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 higher activity in mechanized cotton spinning. They also had higher value-added per capita in industry up to the second half of the 19th century, but not later.

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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.[2] 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 and the inherent endogeneity of which industry the policy maker chooses to protect.

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 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

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

[2] Hamilton (1791) and List (1856).

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 (Crafts, 1985). Both Hamilton and List advocated for infant industry protection for the nascent cotton industries in the US and Germany respectively (Hamilton, 1791; List, 1856).

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 aspect of the setting is helpful, as infant industry mechanisms may be present in mechanized cotton spinning, but not in most other sectors in early 19th century France, as these only switched to factory-based production methods later.

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. In addition, 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. However, as these effects are estimated for a relatively long time horizon, it is not possible to rule out that other mechanisms may (partly) be driving the long-run results. For this reason, I view these results as more suggestive than the short-run ones.

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 2-3 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. I also 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 or prohibitions were imposed on cotton manufactures 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 manufactures from France. Consistent with evolving comparative advantage in cotton manufactures, I find that exports 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 typically 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).[3]

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 historical evidence 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.[4]

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 coun-

[3] As is well known, tariff protection is generally not the most efficient form of intervention, as a production subsidy would not distort consumption choices. See Melitz (2005) for a discussion.

[4] It should also be noted that even if the effect driving the results are external economies of scale, the welfare implications are ambiguous because of the static negative welfare losses stemming from the higher price paid by consumers of cotton yarn. This discussion also abstracts from the myriad of other (arguably overwhelmingly negative) effects of the blockade. The goal of this paper however is not to offer a welfare evaluation of the blockade but rather to use the setting to study the question of whether theoretical infant industry mecahnisms are empirically relevant.

try 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 2 describes the way in which the Napoleonic Wars drove exogenous changes in trade protection from Britain. Section 3 describes the main sources of data, while Sections 4-5 contain the short and long-term empirical analysis, respectively. The final section concludes.

1 The cotton industry in Britain and France

Britain's dominance of the 19th century cotton textile industry is a widely known fact. It may thus be somewhat surprising that as late as the mid-18th century, the cotton textile industry in Britain and France were actually remarkably similar (Riello, 2013). In both countries, cotton textile manufacturing was a new and small industry relative to traditional European textiles such as wool, linen and silk.[5] 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.[6]

1.1 Mechanization in Britain and diffusion of technology to France

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

[5] 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.

[6] 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).

(Allen, 2009). Importantly, they were fairly cheap, and they depreciated fast.[7] This rules out a slow to depreciate, large, one-time investment driving the long-term results.

Mechanization had large effects on the cotton textile 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 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).[8]

Consistent with large improvements in productivity, the price of yarns declined significantly throughout the period as is shown in Figure A.1. 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

[7] 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.

[8] Additional quantitative evidence on external learning effects is provided by David (1970), who estimates strong learning effects for six firms in the 19th century US cotton textile industry.

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 manufactures were 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 technology 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 France was at least double the price of British machine spun yarn in Britain at the beginning of the blockade.[9]

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 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

[9]Figure A.2 compares prices for the full range of counts at the beginning of the blockade.

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.[10]

While technology diffusion was reliant on British know-how, according to the available evidence, both prior to and during the blockade, machines were predominantly produced domestically in France. Chassagne (1991) notes that three different mechanics were already producing roller-spinning machines before 1785, one of whom produced 84 machines for a number of different spinners. During the Napoleonic period, it seems most large firms had their own machine builders for building and repairing the machines (Chassagne, 1991). The emergence of specialized machinery producers was a feature that differentiated the US and Great-Britain from other 19th century cotton textile producing regions (Saxonhouse and Wright, 2004), though even in Britain, this subsidiary industry featuring large firms instead

[10] AN/AFIV/1318 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. Appendix A.6 contains a description of each of the primary archival sources referenced in the paper.

of miscellaneous tradesman and small workshops did not emerge until the 1830s (Cookson, 1994).

Three features of the historical context discussed above are important to keep in mind when interpreting the empirical results as evidence of an infant industry mechanism. First, the similarity of the cotton textile industry in Britain and France prior to mechanization in Britain is significant, as it suggests that economic fundamentals in Britain and France were sufficiently close such that once French spinners were protected from British competition, mechanization was rapidly adopted and became competitive in the longer-term. Put differently, it gives support to the claim that British competition was the key barrier inhibiting French entrepreneurs from adopting the technology, as opposed to differences in economic fundamentals. Second, the fact that French entrepreneurs were highly reliant on British know-how for both domestic machine building and mechanized spinning points to the fact that at pre-blockade protection levels, French spinners were unable to use the new technology in an efficient way. Third, rapid productivity improvements and external to the firm learning effects characterized mechanized cotton spinning. In light of the historical evidence, it seems plausible that learning-by-doing externalities are the mechanism which gave rise to the infant industry effect found in the empirical results, though data limitations do not allow me to test this econometrically.

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.[11]

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

[11] More generally, the Napoloenic blockade took place within the context of the French Revolutionary and Napoleonic Wars (1792-1815). However, the disruption to trade that took place during the period studied here was fundamentaly different to the French Revolutionary Wars that came before (Davis and Engerman, 2006). Appendix A.1.1 contains a detailed discussion of why this was the case.

British ports by the French navy was militarily infeasible.[12] In contrast however, Napoleon was increasingly successful in exerting his direct or indirect influence over most of the Continent.[13] 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.

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 (Edwards, 1967). 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 textile 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 positive about the sales being made from Denmark until as late as August 1807, noting that large quantities of cotton yarn were being smuggled successfully into France.

Disruption to trading routes became even more severe with the onset of the Continental 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 France, the details of which are not relevant for my purposes.[14] The following points are

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

[13] 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).

