Temporary Protection and Technology Adoption: Evidence from the Napoleonic Blockade

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Abstract

This paper uses a natural experiment to estimate the causal effect of temporary trade protection on long-term economic development. I find that regions in the French Empire which became better protected from trade with the British for exogenous reasons during the Napoleonic Wars (1803-15) increased capacity in mechanized cotton spinning to a larger extent than regions which remained more exposed to trade. In the long-run, regions with exogenously higher spinning capacity had: i.) higher activity in mechanized cotton spinning; ii.) higher labor-productivity for mechanized cotton-spinning firms, and; iii.) higher value-added per capita in industry.

JEL code: F13, F63, O14
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> "The principal advantage of the English cotton trade arises from our machines both for spinning and printing (...). It is impossible to say how soon foreign countries may obtain these machines, but even then, the experience we have in the use of them would give us such an advantage that I should not fear the competition." – Joseph Smith and Robert Peel (1786)[1]

A long-standing debate in economics is centered on the question of whether certain industries can become competitive in the long-run if they are given temporary trade protection. The idea, widely known as the infant industry argument, has a long tradition in the history of economic thought, dating back to at least Alexander Hamilton and Friedrich List. Assessing the empirical relevance of these predictions has proven difficult for two reasons. First, infant industry protection is generally granted by the policy-maker at the country-wide level. This implies that even if the industry becomes competitive in the long-run, it is difficult to answer the counterfactual question of whether the industry would have become competitive anyway. Second, in the case of a specific policy intervention, it is not possible to disentangle the effect of the economic mechanism at work from the efficacy of implementation.

The principal contribution of this paper is to estimate the causal effect of temporary trade protection on the development of an infant industry and the economy more generally. I present a natural experiment which replicates infant industry protection without the direct involvement of the policy maker, making it possible to address both identification challenges. I study the effect of temporary trade protection on the mechanized cotton-spinning industry across regions of the French Empire during and after the Napoleonic Wars (1803-15).

Throughout these wars, the French Empire was exposed to a regionally differential, and arguably exogenous, shock to the cost of trading with Britain. In particular, the wars led to a unique historical episode whereby a blockade of Britain was implemented by attempting to stop British goods from entering Continental Europe. Ports were closed to ships carrying British goods, and the military was active in enforcing the blockade along the coastline. In

[1] Quoted in Edwards (1967, p.51).

practice however, holes in the system opened up almost immediately. Instead of achieving the original goal of stopping trade flows between Britain and the Continent, the blockade displaced trade to more circuitous, and hence more expensive routes. In the north of France, effective distance between a given region and London increased markedly, as trade was diverted either to unreliable indirect routes through German regions, or through Southern Europe. In the southern regions of France, effective distance to London changed to a far smaller extent, as trade routes stayed more or less the same. By comparing regions which received a smaller or larger shock, it is possible to empirically evaluate the predictions of the infant industry argument.

The industry examined is mechanized cotton spinning. This was one of the fastest growing and most innovative sectors in the 19th century, playing a key role in the first Industrial Revolution and contributing 25 percent to overall TFP growth in British industry between 1780 and 1860. Both Hamilton and List advocated for infant industry protection for the nascent cotton industries in the US and Germany respectively.

A number of features of the industry in early nineteenth century France make it particularly well-suited to examining the effects of infant industry protection. First, the technology, invented and developed in Britain in the late 18th century, was initially not adopted on a wide scale in France, a country with an initially similar cotton industry. By the beginning of the Napoleonic Wars, the French were not competitive in mechanized cotton spinning.

Second, the machines were cheap and depreciated fast meaning that the long-term results cannot be driven by the gradual depletion of a one-time investment. Finally, this was the first industry to mechanize and adopt modern, factory-based production methods. Differently to traditional cottage industry, modern production methods are generally thought to exhibit the types of increasing returns to scale inherent to infant industry mechanisms. This historical setting thus makes it possible estimate the effect that adoption of mechanized cotton-spinning technology had on the economy more broadly, as protection arguably affected the economy in the long-run only through its effect on mechanized cotton spinning.

I estimate the causal effect of temporary protection in two steps. First, I ask whether trade protection was an important driver of the adoption of mechanized cotton-spinning technology in the short-run, during the disruption to trade. This would be the case if protection rendered profitable previously unprofitable locations by increasing the price of competing imported British yarn. Second, I examine effects in the long-run, after the disruption to trade ended. If temporary protection was successful in changing the long-term profitability of production in a given location through agglomeration economies, we would expect to find persistence in the location of mechanized cotton-spinning activity. Furthermore, I test whether measured labor productivity was higher in the density of local cotton-spinning activity, consistent with models where changing profitability of a location is driven by increasing the productivity of firms producing in the area. Finally, I examine whether adoption of frontier technology in mechanized cotton spinning led to aggregate effects on the regional economy.

To conduct the empirical analysis, a large amount of data was compiled from primary sources. The main outcome variable of interest is capacity in mechanized cotton spinning. I collected data on the number of mechanized cotton spindles (the relevant measure of physical capital) for French departments throughout the nineteenth century from handwritten industrial surveys. For some years, these are available at the firm level. To reconstruct trade routes in use before and during the blockade, data on ships arriving and sailing from Britain to Continental European ports were extracted from a bi-weekly shipping newspaper, the Lloyd's List, over a 20 year period.

To identify the causal effect of trade protection on mechanized spinning capacity in the short-run, I use a difference in difference (DD) estimator with continuous treatment intensity. This compares the size of mechanized cotton spinning capacity across regions which were exposed to smaller or larger increases in the cost of trading with Britain (trade-cost shock for short), before and after the Napoleonic Wars. My empirical strategy is based on the well-documented fact that trade diminishes dramatically with distance, implying that geographic distance plays a role similar to that of artificial barriers to trade such as tariffs. Identification relies on there being no other shock contemporaneous to, and correlated with the trade cost shock. I show evidence in support of this assumption using a number of placebo tests and other robustness checks.

Trade protection had a large and statistically significant effect on the adoption of mechanized cotton-spinning technology. I find that areas which received a larger trade cost shock during the Napoleonic Wars increased production capacity in mechanized cotton spinning to a larger extent than areas which received a smaller shock. The estimated effect is large and statistically significant. Moving from the 25th to the 75th percentile of the shock leads to a predicted increase in spinning capacity which is similar in size to mean spinning capacity at the end of the blockade.

The second part of the empirical strategy examines the extent to which temporary trade protection rendered locations profitable for production in the long-term. I estimate the long-run, local average treatment effect of having a larger regional mechanized cotton spinning industry as a result of temporary trade protection on our outcome variables of interest. For the trade cost shock to be a valid instrument for the post-blockade location of the cotton industry, the shock must be uncorrelated with other determinants of the outcome variables. I build evidence in support of this assumption using placebo tests and other robustness checks.

I find evidence of persistence in the location of mechanized cotton spinning throughout the 19th century. Having one more mechanized spindle in 1812 as a result of higher protection during the blockade increased mechanized spinning capacity by about 3 spindles in 1840, and 5-6 spindles in 1887. As the industry expanded in France throughout the 19th century, the results show that regions which had a first-mover advantage as a result of temporary protection were the ones disproportionately increasing their spinning capacity throughout the 19th century. Moreover, the pattern of persistence is inconsistent with the alternative mechanism of slow technology diffusion from Britain, as more southern regions of France decreased in absolute magnitude in the long-run. Using the trade cost shock to isolate exogenous variation in mechanized cotton spinning, I find that higher post-blockade spinning capacity at the regional level led to higher labor productivity 30 years later at the level of the firm. Productivity increased in the density of local spinning capacity, consistent with models which predict long-run effects of temporary protection as a result of increases in firm productivity. Finally, I examine the extent to which temporary protection affected long-run development more generally through its effect on mechanized cotton spinning. I find that increased protection from British competition increased value added per capita in industry in 1860, through its effect on mechanized cotton spinning, but not later.

Since tariffs were imposed on cotton goods between Britain and France following the end of the Napoleonic Wars, the long-term within-country results are consistent with an infant industry mechanism at work *within* France. It does not necessarily show however, that (a subset of) firms had become competitive at free trade prices. For this reason, I also examine exports of cotton goods from France. Consistent with evolving comparative advantage in cottons, I find that exports of cotton goods increased substantially after the end of the Napoleonic Wars, in levels and relative to British exports of the same. As late as 1850, other countries in Continental Europe had much smaller cotton spinning industries, suggesting that adoption of the technology was far from inevitable.

The results of the paper contribute to several strands of the literature. To the best of my knowledge, this paper is the first to provide well-identified, reduced-form evidence of an infant industry mechanism. To date, the literature has partially addressed the challenges to estimating the effects of temporary trade protection by using calibrated or estimated model parameters to simulate the counterfactual of no-protection in partial equilibrium models (Baldwin and Krugman, 1986, 1988; Head, 1994; Irwin, 2000; Hansen et al., 2003). Without exception, papers in this literature study cases in which the policy-maker implemented tariff protection and as such, cannot address the inherent endogeneity of industry choice.

More generally, the economic theory underlying the infant industry mechanism can be seen in the context of a large class of models which predict that initial conditions are important for determining the long-run location of industries as a result of agglomeration economies. In particular, the paper is related to a growing empirical literature which examines whether temporary shocks can permanently shift the location of economic activity (Davis and Weinstein, 2002; Redding and Sturm, 2008; Kline and Moretti, 2014). In contrast to other mechanisms which the literature has explored, this paper estimates the effect of trade protection on determining industry location and as such, informs the debate on whether infant industry mechanisms are empirically relevant.

The results of this paper raise the question of whether policy intervention may be welfare-maximizing in similar settings. Even setting aside the issue of how policymakers identify such industries, theoretically, this depends crucially on the source and size of agglomeration economies. These are difficult to distinguish and quantify. Krugman (1987), Lucas (1988), Matsuyama (1992) and Young (1991) model external-to-the-firm learning-by-doing, while Krugman and Elizondo (1996) and Puga and Venables (1999) model pecuniary externalities which arise from the interaction of internal to the firm increasing returns to scale, input-output linkages and transport costs. Both strands predict that trade policy may affect the long-term location of industries, though the effect on welfare is generally different. In particular, it is generally not the case that policy intervention is optimal in the latter type of models as Puga and Venables (1999) show. In contrast, intervention can be optimal if the region has a latent comparative advantage in the industry, and the size of the externalities is large in models which feature external economies of scale as discussed by Harrison and Rodríguez-Clare (2010).[2]

[2]As is well known, tariff protection is generally not the most efficient form of intervention, as a production

Data availability limits the extent to which I am able to differentiate between the two types of agglomeration economies in the empirical analysis. However, I present both historical evidence and productivity results consistent with learning-by-doing externalities. This suggestive evidence on external economies of scale does not imply a case for infant industry protection in similar settings. Instead, it serves to highlight the important challenges economies face to the extent that similar mechanisms are present in developing countries today.

