Growth, Import Dependence and War

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May 6, 2016

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.

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 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.

*We thank Avner Offer, Dan Seidmann, Stergios Skaperdas and Huw Strachan for useful comments. We also thank seminar participants at the University of Nottingham, University of Oxford, Syddansk Universitet, Queens University Belfast, VU Amsterdam, ISNIE 2013, and ETSG 2013. Bonfatti received research funding from the School of Economics at the University of Nottingham; O'Rourke received funding from the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013) / ERC grant agreement no. 249546. Both express their gratitude. The usual disclaimer applies.

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 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. Our model formalizes some of the arguments made about these three episodes by prominent historians: Avner Offer's book on Anglo-German rivalry (Offer 1989), Adam Tooze's book on the Nazi German war economy (Tooze 2006), and Michael Barnhart's book on Japan's "preparation for total war"(Barnhart 1987).

We are sure that none of these historians would argue that the mechanism that we describe here "explains"any of these three conflicts in some monocausal way. Lest there be any misunderstanding on the subject, we do not make such a claim either: the origins of the first and second world wars were much too complicated to be "explained"by this or any other formal model. Our model has just two players, but there were many players involved in these conflicts (and so a country like Germany could be a follower relative to the UK, but a leader relative to Russia). It assumes that conflict is motivated by just one cause (a "pie"which both players are struggling to obtain), but international rivalries in the 1910s and 1930s were multi-dimensional. It assumes that countries can be modelled as unitary actors, but internal divisions were important in Wilhelmine Germany, Imperial Japan and elsewhere. And it assumes rationality, even though many important actors in these three episodes were motivated by sentiments such as honour and dignity, or by racial or religious prejudice, or were over-optimistic about their chances in a war, or under-estimated their opponents.

Nevertheless, we hope to convince the reader that the mechanism described by our model was one factor among many at work during these three episodes, and that trade dependence can

sometimes make war more rather than less likely. We should not expect an economic model to be able to explain on its own something as complicated as the outbreak of a world war, but this does not mean that it has nothing to tell us about the past, or that it cannot provide us with lessons that may be useful in the future.

1.1 Trade and war

The optimistic, liberal argument that international trade promotes peace is ancient but controversial (see e.g. Barbieri 1996, Rowe 2005, McDonald and Sweeney 2007, Martin, Mayer and Thoenig 2008 and Harrison and Wolf 2012). One objection is that trade can make countries dependent on others, and therefore vulnerable, in the context of an anarchic world 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).

There is also a large literature on hegemonic wars between rising challengers and dominant powers (Gilpin 1981). Our paper develops a model of trade and hegemonic warfare, in the tradition of recent papers on "rationalist explanations for war" (Fearon 1995, Powell 2006). These start from the premise that wars are costly, and that rational unitary states in dispute with each other should 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, exogenously changes over time (p. 181). For example, consider the case in which a follower exogenously catches up on a leader (Fearon 1995). 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 has 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 our model, we find that it is the follower who may declare war on the leader. International trade, and the opportunities and vulnerabilities which it implies, are central to establishing this otherwise counter-intuitive result. 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.

We model the link between growth and changes in the distribution of power in a context in which both the leader and the follower become increasingly dependent on imported raw materials, and increasingly vulnerable to being cut off from them. We assume that the leader, as befits the hegemon, 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 can mount a blockade of the follower. We show that if dependence on imported raw materials increases over time, the follower can become weaker and not stronger, even if it is growing more rapidly, and can therefore have an incentive to start a pre-emptive war. International trade can thus be crucial in determining the likelihood of war.

