investments entail, and the need to carefully distinguish between growth and reallocation effects (Redding & Turner, 2015). Finally, the literature has developed quantitative spatial models that allow researchers to estimate the aggregate effects of market integration allowing researchers to move beyond estimating local effects.[8]

In terms of their findings, several recent papers show that market integration in this period entailed a substantial reduction of both trade costs (see Donaldson (2018) for trade cost reductions achieved through railroad development in India, and Keller & Shiue (2014) on the removal of man-made barriers across early 19th century German states), and information frictions (Gao & Lei, 2021).

New work also estimates the magnitude of specialization gains across markets in British India and the United States. While the contexts differ, the results consistently find that the reduction in trade costs led to substantial gains from increased specialization based on Ricardian comparative advantage (Donaldson, 2018; Donaldson & Hornbeck, 2016; Hornbeck & Rotemberg, 2023).

In a number of countries, an objective of state-promoted railroad development was to foster industrialization. Recent work speaks both to whether, and, importantly, *how* the railroad affected industrial development. A common finding is that locations treated by the railroad witnessed faster local population growth and urban development (Atack, Haines & Margo, 2011; Hornung, 2015; Jedwab et al., 2015; Berger & Enflo, 2017; Berger, 2019; Büchel & Kyburz, 2020; Bogart, You, Alvarez-Palau, M. & L., 2022). This is true across a multitude of different contexts, from colonial Kenya, where the railroad was introduced in sparsely populated regions that were near autarkic (Jedwab et al., 2015), to England and Wales (Bogart et al., 2022), where market integration and industrial development prior to the railroad were already relatively high. These effects suggest that the structure of the economy may have changed in ways consistent with industrial development. The literature has identified at least two potential mechanisms at play. First, a number of papers find an effect on the scale of manufacturing establishments caused by the railway. That is, by increasing markets size, firms were better able to exploit economies of scale (Hornung, 2015; Tang, 2014; Atack et al., 2011). Second, other papers find important effects on local structural transfor-

[8] Donaldson (2015) provides an excellent overview of these methods.

mation out of agriculture and into manufacturing (Berger, 2019; Lindgren, Pettersson-Lidbom & Tyrefors, 2021; Bogart et al., 2022), though this is not a consistent finding across all papers (see Hornbeck & Rotemberg 2023 for the US.).

While many of these papers suggest that the railroad had an important local effect on industrial development, the aggregate effects are less clear-cut. It may be the case that industrial development would have happened anyway, and the railway served as the coordination device for where it occurred. Though difficult to rule out completely, the fact that we see changes in the scale of firms and the structure of local economic activity suggests that the incentives for establishing modern, factory-based manufacturing changed. Given the limitations inherent to reduced form work, careful quantitative work would be a particularly helpful complement to these studies. Hornbeck & Rotemberg (2023) provides an illustration of such a work, exploring the implications of input frictions for market integration.

2.3 Domestic competition policy

While policies targeted at domestic market integration are aimed at increasing the *size* of the industry, a related question is what *share* of the industry a specific firm captures. This may be relevant for the scale of firms, and their ability to modernize and adopt frontier technologies. Over the course of the 19th century, in many industrialized countries large companies formed cartels to restrict output, set prices, and allocate regional markets in response to overcapacities, and to escape competitive pressure (Chandler 1990, p.71, Fischer 1954).

There was substantial heterogeneity with respect to how governments responded to this trend. Germany, where cartels were legal and deviating behavior of cartel members could be enforced at court (Trebilcock, 1981), was at one extreme. Japanese cartel policies from the 1920s and 1930s can be seen as precursors to the high watermark of industrial policy in the postwar *MITI* era, whereby the government used "administrative guidance" to steer competition (Johnson, 1982). Cartels were not explicitly allowed in Great Britain or France, though in both countries, there was a "gentleman's agreement" among industrialists to limit competition (Landes, 1969, p.246). The United States was at the other extreme. Cartels also emerged, but these were unstable, and the introduction of the *Sherman Antitrust Act* in 1890 put a definitive stop to monopolistic behavior (Chandler, 1990, p.71). As a result, large companies existed on both sides of the Atlantic, but in the US they competed vigorously against each other, while in Europe they did so to a lesser degree.

The empirical literature evaluating the effects of competition policy on industrialization in this era is sparse. An exception is Gross (2020), who finds that the cartel amongst US railroads provided the incentives for adopting a standardized railroad gauge, a potentially welfare-enhancing innovation. However, consumers did not benefit, as the cartel restricted the pass-through of resulting cost savings. Overall, given the prevalence of cartels and large corporations that emerged during the 19th century, we know little about how they affected industrial development. This is an

area ripe for future research.

3 ACCESS TO FOREIGN MARKETS

The 19th century not only experienced the Industrial Revolution, but also a dramatic fall in international trade costs, which paved the way for the First Wave of Globalization (circa 1870-1914). A historically unprecedented international division of labor emerged. Industrialized, "core" economies increasingly exported manufactured products in exchange for agricultural products and industrial inputs from colonies and other, (nominally) independent states. While the technological revolutions that led to this reduction in transport costs are well-known (railroads, telegraphy, and steamships), less appreciated is the role of states in shaping them. In addition, access to foreign markets was often shaped by countries' industrial policies e.g., through export promotion, trade agreements, or protection of intellectual property. We consider these policies in turn.

3.1 Policies to improve access to foreign markets

3.1.1 Colonialism

One of the most salient ways in which imperial countries shaped the terms of global trade was through conquest, empire building and "gunboat diplomacy". A primary motive for colonialism was to secure markets for imperial powers' manufactures (Allen, 2011). Colonies typically did not have independent tariff setting power, and sometimes, out-of-empire tariffs were set to favor the metropoles' products (Romero, 2023). This is illustrated in Figure 3, which shows that tariffs were lower across the board in the two colonies for which we have data relative to both "core" and "periphery" countries. In nominally independent states, imperial powers often used other forms of leverage to extract "unequal treaties" (e.g., China and Japan) that ensured low tariffs for exporters.

3.1.2 Infrastructure development

States also shaped access to foreign markets through infrastructure development policies and projects. These included the building of railroads linking production centers to ports (see also Section 2.2.1), the development of ports, and international infrastructure such as the global telegraph network.

International (typically, submarine) telegraph cables connecting countries and continents relied to different degrees upon government involvement. Direct government ownership was initially modest, and private capital funded the most important, commercially viable trunk lines. Later, governments stepped in and "filled the gaps" by setting up duplicate and alternate lines, raising the publicly owned share of international lines from 7.7% in 1877 to 20.9% in 1903.[9] But even for private lines, the governments played an important role in the background in various ways: by

[9]These shares are calculated from link-specific data kindly provided by Roland Wenzlhuemer and used in Wenzlhuemer (2012).

enabling financing, by allowing telegraph monopolies (with the idea that monopoly profits would be used to finance the investment), by working with other countries to harmonize standards, by financing surveys of the ocean floor, or by putting pressure on governments to grant landing rights on foreign territory (Headrick & Griset, 2001). In fact, the International Bureau of Telegraph Administration, set up in 1868, was the world's first permanent international organization (Headrick, 1991).

Britain dominated the telegraph network, owning 66.3% of the global network in 1892, both via private companies based in London and the British government (Wenzlhuemer, 2012). Historians have argued that the international telegraph network was primarily a "tool of empire"—at one point there was a scheme to build a strategic "All Red Route" which would have connected the globe only through British territories (Headrick, 1981, 163). However, more recent contributions have pointed out that this role may have been overstated, and argue instead that the economic interests of large private companies in cartel relationships drove a large part of the global expansion, while empires coordinated regulatory issues (Winseck & Pike, 2007).