Finally, the paper contributes to the debate on why France was slow to adopt mechanized cotton-spinning technology (Allen, 2009; Crafts, 1995; Landes, 2003). Most closely related to this paper's mechanism is Crafts (1995), who argued that the historical accident of mechanized spinning technology being invented in Britain, and not France, gave that country a significant first-mover advantage which made emulation for follower countries difficult. Moreover, Crouzet (1964) has claimed that countries which received more protection from British competition during the Continental Blockade, such as France, adopted mechanized cotton spinning technology early in the nineteenth century. On the other hand, Heckscher (1922) argued that these events were nothing more than the short-run "hothouse" development of an industry subject to artificial protection. Using the data assembled for this paper, it has been possible to test this question for the case of France by exploiting within-country variation in trade protection.

The paper is organized as follows. The next section discusses mechanization of cotton spinning and its effects on France. Section 3 describes the way in which the Napoleonic Wars drove exogenous changes in trade protection from Britain. Section 4 describes the main sources of data, while Sections 5-6 contain the short and long-term empirical analysis respectively. The final section concludes.

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subsidy would not distort consumption choices. See Melitz (2005) for a discussion.

1 The cotton industry in Britain and France

Britain's dominance of the 19th century cotton industry is a widely known fact. It may thus be somewhat surprising that as late as the mid-18th century, the cotton industry in Britain and France were actually remarkably similar. In both countries, cotton textile manufacturing was a new and small industry relative to traditional European textiles such as wool, linen and silk.[3] Moreover, the cotton industry was marginal not only in relation to other domestic textiles, but also relative to world output, which was dominated by Indian cotton cloth.[4]

1.1 Mechanization in Britain

A series of inventions mechanized the spinning of cotton yarn in Britain in the second half of the 18th century. Traditionally, spinners had spun one thread at a time using a simple wheel. Mechanization increased output per worker as machines were able to spin multiple rovings simultaneously. The new machines diffused rapidly across the British countryside. Importantly, they were fairly cheap, and they depreciated fast.[5] This rules out a slow to depreciate, large, one-time investment driving the long-term results.

Mechanization had large effects on the cotton industry for a number of reasons. First, the machines disrupted the domestic structure of the industry. The size of machines, their complexity and reliance on inanimate power rendered production in the workers' homes obsolete and manufacturing activity moved into large factories. For the first time, production was organized in large structures that required careful organization of work-flow and management of workers (Allen, 2009) . This change was one of the most significant consequences

[3]For example, Chabert (1945) estimates the size of the industries for France in 1788, before the French Revolution, and in 1812, towards the end of the Napoleonic Wars, as follows (in millions of francs); 1788: Linen and hemp: 235, Wool: 225, Silk: 130.8, Cotton: no number given. 1812: Linen and hemp: 242.8, Wool: 315.1, Silk: 107.5, Cotton: 191.6.

[4]It has been estimated that about 3 million pounds of cotton yarn a year were spun in both Britain and France, which compares modestly to Bengal's 85 million pounds of yearly output (Allen, 2009).

[5]Allen (2009) has estimated that the original spinning jenny was priced at about seven times a spinner's weekly wage and it depreciated in about 10 years.

of the First Industrial Revolution, as it radically changed the method of production from rurally organized, cottage industry characterized by small fixed capital investments, to modern, factory based production subject to (external or internal to the firm) increasing returns to scale (Mokyr, 2009).

Historical evidence points to at least one source of external increasing returns to scale in the form of learning-by-doing. Experimentation via trial and error, small improvements made by anonymous workers and entrepreneurs, and experience acquired on the job were important sources of productivity improvements (Mokyr, 2009). For example, Chapman (1970) finds that most cotton mills in England had a remarkably similar structure. Chapman quotes a contemporary, Sir William Fairbairn, on the reason for this; "The machinery of the mills was driven by four water-wheels erected by Mr Lowe of Nottingham. His work, heavy and clumsy as it was, had in a certain way answered the purpose, and as cotton mills were then in their infancy, he was the only person, *qualified from experience*, to undertake the construction of the gearing." (Chapman, 1970, pp. 239-240, my emphasis). Edwards notes that when the mule-jenny, a third generation spinning machine, "left Crompton's [the inventor's] hands it was a crude device, it had to be improved, and the spinners and weavers of muslins had to acquire their skills." (Edwards, 1967, p.4).

Consistent with large improvements in productivity, the price of yarns declined significantly throughout the period as is shown in Figure I in Online Appendix 2. The trend is most dramatic for finer yarns, the real price of which dropped tenfold in as many years, but there was also a decline in lower count (less fine) yarns. The large decrease in price is significant, as it helps to explain why hand-spinners were outcompeted so quickly.

An imbalance in spinning output and downstream weaving capacity soon made British cotton yarn uniquely reliant on exports markets, of which Europe was by far the most important. Crouzet (1987) estimates that around 56-76 percent of Britain's cotton output was exported either in the form of cloth or yarn. 44 percent of cotton cloth and a full 86 percent of cotton yarn exports were destined for the European market, and in particular, France, Germany and Russia. This reliance on the Northern European market for cotton yarn explains why maintaining trade with Europe in cottons was so crucially important during the blockade, despite the risks and large increase in transport costs that were involved.

1.2 Slow adoption of mechanized spinning technlogy in France

Mechanization of cotton spinning in France proceeded very slowly relative to events across the Channel. In 1790, the number of spinning jennies was estimated to be 900 in France, while the number in Britain has been put at 18,000 (Aspin, 1964). Consistent with the lag in technology, French machine spun yarn sold in Paris was at least double the price of British machine spun yarn in London at the beginning of the blockade.[6]

Why was adoption so slow? It is important to note that the British prohibited both the export of spinning machinery and the emigration of engineers and skilled workers until 1843 (Saxonhouse and Wright, 2004). This put an artificial barrier on the diffusion of technology across the Channel. It meant that while the French were able to acquire blueprints of the machines, and with the help of some English and Irish engineers, British best practice, they did not have wide scale access to the tacit type of knowledge that is acquired via learning-by-doing and that would be embedded in the export of machines or workers.

According to the historical evidence, both the state and private entrepreneurs were well aware of the momentous changes taking place across the Channel and both made attempts to foster technology transfer. Horn (2006) writes that “the effort pivoted on acquiring English machines and spreading access to them as widely as possible. As is well known, the French state concentrated on acquiring Arkwright’s water frame and the mule-jenny, both of which were crucial to England’s competitive edge. Industrial spies (...) were commissioned to

[6]Figure II in Online Appendix 2 compares Paris and London prices for the full range of counts on the eve of the Blockade.

acquire these technologies. (...) British machine builders were rewarded for coming to France and given subsidies for each set of machine they sold. The Bourbon government paid the wages of at least 100 foreign workers in machine building and provided large subsidies to innovative French entrepreneurs who financed the construction of advanced textile machinery. Before the adjudication of Arkwright's second patent in 1785, no less than three mechanics were building roller-spinning machines in France. Doggedly, if haphazardly, government action enabled hundreds of English style (if not always functionally equivalent) carding and spinning machines to be put into operation in nearly every major industrial district in France between 1786-1789." (p. 78).

However, it was not just the state which fostered technology diffusion. Chassagne (1991) and Horn (2006) both emphasize that French cotton spinners played an even more important role in the transfer of technology. In Toulouse, Francois Bernard Boyer-Fonfrede recruited 12 engineers from Britain to build a six storey, water powered spinning mill which employed over five-hundred workers. After construction of the mill was complete, three were hired by a firm in Aix, and another by a firm in Gironde (Chassagne, 1991, p.244). In Amiens, another entrepreneur, Jean-Baptiste Morgan, was similarly active in fostering technology transfer. According to Horn, Morgan sent agents to recruit English workers. "Arriving in yearly batches from 1788 to 1790, they provided Morgan with a detailed and precise knowledge of English techniques, and with the mechanical expertise to construct the needed machines and instruct workers in their use." (Horn, 2006, p.83).

What is striking about these accounts is the extent to which technology transfer seems to have been reliant on British know-how. Furthermore, it also seems to be the case that above and beyond the technological expertise required to build the mills and machinery, French workers were also reliant on British training in acquiring best-practice techniques in mechanized spinning and in training weavers to adapt to using the new type of yarn. Consistent with British competition inhibiting French entrepreneurs from entering the industry, mechanized spinners active in France at the time unambiguously laid the finger of blame on British competition.[7]

2 Variation from the Napoleonic Wars

The Continental Blockade prohibiting the entry of British goods onto the European Continent was declared in Berlin in late 1806, following the defeat of the Fourth Coalition against France in Jena - Auerstadt. These events took place within the context of the Napoleonic Wars (1803-1815). During this period, France fought Britain and its allies in a series of campaigns. It is within this historical setting that the motivations and military constraints for both Britain and France can be understood.

The primary aim of the blockade was to weaken Britain economically by denying her access to important Continental European markets. As the last section has shown, Northern-European markets were particularly important for cotton cloth and yarn. However, the stark asymmetry of naval power between Britain and France meant that traditional blockade of British ports by the French navy was militarily infeasible.[8] In contrast however, Napoleon was increasingly successful in exerting his direct or indirect influence over most of the Continent.[9] In this way, though Napoleon could not blockade British ports, he could use his land-based power to do the next best thing, which was to attempt to stop British goods from entering the Continent. Ports were closed to ships carrying British goods, and the military was active in patrolling the coastline.

[7] AN/AFIV/1316 contains a petition from large spinners across the Empire requesting a complete ban on English cloth, while AN/F12/533 contains a petition from the Chamber of Commerce in Rhone (prefecture Lyon) requesting the same.

[8] By 1800, the British had twice the number of warships as the French did (Davis and Engerman, 2006).

[9] By 1806, the French Empire had expanded in size to include all regions of present-day Belgium, parts of Holland, the entire left bank of the Rhine, regions of present-day Switzerland up to and including Geneva, and regions in the North-West of the Italian peninsula, up to Genoa. In addition, Napoleon's relatives were on the thrones of the Kingdom of Holland, the Kingdom of Italy, the Kingdom of Naples and the Kingdom of Spain. The Portuguese royal family had fled to Brazil and Napoleon's relatives were also in power in key German states (Connelly, 1969).

