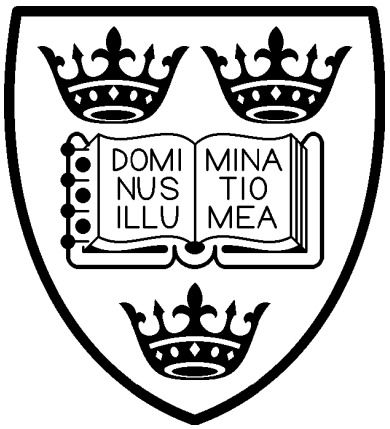

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GROWTH, IMPORT DEPENDENCE AND WAR

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Growth, Import Dependence and War

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Abstract

Existing theories of pre-emptive war typically predict that the leading country may choose to launch a war on a follower who is catching up, since the follower cannot credibly commit to not use their increased power in the future. But it was Japan who launched a war against the West in 1941, not the West that pre-emptively attacked Japan. Similarly, many have argued that trade makes war less likely, yet World War I erupted at a time of unprecedented globalization. This paper develops a theoretical model of the relationship between trade and war which can help to explain both these observations. Dependence on strategic imports can lead follower nations to launch pre-emptive wars when they are potentially subject to blockade.

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1 Introduction

This paper develops a model of trade and war that speaks to two distinct literatures. The first is the literature on whether or not more trade helps reduce the likelihood of warfare. The argument that it does so sits uneasily with the observation that World War I erupted at a time of unprecedented globalization. The second is the literature on war between established and rising powers. A typical prediction is that the established power (or leader) may launch a pre-emptive war against the rising power (or follower), since the latter cannot credibly commit to not use their increased power in the future. And yet it was Japan who attacked the West in 1941, not vice versa.

Our model can help to resolve both apparent paradoxes. We show that import dependence can lead a follower country to lauch pre-emptive wars against the leader if two conditions hold. First, the imports concerned must be strategic in nature. Second, the country must be vulnerable to blockade in the event of war. The model can thus be regarded as a formalization of arguments about trade and war made by some realist scholars in the international relations literature.

Ours is a model of hegemonic war, and hegemonic wars are too infrequent for our arguments to be testable econometrically. We therefore provide a brief historical narrative in which we show how our model can help to make sense of three historical episodes: Anglo-German rivalry prior to World War I; Hitler's expansionist ambitions, and his decision to attack the Soviet Union in 1941; and Japan's decision to attack the West later in the same year. The argument is not that our model "explains"the outbreak of World War I or World War II: we are careful to note how history was more complicated than allowed for in our model. We do however hope to convince the reader that the mechanisms identified by our model were an important factor in all three cases, and that trade dependence can sometimes make war more rather than less likely.

1.1 Trade and war

The optimistic, liberal argument that international trade promotes peace is an ancient one. According to the fourth century rhetorician Libanius:

> God did not bestow all products upon all parts of the earth, but distributed His

> gifts over different regions, to the end that men might cultivate a social relationship because one would have need of the help of another. And so he called commerce into being, that all men might be able to have common enjoyment of the fruits of the earth, no matter where produced.[1]

Much later, Montesquieu famously wrote that "Commerce... polishes and softens (adoucit) barbarian ways",[2] and that "the natural effect of commerce is to lead to peace. Two nations that trade together become mutually dependent; if one has an interest in buying, the other has one in selling; and all unions are based on mutual needs".[3] It is not surprising that Marx ridiculed this notion of *le doux commerce* (Hirschman 1977, p. 62), given that Montesquieu was writing at a time when mercantilist nations were going to war to establish control over profitable long-distance trade routes, with slaves and the commodities they produced being among the most profitable of these trades (Findlay and O'Rourke 2007). Nevertheless, the idea has been durable and influential, not just among academics, but among policy makers, from Cobden to Monnet and beyond, as well.

Trade has been supposed to lessen the probability of war in several ways. First, it restrains the passions (Hirschman 1977); in more economistic terms, it changes preferences such as to make war less likely. Second, even when preferences remain as nationalistic as before, trade creates benefits that will be foregone in the event of war. By raising the opportunity cost of war (Glick and Taylor 2010), it makes it less likely. Third, the incentives which politicians face to preserve the benefits associated with trade can lead to the creation of international institutions, which can themselves help to maintain an open and peaceful international system (Mearscheimer 1990, pp. 42-43).

The argument is a controversial one, however (for a brief survey, see Barbieri 1996, pp. 30-34). While some realist scholars deny the relevance of trade to the issue of international conflict, on the grounds that war and peace are solely determined by security concerns, relative power, and so forth, others have argued that trade makes war more likely. A frequent theme is that trade can make countries dependent on others, and therefore vulnerable, in the context of an anarchic world

[1] Quoted in Irwin (1996, p. 16), who provides a brief summary of the doctrine.
[2] Quoted in Hirschman (1977, p. 60).
[3] Hirschman (1977, p. 80).

in which countries have fundamentally different interests. In the words of John Mearsheimer, "states will struggle to escape the vulnerability that interdependence creates, in order to bolster their national security. States that depend on others for critical economic supplies will fear cutoff or blackmail in time of crisis or war; they may try to extend political control to the source of supply, giving rise to conflict with the source or with its other customers" (Mearsheimer 1990, p. 45). There is a critical difference between international and domestic trade, argues Kenneth Waltz: regions within a country "are free to specialize because they have no reason to fear the increased interdependence that goes with specialization", whereas in an anarchic world, states may fear specialization on the grounds that their potential competitors may gain more than they do, or because trade makes them "dependent on others through cooperative endeavors and exchanges of goods and services" (Waltz 1979, pp. 104, 106; see also Gilpin 1981, p. 220).

The relationship between trade and war has been subject to extensive statistical testing in recent decades (for recent contributions, see Martin, Mayer and Thoenig 2008, and Harrison and Wolf 2012). Using dyadic trade data for the period 1950-2000, Martin et al. find that higher bilateral trade between two countries lowers the probability that they will go to war; but that the more either of these countries trades with third parties, the greater is the probability that they will go to war (since their trade will be less disrupted overall in the event of a bilateral war).

Statistical analyses such as these are extremely informative. However, by definition they tell us something about average correlations. Individual deviations from average experience are particularly important when what we are talking about is warfare - especially if the war in question is a world war. World War I, for example, erupted at a time when the world economy was integrated to an unprecedented extent (O'Rourke and Williamson 1999, Rowe 2005, McDonald and Sweeney 2007). In this paper we develop a model which shows one way in which late 19th century globalization might have made the world a more dangerous, rather than a safer, place.

1.2 Leaders and followers

There is a large literature on hegemonic wars between rising challengers and dominant powers, most famously Gilpin (1981). International trade enters into Gilpin's account, in that the fundamental issue at stake in these wars is the nature of the international system, of which the

international economic system is an important component. But trade is neither the fundamental trigger for hegemonic wars in his account, nor a reliable restraint on such wars occurring: they result from the catch-up of followers on leaders, and the changing marginal costs and benefits of adhering to, protecting, and challenging the status quo.

The aim of the present paper is to develop a model of war and trade that speaks to the literature on hegemonic warfare, by showing that when there is economic and military convergence of followers on leaders, trade can be critical in sparking war. It does so in the context of a recent literature on "rationalist explanations for war" (Fearon 1995, Powell 2006). This literature starts from the premise that wars are costly, and that rational unitary states in dispute with each other should therefore be able to bargain their way to compromises that leave both better off (in probabilistic terms) than they would be in the event that war breaks out. Powell (2006) argues that wars can nevertheless arise as a result of commitment problems. He does so in the context of models in which a pie has to be divided between countries in a setting where (1) countries cannot pre-commit to particular divisions of the pie in the future; (2) countries have the option to launch a war to "lock in" an expected share of future flows; (3) wars are costly, in that they reduce the overall size of the pie; and (4) the distribution of power, which affects how much of the pie countries can lock in, changes over time (p. 181). For example, Powell considers the case in which a follower catches up on a leader for reasons that are not explained in the model. The follower has an incentive to forestall a pre-emptive war by the leader, by promising the leader a sufficiently big slice of the pie in the future. Since it cannot pre-commit to this, and indeed will have an incentive to use its greater power in the future to secure a greater share of the pie, the leader may chose to launch a pre-emptive war in order to lock in a higher share of the spoils while it still has the chance.

In this paper, we develop a model of trade and war in the context of a world in which a follower is catching up on a leader. While our model resembles Powell's, our conclusions are different. Rather than the leader declaring pre-emptive war on the follower, we find that it is the follower who may declare war on the leader, precisely because it is catching up. International trade, and the opportunities and vulnerabilities which it implies, are central to establishing this otherwise counter-intuitive result. Unlike much of the existing literature on trade and war, which just

looks at aggregate trade flows between countries, we take seriously the idea that the structure of international trade matters. Central to our analysis is the assumption that both the leader and the follower need to import raw materials from the rest of the world.

As the follower catches up, it becomes increasingly dependent on imported raw materials, and thus increasingly vulnerable to being cut off from them. We assume that the leader, as befits the hegemonic power, can control the follower's access to raw materials, either because it controls the sources of supply (via formal or informal empire), or because it controls world shipping lanes and is capable of mounting a blockade of the follower. We find that the follower can have an incentive to start a war, to avoid becoming too dependent in the future on natural resources which the leader controls. This is contrary to the standard prediction of the literature on pre-emptive war that it is the leader who has an incentive to start a war (Fearon, 1995, pp. 385-386).

While we borrow our basic theoretical mechanism from the existing literature, our application of these ideas is novel. The paper closest in spirit to ours is Copeland (1996), who constructs a similar argument in which pessimistic expectations of future trade levels can lead trade-dependent countries to declare war. Our contribution is different from his, in that we provide a formal theoretical analysis, which he does not. This means among other things that we can endogenously figure out where these trade expectations come from. We also tell a story in which the process of catch-up, and the strategic nature of trade, play central roles.

1.3 Further related literature

In a recent paper, Acemoglu et al. (2012) present a formal, dynamic model of resource trade and war. Their paper focuses on how, in the presence of an inelastic demand for resources, progressive depletion may increase the value of a resource-rich region, thus increasing the incentives for a resource-scarce country to invade the country the region belongs to (and thus appropriate the resource). The paper studies how different market structures in the natural resource industry - perfectly competitive, or monopolistically controlled by the government of the resource-rich country - may be associated with different probabilities of war. However, while the main focus of their paper is on wars between resource-rich and resource-scarce countries, ours is on wars

between resource-scarce industrialized countries.[4]

Finally, our paper is broadly related to a series of papers by Stergios Skaperdas and co-authors (see Garfinkel et al. 2011 for a good overview) which study the pattern and welfare implications of trade in a context in which two countries may fight over a contested region. The focus of these papers, however, is different from our own: they present static models of the impact of trade (between the two countries and the rest of the world) on the incentives for the two countries to arm and go to war over the contested region. Ours, on the contrary, is a dynamic model of trade between the two countries and the rest of the world, where the dynamics of relative power and trade dependence determine the likelihood of war.

2 Model description

We consider a world with two industrial countries, L and F (for "Leader" and "Follower"), and a third resource-rich country C. To fix ideas, we can identify L and F with early twentieth century Britain and Germany, and C with the rest of the world.

2.1 Economic environment

In both L and F, a final good, z is produced using two inputs, an "industrial input" y and "raw materials" x. The industrial input can be interpreted as all productive inputs (capital, labour, land) that need to be combined with raw materials to produce GDP. It may also include raw materials that exist in abundant supply domestically, in which case x would represent raw materials that need to be at least partially imported. For brevity, we refer to the two inputs simply as industrial input and raw materials in what follows. The production function is:

$$z = \min [y, x] . \tag{1}$$

In words, we need exactly one unit of the industrial input and one unit of raw materials to produce one unit of GDP. If an economy has access to less of one input than of another in any

[4] In somewhat related work, Caselli et al. (2013) find that war between pairs of countries is more likely when at least one country has natural resources, and when these are located near borders.

period, then GDP in that period is equal to the lower of the two inputs, and the excess of the other input is effectively wasted.

The industrial input is not produced; rather, it is something with which economies are endowed. Raw materials are also given by endowments, in the sense that there is a maximum amount that each country can extract in each period at a marginal cost c (which we assume to be constant). Extraction beyond that amount involves an arbitrarily high marginal cost, and is therefore unfeasible. We assume that it costs less than one unit of the final good to extract one unit of raw materials: choosing the final good as the numeraire, $c < 1$.

There is an infinite number of periods, $t = 1, 2, ..., \infty$. At all periods, country C is endowed with an infinitely large endowment of raw materials and with nothing else. As for L and F, their endowments in the first two periods are:

$$\begin{aligned} \overline{y}_1^L &= Y & \overline{y}_2^L &= g_y Y \\ \overline{x}_1^L &= r^L Y & \overline{x}_2^L &= g_x r^L Y \\ \overline{y}_1^F &= bY & \overline{y}_2^F &= a g_y Y \\ \overline{x}_1^F &= r^F Y & \overline{x}_2^F &= g_x r^F Y, \end{aligned} \tag{2}$$

where $g_y \geq g_x \geq 1$, $a \geq b > 0$, $r^L \in [0, 1)$ and $r^F < [0, b)$. Endowments in subsequent periods grow at constant rates g_y and g_x in both countries. In words, we are considering an environment in which two economies of any relative size (b unconstrained) first go through a period of catching up in which F may grow faster than L ($a \geq b$), and then reach a steady state in which they grow at the same, constant rate g_y.[5] In both countries, raw materials are scarce relative to the industrial input ($r^L \in [0, 1)$, $r^F \in [0, b)$), and this scarcity either stays constant or increases over time ($g_y \geq g_x$). If we interpret this environment through the lens of the Solow model, steady state growth is driven by technological progress and population growth, whereas catching up is also driven by capital accumulation. As for growth in the endowment of raw materials, this could be driven by a combination of technological progress and an exogenous process of discovery.

We assume that goods are tradable, that domestic inputs of the raw material are the first to

[5]We assume that catching up is limited to the industrial input. We could allow for F's endowment of raw materials to grow faster during catching up than in steady state. As long as this additional growth is not too high, our qualitative results would not change.

be used in production,[6] and that the production of the final good is only feasible in L and F. Taken together, these assumptions imply that, in any period, L and F first extract all the raw materials that they can in that period, and combine it with domestic industrial capital. They then import their residual demand for raw materials from C, to which they export the final good in return.

At the free trade equilibrium, country J's GDP, total demand for raw materials, and total imports are (for $J \in \{L, F\}$):

$$z_t^J = \overline{y}_t^J \tag{3}$$

$$(x_t^J)_d = \overline{y}_t^J \tag{4}$$

$$m_t^J = \overline{y}_t^J - \overline{x}_t^J. \tag{5}$$

Given an infinitely large endowment in C, the international supply of raw materials is perfectly elastic at the marginal cost of production, c. It follows that the free trade price of raw materials is also c. Define "dependence on imported raw materials" as either the share of imports in total demand for raw materials, or as the share of imports in GDP. Using (3)-(5), these two indicators can be written as:

$$\frac{m_t^J}{(x_t^J)_d} = \frac{\overline{y}_t^J - \overline{x}_t^J}{\overline{y}_t^J}$$
$$\frac{cm_t^J}{z_t^J} = c\frac{\overline{y}_t^J - \overline{x}_t^J}{\overline{y}_t^J}.$$

Figure 1 shows both indicators increasing monotonically over time - converging to 1 and c respectively. (The graph is drawn for the case of the leader, but the same is true for the follower once it has reached steady state.) This suggests that dependence on imported raw materials also increases over time. For future reference, we notice that dependence increases faster, the larger is the ratio $\frac{g_y}{g_x}$.

[6] Equivalently, we could have assumed infinitesimally small transportation costs.

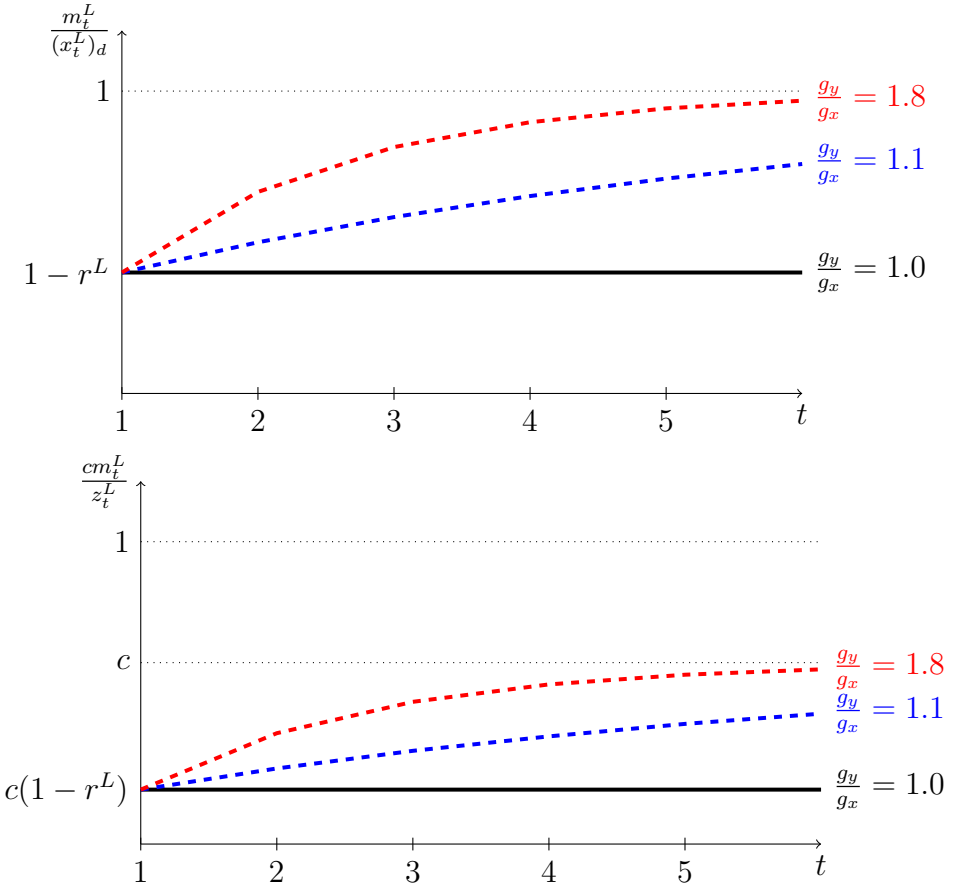

Figure 1: Country L, evolution of imports of raw materials.

