What Made Great Britain so Great? From the Fiscal-Military State to the First Industrial Revolution

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Abstract

Recent research in economic history casts doubts on the role played by good economic institutions in Great Britain after the 1688 Glorious Revolution. What undoubtedly emerged from the latter is a strong Fiscal-Military state under the influence of a Parliament dominated by Whigs. After presenting related empirical evidence, I develop a parsimonious model to understand how the influence of a strong military apparel on international trade can foster the implementation of more productive technologies. When this is the case, development by one country can foster de-industrialization for its trading partners, as has been the case historically in India during the 19th century.

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"When goods don't cross borders, armies will."

Otto T. Mallery

1 Introduction

In the beginning of the 19th century, Great Britain was well on its way towards industrialization. After a few decades, it was followed by countries that are now among the most developed countries on earth. In the meantime, many countries did not exhibit this kind of behavior and recorded a slow growth in productivity. While some of these countries are still poor to this day (most of African countries for example), others started to grow very recently (China and India). This process of a widening gap in terms of GDP per capita between countries that had an early industrial revolution and the others has been called the "Great Divergence". Since the gap is still large to this day, it is very useful to understand what happened back then.

Most of the research on the Industrial Revolution has been focused on Great Britain, which was the first ever country to experience a sustained rise in income per capita and thus productivity starting roughly in 1780. After decades of research, a consensus has not yet been reached about the fundamental cause(s). Since 19th century Great Britain has a lot to do with mechanization of processes formerly executed by human or animal limbs, Mokyr (2002) focuses on the interactions between scientific knowledge, engineers and entrepreneurs. He put forwards the fact that the intellectual environment characteristic of Great Britain during this period fostered innovation because it was socially rewarding.

On the other hand, Allen (2009) focuses on the role of international trade. During the 17th and 18th centuries, England —and later Great Britain after the union with Scotland in 1707—profited a lot from such trade, which had the effect to create an economy with relatively high real wages. Together with the abundance of coal, this encouraged entrepreneurs to adopt new technologies to produce more efficiently and at a larger scale.However, many innovations during that time were not exactly labor saving.

Finally, another interpretation has been proposed recently by North & Weingast (1989) and developed further by Acemoglu et al. (2005) to a larger set of countries. North & Weingast (1989) give a prominent role to the Glorious Revolution of 1688 in fostering sustained economic growth in Great Britain.

By replacing a Monarchy with a government led mainly by the Parliament, itself composed of MP sympathetic with merchants and entrepreneurs, the Revolution created an improved set of political and economic institutions that made it safer to innovate and accumulate capital. Ultimately, this led to the Industrial Revolution. However, the evidence that institutions were indeed more business friendly does not seem very strong. In particular, it is not clear whether the risk of being expropriated was actually lower after the Glorious Revolution (see Clark (2014) and the references therein). Furthermore, other countries developed inclusive economic institutions without experiencing sustained growth of GDP per capita.

At the end of the day, while inclusive economic and politic institutions surely are beneficial to growth, they do not seem to be the main driver. It is still debated that the 1688 Revolution gave birth to better institutions, but what is not so much disputed is the fact that it gave birth to the modern Fiscal-Military state (see Brewer (1989)). During the 18th century, the state took on more and more debt to fund government expenses, the majority of which were directed towards the strenghtening of the Navy and the military apparel in general. In an epoch during which pirates and privateers from competing states roamed the seas, Great Britain slowly but surely emerged as a hegemon in terms of naval power. In this sense, such a power enabled the British economy to gain high profits from international trade. Additionally, some British manufacturers enjoyed captive demand for their products in British colonies, for which military and naval power were essential. In his recent book, Vries (2015) argue that it might have played a big role in the fact that the British economy experienced sustained growth.

The link between the Fiscal-Military state and growth in total factor productivity is not clear however. The goal of this paper is to clarify this link by proposing a parsimonious model of economic growth. In this model, the Fiscal-Military state will permit the opening of new markets for entrepreneurs (think of the opium war for example). As a consequence, this will give more demand for British manufactures and it will thus be more profitable for manufacturers to adopt new technologies and produce at a larger scale[1]. In the words of A.Smith, as quoted in Beckert (2014):

> opening a new an inexhaustible market to all the commodities of Europe, it [slave trade] gave occasion to new divisions of labour and improvement of art, which, in the narrow circle of the ancient com-

[1] In a related paper, Juhász (2015) shows how the Napoleonic Blockade foestered the adoption of better technology in French regions that experienced greater shielding from British competition.

> merce, could never have taken place for want of a market to take off the greater part of their produce.

As stated earlier, this role by itself is not likely to generate a sustained rise in productivity. For it to be the case, the model shows that other features are needed. In particular, trading partners should provide a high level of demand, military power should be important to gain export markets and the bureaucracy has to be efficient so that payments to the government actually end up in building up military power.

In this setup, gaining export markets for one country will mean that a foreign country is losing on demand for its products. As such, growth promoted by military power will be a zero sum game : while one country (in this setup, Great Britain) is industrializing, the trading partner (we can think about India) will be *de-industrializing*. Indeed, the rise of Great Britain as an economic superpower saw the concomitant decrease in industrialization in other countries that were trading partner or outright colonies.

This paper is linked with a large literature that tries to understand the transition from stagnation to growth through the lenses of a microfounded model. A paradigm called Unified Growth Theory (UGT) has emerged recently (see Galor (2005)) and put the emphasis on demographic transition and the demand for human capital. This theory is more an explanation of the underlying mechanisms during the Second Industrial Revolution, which started around the decade 1860. Regarding why England was the first country to industrialize on a large scale, the theory does not have much to say. Quoting Galor (2005):

> Variations in the timing of the transition from stagnation to growth and thus in economic performance across countries (e.g., England's earlier industrialization in comparison to China) reflect initial differences in geographical factors and historical accidents and their manifestation in variations in institutional, demographic, and cultural factors, trade patterns, colonial status, and public policy.

The goal of this paper is precisely to investigate the role of these initial differences and articulate how they might have spurred industrialization through a microfounded growth model. In this sense, this paper is related to recent contributions by Voigtländer & Voth (2006) and Ventura & Voth (2015) who also try to understand the determinants of the British Industrial Revolution using dynamic models, albeit from a different perspective.