While we borrow our basic theoretical mechanism from the existing literature (Powell 2006), 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]

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, let us 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 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.[2] The production function is:

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

The industrial input is not produced, but 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 constant marginal cost c. Extraction beyond that amount involves an arbitrarily high marginal cost, and is therefore unfeasible. We assume that

[1] There is a growing literature on the relationship between trade and war. Glick and Taylor (2010) estimate the impact of war on trade flows, and find that it is large. Acemoglu et al. (2012) present a dynamic model of resource trade and war, focussing 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). They study 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. 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. 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. Finally, a series of papers by Stergios Skaperdas and co-authors (see Garfinkel et al. 2012 for a good overview) 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 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 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] 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.

it costs less than one unit of z to extract one unit of x: choosing z 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 arbitrarily large endowment of raw materials and with nothing else. As for L and F, their endowments in the first two periods are:

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

where $g_y \geq g_x$, $g_y \geq 1$, $g_x \geq 0$, $a \geq b > 0$, $r^L \in [0, 1)$ and $r^F \in [0, b)$. Endowments of the industrial input and raw materials grow in both countries in subsequent periods at constant rates g_y and g_x respectively. 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.[3] In both countries, raw materials are scarce ($r^L \in [0, 1)$, $r^F \in [0, b)$), and this scarcity either stays constant or increases over time ($g_y \geq g_x$).[4]

All goods are freely tradable. Given that C has a perfectly elastic supply of x at a price c, the free trade price of x must also be c. Given $c < 1$, endowments of the industrial input must be fully employed in production. We assume that domestic endowments of raw materials are the first to be used in production,[5] 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, and combine it with domestic industrial capital. They then import their residual demand for x from C, to which they export z in return. Thus, country J's

[3] We could allow for F's endowment of raw materials to also 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.

[4] If we interpret this environment through the lens of the Solow model, steady state growth is driven by capital accumulation, technological progress, and population growth, and faster growth during catching up is driven by faster capital accumulation in this phase. As for growth in the endowment of raw materials (which can be negative, $g_x < 1$), this could be driven by a combination of technological progress and an exogenous process of discovery/depletion.

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

GDP, total demand for x, and total imports (in volumes) are (for $J \in \{L, F\}$):

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

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

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

Define "dependence on imported raw materials" as the share of imports in total demand for x:

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

Figure **??** shows that dependence on imported raw materials increases over time whenever $g_y > g_x$. (The graph is drawn for L, but the same is true for F once it has reached steady state.) For future reference, we notice that dependence increases faster, the larger is the ratio $\frac{g_y}{g_x}$.[6]

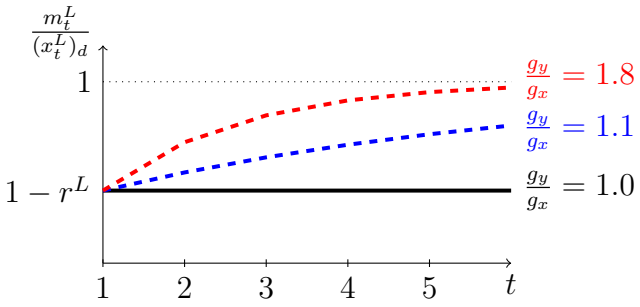

Figure 1: Country L, dependence on imported raw materials.

2.2 Import dependence and relative military power

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

[6] It is easy to show that the growth rate of $\frac{m_t^L}{(x_t^L)_d}$ at any time $t \geq 1$ is equal to $\frac{1 - \frac{g_x}{g_y}}{\frac{m_t^L}{(x_t^L)_d}}$.

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*. 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 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.

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. We refer to this second case as "L having the capacity to blockade". It is easy to show that, if L has the capacity to blockade, it always uses it in times of war. Thus, L having the capacity to blockade is synonymous with L blockading F in times of war.[7] 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 may develop a naval superiority that allows them to control trade routes in case of conflict. In the second case, F's dependence on imported raw materials may have important consequences for relative military power.[8]

[7]As clarified below, to blockade F brings only benefits to L, since it reduces the former country's probability of winning the war. We do not consider the possibility that L uses the capacity to blockade in times of peace. An obvious justification for this assumption is that a blockade is, in itself, an act of war.