2.2 Import dependence and relative military power

L and F may go to war, and we will expand on this in the next section. In this section, we describe how the probability that each country wins the war depends on the two countries' economies.

Suppose that there is a war in period t. The probability that F wins is:

$$q_t^F = \frac{A_t^F}{A_t^F + A_t^L}, \tag{6}$$

where A_t^J is the size of country J's *military apparatus*. In words, we are assuming that the larger is F's military apparatus relative to L's (the larger is A_t^F relative to A_t^L), the higher is the estimated probability that F wins (and the lower is the probability that L wins).

The size of a country's military apparatus will depend on the amount of productive inputs that the country allocates to it. This will typically include some of the industrial capital and other productive inputs (among which abundant raw materials) included in y, but may also include some of the scarce raw materials included in x. This potential dependence of the military apparatus on imported raw materials makes it important to specify the effect of war on the two countries' capacity to trade. If, for example, a country's military apparatus is highly dependent on imported raw materials, and war completely disrupts its capacity to trade, this will clearly have consequences for the country's capacity to win the war.

In this paper, we consider two alternative cases. The first is a symmetric case in which war does not affect the capacity of either country to trade. In this case, dependence on imported raw materials does not matter for relative military power. The second case is an asymmetric one, in which L may blockade F in times of war, but not the other way around. In this second case, war does not affect L's capacity to trade, whereas it disrupts F's. We believe this is an important case, since hegemonic countries often develop a naval superiority that gives them a superior control of trade routes in case of conflict. In this second case, F's dependence on imported raw materials may have important consequences for relative military power.

In the Appendix, we construct a simple two-sector version of the economy, in which we explicitly model the military sector and its dependence on imported raw materials. Here, we

only report the end-product of that more general model, two reduced-form equations linking the size of a country's military apparatus to its endowment of y and imports of x:

$$A_t^L = \beta \overline{y}_t^L \tag{7}$$

$$A_t^F = \beta \left(\overline{y}_t^F - B\alpha m_t^F \right), \tag{8}$$

where $\beta \in (0, 1)$ is the (constant) share of the endowment of y allocated to the military apparatus, $\alpha \in \{0, 1\}$ is an indicator variable that takes the value 1 if the military apparatus is dependent on imports of x (and 0 otherwise), and $B \in \{0, 1\}$ is an indicator variable that takes the value 1 if L has the capacity to blockade F (and 0 otherwise). When L does not have the capacity to blockade ($B = 0$), both countries can continue to import any amount of raw materials needed by the military apparatus. In this case, the only constraint on the size of the apparatus is the amount of industrial input allocated to it, which we assume to be a constant share of the national endowment (β). In other words, military power is only dependent on industrial development in this case. When L has the capacity to blockade ($B = 1$), this country may continue to import any raw materials needed by its military apparatus, but F cannot. Thus, L's military apparatus is the same as before, whereas F's may be smaller.

Equation (8) distinguishes two cases. When $\alpha = 0$, F's military apparatus is not dependent on imported raw materials. We can think of this (see the Appendix) as a situation in which, although general GDP needs one unit of x per each unit of y consumed, the military apparatus needs y only. This would be the case if strategic raw materials typically needed by the military apparatus (e.g. fuels, metals, essential foodstuffs, etc) exist in abundant supply domestically and are therefore included in y, whereas x (and therefore m) is made up of non-strategic raw materials (e.g. luxury foodstuffs, etc). In this case, F may still be prevented from importing raw materials during a war, but this does not matter for relative military power. When $\alpha = 1$, F's military apparatus is dependent on imported raw materials. In the context of the model in the Appendix, this would be the case if the military apparatus needs exactly one unit of x per each unit of y consumed. In this case, the military apparatus is the recipient of a share β of total imports, and its size is reduced by an amount corresponding to this share when $B = 1$.

The capacity to blockade could be thought of as arising in two ways. It could arise in the context of a world in which C remains independent, but in which L gains control over the trade routes linking C to its industrial rival. In this interpretation, the key determinant of the capacity to blockade is the relative size of the countries' navies: L will have the largest navy, and will then have the ability to blockade F (but not vice-versa). The capacity to blockade could also arise in a world in which L gained colonial control over C. Colonial control would give L the power to deprive its rival of the ability to import raw materials, which is what a blockade means in the context of our model.

We think that the first interpretation is more consistent with the structure of our model. As will become clear below, our central assumption is that the capacity to blockade is indivisible, and is therefore affected by war in a way that it cannot be by peaceful negotiations between the two countries. If L's capacity to blockade originated from the control of colonial empires, it would be quite hard to argue for its indivisibility, since colonial empires can be divided in many different ways. In contrast, negotiations over naval power are much more discontinuous in nature - a navy is either dominant, or it is not - and so it is possible that the *expected* impact of war on naval power cannot be obtained through peaceful negotiations.

The growth path specified in the previous section, together with (6)-(8), imply that there are several possible paths for *relative power*, q_t^F. These are represented in Figure 2.[7] The top panel represents the case in which L does not have the capacity to blockade ($B = 0$). In this case, F's relative power increases from period 1 to period 2 (as F catches up on L) and remains constant from period 2 onwards, after F reaches the steady state. The bottom panel represents the case in which L has the capacity to blockade ($B = 1$). There are two subcases. If imports are not strategic ($\alpha = 0$), relative power follows exactly the same path as in the top panel. If imports are strategic ($\alpha = 1$), the path is (qualitatively) reversed: F's relative power declines over time, and this process is faster, the faster is the increase in F's dependence on imported raw materials.[8]

[7]The figure assumes that there is no war at any time. As explained in the next section, if there is a war in period t, the loser's relative power falls to 0 from period $t + 1$ onwards.

[8]Mathematically, relative power is equal to $q_t^F = \frac{r^F}{(\frac{g_y}{g_x})^{t-1} + r^F}$ in this case.

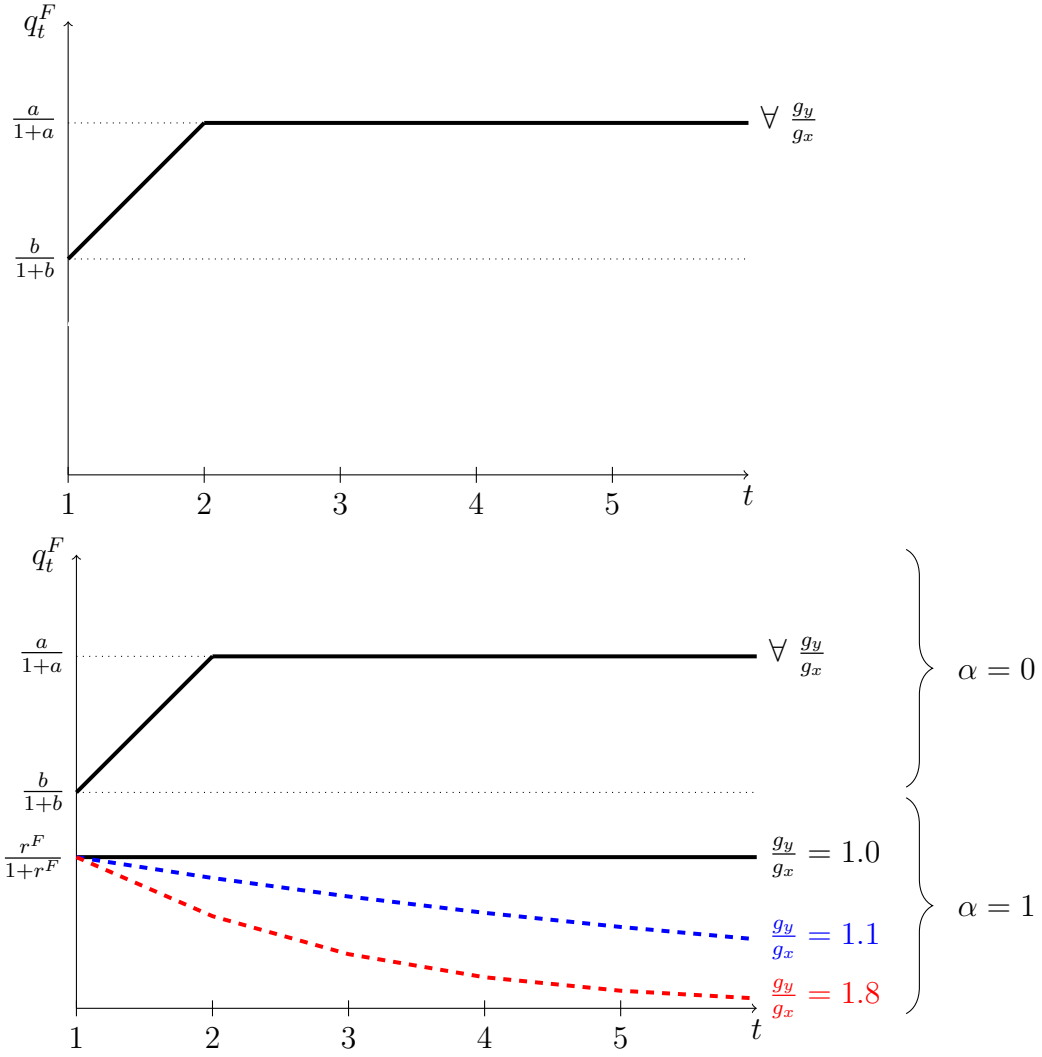

Figure 2: Evolution of relative power. Top panel: case $B = 0$. Bottom panel: case $B = 1$.

2.3 Political environment

Our model follows closely the model of pre-emptive war in Powell (2006). In every period, there is a pie of size 1 that the two countries must partition. The present discounted value of the entire stream of pies is then $P = \frac{1}{1-\delta}$, where $\delta \in [0, 1)$ is the discount factor. The pie may represent a range of contested issues that L and F must settle in each period. These could be non-economic issues, such as the division of overseas territory that matters purely for matters of prestige, or issues that arise because of ideological concerns. Or they could be economic issues, such as the division of territories with an economic value.

The partition of the pie can be done in two ways. On the one hand, in every period t in which there has been no previous war (thus, at least in period 1), the two countries may try to negotiate a *peaceful partition* of the pie. If they reach an agreement, the pie is costlessly partitioned, and the two countries move on to the next period. Alternatively, they may go to *war*. This is won by F with probability q_t^F, and gives the winner the entire current and all future pies. However, war also costs a share k of the present discounted value of all pies. The cost k will depend on a large number of exogenous factors that are idiosyncratic to the specific situation considered. To capture this, we assume that k is drawn, in period 0, from any continuous random distribution with support in $[0, 1]$.

Negotiations to reach a peaceful partition work as follows. First, L decides whether to enter negotiations, or to immediately start a war. In the former case, it offers F a share π_t of the pie. Given this offer, F decides whether to accept, or to reject and start a war. If it accepts, the pie is peacefully partitioned, and the two countries move on to the next period. This structure of negotiations allocates all of the bargaining power to L. That is because by moving first, this country can offer a share making F just indifferent between peace and war. In this way, L can induce F to choose peace, while appropriating the entire surplus from not going to war. We have assumed this extreme distribution of bargaining power just for simplicity: to relax this assumption would not qualitatively change our results.

To summarise, the sequence of events is as follows. In period 0, the cost of war is drawn. Then, in period 1:

1 L can either make a proposal on how to share the period 1 pie, or go to war. If it makes a proposal, F may either accept, in which case the pie is peacefully partitioned, or reject and go to war. If there is a war, this is won by F with probability q_1^F, and the winner gets the entire period 1 pie.

In period $t > 1$:

t If there has been a war at some $T < t$, the winner gets the entire period t pie. If there hasn't been a war, L can either make a proposal on how to share the period t pie, or go to war. If it makes a proposal, F may either accept, in which case the pie is peacefully partitioned, or reject and go to war. If there is a war, this is won by F with probability q_t^F, and the winner gets the entire period t pie.

We assume that, whereas peaceful partition can only allocate the *current* pie, war allocates the current *as well as all future pies*. Without this assumption, war could never happen in equilibrium in the context of our model.[9] To see this, suppose that war only allocated the current pie.[10] Whenever war had not previously occurred, F would accept L's offer if this gave it a (certain) payoff greater than its (expected) payoff from war:

$$\pi_t \geq q_t^F(1-k).$$

But L would always prefer to offer $\pi_t = q_t^F(1-k)$ rather than going to war, since the former option would give it a payoff $1 - q_t^F(1-k)$, while the latter would only give it an expected payoff $(1-q_t^F)(1-k)$. Thus, L would offer $\pi_t = q_t^F(1-k)$, and war would never happen. Intuitively, a costly war can never be optimal when parties can replicate, by means of a peaceful partition, the sharing of the pie that war generates in expectations. This simple example also illustrates that, by moving first, L can appropriate the entire surplus from not going to war.

[9] Skaperdas and Garfinkel (2000) show that, if the cost of arming is taken into account, there is an additional reason why war may occur in equilibrium: because war allocates the pie to the winner in perpetuity, it reduces the future cost of arming. In our model, we assume that both countries only care about the division of the pie. In this environment the channel highlighted by Skaperdas and Garfinkel (2000) is shut down. While one could extend the model to include this additional mechanism, we prefer to leave it out, so as to be able to focus on the one considered in this paper.

[10] For this simple example, we are also assuming that war only costs a share k of the current pie.

In the context of our economic model of military power, the above-mentioned assumption is equivalent to saying that, while peaceful partition does not matter for future military apparatuses and the capacity to blockade, war permanently destroys the loser's military apparatus (and its capacity to blockade, if it has one). Of course, in reality, the difference between the effects of peaceful partition and war will not be so stark. For example, the peaceful partition of territory may well strengthen one country's military apparatus relative to the other's. Similarly, the peaceful partition of overseas empires may strengthen one country's ability to blockade the other, or to defend itself against a blockade. However, even in these cases, it would seem reasonable to assume that the effects of war might be more far-reaching. For example, territory may be just one of many inputs used by the military apparatus, and imperial expansion may not protect a country against the risk of a naval blockade. If this is the case, a war that empowers the winner to dismantle the military apparatus of the loser would probably have more far-reaching effects. To relax our assumption in this sense would not qualitatively affect our results.[11]

2.4 Preliminary results

In this section, we introduce a result that will simplify our analysis in what follows. We begin by introducing the following parametric assumption:

Assumption 1. $r^F \left(\delta \frac{g_y}{g_x} - 1\right) \leq \frac{g_y}{g_x}\left(\frac{g_y}{g_x} - \delta\right)$.

Assumption 1 represents a parametric restriction if and only if $\frac{g_y}{g_x} > \frac{1}{\delta}$.[12] In that case, the assumption requires r^F not to be too large, with an upper limit no lower than $\frac{g_y}{g_x} > 1$. In words,

[11] One additional worry is that countries may be able to use side transfers in negotiations, thus allowing them to redistribute more than the value of the current pie. For example, the pie may represent a piece of territory, but countries may also be able to make concessions on trade policy. There are two reasons why side transfers may not be enough to avoid war. On one hand, if there is any extra value that can be redistributed through side transfers, this might be appropriable by war as well; but if that was the case, the extra value would become part of the pie, and we would then be back to our baseline specification. For example, if war allowed the winner to require trade policy concessions from the loser, the pie would then represent territory plus a settlement on trade policy. On the other hand, unrestricted side transfers may be unfeasible for domestic political reasons: for example, to concede too much to a foreign country may be perceived as dishonourable by public opinion.