Figure 4 illustrates how these developments led to faster communication across the globe, using the fastest measured communication time between London and ports in specific countries from *Lloyd's List* (compiled in Juhász & Steinwender 2018). In the 1840s, communication times were heavily determined by physical distance: While it took 7 days to communicate with the average European port, it took almost 100 days for a one-way message to Australia. Communication times improved substantially, on average by 86%, as the globe became increasingly connected. By 1880, communication between Great Britain and Asia, Northern Europe and Europe was almost instantaneous, while Africa, South America and Australia communicated with a much reduced delay.

3.1.3 Subsidies for shipping

States shaped access to foreign markets through subsidies they provided to shipping firms. Maritime economic historians argue that in countries such as England, Germany and Japan, where rapid industrialization was accompanied by the development of foreign trade, subsidies to shipping were necessary for the profitable operation of many routes (Davies, 2009).[10] In Britain, the earliest steamships were heavily subsidized and regulated (Headrick, 1981). Germany provided subsidies for steam liner services other than Atlantic routes, which could break even because of the profits made with emigrants. Meiji Japan adopted aggressive and generous subsidies to both its shipbuilding and shipping sector (Crawcour, 1997); subsidized the creation of new, long distance routes to Europe and North-America; and also provided a subsidy per route-mile (Davies, 2009).

[10]In fact, lucrative subsidies for the carrying of mail are argued to have played an important role in the adoption of steamships (Headrick, 1981; Davies, 2009).

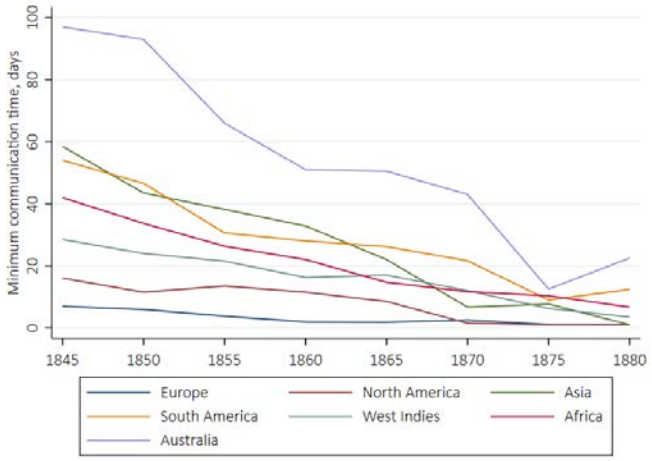

Figure 4: Minimum communication time from region to London, days

Source: Data from *Lloyd's List* compiled in Juhász & Steinwender (2018). We calculate the minimum communication time to a port across all days in a given year, and then average across major ports in a region.

3.1.4 Export promotion policies

While many 19th century neomercantilist thinkers were more focused on developing the domestic market, there were East-Asian thinkers who advocated for the promotion of exports (Helleiner, 2021). In Meiji Japan, a subset of these plans were implemented, including providing trade financing and the use of state trading for some commodities (Ericson, 2020). Export subsidies for heavy manufacturing made an appearance in pre-WW1 Germany, though interestingly, they were managed and administered by upstream, industrial input-producing cartels (Trebilcock, 1981).

3.1.5 Bilateral trade agreements

Governments also used the system of bilateral treaties that emerged in Europe in the 1860s following the Anglo-French Cobden-Chevalier treaty to facilitate foreign market access (Lampe, 2020). Although often interpreted as an early example of a move to free trade in Europe, recent work has shown that tariff reductions were far from universal across product lines and mostly affected manufactured products. Notably, countries such as France, which strategically negotiated bilateral tariff reductions tailored to their domestic export interests, gained the most in terms of increased trade – though the effects on welfare and income are of course a different matter (Lampe, 2009).

3.1.6 Protection of intellectual property

One additional obstacle that firms from industrialized countries faced when accessing foreign markets was infringement of intellectual property rights (IPR). Trademarks signal unobserved product characteristics such as quality or durability, and were especially important in international trade

where buyers and sellers interact at a distance. However, under national law, trademarks were not protected against infringement in foreign countries. In order to help firms in export markets, governments signed agreements with each other: at first bilateral agreements, and later—beginning with the Paris Convention of 1883—multilateral agreements (Higgins, 2012).

3.2 Economic effects of access to foreign markets

Complementing the work discussed in Section 2.2.2, some recent papers have examined the effects of the railroad on opening up the agricultural hinterlands of countries to the world market. The experience of two countries specialized in agricultural exports (colonial Ghana in Jedwab & Moradi (2016), and Argentina in Fajgelbaum & Redding (2022)), show that export opportunities can substantially change the spatial distribution and the level of economic activity in a country. Local economic activity increased and changed in composition in areas which became better connected to export markets due to the railroad. Through the lens of a spatial model, Fajgelbaum & Redding (2022) also find that integration into the world economy increased aggregate welfare substantially.

It is important to note the tension between the single-country studies that find positive local and aggregate effects of increased trade, with the cross-country findings of Pascali (2017), which suggest that the effects of trade on income are negative for some countries. However, Pascali (2017) identifies the local average treatment effect of increased trade driven by reduced shipping times, whereas the single country studies uncover effects driven to a large extent by giving agricultural producers the ability to produce surplus for the export market. The effects of these two distinct forces may well be very different.

A distinct channel through which the new global environment shaped access to export markets was the reduction in communication times that the global telegraph network achieved. The network improved access to international input as well as output markets. It did so via two mechanisms, improving information about foreign supply and demand conditions (which we discuss in Section 5), and allowing buyers and sellers to communicate about product characteristics. Juhász & Steinwender (2018) show evidence for this second mechanism for the case of Britain selling its manufactured products across the globe. The telegraph improved British exports of codifiable products, that is, those for which the desired product characteristics could be communicated in words.

The third channel the literature has examined is the effect of trade policies. Romero (2023) studies the effects of Spain's tariff policy in its colonies on industrial development in Spain. Using a natural experiment that increased market size through captive colonial markets for Spanish cotton textiles, the author finds that innovation increased in Spain. These findings lend support to the notion that imperialism had a role to play in the international division of labor that emerged by the end of our study period.

Finally, Alfaro, Bao, Chen, Hong & Steinwender (2022) exploit the quasi-exogenous introduc-

tion of a trademark law in China in 1923 to advance our understanding of how trademark protection affected the foreign market access of authentic producers. The authors find that the trademark law reallocated market share from counterfeiting to authentic, Western firms, created industry-level growth, but did not raise consumer prices, suggestive of the fact that consumers benefited most from the efficiency gains unlocked by the trademark law.

Notwithstanding the work reviewed above, this part of industrial policy remains critically understudied. Understanding how trade policies put in place in the context of imperialism affected countries is key. If infant industry mechanisms were relevant at this critical juncture, the fact that many countries did not have independent tariff policy is important. Second, the historical literature also suggests that competitiveness in export markets was often shaped by subsidies. It would be important to understand how important these were, particularly given what we know about the importance of fixed costs and the stickiness of exporter relationships from the contemporary setting.

4 ACCESS TO TECHNOLOGY

Any state hoping to emulate Britain's success in manufacturing tried to obtain, copy and "domesticate" British technologies, as well as develop new ones that could successfully compete with British technology using wide-ranging policies.

