Industrial Policy and the Great Divergence*

Réka Juhász (UBC, NBER, and CEPR)

Claudia Steinwender (LMU Munich and CEPR)

Sept. 18, 2023

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. We show that states deployed a vast variety of different policies aimed at, primarily, but not exclusively, fostering industrialization. We discuss the thin, but growing literature that evaluates the economic effects of these policies. We highlight some fruitful avenues for future study.

JEL: L5, N1, N4, N6

Keywords: industrial policy, first wave of globalization, industrialization, infant industry protection, technology policy, transport infrastructure, telegraph, 19th century

*This manuscript has been prepared for Volume 16 of the *Annual Review of Economics*. When citing this paper, please use the following: Juhász R, Steinwender C. 2024. Industrial Policy and the Great Divergence. Annu. Rev. Econ. 16: Submitted. DOI: https://doi.org/10.1146/annurev-economics-091523-044259. We would like to thank Kevin O'Rourke, Brian Varian and Roland Wenzlhuemer for kindly sharing their data with us. We are grateful for insightful discussions with Marina Chucko, Markus Lampe, Nathan Lane, Aldo Musacchio and Carla Salvo and David Weinstein. Melody Echipue, Filip Milojević, Veronica C. Perez, Lynn van den Busch, Esha Vaze, and Sarah Wappel provided outstanding research assistance.

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 and the focus of research has shifted to "deep" roots of growth: geography, institutions and culture. In this paper, we argue that this verdict is premature.

We revisit the historical track record of industrial policy. We do this in the context of the 19th and early 20th century – a critical juncture in economic history.[1] By 1800, it was clear to observers that fundamental changes were taking shape in the British economy, and manufacturing in particular.[2] Through the long nineteenth century, independent countries deployed policies designed to modernize their economies and kickstart structural transformation. This was true of countries such as France, the U.S., and Egypt from early on in the 19th century, as well as others, such as Meiji Japan, Germany, Mexico, and Imperial Russia, where industrial policy emerged later. 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 is, what role did industrial policy play in the period of the Great Divergence?

The idea that states played a crucial role in fostering industrialization in the 19th century has a long tradition in economics. In the 19th century, Friedrich List argued that Britain's turn to free trade policy in the 1840s risked taking away from other countries the very set of policies Britain had used to foster industrialization (List, 1841). A century and a half later, building on qualitative evidence from a larger set of countries and industrial policies, Ha-Joon Chang made a similar case (Chang, 2002). The economic historian Bob Allen has argued that countries needed to adopt a "package" of policies including infant industry tariffs, infrastructure development and education policy to ignite modern industrial development (Allen, 2011). What has been sorely missing is careful empirical evaluation of these policies.

In recent years, a thin but growing literature in economic history 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 it had on the economy. Informed by new work, we find that industrial policy

[1] As such, this paper complements excellent recent work by Koyama & Rubin (2022) which focuses mostly on the historical origins of growth and why the Industrial Revolution emerged when and where it did.

[2] U.S. Treasury Secretary Alexander Hamilton submitted his *"Report on Manufactures"* to Congress in 1791, which many consider to be one of the earliest manifestations of modern industrial policy.

was widely deployed across independent countries using a vast variety of tools.[3] 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 policies.

This new research shows some support for many of these policies, though much more research would be needed to give us a fuller picture. While tariffs may not have been the most important tool to foster burgeoning manufacturing, multiple papers show some support for infant industry type mechanisms, suggesting that at this critical juncture, there were positive, potentially lasting, effects for economies that were able to build up modern manufacturing either through "accidental industrial policies" such as wars and blockades, or through tariff and non-tariff measures.

The creation of integrated national markets is another area where research has found positive local and aggregate effects across a wide variety of contexts. From colonial Ghana, through late 19th century Argentina, to already integrated and industrially advanced Britain, the railroad seems to have brought a multitude of benefits, though findings in the literature are not fully consistent across contexts and studies.

Technology and innovation policy is a third area where the literature has uncovered a potentially important role for the government. New work suggests that technology adoption in follower countries was by no means a passive process. Beyond acquiring machines, entrepreneurs faced a host of obstacles and potential market failures, and the state was often a partner in this process. In particular, the literature has found some support for policies that increased human capital at the very top of the skill distribution. There is also some evidence that suggests that aspects of technology transfer have a public good-like component (for example, translating the necessary knowledge for industry). New work also suggests that captive colonial markets increased innovation in the metropole through market size effects. Government decisions about intellectual property protection likely affected the direction of technical change.

Importantly, however, our analysis reveals that the recent literature has only begun to scratch the surface of evaluating industrial policy in this period. Where some aspects of the literature are more developed, others are sorely lacking. A glaring example is the multitude of policies govern-

[3]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).

ments used to shape access to international sourcing, and export markets. While the technological revolutions which made possible the first wave of globalization are widely appreciated, the role of intentional industrial policy in shaping these outcomes is not sufficiently understood. The submarine telegraph network which emerged in the late 19th century would not have been possible without extensive government involvement. Germany and Meiji Japan subsidized many of the steam liners that made possible their impressive expansion of exports. Colonialism and gunboat diplomacy were widely deployed to secure access to industrial inputs and export markets. How important were these in shaping the international division of labor between core and periphery that emerged by the turn of the 20th century?

While we would welcome more research in all areas of industrial policy in this time period, there are a few particularly promising avenues in our view. First, where long-open questions in the field have benefited from careful identification strategies, reduced form work is inherently suited to answering questions about local effects. Careful quantitative work has begun to emerge in recent years, and more of this type of work would be a fruitful complement to existing work. Second, our findings suggest that there may be important complementarities across policies. For example, some work suggests that infant industry protection was insufficient without access to technology. While applied methods are more suited to evaluating policies "one-at-a-time", our review of actual episodes of industrial policy in this period suggest that states often implemented a bundle of distinct, potentially complementary policies. Our understanding of industrial policy would benefit from better understanding how these interact and potentially complement one another.

Third, existing work has, for the most part, focused on evaluating "softer" interventions such as promoting railroad development and human capital acquisition which benefit many different types of producers. Yet our review of policies suggests there were plenty of "hard" interventions in this period which promoted certain sectors and activities with subsidies and even public ownership. Evaluating these policies would be important. Fourth, when interpreting our results, we are mindful of publication bias. Plenty of countries experimented with industrial policy – many of whom have small industrial bases to this day. Understanding episodes of industrial policies in countries which, for whatever reason, did not end up in today's group of advanced economies would be yet another high priority research area.

We conclude this discussion by noting that, given the state of the current literature, the question of how much of industrialization in the 19th century was driven by government policy (intentional or otherwise), is very much an open question.[4] Relatedly, it is not always straightforward to determine the intention behind a government policy: for many policies there is a debate in the literature about whether policies were driven by demand from industry or voters, or by the desire of the gov-

[4]We also note that we view work on the deep roots of development as complementary to this line of research.

ernment to shape industrialization (strictly speaking, we consider only the latter to be "intentional" industrial policy). This uncertainty is especially true in cases where the role of the government was to coordinate investment, such as for infrastructure projects. The good news is that we can learn from carefully implemented policy evaluations even when we do not fully understand the intention. However, 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.

1 DEFINITION, RATIONALE AND CONCEPTUAL FRAMEWORK

1.1 Defining industrial policy in the 19th century context

We begin by stating our definition of industrial policy, which we borrow from another paper in this volume. 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." (Juhász, Lane & Rodrik, 2023, p. 4). Thus, industrial policy is selective; that is, it targets some prioritized activities at the expense of others. Examples from the 19th century include the promotion of infant industries such as textiles and shipbuilding, the fostering of modern, factory-based manufacturing as opposed to rural, cottage industry production, and promoting research in agriculture. This last examples serves to highlight the fact that while industrial policy was typically associated with fostering industrialization in the 19th century (as its name suggests), industrial policy was used more widely. The selectivity of industrial policy distinguishes it from "horizontal" interventions that do not purposefully change the structure of the economy. A second component of this definition is that an industrial policy should be intentional in the sense that 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. The intellectual basis for this form of state activism was provided by neomercantilist thought, which was influential among thinkers and policymakers around the world.[5] The public

[5] 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."

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

For example, in an attempt to diversify the economy away from export-oriented ranching, early 20th century Uruguay provided state-lending to industry, established economic development institutes to promote productivity, and created state-owned enterprises in sectors previously dominated by foreigners (Helleiner, 2021, pp. 322-323). Meiji Japan implemented a wide-ranging set of policies with the specific intention of emulating Western industrial development. This included the creation of state-owned enterprises in strategic sectors such as cotton textiles and shipbuilding that were equipped with frontier machinery from Britain (Crawcour, 1997). Another example is infrastructure development. Many countries provided extensive subsidies to private firms to build their railroad network, sometimes with the explicit goal of fostering industrial development.

1.2 The economic justification for 19th century industrial policies

Why would we expect these policies to promote economic development and industrialization, as 19th century thinkers and policymakers expected? Economic theory provides two broad justifications.[6] The first are market failures such as externalities and coordination failures. In the presence of these, market forces alone do not deliver the socially desirable level of an activity, which is why state intervention of some form may be desirable. A second justification for industrial policy is the provision of activity-specific public inputs. These are public good type investments, but ones which are designed with a specific activity in mind.

Market failures. The 19th century context offers wide-ranging examples of where we may expect to find these types of market failures. One example are 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, if they are protected from competition, 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 (see Harrison & Rodríguez-Clare (2010) for a detailed exposition).

An important component of developing modern manufacturing in follower countries was adopting technology developed at the frontier (blueprints, machines etc.). However, producers in follower countries may have been reluctant to adopt new technologies developed elsewhere if early adopters in the domestic market produce valuable information for latter entrants – the cost-discovery externality of Hausmann & Rodrik (2003). Relatedly, coordination failures are central to big-push

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

theories of development and industrialization (Murphy, Shleifer & Vishny, 1989). While it may be profitable if all producers adopt modern technologies together, it may not be individually profitable for any, leaving the economy in a low-income equilibrium.

Another distinct market failure which applies both at the technology frontier and in follower countries is that the market may undersupply innovation because the developer of a new technology cannot capture all the benefits. Inventive activity, and the institutions and organizations that shaped it, underwent substantial change throughout the 19th century as governments around the world grappled with how to design institutions to support innovation such as patent protection (Lamoreaux & Sokoloff, 1996).

Activity-specific public inputs. The clearest 19th century example of activity specific public goods 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, that is industrial policy. Other examples we will discuss below 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

A main goal of this paper is to evaluate what we know about the use and efficacy of industrial policies in the 19th century. What policies were used and how effective were the different policies at addressing market failures and providing public inputs? In light of the large number of policy levers used, and the different potential channels through which these policies may affect an economy, we propose a simple conceptual framework to discipline our thinking. This framework will evaluate industrial policies and their effects by examining the different ways producers in an economy are affected by their environment, both on the output and input market side. 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?).