[12] If $\frac{g_y}{g_x} = \frac{1}{\delta}$, Assumption 1 is satisfied for all $r^F \geq 0$. If $\frac{g_y}{g_x} < \frac{1}{\delta}$, the assumption can be re-written as $r^F \geq \frac{g_y}{g_x}\left(\frac{g_y}{g_x} - \delta\right)\frac{1}{\left(\delta \frac{g_y}{g_x} - 1\right)}$. Since the RHS of this condition is negative, the assumption is again satisfied for all $r^F \geq 0$.

while we are allowing for the possibility that F is already more powerful than L in period 1 ($r^F > 1$), we are requiring that this superior initial power not be too large.[13] Assumption 1 ensures that, if L has the capacity to blockade and imports are strategic, the decline in F's relative power decelerates over time. In other words, the Assumption ensures that the dashed blue and red lines in Figure 2, which are always decreasing, are also convex.[14]

Under Assumption 1, we obtain the following:

Result 1. *Suppose $B = 0$, or $B = 1$ and $\alpha = 0$. If war does not happen in period 1, it does not happen in any subsequent period. Suppose $B = 1$ and $\alpha = 1$. Along the equilibrium path, if war does not happen in period 1, it does not happen in any subsequent period.*

Proof. In the Appendix. □

The intuition for Result 1 is simple. As we discuss in the next section, countries only want to go to war in this model because they fear that, if they don't, their relative power will decrease over time. But in our economic environment, relative power changes monotonically over time, and its change is always greatest in period 1. To see this, recall that, if L does not have the capacity to blockade or if imports are not strategic ($B = 0$, or $B = 1$ and $\alpha = 0$), relative power only changes between periods 1 and 2, as F catches up and becomes relatively more powerful. If L has the capacity to blockade and imports are strategic ($B = 1$ and $\alpha = 1$), relative power changes in every period, as F becomes progressively less powerful. Under Assumption 1, however, this change is greatest in period 1.[15]

[13] Recall from equation (8) that, if imports are strategic and H has the capacity to blockade ($\alpha = B = 1$), the size of F's military apparatus is proportional to $r^F Y$. Notice that b (and thus, absent Assumption 1, $r^F < b$) can take any positive value in our setting. In words, the fact that F is a "follower" means that it grows faster than L, but not necessarily that its economy is initially smaller.

[14] Without Assumption 1, the decline in F's relative power would accelerate until some period $T > 1$, and decelerate thereafter. In that case, if war ever happens, it would have to happen in some $t \leq T$. Our results regarding the economic conditions that lead to war would remain qualitatively the same, but the more general timing would greatly complicate the equilibrium.

[15] In the former case, F's relative power is constant from period 1 onwards, whereas in the second case, it keeps decreasing. This explains why there can *never* be a war after period 1 in the first case, whereas in the second case this is only true *along the equilibrium path*. See the proof of Result 1 for further details.

3 Equilibrium

In this section, we derive conditions such that war may occur in period 1. We begin by characterising the equilibrium for a given evolution of relative military power (q_1^F and q_2^F), and we then look at how the evolution of military power (and thus the equilibrium) depends on the characteristics of the world economy.

Suppose that L has offered F a share π_1. The expected payoff to F from rejecting L's proposal and going to war is:

$$V_1^F(W) = q_1^F P(1-k),$$

which can be usefully re-written as:

$$V_1^F(W) = q_1^F(1-k) + \delta q_1^F P(1-k). \tag{9}$$

As discussed above, war has two effects: it allocates the current pie to the winner; and it also allocates all future pies to the winner. If follows that, as indicated in equation (9), F's expected payoff from war is equal to its probability of winning the war times the value of the current pie if there is a war, $1-k$, plus the present discounted value of its probability of winning the war, times the value of all future pies if there is a war, $P(1-k)$.

If F accepts L's offer, the two countries move on to period 2. Since L has all the bargaining power, the payoff that F will receive in this period is its expected payoff from going to war.[16] Thus, F's payoff from accepting L's offer is:

$$\begin{aligned} V_1^F(NW) &= \pi_1 + \delta V_2^F(W) \\ &= \pi_1 + \delta q_2^F P(1-k). \end{aligned} \tag{10}$$

A comparison of equations (10) and (9) immediately reveals that F accepts L's offer if and

[16] That this is true on all possible paths of relative power is shown formally in the proof of Result 1.

only if it is offered a large enough share:

$$V_1^F(NW) \geq V_1^F(W)$$
$$\pi_1 \geq q_1^F(1-k) - \delta(q_2^F - q_1^F)P(1-k) \equiv \underline{\pi}_1. \tag{11}$$

The minimum share that F is willing to accept is equal to its current payoff from going to war, minus a term that reflects the different ways in which war and peaceful partition allocate future pies. On the one hand, war allocates future pies to the winner. This implies that, if F chooses war, its future payoffs are determined by its current military power, q_1^F. On the other hand, peaceful partition does not allocate future pies. Thus, if F chooses peaceful partition, its future payoff will be determined by negotiations in the next period, whose outcome will reflect its military power at that point, q_2^F. If F expects to become more powerful over time ($q_2^F > q_1^F$), peaceful partition gives this country an opportunity to gain time, and get a better deal in the future. Thus, this country may choose peaceful partition even when it is offered less than its current payoff from going to war; that is to say, $\underline{\pi}_1 < q_1^F(1-k)$. If, on the other hand, F expects to become less powerful ($q_2^F < q_1^F$), peaceful partition is a less attractive proposition, since gaining time will lead to (probabilistically) less favourable deals in the future. F may thus reject the offer of a peaceful partition even if it is offered more than its current payoff from war (that is, $\underline{\pi}_1 > q_1^F(1-k)$).

The threshold $\underline{\pi}_1$ is represented by the lower dashed line in Figure 3. The main point to notice is that the threshold can be smaller than zero if $q_2^F - q_1^F$ is sufficiently positive, and larger than one if $q_2^F - q_1^F$ is sufficiently negative.

Now suppose that L wanted to avoid a war. What would be the best way to achieve this? The answer to this question is provided by the solid, thick line in Figure 3. If $\underline{\pi}_1$ lies between zero and one, the best L could do would be to offer exactly $\underline{\pi}_1$: by definition, that would be both sufficient to avoid war, and the cheapest way to do so. But what if $\underline{\pi}_1 < 0$, or $\underline{\pi}_1 > 1$? In the first case, the best L could do would be to offer 0. This is more than what L would ideally like to offer, but it is sufficient to avoid war (since $0 > \underline{\pi}_1$), and it is the cheapest *feasible* way to do so. In the second case, the best L could do would be to offer 1. This, however, would not be

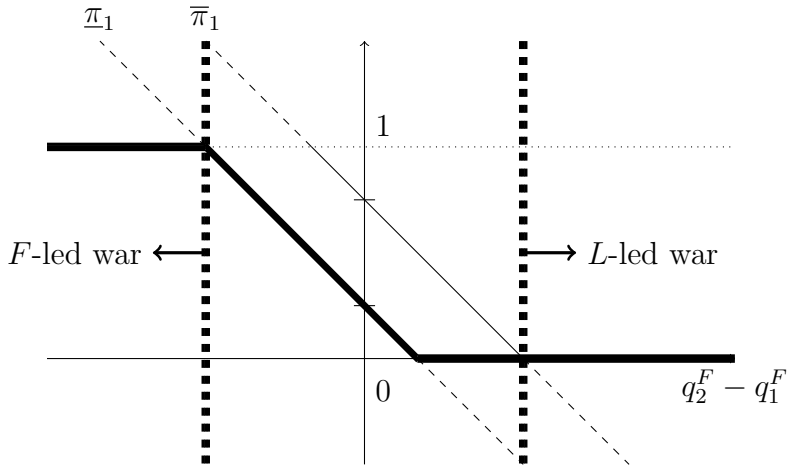

Figure 3: Political equilibrium in period 1.

sufficient to avoid war (since $1 < \underline{\pi}_1$).

This discussion suggests that, whenever $\underline{\pi}_1 > 1$, it is impossible for L to induce F to choose peace. When is this the case? Using equation (11):

$$\begin{aligned} \underline{\pi}_1 &> 1 \\ k &< \frac{q_1^F - \delta(q_2^F - q_1^F)P - 1}{q_1^F - \delta(q_2^F - q_1^F)P} \\ &= \frac{q_1^F - \delta q_2^F - (1-\delta)}{q_1^F - \delta q_2^F}, \end{aligned} \tag{12}$$

where the last step uses the fact that $P = \frac{1}{1-\delta}$. Condition (12) says that a necessary and sufficient condition for $\underline{\pi}_1$ to be greater than one is that the cost of war, k, be lower than a certain threshold.[17] Since k is randomly drawn, this implies a *probability* that $\underline{\pi}_1 > 1$, and therefore a probability that it is impossible for L to induce F to choose peace. Inspection of the right-hand side of (12) immediately reveals that, as expected, this probability can only be positive if $q_2^F < q_1^F$. Furthermore, it is increasing in $q_1^F - \delta q_2^F$,[18] a measure of the decline in F's relative power, in which future power is discounted at the rate δ.

[17] Condition (12) is only the relevant condition if $q_1^F - \delta q_2^F > 0$. If not, the inequality becomes: $k > \frac{q_1^F - \delta q_2^F - (1-\delta)}{q_1^F - \delta q_2^F} > 1$, which however is never true.

[18] Given that k is continuously distributed.

Now, let us turn to the question of when will it be optimal for L to try to induce F to choose peace. By entering negotiations and offering a share π_1 that F accepts, L secures the payoff:

$$\begin{aligned} V_1^L(NW) &= 1 - \pi_1 + \delta[P - V_2^F(W)] \\ &= 1 - \pi_1 + \delta[P - q_2^F P(1-k)] \\ &= 1 - \pi_1 + \delta(1 - q_2^F)P(1-k) + \delta Pk, \end{aligned} \tag{13}$$

where it is anticipated that, if war is avoided in period 1, it is avoided in all subsequent periods.[19] Thus, L will reap the full peace-time value of the stream of future pies, net of F's minimum required payoff, $V_2^F(W)$. Before entering negotiations, however, L faces the option of starting a war, and its expected payoff from doing so is:

$$V_1^L(W) = (1 - q_1^F)(1-k) + \delta(1 - q_1^F)P(1-k). \tag{14}$$

Comparison of (13) and (14) reveals that L enters negotiations if and only if:

$$\begin{aligned} V_1^L(NW) &\geq V_1^L(W) \\ \pi_1 &\leq -(1 - q_1^F)(1-k) - \delta(q_2^F - q_1^F)P(1-k) + 1 + \delta Pk \\ &= q_1^F(1-k) - \delta(q_2^F - q_1^F)P(1-k) + Pk \\ &= \underline{\pi}_1 + kP \equiv \overline{\pi}_1. \end{aligned} \tag{15}$$

The maximum share that L is willing to offer is equal to the minimum share that F is willing to accept, plus the surplus from not going to war. Since avoiding war in period 1 means avoiding war forever, the surplus from not going to war is equal to kP. This has an intuitive explanation. The share $\underline{\pi}_1$ is what makes F indifferent between peace and war. If war was not costly ($kP = 0$), to offer $\underline{\pi}_1$ would also make L indifferent between peace and war. In this case, $\overline{\pi}_1$ would coincide with $\underline{\pi}_1$. But because war is costly ($kP > 0$), to offer $\underline{\pi}_1$ must make L strictly prefer peace to war. This is because if F is indifferent between war and peace, then the surplus from peace is

[19] That this true on all relevant paths of relative power is shown formally in the proof of Result 1.

entirely reaped by L. Thus, when $kP > 0$, it must be true that $\overline{\pi}_1 > \underline{\pi}_1$; in fact, it must be the case that $\overline{\pi}_1 = \underline{\pi}_1 + kP$. The threshold $\overline{\pi}_1$ is represented by the upper dashed line in Figure 3. As is the case for $\underline{\pi}_1$, we note that the threshold $\overline{\pi}_1$ can be smaller than zero if $q_2 - q_1$ is sufficiently positive, and larger than one if $q_2^F - q_1^F$ is sufficiently negative.

Having derived $\overline{\pi}_1$, we can now make an important point about when condition (12) holds, and it is impossible to induce F to choose peace. This case is represented by the region of the diagram that lies to the left of the leftmost vertical line. Because $\overline{\pi}_1 > 1$ in this region, L would be strictly better off by having F accept the entire pie in exchange for peace. Thus, if F was willing to accept, L would be happy to make such offer. We can then say that the war that must occur in this region is "F-led", in the sense that there exists a peaceful partition of the pie that would induce L to choose peace, but that F prefers war to such a partition.

But let us go back to the case in which condition (12) does not hold, and it is possible to induce F to choose peace. When is it optimal for L to do so? Clearly, this is the case if $\overline{\pi}_1 \geq 0$, since L can then obtain peace by offering less than $\overline{\pi}_1$. If $\overline{\pi}_1 < 0$, however - that is, if we are to the right of the rightmost vertical line - L can only obtain peace by offering more than $\overline{\pi}_1$, and this cannot be optimal. Thus, in this region, L will prefer to start a war before entering into negotiations. Again, notice that, because $\underline{\pi}_1 < 0$ in this region, F would be strictly better off by accepting to receive nothing in exchange for peace. Thus, we can say that the war that must occur in this region is "L-led", in the sense that there exists a peaceful partition of the pie that would induce F to choose peace, but L prefers war to such a partition.

Using (15), we can find a condition such that $\overline{\pi}_1 < 0$ is satisfied:

$$\begin{aligned} &\overline{\pi}_1 < 0 \\ &k < \frac{q_1^F - \delta(q_2^F - q_1^F)P}{q_1^F - \delta(q_2^F - q_1^F)P - P} \\ &= \frac{\delta q_2^F - q_1^F}{1 + \delta q_2^F - q_1^F}, \end{aligned} \tag{16}$$

where, again, the last step uses the fact that $P = \frac{1}{1-\delta}$. A necessary and sufficient condition for $\overline{\pi}_1$ to be greater than one is that k be lower than a certain threshold. The probability that this

happens can only be positive if $q_2^F > q_1^F$, and is increasing in $\delta q_2^F - q_1^F$.

We formally introduce the following:

Definition 1. *A J-led war is a war that takes place when there exists a peaceful partition that would induce $-J$ to prefer peace to war, but J prefers war to such a partition.*

To summarise our discussion so far, we have found that (12) is a necessary and sufficient condition for an F-led war, whereas (16) is a necessary and sufficient condition for an L-led war. The former can only hold if $q_2^F < q_1^F$, whereas the latter can only hold if $q_2^F > q_1^F$.

We are now ready to look at how the equilibrium depends on the characteristics of the world economy. We begin by considering the case in which L does not have the capacity to blockade. In this case, the political equilibrium looks as follows:

Proposition 1. *If L does not have the capacity to blockade ($B = 0$), there can only be an L-led war, and only in period 1. Such a war happens if and only if:*

$$k < \Phi \equiv b\frac{\frac{a}{b}(1+b)\left(\delta - \frac{b}{1+b}\right) - 1}{1 + \frac{a}{b}b(1+\delta+\delta b)}. \tag{17}$$

Proof. Using (6) together with (7)-(8) and (2), we obtain $q_1^F = \frac{b}{1+b} \leq \frac{\frac{a}{b}b}{1+\frac{a}{b}b} = q_2^F$. Thus, (12) can never be true, and there cannot be an F-led war. Plugging in $q_1^F = \frac{b}{1+b}$ and $q_2^F = \frac{\frac{a}{b}b}{1+\frac{a}{b}b}$, condition (16) becomes:

$$\begin{aligned} k &< \frac{\delta\frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{b}{1+b}}{1 + \delta\frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{b}{1+b}} \\ &= \frac{\delta\frac{a}{b}b + \delta\frac{a}{b}b^2 - b - \frac{a}{b}b^2}{1 + \frac{a}{b}b + b + \frac{a}{b}b^2 + \delta\frac{a}{b}b + \delta\frac{a}{b}b^2 - b - \frac{a}{b}b^2} \\ &= b\frac{\frac{a}{b}(1+b)\left(\delta - \frac{b}{1+b}\right) - 1}{1 + \frac{a}{b}b(1+\delta+\delta b)}. \end{aligned} \tag{18}$$

□

If L does not have the capacity to blockade, relative military power only depends on industrial catching up. In this environment, Proposition 1 is simply the well-known result that an industrial

leader may find it optimal to start a pre-emptive war against a catching-up follower. Intuitively, catching up will make the follower more powerful in the future ($q_2^F > q_1^F$), and the follower cannot commit not to use this augmented power against the leader. In these circumstance, L may then want to start a pre-emptive war, to defeat the follower before it is too late. Quite intuitively, this happens if and only if the cost of war is small enough ($k < \Phi$).

The comparative statics of the equilibrium are described in the following:

Corollary 1. *Suppose L does not have the capacity to blockade ($B = 0$). If $\delta \leq \frac{b}{1+b}$, an L-led war never happens. If $\delta > \frac{b}{1+b}$, there exists a threshold $(\frac{a}{b})^* = \frac{1}{(1+b)\left(\delta - \frac{b}{1+b}\right)}$ such that an L-led war happens with positive probability if and only if $\frac{a}{b} > (\frac{a}{a})^*$. Furthermore, this probability is, for given b, increasing in $\frac{a}{b}$.*

Proof. The first part follows immediately from inspection of (17). To see that the probability of an L-led war is increasing in $\frac{a}{b}$, notice first that, for any x, the ratio $\frac{x}{1+x}$ is increasing in x. Define $D \equiv \delta \frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{b}{1+b}$. By what we just said, for any given b, D is increasing in $\frac{a}{b}$. But notice that we can re-write the RHS of (18) as $\frac{D}{1+D}$. This implies that, for given b, the RHS of (18) is increasing in $\frac{a}{b}$. □

Corollary 1 relates the probability of an L-led war (the probability that $k < \Phi$) to two key parameters of the model, the discount factor (δ) and the rapidity of catching up $\left(\frac{a}{b}\right)$. If the discount factor is low $\left(\delta \leq \frac{b}{1+b}\right)$, L does not worry too much about F becoming more powerful in the future. In this case, there always exists a partition of the pie that L prefers to pre-emptive war, even if the cost of war is close to zero. In terms of Proposition 1, $\Phi < 0$. If the discount factor is high, on the other hand ($\delta > \frac{b}{1+b}$), L is more worried about the future, and, if F is expected to catch up fast enough ($\frac{a}{b} > \left(\frac{a}{b}\right)^*$), nothing may be able to dissuade L from starting a pre-emptive war. In terms of the proposition, $\Phi > 0$. When this is the case, the probability that war actually happens is higher the faster the catching up (since Φ is increasing in $\frac{a}{b}$).