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

worth noting regarding the implementation of the blockade. First, the series of laws passed by Britain and France had the effect of completely 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 A.3 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 early as 1793 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 (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 centers. 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.

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.[15] 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

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

A.5 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 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 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 centers, 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 textile goods were exported in increasing quantities to Portugal, the Straits of Gibraltar, Malta and Sicily. 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 textiles. 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.[16] 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 and Toulouse to Paris.[17]

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 A.6 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 of all data, including sources

[16] Archives Nationales, F12/1859.
[17] Archives Nationales, F7/8777 and F12/8778.

and potential limitations, can be found in Appendix A.3. Summary statistics are reported in Table A.2.

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 that were in operation during the Napoleonic Wars; Helgoland, Gothenburg, Gibraltar and Malta.[18] 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 380 land kilometers in pre-blockade years to 1,055 land kilometers in blockade years. Consistent with the geographic asymmetry in the success of the blockade, the trade cost shock decreased in intensity as we move from the north to the south of the French Empire.

For departments along the English Channel, the trade cost shock is high for two reasons. First, as they are located geographically close to Britain, their effective distance to London prior to the blockade was small. Second, as trade routes in northern Europe were disrupted to a larger extent than those in the south, these departments became furthest away from London in terms of their effective distance. For example, the department Seine-Maritime (prefecture Rouen) was situated 86 land-based kilometers from London prior to the blockade, and became 1,282 land-based kilometers away during the blockade. This is because the nearest smuggling port was Helgoland. From there, goods needed to make the long journey overland from the German coastline down to Strasbourg and up north again to reach the

[18] Appendix A.3 contains further details on the precise trading routes.

department.[19]

In contrast, the trade cost shock is relatively small for departments in the south. These departments were located further from Britain prior to the blockade, meaning that their effective distance to London was initially high. Moreover, given that trade routes in the south were disrupted to a smaller extent during the blockade, the general direction of trade for these regions did not change. While there was an increase in effective distance as a result of trade being diverted to land routes, this was much smaller than in the north. For example, for Pyrenees-Orientales (prefecture Perpignan), the pre-blockade distance was 548 land-based kilometers, while during the blockade it increased to only 689 land-based kilometers. During the blockade, the algorithm predicts that goods destined for this department were smuggled through Gibraltar and only made an overland journey from Barcelona.

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 and this is also confirmed by British export data.[20] 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 this 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 the firm for the pre-treatment period, and at the level of the department across both periods. In 1803, many firms only reported number of machines and not number of spindles. For these firms, I have imputed the missing observations using a predictive mean matching model.[21] In addition, I observe labor employed and the vintage of machine used. For the pre-treatment year, I also observe a rich set of

[19]For departments closer to the east such as Seine-Maritime, the shortest route passed through Helgoland during the blockade, while for more western departments such as Finistere, the shortest routes passed through Gibraltar, in the south.

[20]Appendix A.3.2.4 contains a more detailed discussion of this point.

[21]More details on the imputation model and robustness to imputation can be found in Appendix A.3.2.1.

covariates for firms, which I exploit in the empirical analysis.

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. 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 from primary sources.

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 department with the largest spinning capacity was located in the south of the empire around Lyon (Rhone). 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 largest spinning department in the French Empire was located along the English Channel (Seine-Maritime). 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, many modern firms in these areas went bankrupt.[22]

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.[23] 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.[24]

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 woolen textiles (Heckscher, 1922) 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 raw 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

[22] Archives Nationales, F12/1570-89. For example, the report from the prefect in Gers states all modern firms picked up in the 1806 survey had gone bankrupt, while that from the prefect of Haute-Garonne also states that many entrepreneurs have shut down.

[23] Archives Nationales, F12/1570-1590. Foreign yarn is blamed by the Rhone department.

[24] Archives Nationales, F12/1581

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.[25] 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.[26] 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 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 effects on spinning capacity. Spindles is the standard measure of physical capital in mechanized cotton spinning.[27] The

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

[26]In its identification strategy, the paper builds on Frankel and Romer (1999); Feyrer (2009a,b); Pascali (2017).

[27]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.

relationship is estimated in levels because of the large number of zeros in the data, however I show robustness to other types of specifications.[28] 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. I also report standard errors clustered at a slightly higher level of aggregation, to account for spatial correlation. To do this, I use the administrative system in place before the formation of departments during the Revolution, the généralités.[29]

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, 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 A.7. The estimated effect of protection from British competition is large and statistically significant. The point estimate of 33.47 in column (1) implies that

[28]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.

[29]The appealing aspect of clustering at this level is that it is reasonable to expect that economic ties within these historical regions may be stronger than across them, providing a natural way of clustering at a higher level of aggregation. However, it should be noted that for a few robustness checks, the number of clusters at the level of généralités falls below 30. Given that clustering with too few groups underestimates the standard error (Bertrand et al., 2004), standard errors clustered at the level of généralités are not reported where the number of clusters falls below 30. To keep the two types of standard errors comparable, I have not used the wild-bootstrap method as suggested by Cameron et al. (2008). Appendix A.3.1.17 contains a more detailed description of how departments were assigned to généralités.

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 400 land based kilometers) is equivalent to moving a department along the English Channel to the Spanish border. That would imply moving Bruges, in present-day Belgium, to Toulouse, in present-day France .

Results are robust to alternative measures of the trade cost shock and different assumptions about the functional form of the specification.[30] 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 (Table A.3, Column (5)).[31]

As the scatterplot in Figure A.7 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. Results are robust to winsorizing the top 10% of the observations (Table A.3, Column (8)). 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 that received a high trade cost shock increased their spinning capacity.

How did departments go about scaling up their spinning capacity? Table A.5 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 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.

[30]Tables A.3 - A.8 contain the results. These are discussed in detail in Appendix A.2.1

[31]For comparison, Tables A.4 presents the results from estimating a standard, binary DD model.