4.1 Policies to facilitate access to technology

Governments pursued two main, likely complementary, strategies: facilitating the absorption of technology from abroad, and fostering domestic innovation.

4.1.1 Knowledge transmission from abroad

There were two critical barriers to importing the technology embodied in machinery. First, Britain banned the export of machinery and tools until 1843 (Saxonhouse & Wright, 2000), as well as the emigration of skilled workers and engineers until 1825 (Landes, 1969; Jeremy, 1977). Second, even if machines could be acquired, tacit knowledge was required to operate it (Landes, 1969; Wright, 1986; Maloney & Caicedo, 2022). Governments tried to overcome these barriers with a variety of policies.

Technology policy. Beginning in France (Horn, 2006), through early 19th century Prussia (Lenoir, 1998), in Egypt under Muhammad Ali (Helleiner, 2021), in China during the Self-Strengthening Movement (Bo, Liu & Zhou, 2023), and in Meiji Japan (Crawcour, 1997; Montgomery, 2000; Jones, 1980), we have evidence of wide-ranging government involvement in facilitating technology absorption. Across these different contexts, books on technology and science were acquired, translated and disseminated; industrial expositions were set up to disseminate knowledge of new technologies; the government purchased foreign technology and supplied it to local firms; in other cases, the state financed model factories equipped with the newest technologies and organizational

techniques; spies and—later—learning missions were sent to observe frontier technologies and organizational forms in frontier countries such as Britain; and foreign educators and engineers were brought in on government payroll. While there are some differences across these government supported technology acquisition efforts depending on the timing and context, there are also striking similarities suggestive of the fact that governments were responding to a widely perceived barrier to technology adoption.

Some of the illegal activities deployed to facilitate technology adoption were enabled by the inadequate protection of intellectual property rights (IPR) in foreign territories. International recognition of IPR started with the 1883 Paris Convention.[11] Before the convention, it was almost impossible for inventors to license their patents abroad (Bilir, Moser & Talis, 2011). As a result, inventors were reluctant to share any of their knowledge across borders. After the Convention, inventors from any country could register their patents abroad, which facilitated international technology transfer.[12]

Colonies had little to no autonomous technology policy. However, sometimes it was in the interest of the colonizer to introduce new technologies to the colony. One example of such a policy is the Dutch Cultivation System in Java in the 19th century, where the Dutch set up factories with state-of-the-art sugar processing technology to increase sugar production, which was then exported to the Netherlands (Dell & Olken, 2020).

Tariff policy. Once Britain lifted its export ban, foreign governments could use trade policy in the form of low tariffs to ensure access to machinery. Figure 3 illustrates the use of this policy for 1905: tariffs on machinery were typically lower than tariffs on final products and even intermediate inputs across a large number of countries, but particularly those in the periphery.

Finance policy. Industrialization required large amounts of capital to finance machinery. Governments supported the financing of industry in a variety of ways that ranged from direct government financing (e.g., subsidies or state ownership), enabling private financing (e.g., through corporate laws, regulation of the banking sector), and regulating foreign investment (e.g., through regulating international financial flows). Direct government financing could take the form of subsidies or public ownership. For example, Lenoir (1998) discusses how early 19th century Prussia bought foreign technology and disseminated it to private firms and built state-financed industries. Similarly, Meiji Japan opened state pilot factories which lost money, but may have contributed to learning through demonstration effects (Morck & Nakamura, 2018; Crawcour, 1997). A more indirect, but no less important way to enable financing was to develop a well-functioning domestic capital market, with access to private investors or banks. For example, corporate laws, that were

[11] For summaries, see https://www.wipo.int/treaties/en/ip/paris/summary_paris.html and Khan (2008).

[12] See also Donges & Selgert (2019), Sáiz (2014) and Nuvolari, Tortorici & Vasta (2020) who document international technology transfer using patents.

developed in the second half of the 19th century in many countries, enabled firms to raise more capital, which they could use to buy machinery or build factories (Guinnane, Harris, Lamoreaux & Rosenthal, 2007). Finally, governments could also allow foreign capital to finance domestic industry. International capital flows surged during the 19th century, especially from the core to the periphery (O'Rourke & Williamson, 2001, p.208).

4.1.2 Fostering innovation

A distinct—and in practice, complementary—set of policies were those that were targeted at encouraging domestic innovation.

Technical education. The creation of elite universities often coincided with states' industrial development pushes and in particular, the technology policies discussed above. This was the case in France, where the creation of the *École Polytechnique*, the *École des mines*, and the *École nationale des ponts et chaussées* coincided with the introduction of technology policies (Landes, 1969, p. 150). Similar policies were enacted in Prussia, which created the Humboldt University in Berlin in 1810 (Lenoir, 1998), as well as Japan, which reformed the entire higher-education system in the 1880s (Montgomery, 2000).

An important goal of these institutions was to create a pool of inventive talent to further industrial development. For example, Trebilcock (1981, p. 62) argues that German schools, polytechnics, and universities were put in place in order to "train scientists capable of conducting industry-related research [and] industrial managers capable of appreciating their discoveries". The United States supported agricultural research by granting government land to research institutions and creating the "land-grant colleges" (Huffman & Evenson, 2008).

Outside universities, technical training had the goal of enabling workers to improve machines. For example, in the French cotton spinning city of Troyes, workers were provided with classes in "chemistry, geometry and mechanics applied to the industrial arts" that outlined problems with existing machines. This was successful: One of these workers led the city of Troyes to become the French center for textile innovation (Horn, 2006, p.291).

There was also intense exchange of knowledge and innovation through the emergence of economic societies, i.e., member organizations that had the goal of improving the local economy by "adopting, producing, and diffusing useful knowledge" (Cinnirella, Hornung & Koschnick, 2022). These societies benefited from different levels of government support ranging from public initiation (in Prussia), to more indirect support (Britain).

Protection of intellectual property rights (IPR). Before the 1790s, only Britain, France, and the United States had some sort of patent system (Bottomley, 2014). In other European countries, the introduction of patent laws was the subject of much debate (Khan, 2008). Opponents argued that IPR, by creating state-sponsored monopolies, reduced competition and thus welfare. As a result, the Netherlands repealed its patent legislation in 1869, and Switzerland only introduced patent

laws towards the end of the 19th century (Schiff, 1971). However, as international technology fairs to showcase innovation became popular, the advocates of IPR protection gradually won the debate (Findling, 2018). Over the course of the 19th century, most countries introduced or substantially modernized national patent laws.

4.2 Economic effects of access to technology

A burgeoning literature focusing on causal identification has studied the effect of a number of these policies on innovation and industrial development. We consider these in turn.

Railways. Recent papers have found large positive reduced form effects of railroad access on both innovation (Perlman, 2016; Andersson, Berger & Prawitz, 2023) as well as technology adoption (Yamasaki, 2017; Americo, 2022; Liu, 2020). Theoretically, these effects could be driven by a variety of channels, but not all of these have found empirical support. So far there is empirical evidence on three channels: i) lowering transport costs to access more advanced machinery (Americo, 2022; Liu, 2020); ii) providing information about the demand for innovation (rather than demand for output) (Andersson et al., 2023); and iii) by reducing transaction costs in patent markets, as railways made it cheaper and faster for buyers, intermediaries and sellers of patents to meet and interact (Andersson et al., 2023).