We illustrate this framework in Figure 1. 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, there were two main ways to change domestic producers' incentives: policies could be targeted at increasing a firm's domestic sales, or they could enable access to foreign markets. In terms of domestic markets, we will evaluate three types of prominent 19th century industrial policies. The first were policies that protected domestic producers from foreign competition, typically through protective import tariffs. The second were policies that increased the *size* of the domestic market by increasing domestic market integration through the removal of man-made barriers to trade or infrastructure development (for example, railroad development). The

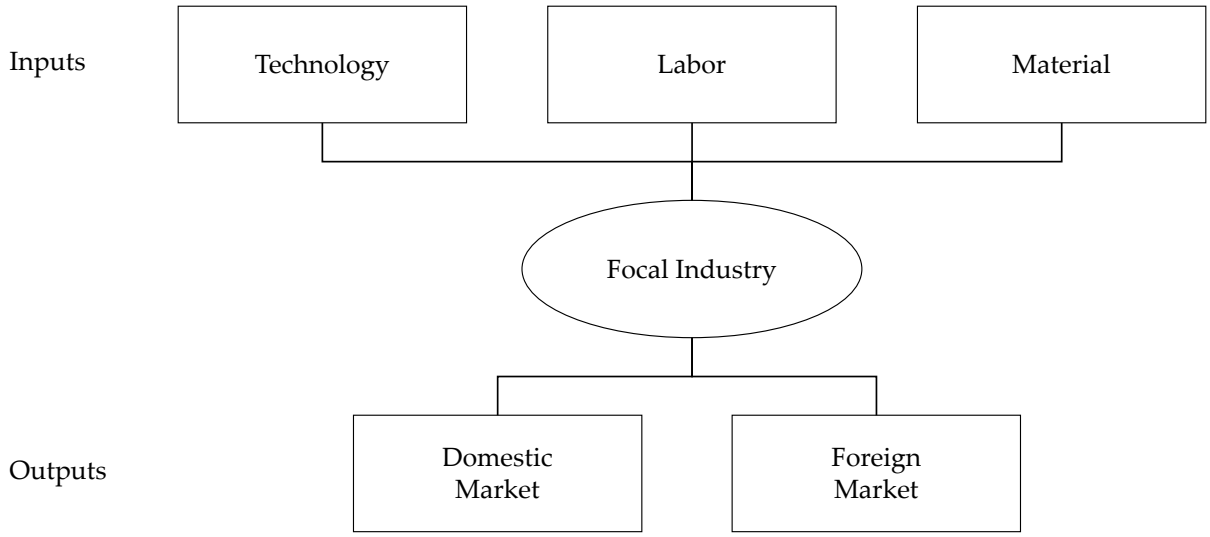

Figure 1: Conceptual framework

third were policies that increased the *share* of the domestic market that individual firms captured, by designing domestic competition policy. In terms of foreign markets, industrial policies were used to increase access to foreign demand by various means. Some, such as those used by Meiji Japan to promote exports are predecessors to modern policies. Others, such as securing colonial markets for domestic manufactures, are more specific to the 19th century context.

On the input side, we can follow the guidance that a production function provides. Producers will benefit when they have access to more productive technology, and when they can source inputs such as labor and material at low cost. A wide array of 19th century policies affected producers through these channels. From Bourbon France, through the early US republic to Meiji Japan, governments smuggled blueprints and machines, hired British engineers and subsidized the take-up of British technology in various ways. Governments supported infrastructure development, such as the laying of submarine cables and railroads, to improve access to foreign or domestically produced materials. And they deployed education policies to increase the pool of (skilled) labor required by an industry.

These economic channels do not exist in isolation and 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.

Of course, the same policy sometimes affected multiple channels. Railroad development is a

good example. We will show below that the railroads affected output market integration, led to better access to material inputs, export markets, technology and ideas. Even in countries where railroad development was state led and had an explicit (industrial) developmental goal, policymakers may not have spelled out, or foreseen, all these effects. Our aim however is to understand how and why industrial policy matters, so a focus on the precise mechanisms through which these effects work is of key interest.

In all of this, the imperial context of the 19th century cannot and should not be ignored as we evaluate policies and outcomes. 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. Colonies were used to secure critical industrial inputs, and were also used as protected markets for imperial powers' manufactures. In the service of these aims, imperial powers deployed "imperial" industrial policies such as colonial railway development. 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.

Moreover, during the age of imperialism, even nominally independent countries may have faced severe restrictions on their policy toolkit. Good examples are Meiji Japan and Imperial China, which were forced by Western powers to adopt a low tariff in the context of the unequal treaties. As we consider the extent to which industrial policy shaped economies during the Great Divergence, we should remember these points. Colonies, and even some "independent" countries lacked access to all or some of the policies imperial powers deployed to shape their own industries.

Finally, we offer some caveats and justifications about the scope of our coverage. First, we focus on the 19th century and early 20th century, beginning with the Napoleonic Wars and ending in the interwar period. This choice is conscious, as our discussion is centered on trying to understand the extent to which technological follower countries used industrial policy to emulate Britain in the context of an increasingly intertwined world.[7] Second, while we focus on industrial policies as defined above, we discuss literature that evaluates the effects of these policies in contexts where they were not implemented for industrial policy reasons. As such, we discuss the burgeoning literature on the effects of railroad development including contexts where the railroad was developed as part of the government's industrial policy, and contexts where it was developed primarily by private investors, or by the government for other reasons. We are aware of two public policies we cover for which there is very little evidence of industrial policy intentionality: public mass educa-

[7]There are certainly interesting and relevant examples of historical industrial policies both before and after this time period. Juhász et al. (2023) provides a discussion of some other recent contributions to industrial policy in a historical context.

tion and immigration. We examine these policies given recent emerging evidence which suggests both primary education and immigration may have mattered for industrial development. Third, we are not, and do not aim to be exhaustive in our coverage of industrial policies. For example, our framework omits policies that work through improving access to land inputs for targeted activities because we did not find a large literature (though future work may conclude that this policy was important and widely used). Finally, while we tried to cover a variety of different contexts, with a particular eye towards moving away from purely Western-centric accounts, our knowledge of the literature is biased by the contexts we have worked in.

2 SHAPING DOMESTIC MARKETS

We begin by examining the three channels that operate through domestic markets. The first are a set of policies that seek to protect domestic markets from foreign competition; the second are a set of policies that seek to integrate domestic markets internally; and the third set of policies aim to regulate the competitive structure of an industry to change the size of the industry that an individual firm captures.

2.1 Protection from foreign competition

In the space of a few decades in the late 18th century, Britain 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 for much of the 19th century. The pace of productivity growth was astounding by historical standards. Cotton yarn and cloth produced in India had been dominant for centuries (Riello, 2013). European producers had tried and failed to attain comparable quality with cottage industry technologies throughout the 18th century. Yet with the advent of mechanized technologies and the factory system, in the space of a few years, British cotton yarn became competitive with Indian yarn – first, at home in Britain, and by the end of the Napoleonic Wars, in India (Broadberry & Gupta, 2009). Very soon thereafter, British cotton textiles dominated markets the world over.

In many parts of the world, a key aim for policymakers and thinkers through the 19th century was acquiring these British technologies and building modern, competitive manufacturing industries. This type of "infant industry" promotion is textbook industrial policy (aimed, in theory, at addressing learning-by-doing externalities). In practice, for most follower countries in the 19th century, this meant trying to build a domestic, mechanized, factory based textile industry as a first step.

Much-discussed policy tools used to promote infant industry in the 19th century are protective import tariffs, or even prohibition.[8] Policy instruments such as these incentivize domestic production by raising the price at home of output for the targeted industry. Strategic protectionism

[8]Prohibition means that imports of certain products are not allowed.

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.

Interestingly, "accidental" infant industry promotion by way of wars and blockades has long animated the debate around infant industry promotion during the long 19th century. In the *National System of Political Economy*, Friedrich List discusses the natural protection from British competition afforded to nascent industries during the Continental System (in Europe) and the Jeffersonian Embargo (in the US) in the early 19th century. List argued that key strides were made during this time period. Eli Heckscher famously countered that there were little lasting positive effects (Heckscher, 1922). Echoing List, the 20th century French economic historian Francois Crouzet argued that only regions that were effectively part of the Continental System industrialized early in Europe (Crouzet, 1964).

Similarly, it has been claimed that WW1 was an important catalyst for the development of nascent industries in Asian and Latin American periphery countries. It turns out that these events have formed the basis of natural experiments that have allowed researchers to better understand the infant industry mechanism. Before we turn to this literature however, we ask to what extent infant industry promotion was deployed through strategic trade policy in the 19th century.

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. On the one hand, different to the contemporary context in which much of world trade is governed by a multilateral, rules-based trading system that has brought tariffs down to low levels, many 19th century countries had a great deal of autonomy over what tariff policy they chose to follow. On the other hand, colonies, and even some nominally independent states had limited to no autonomous tariff setting power.[9]

However, answering the question of how much infant industry protection there was turns out to be difficult for an even more fundamental reason: Tariffs may be deployed for a variety of reasons, only one of which is infant industry promotion. In the 19th century context, an important competing objective was deploying tariffs to raise revenue. In the US, for example, tariff revenue made up 90% of government revenue until the Civil War (Irwin, 2017). Special interests politics were another objective.

There seems to be emerging evidence that the fiscal needs of the state were an important deter-

[9]For example, "independent" China and Japan were forced to sign "unequal treaties" that opened up their countries to trade with the West and severely restricted their ability to impose tariffs. Colonies had no independent tariff-setting power. Panza & Williamson (2015) discuss infant industry promotion through non-tariff measures in early 19th century Egypt, a context in which infant industry tariffs could not be imposed.

minant of tariff policy, perhaps dominating infant industry promotion and other objectives. Lampe (2020) gives multiple examples from the history of 19th century European trade policy, where the fiscal needs of the government (in particular, paying for costly wars) were the main reason for increasing tariffs. Detailed product level tariff data allows Chuchko (2019) to re-evaluate the Menedelev tariffs from Late-Imperial Russia – an often cited example of infant industry tariffs. Through the lens of a Grossman & Helpman (1994) "Protection for Sale" model, the author finds that fiscal revenue collection was the government's dominant concern, trumping industrial protection.

We take a different approach to this question 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 objectives. This basic stylized fact has long been missing from the 19th century context because of data limitations on product-specific tariffs. However, recent data collection efforts provide us with a first glimpse to understand the structure of protection: were tariffs on manufactured products higher than tariffs in other industries?

First, 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. We split countries based on whether they are part of the "core" set of industrialized economies (e.g., Great Britain, US) or whether they formed part of the periphery (e.g., Australia, Norway) – the latter being where we would expect infant industry type arguments to be relevant. Overall, tariffs in core economies seem slightly biased towards agriculture, while in periphery economies the opposite is the case, so there is some evidence of infant industry protection in periphery countries. Yet these patterns are weak, and, on average, the difference between agricultural and manufacturing tariffs are fairly small. However, these averages mask a great deal of heterogeneity across countries. Some countries fit the average characterization well, with strong and consistent pro-agricultural biases in core economies such as the US and Germany, and strong manufacturing biases in periphery countries such as Australia and Denmark. But others buck the trend. France (a core, industrialized economy) had higher manufacturing tariffs, while periphery economies such as Norway protected their agricultural sectors more heavily. Furthermore, there was also heterogeneity over time within countries.

Figure 3 provides a further breakdown of manufacturing tariffs for one single year where data has 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 able to separately examine colonies (in particular, British India and the Union of South Africa). The patterns within manufacturing paint a picture that is more 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.[10]

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

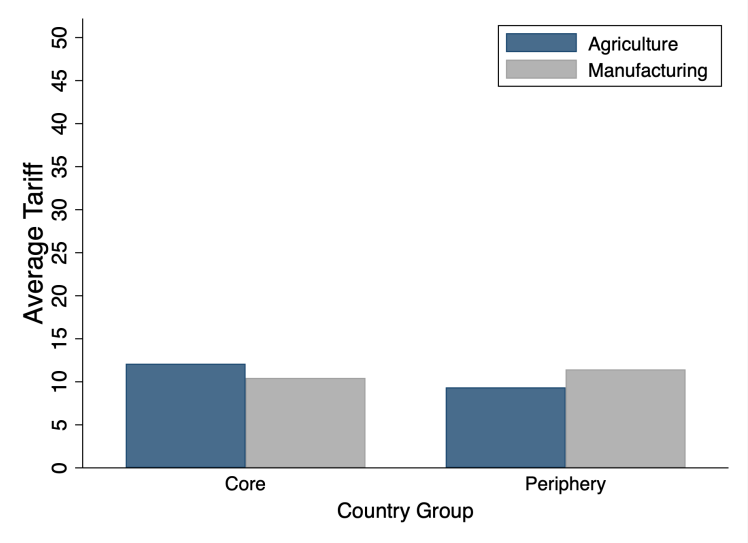

Figure 2: Structure of tariffs: agriculture vs. manufacturing, 1877-1912

Notes: Data are from Lehmann & O'Rourke (2011).