[8]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*

In an online 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:

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

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

where $\beta \in (0,1)$, $\alpha \in \{0,1\}$, and $B \in \{0,1\}$. When L does not have the capacity to blockade ($B = 0$), both countries can continue to import any amount of x during a war. In this case, the only constraint on the size of the apparatus is the amount of y 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 can continue to freely import x during a war, but F cannot. Thus, L's military apparatus is the same as before. When it comes to F's military apparatus, however, we need to distinguish two cases. If $\alpha = 0$, F's apparatus is not dependent on imported raw materials. We can think of this as a situation in which the strategic raw materials needed by the military apparatus[9] are in abundant domestic supply, and are therefore included in y. In this case, F may be prevented from importing x during a war, but this does not matter for relative military power. When $\alpha = 1$, on the contrary, the strategic raw materials needed by the military apparatus are in scarce domestic supply, and are included in x. In this case, the apparatus is the recipient of a share β of total imports, and a blockade reduces its size by an amount corresponding to this share. In what follows, we will say that imported raw materials are "strategic" when $\alpha = 1$.

The growth path specified in the previous section, together with (**??**)-(**??**), imply that there are several possible paths for *relative power*, q_t^F. These are represented in Figure **??**.[10] If $B = 0$, F's relative power increases from period 1 to period 2 (as F catches up on L) and remains constant from period 2 onwards. If $B = 1$, and imports are not strategic ($\alpha = 0$), relative power follows exactly the same path as in the previous case. If imports are strategic ($\alpha = 1$), the path

impact of war on naval power cannot be obtained through peaceful negotiations.

[9] For example fuels, metals, essential foodstuffs, etc.

[10] 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.

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.[11] In other words, dependence on international trade makes it possible for a catching up follower to become militarily *weaker* over time.

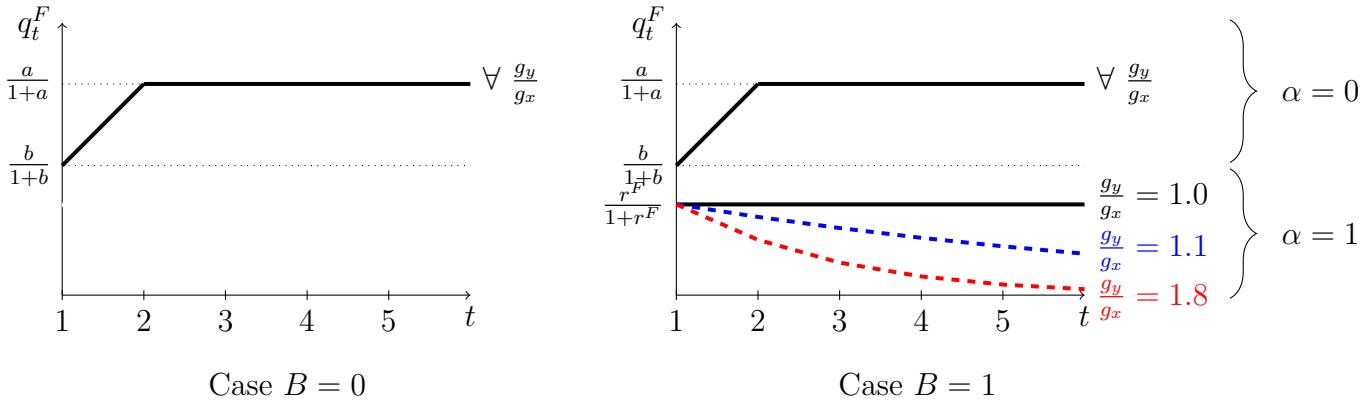

Figure 2: Evolution of relative power.

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.[12][13] 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. 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. We assume that k is drawn, in period 0, from any continuous random distribution with support in $[0, 1]$.

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

[12] The pie may represent a range of contested issues that L and F must settle. These could be non-economic issues, such as the division of 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.

[13] One straightforward extension would be to let the pie grow over time by a constant factor $g_p > 1$ (with $\delta g_p < 1$): our results would still go through, but with δ replaced by δg_p everywhere. This suggests that another special case that we can easily consider is one in which the pie grows at the same rate as the economy, $g_p = g_y$.

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.[14]

To summarise, the timing is as follows. In period 0, k is drawn. Then, in period 1:

1 L can either make a proposal π_1 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 π_t 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.[15] 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

[14]Note that this structure of negotiations allocates all of the bargaining power to L. We have assumed this extreme distribution of bargaining power just for simplicity: to relax this assumption would not qualitatively change our results.