The paper is structured as follows. In section 2 I detail the consequences of the 1688 Glorious Revolution on British political life and provide data to illustrate the rise in the Fiscal Military State. In section 3, I develop a 'big push' static model in which military power can move the economy from a no-growth equilibrium to a high-growth equilibrium. The model is then extended to a dynamic framework that clarifies the roles played by expectations and history. Section 4 concludes.

2 The Glorious Revolution and its Consequences

In November 1688, the army of William of Orange lands at Torbay. In England, the son of Catholic King James II has been born a few months ago, destituting William's wife and daughter of James II, Mary as heir to the throne. By crossing the channel, William and Mary led an army to overthrow James II and restore protestantism as the official faith of England. In this endeavour, they could count on the financial help of the two English parlementarians parties, the Whigs and Tories (see Pincus (2002)). While they have different views about what a government should do, they both wanted to oust king James II from the throne.

James II and his army suffered a quick defeat and he was consequently ousted from the throne. Now William and Mary jointly held the reins of England. This effectively marked the end of England as a pure monarchy and ushered in an era in which the Parliament had a greater role. To be sure, the Parliament already existed and had a role under James II, but it was a diminished one. His main role was to authorize the introduction of new taxes. In practice however, the Parliament was often sidelined during the major part of the 17th century. In addition, successive kings took on debt during this period to fund their wars. Repayment was far from guaranteed and never on the agreed upon terms. As a consequence, the supply of loans was very limited and the interest rate the Crown had to pay was very high.

The actual consequences of the Glorious Revolution on English (and shortly after British) economic and politic institutions are still a subject of debate. In their famous article, North & Weingast (1989) argue that property rights were much more secure after 1688-89. This set the basis for sustained economic growth as entrepreneurs were no longer fearing that their capital might be arbitrarily expropriated. They claim that the new institutional arrangement made it so that members of Parliament did not want to use their new power to confiscate private wealth the way successive kings did before. Finally, they

show that as investors perceived the government to be more accountable, the risk premium on public debt decreased significantly at the end of the 17th century. As a consequence, public debt increased a lot and a new structure was introduced to handle the stock of public debt : the Bank of England. The latter is the reason many historians talk about a Financial Revolution during this period.

These claims are not entirely uncontroversial however. It is true that, from a theoretic point of view more inclusive institutions should foster economic growth. But it is not clear that institutions indeed became more inclusive after the Glorious Revolution. It seems that property rights were not much more protected after 1689. If this was indeed the case, we should have seen the number of patents increase after this period, but it isn't there in the data (see Clark (2014)). As a telling example, precursors in the mechanization of cotton industry such as Hargreaves and Kay both failed to defend their patent rights. Even if institutions indeed became more inclusive after the Glorious Revolution, Great Britain did not engage in sustained economic growth before 1780, so there is a timing issue inherent to this argument.

Instead, what is rather uncontroversial is the fact that government expenses increased a lot after the ousting of James II all the way to 1815, were government spending decreased after the end of the Napoleonic Wars. This increase in government expenses was so large that, despite the steady increase in total revenue per capita coming from taxes (see Figure 2) during this period, government debt still ballooned (see Figure 3). Like most of European countries during this period, the majority of government spending was spent either on the military or on the (Royal) Navy. Indeed, as it has been pointed out in Pincus & Robinson (2011), this came from the fact that Whigs were the dominant force in the Parliament during the 18th century. While Tories were more inclined to limit the reach of the state, Whigs were more content to give a large role to the latter.

Few historians (and much less economists) are wont to put forward the positive role played by such a large increase in military expenditures. To the extent that the latter are considered a waste of money, they must have displaced large sums of capital which could otherwise have been invested in productive activities. Therefore, it is often considered that Great Britain became the first industrial nation *in spite of* having spent so much on the military and the navy. To the contrary, some historians are pushing forward the idea that, in times of mercantilist competition, having the most powerful navy gave a huge advantage to British manufacturers. Indeed, pirates and privateers from competing countries were an ever-present threat to any company wanting to ship goods abroad. While English understood that large profits could be made

by having a strong navy as far back as 1650 they just couldn't master the seas. What the explosion of government spending gave them after 1688 was the effective means to pursue this ambition.

This was by no means a smooth transition however. While Dutch naval power had been hindered through the series of 17th century Anglo-Dutch wars, the British Navy still had to compete with the Spanish one. In addition, French naval power also grew for a couple of decades after the Peace of Utrecht (1713). That was to last until 1739 and the War of Austrian Succession (1740-48), during which Britain forces intervened mostly on the continent to check French hegemony there. As far as Great Britain is concerned, the objective was to keep the french busy on the continent so that they do not devote much resources to naval power. The Seven Years' War (1754-1763) saw British overseas trade actually *expand* (it usually decreased during wars) amid a series of victories by the British military. It is only after 1760 that Great Britain had the means to effectively pursue its goal of an effective 'Blue Water' Policy (**?**). Under such a policy, military and naval power was used defensively in the continent and aggressively abroad. As a result, while major European powers ended up diminished after a protracted war, Great Britain usually got out stronger than before.

This shows in particular in the fraction of industrial production that was directed at export markets. Esteban (1997) finds that the ratio of industrial exports in volume to industrial production in volume is continuously increasing during the 18th century. In particular, the ratio starts to increase dramatically around 1780. Around this time period, the ratio goes from 0.2 in 1780 to around 0.45 at the end of the Napoleonic Wars.

Acemoglu et al. (2005) argue that the rise in Atlantic trade benefited British merchants (among others), which in turn received much support from Whigs members of Parliament. After James II had been ousted from the throne, Whigs played a very important role in the Parliament, which had now an audit right concerning government expenses. As is developed in detail in Brewer (1989), Whigs members were more inclined to increase the role of the state to help merchants and manufacturers. On the other side, Tories were closer to the landed interests and fought for a limited role of the state. From this perspective, it might seem odd that members of Parliament (mostly Whigs) authorized such a large increase in spending to the military and the Royal Navy if such expenses were wasteful. Assuming that they were acting in their own best self-interest, then we need to explain why they supervised such a large increase in military expenses.