4.4 Robustness

To address the concern that the trade cost shock may be correlated with factors that render particular locations more favorable for mechanized cotton spinning, 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 binary variable that 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-power and one water-powered engine according to data from Chanut et al. (2000).[32]

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 the number of universities in existence in 1802 within the territory of the French Empire using data from Valero and Van Reenen (2016). Average human capital is measured as the proportion of men able to 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.

A different identification concern is that other shocks, contemporaneous to and correlated with the trade cost shock, may be (at least partly) driving the results. This is of particular

[32]Crafts and Wolf (2014) study of the locational determinants of British cotton mills in the 1840s. The authors find that water power had a strong positive effect on the number of cotton mill employees in a given region, while coal had a negative albeit less robust effect. They found no or only weak evidence for other natural locational fundamentals such as ruggedness, humidity or hardness of the water.

concern given the highly turbulent time period under investigation. I address these concerns in two ways. First, I consider two other specific shocks contemporaneous to the trade cost shock which could potentially account for part of the estimated effect. I consider whether a differential shock to the imported input, raw cotton, or increased market access through the expansion of the French Empire's influence across Europe can account for the results. Both of these effects may give rise to the estimated baseline effect, though through a mechanism different to that of infant industry. I take a more general approach in the next section by conducting placebo tests for two other textile industries (woollen spinning and leather tanning).

An asymmetric shock to the price of imported raw cotton is particularly problematic, as this would arguably have a disproportionate effect on mechanized cotton spinning, meaning that the placebo industries I examine in the next section may well be unaffected. To understand the extent to which changes in the price of imported raw cotton may be driving the results, Figure A.8 shows price data in the north and the south of the French Empire for different varieties of raw cotton in use at the time; Levantine, Brazilian, US and from French colonies.[33]

As the figure makes clear, prices increased markedly during the Napoleonic Wars, but the shock was fairly 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 those in Britain. Given that both British yarn and raw cotton were imported, why would shocks to these products have a seemingly different spatial pattern?

First, it is important to note that only part of the increase in raw cotton prices can be attributed to the disruption to trade caused by the blockade. Part of the increase was driven by a substantial increase in the tariffs on raw cotton, which affected all regions equally.[34] Heckscher (1922, pp. 274-276) shows some evidence that prices in the empire were generally substantially higher than in other Continental European cities, consistent with the fact that tariffs accounted for part of the increase in French prices.

Second, while the disruption to trade did cause trading routes to shift from sea- to land-based ones driving up the price of raw cotton, differently to British yarn, the fundamental

[33] I have not been able to find a data source for raw cotton prices at a regionally more disaggreagted level. It should be noted that Napoleon experimented with growing cotton around Naples to substitute for other sources. Heckscher (1922, p. 277) cites estimates that put this additional source at not more than 12% of the total raw cotton in use in 1812.

[34] Table A.21 reports tariffs for different varities of raw cotton throughout the period of interest.

direction of trade did not change. The reason for this is that the source country for raw cotton was not Britain. Importantly, much of the raw cotton imported to France was coming from a southerly direction even prior to the blockade. France sourced raw cotton from the Levant, Brazil (by way of Portugal), its colonies and the US. Given their geographic positions, Portuguese and Levantine cotton were imported into France from a southerly direction. Moreover, Bordeaux, located in the south of the Atlantic seaboard was far and above the most important French port prior to the French Revolution, and as such was the main distribution center for colonial and US raw cotton (Marzagalli, 1999).[35] When the blockade disrupted trade in raw cotton, it did so to a large extent not by changing the direction of trade (as was the case for British yarn), but rather by forcing it from predominantly southern sea-routes to southern land-routes which entered the French Empire from the south or through the eastern terrestrial border.

Figure A.9 reports quantitative evidence to support the claim that raw cotton entered France predominantly from a southerly direction. In particular, the share of French imports by the source region from which they are imported is shown. As can be seen, over 50% of the imported raw cotton entered France from Southern Europe in all but one year throughout the blockade. The Atlantic and Eastern border were also relatively important at different points. Imports from Northern-Europe were below 20% for all years. If anything, it seems that more southern regions had better access to raw cotton supplies both before, and in particular, during the blockade consistent with the price evidence. Appendix A.1.3 contains additional historical evidence that describes the particular trade routes used to import raw cotton during the blockade.

All else equal, the large increase in raw cotton prices negatively affected French competitiveness. This may explain why some parts of the empire seemed to face tougher competition from the British during the blockade, despite the fact that all departments were positively affected by the trade cost shock on the import-competing side.[36]

The second contemporaneous shock which could explain the results is that of France's increased market access throughout this period. This could happen both through the annexation of territories, and through France's ever increasing indirect influence over large parts of continental Europe. For example, Ellis (1981, p. 20) describes the aims of the blockade

[35] With the onset of the French Revolutionary Wars, trade was diverted to neutral ports such as Hamburg in the north and Livorno in the south (Marzagalli, 1999).

[36] 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.

as follows; "It is suggested here that the loss of French transmarine markets and sources of supply had some influence on Napoleon's Blockade. If the vacuum left in the French economy was to be filled, the key recovery seemed to lie in the resources of the Continental mainland. New, and it appeared inevitable non-oceanic, supply lines and outlets had to be found to give the imperial economy the stimulus for expansion, especially from 1807 onwards when neutral trade lay in the stranglehold of belligerent Powers."

Table 2 explores robustness of the results to the inclusion of variables that capture changing market potential throughout the blockade. Column (1) restates the baseline effect for comparison, while Column (2) adds the baseline measure of market potential defined in the previous section. Column (3) explores robustness of the results to accounting for the expanding French Empire, which can be thought of as increased *internal* market access. The (time-varying) control for market potential is constructed to include any city that formed part of the Empire in 1803 and 1812, respectively, thereby capturing the effect that annexation had on market access. Figure A.10 shows the spatial distribution of regions annexed between 1803-1812 and the cities they contain. Relative to Column (1), the coefficient of interest is virtually unchanged, while the time varying measure of market potential is negative and insignificant. This is unsurprising. As can be seen from Figure A.10, territories were annexed to the French Empire in fairly equal amounts both along the northern seaboard and in the south.