[15]Garfinkel and Skaperdas (2000) show that, if the cost of arming is taken into account, there is another channel through which war may occur in equilibrium: in a nutshell, war can be attractive because, by allocating the pie to the winner in perpetuity, it reduces the future cost of arming. Because we assume that countries only care about the division of the pie, this channel is shut down in our model. While one could extend the model to include it, we prefer to leave it out, so as to be able to focus on the channel considered in this paper.

destroys the loser's military apparatus (and its capacity to blockade, if it has one).[16][17]

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 **??** represents a parametric restriction if and only if $\frac{g_y}{g_x} > \frac{1}{\delta}$.[18] In that case, it requires r^F not to be too large, with an upper limit no lower than $\frac{g_y}{g_x} > 1$. The assumption 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 dashed lines in Figure 2 are not only decreasing, but also convex.

Under Assumption **??**, we obtain the following (proof in the online Appendix):

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.*

[16] 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.

[17] 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.

[18] If $\frac{g_y}{g_x} \leq \frac{1}{\delta}$, Assumption **??** is satisfied for all $r^F \geq 0$.

The intuition for Result **??** 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, under Assumption **??**, its change is always greatest in period 1.[19][20]

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.

What is the minimum π_1 that L must offer if it wants to avoid a war? To find out, consider F's options. If it rejects L's offer, F gets its expected payoff from war: $q_1^F P(1-k)$. If it accepts, it gets π_1 in period 1; in period 2, because L has all the bargaining power (see footnote 14), it gets its expected payoff from war in that period: $q_2^F P(1-k)$. It follows that F accepts iff:

$$\begin{aligned} \pi_1 + \delta q_2^F P(1-k) &\geq q_1^F P(1-k) \\ \pi_1 &\geq q_1^F(1-k) - \delta(q_2^F - q_1^F)P(1-k) \equiv \underline{\pi}_1. \end{aligned} \tag{9}$$

Thus, the minimum that L must offer to avoid a war is $\underline{\pi}_1$. But what is the maximum that it is willing to offer? To see this, notice that, when offering $\underline{\pi}_1$, L makes F indifferent between peace and war, while securing peace in perpetuity. In this case, therefore, L's payoff is equal to its expected payoff from war, plus the entire peace dividend, kP. Clearly, then, L would be

[19] Without Assumption **??**, the decline in F's relative power accelerates until some period $T > 1$, and decelerates thereafter. In that case, if war ever happens, it would have to happen at 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.

[20] 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 **??** for further details.

willing to offer more than $\underline{\pi}_1$ to avoid war. It would be willing to offer any π_1 such that:

$$\begin{aligned}\pi_1 &\leq \underline{\pi}_1 + kP \\ &= q_1^F(1-k) - \delta(q_2^F - q_1^F)P(1-k) + kP \equiv \overline{\pi}_1 \end{aligned} \tag{10}$$

The thresholds $\overline{\pi}_1$ and $\underline{\pi}_1$ are plotted in Figure **??**. They are both decreasing functions of $q_2^F - q_1^F$, the extent to which relative military power shifts in F's favour. Intuitively, the more relative power shifts in F's favour, the less this country must be offered to induce it to accept (the lower is $\underline{\pi}_1$). That is because to accept allows F to avoid a war, and thus renegotiate the partition of the pie in a way that reflects period 2's military power. For the same reason, the more relative power shifts in F's favour, the less is L willing to offer (the lower is $\overline{\pi}_1$).

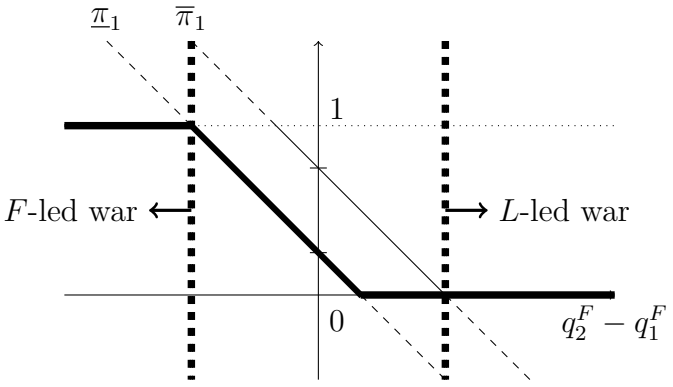

Figure 3: Political equilibrium in period 1.