In what follows, I will develop a model that *potentially* gives a positive role

to military expenses in fostering economic development. This will allow me to derive conditions necessary for a large scale investment in military power to generate an sustained increase in productivity.

3 Understanding the Mechanisms

3.1 The Baseline Static Model

The baseline model is an extension of the "Big Push" model of Murphy et al. (1989). In turn, the model builds on Rosenstein-Rodan (1943) who centers on the role played by aggregate demand externalities. The basic idea is the following : if one firms pays a fixed cost and industrialises, she might not have enough demand to make positive profits. In addition, by producing more efficiently and/or on a larger scale, the firm might generate more demand for others firms. This creates room for multiple equilibria since individual firms do not internalize the fact that by industrialising they raise the demand for other firms. Therefore, while it might not be profitable to be the only one to industrialise, if everybody else does it is likely to be profitable from an individual perspective. Thus, there is a coordination issue. Murphy et al. (1989) focus on a closed economy and present different models in which firms that industrialise generate more demand for other firms, which results in multiple equilibria. There is then a role for the government to try to coordinate the industrialization of many sectors, be it by targeted subsidies or other means.

Following Acemoglu et al. (2005), I will focus on the role played by international trade in promoting industrialization. Instead of putting the emphasis on the role of institutions, I will explore a more direct link through exporter's profits. In my framework, the pecuniary externality will take the following form : there is a large fixed cost needed to build a powerful army / navy, which will grant access to foreign markets. If only one firm pays the large fixed cost, trade opportunities will also benefit other firms that didn't. As such, since the fixed cost is large, the lone firm is likely to make a negative profit. If all firms share the fixed cost however, an individual firm is more likely to get a positive profits if she pays her share of the fixed cost. Depending on how many firms actually pay the fixed cost, the country may or may not experience industrialization. I now move on to the description of the model.

For now, the economy is static and only consists of one period. There is a representative consumer who consumes an array of goods indexed by $q \in$

$[0,1]$ and has the following utility function:

$$\mathcal{U} = \int_0^1 \ln c(q) dq,$$

where $c(q)$ is the amount of good q consumed by the representative consumer. Let $p(q)$ denote the price of good q. It follows from the assumption of log utility that when income of the representative consumer is y, the latter will spend exactly y on each good : $y = p(q)c(q)$. The representative consumer has an endowment L of hours, which it supplies inelasticaly. The consumer owns all the firms in the economy so that it earns all of the profits that they eventually make. Taking the wage as the numeraire, the following holds:

$$y = \Pi + L, \tag{1}$$

where Π is aggregate profits in terms of the real wage.

Before introducing the possibility of international trade, I describe the program of the firms in a closed economy. In each sector q, there is a large number of competitive firms that produce using only labor with a one to one technology (i.e, they have constant returns to scale). As in Murphy et al. (1989), these firms will be referred to as cottage production. There is also a *unique* firm in each sector which has access to a technology with increasing returns. This technology enables the firm to *potentially* produce $\alpha > 1$ units of goods with one unit of labor. To operate this technology, the firm has to pay a fixed cost of F. As in Murphy et al. (1989), this type of firm will be called a monopolist.

In each sector q, the monopolist chooses whether it wants to operate the increasing returns technology or not. To do so, the monopolist maximizes its profits, taking into account that the total real demand for its product is equal to y. Ideally, the monopolist would want to set an infinite price. However, if he sets a price higher than 1, it will loose all its demand to the competitive firms. In the end, the monopolist sets a price of 1. When the income of the representative consumer is y, the profit of the monopolist is then given by:

$$\pi = (1 - x - \frac{1}{\alpha})y - F \equiv ay - F, \tag{2}$$

where $x \in [0,1]$ is the "expropriation rate" in this economy. It reflects the fact that the firm may see a fraction of its output seized if it decides to operate the new technology. In his famous book, Olson (1982) gives an example in Imperial China. There existed a strong guild of producers, each using a low productivity technology and thus resembling the competitive firms in our setup. When one individual started to produce more efficiently and on a larger scale, the guild members gathered in his factory and bit him each in turn until he

was dead. This type of economy would be reflected by a value of x close to 1. In contrast, an economy with a low value for x will resemble an economy with inclusive economic institutions, such as the ones that are the success stories in Acemoglu et al. (2012).

It should also be noted that I take technology as given and focus on the incentives for monopolists to adopt it. As has been described at length by J.Mokyr, the unique relationships between engineers and the scientific establishment during this period played an important role in the development of new technology like steam power, the spinning jenny and the substitution of animate power (humans and animals) for inanimate power (machinery) in general. While it is essential for my purpose that such a technology actually exists, I will focus on what pushed entrepreneurs to actually adopt those technologies.

If a fraction n of the firms adopt the new technology, aggregate profits will be equal to:

$$\Pi(n) = n \cdot (ay - F)$$

As is shown in Murphy et al. (1989), this model has a unique equilibrium. If it is profitable to industrialise at the individual level —if $ay > F$, then it is profitable at the aggregate level. In this case, the economy will industrialise. If this is not the case, the economy will remain backward. Substituting equation (1) into aggregate profits, the economy will remain backward as long as

Assumption 1 : $aL < F$

holds. That is to say, whatever the level of the expropriation rate, the economy will never industrialise. I will maintain this assumption throughout the paper. It is motivated by the fact that there were several examples of nations or city-states that displayed good economic institutions throughout history, although not one experienced the sustained economic growth and rise in productivity that Great Britain experienced starting at the end of the 18th century. Clark (2014) gives the example of Lubeck and the Hanseatic League, in which cities were ruled by a council mostly composed of members of the merchant guilds.