To understand the disruption to trade, it is worth examining two periods separately; the three years leading up the imposition of the Continental Blockade (1803-06), and the the blockade (1806-13) itself. Disruption to trade along the North-Sea ports began in 1803 with the onset of the Napoleonic Wars. Neutral ports along the North-Sea (Hamburg in particular), together with Dutch ports had been traditionally used to continue trading with the British in times of war. However, in a highly symbolic event, Hanover (home to the royal dynasty to which monarchs of Great Britain belonged to) was occupied by the French army. Britain retaliated by imposing a tight blockade of the entire North Sea coast between the Weser and the Elbe, which was then expanded to include ports along the French Channel and the North Sea in 1804 (Davis and Engerman, 2006). Crouzet (1987) considers this period a prequel to the blockade in the sense that trade to Northern Europe was forced onto land routes for the first time significantly driving up the price at which goods entered the Continent. Discussing the effects of the North-Sea blockade on cotton exporters, Edwards writes; "During 1804 and 1805, when the Elbe was blockaded, Germany's share of the total cotton exports to Europe dwindled to a mere three percent, while there was a sharp jump in the trade to Denmark and Prussia." (1967, p. 55). Merchants' letters to Britain were initially positive about the sales being made, noting that large quantities were being smuggled successfully into France.

Disruption to trading routes became even more severe with the onset of the Continental Blockade. With the notable exception of Sweden, at one point or another all other European powers passed laws in line with the aims of the blockade. The historical events that followed the introduction of the Berlin Decree in 1806 are fairly complex and they involve much back and forth retaliation between Britain and the French, the details of which are not relevant for my purposes.[10] The following points are worth noting regarding the implementation of the blockade. First, the series of laws passed by Britain and France had the effect of completely

[10] The interested reader can consult Davis and Engerman (2006).

wiping out neutral shipping on top of the evident damage they did to domestic shipping interests (Irwin, 2005; O'Rourke, 2006). Second, the extent to which Napoleon could ensure successful implementation of the blockade depended on his ability to keep areas outside of France under his control.

To succeed, Napoleon thus relied on all Continental ports to simultaneously enforce the blockade. This turned out to be an insurmountable challenge. Two features of the blockade are key to my empirical strategy: (i) the blockade was, for the most part, well-enforced along the coast of the French Empire implying that goods intended for French markets had to enter the country via third-country ports, and; (ii) the blockade was unevenly successful across Northern and Southern Europe meaning that the traditional north-south direction of British trading routes were reversed, significantly driving up the costs of accessing some areas of France. As a result, while Napoleon was able to successfully implement the blockade along the coastline directly under his control, he could not plug in the gaps in the system which opened up in regions not directly under his control, and he was unable to stop the inflow of goods at the French Empire's overland borders.

2.1 Geographic asymmetry in the success of the blockade

Trade statistics for British exports of manufactured goods and other British produce show the stark divergence in the success of the blockade across Northern and Southern Europe as Figure III in Online Appendix 2 makes clear. Traditionally, Northern Europe had been the more important market for British exports relative to the Mediterranean, with exports to the former being about twice as high as exports to the latter. This pattern was completely reversed during the blockade. While exports to Northern-Europe declined three-fold from peak to trough, trade to the Mediterranean quadrupled. By 1812, exports to the Mediterranean outnumbered exports to Northern-Europe five-to-one.

There was a significant amount of time variation in the effectiveness of the blockade in

Northern-Europe. The British were able to smuggle into Northern Europe using two difficult routes (via Helgoland, a tiny island off the North-Sea coast, and Gothenburg). However, this was possible only in years where Napoleon was unable to commit sufficient troops to implementing the blockade along the North-Sea coast because of fighting elsewhere. Consistent with the British using southern trading routes in years when northern smuggling became particularly difficult, exports to the Mediterranean dropped in 1810, when the northern smuggling routes were open. Kirkman Finlay, a Glaswegian exporter of cottons noted that in 1810 "(...) the trade from Helgoland was also destroyed, since the French emperor whenever peace was made with Austria again closed up entirely every means of introduction from that island" (quoted in Edwards (1967, p. 58)).

The reasons for asymmetry in the success of the blockade outside of the French Empire were two-fold. First, Napoleon was inherently stronger militarily in the north, while the British had the upper-hand in the Mediterranean. From 1803 onwards, Napoleon had made significant territorial gains along the coast of the North-Sea, which meant that French troops were able to directly implement the blockade almost up to the Baltic-Sea in years where sufficient troops could be committed to stopping smuggling.

In the Mediterranean on the other hand, the French navy was in a desperate state as a result of an indiosyncratic political event which took place during the French Revolution. As part of the internal turmoil during the French Revolution, a significant part of the French Mediterranean fleet was destroyed. This was an event from which the French navy could not recover during Napoleon's reign (Rodger, 2005). Furthermore, as a result a Napoleon's misadventure in Egypt (interpreted in Britain as an attempt to reach India), the British made control of the Mediterranean a policy of strategic importance. They controlled a number of points of primary importance in Southern Europe, such as Gibraltar and Malta, both of which became important smuggling centres. Furthermore, they exerted significant influence on Portugal, a historically important ally, and also Sardinia and Sicily. Crouzet (1987) describes how throughout the Napoleonic Wars, the British were able to single-handedly control shipping in the Mediterranean, which he called a "British sea".

Second, and perhaps most catastrophically, the Spanish insurgency against French rule which started in 1808 meant that the entire Iberian peninsula became open to trade with the British. This gave the British a direct, overland link to the French Empire. Together with their control of Gibraltar and shipping on the Mediterranean sea, Southern Europe became the main outlet for British goods, and in particular cotton.

2.2 Smuggling routes

While the trade statistics are informative about regional variation, the high level of aggregation does not make it possible to use them as a way to understand how trading routes between Britain and Continental Europe changed throughout the blockade. To identify these, I collected data from the Lloyd's List on ship movements between Britain and Continental Europe for the period 1787-1814.[11] Using these data, I am able to measure the number of ships sailing between Britain and each Continental European port in any given year. Figure IV in Online Appendix 2 shows time series evidence about the uneven effects of the blockade for different parts of the European coastline. These data confirm regional variation in the blockade found using British export data. They also show that direct shipping to the French Empire during the blockade was virtually non-existent. Finally, they make clear that Baltic ports were used from 1803-1806 when the initial blockade of the Channel and the North-Sea coast was first imposed.

To smuggle successfully, the British needed access to stable ports directly under their control in order to set up their merchant infrastructure. Figure 1 contains data from the Lloyd's List, disaggregated to the level of European ports, for a year before the disruption to trade began (1802), and a blockade year (1809). This figure visualizes the dramatic change

[11] The data will be described in more detail in Section 3.

in trading routes. Each circle is proportionate to the number of ships sailing between Britain and a given port for a given year. There were four ports from where the British conducted a large part of their smuggling during the blockade years; Helgoland and Gothenburg in Northern-Europe, and Gibraltar and Malta in the Mediterranean. With the exception of Gothenburg, each of these belonged directly to the British. They were thus stable ports where merchants were able to stock inventory.

In the north, both Gothenburg and Helgoland were far from ideal as smuggling centres, as neither had direct overland access to Northern Europe. As such, they were reliant either on decreased vigilance along the North-Sea coast (Helgoland), or on Russia and Prussia's shifting allegiances which determined whether ships would be allowed entry (Gothenburg). Marzagalli (1999) describes how merchants from Britain, Holland and Hamburg relocated their business to Gothenburg in order to organize smuggling routes. However during a number of months in 1808, when the blockade was fully effective both along the North-Sea and the Baltic, stocks piled up in Gothenburg as ships arriving from Sweden were continuously denied entry (Crouzet, 1987).

Once goods were smuggled onto the mainland from Helgoland or Gothenburg, they made their way into the French Empire along its eastern border. Ellis writes " (...) smuggling was more active along the inland than the maritime frontiers of the Empire. One reason for this was the nature of the terrain (...). Another was the proximity of foreign entrepots like Frankfrurt, Darmstadt, Mannheim, Heidelberg, Rastatt, Kehl and above all Basel. Within the Empire itself there were many smuggling bases up along the Swiss frontier and down the left-bank of the Rhine." (Ellis, 1981, p. 203)

Southern Europe proved far more permeable to the entry of British goods. Even prior to the Spanish insurgency, with Gibraltar firmly in their possession, and significant sway over much of Portugal, the British had access to a direct, overland connection to France. Edwards (1967) notes that between 1805 and 1807 (prior to the Spanish insurgency) cotton goods were exported in increasing quantities to Portugal, the Straits of Gibraltar, Malta and Sicily in order to penetrate parts of France. The increase in shipping on the West-Mediterranean was driven almost single-handedly by Malta. Crouzet (1987) describes in detail the key importance played by Malta, especially for the smuggling of cotton goods. At one point, 8.8 percent of exports from Britain were taken into Europe via Malta. French consular reports described markets for British yarn in Malta and Bosnia. With respect to the latter, the consul noted that there was no domestic demand for yarn in Bosnia, instead it was purchased exclusively by Viennese merchants for export. Regarding southern smuggling, there is widespread consensus that a favored route for reaching Continental European markets was that taken via Trieste, consistent with the existence of markets for cotton yarn in this region. (Marzagalli, 1999; Crouzet, 1987). Heckscher (1922) gives details of a smuggling route that began from Trieste and brought goods up along the Danube into Germany and finally into France.

Goods were smuggled into France from Spain via the Pyrenees. Archival sources in the form of hundreds of letters between prefects in south-western departments and the government in Paris provide evidence on the scale of smuggling through the Southern border. Similarly to the inland border in the east, the mountainous terrain provided smugglers with a multitude of potential routes which made detection difficult. All border departments reported a multitude of routes with destinations ranging from Bordeaux, Toulouse and Paris.

One final piece of quantitative evidence from internal trade routes within the French Empire confirms that with the onset of the Napoleonic Wars, the direction of trade with Britain was reversed. Figure V in Online Appendix 2 shows the time series for trade from Strasbourg up and down-river along the Rhine. Coinciding with the onset of the blockade, down-river trade (in the south-north direction) increased dramatically, while up-river trade (in the north-south direction) remained stable.

3 Data

In this section, I give a brief overview of the most important datasets which I constructed, and the main variables of interest. A more detailed description, including sources and potential limitations, can be found in Online Appendix 3. Summary statistics for all variables are reported in Table II in Online Appendix 1.

3.1 Quantifying the trade cost shock

I use the Lloyd's List to reconstruct trade routes between Britain and the Continent before and during the Napoleonic Wars. Using this information, supplemented with historical evidence presented in Section 2, I calculate the shortest effective distance to London for each department in the French Empire for both the pre-blockade and blockade period. I account for one of the most important drivers of increasing trade costs; the difference between water- and land-borne routes, by calibrating the ratio of the two to match the fact that, during this period, sailing from Rouen to Marseille was two-thirds of the cost of going overland (Daudin, 2010). Based on these numbers, 1 sea kilometer is equivalent to 0.15 kilometers on land.