The preceding discussion does not paint a clear picture. On the one hand, looking across sectors in Figure 2 suggests infant industry promotion may not have been the main aim of 19th century tariff policy, as the manufacturing bias of tariffs in periphery economies is weak and heterogeneous. Yet looking within sectors in Figure 3, the picture is more consistent with policies that shift relative prices towards infant industries *within* manufacturing, such as textile production (while potentially also giving better access to imported machinery and material inputs – a point we return to in sections and 6). More work on how tariff policy was determined and what its basic patterns were within manufacturing is needed. Yet there is some evidence that, in some countries, some of the time, the structure of tariffs was conducive to shifting prices in favor of light manufactures such as textiles. Thus, we now turn to asking what the economic effects of infant industry protection were, leaving open the question of how intentional or common tariff policy was in terms of infant industry promotion.

2.1.2 Economic effects of tariff protection

The modern economic rationale for the type of strategic tariff protection argued for by neomercantilists are the existence of market failures that impede a new industry from emerging in technological follower countries. Typically, these are learning externalities or coordination failures of the type we discussed in Section 1.2. We note that this justification is highly selective – it does not apply to all or even most industries, and does not apply at all points in an industry's life cycle. In the 19th century context, the main place to look for infant industry mechanisms are in new industries in technological follower countries ("periphery" countries). Specifically, in mechanized,

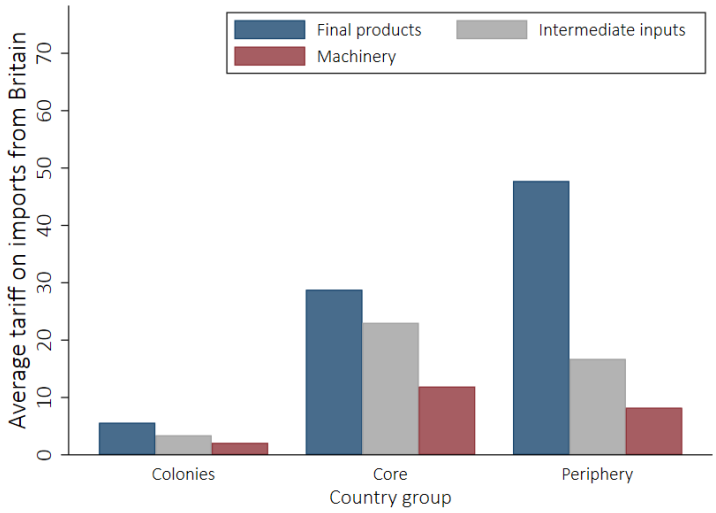

Figure 3: Structure of tariffs: Manufacturing by product type, 1905

Notes: Data are from Varian (2023) and denote average tariffs that countries impose on imports from Great Britain in 1905.

factory-based manufacturing, particularly textiles, which was the engine of 19th century industrial development.

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, so we do not repeat them here (see Rodriguez & Rodrik 2000; Harrison & Rodríguez-Clare 2010; Juhász et al. 2023).[11] 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 (a point first made by Lehmann & O'Rourke 2011).[12]

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 has typically turned away from using variation in tariffs, which are usually endogenous, to using quasi-random time variation in effective protection driven by technological shocks, as well as wars and blockades.[13] While it should be noted that variation in trade openness driven by these types of shocks does not necessar-

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

[12] Harris, Keay & Lewis (2015) examines the effects of the Canadian tariff structure on growth.

[13] These papers thus build on Feyrer (2019) who first used similar exogenous, time-series variation in effective protection.

ily identify the same mechanisms as variation driven by trade policy (Rodriguez & Rodrik, 2000), these papers constitute a substantial step forward in tackling some of the biggest challenges that have plagued this literature.

A helpful place to start is Pascali (2017), which is, in some respects, closest to the earlier tariff and growth literature. The author devises an ingenious identification strategy to isolate a causal effect of trade openness on economic development during the first wave of globalization (1870-1913). The paper relies on the exogenous, time-varying change in trade openness caused by the introduction of steamships. The key idea is that during the age of sail, travel times were determined by wind patterns, which became irrelevant once steamships were introduced. Using this asymmetric, exogenous shock to "effective distance", the author finds that trade openness had, on average, a negative impact on various measures of economic development (income per capita, as well as population and urbanization, which are more appropriate measures in a Malthusian world).

While this is not an infant industry paper *per se*, its findings are consistent with strong infant industry forces at play in the late 19th century, as countries that experienced less opening to trade experienced more growth. This contrasts with neoclassical trade theory, which predicts that increased trade will lead to higher income through specialization effects. However, new trade theory, and particularly infant industry papers featuring external economies of scale have opposite predictions that are consistent with the empirical findings; namely that countries that were more open witnessed slower income growth due to remaining specialized in "low-growth" agriculture (as in Matsuyama 1992).

While new trade theory is not the only lens through which one can interpret these findings (another one being the inclusiveness of political institutions, or the imperial context of the 19th century as we discuss in Section 3), this interpretation is striking: It implies, that, at this critical juncture in economic history, the gains from increased specialization according to static comparative advantage may have been outweighed by developing dynamic comparative advantage in modern manufacturing. Put differently, they suggest that infant industry type mechanisms may have been very important.

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. We view this as complementary evidence to Pascali (2017) in that the paper is focused on understanding the outcomes of quasi-random protection for a leading candidate of infant industry: mechanized cotton spinning. As such, while Pascali (2017) examines country level outcomes, Juhász (2018) zooms in on one particularly important industry.

The setting is one that closely corresponds to textbook infant industry. France had a similar (cottage industry-based) cotton textile industry to Britain's prior to the revolutionary breakthroughs mechanizing production in Britain. The new, mechanized technologies were developed in Britain,

giving that country an important head-start in developing potential external economies of scale. Consistent with this, at the turn of the 19th century, French cotton yarn was not competitive with British, and the new, mechanized technology had not been adopted on a wide scale in France.

Similar to Pascali (2017), the author uses a time-varying shock to trade openness; in this case, the regional variation in the effectiveness of the Napoleonic blockade against British trade in France. Consistent with the infant industry argument, the author finds that French regions better protected from trade with Britain expanded their mechanized spinning capacity during the blockade. Moreover, temporary protection changed the long-term profitability of the industry and industrial development more generally. Through the 19th century, mechanized cotton spinning was located in initially better protected areas of France. These regions also witnessed higher levels of industrial GDP per capita until about 1860, but not beyond.

It is interesting to contrast these findings to Liu (2020) who studies a very similar episode, albeit a century later in China. Like Juhász (2018), the paper studies the development of modern cotton textile manufacturing, in this case though, during and after WW1. The author uses the fact that production and exports from Britain and other combatant countries were disrupted during the war, and Chinese counties thus received differential changes in protection based on how exposed they were to trade initially. In contrast to the Napoleonic period however, the paper finds little evidence of increased activity in more protected 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. The French were able to develop their own spinning machinery and hence, the industry took off as soon as it was protected from British competition. A century later, machinery was more sophisticated and its production much more professionalized (Cookson, 1994). China, like much of the rest of the world, was reliant on imports of spinning machinery from Britain. WW1 thus gave Chinese entrepreneurs, particularly those around ports, a chance at import-substituting industrial development, but crucially, they also cut off a critical input: the necessary technology. The findings from Liu (2020) suggest that lack of access to technology embodied in machines was decisive. Without it, the industry could not expand.

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 equip-

ment.

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. Using detailed data on early cotton spinning mills, the authors show that many plants operated the spinning technology very inefficiently. Moreover, the industry experimented with many different factory layouts, only some of which proved efficient. This suggests that an important component of the externality was a cost-discovery channel a la Hausmann & Rodrik (2003) described above. Early, inefficient plants may have produced important externalities to later entrants by discovering how to optimally run factories in the French setting. Not only is much of this type of knowledge tacit, but the authors also argue that optimal mill layout likely depended on a host of local conditions. 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. However, even from this small number of papers, these findings require qualification. Access to technology, particularly in the form of (imported) capital equipment is likely necessary in most cases. Thus, a protective tariff, in and of itself, might not have been sufficient. On the other hand, it is not clear that strategic tariff policy was the most important form of infant industry promotion. "Accidental" infant industry promotion by way of wars and shocks may have been more important empirically than policymakers intentional use of tariff policy. Perhaps this is unsurprising given the competing uses of tariffs for raising revenue and special interest politics. This is a sobering insight, given the importance of tariffs to prior research, as well as recurring debates about the role of tariff policy in 19th century development.

2.2 Domestic market integration

At the turn of the 19th century, domestic markets were highly fragmented almost everywhere.[14] 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. Before writing *The National System of Political Economy* for which he is best known, Friedrich List advocated for domestic market integration in Germany through the construction of a national rail network (Hornung, 2015) and the removal of tolls and taxes across states (Keller & Shiue, 2014).

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). Many in France were drawn to moving customs to the foreign border as they saw it as a way to nurture domestic industry and protect it from foreign competition (Bosher, 1964).

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."[15]

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 combi-

[14] England is a notable exception. Its domestic transport network improved substantially between 1600-1800 before the advent of the railroad as a result of canal and turnpike construction (Bogart, 2017; Satchell, 2017). Daudin (2010) shows evidence that some districts in France had access to relatively large markets even prior to the French Revolution.

[15] 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.

nation 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 Sweden, the state built the main network (Berger, 2019). The government also played a role in financing in Meiji Japan, but the lack of sufficient funding opened the way for private sector involvement (Tang, 2014). In Argentina, private investors built the most profitable lines, while the state financed the more rural ones (Fajgelbaum & Redding, 2022). In the global periphery, the lack of developed capital markets meant that foreign firms often undertook the bulk of railroad construction. 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. In politically unified France, policymakers and thinkers since Jean-Baptiste Colbert in the 17th century had attempted to create a single market by removing internal tolls and taxes.[16] However, special interests and the state's need for revenue repeatedly blocked efforts 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. Colonial governments built railroads for a variety of reasons that served their interests. Primary among them were military security (the main objective of the railroad in British India; Donaldson (2018)), geopolitical power (a primary motivation during the Scramble for Africa at the turn of the 20th century; Jedwab, Kerby & Moradi (2015)), and the transport of raw materials from the interior to the ports for export (Jedwab & Moradi, 2016). In short, while in colonies, the railroad was a tool of empire (Headrick, 1981), it nonetheless reduced transportation costs and increased market integration.

2.2.2 Economic effects of domestic market integration

The previous section demonstrated that through the 19th century, states around the globe undertook policies and investments to increase domestic market integration (intentionally or otherwise), often substantially so. What were its effects? Did domestic market integration achieve the aims that

[16] Colbert was Comptroller of Finances under Louis XIV.

19th century thinkers envisioned? This question has captivated economic historians for decades. Rostow (1960, p.302) believed that the introduction of the railroad was "the most powerful single initiator of take-offs". Others have been more skeptical. Fishlow (1965) questioned the direction of causality, namely, whether railroads induced, or followed economic growth. In a seminal work, Fogel (1964) made a compelling case that in the U.S. context, the extension of the existing canal and navigable waterway network would have entailed similar effects, at least in terms of agricultural development.

The past decade has seen a proliferation of high quality work that shines new light on these questions. 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 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 the multitude of problems that make evaluating the effects of market integration difficult. On the one hand, the papers surveyed below all deal explicitly with the endogeneity problems that these policies and investments entail. Two popular approaches are the use of planned but not built infrastructure (railroad lines) as a placebo, and the use of straight, "least cost" lines connecting major cities as an instrumental variable. On the other hand, the papers attempt to carefully distinguish between growth and reallocation effects (Redding & Turner, 2015). For example, many papers evaluate the impact of the railroad on the size of the nearby population. However, estimates may be biased if the railroad leads to a reallocation of the population between treated and control units. Papers typically try to address this by examining the robustness of results at larger spatial units (e.g., Hornung 2015).

Finally, the literature has developed quantitative spatial models that allow researchers to estimate the aggregate effects of market integration. Different to reduced form methods, these models allow researchers to move beyond estimating local effects.[17]

Effects on price gaps and price volatility A natural starting point is to ask how much market integration was achieved by domestic market integration policies? This is a question about the magnitude of trading frictions (e.g., trade costs or information frictions) and in particular, the extent to which policies pursued through this time period brought them down. The challenge is that these frictions are not observed by the researcher. New work has used creative data and unique

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

episodes to shed light on this question.