To capture increased access to continental European markets outside of France's expanding internal market, I calculated the same measure of market potential for regions *outside* of the French Empire. In particular, any city belonging to a region classified by Grab (2003, p. 17) to be a French satellite as of 1812 was included.[37] I also construct a more conservative measure that drops all of Spain. As a result of the insurgency against French rule and British military presence, it is unlikely that French firms enjoyed easy access to Spanish markets. Columns (4)-(5) show the estimation results when including these controls interacted with a time dummy (one-by-one). In both cases, the coefficient of interest increases somewhat in size and remains highly significant. The controls enter with a positive coefficient, but only the measure excluding Spain is significantly different from zero. While there is some evidence for increased access to third markets having a positive effect on spinning capacity, given the distribution of French satellites, the market potential measure is largest for areas along the

[37]This included most of Germany and Italy, all of Spain, the Illryian provinces and the Grand Duchy of Warsaw as shown in Figure A.11. Note that the Illryian provinces were in fact annexed to the French Empire, however as they were geographically separate from the rest of France, it seemed more reasonable to include them in the external measure of market potential.

eastern border. As such, it is not highly correlated with the trade cost shock and does not affect the coefficient of interest in a quantitatively important way. Finally, Columns (6)-(7) show that the results are robust to including both internal and external measures of market potential simultaneously.

4.5 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. The previous section considered a number of specific shocks that could have confounded the effect of interest. 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. The results presented here also build evidence for the exclusion restriction, which requires that the shock affects the long-term outcome variables of interest only through its effect on spinning capacity.

Table 3 presents 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 the firm level data observed in 1803 and 1806 contain the date the firm was founded, we know which firms were already active in 1794. Using this information, I approximate spinning capacity at the departmental level in 1794 by using spinning capacity in 1803 for firms already active 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 Table A.5 for the period 1803-06 are representative more generally, we should expect the extensive margin to be the quantitatively more important way in which departments increased spinning capacity. Column (1) estimates the baseline regression for the pre-treatment period. The estimated coefficient is small and statistically significant at 5 percent. As Columns (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 (4) and (5) 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 that 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. These placebo tests are informative about the extent to which the results for mechanized cotton may be driven by mechanisms other than decreased import competition from the technological leader.

In an influential paper, Crouzet (1964) argued that the period of the French Revolutionary and Napoleonic Wars had a long lasting negative effect on the Atlantic and Mediterranean seaboard as a result of France being shut out of overseas trade during this period.[38] Another concern is whether the war effort may have had a spatially differential effect. If the war effort had a larger effect on those areas of France closer to Britain, this may confound the coefficient of interest. For both of these identification concerns, the placebo tests are useful, as these types of confounders should also affect other industries.

Columns (6) and (7) show that the effect which I find for cotton spinning is not present for

[38] Appendix A.2.4 discusses this mechanism in more detail.

two other industries, wool yarn (a direct substitute) and leather.[39] Both products were less intensively traded with Britain, and there was no technological change in either industry.[40] For these reasons, the trade shock should not have had a significant effect on the spatial distribution of activity, which is precisely what I find. This provides further evidence that the mechanism driving the results is decreased import competition from the technological leader, Britain.[41]

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 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.[42] To test these predictions, I compare outcomes in the 19th and 20th century in regions which had higher or lower post-blockade

[39]It should be noted that pre-treatment data for these industries is observed in 1792 (woolen spinning) and 1794 (leather tanning), rather than in 1803 as is the case for cotton.

[40]Appendix A.1.2 provides additional details on these industries in support of these statements.

[41]Appendix A.4 contains further robustness checks. In Table A.9, I show that the results are robust to the inclusion of time-varying controls for the historical location of cotton manufacturing, the location of downstream weaving, year of incorporation into the French Empire (proxying for both institutional change and access to a large, internal market), conscription rates (exploring whether results are driven by a spatially uneven negative labor supply shock unevenly pushing firms into mechanization through factor price effects) and distance to the nearest Atlantic trading port.

[42]Whether the industry becomes competitive in the long-run is partly a question of whether protection lasts for a sufficiently long time. For example, in the case of a learning-by-doing externality, the size of the initial productivity gap and the speed of learning would determine how long protection needs to last. Whether this holds true in this setting is an empirical question.

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 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

$$Y_{it} = \alpha_0 + \beta_{0t} S_{i(1812)} + \eta_{it} \tag{2}$$

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

where Y_{it} is the departmental (i) outcome at time t (spinning capacity or 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. $\Delta ln(D_i)$ is the trade cost shock defined in Section 3.

For the case of long-term outcomes, the main challenge for identification of β_{0t} is omitted variable bias. In particular, we expect $S_{i(1812)}$ to be correlated with unobservable locational fundamentals in the error term, η_{it}, which also affect the outcome variables of interest. To overcome this challenge, I propose using the trade-cost shock as an instrument for post-blockade spinning capacity. The identifying assumption for the 2SLS estimation strategy to render consistent estimates for β_{0t} is that the trade cost shock is uncorrelated with the error term η_{it}. 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 to the inclusion of lagged spinning capacity as a control. This latter is important, as it controls for geographic persistence in the location of mechanized spinning. A placebo test builds additional support for the validity of the instrument. However, it should be noted that given the long time horizon over which these effects are estimated, it is not possible to fully rule out that the estimated effects are (partly) driven by other forces. Any shock that affects the French economy over the long time horizon that is examined and that is correlated with the trade cost shock would confound the effect of interest. For this reason, I view the long term results presented in this section more as suggestive rather than conclusive evidence on the long-run effects of temporary protection.