To quantify the shortest route prior to the onset of the Napoleonic Wars, I allow trade to pass through any port that was in use between 1787-1814. To calculate the shortest route between London and each department during the Napoleonic Wars, I restrict possible routes to the ones which were in operation during the Napoleonic Wars; Helgoland, Gothenburg, Gibraltar and Malta.[12] For any department i, the algorithm then picks the least cost path. The trade cost shock, defined as the log-change in the shortest route to London for each department, can be seen in Figure 2, where darker shading shows a larger shock. Effective distance to London increased from a mean of 379 land kilometers in pre-blockade years to 1,055 land kilometers in blockade years. Consistent with the geographic asymmetry in the

[12]Online Appendix 3 contains further details on the precise trading routes.

success of the blockade, the trade cost shock decreased in intensity as we move from the north-western to the south-eastern parts of the French Empire.

To what extent does this measure accurately capture the increase in trading costs between Britain and a given department in France? One worry is that by excluding any form of direct smuggling between Britain and France, we are introducing systematic measurement error. While it is certainly true that some direct smuggling between Britain and France took place during the Napoleonic Wars, historians seem to agree that this was far riskier than indirect smuggling routes (Heckscher, 1922). The fact that third-country ports were used is indicative of the fact that either direct smuggling was quantitatively unimportant, or that the risks associated with it were sufficiently high that taking more circuitous routes was at least as profitable. In either case, this implies that my measure should do a relatively good job of capturing the change in trade costs.

3.2 Short-run outcome variables

I measure production capacity in mechanized cotton spinning both before (1803) and towards the end of the blockade (1812) using prefectural reports on mechanized cotton spinners. These data are available at the level of firm for the pre-treatment period, and at the level of the department across both periods. In 1803, many firms only report number of machines and not number of spindles. For these firms, I have imputed the missing observations using a predictive mean matching model.[13] In addition, I observe labor employed and the vintage of machine used. For the pre-treatment year, I also observe a rich set of covariates for firms, which I exploit in the empirical analysis. I also collected departmental data on the woolen spinning and leather tanning sectors in order to conduct falsification tests.

[13]More details on the imputation model and robustness to imputation can be found in Online Appendix 3.

3.3 Long-run outcome variables

I measure outcomes in the long-run along a number of dimensions. I examine persistence in mechanized spinning capacity using data on spindles for 1840 and 1887 compiled from industrial firm surveys and annual statistical reports. I impute spindle data for firms with missing spindles in 1840 using an identical predictive mean matching model to the one used in the short-run analysis. Firm level data from Chanut et al. (2000) for 1840 makes it possible to estimate labor productivity. I observe value added in agriculture, manufacturing and services at four points in time across the 19th and 20th century from Combes et al. (2011). Finally, to examine exporting outcomes, I digitized product level export data for the period 1787-1828.

4 Short-term Empirical Strategy and Results

In this section, I first describe the evolution of mechanized cotton spinning during the Napoleonic Wars and then turn to estimating the short-run effect of trade protection.

4.1 Mechanized spinning during the Napoleonic Wars

Figure 3 shows the variation in spinning capacity which will be used to estimate the effect of trade protection on domestic production capacity. The figure shows the spatial distribution of spinning capacity across the French Empire in 1803, prior to the onset of the Napoleonic Wars, and in 1812, towards the end of the blockade.

In 1803, a number of departments across the French Empire reported some mechanized spinning activity. Notably, the two departments with the largest spinning capacity were in the south of the empire around Lyon (Rhone and Loire). Between 1803 and 1812, spinning capacity in the French Empire increased by about 370 percent, from 380,000 to around 1.4 million spindles. A look at Figure 3 reveals the extent to which growth in spinning capacity was distributed unevenly. Particularly striking is the increase in spinning capacity along the English Channel, where the increase in the costs of trading with Britain was the largest. By 1812, the two largest spinning departments in the French Empire were located along the English Channel (Seine-Maritime and Nord). In general, more southern regions of the Empire stagnated. In particular, south-eastern regions along the border with Spain saw outright decline in all departments. According to reports from the prefects, modern firms in these areas went bankrupt.

Reports from various departments paint a picture consistent with the numbers. Southern departments unanimously complained about a collapse in demand, with some blaming competition from foreign yarn. The situation in the northern departments could not have been more different. A report from the Nord stated that there was not much change in activity in linens, woolens and hemp. In contrast, they stated, trends in mechanized cotton spinning were completely different. In this branch of the textile sector, *despite* the high price of raw cotton, activity had picked up considerably, particularly during 1809 and 1810.

The most detailed price data for machine spun cotton yarn in France available for the period of the blockade comes from reports for the Eure department. Monthly data for 1807-10 shows a pattern consistent with increased levels of trade protection in more northern departments (Online Appendix 2, Figure VII). Machine-spun cotton yarn in this northern department moved very closely with the price of raw cotton, which increased markedly throughout the blockade in France. The price of a half-kilogram of 26 count yarn was between 2-3 times the price charged in London prior to the blockade. Given that raw cotton prices did not increase in Britain (as I will show below), the tight co-movement between raw cotton prices and domestic yarn in northern France suggests that the effective price for low-count, British cotton yarn in northern France was generally higher than the price that French machine spinners were charging. Put differently, low-count, British, imported yarn was not competitive in the Eure department throughout this time period.

It is worth bearing in mind, that the large increase in spinning came at a time when the economic environment was highly uncertain and a number of factors specific to the cotton industry made any form of development surprising. Importantly, cotton did not enjoy particularly favorable government support. This point should be taken into consideration when thinking both about the importance of state support for the cotton industry. The army used exclusively woolen textiles (Grab, 2003) and Napoleon remained highly ambivalent of developments in the cotton industry because of its reliance on imported inputs. In fact, cotton was the only textile to flourish in the French Empire during the Napoleonic Wars, despite it being the only textile singularly reliant on an imported input traded via sea-routes. Napoleon was constantly trying to find substitutes for cotton. He declared, “it would be better to use only wool, flax and silk, the products of our own soil, and to proscribe cotton forever on the Continent”(Heckscher, 1922, p. 277) . In 1810, he offered a prize of one million francs for the invention of a flax-spinning machine and placed high tariffs on imports of raw cotton, despite the fact that prices had increased significantly during the blockade because of the disruption to trade.

4.2 Short-run empirical strategy

I now turn to estimating the extent to which trade protection was an important driver of the adoption of mechanized spinning technology. This would be the case if trade protection rendered profitable previously unprofitable locations. If entrepreneurs were not competitive at pre-blockade import prices for British yarn, and they became competitive once disruption to trade drove up the price of British yarn sufficiently to make entry profitable, we would expect to find a large effect of trade protection on adoption of mechanized cotton spinning capacity.

My empirical strategy is based on the well-documented fact that trade diminishes dramatically with distance, implying that geographic distance plays a role similar to that of artificial barriers to trade such as tariffs.[14] Geographic distance however is constant over time, making it generally difficult to disentangle the effect of distance from other regional characteristics fixed over time. I exploit the fact that while geographic distance between Britain and French regions did not change during the blockade, the set of possible trading routes did, leading to changes in effective distance between Britain and a given French region.[15]. I use variation in the extent to which effective distance to London changed for a given department to estimate the short-run effect of trade protection on mechanized cotton spinning capacity. This leads to the following specification, similar in spirit to a standard difference-in-difference (DD) estimator;

$$S_{it} = \alpha_i + \delta_t + \gamma lnD_{it} + \epsilon_{it} \tag{1}$$

S_{it} is a measure of mechanized spinning capacity in region i at time t, lnD_{it} is the natural logarithm of effective distance to Britain in department i at time t, α_i controls for time-invariant fixed effects at the regional level, and δ_t controls for the effect of aggregate shocks over time. γ is the parameter of interest, which we expect to be positive if trade protection from the industrial leader, Britain, is an important driver of mechanization.

The unit of observation for the majority of the analysis is the department, which I observe in 1803, prior to the Napoleonic Wars, and in 1812, towards the end of the blockade. I observe 88 of the 109 departments which made up the French Empire in both periods. Spinning capacity is measured as the number of spindles per thousand inhabitants. Spindles are normalized by departmental population to account for the fact that larger departments may increase spinning capacity more in response to the same shock simply because of their size. In calculating per capita variables, I use population measured in 1811 across all short-run and long-run specifications, to avoid confounding endogenous population responses with the

[14] See Head and Mayer (2014) for a recent discussion on the gravity literature.

[15] In its identification strategy, the paper builds on Frankel and Romer (1999), Feyrer (2009a), Feyrer (2009b) and Pascali (2015)

effects on spinning capacity. Spindles is the standard measure of physical capital in mechanized cotton spinning.[16] The relationship is estimated in levels because of the large number of zeros in the data, however I show robustness to other types of specifications.[17] Effective distance to London in 1803 and 1812 is quantified using the measure described in Section 3. I report standardized coefficients in italics and I calculate two types of standard errors. Standard errors clustered at the level of the department to account for serial correlation are reported in parentheses, while standard errors which account for both serial and spatial autocorrelation as suggested by Conley (1999) are reported in curly brackets.[18]

The estimation strategy compares outcomes in regions of the French Empire which received a large trade cost shock to regions which received a smaller shock before and after the disruption to trade. Differently to a standard DD strategy, treatment intensity is continuous. Furthermore, the nature of the trade cost shock is such that all units are affected to some extent by the disruption to trade. The latter is not problematic for identification to the extent that the effect of interest is trade protection, and not the effect of the blockade itself. Identification relies on there being no shocks contemporaneous to and correlated with the trade cost shock. There are two main concerns for identification. First, some areas of the French Empire may simply have been more conducive to the new technology. If these variables were correlated with the trade cost shock, and they exerted a time-varying effect on spinning capacity, my identification strategy would be undermined. Second, the differential trade cost shock took place in the context of the Napoleonic Wars, a highly turbulent period,

[16]Importantly, this is not a measure of the number of machines, the productivity of which may change over time, but rather it is the piece of equipment onto which the thread is twisted. As there is a one to one correspondence between spindles and thread spun on a single machine, improvements in technology which made it possible for a machine to be equipped with more spindles will be picked up by this measure.

[17]In particular, 39 and 36 departments reported no mechanized spindles in 1803 and 1812 respectively. 28 departments had no mechanized spinning capacity in both 1803 and 1812.

[18]Conley's standard errors are calculated using the code provided in Hsiang (2010). The spatial decay is set to zero at a distance of 0.5 degrees. I experimented with increasing the cutoff, but as the standard errors decrease for some of the specifications in this case, I show results for allowing spatial correlation to be nonzero for departments very close together, to understand the direction in which standard errors are altered relative to the baseline.

raising the concern that forces besides the trade cost shock are driving the effects that I find. In the following, I address both concerns.