In contrast, the following channels have *not* found support in the literature. First, while railways increased access to output markets (see Section 2.2.2), this did not in turn incentivize innovation or technology adoption (Perlman, 2016). This is surprising and unexpected given the contemporaneous literature (Shu & Steinwender, 2018). It is also in contrast to access to export markets, which *has* been found to spur innovation (Romero (2023); though this was driven by tariff changes rather than by railways). Second, railways did not spur innovation by facilitating the exchange of ideas among inventors (Perlman, 2016; Yamasaki, 2017). This is in contrast to a reduction in postage costs, which has been shown to increase the exchange of ideas and innovation in Britain (Hanlon, Heblich, Monte & Schmitz, 2022). More research on these channels is needed to understand these unexpected findings.

Intellectual property rights protection. The economic literature studying domestic innovation has revealed some surprising findings. For example, patent protection was not necessary for 19th century innovation: Using innovation data on technology fairs in 1851 and 1876 (which is more complete than patent data), Moser (2005) shows that countries without patent protection contributed as much, if not more, high-quality innovations than countries with patent protection. However, patent protection had a *directive* effect on innovation: Without patent protection, innovation is more likely to occur in industries where secrecy can be used as an alternative form of protection. In contrast, Hanlon & Jaworski (2021) find that stronger IP protection does increase innovation in the context of airframe design protection in the US in the 1920s, but it also *decreases* innovation in complementary products: aero-engines. These studies suggest two points:

First, patent protection was not the only form of IP protection. Second, considering the heterogeneous effects across industries and spillovers, policymakers needed to carefully consider the type of industry they were trying to develop when deciding about IPR protection policies.

International treaties that protect foreign patents have been shown to increase patenting of foreign innovations, especially from frontier countries (Bilir et al., 2011). However, to stimulate economic development, the follower country also needs the foreign patent to be *used*, not just registered. This could take place either by the foreign inventor commercializing the patent in the follower country, or by licensing the patent to somebody who would (Fisher, 2023). The latter can be made compulsory by the follower country, which was first allowed in the Paris Convention of 1883, but continues to be intensely debated. Surprisingly, compulsory licensing has been shown to increase innovation both in the follower and the leader country (Moser & Voena, 2012; Baten, Nicola & Moser, 2017). The first result suggests that licensing does not crowd out innovation, while the latter suggests that the competition effect from the follower country can dominate the reduced returns to innovation for the inventor in the frontier country.

Technical education. There is evidence that states' investments into universities and research institutions had positive effects, both by fostering innovation and enabling technology adoption. For the case of Germany, Dittmar & Meisenzahl (2022) show that cities close to universities increase both technology adoption, as measured by mechanization, as well as original innovation, as measured by prizes for industrial innovation. Relatedly, for the case of United States, the exogenous establishment of land-grant colleges increased the density of engineers and income per capita (Maloney & Caicedo, 2022). The authors show that a large share of the positive effect of engineers works through technology adoption, for example by adopting hybrid corn or introducing tractors. Interestingly, the effect of universities on innovation was not restricted to manufacturing; Kantor & Whalley (2019) show that agricultural experiment stations, created at land grand colleges, improved agricultural productivity nearby.

Similarly, locations with economic societies are found to have been more innovative, as they established vocational schools to create skilled workers needed to implement new technologies, and facilitated the diffusion of ideas and new inventions across regions (Cinnirella et al., 2022).

Foreign inventors. We are not aware of papers evaluating the effect of governments' targeted hiring of foreign inventors, but we may be able to draw some conclusions from the literature studying immigration waves. These have estimated positive effects on innovation in the host country, as inventors brought their skills with them (Akcigit, Grigsby & Nicholas, 2017; Arkolakis, Lee & Peters, 2020). Correspondingly, immigration restrictions have been found to negatively affect innovation (Moser & San, 2020; Doran & Yoon, 2020). It should be noted however, that this literature only informs industrial policies that targeted foreign skilled workers in some contexts. In Meiji Japan, for example, foreign workers stayed for only a short time, and they were not encouraged to

learn Japanese – hence the term "live machines" (Jones, 1980).

Colonial technology transfer. The "accidental" technology transfer policy of colonizers has been studied in the context of Java. While colonies typically suffered both in the short and on the long run from the extractive institutions colonizers set up, in this rare case of technology transfer, the local economy benefited in the long run, despite the transferred technologies having become obsolete. Dell & Olken (2020) show that areas close to where the Dutch established a sugar factory are still more industrialized and have more per capita income today as structural change and complementary infrastructure development spurred persistent economic development.

Technology absorption. Juhász, Sakabe & Weinstein (2023a) study one of the largest public-led technology absorption efforts – those of Meiji Japan, which were focused on acquiring Western knowledge (Montgomery, 2000). The authors show that industry level productivity growth in Japan was highest in sectors that had the most to benefit from absorbing Western technologies. However, this pattern of productivity growth only emerged after the government provided an activity-specific public input: a large, technical dictionary that created a common vocabulary of technical terms ("jargon"), which made it possible to translate Western knowledge. These findings suggest that one reason why the 19th century witnessed limited cross-country diffusion of technology is that public inputs to technology absorption were a necessary condition for industrial development in follower countries.

Financing policies. There are, to the best of our knowledge, very few papers that evaluate how financing policies affect industrial development. A rare exception is Gregg (2020), who studies the effects of incorporation in late Imperial Russia. The author finds positive labor productivity effects, as it enables firms to buy more machinery.

Overall, the literature has made progress evaluating individual policies, and found largely positive effects. However, there remain open questions. Some policies, such as tariffs or targeted immigration have not yet been evaluated. For other policies, we need to better understand channels: does railway-induced market access really not affect innovation? How did IPR policies affect technology adoption in follower countries? How does IPR's adverse effects on some sectors affect industrial development? While governments were conscious about targeting either innovation or technology adoption, empirical studies are not yet very informative about whether specific policies were more efficient at fostering one or the other. Finally, governments often implemented a bundle of policies trying to affect different aspects of the technology adoption process rather than specific policies in isolation. It would be important to understand which policies are complements or substitutes, and whether positive effects of individual policies may be attributed to other measures being in place in the background.

5 ACCESS TO MATERIAL INPUTS

Industrial production required access to material inputs, which needed to be sourced domestically or internationally. Consider the case of cotton textiles. Its most important raw input, cotton, was grown primarily in the South of the US, while most mechanized textile manufacturing took place in Great Britain, continental Europe, and later, New England. Manufacturers also required dyes, such as indigo, which were extracted from tropical plants and therefore often required international sourcing from colonies. Another key input to mechanized textile production, steam power, required access to coal, which was produced domestically but needed to be transported via railways. Policymakers adopted many policies to facilitate access to inputs – both domestically and internationally.

5.1 Policies to facilitate access to material inputs

Infrastructure. The 19th century experienced dramatic technological transport revolutions, leading to substantial reductions in international freight costs (Mohammed & Williamson, 2004). Governments were often involved, in conjunction with private investors. For example, the Suez Canal Company, which opened the Suez canal in 1869, was owned by French investors and the Egyptian ruler, who later sold his shares to the British government (Fisher & Smith, 2023). The Panama canal was opened in 1914 under US ownership (Montero Llácer, 2005).

The international transport network was complemented with domestic transport networks in foreign countries. In African colonies, railroads were constructed to secure access to tropical products. In independent countries, "foreign policy" by Western powers was more subtle. In Brazil, British private investors built railways and ports, but multiple directors of these railroad companies were members of British parliament (Summerhill, 2003, p. 47). Ironically, the British development of the Brazilian rail network served as "accidental" industrial policy for the host country, as it was soon also used by the domestic industrial sector. Brazilian flour mills used the São Paolo railway to import wheat from Argentina, and Brazilian cotton mills used the railroads to source cotton from the interior (Graham, 1968, pp. 125-126).