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). According to these results, 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_{it}, 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 4 - 6 reports the results from estimating the long-run effects. 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 are reported in parentheses, while standard errors clustered at the level of généralités are reported in curly brackets.

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.[43] This is the strongest evidence against an alternative

[43]Depending on the size of internal trade costs, a less competitive mechanized spinning sector in southern departments may either survive or decline in the long-run according to the infant industry model. Internal transportation costs in France were falling throughout the 19th century (Combes et al., 2011) because of innovations such as the railroad. It is therefore plausible that less competitive regions which managed to

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 4 contains the estimation results that examine persistence in the location of mechanized cotton spinning.[44] 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) - (8) 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 (9) - (16)), which use only variation in post-blockade mechanized cotton spinning activity caused by uneven trade protection, are positive and significant. Across both OLS and 2SLS specifications, I estimate the coefficient without additional controls, and add lagged spinning capacity (measured in 1803) and additional controls measured prior to the blockade. The preferred specification includes lagged spinning capacity only as an additional control (Columns (10) and (14)), as it is possible that additional, predetermined controls affect outcomes through lagged spinning capacity and are thus already controlled for.

The local average treatment effect of one additional spindle in 1812 is about 2.1-3.4 spindles in 1840 and 4.7-6.2 spindles in 1887.[45] Inclusion of pre-blockade spinning capacity as a control is suggestive of the extent to which the blockade caused a significant shift relative to pre-blockade mechanization patterns; across all specifications, pre-blockade spinning capacity enters with a negative sign and is generally statistically significant.[46] Moreover, inclusion of lagged spinning capacity strengthens the first stage. For specifications that include this variable, the Kleibergen-Papp F-statistic for the first stage is consistently above 10, the rule of thumb suggested by Staiger and Stock (1997) when assessing whether a specification suffers from a weak instrument problem.[47]

In thinking about these effects, it is important to note that the size of the cotton industry grew dynamically throughout the 19th century.[48] These results therefore suggest that even

survive foreign and internal competition during the blockade, were outcompeted once domestic competition became tougher as regional markets became more integrated throughout the 19th century.

[44]The first stage and reduced form are reported in Table A.10.

[45]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.

[46]The raw correlation between spinning capacity in 1803 and 1812 is 0.66.

[47]It should be noted that for specifications estimated for the 1840s data, the reduced forms are marginally not significant at conventional levels in some cases.

[48]The number of spindles grew from about 1 million in 1812, to 3 million in 1840 and almost 5 million

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

I assess the validity of the instrument by estimating the effect of post-blockade spinning capacity on pre-blockade spinning capacity in Table 5. 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 0.03. This constitutes some support for the validity of the instrument.

Second, 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 manufacturing for 19th century development, it is plausible that adopting frontier technology from Britain caused positive aggregate effects for the regional economy. Mechanized 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 cotton manufacturing 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 using data from Combes et al. (2011). I divide these variables by departmental population in 1811 to avoid confounding effects on industrial value added with endogenous population responses. Table 6 contains the results from estimating equation 2 without additional controls and adding lagged spinning capacity as a control.[49] The OLS estimates in Columns (1) - (8) 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 (9) - (16) use only variation in post-blockade spinning capacity caused by the uneven trade cost shock. The estimated local average

in 1887. This is despite the fact that France lost one of its largest spinning regions, Alsace, to Germany in 1871.

[49]The first stage and reduced form are reported in Table A.11.

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 A.12 and A.14 in Appendix A.4). I find no statistically significant effect across all years on value added in agriculture or services (Tables A.16 and A.18 in Appendix A.4). 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 and non-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 A.13 show exporting outcomes. In particular, I plot the level of exports, net exports and exports of cotton manufactures relative to the same in Britain until 1830.[50] 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 manufactures. By the end of the blockade, they had become net exporters.[51] Exports increased dynamically after the end of the Napoleonic Wars. By 1828, 7.5% of French exports were in cotton textiles. 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 A.14 shows evidence to the contrary. As late as 1850, France and Belgium – both part of the French

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

[51]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.

Empire up to 1815 – had a higher level of cotton spinning activity than other countries.[52] The transformation which the French Empire's cotton industry had undergone in the space of about fifteen years does not seem to match the experience of other Continental countries in the early 19th century.

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 short-run adoption of mechanized cotton spinning technology and 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.

An additional element of the historical setting studied in this paper that is worth bearing in mind when thinking about the challenges faced by developing countries today is the restriction on exports of British machinery throughout the period of interest. A recent literature has shown that the reduction of tariffs on imported intermediate inputs has large effects on firms' estimated productivity and product scope (Amiti and Konings, 2007; Goldberg et al., 2010; Halpern et al., 2015). In a world where developing countries have the ability to import high quality inputs or capital from abroad, an important question is the extent to which infant industry mechanisms remain relevant.

[52] Although by 1850, Austria had similar levels to France but not Belgium.

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, in particular the precise source of agglomeration economies and the scope for importing capital to alleviate infant industry problems, 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	33.47	33.48	34.78	24.73	32.96	42.18	38.82
	0.47	*0.47*	*0.49*	*0.35*	*0.46*	*0.52*	*0.48*
	(9.80)	(9.89)	(10.47)	(10.90)	(9.75)	(12.54)	(13.23)
	{10.00}	{10.06}	{10.58}	{11.07}	{10.01}	{13.50}	{13.46}
Streams X 1812		-0.14					-1.16
		(1.50)					(2.17)
Coal X 1812			-3.93				4.11
			(4.21)				(7.47)
Market potential X 1812				41.05			30.19
				(21.58)			(30.19)
Knowledge access X 1812					40.87		34.90
					(15.22)		(21.79)
Literacy X 1812						46.41	27.79
						(21.16)	(18.86)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	176	176	176	176	176	126	126
Adjusted R-squared	0.34	0.33	0.34	0.36	0.37	0.42	0.45
Num. clusters (dept)	88	88	88	88	88	63	63
Num. clusters (gen)	40	40	40	40	40	30	30

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, standard errors clustered by généralités 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 A.3.