Figure 4 represents the equilibrium in $\left(\delta, \frac{a}{b}\right)$ space. The thick solid curve represents the threshold $\left(\frac{a}{b}\right)^*$, which as Corollary 1 indicates is a declining function of δ. (The dashed curve labelled $\left(\frac{a}{b}\right)^* \left[r^F\right]$ should be ignored for now.) The grey area indicates the parameter range for which an L-led war is possible. For $\delta \leq \frac{b}{1+b}$, war is not possible (the grey area is asymptotically

tangential to the vertical dashed line labelled $\frac{b}{1+b}$). For $\delta > \frac{b}{1+b}$ war is possible if and only if $\frac{a}{b} > \left(\frac{a}{b}\right)^*$, and it gets more likely as $\frac{a}{b}$ increases (moving in the direction of the arrows in the figure). The fact that the threshold $\left(\frac{a}{b}\right)^*$ is continuously decreasing in δ indicates that as countries care more about the future, an equilibrium with a zero probability of war becomes harder to sustain.

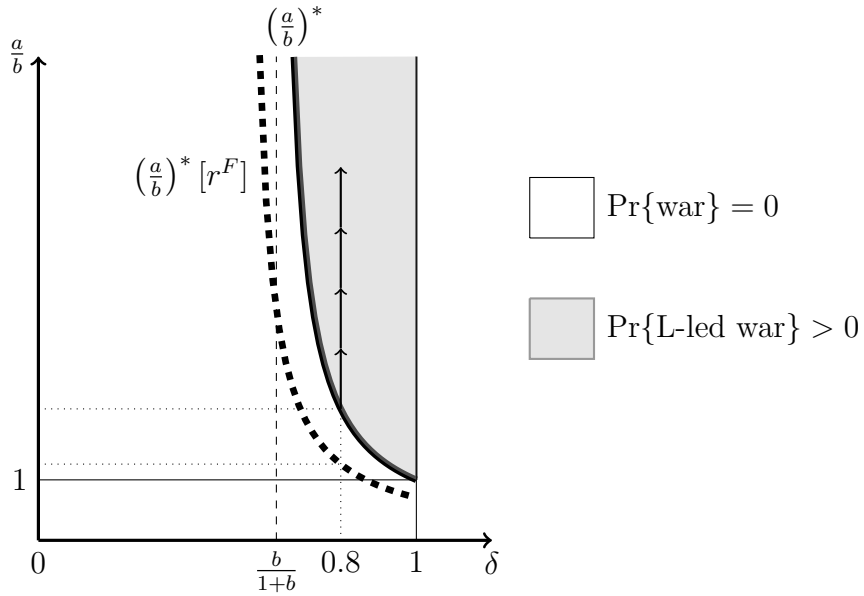

Figure 4: Equilibrium when L does not have the capacity to blockade.

One important point that emerges from Figure 4 is that, for all $\delta < 1$, some catching up is sustainable even in an equilibrium with a zero probability of war. In other words, as long as citizens or policy-makers weigh the future less than the present, an industrial leader may be willing to tolerate a decline in its relative military power, provided that this does not happen too fast. This may be important in explaining why, in reality, industrial catching up happens all the time, but only rarely leads to major political frictions.

Next, we consider the more interesting case in which L has the capacity to blockade:

Proposition 2. *If L has the capacity to blockade ($B = 1$) there are two cases:*

- *If imports are not strategic ($\alpha = 0$), the equilibrium is the same as the one described in*

Proposition 1 and Corollary 1.

- *If imports are strategic ($\alpha = 1$), there can only be an F-led war, and only in period 1. This happens if and only if:*

$$k < \Gamma \equiv \frac{\frac{g_y}{g_x}\left[\frac{r^F+1}{r^F}\left(\delta - \frac{1}{1+r^F}\right)\right] - 1}{\frac{g_y}{g_x} + r^F(1-\delta) - \delta}. \tag{19}$$

Proof. If $\alpha = 0$, the proof of Proposition and Corollary 1 applies. If $\alpha = 1$, using (6) together with (7)-(8) and (2), we obtain $q_1^F = \frac{r^F}{1+r^F} \geq \frac{r^F}{\frac{g_y}{g_x}+r^F} = q_2^F$. Thus, (16) can never be true, and there cannot be an L-led war. Plugging in $q_1^F = \frac{r^F}{1+r^F}$ and $q_2^F = \frac{r^F}{\frac{g_y}{g_x}+r^F}$, condition (12) becomes:

$$\begin{aligned} k &< \frac{\frac{r^F}{1+r^F} - \delta\frac{r^F}{\frac{g_y}{g_x}+r^F} - (1-\delta)}{\frac{r^F}{1+r^F} - \delta\frac{r^F}{\frac{g_y}{g_x}+r^F}} \\ &= \frac{\frac{g_y}{g_x} + r^F - \delta - \delta r^F - \frac{g_y}{g_x}\frac{1}{r^F} - 1 + \frac{g_y}{g_x}\delta\frac{1}{r^F} + \delta - \frac{g_y}{g_x} - r^F + \frac{g_y}{g_x}\delta + \delta r^F}{\frac{g_y}{g_x} + r^F - \delta - \delta r^F} \\ &= \frac{\frac{g_y}{g_x}\left[\frac{r^F+1}{r^F}\left(\delta - \frac{1}{1+r^F}\right)\right] - 1}{\frac{g_y}{g_x} + r^F(1-\delta) - \delta}. \end{aligned} \tag{20}$$

□

The capacity to blockade is a valuable military tool in L's hands, but only if F's imports are strategic (in the sense that they are required for the military apparatus to be able to operate). If not - if, for example, F imports mostly non-essential raw materials such as luxury foodstuffs - relative military power still depends on industrial catching up alone, and the equilibrium is the same as in Proposition 1. If imports are strategic, on the other hand - if, for example, F imports fuels, metals and essential foodstuffs - Proposition 2 delivers the new result that the follower may launch a pre-emptive war against the leader. This is because the follower now becomes *less* powerful over time ($q_2^F < q_1^F$) despite its economy growing more rapidly. Intuitively, the growth of F's military apparatus is now constrained by the growth of domestic supplies of strategic raw materials (g_x), whereas L's military apparatus is free to expand at the rate of steady-state

growth (g_y). Thus, it may now be the follower that wants to defeat the leader before it is too late. As before, war occurs if and only if the cost of war is small enough ($k < \Gamma$).

The comparative statics of the new equilibrium are as follows:

Corollary 2. *Suppose L has the capacity to blockade ($B = 1$), and imports are strategic ($\alpha = 1$). Then, if $\delta \leq \frac{1}{1+r^F}$ an F-led war never happens. If $\delta > \frac{1}{1+r^F}$, there exists a threshold $(\frac{g_y}{g_x})^* = \frac{1}{\frac{r^F+1}{r^F}\left(\delta - \frac{1}{1+r^F}\right)}$ such that an F-led war happens with positive probability if and only if $\frac{g_y}{g_x} > (\frac{g_y}{g_x})^*$. Furthermore, the probability is increasing in $\frac{g_y}{g_x}$.*

Proof. The first part follows immediately from inspection of (19). To see that the probability of an F-led war is increasing in $\frac{g_y}{g_x}$, define $E \equiv \frac{r^F}{1+r^F} - \delta\frac{r^F}{\frac{g_y}{g_x}+r^F}$, an increasing function of $\frac{g_y}{g_x}$. Next, notice that for any x, the ratio $\frac{x-(1-\delta)}{x}$ is increasing in x. But we can re-write the RHS of (20) as $\frac{E-(1-\delta)}{E}$. This implies that the RHS of (20) is increasing in $\frac{g_y}{g_x}$. □

Corollary 2 relates the probability of an F-led war (the probability that $k < \Gamma$) to δ and $\frac{g_y}{g_x}$. The latter is a parameter that was shown to be directly related to the rapidity with which import dependence increases over time. As is the case with an L-led pre-emptive war, an F-led pre-emptive war is never possible if the discount factor is low $\left(\delta \leq \frac{1}{1+r^F}\right)$. This is because, in this case, F is not worried enough by its declining power to prefer war to a peaceful partition. In terms of Proposition 2, $\Gamma < 0$. If the discount factor is high, on the other hand $\left(\delta > \frac{1}{1+r^F}\right)$, so that F is sufficiently worried about its declining power, a pre-emptive war is possible, but if and only if F's import dependence increases fast enough $\left(\frac{g_y}{g_x} > \left(\frac{g_y}{g_x}\right)^*\right)$. Furthermore, a pre-emptive war is more likely, the faster is the increase in import dependence. In terms of Proposition 2, $\Gamma > 0$, and Γ is increasing in $\frac{g_y}{g_x}$. Intuitively, a faster increase in import dependence implies that F's military apparatus is more constrained in its growth relative to L's, and therefore that F's military power is declining more quickly.

The new equilibrium is represented in $\left(\delta, \frac{g_y}{g_x}\right)$ space in Figure 5.

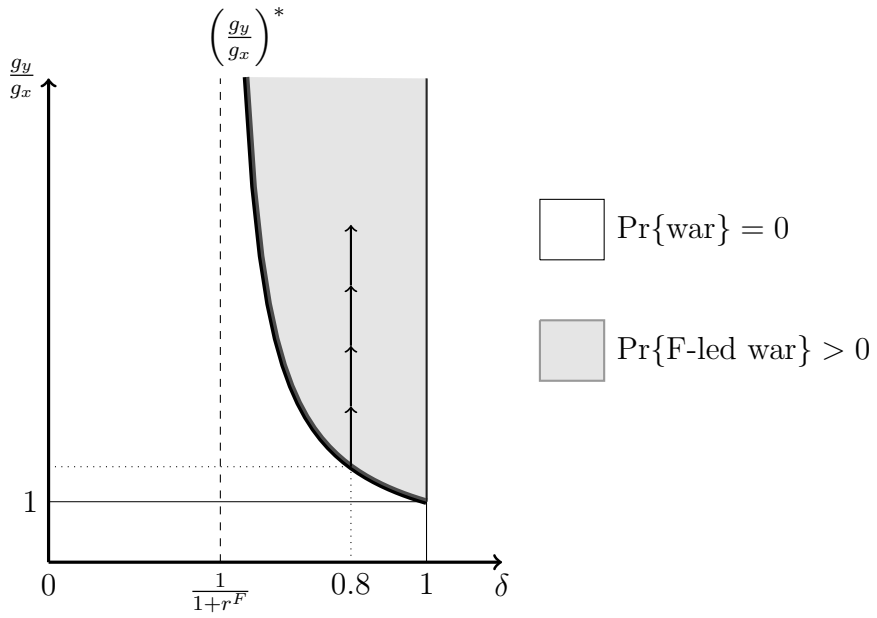

Figure 5: Equilibrium when L has the capacity to blockade.

4 Negotiations over the capacity to blockade

So far, we have assumed that, if L has the capacity to blockade, countries must take this initial condition as given. It is conceivable, however - and indeed rather plausible - that factors that determine the capacity to blockade (such as relative naval power) may be the subject of negotiations. In this section, we extend our model to allow countries to negotiate over the capacity to blockade in period 1. In keeping with the structure of negotiations utilised so far, we assume that L may offer to surrender the capacity to blockade as part of its period 1 proposal. If it does so and F accepts, the capacity to blockade is dismantled by the beginning of period 2, and, from that period onwards no country has the capacity to blockade.[20] As a tie-breaking rule, we assume that L does not surrender the capacity to blockade unless doing so strictly increases its payoff.

We modify the timeline as follows (additions in bold):

1.0 L **can propose to surrender the capacity to blockade (with effect from period 2**

[20]The assumption that it takes one period to dismantle the capacity to blockade is probably realistic, but is not crucial for our results.

onwards).

1.1 L can either make a proposal on how to share the period 1 pie, or go to war. If it makes a proposal, F may either accept, in which case the pie is peacefully partitioned, or reject and go to war. If there is a war, this is won by F with probability q_1^F, and the winner gets the entire period 1 pie.

In period $t > 1$:

t If there has been a war at some $T < t$, the winner gets the entire period t pie. If there hasn't been a war, L can either make a proposal on how to share the period t pie, or go to war. If it makes a proposal, F may either accept, in which case the pie is peacefully partitioned, or reject and go to war. If there is a war, this is won by F with probability q_t^F, and the winner gets the entire period t pie.

It is important to notice that the capacity to blockade is assumed to be indivisible: either L surrenders it, or not.[21][22] Even though this assumption could be relaxed, some degree of indivisibility is required for our results to go through.

If L surrenders the capacity to blockade, we have $B_1 = 1$, but $B_t = 0$ for all $t > 1$. Clearly, if imports are not strategic, this has no effect on the path of relative power, which is the same as indicated in the bottom panel of Figure 2 for the case $\alpha = 0$. If imports are strategic, however, we have a new path of relative power. This is illustrated in Figure 6, which modifies the bottom panel of Figure 2 (and only considers the case $\alpha = 1$). The three bottom lines represent the case in which L does not surrender the capacity to blockade, $B_t = 1 \; \forall \; t \geq 1$. The new path - for the case in which L surrenders the capacity to blockade - is represented by the heavy dashed line: F's military power increases as F catches up on L, and remains constant from period 1 onwards. This increase is larger than in the case in which L never has the capacity to blockade (top panel

[21] According to Powell (2006), we are also implicitly assuming that countries cannot commit to accept the result of a randomised decision regarding the capacity to blockade. Since we have repeatedly assumed lack of commitment in this paper, this further assumption seems reasonable.

[22] We are also assuming that the decision regarding the capacity to blockade can be made independently of the decision regarding how to share the pie. This rules out the possibility that war could occur because of difficulties in sharing specific parts of the pie, whose control matters for the capacity to blockade. In our model, negotiations about the capacity to blockade are not in themselves a cause of war; rather, they are a tool helping countries to avoid war.

of Figure 2), since now F gets stronger both because of catching up, and because L relinquishes the capacity to blockade.

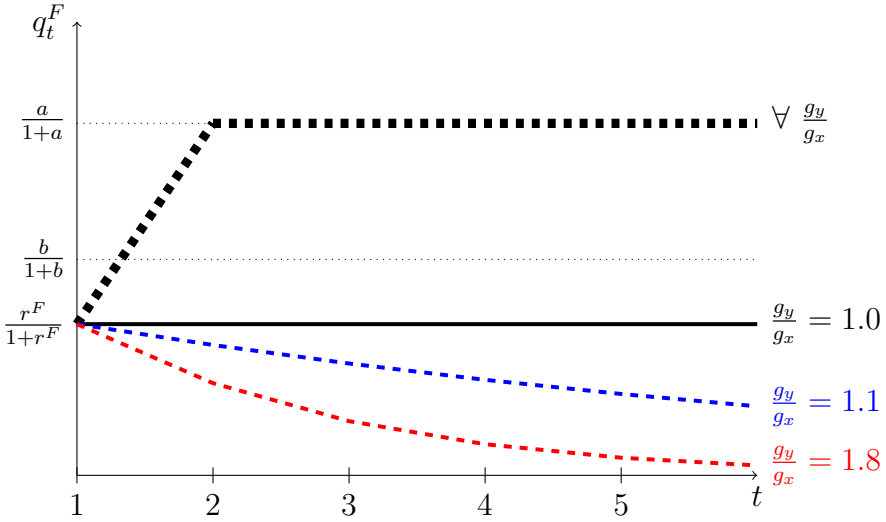

Figure 6: Evolution of relative power, case $B_1 = 1$, $\alpha = 1$.

If L does not surrender the capacity to blockade, the evolution of relative power remains the same as in the previous section. Thus, Result 1 still applies. If L surrenders the capacity to blockade, however, we need the following:

Result 2. *Suppose $B_1 = 1$ but $B_t = 0$ for all $t > 1$. If war does not happen in period 1, it does not happen in any subsequent period.*

Proof. In the Appendix. □

Result 2 implies that we only need to ascertain whether or not war happens in period 1. Conditions (12) and (16) are then the relevant condition for an F-led and L-led war. The equilibrium of the extended model looks as follows:

Proposition 3. *If L has the capacity to blockade and can choose to surrender it, there are two cases:*

- *If imports are not strategic ($\alpha = 0$), L does not surrender the capacity to blockade, and the equilibrium is the same as the one described in Proposition 1 and Corollary 1.*

- *If imports are strategic ($\alpha = 1$):*
  - *If $k \geq \Gamma$, L does not surrender the capacity to blockade and there is no war.*
  - *If $k < \Gamma$, there exists*

$$\Phi[r^F] \equiv b\frac{\frac{a}{b}(1+r^F)\left(\delta - \frac{r^F}{1+r^F}\right) - \frac{r^F}{b}}{1 + \frac{a}{b}b(1+\delta+\delta r^F)} \tag{21}$$

such that, if $\Phi(r^F) < \Gamma$ and $k \in (\Phi(r^F), \Gamma)$, L surrenders the capacity to blockade, and there is no war; otherwise, L does not surrender the capacity to blockade, and there is an F-led war. [23]

Proof. In the Appendix. □

Proposition 3 modifies Proposition 2 in one important way. If imports are strategic and the cost of war is low ($k < \Gamma$) - a situation in which, absent negotiations over the capacity to blockade, an F-led war is unavoidable - there is now a range of parameters such that war can be avoided. In particular, if the new threshold $\Phi[r^F]$ is smaller than Γ, and the cost of war is not *too* low ($k \in (\Phi(r^F), \Gamma)$), L offers to surrender the capacity to blockade, and this is enough to induce F not to start a war. It is important to notice, however, that an F-led war may still be unavoidable. Intuitively, L would like to avoid an F-led war, and realises that it could do so by surrendering the capacity to blockade. But to surrender the capacity to blockade would leave L vulnerable to F's military ascent, a scenario that is worse than immediate war if $k \leq \Phi[r^F]$. In this case, it would be pointless for L to surrender the capacity to blockade, since if it did then it would itself decide to start a war.[24] The threshold $\Phi[r^F]$ is larger than Φ, since, as discussed above, to surrender the capacity to blockade makes F's ascent faster than in the case examined in Proposition 1.