In what follows, I will add the possibility for firms to finance the government in its building of a large army / navy, which will give access to foreign markets. The positive role of such an investment on demand from abroad is justified on the grounds that often countries that had dominions prohibited other nations to trade with it. Furthermore, nations also financed privateers to attack merchant ships of other competing nations. Therefore, a strong navy

had the double use to defend one's nation ships as well as plunder the ones of its foreign competitors, especially during times of war. In more general terms, the British government also used public monies to finance foreign armies so that no country in continental Europe will emerge as the hegemon and restrict trading opportunities for British merchants (see the example of the Continental System put in place by Napoleon after conquering a large part of Europe at the start of the 19th century in Kennedy (1987)).

3.2 Open Economy

To finance the building of a strong army / navy, each monopolist can make a payment of B. Because the actual payment made by each monopolist does not necessarily end in actually building the army / navy, the effective revenue by the government is equal to

$$B \cdot \gamma, \quad \gamma \in [0,1]$$

where γ is an index of the efficiency of the bureaucracy. In a lot of countries, tax farmers and other intermediates were often needed to collect taxes from different agents and bring it to the central fiscal authority. In the process, the intermediaries take his share so that $\gamma < 1$ in general. A telling example is the case of China under the Qing dynasty (see Vries (2015)). While peasants and merchants were taxed a lot, the actual revenues that ended up in Peking were very small. More often that not, tax farmers and the infamous runners were not employed by the central state and had to make do on their own. As a consequence, large sums of tax money actually remunerated intermediaries instead of ending in the coffers of the state. This has to be contrasted with 19th century Great Britain, in which actual payments were much closer to the revenues of the Central State and the bureaucracy was much more efficient. This would be translated by a value of γ close to 1 in our setup. In the case that n firms actually finance the building of an army / navy, the individual profit of a monopolist is given by:

$$\pi(n) = a\left\{\frac{1}{2} + \theta(nB\gamma - n^*B^*\gamma^*)\right\}(y + y^*) - F - B, \quad 0 < \theta \leq 0.5, \qquad (3)$$

where variables with '*' refer to the foreign economy. As in Hirschleifer (1989) and more recently Gartzke & Rohner (2011), the term in brackets is the 'Contest Success Function'. Indeed, to the extent that consumers at home as well as abroad are indifferent between a good that is produced at home or abroad, the share of total demand captured by the home firm will depend on the *relative* size of its military / navy. The parameter θ measures the importance played by

having a strong military apparel on absorbing foreign demand. In the special case where $\theta = 0$ and $y = y^*$, the monopolist does not pay the cost B and the profit function collapses to the one in equation (2). If, on the other hand, $\theta = 0.5$, then having a strong military apparel is very important for gaining export markets. While the former played an important role in the 18th century, its role declined steadily after and especially during the 19th century (see Kennedy (1987)).

During the 18th century, Great Britain became increasingly implied in conflicts in Europe. Had the Tories dominated the political agenda, this would surely not have been the case. What they wanted was a small state with a Navy that could enforce control of the colonies (see Pincus & Robinson (2011)). The Whigs on the other hand, were more willing to engage in European conflicts to nip French hegemonic ambitions in the bud. The point was often made that should the French ever dominate Europe, demand for British manufactures would decrease substantially. With this in mind, it made sense to have a strong military / navy in Great Britain during this century and might have helped maintaining foreign demand for home products. In terms of the model then, the period might be characterized by a large value of the parameter θ.

For simplicity, assume that both country are of the same size, i.e $y = y^*$. Assume further that only one firm in the home country decides to finance the building of the military apprel. Its profit will be given by:

$$\begin{aligned}\lim_{n\to 0} \pi(n) &= aL - F - \theta n^* B^* \gamma^* - B \\ &\leq aL - F < 0,\end{aligned}$$

where I have used the fact that $y \sim L$ when n is close to zero and the last strict inequality follows from Assumption 1. As a result, it is never profitable for an individual firm to pay alone for the building of the military apparel. The latter will profit to all other firms, but since they do not share the costs, the initial firm will have no incentive to pay alone. In the end, a lone firm paying for the military apparel by itself is never an equilibrium outcome.

From equation (3), it is evident that as the number of monopolists that adopts the new technology grows, the profit of an individual monopolist does also. More specifically, there exists a unique threshold value $\tilde{n}$ such that if at least $\tilde{n}$ monopolists adopt the new technology, then it is profitable for anyone else to do so. Formally, $\tilde{n}$ is given by the following expression:

$$\tilde{n} = \frac{1}{B\gamma}\left\{ n^* B^* \gamma^* + \frac{1}{\theta}\left(\frac{B+F}{a(L+y^*)} - \frac{1}{2} \right) \right\}.$$

To make things interesting, I assume that the various parameters are such that

$\tilde{n} > 0$. Aside from B, the effect of the different coefficients is quite straightforward. If $n^* B^* \gamma^*$ is large, which means that the foreign country has a powerful army, a larger number of firms need to finance the building of the military apparel. The larger is F, the larger the fixed cost associated with the implementation of the new technology. Therefore, as individual profits increase with n, a larger number of firms investing in the military apparel is needed to cover the costs. The more efficient the bureaucracy (γ is high) and the more important the military apparel is for gaining export markets (θ is high), the lower the number of firms investing in it is needed for profits to be positive. If the military apparel is useless to gaining export markets, then whether the bureaucracy is efficient or not is essentially irrelevant. Conversely, if military power is important but the bureaucracy is incompetent, then it will be harder to achieve industrialization. All of these shortcomings will increase the value of $\tilde{n}$ and if the latter is too high, it will never be profitable for an individual firm to invest in the military and adopt the new technology. Finally, it will be useless to increase the military apparel to gain export markets if the size of the other country is too small, i.e if y^* is low. As such, the home country needs a foreign country that is somewhat developed so that international trade is profitable. These remarks are summarized by the following proposition:

Proposition 1 *The model exhibits multiple equilibria if and only if* $\tilde{n} \leq 1$.

If $\tilde{n} > 1$, it will never be profitable for an individual firm to pay the government for the military and adopt the new technology. As a consequence, the economy will remain backward. To the contrary, if $\tilde{n} \leq 1$, if a firm anticipates that at least $\tilde{n}$ firms will pay the government and adopt the new technology, then it is profitable to do the same.