4.3 Baseline results

Table 1 contains the results from estimating equation 1. The scatterplot and the baseline linear fit is plotted on Figure VI in Online Appendix 2. The estimated effect of protection from British competition is large and statistically significant. The point estimate of 33.11 in column (1) implies that moving from the 25th to the 75th percentile of the trade cost shock leads to a predicted increase in spinning capacity per capita that is about the same size as mean spinning capacity in 1812 across departments. To assess the relative size of the shock, moving from the 25th and 75th percentile (roughly 800 land based kilometers) is equivalent to moving the department with the smallest pre-blockade effective distance to London to the point that is furthest away in the empire. That would imply moving Bruges, in present-day Belgium, to Turin, in present-day northern Italy .

Results are robust to alternative definitions of the trade cost shock and different assumptions about the functional form of the specification (Columns (1) - (6) in Table III in Online Appendix 1). Moreover, they are robust to winsorizing the top 10% of the observations (Column (7)). As the scatterplot in Figure VI makes clear, there is large variation in the extent to which spinning capacity increased during this time period, raising the concern that the effect may be driven by a small number of outliers. This is not the case. Identification comes not only from regions which were large to begin with, or regions which saw the largest increases in spinning capacity. This is also apparent from the scatterplot, which shows the remarkable extent to which all departments witnessed an increase in their spinning capacity. In order to understand the extent to which treatment intensity is continuous, I include a time-varying intercept for departments above median latitude, which will soak up much of the binary, north-south variation. Consistent with continuous treatment intensity, results remain similar in magnitude and statistically significant (Column (8)).[19]

I explore robustness of the results to the addition of variables measuring natural or acquired locational advantage (Columns (2) - (7) in Table 1). While fixed effects soak up any time-invariant confounder correlated with effective distance to London, there is a concern that the time-varying effect of fundamentals may be driving the results. I include variables one-by-one (Columns (2)-(6)), and simultaneously (Column (7)). Each variable is interacted with a dummy variable which takes the value of one in the treatment period, and zero otherwise. Across all columns, the coefficient remains similar in magnitude and statistically significant. Cheap access to power sources such as fast-flowing streams (measured as mean streamflow in the department) and distance to the nearest coalfield do not exert a statistically significant time-varying effect. For the case of France this makes sense; as late as the 1840s, the median cotton spinning firm used no steam-powered machines and one water-powered one according to data from Chanut et al. (2000). During the Napoleonic Wars, the vast majority of firms were likely still using machines which were hand-powered.

To control for the time-varying effect of access to large centers of urban population, I construct the reduced form measure of market potential (Harris, 1954) widely used in the literature. This is defined as $\sum_j \frac{Pop_c}{dist_{cj}}$, where Pop_c is the population of city c in 1800 and $dist_{cj}$ is the distance between department j and city c. Data on city populations across the territory of the French Empire is from Nunn and Qian (2011).

I also control for the time-varying effect of human capital in a flexible way by differentiating between upper-tail knowledge and average human capital following the work of Squicciarini and Voigtländer (2015). Access to upper-tail knowledge is defined similarly to market potential, but I replace urban population in 1800 by market access to universities in existence in 1802 within the territory of the French Empire using data from Valero and Van Reenen (2015). Average human capital is measured as the proportion of men able to

[19]For comparison, Tables IV presents the results from estimating a standard, binary DD model.

sign their wedding certificates in 1786 as reported in Furet and Ozouf (1982). While the coefficient of interest remains positive and significant, it is interesting to note that these three "acquired" fundamentals enter with a positive sign and are statistically significant.

Another concern is that of a potentially asymmetric shock to raw cotton prices on the input side during the wars confounding the estimated effects. Differently to cotton yarn however, the source of raw cotton was not Britain, but other countries.[20] For this reason, imports of raw cotton were not resisted, and the French attempted to secure access to raw cotton using the same trading routes as before the blockade. The general difficulty of sea transportation meant however, that the trading routes became more difficult and risky, and hence more costly. This drove up the price of raw cotton, but in a symmetric fashion across the Empire.

Figure VIII in Online Appendix 2 shows that for all four varieties of raw cotton in use across the French Empire, prices increased markedly during the Napoleonic Wars, but the shock was symmetric in the north and the south. For the case of Brazilian cotton, where one specific variety (Pernambuco) can consistently be matched to London prices, it is also clear that French prices increased to a greater extent than the British. All else equal, this negatively affected French competitiveness. This may explain why some parts of the empire seemed to face tougher competition from the British, despite the fact that all departments were positively affected by the trade cost shock on the import-competing side.[21]

How did departments go about scaling up their spinning capacity? Table V in Online Appendix 1 examines the extent to which increases in spinning capacity were driven by firm entry (extensive margin) relative to pre-existing firms investing in more capacity (intensive

[20]In particular, the French used raw cotton from four sources; the Levant, Brazil (by way of Portugal), the US and cotton from colonial sources.

[21]There is a remaining concern that the quality of raw cotton which was in relatively high supply may have affected incentives to specialize in a particular quality of spun yarn. This may have affected machine choice as in Hanlon (2015). In the following section, I show that the trade cost shock did not lead to a change in the type of machine used.

margin). Exploiting the fact that firm level data is available for the initial period of the Napoleonic Wars, in particular during the North Sea blockade (1803-1806), I find that the extensive margin accounted for the vast majority of the effect, at least during this time period. This is important, as learning-by-doing models of infant-industry implicitly assume that a financial constraint inhibits any one entrepreneur from being able to grow sufficiently large in order to internalize externalities. The fact that most of the increase in capacity was driven by new firms entering the market is consistent with a mechanism where firms do not internalize the force which will render production profitable in the long-term.

4.4 Placebo tests

The disruption to trade took place during a turbulent period of French history. The second main concern in terms of identification is the extent to which the estimated effect is indeed driven by differential trade protection as opposed to unobservables correlated with the trade cost shock. To gain a better understanding of the forces driving my results, I conducted a number of placebo tests. Furthermore, in the following section, I will use the trade cost shock as an instrument for the post-blockade location of mechanized cotton-spinning capacity. These results also build evidence for the exclusion restriction, which requires that the shock affects our long-term outcome variables of interest only through its effect on spinning capacity.

Table 2 summarizes these results. Columns (1) - (3) estimates the effect of the trade cost shock on spinning capacity in the pre-treatment period between 1794-1803. In the absence of similar data for this period, I have constructed an approximation to spindles in 1794. By exploiting the fact that I observe the age of firms alive in 1803, I estimate actual spinning capacity at the departmental level in 1794 by using spinning capacity in 1803 for firms already alive in 1794. This assumes that all growth in spinning capacity took place on the extensive margin of firm entry and that firms did not go bankrupt, neither of which are likely to hold. However, to the extent that results from the period 1803-06 are representative more generally, we should expect the extensive margin to be the main channel of adjustment. Column (1) estimates the baseline regression for the pre-treatment period. The estimated coefficient is small and statistically significant at 10 percent. As Column (2) and (3) show, the effect is spurious, and seems to be driven by omitting the time-varying effect of market potential. Inclusion of this variable decreases the point estimate on the trade cost shock which is no longer differentiable statistically from zero.

Columns (5) and (6) investigate the extent to which other variables of interest in mechanized cotton spinning were affected by the trade cost shock. This is important as it helps understand the type of mechanism which may be driving our results. Column (4) finds that capital-labor ratios (at the level of the department) within mechanized cotton spinning did not change systematically with the trade cost shock. This is an important finding, as an alternative mechanism to differential trade protection from the British could be that factor prices changed differentially across the French Empire rendering the adoption of capital-biased mechanized spinning technology more attractive in some places. More sophisticated machines with a larger number of spindles substituted for relatively more labor, and thus an uneven factor price shock across the French Empire should have altered the capital-labor ratio at the departmental level, even within mechanized cotton spinning.

Column 5 shows that the trade cost shock was not associated with differential quality upgrading at the level of the department. I use information on the type of machines in use in each department to estimate whether the trade cost shock differentially affected the type of machines firms used. The data allow me to differentiate between two types of machines "filatures continus" and "mull-jennys". The former were less modern machines, with significantly fewer spindles on average per machine, and they were mainly used for spinning less fine yarn. To the extent that larger investments in the north during the Napoleonic Wars, also entailed upgrading into more modern and capital-intensive machinery, the long term results which I find in the following section could be driven by a a head-start in upgrading to higher quality machines. To the contrary, I find that the trade cost shock had no differential effect on the proportion of newer type machines in a given department.

I subject the results to further scrutiny by asking whether the trade cost shock had a differential effect on industries which were less intensively traded with Britain and in which there was no similar change in technology. If differential protection is indeed driving my results, we would expect to find no similar effect for such industries. Columns (6) and (7) show that the effect which I find for cotton spinning is not present for two other industries, wool yarn (a direct substitute) and leather.[22] Both products were less intensively traded with Britain, and there was no technological change in either industry. For these reasons, the shock should not have had a significant effect on the spatial distribution of activity, which is precisely what I find.

Online Appendix 1 contains further robustness checks. In Table VI, I show that the results are robust to the inclusion of time-varying controls for the historical location of cotton spinning, the location of downstream weaving, years since incorporation into the French Empire (proxying for both institutional change and access to a large, internal market) and conscription rates (exploring whether results are driven by a spatially uneven negative labor supply shock unevenly pushing firms into mechanization through factor price effects).

5 Long-term Empirical Strategy and Results

The previous section established that trade protection from Britain had a positive effect on mechanized cotton spinning capacity in the short-run, while protection lasted. In this section, I turn to examining the long-run effects of temporary trade protection. First, I examine outcomes within France by exploiting exogenous variation in post-blockade spinning

[22] It should be noted that pre-treatment data for these industries is observed in 1792, rather than in 1803 as is the case for cotton.

capacity. While trading routes with Britain were restored to their post-blockade level after the Napoleonic Wars drew to a close, tariff and non-tariff trade barriers were put in place between the two countries (O'Rourke and Williamson, 2001). For this reason, I also examine exporting outcomes for France as a whole to establish the extent to which a subset of firms had become sufficiently productive to export.

5.1 Within country outcomes

An infant industry mechanism would predict that temporary trade protection renders a location profitable for production not only in the short-term, while protection lasts, but also in the long-term, once protection is removed. To test these predictions, I compare outcomes in the 19th and 20th century in regions which had higher or lower post-blockade spinning capacity as a consequence of differing levels of protection.

First, I ask whether the location of mechanized cotton spinning showed persistence over time. Higher protection from British competition during the blockade increased mechanized spinning capacity while differential protection lasted. To the extent that temporary protection rendered locations profitable in the long-run, we would expect to find persistence in the location of cotton spinning. Second, I ask whether labor productivity increased in the density of local mechanized cotton spinning activity as predicted by infant industry models where production becomes profitable in the long-run as a result of increases in firm productivity. Finally, I examine whether trade protection had aggregate effects on the regional economy through its effect on mechanized cotton spinning.