The comparative statics of the equilibrium can be summarised as follows:

[23] Notice that there is never an equilibrium in which there is a war and L surrenders the capacity to blockade, since that wouldn't make sense from L's point of view.

[24] To surrender the capacity to blockade when $k = \Phi[r^F]$ would make L indifferent between starting a war or not (since peace would give it exactly $\overline{\pi}_1$). Under our tie breaking rule for the decision on war, L would then not start a war. Since to surrender the capacity to blockade would leave L's payoff unchanged, our tie breaking rule for the decision on the capacity to blockade ensures that L does not surrender it.

Corollary 3. *Suppose L has the capacity to blockade and can choose to surrender it, and imports are strategic ($\alpha = 1$). Then, if $\delta \leq \frac{1}{1+r^F}$, an F-led war never happens. If $\delta > \frac{1}{1+r^F}$, there exists $\left(\frac{a}{b}\right)^* \left[r^F\right] = \frac{\frac{r^F}{b}}{(1+r^F)\left(\delta - \frac{r^F}{1+r^F}\right)}$ such that an F-led war happens with positive probability if and only if $\frac{a}{b} \geq \left(\frac{a}{b}\right)^* \left[r^F\right]$ and $\frac{g_y}{g_x} > (\frac{g_y}{g_x})^*$. Furthermore, this probability is increasing in $\frac{a}{b}$ (for given b) if $\Phi[r^F] < \Gamma$, and is increasing in $\frac{g_y}{g_x}$ if $\Phi[r^F] > \Gamma$.*

Proof. By Proposition 3, there is a war if and only if $k < \min\left\{\Gamma, \Phi[r^F]\right\}$. The first part then follows immediately from inspection of (19) and (21). To see that the probability of an F-led war is increasing in $\frac{a}{b}$ if $\Phi[r^F] < \Gamma$, and increasing in $\frac{g_y}{g_x}$ if $\Phi[r^F] > \Gamma$, notice that the RHS of (31) is increasing in the numerator, which in turn is increasing in $\frac{a}{b}$. Furthermore, Γ has been shown to be increasing in $\frac{g_y}{g_x}$ in the proof to Corollary 2. □

As with Proposition 2, war can only occur if F is worried enough about becoming increasingly dependent on imported raw materials in the future $\left(\delta > \frac{1}{1+r^F}\right)$, and this dependence is expected to increase fast enough $\left(\frac{g_y}{g_x} > (\frac{g_y}{g_x})^*\right)$. For war to be unavoidable, however, we now *also* need F to be catching up fast enough. In terms of Proposition 3, we now need not only $k < \Gamma$, but also $k \leq \Phi(r^F)$. This second dimension is critical, since the rapidity of F's catching up determines how vulnerable L becomes after surrendering the capacity to blockade. If catching up is slow, $\left(\frac{a}{b} < \left(\frac{a}{b}\right)^* \left[r^F\right]\right)$, L remains strong even after surrendering the capacity to blockade, and is therefore willing to do so to avoid an immediate war. In terms of Proposition 3, $k > \Phi(r^F)$ in this case. If catching up is fast, on the other hand $\left(\frac{a}{b} \geq \left(\frac{a}{b}\right)^* \left[r^F\right]\right)$, L is greatly weakened by the loss of the capacity to blockade, and may prefer to retain this capacity even if this leads to an F-led war. In terms of the proposition, $k \leq \Phi(r^F)$.

The new threshold, $\left(\frac{a}{b}\right)^* \left[r^F\right]$, is represented by the dashed, thick curve in Figure 4. It is easy to see that, for any $r^F \in [0, b)$ - that is, whenever F is initially dependent on imported raw materials - the new threshold is always lower than the threshold $(\frac{a}{b})^*$.[25] For the case when $\delta = 0.8$, Figure 7 represents the equilibrium in $\left(\frac{a}{b}, \frac{g_y}{g_x}\right)$ space. In the figure, the grey area represents the parameter range for which an F-led war is possible. If negotiations about the capacity to blockade were impossible, there would be war whenever $\frac{g_y}{g_x} > \left(\frac{g_y}{g_x}\right)^*$. The ability

[25] If $r^F = b$, the two thresholds coincide.

to negotiate means that war can now be avoided if $\frac{a}{b} < \left(\frac{a}{b}\right)^* \left[r^F\right]$. The thin vertical rectangle thus shows the parameter range for which being able to negotiate about the capacity to blockade leads to war being avoided.

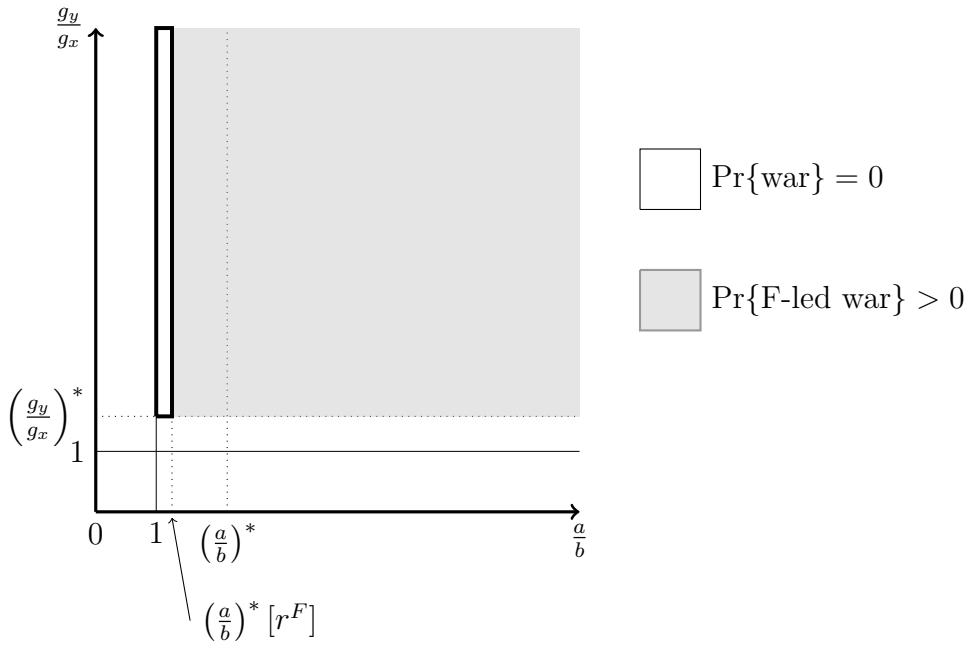

Figure 7: Equilibrium when L has the capacity to blockade and can choose to surrender it, and $\alpha = 1$ ($\delta = 0.8$).

One interesting point that emerges from Figures 4 and 7 is that, when L has the capacity to blockade, there may still exist a speed of catching up that is sustainable in an equilibrium with a zero probability of war. However, since $\left(\frac{a}{b}\right)^* \left[r^F\right] \leq \left(\frac{a}{b}\right)^*$, this speed is lower than when L does not have the capacity to blockade. Intuitively, the capacity to blockade makes L more powerful, and thus less willing to accept F's military ascent.

The key message of this section is that, when there is *both* rapid catching up *and* a rapid increase in dependence on imported natural resources, an F-led war can occur, *even if* L and F are able to negotiate about the capacity to blockade. Rapidly growing import dependency makes F willing to risk a war in order to break L's capacity to blockade, and F's rapid growth makes L unwilling to surrender this capacity via peaceful negotiations.

5 A brief historical discussion

Our model predicts that war may arise when a rising power finds itself needing increasing amounts of imported raw materials, and where these raw materials are necessary for the waging of war. A follower-led war is more likely, the more rapidly the follower's import dependence grows (Corollary 2). It is also more likely (in a context where bargaining over the capacity to blockade is possible) the more rapidly the follower is catching up on the leader (Corollary 3). Can we find examples of this mechanism in action? There is a substantial body of historical literature which suggests that it was in fact at work in the first half of the twentieth century, and that concerns over the supply of imported, strategic, raw materials was an important motivating factor at various points in time for both German and Japanese military planners. In the words of Azar Gat, "the quest for self-sufficiency in strategic war materials became a cause as well as an effect of the drive for empire, most notably in the German and Japanese cases towards and during the Second World War" (Gat 2006, p. 556). This seems especially obvious in the Japanese case, in particular.

Of course, the world is vastly more complicated than the simple structure envisaged in our model, or any other, and we would not want to argue that our mechanism can "explain" the Second World War in some monocausal way: far from it. Apart from anything else, decision makers in many countries were involved in the run-up to that war, not just in two. We do however think that our model provides useful insights into the origins of both this war, and the world war which preceded it. In what follows, therefore, we provide a brief account of three historical episodes: the build-ups to the First World War, the Second World War in Europe, and the Second World War in Asia. In each case, the historical narrative will be followed by a discussion of the ways in which the mechanisms identified by our model are relevant in understanding the episode in question, as well as of the ways in which reality was more complex than allowed in the theoretical discussion above.

5.1 Anglo-German naval rivalry and World War I

We begin by looking at how international trade and the possibility of blockade was one source of international tension in the years leading up to the First World War. This is a useful starting point since that conflict, and the lessons people learned from it, were so important in setting the stage for the disasters that followed. It is important to recognize from the outset that Franco-German rivalry over Alsace-Lorraine, or the tensions between Serbia and Austria-Hungary, or between Russia and Austria-Hungary, would have existed even in the absence of concerns over trade.[26] Nonetheless, trade-related strategic concerns did exist and were important at various times for particular key players.

Towards the end of the eighteenth century, Britain started to experience very rapid population growth and industrialisation. Population growth created the need for large imports of food, given a limited British land endowment and diminishing returns to labour. Industrialisation created the means to pay for these imports. The British economy thus became crucially dependent on international trade (Clark, O'Rourke and Taylor 2014), and naval supremacy became a strategic imperative. This dependence on trade came at a good time for Britain, in that there were still frontier territories which could be settled by people who would otherwise have had to be fed at

[26]Ralph Hawtrey (1952), pp. 78-9 points out that there is a trade angle in the second case, in that Austria-Hungary was worried about losing Trieste and Fiume to an expanded Serbia, and on the other hand hoped for access to the Aegean in the event of a successful war. An outlet to the Adriatic was of great interest to the Serbs, and this provoked a major European crisis during 1912-13, with the Austrians insisting on the creation of an independent Albania precisely so as to prevent this from happening (Strachan 2001, p. 51, Clark 2012, p. 282). The Austrians could not accept a Serbian port on the Adriatic, since they feared that the combination of Italian and Serbian naval strength would undermine their hegemony there, and make Trieste vulnerable to blockade (MacMillan 2013, p. 454). Meanwhile, the Turkish Straits were of key strategic significance to the Russians, which is why the appointment in December 1913 of the German Liman von Sanders to the command of an Ottoman army corps, with responsibility for defending the Straits and Constantinople against possible attack, provoked such a crisis in Russo-German relations (Clark 2012, p. 339). The Straits were obviously important on straighforward strategic grounds, since they lay in the way of Russian naval access to the Mediterranean, but they were also a crucial choke point for Russian grain exports, which generated the foreign exchange needed to import machinery and equipment, including military equipment, and to service foreign loans which often came from France and often had strategic motives. Machinery imports also came largely through the Straits (MacMillan 2013, p. 447). For Clark (2012, pp. 347, 485) the concern for control of the Staits was a key reason why Russian attention became increasingly focussed on its Balkan "hinterland" in the years immediately before the war. The Allied decision in 1915 to mount the campaign in the Dardanelles was partly a reaction to the stalemate on the Western Front, but it was also partly motivated by the sorts of concerns raised in this paper. Russia needed to be able to export grain through the Turkish Straits in order to earn foreign exchange, while Britain had an interest in regaining access to Russian grain so as to increase food supplies at a time of rising prices (Lambert 2012, pp. 334-337). The iron ore of Alsace-Lorraine was an important strategic resource. But we do not want to push the issue.

home. Moreover, the frontiers also permitted an enormous expansion in food production which new transport technologies brought back to Britain increasingly cheaply, under the protection of the Royal Navy (Belich 2009). Whatever may be said about her colonial adventures during this period, Britain's naval hegemony during the nineteenth century was a relatively benign one, in that under the *pax Britannica* the seas were made free for commerce for traders from all nations. However, this did not stop other nations from resenting it.

British hegemony could not last for ever, as the new technologies of the Industrial Revolution spread to Continental Europe. In the words of Paul Kennedy (1980, p. 410), "The colonial quarrels, naval rivalry and disagreement over the European balance of power which drove Britain and Germany apart, were in effect the strategical and geopolitical manifestations of the relative shift in the economic power of these two countries between 1860 and 1914." By the late nineteenth century a newly unified Germany was industrialising rapidly, and catching up on (or even overtaking) Britain. In 1870 UK coal production was 331 per cent higher than German coal production; by 1913 the margin was down to 54 per cent. Pig iron production was 4.8 times higher in the UK than in Germany in 1870; it was 61 per cent higher in Germany than in the UK in 1913. In 1870 the UK produced 590,000 tonnes of sulphuric acid, as against Germany's 43,000 tons; in 1913 Germany produced 1.7 million tonnes, as opposed to just 1.1 million tonnes in the UK (Broadberry et al. 2010, p. 75). Not only was German industry growing much faster than British industry, her population was also expanding more rapidly. The populations of Germany and the UK in 1870 were 40 million and 32 million respectively; they were 65 million and 46 million in 1913 (Bolt and van Zanden 2013). Together, these trends implied that total German GDP, which had been 28 per cent lower than UK GDP in 1870, was 6 per cent higher in 1913. In the language of our model, $\frac{a}{b}$ was high.

Population growth and industrialization increased Germany's relative economic and military power, while at the same time making her increasingly dependent on imports of food and raw materials: $\frac{g_y}{g_x}$ was high as well. The percentage of German imports accounted for by raw materials increased from 41 per cent in 1893 to over 57 per cent in 1913. While Germany had been a net exporter of iron ore in 1897, she was importing almost 30 per cent of her needs by 1913, despite more than doubling her production (Copeland 1996, p. 28). Imports of food grew much more

rapidly than the economy as a whole, despite agricultural protection (Offer 1989, p. 322). All this meant that Germany, like Britain, was now becoming increasingly dependent on foreign trade. And 74 per cent of these imports were arriving by sea, either directly or indirectly (*ibid*, p. 335), implying that they were potentially vulnerable to blockade by the British. Between 1880 and 1913, Europe's share in German trade declined by 30 per cent, while the share of overseas countries, and especially Latin America, was rising (Fischer 1967, p. 12).

In a classic book, Avner Offer (1989) argues that the vulnerability which this implied was one factor among several which ultimately led to war, and the collapse of that period's globalization. According to Offer, a key element in the sequence of decisions which led to World War I was the fact that *both* Germany and Britain were increasingly dependent on overseas imports of food and raw materials. "The economies of both Britain and Germany came to depend on hundreds of merchant ships that entered their ports every month. Overseas resources, the security of the sea lanes and the economics of blockade affected the war plans of the great powers and influenced their decision to embark on war" (Offer 1989, p. 1). Far from ushering in an era of universal peace, many German leaders drew the same conclusion as Admiral Tirpitz: "We had global commerce (*Weltwirtschaft*), which compelled us to *Weltmacht*" or world power (Kennedy 1980, p. 311).

Interestingly, although there were long-standing colonial rivalries between Britain and Germany during this period, they were relatively easy to resolve: in the language of our model, the colonial "pie" was easily divisible. "(B)ecause many of the colonial disputes had their origins in commercial activities – and were to that extent concrete and quantifiable; and because they concerned so much of the world – and only megalomaniacs could insist that *every* region was indispensable for British security or Germany's growing trade requirements – a *modus vivendi* was possible...Colonial bargains, often conducted with both sides protesting that they had made the greatest concessions, were common enough events" (Kennedy 1980, p. 411). Indeed, as late as 1913, Germany and Britain agreed on how to deal with Portuguese colonies in Africa in the event of the Portuguese Empire collapsing (Clark 2012, p. 335).