Instead of putting the emphasis on one specific driver, what the model stress is the interaction between different drivers. If an economy develops a huge navy but there is not much to gain from international trade, then industrialization is not likely to follow.[2] Conversely, inclusive economic institutions are not important in and of themselves, but rather they have to be coupled with the fact that there are profits to be made from international trade (y^* is high). Further, if military power is important (θ is close to $1/2$), then good institutions and a good bureaucracy will be an essential driver for adopting new technologies.

[2]Under the Ming dynasty in China, Emperor Yongle funded a large navy to raid the coasts of Africa, Arabia and South-East Asia under the command of Admiral Zheng He. The actual economic impact of those missions was not evident however and they were brutally stopped by the next emperor. The fleat was left to rot and was not revived for centuries.

What matters ultimately is that the monopolist should expect a large demand for his product in order to cover his fixed cost(s). In this respect, the historical example of Samuel Greg is interesting. A cotton merchant, he started a factory at the banks of the Bollin river, using the force generated by the stream to run his spinning machines. According to his biographer Mary.B Rose, he was "responding to the growing demand for cloth" (as quoted in Beckert (2014)). According to the model, the state can be a potential trigger to such an increase in demand. It is then natural to ask : what was the role of the state in shaping demand for Greg's (and others) manufactures? Quoting again Beckert (2014):

> [...]the power they [Greg and his contemporaries] harnessed in water was only possible because of the power harnessed by war capitalism. Slavery, colonial domination, militarized trade, and land expropriations provided the fertile soil from which a new kind of capitalism would sprout. [...] Greg had deep roots in war capitalism, its violent appropriation of territory and slave labor, as well as its reliance on the imperial state to secure new technologies and markets.

As in the model then, a strong Military-Fiscal state generated a high level of demand, which prompted S.Greg to pay the fix cost and implement a new, more efficient, technology. According to Beckert (2014), it is estimated that he made an initial investment of £3000, or approximately half a million current U.S dollars.

An obvious extension of the model is to include distortionary taxation. In fact, as can be seen from Figure 2, taxes did record a strong increase during the 18th century. During this period, most of the tax receipts came from the excise and custom duties. It is then natural to include distortionary taxation as a sales tax in the model. As such, the tax would end up in the a parameter of the model, with higher taxes generating a lower value for this parameter. In this setup, higher taxes would retard industrialization by increasing $\tilde{n}$, but their impact will be lower the more important is the military apparel for trade. Furthermore, higher taxes will represent a larger military capability, which will also dampen the negative effects of the tax by generating more demand for monopolistic firms.

While the model is parsimonious and thus permits a clear inscpection of the mechanisms, it leaves important questions unanswered. To the extent that there are indeed multiple equilibria, the model does not provide guidance as to which equilibrium will actually emerge. In addition, development is a inherently dynamic process. As such, initial conditions (history) might play an im-

portant role for the onset of large scale industrialization. Following Krugman (1991), I will develop a dynamic version of the model to explicitly consider the relative role of history and expectations.

3.3 A Dynamic Model

I now allow for the number of firms that jointly adopt the new technology and pay the government for building a strong military force to be time-varying. Similarly, I assume that the fixed cost associated to the building of the factory is also time-varying and is equal to

$$F_t = a\left\{\frac{1}{2} + \theta(n_t B\gamma - n^* B^* \gamma^*)\right\} y_t \quad \forall t.$$

This amounts to saying that profits generated at home by the firm adopting the new technology are exactly zero. What this buys me is that now individual profit is a linear function of n_t. Without this assumption, $\pi(n_t)$ would be a highly non-linear function and the dynamics of the model much harder to characterize. [3] On empirical grounds, this is not a crazy assumption because while profits made by the cotton industry at home were very small (see Clark (2014)), the profits of merchants from international trade were very high (see Braudel (1992)). It follows that now individual profits are strictly positive if and only if a firm expects the number of firms to be strictly greater than

$$\tilde{n}_t = \frac{1}{B\gamma}\left\{n^* B^* \gamma^* + \frac{1}{\theta}\left(\frac{B}{ay^*} - \frac{1}{2}\right)\right\}.$$

Now assume that for whatever reason (cultural persistence, path dependence etc.) the economy starts with a number of industrialized sectors equal to $n_0 > 0$. If there is no additional cost associated with setting up a large scale factory (other than the payment to the government for the military), then if all monopolists expect the others to do the same thing, there will be industrialization. In other words, the initial position does not matter at all and the equilibrium is indeterminate. Now if we assume that there are some additional costs associated with industrialization, such as constraints on social mobility, then the initial position will matter. When there is such an adjustment cost related to industrialization, then increasing n_t by a small amount becomes an *investment* decision, since it depends on future expected profits by the industrializing firm.

[3] The same would happen if I assumed that the military apparel would be partially financed by a sales tax. For this reason, I still focus on the case where monopolist finance government debt.

Accordingly, I rewrite total income in the home country as follows:

$$y_t = \pi(n_t)n_t + 1 - n_t - \frac{\dot{n_t}^2}{2\phi}. \tag{4}$$

The first term is profit generated by the firms that finance the government and adopt the new technology, of which there is a measure n_t. The second term is the income of workers employed in competitive sectors. Because of constant returns to scale, the wage is equal to 1 and the total wage bill is thus $1 - n_t$. Finally, the last term represents the quadratic adjustment cost, where $\dot{n_t}$ stands for the time derivative of n_t and $1/\phi$ measures the level of the adjustment cost.

I follow Krugman (1991) and assume that individuals are able to borrow or lend at a given constant world interest rate of r. The fact that it is constant will be helpful to determine the dynamics of the model. We can think of different monopolists as a pool, the objective of which is to maximize the discounted sum of future output

$$\int_0^\infty y_t e^{-rt} dt. \tag{5}$$

The Hamiltonian of this optimal control problem is given by:

$$H_t = y_t + q_t \dot{n_t},$$

were q_t is the co-state variable and is the value of having one more (infinitesimally small) monopolist adopting the new technology. The two optimality conditions for this maximization program are given by:

$$\dot{n_t} = \phi q_t \tag{6}$$

$$\dot{q_t} = rq_t - \pi(n_t) + 1 - \pi^{'}(n_t). \tag{7}$$

This system of equations nests the one obtained by Krugman (1991), in which firms do not take into account the effect of n_t on profits. To make further progress however, one has to specify the actual functional form of $\pi(n_t)$. In Krugman (1991), this is assumed to be an ad-hoc function, whereas in this model it is given by maximization of profits by each monopolist. Before characterizing the dynamics explicitly, we can see that there are two potential solutions to this program.