Table 2: Robustness to changing market access

	Dependent variable: Spindles per thousand inhabitants						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Effective distance	33.47	24.73	33.58	40.56	38.50	44.04	30.33
	0.47	*0.35*	*0.47*	*0.57*	*0.54*	*0.62*	*0.43*
	(9.80)	(10.90)	(9.90)	(12.37)	(10.41)	(11.36)	(12.15)
	{10.00}	{11.07}	{10.15}	{13.49}	{11.04}	{11.74}	{12.59}
Market potential X 1812		41.05					32.04
		(21.58)					(22.55)
Market potential (time var.)			-20.68			-248.90	
			(92.70)			(136.52)	
Market potential (ext.) X 1812				40.04			
				(33.48)			
Market potential (ext. exc. ESP) X 1812					32.41	59.60	23.72
					(13.38)	(19.04)	(14.58)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	176	176	176	176	176	176	176
Adjusted R-squared	0.34	0.36	0.33	0.34	0.36	0.37	0.37
Num. clusters (dept)	88	88	88	88	88	88	88
Num. clusters (gen)	40	40	40	40	40	40	40

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: Market potential as defined previously (market access to urban population in 1800); Market potential (time var.) is a time varying measure which takes account of changes in the border of the French Empire between 1803-1812; Market potential (ext.) is market access to urban population in territories outside the boundaries of the French Empire under French influence; Market potential (ext. exc. ESP) drops Spanish cities from the measure because of the insurgency against French rule. All controls except Market potential (time var.) are interacted with a dummy variable that takes the value of one in 1812 and is zero otherwise. Standardized coefficients in italics. Standard errors clustered at the level of the department in parentheses, standard errors clustered by généralités in curly brackets. For further details on the data, see Appendix A.3.

Table 3: Falsification tests

	Pre-treatment period: 1794-1803			Treatment period: 1803-1812			
	(1) Spind.	(2) Spind.	(3) Spind.	(4) K/L	(5) Mach.	(6) Wool	(7) Leather
Effective distance	5.89	3.32	2.08	-0.07	-0.02	-2.25	-0.02
	0.18	*0.10*	*0.06*	*-0.07*	*-0.06*	*-0.07*	*-0.13*
	(2.94)	(3.56)	(4.90)	(0.26)	(0.10)	(2.93)	(0.01)
	{3.22}	{4.01}	{5.69}			{3.11}	
Market potential X 1812		12.08	9.47				
		(5.85)	(8.93)				
Streams X 1812			-0.10				
			(0.53)				
Coal X 1812			2.53				
			(3.23)				
Knowledge access X 1812			4.93				
			(5.74)				
Literacy X 1812			0.44				
			(3.33)				
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	176	176	126	78	74	138	116
Adjusted R-squared	0.19	0.21	0.15	0.32	0.11	0.18	0.05
Num. clusters (dept)	88	88	63	39	37	69	58
Num. clusters (gen)	40	40	30	23	21	32	28

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 log number of spindles per unit of 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. 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 Appendix A.3. Standardized coefficient in italics. Standard errors clustered at the level of the department in parentheses, standard errors clustered by généralités in curly brackets. The latter is not reported in cases where the number of généralités is less than 30.

Table 4: Persistence in the location of cotton spinning activity, 1840-1887 - OLS and 2SLS

	Dependent variable: Spindles per thousand inhabitants															
	OLS								2SLS							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
DepVar measured in	1840	1840	1840	1840	1887	1887	1887	1887	1840	1840	1840	1840	1887	1887	1887	1887
Spindles 1812	2.23	3.04	1.95	2.47	3.43	4.75	3.49	5.06	2.49	2.12	3.41	2.68	5.17	4.72	6.24	4.85
	(0.78)	(0.99)	(0.85)	(0.93)	(1.24)	(1.54)	(1.31)	(1.71)	(1.13)	(1.27)	(1.05)	(0.93)	(1.22)	(1.26)	(1.93)	(1.39)
	{0.81}	{0.99}	{0.86}	{0.93}	{1.29}	{1.57}	{1.37}		{1.11}	{1.27}	{1.06}	{0.94}	{1.28}	{1.29}	{2.15}	
Spindles 1803		-2.95		-1.55		-4.69		-4.86		-1.61		-1.85		-4.64		-4.57
		(1.53)		(1.01)		(2.17)		(2.42)		(1.56)		(1.04)		(1.68)		(1.84)
Literacy			119.93	71.18			114.36	-16.63			55.75	60.98			-44.49	-4.29
			(60.19)	(55.35)			(91.42)	(92.54)			(74.68)	(55.34)			(150.41)	(95.46)
Market potential			31.39	2.67			45.42	-33.57			-131.66	-15.75			-239.48	-16.38
			(101.65)	(109.61)			(150.51)	(132.55)			(161.27)	(104.61)			(242.47)	(129.33)
Knowledge access			-155.58	-141.21			-183.81	-159.55			-163.82	-140.59			-219.59	-159.00
			(80.52)	(83.05)			(119.19)	(108.88)			(86.21)	(78.31)			(119.44)	(101.80)
Coal			-39.01	-27.19			-19.14	12.23			-55.88	-27.43			-56.09	12.76
			(25.30)	(20.57)			(45.69)	(44.00)			(42.29)	(18.84)			(81.23)	(41.19)
Streams			-8.16	-11.19			-16.34	-16.85			-3.93	-10.45			-9.22	-17.54
			(7.28)	(5.80)			(14.88)	(10.08)			(8.93)	(4.86)			(14.32)	(8.34)
Observations	75	70	68	63	72	67	66	61	75	70	68	63	72	67	66	61
Adjusted R-squared	0.32	0.39	0.54	0.61	0.49	0.61	0.47	0.61								
KP F-stat									7.404	12.78	3.247	10.35	8.281	15.21	3.169	10.15
Num. clusters (gen)	34	34	31	30	33	33	30	29	34	34	31	30	33	33	30	29

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. Regressor of interest: Spindles per thousand inhabitants in 1812. The instrument is the trade cost shock. Controls: Spindles per thousand inhabitants in 1803, 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. 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 Appendix A.3. Robust standard errors in parentheses, standard errors clustered by généralités in curly brackets. The latter is not reported in cases where the number of généralités is less than 30.