By contrast, in British eyes naval hegemony was vital for the country's survival, making naval security a far more likely cause of conflict. As Joll and Martel (2007, p. 229) say, "the

threat to the empire that Germany appeared to represent was not a threat to any particular colony...but rather a general challenge that the German navy appeared to be making to Britain's strategic lines of communication and its world-wide trade... It was because the German challenge to Britain's imperial position was a general one rather than a specific set of territorial demands that it seemed so dangerous". In the language of our model, naval hegemony - and thus the capacity to blockade - was indivisible. On the issue of maintaining naval superiority, therefore, the British were intransigent. For example, at a conference held in the Hague in 1907, Sir Edward Grey, the British Foreign Secretary, insisted that Britain "must retain its 'offensive' capacity to drive other navies from the seas and that Britain would not permit any restrictions of the right of blockade"(Joll and Martel 2007, p. 100).

In many German eyes, however, an end to that hegemony was essential in order to compel Britain to grant Germany the "world-political freedom" which increasing numbers of German intellectuals and policy makers were demanding (pp. 416-7). The result was that in 1898 Germany embarked on a naval buildup whose aim was to achieve naval parity with Britain, not globally, but locally (that is to say, in the waters between the two countries). By making naval warfare with Germany excessively risky, it was hoped that Britain would be compelled to seek better long term relations with the Reich (MacMillan 2013, pp. 94-95).[27] But this strategy completely underestimated the importance of preserving naval hegemony in British eyes: it was essential both for the security of the Empire, and of Britain herself. The result was a naval arms race which Britain eventually won, but which in the process helped to shift British strategic thinking in an anti-German, rather than a pro-German, direction.

British planners, initially concerned about their own vulnerabilities, started to focus on German vulnerabilities and the potential of blockades as a weapon against Germany. Geography was on Britain's side, as well as her traditional naval superiority, since Britain could deny Germany access to the Atlantic by the simple expedient of blockading the English Channel and North Sea. In the words of Nicholas Lambert (2012, p. 498), "the prospect of a meltdown in the global

[27]German planners had worried about a British first strike as Germany passed through the "danger zone" , the period during which she was building up her naval strength. This would have corresponded to L launching a pre-emptive strike on F so as to lock in her first period advantage, along the lines of standard theories of wars between leaders and followers. The fear proved unfounded, however, since Britain had another option available to it: building more ships.

trading system [in the event of war] appeared to offer Britain a strategic opportunity as well as a strategic danger. Consideration of the trade defense problem...led certain naval planners to contemplate the vulnerability of future enemies to such an Armageddon. They began toying with the idea of harnessing Britain's naval supremacy to her effective monopoly control over the infrastructure of the global trading system (shipping, financial services, and global communications). If practicable, they thought, the Admiralty might intensify pressure on the enemy's economy with potentially decisive results...In 1912, Britain's political leaders approved the plan for economic warfare as the basis of strategic action in the event of war against Germany."This warfare would not only involve a physical blockade, but a financial and commercial one which would cripple the German financial system as well as deprive her of imports. It was thought that this would be so effective than an ensuing war would be short.

The Edwardian naval arms race may not have been the cause of World War I, but the strategic considerations underlying it were surely one of the causes (Howard 1991). It stoked great animosity on both sides, and led British policy makers to regard Germany as a greater threat than its traditional imperial rivals, France and Russia. There were some attempts to negotiate an end to the naval arms race, notably the famous mission of Lord Haldane to Germany in 1912, but this came to nothing principally because the British were unwilling to concede naval hegemony in any circumstances, and were in any case winning the race (Clark 2012, p. 319). Consistent with the logic of Proposition 3, the growth in German economic and military power was simply too threatening for the British to be willing to concede their major strategic asset, which was the ability to blockade Germany in the event of war. As Sir Edward Grey, the British Foreign Secretary, told the Canadian Prime Minister in 1912, "There are practically no limits to the ambitions which might be indulged by Germany, or to the brilliant prospects open to her in every quarter of the globe, if the British navy were out of the way. The combination of the strongest Navy with that of the strongest Army would afford wider possibilities of influence and action than have yet been possessed by any Empire in Modern Times"(Steiner 1977, p. 42).[28]

Unfortunately, the failure to make any headway in challenging Britain's naval superiority,

[28]Thus, Britain could not tolerate the establishment of a German port in Morocco, which is why she eventually sided decisively with France in 1911 during the Second Moroccan Crisis (Strachan 2001, p. 25, Clark 2012, p. 209).

and the consequent difficulty of pursuing a meaningful *Weltpolitik*, prompted some in Germany to argue for a strategy of German continental dominance, based on a European economic bloc with Germany at its centre (Strachan 2001, pp. 46-7).[29] Their strategy during the Haldane talks, for example, was to offer a recognition of British naval superiority in return for a British promise of neutrality in the event of a continental war. But once again, none of this was even remotely acceptable to Britain. Not only would continental hegemony have increased German economic and military power, it would have granted her access to Atlantic ports beyond the British bottlenecks at Dover and the waters between Scotland and Norway. "The establishment of a German hegemony over the continent of Europe would enable the Germans to outbuild the British and to use continental ports to dominate the high seas and the Channel. Britain's naval supremacy and her interest in the preservation of the balance of power in Europe were inexorably linked"(Steiner 1977, p. 59). As Sir Edward Grey said in 1911, if a European power achieved continental hegemony Britain would permanently lose its control of the sea, which would in turn mean its separation from the Dominions and the end of the Empire (Howard 1972, pp. 51-52). And so Britain's need for naval hegemony had implications for its policies regarding the European Continent as well, despite the desire of many British policymakers to avoid any continental entanglements. Paradoxically, Britain's traditional maritime orientation meant that it was *more* likely that she would intervene in a continental war, or a least a war in which France risked being destroyed by Germany.

There are several ways in which our model resonates with the history of this period. Germany was clearly catching up rapidly on Britain, and in terms of of GDP was actually overtaking her: $\frac{a}{b}$ was high. Rapid growth implied that Germany was becoming increasingly dependent on imported raw materials: $\frac{g_y}{g_x}$ was high as well. Increasing dependence on trade was one factor leading Germany to challenge British naval hegemony, as our model predicts, and rapid German

[29]If a strategy of expanding economically to the south and east eventually provided overland routes through the Ottoman Empire and into Asia, then so much the better, although here again there were some risks that the British could not tolerate. German access to Iraqi oilfields was bad enough, but a German port on the Persian Gulf posed an unacceptable risk: British planners "feared that the Germans, freed through a land route to the east from the constraints imposed by British global naval dominance, might come to threaten Britain's pre-eminence in colonial trade"(Clark 2012, p. 337). In the event, the dispute between Germany and Britain on the subject of a proposed railway line through the Ottoman Empire was settled (in June 1914) by Germany conceding that control of the final stretch of the railroad, from Basra to the Gulf, be controlled by the British (Clark 2012, p. 338).

growth made Britain unwilling to concede this, again as our model predicts. But other factors were at play as well, even in explaining Anglo-German rivalry. Both British and German naval planners were aware that Britain, as well as Germany, was vulnerable to blockade should she ever lose naval hegemony: this is something which we have not considered in our model, although it is consistent with it. There were also domestic political considerations lying behind the German naval programme.

Furthermore, the First World War did not arise as a result of this rivalry, but rather as a result of a dispute between Austria-Hungary and Serbia, which brought in first Russia on the side of Serbia, and then Germany on the side of her Austro-Hungarian ally. There was certainly an element of forward-looking calculation in the German decision, in that her military planners were worried about the fact that Russia was growing rapidly, and becoming more militarily powerful, and that if a war between the two countries was coming anyway, it would be better to have it sooner rather than later. This is the classic logic of the pre-emptive war waged by the leader on the follower (since in the context of the Russo-German relationship, Germany was clearly the leader). However, German strategic doctrine also implied that war with Russia meant the immediate invasion of both France and Belgium. It was in this context that British concerns about German continental hegemony became relevant, and indeed these were mentioned by Grey in his speech to Parliament on August 3.

In the end, it was Britain, the leader in terms of our model, that declared war on the follower, Germany, rather than vice versa (although the Germans declared war on both Russia and France, knowing that this might prompt such a decision on the part of the British). There were many factors that led Britain to declare war on Germany, rather than stand aloof from the unfolding conflict on the continent, with different reasons appealing to different government ministers and Members of Parliament. Britain's treaty obligations to uphold Belgian neutrality were important for some. A feeling that it would be morally wrong to leave French ports unprotected, when France had moved her fleet to the Mediterranean so as to defend British interests there, leaving the Royal Navy free to concentrate on the threat from Germany, was another important factor. As was true in all the major capitals at the time, statesmen were as concerned by the demands of dignity and honour as by any rational calculus, and probably more so. But

strategic concerns about import dependence and naval strength also mattered. Many British policy makers were prepared to go to war if the alternative was German continental dominance, which would inevitably (as they saw it) translate into naval dominance as well. And frustration at the constraints which British naval hegemony placed on Germany's ability to pursue its interests had earlier led German policy makers to challenge that hegemony, helping to set the two nations on an eventual collision course.

5.2 World War II in Europe

The experience of the First World War did not lessen worries about dependence on overseas food and raw materials: on the contrary. The German population may not have starved as a result of the British blockade, but food shortages had an important effect in lowering German morale, and the blockade was decisive in forcing Germany to surrender and sign the Treaty of Versailles (Offer 1989). In the language of our model, the war made the dependence of q_t^F on B abundantly clear. During the 1920s, German nationalists increasingly justified autarky, not on economic grounds, but because it was necessary in time of war (Smith 1986, p. 210). Karl Haushofer, the founder of German geopolitics, and someone whose ideas apparently influenced Hitler, developed the notion of *Lebensraum* which extended beyond its agrarian origins, so that it could for example be defined as "the geographic surface area needed to conduct a successful military defense of the nation" (p. 221).[30] More importantly, German military planners in the 1920s drew the lesson from World War 1 that war was now fundamentally economic in nature, and that defending the nation required meeting the needs not only of the military, but of the civilian population as well. They thus developed the concept of *Wehrwirtschaft*, or the defense economy, which would be built up during peacetime so as to ensure that the nation was capable of fighting the total wars of the future (Overy 1988, p. 614; Overy 2002, p. 178; Volkmann 1990, p. 195). In Hitler, the proponents of *Wehrwirtschaft* found an enthusiastic supporter.

In *Mein Kampf* and elsewhere, Hitler explicitly considered two alternative ways of feeding the

[30]The *Lebensraum* tradition in German imperialist thought was agrarian, anti-industrial, and anti-modern. It sought land on which to plant German settlers. It stands in contrast to the *Weltpolitik* tradition which was pro-industrial, modernising, and sought colonies to provide secure markets and raw materials supplies (Smith 1986).

growing German population: exporting manufactures and using the proceeds to import primary products; or acquiring new soil through violence. Not surprisingly, he preferred the latter, in part because dependence on trade meant vulnerability to blockade (Overy 2002, p. 179; Tooze 2006, p. 169). Again and again, Hitler returned in his speeches and writings to the need for secure supplies of both food and raw materials, which were in the long run to be acquired by military conquest. As he put it in his memorandum of August 1936, which became the basis for the famous Four Year Plan, "The final solution (to the problem of German import dependence) lies in extending (the) living space of our people and/or the sources of its raw materials and foodstuffs." [31] The key was the Soviet Union. As early as 1931 he told a Party member that "Europe needs the grain, meat, the wood, the coal, the iron, and the oil from Russia in order to be able to survive" (Overy 2009, p. 51), and shortly before the war began he told a Swiss diplomat that "I need the Ukraine, so that no one will starve us out as they did in the last war" (Hildebrand 1973, p. 88).

The long run strategic goals motivating Hitler's quest for *Lebensraum* were explicitly spelled out in his speech to the heads of the armed forces of November 1937. According to notes taken at the meeting,[32] he stated that:

"There was a pronounced military weakness in those States which depended for their existence on foreign trade. As our foreign trade was carried on over the sea routes dominated by Britain, it was more a question of security of transport than one of foreign exchange, which revealed in time of war the full weakness of our food situation. The only remedy, and one which might appear to us visionary, lay in the acquisition of greater living space – a quest that has at all times been the origin of the formation of States and of the migration of peoples...If, then, we accept the security of our food situation as the principal question, the space necessary to ensure it can be sought only in Europe, not, as in the liberal-capitalist view, in the exploitation of colonies. It is not a matter of acquiring population but of gaining space for agricultural use. Moreover, areas producing raw materials can be more usefully sought in Europe, in immediate proximity to the

[31] Available at http://germanhistorydocs.ghi-dc.org/pdf/eng/English61.pdf.

[32] This is the so-called Hossback memorandum, available at http://germanhistorydocs.ghi-dc.org/pdf/eng/English50.pdf.

Reich, than overseas..." [33]

Hitler's consistently stated desire for *Lebensraum*, his view that the struggle between races was natural and unavoidable, and his obsessive anti-semitism, meant that war was inevitable in the long run as long as he remained in power. The practical problem which Hitler faced from 1933 onwards was how to achieve the extensive rearmament which he needed to fulfill his objectives. Germany was extremely or entirely dependent on imports for its supplies of such strategically vital raw materials as bauxite, chromium, copper, iron, lead, nickel, oil, rubber, and zink (Volkmann 1990, p. 246). The ultimate objective was to grab these resources by bullying or force of arms, but in the interim they had to be bought with scarce foreign exchange, which in turn meant exporting. This was problematic, not only because of the protectionism and depressed economic conditions of the 1930s, but because once the German economy had recovered from the Depression, and capacity constraints once again became binding, more exports meant fewer resources devoted to the military industrial complex.

The response in the first instance was a series of policies trying to construct an increasingly autarkic economy: in terms of our model, increasing r^F and g_x. Once this policy had reached its limits, war became necessary in the short as well as the long term. Thus, the New Plan of 1934 sought to prioritize imports of strategic raw materials and food over consumer goods (Volkmann 1990, p. 245); Goering was appointed special commissioner for foreign exchange and raw materials in April 1936; and the Four Year Plan announced later that year led to massive investments in synthetic oil and rubber technologies, as well as plans to increase the exploitation of domestic iron ores. The Four Year Plan marked a transitional phase before Hitler's long run goals could be achieved, and sought to make the German economy as war-ready, and blockade-proof, as possible (Overy 2009, pp. 54-5; Tooze 2006, pp. 219-222). Hitler now demanded that the economy and army be ready for war within four years. By November 1937 Hitler had taken the decision to begin the phase of armed expansion, in particular by attacking Czechoslovakia (as well as by annexing Austria), with 1943-5 being set as a deadline for beginning the broader conflict with Germany's more powerful enemies, such as the USSR, since they were now rearming.

[33]The fact that labour-to-land ratios were higher to the East than in Germany, but that the Nazis wanted land rather than people, suggested an obvious logical corollary, from whose murderous implications Nazis such as Walther Darr and Herbert Backe would not shrink (Tooze 2006).

There then began a phase in which German policy was to "enlarge the economic base of the Reich by territorial accretions" (Volkmann 1990, p. 277), either peacefully or if necessary through violence. The annexations of Austria and Czechoslovakia in 1938 and 1939 provided the Reich with lignite, coal, and iron ore, as well as heavy industry (Overy 2002, pp. 197, 227). Unfortunately, successive territorial annexations did not make Germany self-sufficient, and in some ways they made its import dependence worse: Austria, for example, was also a net importer of food and raw materials (Tooze 2006, p. 246). As Richard Overy (2009, p. 72) puts it, "Rearmament made the economic conquest of Eastern Europe a necessity" and Germany tried to increase its economic hold over the resources of Hungary, Bulgaria and Romania via a series of bilateral deals.

This strategy had its limits, however, with an enlarged Germany still far from strategic self-sufficiency, even taking German domination of the Balkans into account (Volkmann 1990, pp. 350-358). According to Adam Tooze (2006), the armament drive was in trouble by the summer of 1939, and the consequence was a decision for immediate war; on August 22, Hitler told his commanders that "It is easy for us to make decisions. We have nothing to lose; we have everything to gain. Because of our restrictions [Einschränkungen] our economic situation is such that we can only hold out for a few more years."[34] The immediate goal was Poland, whose domination was "necessary, in order to guarantee the supply of agricultural products and coal for Germany" (Overy 2002, p. 222). However, Russian resources, which were the ultimate prize, were still essential in order to make the Nazi empire blockade-proof (Kaiser 1980, pp. 277-9; Volkmann 1990, p. 258; Hildebrand 1973, p. 92). The conclusion of the Nazi-Soviet pact was thus of fundamental significance for Hitler, who could now invade Poland confident that even if Britain and France intervened, "We need not be afraid of a blockade. The East will supply us with grain, cattle, coal, lead and zinc."

Despite this confidence, German imports of industrial raw materials declined dramatically in the first months of the war. Tooze argues that in consequence, Hitler felt that he had no alternative but to gamble on an all-out assault on the West. A long war was not in Germany's

[34]Available at http://germanhistorydocs.ghi-dc.org/pdf/eng/English56.pdf. In terms of our model, he was arguing that $q^F_{t+1} < q^F_t$.

interests, while success would bring with it the industrial resources of Belgium and northern France (Tooze 2006, pp. 332-3, 336-7, 357). The stunning victories of 1940 gave Hitler control over most of continental Western Europe, but not the hoped-for defeat of Britain and her Empire. Furthermore, Nazi Europe as a whole was still far from constituting a self-sufficient war economy (Tooze 2006, pp. 411, 418, 419). In June 1941, the Brookings Institution published a study comparing the trade statistics of the countries which now comprised Nazi Europe as a whole with those of the old German Reich, based on trade statistics for 1929 and 1937 (Lewis 1941). It showed that the new Nazi empire, taken as a whole, would have been a net exporter of manufactures, and a net importer of food and raw materials, in those pre-war year, and that it imported more raw materials than the old Germany, rather than less. It was a net importer of cereals, and was very dependent on the outside world for such vital commodities as rubber, copper and oil, all essential in time of war. The Brookings study suggested that even in peace time, Nazi Europe would not be self-sufficient: conquest had made the Nazi regime more dependent on imports, not less.