I estimate IV specifications of the following form

$$Y_{i(j)t} = \alpha_0 + \beta_0 S_{i(1812)} + \eta_{i(j)t} \tag{2}$$

$$S_{i(1812)} = \alpha_1 + \beta_1 \Delta ln(tradecost_i) + \omega_i \quad (3)$$

where $Y_{i(j)t}$ is the departmental (i), or firm level (ij) outcome at time t (spinning capacity, labor productivity, industrial value-added), $S_{i(1812)}$ measures the size of mechanized cotton spinning in department i in 1812 using the same measure of spindles per thousand inhabitants that was used in the previous section. $\Delta ln(tradecost_i)$ is the trade cost shock defined in Section 3.

For all three types of long-term outcomes, the main challenge for identification of β_0 is omitted variable bias. In particular, we expect $S_{i(1812)}$ to be correlated with unobservable locational fundamentals in the error term, $\eta_{i(j)t}$, which also affect the outcome variables of interest. Using the trade-cost shock as an instrument for post-blockade spinning capacity solves the endogeneity problem, as it only uses variation in spinning capacity that was caused by the plausibly exogenous trade cost shock.

The identifying assumption for the 2SLS estimation strategy to render consistent estimates for β_0 is that the trade cost shock is uncorrelated with the error term $\eta_{i(j)t}$. To build evidence in support of the validity of the instrument, I show both robustness of the results to the inclusion of measures of natural or acquired locational fundamentals and placebo checks.

The previous analysis has also shown substantial evidence supporting the exclusion restriction. This requires trade protection to affect the outcome variables of interest only through its effect on the size of post-blockade mechanized cotton spinning. Particularly important in building evidence for this, are the placebo tests showing no similar effect of the trade cost shock on other industries, and the placebos which find no effect within mechanized cotton spinning on capital-labor ratios (no evidence on aggregate factor price shocks) and the quality of machines (no evidence on differential quality upgrading). The trade cost shock indeed seemed to work only through increasing the size of mechanized cotton spinning sector.

Nevertheless, as it is not possible to rule out every channel via which the trade cost shock may effect outcomes $Y_{i(j)t}$, I present both the 2SLS and the reduced form estimates across all specifications. Even if the exclusion restriction did not hold, the reduced form specifications would still identify the effect of trade protection on long run outcomes under the weaker assumption that the trade cost shock is uncorrelated with other determinants of the outcome variables of interest.

Tables 3 - 5 reports the results from estimating the long-run effects for all three outcomes. Across the different tables, the sample size is different for a number of reasons, including changes in territory and missing observations for the control variables. Relative to the short-run analysis, the sample is reduced in size because France lost all territorial gains made throughout the period 1793-1815. In every instance, I have chosen the largest possible sample on which to estimate the effects of interest instead of limiting the analysis to a significantly smaller, but consistent sample. I report two types of standard errors; Huber-White robust standard errors or clustered standard errors are reported in parentheses depending on the specification (firm or departmental level) and Conley standard errors adjusting for spatial autocorrelation are reported in curly brackets.

The Kleibergen-Papp F-statistic for the first stage is generally below 10, the rule of thumb suggested by Staiger and Stock (1997), raising the concern that the instrument may be weak. This could lead to highly biased 2SLS coefficients. In the just identified case however, IV is approximately median unbiased. As Angrist and Pischke (2008) discuss, if the instruments are genuinely weak in the just identified case, the standard errors would be too imprecise to be useful, which is not what I find. Moreover, both the first stage and reduced form coefficient on the trade cost shock are of the expected sign and magnitude, and are generally highly statistically significant. This builds further evidence that the instrument is not weak.

I begin by estimating persistence in the location of mechanized cotton spinning. Figure 4 visualizes the spatial distribution of spindles per thousand inhabitants across the departments for the two time periods which I examine, 1840 and 1887. One of the most striking aspects of the evolution of spinning capacity over time is the almost complete decline of cotton spinning in the more southern departments. As more northern departments kept increasing their spinning capacity throughout the 19th century, southern departments not only stagnated, but actually shrank in absolute size. This is the strongest evidence against an alternative mechanism under which slowly diffusing technology from Britain drives the results. In this case, we would expect more southern departments to expand over time as they acquire technology, which is the opposite of what I find.

Table 3 contains the estimation results. Spinning capacity in 1840 and 1887 is measured as the number of mechanized spindles per thousand inhabitants, holding population unchanged at its 1811 level. Unsurprisingly, the OLS estimates (Columns (1) - (4)) point to a positive and significant correlation between spinning capacity in 1812 and subsequent years. The forces which rendered a particular department attractive for mechanized cotton spinning in 1812 showed a high degree of persistence across time. More interestingly, the 2SLS estimates (Columns (5) - (8)), which use only variation in post-blockade mechanized cotton spinning activity caused by uneven trade protection, are positive and significant. The local average treatment effect of one additional spindle in 1812 is about 2-3 spindles in 1840 and 5-6 spindles in 1887.[23]

In thinking about these effects, it is important to note that the size of the cotton industry grew dynamically throughout the 19th century.[24] These results therefore show that even in a dynamically expanding industry, first mover advantage had very long-lasting effects in the sense that regions which developed their cotton spinning industries early, because of

[23] I have not been able to find data on departmental cotton spinning capacity for the 20th century, which is why the analysis ends in the late 19th century.

[24] The number of spindles grew from about 1 million in 1812, to 3 million in 1840 and almost 5 million in 1887. This is despite the fact that France lost one of its largest spinning regions, Alsace, to Germany in 1871.

idiosyncratically high protection, were the ones which kept expanding as the industry grew.

I test the validity of the instrument by estimating the effect of post-blockade spinning capacity on pre-blockade spinning capacity (measured in 1803) in Table VII in Online Appendix 1. The OLS estimates (Columns (1) - (2)) are positive and statistically significant, highlighting the endogeneity problem caused by omitted variable bias. The estimated local average treatment effect, however, is statistically indistinguishable from zero (Columns (3)-(4)) as are the coefficients for the reduced form (Columns (7)-(8)). In fact, the baseline IV point estimate is 0.01. This constitutes strong support for the validity of the instrument.

Table 4 explores the extent to which firm productivity increased in the density of economic activity. I regress the natural logarithm of the value of output per worker in 1840 on post-blockade spinning capacity in 1812. I trim the top and bottom 10 percent of the data.[25] Columns (1) - (3) contain the OLS estimates. I estimate the baseline regression (Column (1)) and then add firm (Column (2)), and departmental controls (Column (3)).[26] I find a positive and significant correlation between spinning capacity at the level of the department in 1812 and firm labor productivity. Columns (4) -(6) contain the local average treatment effect of higher spinning capacity. I find that for a one standard deviation increase in spinning capacity in 1812, firm labor productivity in 1840 was 0.2-0.5 standard deviations higher. These results are consistent with infant industry models in which firm productivity increases in cumulative local production because of learning-by-doing externalities.

Finally, I estimate the effect on aggregate departmental value added per capita in industry in order to understand the wider implications of adopting this technology. Given the importance of cotton for 19th century development, it is plausible that adopting frontier technology from Britain caused positive aggregate effects for the regional economy. Mecha-

[25]Results are robust to alternative trimming cutoffs.

[26]Firm level controls include a proxy for firm size (value of primary materials used), the share of women and children employed in the firm and binary indicators for whether the firm uses steam or water-powered machines.

nized cotton spinning was one of the most innovative industries in the 19th century. Crafts (1985) estimates that a full 25 percent of TFP growth between 1780-1860 was accounted for by the cotton industry alone. In France, 20 percent (15 percent) of industrial employment was in cottons in 1840 (1860) according to data from Chanut et al. (2000). It could also be the case, however, that if France did not have a latent comparative advantage in mechanized cotton spinning, then specialization in this sector led to negative effects on the adopting regional economies because of the misallocation of resources from their most productive use.

I observe industrial value added at four points in time; 1860, 1896, 1930 and 2000. I divide these variables by departmental population in 1811 to avoid confounding effects on industrial value added with endogenous population responses. Table 5 contains the results from estimating equation 2 without additional controls. The OLS estimates in Columns (1) - (4) are large, positive, statistically significant and remarkably stable for all years through 2000. The forces which drove some departments to adopt the frontier technology in cotton spinning in the early 19th century also led them to specialize in the highest value added industries throughout the last two centuries. Columns (5) - (8) use only exogenous variation in post-blockade spinning capacity caused by the uneven trade cost shock. The estimated local average treatment effect of having one more spindle in 1812 for industrial value added per capita is positive and significant in 1860. The point estimate decreases in size over time and from 1896 onwards, the coefficient is longer distinguishable statistically from zero.

The results are robust to the addition of departmental controls and to calculating industrial value added per capita in terms of contemporaneous population (Tables VIII and IX in Online Appendix 1). I find no statistically significant effect across all years on value added in agriculture or services (Tables X and XI in Online Appendix 1). Taking these results together, temporary protection enabled regions to adopt and develop an industry which was highly innovative throughout the 19th century. Not only did the specific industry develop in the long-term, but the results point to higher aggregate industrial economic activity in these regions, though this dissipated over time. Rather than diverting resources from their most productive use, it seems to be the case that trade protection enabled regions in France to enter a sector which was key to 19th century development.

5.2 Exporting outcomes

I now turn to examining exporting outcomes. The presence of tariff barriers implies that the within country results are not sufficient for showing that some regions of France had become competitive at international prices. Panels A-C in Figure IX in Online Appendix 2 show exporting outcomes. In particular, I plot the level of exports, net exports and exports relative to the same in Britain until 1830.[27] As the figures make clear, the French cotton industry underwent a radical transformation during the period I examine. Prior to the Napoleonic Wars, France was a net importer of cotton goods. By the end of the blockade, they had become net exporters.[28] Exports increased dynamically after the end of the Napoleonic Wars. By 1828, 7.5% of French exports were in cotton goods. France had not only become competitive in export markets, but according to all the available evidence, the sector became important for the overall economy. Exports increased not only in levels, but also relative to British exports of the same, suggesting some convergence to Britain.

Was the adoption of mechanized cotton spinning and the emergence of a competitive cotton sector simply a matter of time for Continental follower countries? Figure X in Online Appendix 2 shows evidence to the contrary. As late as 1850, France and Belgium – both part of the French Empire up to 1815 – had a higher level of cotton spinning activity than other countries. The transformation which France's cotton industry had undergone in the space of about fifteen years, does not seem to match the experience of other Continental

[27] The data do not differentiate between exports and re-exports until the 1820s. I have omitted re-exports once they are separately entered.