Donaldson (2018) examines the extent to which the massive 60,000 kilometer railroad network built in British India integrated agricultural markets. The setting is interesting, as the transport network prior to the railroad age was poor, and many inland regions were near autarkic. A major strength of this study is the availability of price data on a commodity (salt) that was only produced in a unique location but was consumed throughout the country. This feature of the data is helpful as it means that we know the origin district of a commodity in each destination district which allows us to infer trade costs. The analysis reveals that trade costs across districts were substantial, but were significantly reduced by the railroad. By reducing trade cost and effective distance between locations, the railroad integrated agricultural markets in India.

Keller & Shiue (2014) provide complementary evidence on the effects of removing man made barriers to trade. Using wheat price gaps across 40 German cities, they find that joining the Zollverein (the free trade customs union that removed internal tariffs and imposed uniform external ones) reduced wheat price gaps by about a third.

A third recent paper provides evidence on the effect of reductions in information frictions. Gao & Lei (2021) examine the effect of the introduction of the telegraph network in China in the 19th century on food prices. Different to other countries, China rolled out the telegraph independently of the rail network which allows the authors to isolate the impact of information frictions from those of trade costs. The authors show that the reduction in information frictions had substantial effects on grain price volatility. Connection to the telegraph reduced both the size and the incidence of extreme grain prices. Moreover, the telegraph dampened price responses to extreme local weather shocks, but increased the responsiveness to shocks in other, connected districts. The study thus shows support for a distinct mechanism: that of a reduction in trading frictions leading to increased risk sharing across the economy.

In summary, these papers show that a number of different policies pursued during this time period to create national markets had the effect of substantially decreasing trade costs. Price gaps across districts converged, and we see evidence of increased risk sharing across regions.

Regional specialization To what extent did these market integration policies lead to gains from increased regional specialization? New work examines the strength of these forces across markets in British India and the United States. While the contexts differ, this new work consistently finds that the reduction in trade costs led to gains from increased specialization based on Ricardian comparative advantage.

Donaldson (2018) estimates that Indian districts connected to the railway witnessed a 16% increase in real agricultural income relative to unconnected districts. The author estimates that roughly half the reduced form gains are driven by decreased trade costs through the lens of a quan-

titative Ricardian trade model. In complementary work, Donaldson & Hornbeck (2016) develop a novel methodology for estimating the aggregate impact of railroads on the U.S. agricultural sector. The authors deal directly with a common challenge in the transport infrastructure literature, namely that its placement in a particular location affects all locations through the trade network. Their approach, which also leverages quantitative Ricardian trade theory, captures both the direct and indirect effect of the railroad on districts through a model-based market access term. The authors estimate that removing the entire rail network in 1890 would have lowered agricultural land values by 60% and led to a 3.2% loss in annual GNP. Finally, Hornbeck & Rotemberg (2023) find even larger welfare effects for the US economy. Their study, which builds on the theoretical framework in Donaldson & Hornbeck (2016), finds that the railroad increased aggregate productivity in US manufacturing substantially. The reason these estimated gains are larger than that estimated in the previous literature is due to the fact that the railroad encouraged the increase of economic activity in a distorted economy.

Effects on industrial development In a number of countries, an objective of state-promoted railroad development was to foster industrialization. The last few years have seen a proliferation of high quality work that informs both whether, and, importantly, how the railroad affected industrial development.

A common finding is that locations treated by the railroad witnessed faster local urban development. In fact, this seems to be a consistent finding across a wide variety of contexts. In the American Midwest, Atack, Haines & Margo (2011) find that development of the railroad accounts for about 60% of the observed urbanization in the Midwest during their sample period. In Prussia, the local, causal effect of railroad treatment for a city was about 1-2% higher population growth a year (Hornung, 2015). The railroad is estimated to have increased urban population both in England and Wales (Bogart, You, Alvarez-Palau, M. & L., 2022), where market integration and industrial development prior to the railroad were already relatively high, and in colonial Kenya, where the railroad was introduced in sparsely populated regions that were near autarkic (Jedwab et al., 2015). Similarly, multiple papers find an increase in the population of spatial units (urban or otherwise) near a railway station (Berger & Enflo, 2017; Berger, 2019; Büchel & Kyburz, 2020).

These effects suggest that the structure of the economy may have changed in ways consistent with industrial development, though it is silent about why. A strength of much new work is the ability to dig deeper into measuring industrial development and structural transformation more directly and also speaking to the potential mechanisms at play.[18]

[18]It is likely that part of the effects many of these studies capture is reallocation. Using the location of historical US Post Offices, Hodgson (2018) shows that post offices that were "almost" connected to the railroad had a lower probability of surviving than both those that were connected and those that remained isolated.

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) shows that in Prussia, firms in cities treated by the railway were almost twice as large as their counterparts in non-treated cities, with no effect on the total number of firms. Similarly, in the context of Japan, Tang (2014) finds that the railway led to higher average firm capital, a proxy for firm scale. Interestingly, Atack et al. (2011) find that the railway played a role in the rise of the factory in the US context, though Hornbeck & Rotemberg (2023) find no effect on firm size in the US setting, but rather an increase in the number of firms.

Second, a number of papers find important effects on local structural transformation and industrial development, though this is not a consistent finding across all papers. Berger (2019) and Lindgren, Pettersson-Lidbom & Tyrefors (2021) find impressive increases in manufacturing activity in the context of Sweden. In fact, based on a staggered event study research design, Lindgren et al. (2021) find a 130% increase in non-agricultural income over a time horizon of 30 years in rural geographies treated by the railroad. In England and Wales, Bogart et al. (2022) find evidence for structural transformation with railway treatment leading to a movement of labor out of agriculture and into industry. For the US, Hornbeck & Rotemberg (2023) also find productivity growth in manufacturing, however, no change in the broad composition of economic activity, as the output share of manufacturing remained constant.

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. 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 these 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 to increase the *size* of the industry, a related question is how much of the *share* of the industry does a specific firm capture. This may be relevant for the scale of firms, and their ability to modernize and adopt frontier technologies.

In fact, over the course of the 19th century, large companies and cartels emerged in many industrialized countries. Why did this happen, and what was the role of governments in this development? One reason for the emergence of cartels were overcapacities in the industry as a result of large investments or economic booms. To escape the competitive pressure, companies formed cartels to restrict output, set prices, and allocate regional markets (Chandler 1990, p.71ff, Fischer

1954).

There was a fair amount of heterogeneity with respect to how governments responded to this trend. At one extreme was Germany: accompanied by an intense public debate, the German Supreme Court decided in 1897 that cartels were legal, and deviating behavior of cartel members could be enforced at court. As a consequence, Germany became the "largest cartel land of Europe" (Fischer, 1954, p. 443). However, this development was not the result of an active industrial policy of the German government; instead, the government preferred not to interfere with economic and judicial developments (Trebilcock, 1981, p.74). In contrast, informed by the German experience, Japan actively experimented with replacing competition with cartels in the 1920s and 1930s. In fact, Johnson (1982) characterizes the government's cartel policies from this era as precursors to the high watermark of industrial policy in the postwar *MITI* era whereby the government used "administrative guidance" to steer competition.

The United States was at the other extreme. Cartels also emerged, but these were unstable, as common law in the US did not allow for the enforcement of cartel agreements. The introduction of the *Sherman Antitrust Act* in 1890 put a definitive stop to monopolistic behavior (Chandler, 1990, p.71ff).[19] In parallel, incorporation laws emerged that allowed for the establishment of holding companies. 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.

Other countries were in between. While no country adopted an antitrust law comparable to the US before WW II, cartels were not explicitly allowed in Great Britain or France either. However, in both countries there was a "gentleman's agreement" among industrialists to limit competition (Landes, 1969, p.246).

To the best of our knowledge, the empirical literature evaluating the effects of competition, or the absence of it, on industrialization in this era is lacking. Did the antitrust law and resulting competition push the US towards becoming the industrial leader by WW1? Alternatively, were cartels and the resulting scale important for industrial development and innovation?

One example of a fruitful contribution to these issues is Gross (2020), who shows that collusion among US railroads in the 1880s enabled the adoption of a standard railroad gauge in the United States—an enormous engineering undertaking, during which 13,000 miles of railroad tracks were changed in just 36 hours. The author shows that the cartel provided the incentives for undertaking this massive investment, a potentially welfare-enhancing innovation as it increased efficiency. However, consumers did not benefit from it, as the cartel restricted the pass-through of resulting cost savings to consumers and kept prices stable. These producer surplus increases are also reflected in a surge of stock market returns of railroad investors.

[19]There is, however, some debate about the intention of the law. For example, Grandy (1993) argues that Congress was concerned about producer rather than consumer surplus.

Overall, given the prevalence of cartels and large corporations that emerged during the 19th century, we know little about whether they have contributed to or hindered industrialization. This is an area ripe for future research.

3 ACCESS TO FOREIGN MARKETS

Our period of study plays out against the backdrop of not only the Industrial Revolution, but also the dramatic fall in international trade costs which paved the way for the First Wave of Globalization (circa 1870-1914). This period of increased integration saw the emergence of an international division of labor that was historically unprecedented. 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 (railroads, telegraphy, and steamships) that made this dramatic reduction in transport costs possible are well-known, less appreciated is the role of states in shaping them. In fact, the terms of global competition were not set by market forces alone. Instead, access to foreign markets was often shaped by countries' industrial policies.

3.1 Policies to improve access to foreign markets

We discuss the various policies that governments implemented to improve foreign market access in turn: colonialism, the development of transport and communications infrastructure, direct subsidies for shipping companies, export promotion, international trade agreements, and the international protection of property rights.

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 the type of "gunboat diplomacy" which was used to forcibly open Japan and China to trade in the middle of the 19th century. 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.[20] In nominally independent states, imperial powers often used other forms of leverage to extract "unequal treaties" that ensured low tariffs for exporters. This was the case for Japan and China, which had no autonomous tariff-setting power until the 20th century. Prior to that, tariffs were set at uniformly low rates, giving imperial powers low tariff access to these markets.

[20]The two colonies are British India and the Union of South Africa.

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 (discussed in detail in 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 on different degrees of 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.[21] But even for private lines, the governments played an important role in the background in various ways: by 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.

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

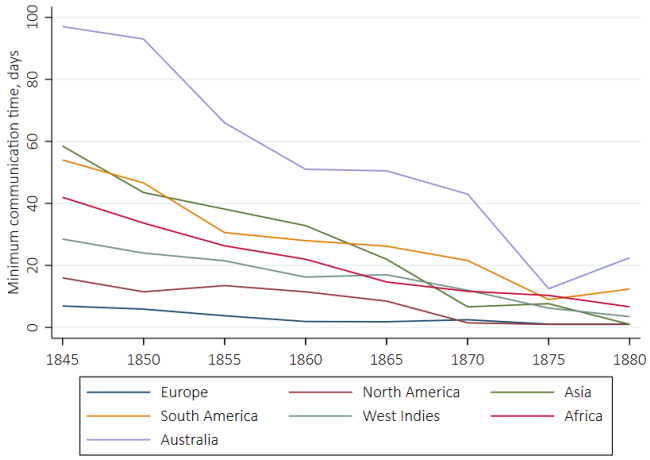

Figure 4: Minimum communication time from region to London, days

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.

3.1.3 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 (at a minimum, mail subsidies) were necessary for the profitable operation of many routes (Davies, 2009).[22]

In Britain, the earliest steamships were heavily subsidized and regulated. The *Peninsular and Oriental Steam Navigation Company* received £160,000 a year beginning in 1845 for its service to India and China (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). As such, the shipping companies that served Japan did not become dominated by Western firms, and most relevant for this section, Japan subsidized the creation of new, long distance routes to Europe and North-America. At times, the Meiji government also provided a payment for route-mileage (Davies, 2009).

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,

[22]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).

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

Another important industrial policy package that governments used to facilitate foreign market access was the system of bilateral treaties that emerged in Europe in the 1860s following the Anglo-French Cobden-Chevalier treaty (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). We will discuss how international agreements to protect patents affected innovation in section 4, but trademarks were another type of intellectual property that were commonly counterfeited. Trademarks signal unobserved product characteristics such as quality or durability, and were especially important in international trade, when buyers and sellers interact at a distance. However, trademarks were not protected against infringement in foreign countries. So 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

Considering the dramatic decline in international trade costs, increased global trade, and the vast array of industrial policies that tried to foster exporting in the 19th century, the academic literature on the effects of international market access is surprisingly thin. Until recently, there has been very little empirical literature on how any of the policies above shaped economies and the development of the global economy. We discuss a handful of recent papers below, which, while welcome advances, only scratch the surface of open questions in need of investigation.