Domestic infrastructure development was also critical for access to inputs, e.g., the railroad for transporting coal. The British Stockton and Darlington Railway opened in 1825 transported coal, while the Liverpool to Manchester Railway opened in 1830 transported imported raw cotton from the port of Liverpool to the cotton textile manufacturing factories in Lancashire (Shaw-Taylor & You, 2018).[13]

Colonization. A primary motivation for acquiring colonies was to secure access to raw materials, such as tropical products (Allen, 2011). For example, West Africa supplied palm oil, a

[13] Access to coal likely affected the location of industry more generally, at least during industrialization in Europe (Fernihough & O'Rourke, 2020).

lubricant for machinery and railway equipment, and Malaya supplied rubber. Imperial powers also directly shaped what was produced (DeLong, 2022, p.46). For example, the British introduced the rubber plant in Malaya from Brazil. In German, Belgian and French colonies in West Africa, land was expropriated and given to European investors to develop mining and plantations (Allen, 2011).

Trade policy. Setting low tariffs on imported materials inputs, combined with high tariffs on industrial outputs was an industrial policy advocated for by Friedrich List. The first British Prime Minister Robert Walpole described this as early as 1721: "It is evident that nothing so much contributes to promote the public well-being as the exportation of manufactured goods and the importation of foreign raw material." (List, 1841, p. 32). As a result, Britain reduced or eliminated import duties on raw materials that were used in manufacturing (Brisco, 1907, pp.136-139). Similarly, Sweden placed low tariffs on raw cotton and high tariffs on cotton cloth after the end of the Napoleonic wars (Chang 2002, p.39). Figure 3 illustrates the use of industrialization-fostering trade policy across countries. While tariffs on intermediate inputs are on average lower than tariff on final products for all types of countries, this difference is small for core, industrialized countries, and much larger for periphery countries.

5.2 Economic effects of access to material inputs

Considering the importance that governments placed on access to material inputs, the academic literature assessing whether these policies had the desired effects is rather thin.[14]

Steinwender (2018) focuses on the role of information frictions in international sourcing, using the example of Britain sourcing raw cotton from the United States. The transatlantic telegraph connection provided faster information on cotton demand at destination markets. As a result, cotton exports adjusted to the improved information, leading to a better integration of the transatlantic cotton markets in New York and Liverpool. This led to substantial estimated efficiency gains from the telegraph, equivalent to 8% of the export value.[15]

While infrastructure such as railways or the telegraph may directly improve buyers' access to inputs by lowering trade frictions, Chen, Qi & Wang (2022) show evidence of an indirect channel: Suppliers themselves can respond to reduced frictions by offering higher quality inputs. The authors use the spread of the railway and telegraph network to show that increased market access or reduced risk incentivized cotton farmers to upgrade the quality of domestic varieties, thereby improving the quality of domestic inputs used in textile manufacturing.

So far, we have argued that governments that wanted to foster industrialization adopted policies

[14] Papers studying trade policies or transport infrastructure improvements often estimate the reduced form effect of market access and domestic market integration without disentangling between the channels of access to input or output markets. We discuss these more general papers in Sections 2.2 and 3.

[15] Cotterlaz & Fize (2021) provides related evidence on this information provision channel of the telegraph on trade of all goods, exploiting the international expansion of news agencies.

to improve access to inputs to help the domestic industry. Hanlon (2015) provides an interesting twist on this perspective by showing that the scarcity of inputs itself can lead to more innovation, as domestic firms try to make alternative inputs more productive. The author examines this in the context of the American Civil War which reduced the supply of high-quality, American cotton to British textile manufacturers. The manufacturers responded by improving the machinery that made the alternative, lower-quality cotton from India, more productive. Intriguingly, this directed technological progress was large enough to fully offset the scarcity shock.

One important argument for industrial policy is that some form of temporary subsidization can create permanent advantages through learning-by-doing externalities. While this mechanism is mostly discussed in the context of trade protection (see Section 2.1), this argument can also be made for access to cheap inputs. Hanlon (2020) makes this case using the US metal shipbuilding industry in the 19th century as an example. When the British cost advantage in iron disappeared by the 1880s, US shipmakers failed to catch up, presumably because they had fallen too far behind on the learning curve, or because their fundamental productivity was simply lower. While learning-by-doing externalities are often invoked in the literature to explain persistent effects, Hanlon (2020) is the first to provide direct evidence on this channel: by showing that US shipmakers exogenously exposed to more learning opportunities (through nearby Navy shipyards) were more likely to make the transition from wood to metal ship production.

While access to inputs benefits the sourcing country, the same is unlikely to be true for the providing country when it is a colony. A recent contribution highlights the negative long term effects of input-sourcing in the context of rubber concessions in the Belgian Congo – infamous for its particularly brutal exploitation of the local population (Lowes & Montero, 2021). Using the arbitrary drawing of concession borders, the authors find negative effects on present-day education, wealth and health driven by a lower provision of public goods. However, to compensate for the weak political institutions, individuals developed stronger social networks, suggesting that formal and informal institutions may act as (imperfect) substitutes.

These contributions highlight that access to raw materials and the policies that facilitated them had an effect on industrialization, though more work is needed. We have alluded to government involvement in international infrastructure development, though the extent to which this was intentional industrial policy is not well understood. The literature has also begun to examine the effects on selling countries, including colonies. A fruitful direction for future research would be to disentangle the access to input from access to output markets for infrastructure developments or trade policy. For example, trade policy is often characterized as "protective" or "open" depending on average tariffs. However, as the analysis in this paper reveals, a trade policy to support industrialization may have benefited from a combination of high tariffs on outputs in infant industries, and low tariffs on material inputs and machinery (though the full welfare effects of such a policy are a

different matter). Similarly, the historical analysis of international transport infrastructure projects may be able to generate additional insights when the input-output structure of the economy, and the existing international division of labor are accounted for.

6 ACCESS TO LABOR

Industrialization led to an increased demand for labor in manufacturing. In principle, three policies could be used to increase (skilled) labor supply for industrialization: i) education policies including both basic education and technical education; ii) immigration policies, possibly targeted at certain skill types; and iii) working regulation policies, such as child and female labor regulations, and regulations on working hours and days. However, only one of these policies was intentionally used by governments to foster industrialization: specific training and education targeted at technical skills. Many governments expanded their middle and higher education in order to increase the provision of skilled workers and engineers, especially linked to industrial applications. During the Napoleonic period, Jean-Antoine Chaptal, Minister of the Interior, implemented education reforms that gave students hands-on, practical experience with advanced machinery. In fact, Chaptal is one of the figures credited with uniting educational and industrial goals in France (Horn, 2006). The *Écoles d'arts et métiers* which integrated practical and theoretical knowledge continued to be developed and satisfied industrial demand for graduates throughout the 19th century (Day, 1978). 19th century Prussia implemented education reforms which featured technical education for handworkers and manufacturers (Lenoir, 1998). Germany continued to provide vocational education at all levels from primary to higher education, which is reflected in educational spending between 1872 and 1914 almost reaching the level of military spending (Trebilcock, 1981, p. 63). In a similar vein, Japan also provided vocational training in industrial skills, initially in schools attached to government industrial establishments (Crawcour, 1997).