If the roots of system are such that there is a unique equilibrium, then history determines everything. If $n_0 > \tilde{n}_0$, it is profitable for all firms to invest in the government sponsored military and adopt the new technology, so that $\lim_{t\to\infty} = 1$. Conversely, if the economy starts at $n_0 < \tilde{n}_0$, we will have $\lim_{t\to\infty} = 0$ and the economy will experience declining industrialization. In this model, history determines everything and there is no room for multiple

equilibria in the long run. In each case, the initial value of q, which is a jump variable, will adjust so that the transversality condition of this model is respected and the economy will go along its saddle path.

If the roots of the system are such that there are multiple equilibrium, then expectations will play an important role. I what follows, I assume that the parameters are such that the system has a unique equilibrium. Specifically, we can rewrite the expression for profits as:

$$\pi(n_t) = \beta n_t + \delta,$$

where $\beta = a\theta B\gamma y^*$ and $\delta = a(\frac{1}{2} - \theta n^* B^* \gamma^*)y^* - B$. Then it follows that the system is saddle-point stable if $r^2 > 4\beta\phi$. The phase diagram of the dynamic system can be represented as in Figure 1. What is important is that the $\dot{q}_t = 0$ locus crosses the abscissa at $n_t = \overline{n}$, where

$$\overline{n} = \frac{1-\delta}{2\beta}.$$

Therefore, if the parameters are such that $\overline{n} < n_0$, the economy will steadily converge to $n_\infty = 1$. For this to happen, the bureaucracy has to be efficient (γ is high) while the foreign country's one does not (γ^* is low). To the extent that the foreign country is not powerful enough to encroach on the home country's trade —if $\frac{1}{2} > \theta n^* B^* \gamma^*$, better institutions (a higher a) and a larger foreign economy (a higher y^*) lower the threshold for industrialization. On the contrary, if the foreign country is powerful enough, industrializing will generate negative profits and thus will not happen. This is all the more true as military spending is important to gain export markets (when θ is high).

The home economy with a low $\overline{n}$ looks very much like England and later Great Britain in the century following the glorious revolution. If we think of this revolution as a rise in γ which enabled the state to effectively build a strong army, then the model says that this may be what put this country on the path of industrialization. Quoting Brewer (1989):

> Though my account is very much concerned with war, it deals with bookkeping not battles, with ink-stained fingers rather than bloody arms. Its focus is upon administration, on logistics and, above all, on the raising of money. Its heroes, if any there are, are clerks in offices.

Along the way, we will see a rise in aggregate productivity, which is given by $n_t \cdot \alpha$ in this model. Consistent with empirical evidence, the level of debt will increase as well (it is given by Bn_t) and the share of profits in national income $n_t\pi(n_t)/y_t$ will also.

While the Industrial Revolution was earlier thought of as a radical breakthrough, recent historical research points to a more gradual phenomenon (see Crafts & Harley (1992)). In Figure 1 I have diplayed a saddle path that has this property. After the condition for the start of theindustrial revolution is reached, much of the adjustment is done through the co-state variable q_t. As n_t converges to its steady state value of 1, growth in productivity accelerates. Formally, we can use equations (6) and (7) to get the low of motion for n_t:

$$\ddot{n}_t = r\dot{n}_t - \beta n_t + 1 - \delta - \beta. \tag{8}$$

For simplicity, consider the case where $\delta + \beta = 1$. In this case, a gradual adjustment for the rise in productivity will occur iff

$$\ddot{n}_t > 0 \quad \Leftrightarrow \quad \frac{\dot{n}_t}{n_t} > \frac{\beta}{r}.$$

This condition will be satisfied if r is high and/or the elasticity of individual profit with respect to one more monopolist using the new technology is low.