Complementing the work discussed in section 2.2.2 on domestic market integration, some recent papers have examined the effects of opening up the agricultural hinterlands of countries to the world market. These papers find that export opportunities can substantially change the spatial distribution and the level of economic activity in a country. Jedwab & Moradi (2016) examine the effects of the colonial railroad in Ghana. Built to link the coast to mining areas, the railroad

traversed initially low-populated tropical forests. However, as these areas were suitable for cocoa cultivation, Ghana soon became the world's largest exporter of cocoa, and the Gold Coast the richest colony in Africa. The authors show that due to the export opportunities which emerged because of the railroad, rural and urban population along the railroad grew, as did other measures of development.

In a similar vein, Fajgelbaum & Redding (2022) use Argentina's integration into the world economy in the 19th century to examine its effects on the domestic economy. Using the reduction in transatlantic freight rates, and the rollout of the domestic railroad to agricultural hinterlands, the authors examine the impact of the ensuing agricultural export boom on the development of the economy. They find that the spatial distribution of economic activity changed substantially. Locations closer to world markets had higher population densities, were more urbanized, and were more specialized in traded (agricultural) goods that were more transport-cost sensitive. Through the lens of a spatial model, the authors find that integration into the world economy increased welfare by about 7.1%. This is in line with earlier work, which also found evidence for similar welfare gains from economic integration in this period for Japan (Bernhofen & Brown, 2005).

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), that suggest that the effects of trade on income are negative for some countries in this period. In section 2.1, we viewed these results through the lens of trade theory. A different interpretation would be to view these findings through the lens of the "imperialist industrial policies" discussed in this section. In a world in which colonies and many independent countries had trade and other policies forced upon them, finding that global commerce does not benefit everyone may be less than surprising. Moreover, Pascali (2017) identifies the local average treatment effect of increased trade driven by reduced shipping times, whereas the single country studies we discuss above 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 and allowing buyers and sellers to communicate about product characteristics. We focus on the role of the first channel in section 6, where this mechanism is applied to Britain's sourcing raw cotton from the US in Steinwender (2018). The second mechanism is equally important, as Juhász & Steinwender (2018) show for the case of Britain selling its manufactured products across the globe. The telegraph helped buyers and sellers communicate desired product characteristics, which is easier if the product is "codifiable", i.e., if the product can be specified in words. For example, yarn was codifiable by specifying its

"count", a number that indicated the degree of fineness or density. On the other hand, printed cloth was not codifiable, as product characteristics were tied to the inspection of a physical cloth sample. Overall, the authors show that the telegraph improved British exports of codifiable products through the product specification channel.

The third channel the literature has examined is the effect of trade policies. In intriguing new work, Romero (2023) studies the effects of Spain's tariff policy in its colonies on industrial development in Spain. As noted above, metropoles often used colonies as captive output markets for their manufactures. Yet determining the effects of these "imperial industrial policies" is difficult because of the endogeneity problem inherent to tariff policy. The author exploits the fact that Spain imposed high out-of-empire tariffs on cotton textiles in its colonies as leverage in trade negotiations with France, which unexpectedly failed. Thus, the tariffs remained high (increasing to 65%, from 35%), and, as a consequence, for a few years in the late 19th century, Spain had access to an exogenously larger market for cotton textiles, as colonial markets became captive. The author finds that larger markets increased innovation in Spain – in fact, it increased both novel, indigenous patenting, and introduction patents, which protected ideas developed outside of 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 introduction of a trademark law in China in 1923 to advance our understanding of how trademark protection affected the foreign market access of authentic producers. This policy enabled Western firms to get better protection from counterfeits (in this case, by Japanese manufacturers) in the Chinese market. An analysis of firm-level micro data for Shanghai in the 1920s reveals that the trademark law reallocated market share from counterfeiting to authentic, Western firms, created industry-level growth, but did not raise consumer prices. This suggests that consumers, rather than producers, benefited most from the efficiency gains unlocked by the trademark law.

While the emerging literature investigating some of the many policies adopted to promote exporting is a welcome advance, the general point remains that this part of industrial policy in the 19th century is critically understudied. First, understanding how trade policies put in place in the context of imperialism affected both colonies and metropoles seems to be a key question. If infant industry mechanisms were relevant at this critical juncture, the fact that many countries did not have independent tariff policy and often served as a captive markets for the metropole's manufactures is important. Second, the historical literature also suggests that competitiveness in export markets was often shaped by subsidies, be they intentional industrial policy or not. 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

A defining aspect of the 19th century context was that Britain and a handful of other Western European countries developed novel technologies that were meaningfully different to anything that had come before. Modern manufacturing relied on new machines that used inanimate power sources for the first time (initially water, and, later, steam-power). Production moved from peoples' homes and artisanal workshops to large-scale factories the likes of which had never been seen. Any state hoping to emulate Britain's success in manufacturing tried to obtain, copy and "domesticate" these technologies, as well as develop new ones that could successfully compete with British technology.

4.1 Policies to facilitate access to technology

From the earliest days of the Industrial Revolution in Britain, governments in other countries tried to facilitate their own technological capacity in a variety of ways. There were two main, likely complementary, strategies. Governments could facilitate the absorption of technology from abroad (typically, from Great Britain or, later, other Western countries), and they could try to foster domestic innovation.

4.1.1 Knowledge transmission from abroad

While much of the new technology developed in Britain was embodied in the machinery, there were two critical barriers to simply trying to import the technology. 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 the machines could be acquired, there is widespread agreement that a great deal of tacit knowledge was required to operate it (Landes, 1969; Wright, 1986; Maloney & Caicedo, 2022).

Here, we first review technology policies used by countries through the 19th century to facilitate the absorption of foreign technologies, with and without access to machinery imports. Second, we examine the extent to which tariff policy was favorable to machinery imports once the ban on machinery exports was lifted. We finish with a third, supporting set of policies, which facilitated the financing of the needed machinery and equipment.

Technology policy. Studwell claims that "Technology policy, not science policy, is the key to the early stages of industrial development" (Studwell, 2013, p. 17). Indeed, starting from France, the first technological follower country to industrialize, we have evidence of wide-ranging government involvement in facilitating technology absorption. Horn (2006) documents the variety of ways in which the French state, from the Bourbon regime through the politically tumultuous first half of the 19th century, implemented industrial policies designed to absorb the new technologies from Britain.

Under the French Revolutionary government, the Bureau of Consultation "coordinated, supported and reported" on various efforts at technology absorption, some of them legal, some of them

illegal (Horn, 2006, p. 176).[23] Books on technology and science were acquired, translated and disseminated. French spies and entrepreneurs acquired machines, and British artisans, mechanics and entrepreneurs trickled into France, in defiance of the British bans, and sometimes compensated by the Bureau. Industrial expositions were set up to "improve the French economy through the spread or introduction of new technologies and by strengthening the market for industrial goods" (Horn, 2006, p. 188).

Interestingly, we see similar types of technology absorption policies implemented through the 19th century in a variety of different contexts. In early 19th century Prussia, Lenoir (1998) describes an almost unbroken line of economic policy intended to stimulate economic development through the first half of the 19th century, much of which is technology policy. It included the dissemination of technical information, supplying government purchased foreign technology to private firms, and the building of state-financed model factories equipped with the newest technologies and organizational techniques.

Outside of the West, we see similar technology policies emerge in Egypt under Muhammad Ali (Helleiner, 2021), in China during the Self-Strengthening Movement (Bo, Liu & Zhou, 2023), and in Meiji Japan. Japan's technology policy efforts were wide-ranging and large-scale, perhaps more so than any previous effort. Yet, they also echo earlier policies from other countries. Montgomery asserts that scientific knowledge was seen as "the key to modernizing the country" (Montgomery, 2000, p. 216). Important pillars of the technology policy included learning missions to the West, foreigners (most prominently, educators and engineers), many of whom were employees of the Meiji government (Hirakawa & Wakabayashi, 1989), and the translation of Western science (Montgomery, 2000). The number of foreign government employees was 520 at its peak in 1870, and it accounted for a substantial proportion of government spending (Hirakawa & Wakabayashi, 1989). The government was also involved in copying foreign designs, and sometimes even managed to upgrade the machinery and export it back (Studwell, 2013, p. 72).

Some of the illegal activities to adopt foreign technologies were enabled by the inadequate protection of intellectual property rights (IPR) in foreign territories. International recognition of IPR started with the 1883 Paris Convention.[24] Before the convention, it was almost impossible for inventors to license their patents abroad (Bilir, Moser & Talis, 2011). As a result, inventors were very reluctant to share any of their knowledge across borders. The Convention, which is still in force, changed this: Inventors from any country could register their patents abroad (this is called "national treatment"), which facilitated international technology transfer.[25]

As with other industrial policies, colonies had little to no autonomous technology policy. How-

[23] This section draws on Horn (2006).

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

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

ever, sometimes it was in the interest of the colonizer to introduce new technologies to the colony in order to increase output. 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. The difference was largest for countries in the periphery. Moderately protective countries like Norway, Greece or Roumania did not impose any tariffs on textile or locomotive machinery, while highly protective countries such as Russia, Portugal or Spain charged very low tariffs on machinery.

Policies improving access to finance. 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) explains how early 19th century Prussia bought foreign technology and disseminated them to private firms and build state-financed industries. Similarly, Meiji Japan opened state pilot factories which lost money, but may have contributed to learning through demonstration effects (Crawcour, 1997). A more indirect, but no less important way to enable financing was to enable a well-functioning domestic capital market, with access to private investors or banks. For example, corporate laws, that were 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. This was popular, as international capital flows surged during the 19th century, especially from the core to the periphery (O'Rourke & Williamson, 2001a, p.208). However, some governments, such as Prussia and Japan, were very skeptical of foreign investors, and actively discouraged FDI (Studwell, 2013, p. 72).

4.1.2 Fostering innovation

A distinct—and in practice, complementary—set of policies were those that were targeted at encouraging domestic innovation. There were two key policies relevant in this context.

First, 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 other technology policies we already discussed (Landes, 1969, p. 150). The government also trained workers with skills that would allow them to improve the machines. In the 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 ended up leading the city of Troyes to become the French center for textile innovation (Horn, 2006, p.291). Similar policies took place in Prussia, which created the Humboldt University in Berlin in 1810 (Lenoir, 1998), as well as Japan, where the reform of the entire higher-education system in the 1880s was based on the German model (Montgomery, 2000). Different to technology adoption policies, however, 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". In fact, several recent papers highlight the important role of engineers for innovation and industrialization (Nuvolari et al., 2020; Maloney & Caicedo, 2022; Hanlon, 2022), as well as the role of upper tail human capital in industrial development more generally (Mokyr, 2005; Squicciarini & Voigtländer, 2015). Though these policies were typically focused on industrial development, this was not always the case. The United States supported agricultural research by granting government land to research institutions and creating the "land-grant colleges" (Huffman & Evenson, 2008).

Second, the protection of intellectual property rights (IPR) of inventors was a key policy question during this era. 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). Critiques in the "patent controversy" argued that IPR, by creating state-sponsored monopolies, reduced competition and thus welfare. They suggested alternative policies such as R&D subsidies or prizes, if any government intervention was required at all. The critiques were successful in a number of countries, at least temporarily: the Netherlands famously repealed its patent legislation in 1869, and Switzerland only introduced patent laws towards the end of the 19th century (Schiff, 1971). The issues with the lack of property rights protection became apparent as governments started to organize and support technology fairs that showcased their own innovations but also innovations from all over the worlds and allowed for the international exchange of knowledge (Findling, 2018). Gradually the advocates of IPR protection won the debate, and over the course of the 19th century, most countries introduced national patent laws. Furthermore, existing patent laws were substantially modernized which resulted in reduced patenting cost and higher accessibility, as in the case of France or Great Britain.