Despite the fact that neither mass education, nor immigration or child and female labor supply policies were used by governments to intentionally foster industrialization, there is empirical evidence that all of them contributed to industrialization. For example, general education has been shown to be important for industrial catch-up of a follower country like Prussia, presumably because it facilitates the adoption of new technologies (Becker & Woessmann, 2009; Becker, Hornung & Woessmann, 2011). Similarly, positive immigration shocks have been found to increase factory-based manufacturing (Kim, 2007), while negative shocks may have reduced manufacturing output and wages (Long, Medici, Qian & Tabellini, 2023; Abramitzky, Ager, Boustan, Cohen & Hansen, 2023). A possible channel (besides increasing innovation, see Section 4) is the complementarity between immigration and capital investment (Lafortune, Lewis & Tessada, 2019). Domestic migration from agricultural to industrial districts driven by the railway had similarly positive effects on industrialization (Pérez, 2017). Finally, female and child labor supply has also

been shown to contribute to industrialization (Goldin & Sokoloff, 1982).

One reason for why these policies, though effective for industrial development, may not have been used as industrial policy is that the surveyed papers do not provide a cost-benefit analysis. Perhaps alternative policies, such as targeted vocational training, fared better in this respect. However, research on the latter is rare. Only for the case of Germany is there evidence that vocational schools, designed in cooperation with industrial associations and with a curriculum targeted at providing the training for industrial occupations, increased industrialization and innovation (Semrad, 2015). Another reason for why these policies were not introduced may have been distributional concerns. For example, while encouraging immigration may have fostered industrial progress in the US, natives may have been opposed to it for fear of losing out.

7 CONCLUSION AND DIRECTIONS FOR FUTURE WORK

Our overview of the wide-ranging policies used to shape economic activity and the relatively thinner literature evaluating their effects leads us to conclude that these policies have been overlooked in economics for far too long. A welcome effect of the recent, twenty-first century revival of industrial policy would be a more thorough and careful evaluation of how industrial policy shaped the emerging global division of labor and development trajectories in the long 19th century.

We conclude by highlighting some particularly promising avenues for future work. First, there may be important complementarities across policies. For example, some work suggests that infant industry protection was insufficient without access to technology. In fact, the historical episodes we discuss illustrate that states often implemented a bundle of policies, rather than specific, standalone policies. Our understanding of industrial policy would benefit from better understanding how these interact and potentially complement one another. Second, existing work has, for the most part, focused on evaluating "softer" interventions such as promoting railroad development and human capital acquisition instead of common "hard" interventions such as subsidies and public ownership. Third, careful quantitative work has begun to emerge as a fruitful complement to reduced form work to study general equilibrium beyond local effects and the combination of these methods seems important for future work. Fourth, when assessing the effectiveness of industrial policy we need to be mindful of publication bias and welcome research on industrial policies in countries where it apparently failed. Identifying the reasons behind unsuccessful industrial policy is as important as learning from the successes.

References

Abramitzky R, Ager P, Boustan L, Cohen E, Hansen CW. 2023. The effect of immigration restrictions on local labor markets: Lessons from the 1920s border closure. *American Economic Journal: Applied Economics* 15(1):164–91

Akcigit U, Grigsby J, Nicholas T. 2017. Immigration and the Rise of American Ingenuity. Working Paper 23137, National Bureau of Economic Research

Alfaro L, Bao CG, Chen MX, Hong J, Steinwender C. 2022. Omnia Juncta in Uno: Foreign Powers and Trademark Protection in Shanghai's Concession Era. Working Paper 29721, National Bureau of Economic Research

Allen RC. 2011. Global Economic History: A Very Short Introduction. Oxford University Press.

Americo P. 2022. The Industrialization Path: Railroads, Technology Adoption, and Structural Transformation in Brazil, 1872-1950. Working paper

Andersson D, Berger T, Prawitz E. 2023. Making a Market: Infrastructure, Integration, and the Rise of Innovation. *The Review of Economics and Statistics* 105(2):258–274

Arkolakis C, Lee SK, Peters M. 2020. Immigration, Innovation, and Spatial Economic Development: Theory and Evidence from the Age of Mass Migration. Tech. rep.

Atack J, Haines M, Margo RA. 2011. Railroads and the Rise of the Factory: Evidence for the United States, 1850–1870. Stanford University Press, 1st ed., 162–179

Baten J, Nicola B, Moser P. 2017. Compulsory Licensing and Innovation – Historical Evidence from German Patents after WWI. *Journal of Development Economics* 126:231–242

Becker SO, Hornung E, Woessmann L. 2011. Education and Catch-Up in the Industrial Revolution. *American Economic Journal: Macroeconomics* 3(3):92–126

Becker SO, Woessmann L. 2009. Was Weber Wrong? A Human Capital Theory of Protestant Economic History. *The Quarterly Journal of Economics* 124(2):531–596

Berger T. 2019. Railroads and Rural Industrialization: Evidence from a Historical Policy Experiment. *Explorations in Economic History* 74:101277

Berger T, Enflo K. 2017. Locomotives of local growth: The short- and long-term impact of railroads in Sweden. *Journal of Urban Economics* 98:124–138

Bilir LK, Moser P, Talis I. 2011. Do Treaties Encourage Technology Transfer? Evidence from the Paris Convention. *SSRN Electronic Journal*

Bo S, Liu C, Zhou Y. 2023. Military investment and the rise of industrial clusters: Evidence from China's self-strengthening movement. *Journal of Development Economics* 161:103015

Bogart D, You X, Alvarez-Palau E, M. S, L. ST. 2022. Railways, Divergence, and Structural Change in 19th Century England and Wales. *Journal of Urban Economics* 128

Bosher JF. 1964. The Single Duty Project: A Study of the Movement for a French Customs Union in the Eighteenth Century. University of London, the Athlone Press; distrib. by Oxford University Press, New York

Bottomley S. 2014. Introduction. Cambridge Intellectual Property and Information Law. Cambridge University Press, 1–30

Brisco NA. 1907. The Economic Policy of Robert Walpole. New York Chichester, West Sussex: Columbia University Press

Büchel K, Kyburz S. 2020. Fast track to growth? Railway access, population growth and local displacement in 19th century Switzerland. *Journal of economic geography* 20(1):155–195

Chandler AD. 1990. Scale and Scope: The Dynamics of Industrial Capitalism. Harvard/Belknap

Chang HJ. 2002. Kicking Away the Ladder: Development Strategy in Historical Perspective. Anthem studies in development and globalization. Anthem

Chen T, Qi H, Wang J. 2022. Railways, Telegraph and Technology Adoption: The Introduction of American Cotton in Early 20th Century China (Working Paper)

Chuchko M. 2019. Political Economy of Tariff Formation: The Case of Mendeleev's Tariff of 1891 in the Late Russian Empire. Working Paper. Ph.D. thesis, Universidad Carlos III de Madrid

Cinnirella F, Hornung E, Koschnick J. 2022. Flow of Ideas: Economic Societies and the Rise of Useful Knowledge. ECONtribute Discussion Papers Series 175, University of Bonn and University of Cologne, Germany

Cotterlaz P, Fize E. 2021. Information in the First Globalization: News Agencies and Trade (CEPII Working Paper)

Crawcour ES. 1997. Industrialization and Technological Change, 1885–1920. *The economic emergence of modern Japan* :50–115

Davies P. 2009. Japanese Shipping and Shipbuilding in the Twentieth Century: The Writings of Peter N. Davies, vol. 2. Global Oriental