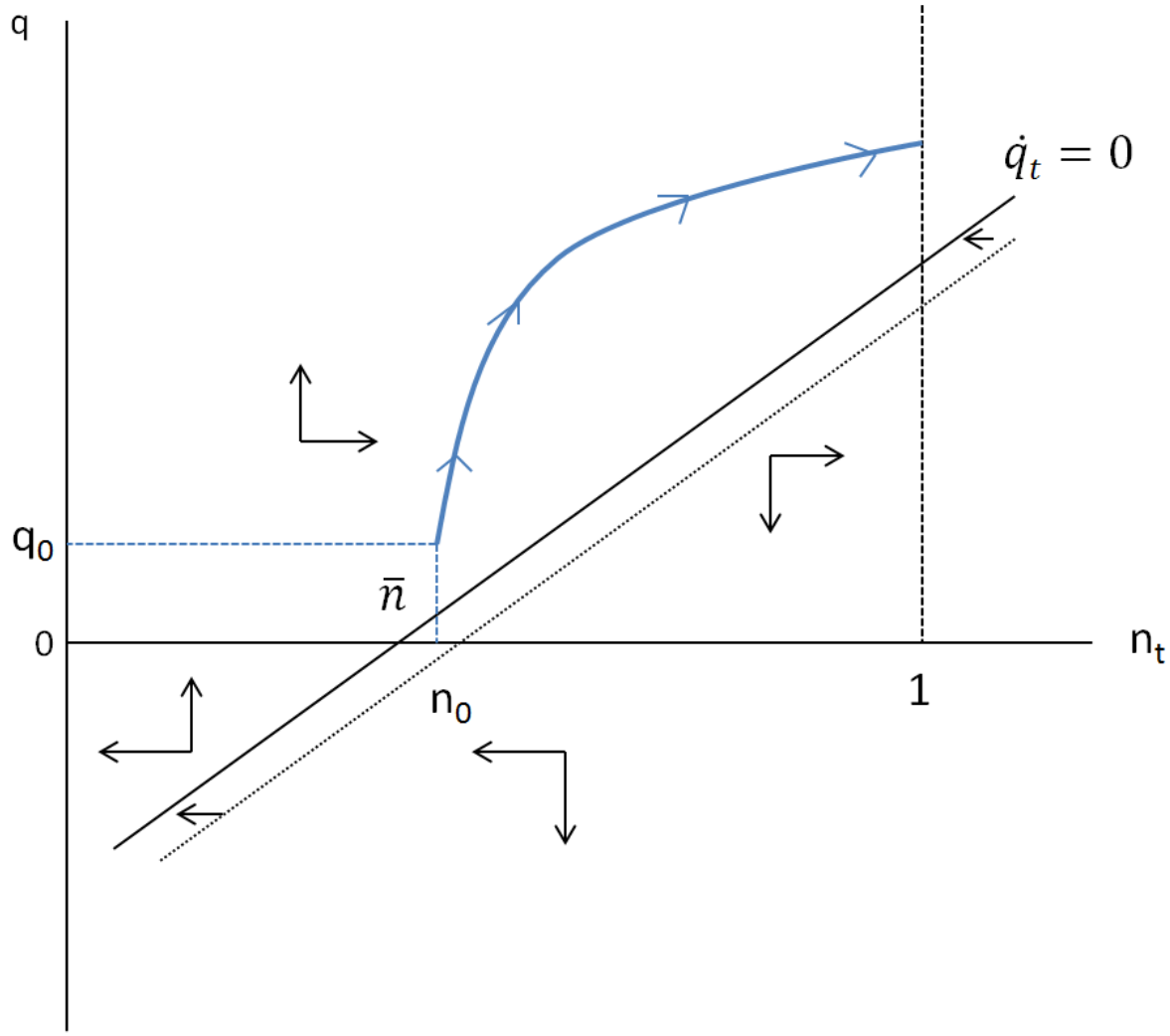

Figure 1: Dynamics of Industrialization after 1688 Glorious Revolution

We can also look at a model from a different perspective, i.e the one of the foreign country which we have taken as given up until now. What was notable as Great Britain grew more and more during the 19th century is that a parallel phenomenon of *de-industrialization* occurred in other countries, like China and India. Quoting Kennedy (1987) (emphasis is mine):

> Not only did their [India and China] shares of total world manufacturing shrink relatively, simply because the West's output was rising so swiftly; but in some cases their economies declined absolutely,

that is, they *de-industrialized*, because of the penetration of their traditional markets by the far cheaper and better products of the Lancashire textile factories.

This is evident from Figure 4, which uses data from Bairoch (1982). At the same time as per capita industrial production in the UK increases, it decreases in India even though it is starting already from a very low level.

Assume that now India is the home country. If the foreign country is increasing its military expenditure and is colonizing you on top of that, then as an individual firm you stand to make negative profits if you want to adopt the new technology. From the perspective of the model, the development of Great Britain will be reflected by an increase in $\overline{n}$, which will make it harder for the home country to industrialize.

At the end of the day, the way the model is set up gives a role for the state to promote industrialization at the national level. At the international level however, this will foster *de-industrialization*.

Another take away from the model is that *size matters*. As such, it became increasingly difficult for city states like Venice to compete with nation state and empires. Indeed, the demise of the Venetian economy can be seen as a consequence of the increasing influence of ships from the Ottoman empire in the Mediteranean see. Due to its sheer size, the Ottoman empire had much more resources to devote to military / navy power. In more general terms, the city-state as an institutional construct started to disappear as war involved an increasing amount of resources over the centuries (see Tilly (1990)).

4 Conclusion

The take off of the British economy is often associated with *laissez-faire* policies. As the story goes, a small government mainly concerned with maintaining law and order left private agents more incentives to pursue their own self-interest. However, historical data and accounts tell a more nuanced story.

The British government can not by any means be said to be small considering the impressive increase in taxation, government spending and public debt during the 18th century. It is however true that this large build up was mainly used for coercion towards colonies and competing states, while at home the state did not encroach much on economic activity. This permitted British en-

trepreneurs to pursue free enterprise at home, while enjoying a large demand from outside markets. In turn, this demand might have fostered the implementation of more efficient techniques that had been developed throughout the 17th and 18th centuries.

Naturally, other forces were surely at work during the First Industrial Revolution in Great Britain. In particular, the model developed here is silent on the dynamics of population and human capital accumulation that have been put forward in the recent literature on Unified Growth Theory. As such, this paper main result is to show that increased spending on military and navy might have helped rather than impeded industrialization in Great Britain during the 18th century.