The major supplier of many of these raw materials was the USSR, which had abundant supplies of ores, oil and grain (Tooze 2006, p. 420). In 1940 the USSR supplied Germany with 74 per cent of its phosphates imports, 67 per cent of its imported asbestos, and 34 per cent of its oil (*ibid.*, p. 321): Hitler thus found himself "dependent on the very power which he was intending to destroy" (Hildebrand 1973, p. 92). This dependence was increasingly unacceptable, since it gave Stalin more and more leverage *vis à vis* the Nazis, which he was not slow to exploit. As the German General Halder wrote in his diary, "Every weakness in the position of the Axis brings a push by the Russians. They cannot prescribe the rules for transactions, but they utilize every opportunity to weaken the Axis position" (quoted in Tooze 2006, p. 422). For example, Russian bargaining strength meant that the Soviets were able to obtain as many machine tools as the *Wehrmacht* until May 1941 (*ibid.*, pp. 422-3). Even more alarmingly, the Soviets were encroaching in the Balkans, from where the Germans imported aluminium, chrome, copper, lead, manganese, nickel, oil, and tin (Robertson 1989, p. 371).

In the same month that the Brookings Institute published its study, Operation Barbarossa was launched. In retrospect, Hitler's decision to invade the Soviet Union seems suicidal, but

at the time there was "a strong economic impulse behind it" (Overy 2002, p. 352). German planners saw the conquest of Soviet resources as being essential for the German war effort, before American resources began to weigh too heavily in the balance in favour of Britain (Tooze 2006, pp. 420-425). Trading with the Soviets had never been Hitler's long run objective: achieving self-sufficiency by *seizing* those resources was his ultimate goal. Now trade with the USSR was becoming increasingly costly in the short run. In Hitler's OKW Directive of June 11, 1941, the first strategic task which he set the armed forces after their expected *Blitzkrieg* victory in Russia was that "The newly conquered territories in the East must be organised, made secure, and, in full co-operation with the Armed Forces, exploited economically" (Trevor-Roper 1964, p. 79). Similarly, in August Hitler took the view that the main priority was not the capture of Moscow, but "to seize the Crimea and the industrial and coal region on the Donets, and to cut off the Russian oil supply from the Caucasus area" (*ibid.*, p. 95).

There was nothing rational about Hitler's racial theories and rabid nationalism. However, his desire for *Lebensraum* is quite consistent with our model. *Vis à vis* the Western nations, the Nazi state was a rising power, whose dependence on trade left it vulnerable to blockade by sea: both $\frac{a}{b}$ and $\frac{g_y}{g_x}$ were high. True, World War 2 did not result from a direct Nazi challenge to Western naval supremacy. It did however arise in large part because of Hitler's desire to break free from the constraints which the Western ability to blockade imposed upon him, the difference being that he attempted to do so by dominating or conquering territory to his East. Hitler saw this as necessary if he were ever to be able to challenge Britain, and especially the United States, for global domination. As for the decision to attack the Soviet Union, this was in part a pre-emptive strike on a rising challenger who would be too strong to take on eventually. But as we have seen, it also in part reflected a fear of being dependent on imports from a potential enemy.

The key issue in our model is the relative growth in military capacity of the two countries over time, which depends not only on the growth rates of their economies, but on their respective capacities to blockade. With its vast continental territory and abundant resources, as well as its Pacific coastline, Russia was impossible for Germany to blockade. As such, it could be thought of as combining the characteristics of both an the catching-up industrial country F and of the resource-rich country C in our model. Germany, on the other hand, was vulnerable to blockade

by Russia: Stalin could at any time have turned off the tap, and refused to supply the Nazis with vital supplies. In the context of our model, this implies that German military power could only grow slowly, as long as the Soviet power to blockade went unchecked. Indeed, if you assume that Germany's endowment of raw materials, x, was constant, then its military apparatus would effectively be constant as well, while Russia's was growing at the same rate as the Russian economy. The relative military power of the Nazis was thus declining over time, and by even more than the Soviet rearmament drive on its own would suggest.

The USSR's superior growth rate gives one reason why the Nazis might have wanted to invade Russia (Proposition 1). As we have seen, in 1937 Hitler believed that war against the Soviet Union should begin by 1943-5. A suitably modified version of our model, in which the Soviet Union was a combination of F and C, would predict that Stalin's power to blockade Germany made it *even more likely* that Hitler would invade. Nor is it difficult to understand why Stalin would not have wanted to negotiate away this capacity to blockade. Doing so would have involved conceding territory, and war might have been inevitable anyway – in the context of our model, because of the USSR's superior growth rate, but also because of Hitler's ideological anti-Bolshevism and his search for *Lebensraum*.

5.3 World War 2 in Asia

Meanwhile, population growth and industrialisation in another archipelago, at the opposite end of Eurasia, meant that Japan was now faced with similar choices about how to acquire for itself the primary products which it needed. Japan's industrial output had been growing more rapidly than American output since 1890 (Bénétrix et al. 2013). Her population had been keeping pace with America's population over the same period, and growing much more rapidly than the British population. Between 1920 and 1938, Japan's industrial output grew at an average of 6.7 per cent per annum, much higher than the growth rates recorded in the USA (1.2 per cent, although that reflected the severity of the Great Depression) and UK (3 per cent) over the same period. Rapid growth meant an increase in Japan's relative military power. This had already been dramatically displayed during the Russo-Japanese war of 1904-5, when Japan inflicted a humilating defeat on a major European power, and it continued to grow during the interwar

period. This was a case where $\frac{a}{b}$ was unambiguously high.

However, Japan was endowed with very few natural resources, and rapid growth meant greater dependence on trade: $\frac{g_y}{g_x}$ was also clearly very high. This left Japan vulnerable in the event of a conflict with the UK or United States. Japan was far less self-sufficient than Germany: "the domestic Japanese economy on the eve of the war produced only 16.7 per cent of her total iron ore consumption, 62.2 per cent of her steel consumption, 40.6 per cent of her aluminium consumption, 20.2 per cent of her crude oil consumption, and 31.3 per cent of her salt consumption". Japan was completely reliant on imports for such strategic minerals as nickel and bauxite (Milward 1977, pp. 31-2). The United States was a major supplier of several crucial materials to Japan, including oil, scrap iron, and raw cotton (Liberman 1996, p. 169); it supplied Japan with two thirds of her oil in 1936 (Millward, *op. cit.*). On the other hand, if Japan managed to seize control over not only Manchuria and China, but Southeast Asia as well, then planners estimated that she would be self-sufficient in the major strategic commodities, aside from nickel (*ibid*).

A group of "total war" military officers, having observed Germany's experience during World War I, became convinced that Japan would only be secure if it was self-sufficient. "War hereafter would be protracted, according to Asian observers of the European conflict, and nations had to be able to supply themselves during wartime with adequate quantities of raw materials and manufactured goods. Reliance on other countries for the materiel of war was a sure path to defeat...The need for security became, slowly, an impulse for empire, and it led directly to the Pacific War" (Barnhart 1987, p. 9). The liberal 1920s were not conducive to the search for imperial autarky, but by the 1930s these officers were able to set in motion plans for the conquest of first Manchuria, then China proper, and finally South East Asia. They were aided by the collapse of the international economy during the Great Depression: "If the industrial-commercial world economy was to be partitioned rather than open, the pressure for territorial grab became irresistible" (Gat 2006, p. 556).

Yasuba (1996) argues that the militarists' argument that Japan needed to invade Manchuria in order to secure vital natural resources was flawed, in that natural resources only became scarce once war had started (given that modern warfare required the rapid development of heavy industry with its large raw materials requirements). The argument may well be correct, but

our model suggests that it would have been irrelevant in the minds of military planners, even had they agreed with the proposition. In our model, imports of raw materials that are required for purely civilian purposes can never be a cause of war; only raw materials that are essential for warfare itself can prompt follower countries to go to war, and this seems to be largely what happened. [35]

In the absence of control over Southeast Asia, war with China increased the need for imported raw materials from the West, but it also increased Western suspicion of Japan and aid to China. German victories in 1940 offered Japan the occasion to seize French Indochina, and opened up the possibility of an invasion of British and Dutch Southeast Asia. This prospect was unacceptable not only to the British, who were not well positioned to do much about it, but to the United States as well. Aside from the potential threat to the Philippines, the US also imported raw materials such as rubber from Southeast Asia (Marshall 1995), and so did Britain, which the US was seeking to protect, and which was in trouble enough as it was. The US response, unfortunately, confirmed in the minds of Japanese planners that their basic assumption, that a reliance on trade was dangerous for national security, was correct. In July 1940 the President was empowered to ban the export of strategic commodities, and soon the US had banned the export of scrap iron and steel, aviation fuel and other commodities. While in the short run Japan could live with this, having stockpiled American raw materials since 1937, the ban on oil exports which came in July 1941 was a very different matter, and was seen as a *de facto* declaration of war.[36] As in Germany, the fact that critical raw materials were now in short supply became an argument, not for restraint, but for an immediate all-out war (Ferguson 2008), since it implied that $q^F_{t+1} < q^F_t$.

This case seems to fit our model reasonably well. Japan was growing relatively rapidly, and becoming more dependent on imported raw materials, just as is true of the follower country in our model. The European imperial powers and the United States possessed colonies which produced vital raw materials, or (as in the case of US oil) produced those raw materials domestically. This

[35] On the other hand, the timing of the war against China was seen as a disaster by the total war officers, who had hoped for more time to build up Japan's industrial base and consolidate the economic relationship with China (Barnhart 1987).

[36] As is well known, Roosevelt had not envisaged the oil embargo as being a complete one, but the State Department officials who implemented the embargo ensured that it became one (Iriye 1987, p. 150).

implied an ability to blockade which was actually used by the United States in the run-up to war. Japan's invasions of Manchuria, China and Southeast Asia were motivated by a desire for economic and strategic self-sufficiency, which was to be formalised via the creation of a Greater East Asia Co-Prosperity Sphere. This would have deprived the Western powers of the ability to blockade Japan. But achieving self-sufficiency required launching an attack on the Western powers, despite Japan's economic and military inferiority relative to America.

6 Conclusions

This paper has developed a model in which a follower country may choose to launch a pre-emptive attack on a leader, despite the fact that it is growing more rapidly. Faster growth may not translate into greater military strength if the leader has the capacity to blockade; since the leader cannot pre-commit to not use this capacity in the future, the follower may choose to launch a pre-emptive war in an attempt to secure its access to strategic raw materials.

Both the Japanese and the German experiences suggest that the search for self-sufficiency, seen as desirable in case it is required in the event of warfare, can itself lead to war. Once armed conflict is seen as a possibility, perceived vulnerability increases, as does the demand for those natural resources needed in war (Yasuba 1996, Tooze 2006). Oil and rubber, for example, were essential for motorized warfare, which was itself essential for resource-scarce nations seeking quick military victories; but neither Germany nor Japan had their own domestic supplies of either of these, or of other vital commodities. If war meant an increased need for these resources, but also implied that potential adversaries would no longer supply them, at any price, then the temptation to engage in land grabs inevitably grew.

Several historians have noted that there was a circularity to some of the strategic and military logics that were driving nations to war in the 1930s. In the case of Germany, David Kaiser (1980, p. 282) wrote that "Having insisted upon rearmament for the sake of conquest, he (Hitler) found himself in a situation where conquest was the only means of continuing rearmament. His belief that Germany must conquer a self-sufficient economic empire, rather than rely upon world trade, had become a self-fulfilling prophecy." In the case of Japan, Hatano and Asada (1989,

pp. 399-400) comment that Japanese military thinking during this period "was characterised by peculiarly circular reasoning: to prepare for hostilities with the Anglo-American powers, Japan would have to march into Indochina to obtain raw materials; the United States would counter by imposing an economic embargo; this in turn would compel Japan to seize the Dutch East Indies to secure essential oil, a step that would lead to hostilities with the United States." Similarly, Ralph Hawtrey (1952, p. 72) once wrote that "the principal cause of war is war itself" in that "the aim for which war is judged worth while is most often something which itself affects military power." As Kaiser noted, the danger with circular logics is that they can become self-fulfilling.

Today's China is a rapidly industrialising follower country which is converging on the US and becoming more dependent on imported raw materials. Standard political economy considerations imply that it would be difficult if not impossible to unwind today's globalization, on which the Chinese economy depends: production is so fragmented, and the Chinese and Western economies so inter-dependent, that a move away from free trade would be impossibly costly, not just in the aggregate, but for large corporations that wield considerable political as well as economic power. This paper sounds a cautionary note: if strategic considerations were ever allowed to gain an upper hand, the world would become a much more dangerous place.

In August 1941 Churchill and Roosevelt met in Placentia Bay, and issued a proclamation known as the Atlantic Charter, which amounted to statement of war aims by what would soon become the Western Allies. The fourth principle declared that the United Kingdom and United States would "endeavor, with due respect for their existing obligations, to further the enjoyment by all States, great or small, victor or vanquished, of access, on equal terms, to the trade and to the raw materials of the world which are needed for their economic prosperity." This statement was issued at a time when the United States and Japan were hurtling towards war over precisely this issue. Rather than being seen as an olive branch by the Japanese, however, it was dismissed as an assertion by the British and Americans that they would continue to control world markets after the war (Iriye 1987, pp. 154-6).

And yet to a large extent this principle did serve as one of the foundations for the world order after 1945, although it was waived in the case of both cold and hot wars in the late 20th century. By and large we all tend to assume that money confers the right to buy whatever we need at the

going price on world markets. Both our model and the historical experience suggests that this assumption is an important safeguard of peace, especially at a time when rising powers become increasingly dependent on world markets for food and raw materials.

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Appendix

Micro-foundation of equations 7 and 8

Since what follows applies equally to all periods, we drop the subscript t to simplify the notation. There are now two sectors, the military and the civilian sector, and four types of raw materials: one abundant and used in the military sector (denoted by d_M), one abundant and used in the civilian sector (d_C), one scarce and used in the military sector (x_M), and one scarce and used in the civilian sector (x_C). Endowments of abundant raw materials are assumed to be arbitrarily large. Endowments of scarce raw materials are denoted by $\overline{x}^J_M$ and $\overline{x}^J_M$, and their sum, $\overline{x}^J = \overline{x}^J_M + \overline{x}^J_C$, is taken to be as defined in (2).

Technology in the two sectors is:

$$z_M = \min\left(y_{d_M}, d_M\right) + \min\left(y_{x_M}, \zeta_M x_M\right)$$
$$z_C = \min\left(y_{d_C}, d_C\right) + \min\left(y_{x_C}, \zeta_C x_C\right),$$

where we have distinguished four types of industrial input (each of them to be combined with a different type of raw material) and $\zeta_M, \zeta_C > 0$ are parameters.

We can now specify, for each country $J \in \{L, F\}$, the dependence of each sector on scarce raw materials, simply by specifying the endowments of the four types of industrial input. We make the admittedly unrealistic assumption that both countries are endowed with the same proportions of the four types of industrial input. This is just a simplification: since L's dependence on scarce raw materials does not matter for the equilibrium, we could have assumed *any* proportions for this country, with no consequences for the equilibrium. Endowments are:

$$\begin{array}{ll} \overline{y}^J_{d_M} = (1-\alpha)\beta\overline{y}^J & \overline{y}^J_{x_M} = \alpha\beta\overline{y}^J \\ \overline{y}^J_{d_C} = (1-\gamma)(1-\beta)\overline{y}^J & \overline{y}^J_{x_C} = \gamma(1-\beta)\overline{y}^J \end{array} \tag{22}$$

where $\alpha, \beta, \gamma \in [0, 1]$. The endowments in (22) are best illustrated by means of an example. If the industrial input used in the military sector consists of soldiers and tanks, then β is the share of soldiers and tanks in the national endowment of the industrial input. Next, suppose that one

needs food to feed soldiers, and fuel to operate the tanks. If food and fuel are both in abundant domestic supply, $\alpha = 0$. In words, all of the industrial input used in the military sector is of the y_{d_M} type, since it is only to be combined with abundant raw materials. Symmetrically, if both food and petrol are scarce, $\alpha = 1$: all of the industrial input used in the military sector is of the y_{x_M} type, since it is only to be combined with scarce raw materials. Finally, if food is abundant but fuel is scarce, $\alpha \in (0, 1)$, with α reflecting the share of tanks in the total industrial input used in the military sector. In words, only a share α of the industrial input used in the military sector is of the y_{x_M} type (tanks), since only this share needs to be combined with scarce raw materials.