Day CR. 1978. The Making of Mechanical Engineers in France: The Ecoles d'Arts et Métiers, 1803-1914. *French Historical Studies* 10(3):439–460

Dell M, Olken B. 2020. The Development Effects of the Extractive Colonial Economy: The Dutch Cultivation System in Java. *Review of Economic Studies* 87(1):164–203

DeLong JB. 2022. Slouching Towards Utopia. Basic Books

Diaz G. 2017. Railway investment in Uruguay before 1914: profitability, subsidies, and economic impact. *European Review of Economic History* 21(3):280–301

Dittmar J, Meisenzahl RR. 2022. The Research University, Invention, and Industry: Evidence from German History. CEP Discussion Papers dp1856, Centre for Economic Performance, LSE

Donaldson D. 2015. The Gains from Market Integration. *Annual Review of Economics* 7(1):619–647

Donaldson D. 2018. Railroads of the Raj: Estimating the Impact of Transportation Infrastructure. *American Economic Review* 108(4-5):899–934

Donaldson D, Hornbeck R. 2016. Railroads and American Economic Growth: A "Market Access"' Approach. *The Quarterly Journal of Economics* 131(2)

Donges A, Selgert F. 2019. Technology transfer via foreign patents in Germany, 1843–77. *The Economic History Review* 72(1):182–208

Doran K, Yoon C. 2020. Immigration and Invention: Evidence from the Quota Acts. Working paper

Ericson SJ. 2020. Financial Stabilization in Meiji Japan: The Impact of the Matsukata Reform. Cornell University Press

Fajgelbaum P, Redding SJ. 2022. Trade, Structural Transformation, and Development: Evidence from Argentina 1869–1914. *Journal of Political Economy* 130(5):1249–1318

Fernihough A, O'Rourke KH. 2020. Coal and the European Industrial Revolution. *The Economic Journal* 131(635):1135–1149

Findling J. 2018. Encyclopedia Britannica, chap. World's Fair

Fischer CE. 1954. Die geschichte der deutschen versuche zur lösung des kartell- und monopolproblems. *Zeitschrift für die gesamte Staatswissenschaft / Journal of Institutional and Theoretical Economics* 110(3):425–456

Fisher WB, Smith CG. 2023. Encyclopedia Britannica, chap. Suez Canal

Fisher WW. 2023. Encyclopedia Britannica, chap. Patent

Gao P, Lei YH. 2021. Communication Infrastructure and Stabilizing Food Prices: Evidence from the Telegraph Network in China. *American Economic Journal: Applied Economics* 13(3):65–101

Goldin C, Sokoloff K. 1982. Women, Children, and Industrialization in the Early Republic: Evidence from the Manufacturing Censuses. *The Journal of Economic History* 42(4):741–774

Graham R. 1968. Britain and the Onset of Modernization in Brazil 1850-1914. Cambridge Univer-

sity Press

Gregg AG. 2020. Factory Productivity and the Concession System of Incorporation in Late Imperial Russia, 1894–1908. *American Economic Review* 110(2):401–27

Gross DP. 2020. Collusive Investments in Technological Compatibility: Lessons from U.S. Railroads in the Late 19th Century. *Management Science* 66(12):5683 – 5700

Guinnane T, Harris R, Lamoreaux NR, Rosenthal JL. 2007. Putting the Corporation in its Place. *Enterprise & Society* 8(3):687–729

Hanlon W, Jaworski T. 2021. Spillover Effects of Intellectual Property Protection in the Interwar Aircraft Industry. *The Economic Journal* 132(645):1824–1851

Hanlon WW. 2015. Necessity Is the Mother of Invention: Input Supplies and Directed Technical Change. *Econometrica* 83(1):67–100

Hanlon WW. 2020. The Persistent Effect of Temporary Input Cost Advantages in Shipbuilding, 1850 to 1911. *Journal of the European Economic Association* 18(6):3173–3209

Hanlon WW, Heblich S, Monte F, Schmitz MB. 2022. A Penny for Your Thoughts. Tech. rep., National Bureau of Economic Research

Harrison A, Rodríguez-Clare A. 2010. Chapter 63 - Trade, Foreign Investment, and Industrial Policy for Developing Countries. In *Handbooks in Economics*, eds. D Rodrik, M Rosenzweig, vol. 5 of *Handbook of Development Economics*. Elsevier, 4039–4214

Hausmann R, Rodrik D. 2003. Economic development as self-discovery. *Journal of Development Economics* 72(2):603–633

Headrick DR. 1981. The tools of Empire: Technology and European imperialism in the nineteenth century. Oxford University Press

Headrick DR. 1991. The Invisible Weapon: Telecommunications and International Politics, 1851-1945. Oxford University Press, USA

Headrick DR, Griset P. 2001. Submarine Telegraph Cables: Business and Politics, 1838-1939. *The Business History Review* 75(3):543–578

Helleiner E. 2021. The Neomercantilists: A Global Intellectual History. Cornell University Press

Higgins DM. 2012. "Forgotten Heroes and Forgotten Issues": Business and Trademark History during the Nineteenth Century. *The Business History Review* 86(2):261–285

Horn J. 2006. The Path Not Taken: French Industrialization in the Age of Revolution, 1750-1830. MIT Press

Hornbeck R, Rotemberg M. 2023. Railroads, Reallocation, and the Rise of American Manufactur-

ing. Tech. rep., National Bureau of Economic Research

Hornung E. 2015. Railroads and Growth in Prussia. *Journal of the European Economic Association* 13(4):699–736

Huffman W, Evenson R. 2008. Science for Agriculture: A Long-Term Perspective, Second Edition. *Science for Agriculture: A Long-Term Perspective, Second Edition* :1–314

Huurdeman AA. 2003. The Worldwide History of Telecommunications. John Wiley & Sons

Irwin DA. 2017. Clashing over Commerce: A History of US Trade Policy. University of Chicago Press

Irwin DA. 2019. Does Trade Reform Promote Economic Growth? A Review of Recent Evidence

Jedwab R, Kerby E, Moradi A. 2015. History, Path Dependence and Development: Evidence from Colonial Railways, Settlers and Cities in Kenya. *The Economic Journal* 127(603):1467–1494

Jedwab R, Moradi A. 2016. The permanent effects of transportation revolutions in poor countries: Evidence from Africa. *The Review of Economics and Statistics* 98(2):268–284

Jeremy DI. 1977. Damming the Flood: British Government Efforts to Check the Outflow of Technicians and Machinery, 1780-1843. *The Business History Review* 51(1):1–34

Johnson C. 1982. MITI and the Japanese miracle: the growth of industrial policy, 1925-1975. Stanford university press

Jones HJ. 1980. Live machines: hired foreigners and Meiji Japan. *(No Title)*

Juhász R. 2018. Temporary protection and technology adoption: Evidence from the Napoleonic Blockade. *American Economic Review* 108(11):3339–3376

Juhász R, Sakabe S, Weinstein D. 2023a. The Industrial Revolution, learning from the West and the evolution of comparative advantage. Tech. rep.