[28] It is difficult to interpret net exports for the period of the blockade, as smuggling meant that much of the import data is presumably not reported in the official statistics.

countries.

6 Conclusion

This paper has used the natural experiment of the Napoleonic Blockade to estimate the causal effect of temporary trade protection on the short and long-term development of an infant industry which was key to nineteenth century development, mechanized cotton spinning. Temporary protection had a large and positive effect on the long-term location of the industry and the economy more generally.

How do the findings from this particular historical episode inform the broader question of how openness to trade affects development? An interesting aspect of this episode is the extent to which the setting seems general to the development experience of many countries as they enter structural transformation. Differences between Britain and France were small prior to the invention of mechanized cotton spinning, at least relative to differences between rich and poor countries today. Seen in this light, it would seem that the extent to which infant industry mechanisms could inhibit economies from moving into these sectors is large. However, many of the prerequisites for the development of mechanized spinning were in place across large areas of the French Empire, meaning that once import competition was sufficiently low, mechanization was rapidly adopted. This point suggests that in cases where the underlying conditions are not in place, infant industry protection can turn out to be an extremely blunt tool, irrespective of whether the policy would be optimal or not.

To the extent that similar mechanisms are present today, the findings of this paper should highlight the difficult challenges that developing countries face as they enter structural transformation. Gaining a deeper understanding of these mechanisms, particularly the precise source of agglomeration economies present in these types of settings, would be a fruitful direction for future research.

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A Tables

Table 1: Short-run effect of trade protection on mechanized cotton spinning capacity

	Dependent variable: Spindles per thousand inhabitants						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Effective distance	33.11***	33.14***	34.69***	24.44**	32.70***	41.50***	38.29***
	0.464	*0.465*	*0.486*	*0.343*	*0.458*	*0.582*	*0.537*
	(9.775)	(9.875)	(10.38)	(10.83)	(9.707)	(12.44)	(12.98)
	{6.371}	{6.408}	{6.774}	{7.207}	{6.350}	{8.607}	{8.323}
Streams		-0.336					-1.574
		(1.533)					(2.173)
Coal			-4.571				3.502
			(3.723)				(5.877)
Market potential				41.10*			30.13
				(21.60)			(29.99)
Knowledge access					41.42***		35.44
					(15.33)		(21.92)
Literacy						49.25**	31.65
						(21.32)	(19.09)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Departmental FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	176	176	176	176	176	126	126
Number of dept	88	88	88	88	88	63	63
Adj. R-squared	0.330	0.326	0.336	0.351	0.361	0.412	0.444

Dependent variable: Spindles per thousand inhabitants in department i at time t. Departmental population held constant at its 1811 level. Effective distance is measured as the natural logarithm of the shortest route to London for each department i at time t. Controls (all interacted with an indicator variable which takes the value of one in 1812 and is zero otherwise): Literacy measured as the proportion of men able to sign their wedding certificate in 1786; Coal is the inverse of log distance to the nearest coalfield; Streams is defined as the natural logarithm of mean streamflow (m3/s); Knowledge access is defined as market access to universities in 1802; Market potential is defined as market access to urban population in 1800. Standardized coefficients in italics. Standard errors clustered at the level of the department in parentheses, Conley standard errors adjusted for spatial and serial autocorrelation in curly brackets. The number of observations differ across columns because of missing observations for the literacy measure. For further details on the data, see Online Appendix 3. Notation for statistical significance based on clustered standard errors as follows: *** p<0.01, ** p<0.05, * p<0.1

Table 2: Falsification tests

	Pre-treatment period: 1794-1803			Treatment period: 1803-1812			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Spind.	Spind.	Spind.	K/L	Mach.	Wool	Leather
Effective distance	5.539*	2.657	0.953	-0.092	-0.002	-2.263	-0.009
	0.176	*0.0842*	*0.030*	*-0.089*	*-0.005*	*-0.072*	*-0.064*
	(3.054)	(3.687)	(5.150)	(0.243)	(0.103)	(2.924)	(0.018)
	{2.427}	{2.679}	{3.547}	{0.190}	{0.067}	{1.904}	{0.012}
Market potential		13.67**	11.51				
		(6.272)	(10.36)				
Streams			-0.119				
			(0.609)				
Coal			1.821				
			(2.459)				
Knowledge access			4.207				
			(6.648)				
Literacy			-0.719				
			(3.691)				
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Departmental FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	176	176	126	78	74	138	138
Number of dept	88	88	63	39	37	69	69
Adj. R-squared	0.171	0.197	0.132	0.296	0.081	0.182	-0.004

Columns (1) - (3): Pre-treatment trends test for mechanized cotton spinning. Columns (4) - (5): Falsification test for other outcome variables in mechanized cotton spinning. Columns (6) - (7): Placebo test for two other industries; wool spinning and leather tanning. Dependent variable in Columns (1) - (3): Number of spindles per thousand inhabitants in department i in 1794 and 1803. Departmental population held constant at its 1811 level. Column (4): Capital-labor ratio in mechanized cotton spinning in department i at time t measured as the number of spindles relative to labor employed. Column (5): Capacity in different vintages of machines measured as the proportion of spindles used in mule jennys relative to spindles in "filatures continus" in department i at time t. Column (6): Labor employed in woolen spinning per thousand inhabitants in department i at time t. Employment measured in 1792 and 1811. Column (7): Number of leather tanning firms in department i at time t. Number of firms measured in 1794 and 1811. Effective distance is calculated as the natural logarithm of the shortest route to London for each department i at time t. Controls (all interacted with an indicator variable which takes the value of one in 1812 and is zero otherwise): Literacy measured as the proportion of men able to sign their wedding certificate in 1786; Coal is the inverse of log distance to the closest coalfield, Streams is defined as the natural logarithm of mean streamflow (m3/s); Knowledge access is defined as market access to universities in 1802; Market potential is defined as market access to urban population in 1800. Standardized coefficient in italics. Standard errors clustered at the level of the department in parentheses, Conley standard errors adjusted for spatial and serial autocorrelation in curly brackets. The number of observations differ across columns (1) - (3) because of missing observations for the literacy measure. Columns (5) - (6) are estimated on the subsample of departments with positive spinning capacity in both 1803 and 1812. The dependent variable is only defined for these departments. Sample size differs across columns as not all departments reported labor employed and the type of machine used. Columns (6) - (7) are estimated on the largest sample for which the data are available. For further details on the data, see Online Appendix 3. Notation for statistical significance based on robust standard errors clustered at the level of the department as follows: *** p<0.01, ** p<0.05, * p<0.1

Table 3: Persistence in the location of cotton spinning activity, 1840-1887

	Dependent variable: Spindles per thousand inhabitants							
	OLS				2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DepVar measured in:	1840	1840	1887	1887	1840	1840	1887	1887
Spindles 1812	2.232***	1.927**	3.429***	3.451**	2.483**	3.443***	5.214***	6.340***
	(0.782)	(0.862)	(1.240)	(1.318)	(1.142)	(1.084)	(1.226)	(2.050)
	{0.774}	{0.814}	{1.225}	{1.245}	{1.175}	{1.104}	{1.230}	{2.031}
Literacy		119.0**		136.7		51.11		-10.77
		(59.38)		(86.26)		(75.78)		(138.8)
Coal		-29.45		-10.21		-42.42		-37.24
		(20.98)		(36.24)		(35.27)		(64.55)
Streams		-9.032		-16.98		-5.054		-9.777
		(7.568)		(15.10)		(9.257)		(14.78)
Knowledge access		-157.6*		-175.1		-167.4*		-203.3*
		(80.56)		(116.7)		(85.89)		(119.5)
Market potential		37.92		43.56		-129.9		-266.0
		(102.2)		(150.2)		(165.4)		(270.2)
Observations	75	68	72	67	75	68	72	67
Adj. R-squared	0.322	0.529	0.486	0.469				
	Dependent variable: Spindles per thousand inhabitants							
	First Stage				Reduced form			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DepVar measured in:	1812	1812	1812	1812	1840	1840	1887	1887
Trade cost shock	39.60***	31.80*	41.85***	31.14*	98.30	109.5*	218.2**	197.4*
	(14.76)	(17.86)	(14.78)	(17.84)	(65.09)	(64.09)	(94.08)	(98.98)
	{14.32}	{16.62}	{14.33}	{16.60}	{62.43}	{67.14}	{97.22}	{94.79}
Literacy		29.65		34.70		153.2**		209.2**
		(21.04)		(22.27)		(60.97)		(97.23)
Coal		9.624		10.31		-9.281		28.13
		(10.45)		(10.65)		(17.94)		(47.37)
Streams		-1.289		-1.227		-9.491		-17.56
		(2.780)		(2.791)		(7.542)		(16.95)
Knowledge access		36.90		38.86		-40.29		43.09
		(27.17)		(26.74)		(66.64)		(129.2)
Market potential		57.90		56.37		69.53		91.33
		(42.44)		(41.35)		(94.78)		(210.0)
Observations	75	68	72	67	75	68	72	67
KP F-stat	7.201	3.170	8.016	3.045				
Adj. R-squared	0.143	0.209	0.160	0.211	0.051	0.211	0.185	0.154

Dependent variable: Spindles per thousand inhabitants for the respective year denoted at the top of each column. Departmental population held fixed at its 1811 level across all variables measured in per capita terms. The instrument is the trade cost shock. Controls: Literacy measured as the proportion of men able to sign their wedding certificate in 1786; Coal is the inverse of log distance to the closest coalfield; Streams is defined as the natural logarithm of mean streamflow (m3/s); Knowledge access is defined as market access to universities in 1802; Market potential is defined as distance to urban population in 1800. All variables measured at their pre-blockade values. Robust standard errors in parentheses, Conley standard errors adjusted for spatial autocorrelation in curly brackets. The number of observations differ across columns as controls are missing for some departments, while territorial losses to Germany in 1871 account for the difference in observations across the years 1840 and 1887. For further details on the data, see Online Appendix 3. Notation for statistical significance based on robust standard errors as follows: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Productivity outcomes for cotton spinning firms, 1840