4.2 Economic effects of access to technology

There is a large economics literature studying innovation and technology diffusion during the Industrial Revolution. In our discussion, we focus on contributions that are informative about the effects of industrial policies, rather than technological change driven by other mechanisms. While the early literature focused on interpreting correlations, the recent literature has focused more on causal identification, leading to a burgeoning literature that revolves especially around four policies: railways, trade policy, intellectual property rights protection (such as patent laws), the creation of universities and related institutions, and colonial technology transfer.

4.2.1 Effects of the railway

Recently, there have been a number of papers studying the role of the railway for innovation and technology diffusion. Innovation could be an indirect consequence of increased access to output markets (which we discuss in section 2.2.2) increasing the returns to innovation and thus incentivizing innovation or technology adoption (Sokoloff, 1988).[26] In addition, there may be direct channels by which railways increase innovation. For example, the railway, by reducing transport costs, may directly improve access to more advanced machinery. In addition, since the railway improves the transportation of not just goods, but also people and mail, it may foster innovation and improve knowledge exchange among inventors and researchers.

Overall, recent papers typically find positive and often quite large reduced form effects of railroad access on innovation, using spatially disaggregated data. For example, Perlman (2016) and Andersson, Berger & Prawitz (2023) find positive effects on innovation as measured by patents (for the United States and Sweden, respectively), while Yamasaki (2017) and Americo (2022) find positive effects on technology adoption (as measured by steam power for Japan, and mechanized cotton spindles for Brazil, respectively). These papers pay close attention to identifying causal effects, typically using some sort optimal least cost route as an instrument for actual, potentially endogenous routes. More challenging in this literature has been to determine the channel driving these reduced form effects. So far, researchers have not found direct empirical evidence on the output market access channel (Perlman, 2016).

Neither is there evidence that the railway spurred the cumulative process of innovation by facilitating the exchange of ideas (Perlman, 2016; Yamasaki, 2017).[27] Instead, two other channels are directly supported by recent analysis. For original innovation, Andersson et al. (2023) stresses a more nuanced version of the market access channel, by emphasizing that inventors learn about the demand for innovation (rather than about demand for output, or about other ideas). What is more, inventors are better able to capitalize on their ideas as transaction costs in patent markets

[26] This argument goes back to Schumpeter (1934).

[27] This is particularly interesting, given that Hanlon, Heblich, Monte & Schmitz (2022) find that reductions in postage costs did increase the exchange of ideas and innovation in Britain.

are also reduced by the railway: The railway made it cheaper and faster for buyers, intermediaries and sellers of patents to meet and interact. More relevant for technology adoption, Americo (2022) provides evidence for the direct channel of the railway lowering transport cost of machinery, thus increasing access to foreign technology. This is consistent with Liu (2020), who found that machine imports were important for growth in the Chinese textile industry as we discussed in section 2.1. Overall, the lack of direct evidence on the output market access channel is surprising and unexpected (given, for example, the large literature on the positive effect of access to export markets on innovation in the contemporary setting, see Shu & Steinwender (2018) for an overview).

4.2.2 Effects of trade policy

Turning to trade policy, we find contrasting results. Romero (2023) finds positive effects of access to export markets on innovation, using a tariff shock that increased the demand for Spanish cotton textiles from their colonies. The author finds that this increased Spanish innovation (discussed in Section 3). Interestingly, Spanish innovation remained high even after the colonies became independent after a few years and were no longer captive markets. An interesting feature of this paper is that it studies original innovation in a follower country, whereas the papers above tended to find innovation for leader countries such as the United States and Sweden, and technology adoption for follower countries such as Japan or Brazil. Two important open directions for future researchers remain: First, is access to output markets in foreign countries (such as those studied in Romero (2023)) more conducive to innovation than access to domestic output markets (as driven by the railway in Perlman (2016))? Second, there is a surprising lack of research on how trade policy that increased access to export markets affected innovation and technology adoption in the 19th century.

4.2.3 Effects of IPR

The idea that the protection of intellectual property rights incentivize innovation and disseminate knowledge, creating subsequent economic growth, goes back to at least Adam Smith. Since Britain established its patent system in the 17th century, and patenting activity tracked the evolution of the Industrial Revolution, the statistical correlation seemed to support this idea (Mokyr, 2009; North, 1981). However, the literature also found counterarguments (Mokyr, 2009; Allen, 2009; Khan & Sokoloff, 2001), and recent empirical contributions using novel micro-data and exogenous historical experiments have called for a more nuanced perspective.[28] Some of these recent insights inform the questions a policymaker may have when assessing whether IPR could be used as industrial policy: Which IPR policy fosters domestic innovation best? Which IPR policy fosters international knowledge transmission? Should a country rely on the former or the latter?

The economic literature studying domestic innovation has revealed some surprising findings.

[28]For more details, see recent reviews of this literature by Moser (2016) and Moser (2013).

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 (such as Switzerland, Denmark, or the Netherlands) 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, such as scientific instruments, dyes, and food processing. 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.

Follower countries may have been able to improve the international transfer of technology through better patent protection of foreign patents, as first facilitated by the 1883 Paris Convention discussed above. Bilir et al. (2011) exploit the subsequent, arguably exogenous accession of the US in 1887 and find that international treaties indeed increase technology transfer, comparing patents from foreign inventors from countries that were already treaty members to foreign inventors that were not. Patent protection is especially important for sourcing knowledge from frontier countries, as effects were strongest for foreign inventors from the most developed countries.

To facilitate economic development, however, it is not enough for a foreign invention to be patented in the follower country. The follower country also needs the patent to be used, either by the inventor commercializing it or by licensing the patent to somebody who would Fisher (2023). In certain cases, the follower country may be interested in allowing its firms to commercialize the foreign patents without the consent of the foreign inventor. This is called "compulsory licensing", and has been a legal possibility since the Paris Convention of 1883, but continues to be hotly debated.[29] What are the effects of compulsory licensing on the inventor and the follower country? Exploiting a plausibly exogenous historical event, where the US introduced compulsory licensing of German patents under the "Trading with the Enemy Act" (TWEA) in 1917, Moser & Voena (2012) show that the compulsory licensing increased innovation in the follower country, the US. This is surprising, as one would imagine that compulsory licensing yields access to foreign technologies and therefore substitutes for domestic innovation. However, as this episode shows, an alternative channel dominates: access to foreign inventions strengthens domestic innovation incentive and capabilities. What happens to innovation in the inventor country? A companion paper

[29]This is only possible under certain circumstances, e.g., if the patent is held but not commercialized in the foreign country.

by Baten, Nicola & Moser (2017) shows that, surprisingly, patenting in Germany also increased, suggesting that the competition effect can dominate the reduced returns to innovation.

4.2.4 Effects of universities and other knowledge institutions

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 awarded in the prestigious 1851 technology fair in Germany. The authors use the Napoleonic invasion of Germany, which led to a major pro-science change in German universities for exogenous variation. Relatedly, for the case of United States, land-grant colleges which were created for exogenous reasons during the 1862 Morrill Program had a similar effect (Maloney & Caicedo, 2022). Counties nearby experienced an increase in the density of engineers and higher income per capita. 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 industries. Kantor & Whalley (2019) show that agricultural experiment stations, which were created at land grand colleges after 1887 improved agricultural productivity nearby.

Besides universities, in many contexts, 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 were often initiated by individuals in the private sector, sometimes later supported by the government or royalty, as in the case of the *Royal Society of Arts* in Great Britain, and sometimes initiated by government officials, as in some Prussian states. The societies were very effective in fostering innovation: Cinnirella et al. (2022) show that locations with more society members were more innovative, both with respect to patents and the more comprehensive measure of technology fair exhibits. The societies achieved this through two channels: they established vocational schools that created the skilled workers needed to implement new technologies, and they facilitated the diffusion of ideas and new inventions across regions.

4.2.5 Effects of foreign workers

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. Two recent examples are papers by Akcigit, Grigsby & Nicholas (2017) and Arkolakis, Lee & Peters (2020) which assess the effects of immigrants on US innovation. Between 1880 and 1930, there was a mass migration of mainly European immigrants to the US. During the same

time, the US overtook all other countries to become the global technology leader. A natural question emerges: How much did immigrants contribute to this transformation? Akcigit et al. (2017) show that immigrant inventors were more productive than native inventors, even though their labor income was lower. Arkolakis et al. (2020) collect data on the occupation of migrations *before* immigration and show that the skills of migrants were transferred to the host country: Immigrants from especially innovative source countries such as Germany or Britain increased innovation, as measured by patenting, in the US. The paper also illustrates a fruitful direction for the analysis of industrial policy analysis: By combining reduced form estimates with a quantitative spatial model, we can evaluate policies by running counterfactuals. For example, the authors develop a model to evaluate the restrictions that the US eventually placed on immigration, and reveal that these have a significant negative effect on economic growth. Two recent empirical contributions confirm the negative effect of immigration restrictions on innovation, exploiting the introduction of immigration quotas in the US in 1921 (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).

4.2.6 Effects of colonial technology transfers

The "accidental" technology transfer policy of colonizers has been studied in the context of Java, which was colonized by the Dutch in the 19th century. While colonies typically suffered both in the short and on the long run from the extractive institutions that colonizers used to extract commodities, 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. The authors explain that this persistence is most likely created by two mechanisms: First, a lasting structural transformation occurred in treated villages, as not only the sugar industry but also its downstream industries (i.e, food-processing) developed and persisted most likely due to agglomeration effects. Second, infrastructure investment (electricity, education, transport) was increased and continued to be invested in even once the Dutch left.

4.2.7 Effects of technology absorption policies

Our discussion highlights that there is a relatively large, and fairly wide-ranging literature that studies the effects of individual industrial policies deployed by states to foster local innovation and technology adoption. However, the preceding section illustrated that many technological follower states became actively involved in the very process of technology absorption from abroad (usually,

Britain).[30] Juhász, Sakabe & Weinstein (2023a) study the largest of these technology absorption efforts – those of Meiji Japan, which were focused on acquiring Western knowledge. The authors show that industry level productivity growth was largest in the sectors that had the most to benefit from absorbing Western technologies. They find, however, that this pattern of productivity growth only emerged after the government produced a large, technical dictionary that created a common vocabulary of technical terms ("jargon"), which in turn made it possible to begin to translate Western knowledge (much of which was, again, done by the government). Provision of a dictionary to facilitate technology absorption is a nice example of an activity specific public-good.[31]

4.2.8 Effects of access to finance policies

While there is a rich literature studying the patterns of historical international capital flows, there are, to the best of our knowledge, very few papers that evaluate how financing policies affect industrial development. This may be related to the lack of historical micro-data at the level of firms or even industries. Gregg (2020) is a rare example that uses firm-level data to enhance our understanding. She estimates the causal effect of incorporation on firm performance, using data on Russian manufacturing firms from 1894-1908. There is positive selection into the corporate form: Russian firms that incorporate are more productive. After incorporation, firms were able to buy more machinery, which led to higher labor productivity (but did not affect total factor productivity).

Overall, this section illustrates that governments used a wide range of policies to support technological progress—this is arguably related to the tight linkage between the Industrial Revolution and technological change. The literature has made progress evaluating some individual policies, and found largely positive effects. However, some questions remain open. For example, does railway-induced market access really not affect innovation? Similarly, how did IPR policies affect international knowledge diffusion? Since some studies point to policies affecting the direction of innovation in addition to its scale, we should also investigate potentially adverse effects on those sectors from where innovation is drawn away. While governments were conscious about targeting either innovation or technology adoption, the empirical studies are not yet very informative about whether specific policies were more efficient at fostering one or the other. Finally, we observe that governments rarely adopted specific policies in isolation. Most often, they implemented a bundle of policies trying to affect different aspects of the technology adoption process. 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.

[30] By this, we mean policies that facilitate the absorption of knowledge required to effectively adopt the new machines and production processes.

[31] Relatedly, Bo et al. (2023) show spillover effects on private industrial development of the more limited Self-Strengthening Movement in China.

5 ACCESS TO LABOR

The massive growth caused by industrialization led to an increased demand for labor in manufacturing. What type of labor fostered industrialization? How was that labor supplied, and how could governments increase the supply of the required labor? These were the key questions policymakers needed to understand in order to influence the successful transformation to an industrialized economy.