Juhász R, Squicciarini MP, Voigtländer N. 2023b. Technology adoption and productivity growth: Evidence from industrialization in France. Tech. rep., National Bureau of Economic Research

Juhász R, Lane NJ, Rodrik D. 2023. The New Economics of Industrial Policy. Working Paper 31538, National Bureau of Economic Research

Juhász R, Steinwender C. 2018. Spinning the Web: The Impact of ICT on Trade in Intermediates and Technology Diffusion. Working Paper 24590, National Bureau of Economic Research

Kantor S, Whalley A. 2019. Research Proximity and Productivity: Long-Term Evidence from Agriculture. *Journal of Political Economy* 127(2):819–854

Keller W, Shiue CH. 2014. Endogenous Formation of Free Trade Agreements: Evidence from the Zollverein's Impact on Market Integration. *The Journal of Economic History* 74(4):1168–1204

Khan BZ. 2008. An Economic History of Patent Institutions. In *EH.Net Encyclopedia*, ed. R Whaples

Kim S. 2007. Immigration, Industrial Revolution and Urban Growth in the United States, 1820-1920: Factor Endowments, Technology and Geography. Working Paper 12900, National Bureau of Economic Research

Lafortune J, Lewis E, Tessada J. 2019. People and Machines: A Look at the Evolving Relationship between Capital and Skill in Manufacturing, 1860–1930, Using Immigration Shocks. *The Review of Economics and Statistics* 101(1):30–43

Lampe M. 2009. Effects of Bilateralism and the MFN Clause on International Trade: Evidence for the Cobden-Chevalier Network, 1860-1875. *The Journal of Economic History* 69(4):1012–1040

Lampe M. 2020. European Trade Policy in the 19th Century. In *Oxford Research Encyclopedia of Economics and Finance*

Landes DS. 1969. The Unbound Prometheus. Cambridge University Press

Lehmann SH, O'Rourke KH. 2011. The Structure of Protection and Growth in the Late 19th Century. *The Review of Economics and Statistics* 93(2):606–616

Lenoir T. 1998. Revolution from Above: The Role of the State in Creating the German Research System, 1810-1910. *The American Economic Review* 88(2):22–27

Lindgren E, Pettersson-Lidbom P, Tyrefors B. 2021. The causal effect of transport infrastructure: Evidence from a new historical database. Tech. rep., IFN Working Paper

List F. 1841. The National System of Political Economy. Longmans, Green, and Company.

Liu C. 2020. The Effects of World War I on the Chinese Textile Industry: Was the World's Trouble China's Opportunity? *The Journal of Economic History* 80(1):246–285

Long J, Medici C, Qian N, Tabellini M. 2023. The Impact of the Chinese Exclusion Act on the U.S. Economy. Working paper

Lowes S, Montero E. 2021. Concessions, Violence, and Indirect Rule: Evidence from the Congo Free State. *The Quarterly Journal of Economics* 136(4):2047–2091

Maloney WF, Caicedo FV. 2022. Engineering Growth. *Journal of the European Economic Association* 20(4):1554–1594

Matsuyama K. 1992. Agricultural Productivity, Comparative Advantage and Economic Growth. *Journal of economic theory* 58(2):317–334

Mohammed SI, Williamson JG. 2004. Freight Rates and Productivity Gains in British Tramp Shipping 1869-1950. *Explorations in Economic History* 41(2):172–203

Mokyr J, John VCN. 2007. Distributional Coalitions, the Industrial Revolution, and the Origins of Economic Growth in Britain. *Southern Economic Journal* 74(1):50–70

Montero Llácer FJ. 2005. Panama Canal Management. *Marine Policy* 29(1):25–37

Montgomery SL. 2000. Science in Translation Movements of Knowledge through Cultures and Time. University of Chicago Press

Morck R, Nakamura M. 2018. Japan's ultimately unaccursed natural resources-financed industrialization. *Journal of the Japanese and International Economies* 47:32–54

Moser P. 2005. How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs. *American Economic Review* 95(4):1214–1236

Moser P, San S. 2020. Immigration, Science, and Invention. Lessons from the Quota Acts. Working paper

Moser P, Voena A. 2012. Compulsory Licensing: Evidence from the Trading with the Enemy Act. *American Economic Review* 102(1):396–427

Murphy KM, Shleifer A, Vishny RW. 1989. Industrialization and the Big Push. *Journal of political economy* 97(5):1003–1026

Nuvolari A, Tortorici G, Vasta M. 2020. British-French technology transfer from the Revolution to Louis Philippe (1791-1844): evidence from patent data. CEPR Discussion Papers 15620, C.E.P.R. Discussion Papers

O'Rourke KH, Williamson JG. 2001. Globalization and History: The Evolution of a Nineteenth-Century Atlantic Economy, chap. 11: Forging and Breaking Global Capital Markets. MIT Press

Pascali L. 2017. The Wind of Change: Maritime Technology, Trade, and Economic Development. *American Economic Review* 107(9):2821–2854

Pérez S. 2017. Railroads and the Rural to Urban Transition: Evidence from 19th-Century Argentina

Perlman ER. 2016. Dense Enough To Be Brilliant: Patents, Urbanization, and Transportation in Nineteenth Century America. CEH Discussion Papers 036, Centre for Economic History, Research School of Economics, Australian National University

Redding SJ, Turner MA. 2015. Transportation Costs and the Spatial Organization of Economic Activity, vol. 5. North-Holland, Elseiver

Rodriguez F, Rodrik D. 2000. Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence. *NBER macroeconomics annual* 15:261–325

Romero DA. 2023. An Empire Lost: Spanish Industry and the Effect of Colonial Markets on Trade

and Innovation

Sáiz P. 2014. Did patents of introduction encourage technology transfer? Long-term evidence from the Spanish innovation system. *Cliometrica* 8

Saxonhouse G, Wright G. 2000. Technological Evolution in Cotton Spinning, 1878-1933. *The Fibre That Changed the World: The Cotton Industry in International Perspective, 1600-1990s* :129–52

Schiff E. 1971. Industrialization without National Patents: The Netherlands 1868–1912, Switzerland 1850–1907. Princeton University Press.

Semrad A. 2015. Modern secondary education and economic performance: the introduction of the Gewerbeschule and Realschule in nineteenth-century Bavaria. *The Economic History Review* 68(4):1306–1338

Shaw-Taylor L, You X. 2018. The Online Historical Atlas of Transport, Urbanization and Economic Development in England and Wales c.1680-1911., chap. The development of the railway network in Britain 1825-1911

Shu P, Steinwender C. 2018. The Impact of Trade Liberalization on Firm Productivity and Innovation. University of Chicago Press, 39–68

Steinwender C. 2018. Real Effects of Information Frictions: When the States and the Kingdom Became United. *American Economic Review* 108(3):657–96

Studwell J. 2013. How Asia Works: Success and Failure In the World's Most Dynamic Region. Grove Atlantic

Summerhill WR. 2003. Order Against Progress Government, Foreign Investment, and Railroads in Brazil, 1854-1913. Stanford University Press

Tang JP. 2014. Railroad Expansion and Industrialization: Evidence from Meiji Japan. *The Journal of Economic History* 74(3):863–886

Trebilcock C. 1981. Industrialisation of the Continental Powers 1780-1914. Routledge

Varian BD. 2023. British exports and foreign tariffs: Insights from the Board of Trade's foreign tariff compilation for 1902. *The Economic History Review* 76(3):827–843

Wenzlhuemer R. 2012. Connecting the Nineteenth-Century World: The Telegraph and Globalization. Cambridge University Press

Winseck DR, Pike RM. 2007. Communication and Empire: Media, Markets, and Globalization, 1860–1930. Duke University Press

Wright G. 1986. Old South, New South: Revolutions in the Southern Economy Since the Civil

War. Basic Books, New York

Yamasaki J. 2017. Railroads, Technology Adoption, and Modern Economic Development: Evidence from Japan. ISER Discussion Paper 1000, Institute of Social and Economic Research, Osaka University