Table 5: Placebo for persistence in the location of mechanized cotton spinning

	Dependent variable: Spindles per thousand inhabitants							
	OLS		2SLS		First stage		Reduced form	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DepVar measured in	1803	1803	1803	1803	1812	1812	1803	1803
Spindles 1812	0.28	0.31	0.03	-0.08				
	(0.11)	(0.12)	(0.11)	(0.27)				
	{0.13}	{0.14}	{0.13}	{0.32}				
Literacy		-17.19		-1.25		24.22		-3.27
		(8.51)		(10.07)		(21.71)		(8.04)
Market potential		-14.62		29.29		54.79		24.72
		(12.96)		(34.77)		(42.93)		(20.50)
Knowledge access		5.34		8.31		40.16		4.96
		(7.77)		(10.64)		(27.90)		(13.56)
Coal		4.38		9.14		12.32		8.11
		(5.62)		(11.91)		(14.65)		(9.37)
Streams		1.36		0.30		-0.81		0.37
		(1.66)		(1.43)		(2.66)		(1.46)
Trade cost shock					42.68	35.82	1.31	-2.99
					(16.21)	(20.00)	(5.23)	(8.83)
					{17.44}	{21.49}	{6.22}	{10.91}
Observations	71	63	71	63	71	63	71	63
Adjusted R-squared	0.40	0.41			0.15	0.22	-0.01	-0.01
KP F-stat			6.937	3.208				
Num. clusters (gen)	34	30	34	30	34	30	34	30

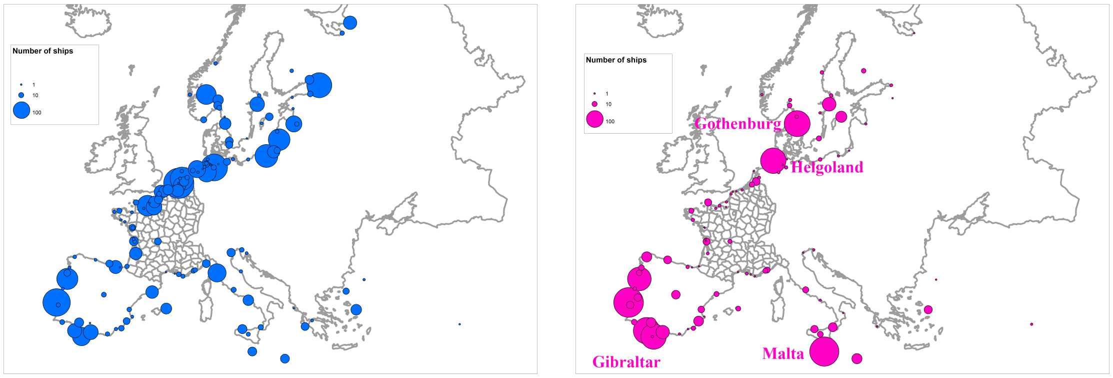
Dependent variable: Spindles per thousand inhabitants by department for the respective year denoted at the top of each column. Departmental population held fixed at its 1811 level across all variables measured in per capita terms. Regressor of interest: Spindles per thousand inhabitants in 1812. The 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 defined as distance to urban population in 1800. The number of observations differ across columns as controls are missing for some departments. Robust standard errors in parentheses, standard errors clustered by généralités in curly brackets.

Table 6: Industrial value added per capita outcomes, 1860-2000 - OLS and 2SLS

	Dependent variable: Natural logarithm of industrial value added per capita															
	OLS								2SLS							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
DepVar measured in	1860	1860	1896	1896	1930	1930	2000	2000	1860	1860	1896	1896	1930	1930	2000	2000
Spindles 1812	0.0047	0.0037	0.0039	0.0025	0.0053	0.0040	0.0041	0.0025	0.0079	0.0075	0.0012	0.0010	0.0015	0.0016	0.0040	0.0031
	0.5007	*0.3925*	*0.3771*	*0.2394*	*0.5244*	*0.3965*	*0.4141*	*0.2527*	*0.8433*	*0.7987*	*0.1173*	*0.0937*	*0.1461*	*0.1590*	*0.4032*	*0.3128*
	(0.0009)	(0.0012)	(0.0010)	(0.0012)	(0.0013)	(0.0016)	(0.0011)	(0.0012)	(0.0026)	(0.0026)	(0.0026)	(0.0026)	(0.0029)	(0.0030)	(0.0025)	(0.0026)
	{0.0010}	{0.0013}	{0.0011}	{0.0013}	{0.0014}	{0.0016}	{0.0011}	{0.0012}	{0.0021}	{0.0021}	{0.0024}	{0.0025}	{0.0029}	{0.0028}	{0.0024}	{0.0025}
Spindles 1803		0.0035		0.0048		0.0046		0.0053		-0.0020		0.0070		0.0081		0.0044
		(0.0020)		(0.0019)		(0.0020)		(0.0017)		(0.0035)		(0.0036)		(0.0041)		(0.0032)
Observations	73	68	71	66	73	68	73	68	73	68	71	66	73	68	73	68
Adjusted R-squared	0.2401	0.2414	0.1298	0.1369	0.2648	0.2772	0.1598	0.1718								
KP F-stat									7.079	12.60	7.994	15.25	7.079	12.60	7.079	12.60
Num. clusters (gen)	33	33	32	32	33	33	33	33	33	33	32	32	33	33	33	33

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. Regressor of interest: Spindles per thousand inhabitants in 1812. The instrument is the trade cost shock. Standardized coefficient in italics. The number of observations differ across columns because of territorial losses to Germany between 1871 - 1919. For further details on the data, see Appendix A.3. Robust standard errors in parentheses, standard errors clustered by généralités in curly brackets.