5.1 Policies to facilitate access to labor

There were three principal ways in which governments were able to increase labor supply. The first one includes education policies that increased the skill level of the existing population—this could be basic education, or education targeted at technical skills. The second one includes immigration policies that are favorable, possibly targeted at a certain skill types. The last set of policies relate to regulating the working conditions of the existing population (for example, by allowing or preventing child and female labor, or by regulating the hours worked per day or week).

However, with one exception—the provision of vocational and technical training—there is no evidence that governments used any of these policies to actively improve industrialization, as per our definition of industrial policy. Schooling improved, there was mass migration (from Europe to the United States), and labor regulations changed, but none of this happened as intentional industrial policy.

We will first explain why neither of these policies constitute industrial policy as per our definition, before we turn to discussing technical training policies, which were deployed as intentional industrial policy. First, the 19th century witnessed a rise in the provision of general education. This was especially true for the countries that developed fastest, such as the US, which made an early shift from private tuition towards publicly financed schools (Goldin & Katz, 2008). Countries at the periphery, such as Brazil, Russia, India and China lagged behind: only between 4 and 12% of school-age children attended primary school in 1910, whereas this number was larger than 80% in Germany, UK and the US (Chaudhary, Musacchio, Nafziger & Yan, 2012). However, the improvement in schooling in "core" countries was driven by three reasons that are unrelated to industrial policy: by increased demand driven by a more prosperous population, by broadened political participation, and by the willingness of the political and economic elite to provide it (Chaudhary et al., 2012). For example, in 19th century Prussia, Cinnirella & Hornung (2016) show that agricultural reforms that reduced serfdom and produced a new class of peasants increased the demand for education. Go & Lindert (2010) show that in North America, the broad spread of political voice within communities and decentralized government enabled publicly funded mass schooling. There are some examples mentioned in the literature where elites, rather than government, used education policy as "industrial policy", i.e., to improve the skills or size of the labor force. For example,

elites in Chinese and Brazilian port cities spent more on education in order to increase their income through better access to labor (Chaudhary et al., 2012).

Second, the 19th century was also a period of mass migration: Between 1850 and 1914, 500,000 to 1 million European immigrants reached the US every year. At first, these migrants came from Great Britain, Ireland, German, and Scandinavia; later migrants came from Central, Eastern, and Southern Europe; and they were typically unskilled (Cohn, 2017). Migration was mainly driven by economic reasons as well as religious and political persecution, rather than industrial policy. The US neither restricted nor encouraged immigration until 1882, when it excluded Chinese citizens from immigrating, which was extended to Japanese citizens in 1907. The first time that US immigration policy took into account economic considerations was in 1917, when a literacy test was introduced in order to select skilled rather than unskilled migrants. In 1921, free immigration into the US ended, when the US set strict immigration quotas.

Finally, women and children satisfied a larger share of the demand for unskilled labor, especially during the First Industrial Revolution (Humphries, 2013; Goldin & Sokoloff, 1982). This was again driven by economic reasons: Before industrialization, it had been common for children to work at home in the cotton industry. When industrialization started, they moved their work to the factories. Mechanization increased the demand for routine tasks that did not require physical strength, and children supplied them. However, this practice generated a heated debated, and over the course of the 19th century, restrictions were implemented. For example, the *Ten Hours Bill* of 1847 limited working hours in Great Britain to 10 for children and women (Tuttle, 2001). In summary, working regulations were clearly not used as industrial policy, if anything, the stricter work regulations led by social considerations led to a reduction of labor supply for the industrialized districts.

The one policy that governments intentionally used to foster industrialization was specific training and education targeted at technical skills. Governments in many countries 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).

5.2 Economic effects of access to labor

While our interest is in understanding whether specific policies designed to increase the supply of different types of labor contributed to industrialization, the early economics literature has focused on the question of which types of skills were important for industrialization. Most specifically, the literature has been focused on the question of whether the industrial revolution was "deskilling" or not, i.e., did industrialization demand unskilled or skilled labor? An argument for the deskilling hypothesis is that the transition from artisan workshop-to-factory production reduced the need for skilled workers (Goldin & Katz, 1998). An argument against it is that knowledge and engineering is important for innovation, and this requires high skills (see also our discussion of the policies to increase the supply of inventors in section 4). The empirical patterns reconcile these opposing views by highlighting that the labor force experienced polarization: Unskilled workers benefited from the transition of production from homes and workshops to factories at the expense of artisans (O'Rourke, Rahman & Taylor, 2013). The share of unskilled workers rose from 20% in the late 16th century to almost 40% in the early 19th century, but the share of semi-skilled blue collar workers declined (de Pleijt & Weisdorf, 2017).[32] At the same time, labor demand increased at the upper middle and upper parts of the skill distribution: factories needed skilled workers to install, operate, and maintain the machines. In addition, the industry needed workers and engineers that were able to adopt and adapt the new technology. And at the very top of the distribution, highly skilled engineers were demanded that invented new machines and processes and solved problems with existing machinery.

Despite the fact that there is little evidence that mass public education was advanced anywhere with intentional industrial policy goals, we discuss it here for the following reason: This was a government policy that many eventually industrialized countries adopted—albeit for mostly different reasons—, while most periphery countries did not. Thus, in trying to understand what governments around the world did to foster industrialization, this seems like an important policy to cover. Given that the level of literacy was low among factory workers, the literature had initially concluded that general education was not important for industrialization (Mitch, 1993a). For example, only 4.9% of male workers were in occupations that required literacy in 1841, with an additional 22.5% of male workers in occupations in which literacy was likely to be useful (Mitch, 1993b, p. 259). Crafts (1995) challenged this view, arguing that education did contribute to the industrialization in Great Britain because it stimulated innovation and technological change. Becker & Woessmann (2009) and Becker, Hornung & Woessmann (2011) contribute empirical evidence to this issue in

[32] This changed at the beginning of the 20th century, when the emergence of electricity powered production substituted for unskilled workers, as Goldin & Katz (1998) show for the United States.

the context of 19th century Prussia. Using the larger literacy of Protestants as exogenous variation for education, Becker & Woessmann (2009) find that more educated counties have a larger employment share in manufacturing and services. In follow-up work, Becker et al. (2011) exploit additional information within sectors, and confirm that basic education led to industrialization—however, not in the textile industry, where innovation was arguably less disruptive. This suggests that the benefits to education may be different for industrial followers and leaders: it is possible that formal education is not important for leaders who innovate, but more for follower countries who need to adopt the new technologies.

As to the question of whether immigration caused industrialization, the early literature found evidence for the opposite causal direction, i.e., that industrialization caused immigration: changing wages due to industrialization in different countries explained the patterns of mass migration in the 19th century.[33] In terms of the consequences of migration on the host country, Kim (2007) and Long, Medici, Qian & Tabellini (2023) both examine the effect of immigration on the structure of the US economy.[34] The papers use different immigration shocks, but find consistent effects: Kim (2007) exploits the *increases* in the foreign-born population driven by immigration from Europe, while Long et al. (2023) exploits the *reduction* of Chinese immigrants driven by the 1882 Chinese Exclusion Act. The positive shock increases factory-based manufacturing, while the negative shock reduces manufacturing output and wages. These studies seem to suggest that immigrants were an important source of industrialization in the US, and Lafortune, Lewis & Tessada (2019) provides evidence for a potential reason: in this time period, immigration and capital investments were complementary.[35][36]

For the case of domestic migration, we have some recent evidence that migration led to structural transformation from agriculture to manufacturing. Pérez (2017) studies this for the case of Argentina, where the railroad led to outmigration from agricultural to industrial districts—even though labor supply was not the objective of railway construction. Using similar identification strategies as discussed above to deal with the endogeneity of the railroad network, Pérez (2017) shows access to railroads let to outmigration of children of farmers, which ended up working in white- or blue-collar jobs rather than farming.

In an early contribution, Goldin & Sokoloff (1982) argue that the labor supply of women and children contributed to the fact that in the US, industrialization started in New England. The au-

[33] For example, see O'Rourke & Williamson (2001b), Hatton & Williamson (1998) or Cohn (2017).

[34] For a recent review of the literature on immigration on other outcomes in this time period, see Abramitzky & Boustan (2017).

[35] However, this is not replicated by Abramitzky, Ager, Boustan, Cohen & Hansen (2023), who do not find manufacturing contractions once the US introduced immigration quotas in 1921.

[36] Another strand of the literature examines the effect of immigration on invention, which we discussed in section 4.

thors argue that mechanization increased the demand for unskilled workers which could be satisfied by children and women. Due to specialization into different types of agricultural products, the opportunity cost of unskilled labor was lower in the North than in the South. In further research, it would be interesting to see whether a causal relationship could be established, and whether this relationship holds for other industrialized countries. Furthermore, once labor regulations tightened, it would be interesting to study whether this weakened subsequent industrialization.

Despite its widespread use as industrial policy, the empirical evidence of vocational training on industrialization is scarce. Semrad (2015) studies the introduction of vocationally oriented secondary schools across Bavarian counties between 1829 and 1907. The introduction was decided by the Bavarian King Ludwig I, but the schools were designed in cooperation with industrial associations and provided a curriculum targeted at providing the training for industrial occupations. The author finds evidence that vocational education contributed to industrialization of the then backward Bavaria: Counties that opened a vocational school saw a larger employment share in manufacturing (and services) and more patenting, even after controlling for the growth in general secondary education.

Overall, this literature suggests that two broad policies, education and immigration, had positive effects on industrialization—even though these policies were rarely used with this intention. One reason for why these policies, though effective for industrial development, may not have been used is that the surveyed papers do not provide a cost-benefit analysis of, e.g., public education provision. Perhaps alternative policies, such as targeted vocational training, fared better in this respect. 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. To deepen our understanding of the role of industrial policy in the Great Divergence, more research would be helpful: especially with respect to the widely used vocational education policies.

6 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, a relatively simple production process even by 19th century standards. 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.

6.1 Policies to facilitate access to material inputs

We discuss industrial policies that facilitated access to inputs, noting that many of them are similar to the ones we discussed in section 3: infrastructure, colonialism and trade policy.

6.1.1 Infrastructure

Besides the development of the telegraph network (see section 3), the 19th century experienced dramatic technological transport revolutions such as the introduction of steam ships and the opening of canals. The Suez canal was opened in 1869 by the Suez Canal Company, which was owned by French investors and the Egyptian ruler at the time, who in 1875 sold his shares to the British government (Fisher & Smith, 2023). The Panama canal was opened in 1914 under US ownership and control (Montero Llácer, 2005). These developments led to a dramatic fall in international freight cost (Mohammed & Williamson, 2004). Thus, while private investors were heavily involved in the projects, similar to the submarine cable network discussed in section 3, government involvement also shaped these investments.

However, developing efficient sea transportation was often not sufficient to reach the foreign markets—instead, the domestic transport network in foreign countries often also needed to be developed to reach inland locations where the input was produced. In colonies, particularly those located in Africa, one of the primary motivations for railroad construction was to secure access to tropical products for the colonizer. In independent countries, "foreign policy" by Western powers was more subtle. In Brazil, British private investors, who were motivated by profits, built railways and ports, but multiple directors of these railroad companies were also members of British parliament (Summerhill, 2003, p. 47). While this infrastructure was mainly built to facilitate Brazilian exports of commodities such as coffee and manganese, it was soon also used by the Brazilian industrial sector to source raw inputs either domestically or from abroad. For example, 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). Thus, the British development of Brazilian rails also served as "accidental" industrial policy for Brazil.

While international sourcing was the more complex challenge, domestic infrastructure development, primarily the domestic rail network, was also critical for access to inputs. The railroad was especially important for transporting coal as it had the highest weight to value ratio among commodities. In fact, the early railways in Britain were built to transport coal in and around coal mines. The Stockton and Darlington Railway that opened in Great Britain in 1825 transported predominantly coal, while the Liverpool to Manchester Railway that opened in 1830 transported imported raw cotton from the port of Liverpool to the cotton textile manufacturing factories in Lancashire (Shaw-Taylor & You, 2018).[37] As we discuss in section 2.2, the degree of government

[37] Access to coal likely affected the location of industry more generally, at least during industrialization

involvement in the construction of domestic railway networks varied widely across countries.