Given F's endowments of the industrial input, sectoral demand for scarce raw materials is:

$$(x_M^J)_d = \frac{\alpha}{\zeta_M}\beta\overline{y}^J$$
$$(x_C^J)_d = \frac{\gamma}{\zeta_C}(1-\beta)\overline{y}^J,$$

which implies total demand:

$$(x^J)_d = (x_M^J)_d + (x_C^J)_d = \left[\frac{\alpha}{\zeta_M}\beta + \frac{\gamma}{\zeta_C}(1-\beta)\right]\overline{y}^J.$$

Since we can always chose physical units so that $\left[\frac{\alpha}{\zeta_M}\beta + \frac{\gamma}{\zeta_C}(1-\beta)\right] = 1$, the above becomes $(x^J)_d = \overline{y}^J$, which in turn implies that total imports can be written as $m^J = \overline{y}^J - \overline{x}^J$. If we additionally assume that the two types of scarce raw materials have the same share in the total domestic endowment as they have in total demand, we can write:

$$m_M^J = (x_M^J)_d - \overline{x}_M^J = \frac{\alpha}{\zeta_M}\beta(\overline{y}^J - \overline{x}^J) = \frac{\alpha}{\zeta_M}\beta m^J$$
$$m_C^J = (x_C^J)_d - \overline{x}_C^J = \frac{\gamma}{\zeta_C}(1-\beta)(\overline{y}^J - \overline{x}^J) = \frac{\gamma}{\zeta_C}(1-\beta)m^J.$$

This multi-sector model is equivalent to the aggregate model presented in the paper, since it implies the same link between exogenous and endogenous variables in equilibrium.[37] To see this,

[37]The production technology of the economy cannot however be represented by (1).

notice that we can we can write:

$$\begin{aligned} z^J &= \overline{y}^J \\ (x^J)_d &= \overline{y}^J \\ m^J &= \overline{y}^J - \overline{x}^J, \end{aligned}$$

which are the exact equivalent of (3)-(5), and, calling $A^J = z_M^J$:

$$\begin{aligned} A^L &= \beta \overline{y}^L \\ A^F &= \beta \overline{y}^F - B\zeta_M m_M^F \\ &= \beta \left(\overline{y}^F - B\zeta_M \frac{\alpha}{\zeta_M} m^F \right) \\ &= \beta \left(\overline{y}^F - B\alpha m^F \right), \end{aligned}$$

which are the exact equivalent of (7)-(8).

Proof of Result 1

Consider any t such that war has not already happened, and assume $q_s^F \geq q_{s+1}^F$ for $s \geq t+1$. Suppose that, if there is no war in t, there will be one in $T > t$ (note that it could be the case that $T = \infty$, in which case there will never be war). In that case, payoffs in T will be:

$$\begin{aligned} V_T^F &= q_T^F P(1-k) \\ V_T^F &= (1 - q_T^F) P(1-k). \end{aligned}$$

For peace to prevail in $T-1$, F will have to be offered at least:

$$\begin{aligned} \pi_{T-1}^* &= \max \left\{ 0, \arg_{\pi_{T-1}} \left[\pi_{T-1} + \delta q_T^F P(1-k) = q_{T-1}^F P(1-k) \right] \right\} \\ &= \max \left\{ 0, q_{T-1}^F (1-k) - \delta (q_T^F - q_{T-1}^F) P(1-k) \right\} \\ &= q_{T-1}^F (1-k) - \delta (q_T^F - q_{T-1}^F) P(1-k), \end{aligned}$$

where the last equality follows from $q^F_{T-1} \geq q^F_T$. Since L moves first, it will offer exactly π^*_{T-1} (it must be the case that $\pi^*_{T-1} \leq 1$, or else war could not be avoided). Payoffs in $T-1$ will then be:

$$\begin{aligned}
V^F_{T-1} &= q^F_{T-1}P(1-k) \\
V^L_{T-1} &= 1 - \pi^*_{T-1} + \delta(1-q^F_T)P(1-k) \\
&= 1 - q^F_{T-1}(1-k) + \delta(q^F_T - q^F_{T-1})P(1-k) + \delta(1-q^F_T)P(1-k) \\
&= 1 - q^F_{T-1}(1-k) - \delta q^F_{T-1}P(1-k) + \delta P(1-k) \\
&= 1 + \delta P - q^F_{T-1}(1-k) - \delta q^F_{T-1}P(1-k) - k\delta P \\
&= P - q^F_{T-1}P(1-k) - k\sum_{s=1}^{\infty}\delta^s.
\end{aligned}$$

Similarly, in period $T-2$, L will offer:

$$\begin{aligned}
\pi^*_{T-2} &= \max\left\{0, \arg\left[\pi_{T-2} + \delta q^F_{T-1}P(1-k) = q^F_{T-2}P(1-k)\right]\right\} \\
&= q^F_{T-2}(1-k) - \delta(q^F_{T-1} - q^F_{T-2})P(1-k),
\end{aligned}$$

implying payoffs:

$$\begin{aligned}
V^F_{T-2} &= q^F_{T-2}P(1-k) \\
V^L_{T-2} &= 1 - \pi^*_{T-2} + \delta\left[P - q^F_{T-1}P(1-k) - k\sum_{s=1}^{\infty}\delta^s\right] \\
&= 1 - q^F_{T-2}(1-k) + \delta(q^F_{T-1} - q^F_{T-2})P(1-k) + \delta\left[P - q^F_{T-1}P(1-k) - k\sum_{s=1}^{\infty}\delta^s\right] \\
&= 1 - q^F_{T-2}(1-k) - \delta q^F_{T-2}P(1-k) + \delta\left[P - k\sum_{s=1}^{\infty}\delta^s\right] \\
&= 1 + \delta P - q^F_{T-2}(1-k) - \delta q^F_{T-2}P(1-k) - k\delta\sum_{s=1}^{\infty}\delta^s \\
&= P - q^F_{T-2}P(1-k) - k\sum_{s=2}^{\infty}\delta^s.
\end{aligned}$$

Using this logic recursively, payoffs in period $t+1 = T-(T-t-1)$ will then be:

$$V_{t+1}^F = q_{t+1}^F P(1-k) \tag{23}$$

$$V_{t+1}^L = P - q_{t+1}^F P(1-k) - k\sum_{s=T-t-1}^{\infty}\delta^s. \tag{24}$$

Now, suppose that F is offered π_t. Its payoffs from rejecting and from accepting are:

$$V_t^F(W) = q_t^F P(1-k)$$
$$V_t^F(NW) = \pi_t + \delta V_{t+1}^F = \pi_t + \delta q_{t+1}^F P(1-k).$$

F accepts iff $V_t^F(NW) \geq V_t^F(W)$, or:

$$\pi_t \geq q_t^F(1-k) - \delta(q_{t+1}^F - q_t^F)P(1-k) \equiv \underline{\pi}_t. \tag{25}$$

If $\underline{\pi}_t > 1$, there exists no feasible π_t that induces F to accept. Using (25), $\underline{\pi}_t > 1$ iff:

$$\begin{aligned} k &< \frac{q_t^F - \delta(q_{t+1}^F - q_t^F)P - 1}{q_t^F - \delta(q_{t+1}^F - q_t^F)P} \\ &= \frac{q_t^F - \delta q_{t+1}^F - (1-\delta)}{q_t^F - \delta q_{t+1}^F}. \end{aligned} \tag{26}$$

Next, consider L's decision. Its payoffs from immediately starting a war, or from offering a π_t that avoids war, are:

$$V_t^L(W) = (1-q_t^F)P(1-k)$$
$$V_t^L(NW) = 1 - \pi_t + \delta V_{t+1}^L = 1 - \pi_t + \delta(1-q_{t+1}^F)P(1-k) + \delta Pk - k\sum_{s=T-t}^{\infty}$$

L offers π_t iff $V_t^L(NW) \geq V_t^L(W)$, or

$$\begin{aligned}\pi_t &\leq -(1-q_t^F)(1-k) - \delta(q_{t+1}^F - q_t^F)P(1-k) + 1 + \delta Pk - k\sum_{s=T-t}^{\infty}\delta^s \\ &= q_t^F(1-k) - \delta(q_{t+1}^F - q_t^F)P(1-k) + Pk - k\sum_{s=T-t}^{\infty}\delta^s \\ &= \underline{\pi}_t + k\sum_{s=0}^{T-t-1}\delta^s \equiv \overline{\pi}_t.\end{aligned} \tag{27}$$

If $1 < \underline{\pi}_t < \overline{\pi}_t$, there exists no feasible π_t that F is willing to accept, and there will be war in t. If $\underline{\pi}_t < \overline{\pi}_t < 0$, there exists no feasible π_t that L is willing to offer, and there will be war in t. Using (27), $\overline{\pi}_t < 0$ iff:

$$\begin{aligned}k &< \frac{q_t^F - \delta(q_{t+1}^F - q_t^F)P}{q_t^F - \delta(q_{t+1}^F - q_t^F)P - \sum_{s=0}^{T-t-1}\delta^s} \\ &= \frac{\delta q_{t+1}^F - q_t^F}{\sum_{s=0}^{T-t-1}\delta^s(1-\delta) + \delta q_{t+1}^F - q_t^F}.\end{aligned} \tag{28}$$

In all other possible cases ($\underline{\pi}_t < 0 \leq \overline{\pi}_t$, $0 \leq \underline{\pi}_t < \overline{\pi}_t \leq 1$, $\underline{\pi}_t \leq 1 < \overline{\pi}_t$) there exists π_t that L is willing to offer and F willing to accept, and there is no war in t. Thus, there is a war in t iff either (26) or (28) holds. Notice that (26) can only hold if $q_{t+1}^F < q_t^F$, (28) can only hold if $q_{t+1}^F > q_t^F$.

If $B = 0$, or if $B = 1$ and $\alpha = 0$, $q_1^F \leq q_2^F$ and $q_t^F = q_2^F$ for all $t > 2$. Thus, the assumption under which (23) and (24) are derived holds true. Consider any $t > 1$ such that war has not happened before. Because $q_{t+1}^F = q_t^F$, neither (26) nor (28) hold, so there is no war in t. It follows that, if war does not happen in period 1, it does not happen in any subsequent period.

If $B = 1$ and $\alpha = 1$, $q_{t+1}^F \leq q_t^F$ for all $t \geq 1$. Again, the assumption under which (23) and (24) are derived holds true. We begin by showing that, under Assumption 1, $q_t^F - \delta q_{t+1}^F \geq q_{t+1}^F - \delta q_{t+2}^F$ for all $t \geq 1$. Using (6) together with (7)-(8) and (2), this is equivalent to showing that:

$$\frac{r^F}{\left(\frac{g_y}{g_x}\right)^{t-1} + r^F} - \delta\frac{r^F}{\left(\frac{g_y}{g_x}\right)^{t} + r^F} \geq \frac{r^F}{\left(\frac{g_y}{g_x}\right)^{t} + r^F} - \delta\frac{r^F}{\left(\frac{g_y}{g_x}\right)^{t+1} + r^F}. \tag{29}$$

Inequality (29) can be transformed as follows:

$$\left(\frac{g_y}{g_x}\right)^{2t+1} + r^F\left(\frac{g_y}{g_x}\right)^{t+1} + \left(\frac{g_y}{g_x}\right)^{t} r^F + (r^F)^2 - \delta\left[\left(\frac{g_y}{g_x}\right)^{2t} + r^F\left(\frac{g_y}{g_x}\right)^{t+1} + \left(\frac{g_y}{g_x}\right)^{t-1} r^F + (r^F)^2\right] \geq$$
$$\left(\frac{g_y}{g_x}\right)^{2t} + r^F\left(\frac{g_y}{g_x}\right)^{t+1} + \left(\frac{g_y}{g_x}\right)^{t-1} r^F + (r^F)^2 - \delta\left[\left(\frac{g_y}{g_x}\right)^{2t-1} + r^F\left(\frac{g_y}{g_x}\right)^{t} + \left(\frac{g_y}{g_x}\right)^{t-1} r^F + (r^F)^2\right].$$

The above inequality can be simplified into:

$$\left(\frac{g_y}{g_x}\right)^{2t}\left[\left(\frac{g_y}{g_x}\right) - \delta\right] + \left(\frac{g_y}{g_x}\right)^{t} r^F\left[1 - \delta\left(\frac{g_y}{g_x}\right)\right] \geq$$
$$\left(\frac{g_y}{g_x}\right)^{2t-1}\left[\left(\frac{g_y}{g_x}\right) - \delta\right] + \left(\frac{g_y}{g_x}\right)^{t-1} r^F\left[1 - \delta\left(\frac{g_y}{g_x}\right)\right],$$

which further simplifies into:

$$\left(\frac{g_y}{g_x}\right)^{2t-1}\left(\frac{g_y}{g_x} - 1\right)\left(\frac{g_y}{g_x} - \delta\right) \geq \left(\frac{g_y}{g_x}\right)^{t-1}\left(\frac{g_y}{g_x} - 1\right) r^F\left(\delta\frac{g_y}{g_x} - 1\right)$$
$$\left(\frac{g_y}{g_x}\right)^{t}\left(\frac{g_y}{g_x} - \delta\right) \geq r^F\left(\delta\frac{g_y}{g_x} - 1\right). \tag{30}$$

Now if $\delta \leq \frac{g_x}{g_y}$, (30) holds for all $t \geq 1$ (since $r^F > 0$ and $\frac{g_y}{g_x} \geq 1$). If $\delta > \frac{g_x}{g_y}$, Assumption 1 is sufficient for (30) to hold for all $t \geq 1$. Now, consider any $t > 1$ such that war has not happened before. Because $q^F_{t+1} \leq q^F_t$, only condition (26) can hold.[38] Suppose it does. Because the RHS of (26) is increasing in $q^F_t - \delta q^F_{t+1}$, and $q^F_{t-1} - \delta q^F_t \geq q^F_t - \delta q^F_{t+1}$ for all $t > 1$, (26) must hold in period $t-1$ as well. This logic can be used recursively, to show that if (26) holds in $t > 1$, it must also hold in $t = 1$. Symmetrically, if (26) does not hold in $t = 1$, it does not hold in $t > 1$. Because, in equilibrium, war happens iff (26) holds, this proves that, along the equilibrium path, if war does not happen in period 1, it does not happen in any subsequent period.

Proof of Result 2

If $B_1 = 1$ but $B_t = 0$ for all $t > 1$, $q^F_1 \leq q^F_2$ and $q^F_s = q^F_2 \ \forall\ s > 2$, for both $\alpha = 0$ and

[38] It follows that an L-led war may only happen if $B = 0$, or if $B = 1$ and $\alpha = 0$. For these cases, it was shown above that, if war does not happen in period 1, it does not happen in any subsequent period. This justifies the way in which we derived equation (13) in the main text.

$\alpha = 1$. Consider any $t > 1$ such that war has not happened before. Because $q^F_{t+1} = q^F_t$, neither (26) nor (28) hold, so war does not take place. It follows that war can only take place in period 1.

Proof of Proposition 3

If L has not surrendered the capacity to blockade, Proposition 2 applies. If L has surrendered the capacity to blockade, if $\alpha = 0$, we obtain $q^F_1 = \frac{b}{1+b} \leq \frac{\frac{a}{b}b}{1+\frac{a}{b}b} = q^F_2$. Thus, (12) can never be true. As for (16), plugging in $q^F_1 = \frac{b}{1+b}$ and $q^F_2 = \frac{\frac{a}{b}b}{1+\frac{a}{b}b}$, the condition becomes (17). Thus, Proposition 1 applies. If $\alpha = 1$, we obtain: $q^F_1 = \frac{r^F}{1+r^F} \leq \frac{\frac{a}{b}b}{1+\frac{a}{b}b} = q^F_2$. Thus (12) can never be true. As for (16), plugging in $q^F_1 = \frac{r^F}{1+r^F}$ and $q^F_2 = \frac{\frac{a}{b}b}{1+\frac{a}{b}b}$, the condition becomes:

$$\begin{aligned} k &< \frac{\delta\frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{r^F}{1+r^F}}{1+\delta\frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{r^F}{1+r^F}} \\ &= \frac{\delta\frac{a}{b}b + \delta\frac{a}{b}br^F - r^F - \frac{a}{b}br^F}{1+\frac{a}{b}b + r^F + \frac{a}{b}br^F + \delta\frac{a}{b}b + \delta\frac{a}{b}br^F - r^F - \frac{a}{b}br^F} \\ &= b\frac{\frac{a}{b}(1+r^F)\left(\delta - \frac{r^F}{1+r^F}\right) - \frac{r^F}{b}}{1+\frac{a}{b}b(1+\delta+\delta r^F)} \equiv \Phi[r^F]. \end{aligned} \tag{31}$$

Thus, there can only be an L-led war, and iff $k < \Phi[r^F]$. Now consider L's decision to surrender the capacity to blockade. The only possible gain from surrendering the capacity to blockade is that it avoids war. If $\alpha = 0$, war happens iff $k < \Phi$ independently of L's decision, and so L does not surrender the capacity to blockade. If $\alpha = 1$, there are two cases. If $k \geq \Gamma$, there is no war if L does not surrender the capacity to blockade, and so it does not surrender it. If $k < \Gamma$, there are three subcases. If $\Phi[r^F] < \Gamma$ and $k \in (\Phi(r^F), \Gamma)$, there is a war iff L does not surrender the capacity to blockade. Furthermore, L is strictly better off by avoiding war, since $k > \Phi[r^F]$ implies $\overline{\pi}_1 > 0$ (and so L can avoid war by offering $\pi_1 < \overline{\pi}_1$). So, L surrenders it. If $\Phi[r^F] < \Gamma$ and $k = \Phi[r^F]$, there is a war iff L does not surrender the capacity to blockade, but L is indifferent with respect to war (since it can only avoid it by offering $\pi_1 = \overline{\pi}_1$). So it does not surrender it. Finally, If $\Phi[r^F] \geq \Gamma$, or $\Phi[r^F] < \Gamma$ and $k < \Phi[r^F]$, there is war independently of whether L surrenders the capacity to blockade. Thus, L does not surrender it.