	OLS			2SLS		
	(1)	(2)	(3)	(4)	(5)	(6)
Depvar	Prod 1840	Prod 1840	Prod 1840	Prod 1840	Prod 1840	Prod 1840
Spindles 1812	0.000384*	0.000451***	0.000446***	0.00108**	0.00116**	0.000521***
	0.187	*0.219*	*0.217*	*0.524*	*0.564*	*0.254*
	(0.000196)	(0.000146)	(0.000105)	(0.000467)	(0.000450)	(0.000185)
	{0.000185}	{0.000140}	{0.000103}	{0.000447}	{0.000430}	{0.000188}
Share women		-0.233*	-0.181*		-0.284*	-0.184*
		(0.122)	(0.103)		(0.151)	(0.0962)
Share children		-0.229	-0.245		-0.161	-0.241
		(0.149)	(0.175)		(0.206)	(0.176)
Steam power		-0.136**	-0.127**		-0.161**	-0.131**
		(0.0531)	(0.0542)		(0.0804)	(0.0563)
Water power		0.0185	-0.0218		0.0239	-0.0227
		(0.0583)	(0.0519)		(0.0697)	(0.0506)
Inputs		0.0855*	0.135***		0.0949**	0.135***
		(0.0468)	(0.0294)		(0.0428)	(0.0291)
Literacy			0.376**			0.385**
			(0.154)			(0.155)
Market potential			0.123*			0.127*
			(0.0710)			(0.0712)
Knowledge potential			-0.227***			-0.225***
			(0.0694)			(0.0685)
Observations	405	405	361	405	405	361
Number of departments	35	35	32	35	35	32
Adj. R-squared	0.033	0.105	0.196			
	First Stage			Reduced form		
	(1)	(2)	(3)	(4)	(5)	(6)
Depvar	Spind 1812	Spind 1812	Spind 1812	Prod 1840	Prod 1840	Prod 1840
Trade cost shock	82.61*	86.14*	161.0**	0.0890***	0.0999***	0.0839*
	0.488	*0.509*	*0.951*	*0.256*	*0.287*	*0.241*
	(44.55)	(44.19)	(60.26)	(0.0263)	(0.0267)	(0.0443)
	{42.34}	{41.83}	{ 57.16}	{0.026}	{0.027}	{.0435}
Share women		99.59	64.11		-0.169*	-0.151
		(87.03)	(68.47)		(0.0961)	(0.0999)
Share children		3.289	-34.44		-0.158	-0.259
		(108.7)	(90.03)		(0.132)	(0.176)
Steam power		50.26	40.08		-0.103**	-0.110**
		(30.33)	(32.45)		(0.0473)	(0.0467)
Water power		-5.311	-0.336		0.0177	-0.0228
		(23.03)	(13.51)		(0.0551)	(0.0493)
Primary materials		1.936	-10.89		0.0971**	0.129***
		(8.824)	(8.547)		(0.0412)	(0.0291)
Literacy			-318.0*			0.219
			(182.2)			(0.153)
Market potential			-197.8**			0.0239
			(90.85)			(0.0841)
Knowledge access			148.3			-0.148**
			(93.44)			(0.0594)
Observations	405	405	361	405	405	361
Number of departments	35	35	32	35	35	32
KP F-stat	3.439	3.80	7.14			
Adj. R-squared	0.225	0.251	0.384	0.060	0.132	0.173

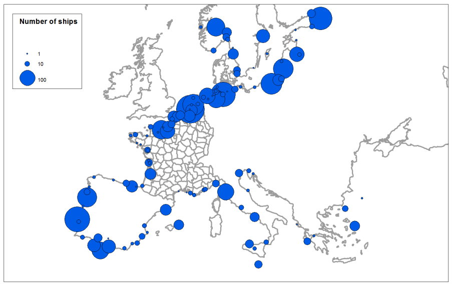
Dependent variable: Natural logarithm of the value of output per worker for the trimmed sample of firms which declared their sector as cotton spinning in the 1839-47 census of manufacturing firms. The top and bottom 10% of the productivity distribution was trimmed. Spindles 1812 is measured as the number of spindles per thousand inhabitants relative to population in 1811. The instrument is the trade cost shock. Firm controls: (log) raw material, share of women employed, share of children employed, indicator variables which take the value of 1 if a firm used steam power and water power, and 0 otherwise. Department controls: market potential, knowledge access, literacy (all variables measured at their pre-blockade values.). Sample size varies across columns because of missing observations for departmental controls. Standardized coefficient in italics. Robust standard errors clustered at the level of the department in parentheses, Conley standard errors adjusted for spatial autocorrelation in curly brackets. For further details on the data, see Online Appendix 3. Notation for statistical significance based on clustered standard errors as follows: *** p<0.01, ** p<0.05, * p<0.1

Table 5: Industrial value added per capita outcomes, 1860-2000

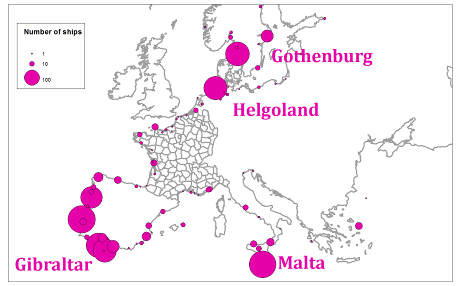
	Dependent variable: Natural logarithm of industrial value added per capita							
	OLS				2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DepVar measured in:	1860	1896	1930	2000	1860	1896	1930	2000
Spindles 1812	0.00453***	0.00427***	0.00519***	0.00410***	0.00714***	0.00260	0.000851	0.00393
	0.470	*0.510*	*0.488*	*0.405*	*0.741*	*0.311*	*0.0801*	*0.388*
	(0.000869)	(0.000951)	(0.00130)	(0.00111)	(0.00241)	(0.00186)	(0.00302)	(0.00255)
	{0.000858}	{0.000938}	{0.00128}	{0.00109}	{0.00237}	{0.00187}	{0.00308}	{0.00253}
Observations	72	70	72	72	72	70	72	72
Adj. R-squared	0.246	0.300	0.264	0.157				
	First Stage				Reduced form			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DepVar measured in:	Spind 1812	Spind 1812	Spind 1812	Spind 1812	VA 1860	VA 1896	VA 1930	VA 2000
Trade cost shock	39.78**	42.42***	39.78**	39.78**	0.284***	0.110	0.0339	0.156
	0.378	*0.403*	*0.378*	*0.378*	*0.280*	*0.125*	*0.030*	*0.146*
	(15.41)	(15.43)	(15.41)	(15.41)	(0.102)	(0.096)	(0.128)	(0.113)
	{14.95}	{14.95}	{14.95}	{14.95}	{0.101}	{0.095}	{0.128}	{0.110}
Observations	72	70	72	72	72	70	72	72
KP F-stat	6.667	7.560	6.667	6.667				
Adj. R-squared	0.137	0.156	0.137	0.137	0.082	0.005	-0.013	0.009

Dependent variable: Natural logarithm of industrial value added per capita measured at the level of the department. For the first stage regressions, dependent variable is spindles per thousand inhabitants in 1812. Departmental population held fixed at its 1811 level across all variables measured in per capita terms. The instrument is the trade cost shock. Standardized coefficeint in italics. Robust standard errors in parentheses, Conley standard errors adjusted for spatial autocorrelation in curly brackets. The number of observations differ across columns because of territorial losses to Germany between 1871 - 1919. For further details on the data, see Online Appendix 3. Notation for statistical significance based on robust standard errors as follows: *** p<0.01, ** p<0.05, * p<0.1

B Figures



(a) 1802 (pre-blockade)



(b) 1809 (blockade)

Figure 1: Number of ships travelling between the given port and Britain

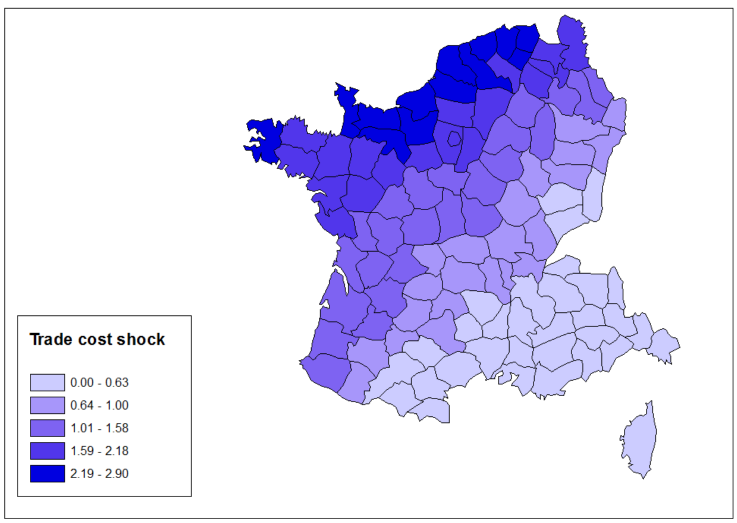
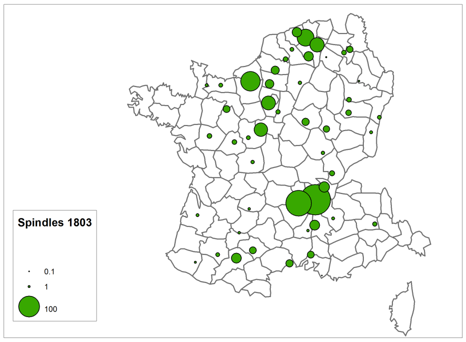
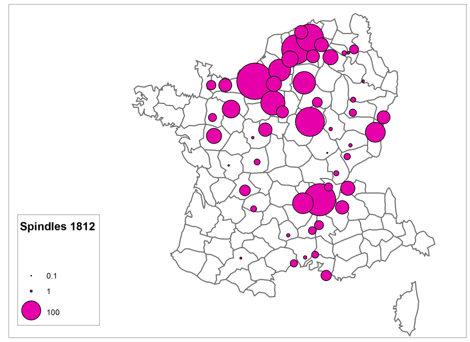


Figure 2: Trade cost shock

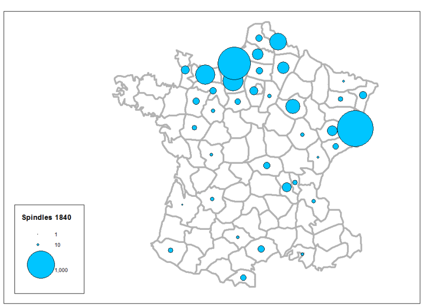


(a) Spindles per ’000 inhabitants, 1803

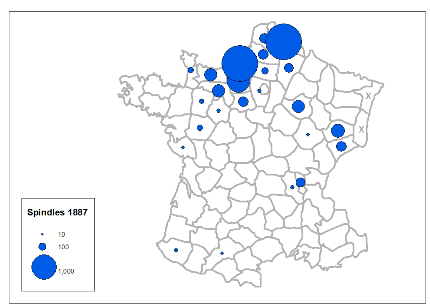


(b) Spindles per ’000 inhabitants, 1812

Figure 3: Variation used: short-run regressions



(a) Spindles per ’000 inhabitants, 1840



(b) Spindles per ’000 inhabitants, 1887

Figure 4: Variation used: long-run persistence regressions

Note: The label "X" denotes the two departments, Haut-Rhin and Bas-Rhin, ceded to Germany 1871 - 1918. Data for 1887 is not available for these regions.