B Figures



(a) 1802 (pre-blockade)

(b) 1809 (blockade)

Figure 1: Number of ships traveling between the given port and Britain. Source: Lloyd's List.

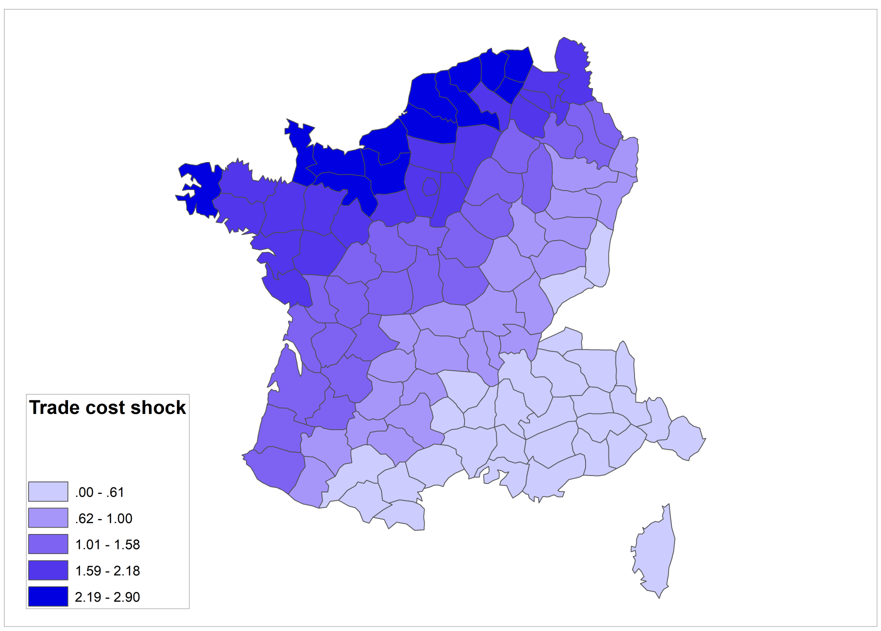
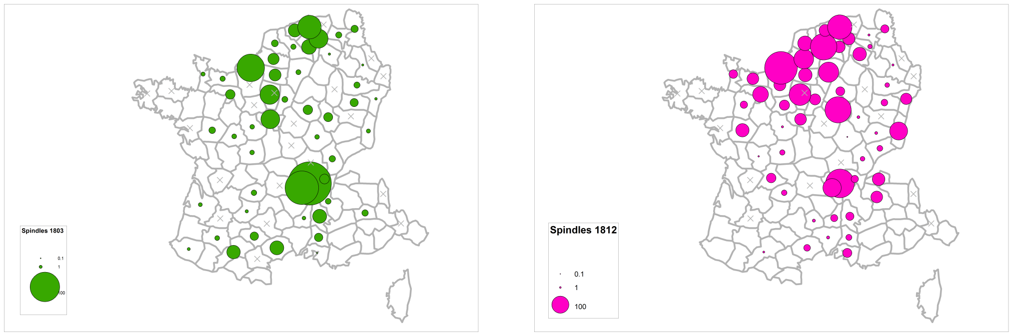


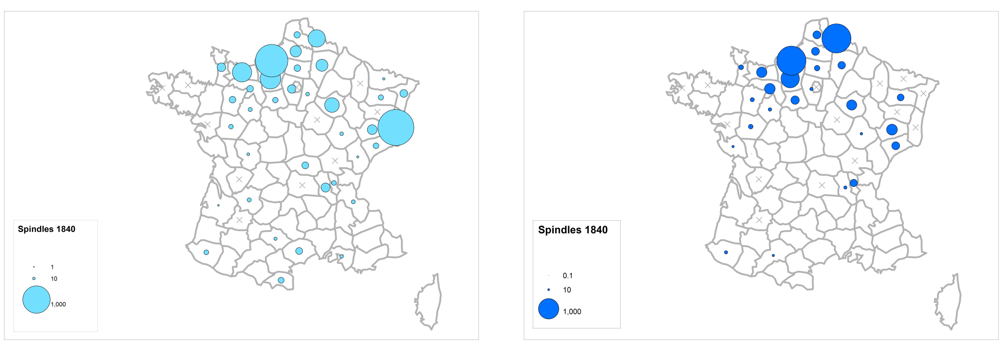
Figure 2: Trade cost shock (log change in effective distance to London)



(a) Spindles per ’000 inhabitants, 1803 (b) Spindles per ’000 inhabitants, 1812

Figure 3: Variation used: short-run regressions

Notes: "X" denotes missing or dropped observations. Departments observed for only one time period not shown to ensure comparability of the graphs across the two time periods. Scale not comparable across time periods.



(a) Spindles per ’000 inhabitants, 1840 (b) Spindles per ’000 inhabitants, 1887

Figure 4: Variation used: long-run persistence regressions

Notes: "X" denotes missing or dropped observations. Departments not observed in 1812 not shown as these are missing from the regressions as the regressor of interest is not observed. Haut-Rhin and Bas-Rhin were ceded to Germany 1871 - 1918. Data for 1887 is not available for these latter departments. Scale not comparable across time periods.