6.1.2 Colonization

A primary motivation for acquiring colonies was to secure access to tropical products, often raw materials needed for industry (Allen, 2011). West Africa supplied palm oil (a lubricant for machinery and railway equipment), Malaya supplied rubber and so on. Not only did imperial powers exploit the resources of their colonies, they 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).

6.1.3 Trade policy

Another industrial policy tool that states had at their disposal was tariff policy, and in particular, lowering tariffs on imported materials inputs combined with higher tariffs on industrial outputs. This was the approach Friedrich List supported, based on historical precedent. Robert Walpole, the first British Prime Minister, 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 or increased duty drawbacks 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 this policy across countries, distinguishing tariffs on intermediate manufactured inputs such as cotton yarn and industrial chemicals from tariffs on final products such as cotton textiles. 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 countries", i.e., the main industrialized countries from Western-Europe and the U.S., and much larger for "periphery" countries. The latter group includes countries like Australia, Canada and Norway, which had very low tariffs on inputs and moderate tariffs on outputs, as well as countries like Russia, Spain or Portugal, who had high input tariffs but even higher output tariffs.

6.2 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. 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 discussed these more general papers in sections 2.2 and 3. In the following, we focus on papers that discuss the role of inputs specifically.

in Europe (Fernihough & O'Rourke, 2020).

Steinwender (2018) focuses on the role of information frictions in international sourcing, using the example of Britain sourcing raw cotton from the United States. Cotton merchants in the US (who bought the raw cotton from US cotton farmers) could ship the cotton to the textile industry in the North of the US or export it to England (from where it was often re-exported to other continental ports). Because the cotton demand fluctuated in the different destination markets and because shipping took time, cotton merchants needed to forecast demand when making their shipping decision, using the latest information about the destination market. However, before the telegraph, this information was often outdated. The transatlantic telegraph connection between New York and England changed this, by moving from a 10-day information delay to almost instantaneous information transmission. Cotton exports adjusted to the improved information, leading to a better integration of the transatlantic cotton markets in New York and Liverpool. The better temporal alignment of supply and demand led to substantial estimated efficiency gains from the telegraph, equivalent to 8% of the export value.[38]

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. For the case of cotton production in early 20th century China, 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 the domestic variety, thereby improving the quality of domestic inputs.

So far, we have argued that governments that wanted to foster industrialization may improve access to inputs to help the domestic industry. However, 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 shows 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), the same argument can be made for other types of industrial policies. Hanlon (2020) makes this case for access to cheap inputs, using the metal shipbuilding industry in the 19th century as example. When metal ships were introduced in the 1850s, British metal shipbuilders thrived as they had access to cheap metal

[38] 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.

from their large domestic iron industry. Interestingly, when this cost advantage disappeared by the 1880s, US ship makers 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 may not be true for the providing country when it is a colony, as colonizers used "extractive institutions" including violence, forced labor and land expropriation. A large literature has developed around estimating the economic effects of different types of institutions on economic development, following the seminal contributions by Acemoglu, Johnson & Robinson (2001, 2002, 2005).[39] A recent contribution that highlights the input-extracting role of colonies is Lowes & Montero (2021). They study the case of Congo, infamous for its particularly brutal exploitation as the personal property of King Leopold II of Belgium. The King granted "concessions" to private companies that gave them monopoly rights over the extraction of rubber within designated areas. Using the arbitrary drawing of concession borders for identification, the authors find negative effects on present-day education, wealth and health. A particular contribution of this paper is the identification of the underlying mechanism: Former concession areas, which had company-appointed village chiefs brutally enforcing rubber extraction, continue to have hereditary instead of elected leaders who are less likely to provide 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 had an effect on industrialization in some contexts, 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

[39] We refer to literature reviews by Nunn (2009); Durlauf (2020) and Michalopoulos & Papaioannou (2020) for discussions of this literature.

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.

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

Abramitzky R, Boustan L. 2017. Immigration in american economic history. *Journal of Economic Literature* 55(4):1311–45

Acemoglu D, Johnson S, Robinson J. 2005. Institutions as a Fundamental Cause of Long-Run Growth. In *Handbook of Economic Growth*, eds. P Aghion, S Durlauf, vol. 1, Part A, chap. 06. Elsevier, 1st ed., 385–472

Acemoglu D, Johnson S, Robinson JA. 2001. The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review* 91(5):1369

Acemoglu D, Johnson S, Robinson JA. 2002. Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution. *The Quarterly Journal of Economics* 117(4):1231–1294

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. 2009. The British Industrial Revolution in Global Perspective. New Approaches to Economic and Social History. Cambridge University Press

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

Bernhofen DM, Brown JC. 2005. An Empirical Assessment of the Comparative Advantage Gains from Trade: Evidence from Japan. *American Economic Review* 95(1):208–225

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. 2017. The Turnpike Roads of England and Wales. In: The Online Historical Atlas of Transport, Urbanization and Economic Development in England and Wales c.1680-1911. Cambridge

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

Broadberry S, Gupta B. 2009. Lancashire, India, and shifting competitive advantage in cotton textiles, 1700–1850: The neglected role of factor prices. *The Economic History Review* 62(2):279–305

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

Chaudhary L, Musacchio A, Nafziger S, Yan S. 2012. Big BRICs, weak foundations: The beginning of public elementary education in Brazil, Russia, India, and China. *Explorations in Economic History* 49(2):221–240

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. 2016. Landownership concentration and the expansion of education. *Journal of Development Economics* 121:135–152

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

Cohn RL. 2017. Immigration to the United States. In *EH.Net Encyclopedia*, ed. R Whaples

Cookson G. 1994. Innovation, Diffusion, and Mechanical Engineers in Britain, 1780-1850. *The Economic History Review* 47(4):749–753

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

Crafts NFR. 1995. Exogenous or Endogenous Growth? The Industrial Revolution Reconsidered. *The Journal of Economic History* 55(4):745–772

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

Crouzet F. 1964. Wars, Blockade, and Economic Change in Europe, 1792–1815. *The Journal of Economic History* 24(4):567–588

Daudin G. 2010. Domestic Trade and Market Size in Late-Eighteenth-Century France. *The Journal of Economic History* 70(3):716–743

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

de Pleijt AM, Weisdorf JL. 2017. Human Capital Formation from Occupations: the "Deskilling

Hypothesis" Revisited. *Cliometrica, Journal of Historical Economics and Econometric History* 11(1):1–30

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

Durlauf SN. 2020. Institutions, Development, and Growth: Where Does Evidence Stand? Princeton University Press, 189–217

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

Feyrer J. 2019. Trade and Income—Exploiting Time Series in Geography. *American Economic Journal: Applied Economics* 11(4):1–35

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 Theoreti-*

cal Economics 110(3):425–456

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

Fisher WW. 2023. Encyclopedia Britannica, chap. Patent

Fishlow A. 1965. American Railroads and the Transformation of the Antebellum Economy. Cambridge, MA: Harvard University Press

Fogel RW. 1964. Railroads and American Economic Growth: Essays in Econometric History. Baltimore, MD: Johns Hopkins University Press

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

Go S, Lindert P. 2010. The Uneven Rise of American Public Schools to 1850. *The Journal of Economic History* 70(1):1–26

Goldin C, Katz L. 2008. The Race between Education and Technology. Cambridge, MA: Harvard University Press

Goldin C, Katz LF. 1998. The Origins of Technology-Skill Complementarity. *The Quarterly Journal of Economics* 113(3):693–732

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 University Press

Grandy C. 1993. Original Intent and the Sherman Antitrust Act: A Re-examination of the Consumer-Welfare Hypothesis. *The Journal of Economic History* 53(2):359–376

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

Grossman GM, Helpman E. 1994. Protection for Sale. *The American Economic Review* 84(4):833–850

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. 2022. The Rise of the Engineer: Inventing the Professional Inventor During the Industrial Revolution. Working Paper 29751, National Bureau of Economic Research

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

Harris R, Keay I, Lewis F. 2015. Protecting infant industries: Canadian manufacturing and the national policy, 1870–1913. *Explorations in Economic History* 56:15–31

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

Hatton TJ, Williamson JG. 1998. The Age of Mass Migration: Causes and Economic Impact. Oxford University Press

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

Heckscher EF. 1922. The Continental System: An Economic Interpretation. Clarendon Press

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

Hirakawa S, Wakabayashi BT. 1989. Japan's Turn to the West. *The Cambridge History of Japan* 5:432–98

Hodgson C. 2018. The effect of transport infrastructure on the location of economic activity: Railroads and post offices in the American West. *Journal of Urban Economics* 104:59–76

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 Manufacturing. 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

Humphries J. 2013. Childhood and Child Labour in the British Industrial Revolution. *The Economic History Review* 66(2):395–418

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

Khan BZ, Sokoloff KL. 2001. History Lessons: The Early Development of Intellectual Property Institutions in the United States. *The Journal of Economic Perspectives* 15(3):233–246

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

Koyama M, Rubin J. 2022. How the World Became Rich: The Historical Origins of Economic Growth. John Wiley & Sons

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

Lamoreaux NR, Sokoloff KL. 1996. Long-term change in the organization of inventive activity. *Proceedings of the National Academy of Sciences* 93(23):12686–12692

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

Michalopoulos S, Papaioannou E. 2020. Historical Legacies and African Development. *Journal of Economic Literature* 58(1):53–128

Mitch D. 1993a. The british industrial revolution, chap. The Role of Education and Skill in the British Industrial Revolution. Routledge

Mitch D. 1993b. The Role of Human Capital in the First Industrial Revolution. In *The British Industrial Revolution: An Economic Perspective*, ed. J Mokyr. Boulder: Westview, 267–307

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. 2005. Long-Term Economic Growth and the History of Technology. In *Handbook of Economic Growth*, eds. P Aghion, S Durlauf, vol. 1, Part B, chap. 17. Elsevier, 1st ed., 1113–1180

Mokyr J. 2009. Intellectual Property Rights, the Industrial Revolution, and the Beginnings of Modern Economic Growth. *The American Economic Review* 99(2):349–355

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

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. 2013. Patents and Innovation: Evidence from Economic History. *Journal of Economic Perspectives* 27(1):23–44

Moser P. 2016. Patents and Innovation in Economic History. *Annual Review of Economics* 8:241–258

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

North DC. 1981. Structure and Change in Economic History. Norton, New York

Nunn N. 2009. The Importance of History for Economic Development. *Annual Review of Economics* 1(1):65–92

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, Rahman AS, Taylor AM. 2013. Luddites, the industrial revolution, and the demographic transition. *Journal of Economic Growth* 18(4):373–409

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

O'Rourke KH, Williamson JG. 2001b. Globalization and History: The Evolution of a Nineteenth-Century Atlantic Economy, chap. 7: Mass Migrations: Why they moved. MIT Press

Panza L, Williamson JG. 2015. Did Muhammad Ali foster industrialization in early nineteenth-century Egypt? *The Economic History Review* 68(1):79–100

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

Riello G. 2013. Cotton: The Fabric that Made the Modern World. Cambridge University Press

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

Rostow WW. 1960. The Stages of Economic Growth: A Non-Communist Manifesto. Cambridge University Press

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

Satchell M. 2017. The online historical atlas of transport, urbanization and economic development in england and wales c.1680-1911, chap. Navigable waterways and the economy of England and Wales: 1600-1835

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.

Schumpeter JA. 1934. The Theory of Economic Development: An Inquiry Into Profits, Capital, Credit, Interest, and the Business Cycle. Cambridge, MA: Harvard 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

Sokoloff K. 1988. Inventive Activity in Early Industrial America: Evidence From Patent Records, 1790 - 1846. NBER Working Papers 2707, National Bureau of Economic Research, Inc

Squicciarini MP, Voigtländer N. 2015. Human Capital and Industrialization: Evidence from the Age of Enlightenment. *The Quarterly Journal of Economics* 130(4):1825–1883

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

Tuttle C. 2001. Child Labor during the British Industrial Revolution. In *EH.Net Encyclopedia*, ed. R Whaples

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