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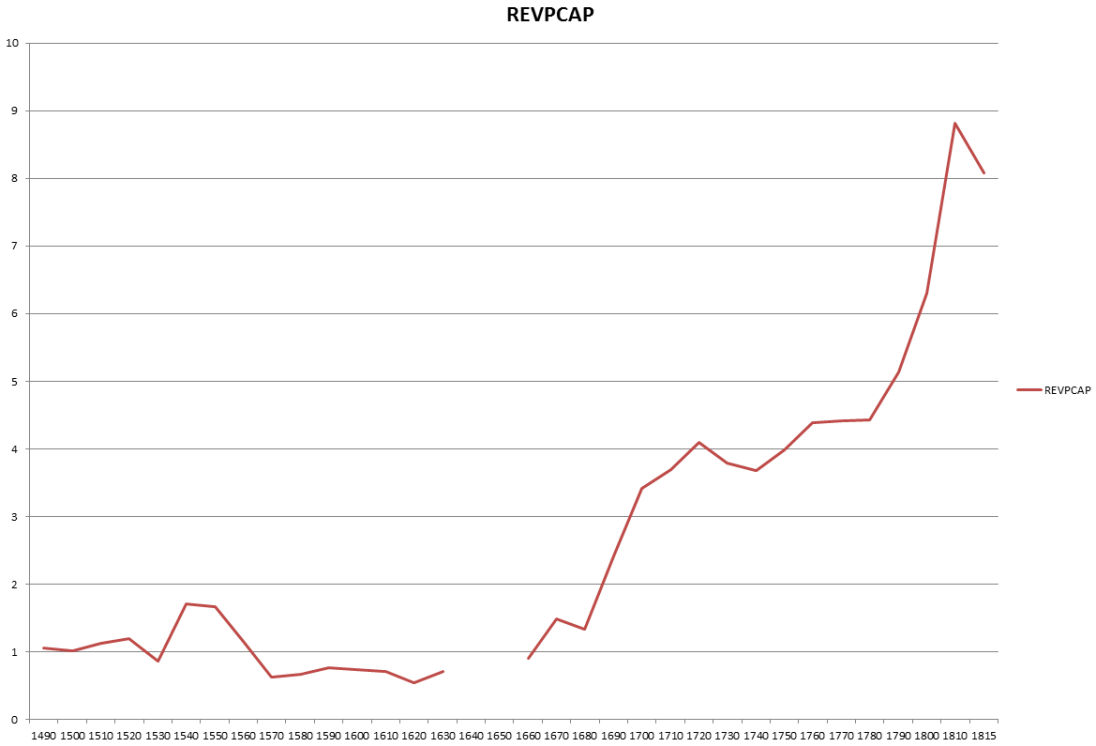
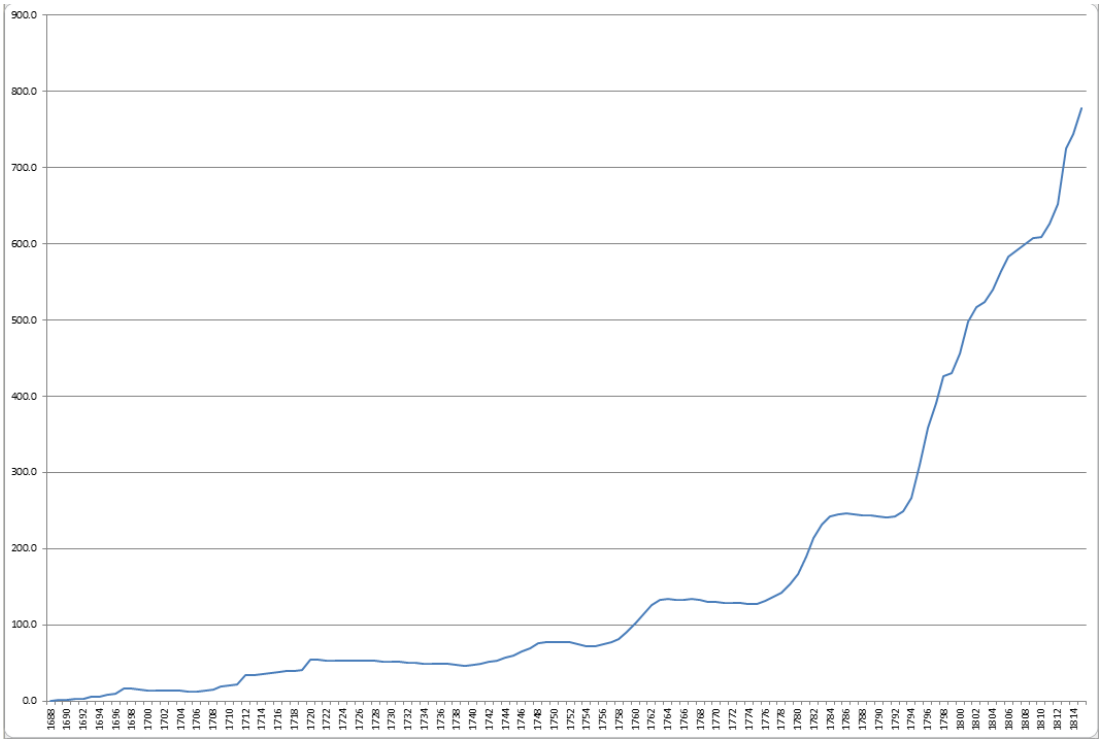
A Figures

Figure 2: Total Revenue Per Capita, England 1490-1815 (in constant prices of 1451-75) (Nine-year moving average)



Source: O'Brien, Patrick K. and P.A, Hunt (1999) "England 1485-1815," in Richard Bonney ed. The Rise of the Fiscal State in Europe, 1200-1815, Oxford: Oxford University Press. Data avilable at: `http://esfdb.websites.bta.com/table.aspx?resourceid=11287`

Figure 3: Nominal or Par Value of National Debt (1688-1815)



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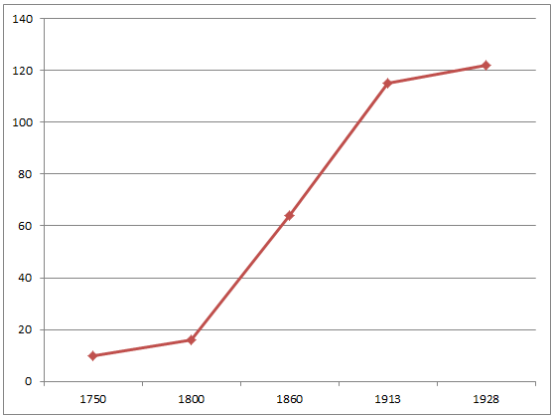
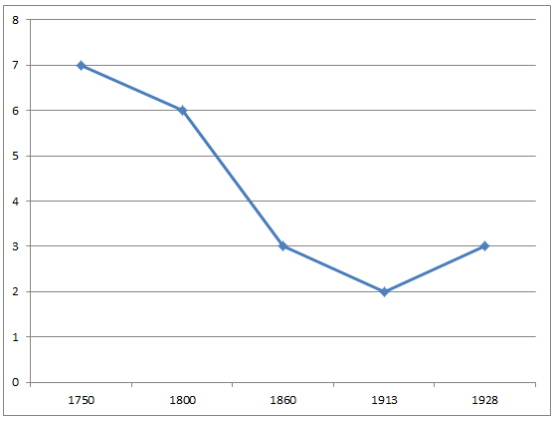
`http://www.bankofengland.co.uk/research/Pages/onebank/threecenturies.aspx`



(a) UK



(b) India

Figure 4: Per Capita Levels of Industrialization (UK 1900 = 100) in UK and India. Source Bairoch (1982)

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