Suppose again that L wants to avoid a war. What is the best way to achieve this? The answer to this question is provided by the solid, thick line in Figure **??**. If $\underline{\pi}_1 \in [0,1]$, the best L can do is to offer exactly $\underline{\pi}_1$: by definition, that is 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 can do is to offer 0. This is more than what L would ideally like to offer, but it is sufficient to avoid war, and the cheapest *feasible* way to do so. In the second case, the best L can do is to offer 1. This, however, is not sufficient to avoid war, which must then occur. Thus, war must occur if $\underline{\pi}_1 > 1$. Using the

definition provided in (**??**), a necessary and sufficient condition for $\underline{\pi}_1 > 1$ is:

$$k < \frac{q_1^F - \delta q_2^F - (1-\delta)}{q_1^F - \delta q_2^F}. \tag{11}$$

The RHS of (**??**) is always smaller than one,[21] and greater than zero if and only if $q_1^F - \delta q_2^F > 1 - \delta$. A necessary condition for this to happen is $q_1^F > q_2^F$. Thus, given that k takes a value in $[0, 1]$, it is never the case that $\underline{\pi}_1 > 1$ if k is large enough, and a necessary condition for $\underline{\pi}_1 > 1$ is $q_1^F > q_2^F$.

But when does L want to avoid war? Clearly, it does so if $\overline{\pi}_1 \geq 0$, since it can obtain peace by offering less than $\overline{\pi}_1$. If $\overline{\pi}_1 < 0$, however, L can only obtain peace by offering more than $\overline{\pi}_1$, which is not optimal. Thus, in the region to the right of the rightmost vertical line, L prefers to start a war before entering into negotiations. In other words, war must also occur if $\overline{\pi}_1 < 0$. Using the definition provided in (**??**), a necessary and sufficient condition for $\overline{\pi}_1 < 0$ is:

$$k < \frac{\delta q_2^F - q_1^F}{1 + \delta q_2^F - q_1^F}. \tag{12}$$

Again, the RHS of (**??**) is aways smaller than one, and greater than zero if and only if $\delta q_2^F - q_1^F > 0$, which in turn requires $q_2^F > q_1^F$. Thus, it is never the case that $\overline{\pi}_1 < 0$ for k large enough, and a necessary condition for $\overline{\pi}_1 < 0$ is $q_2^F > q_1^F$.

We next 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.*

By Definition **??**, the war that occurs when (**??**) holds is F-led, since L would prefer the partition $\pi_1 = 1$ to war, but F prefers war to such a partition. Symmetrically, the war that occurs when (**??**) holds is L-led, since F would prefer $\pi_1 = 0$ to war, but L prefers war to such a partition.

In summary, a war occurs if and only if either (**??**) or (**??**) hold, and it is F-led war in the first case, but L-led in the second. In both cases, the occurrence of war depends on the evolution of

[21] To see this, notice that it is increasing in $q_1^F - \delta q_2^F$, and equal to $\delta < 1$ for $q_1^F - \delta q_2^F = 1$ (the maximum value that this term can take).

relative military power. We next look at how the characteristics of the world economy determine the evolution of military power, and thus the occurrence of war. Consider first the case in which L does not have the capacity to blockade (the proofs of all propositions and corrolaries are given in the Appendix):

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:*

$$k < \Phi \equiv b\frac{\frac{a}{b}(1+b)\left(\delta - \frac{b}{1+b}\right) - 1}{1 + \frac{a}{b}b(1+\delta+\delta b)}. \tag{13}$$

If L does not have the capacity to blockade, relative military power only depends on industrial catching up. In this environment, Proposition **??** 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 circumstances, L may want to start a pre-emptive war so as to defeat the follower before it is too late. 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 $\frac{a}{b}$.*

Corollary **??** relates the probability of an L-led war to two key parameters of the model, the discount factor (δ) and the rapidity of catching up $\left(\frac{a}{b}\right)$. If δ is low, 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 war, even if the cost of war is close to zero. In terms of Proposition **??**, $\Phi < 0$. If δ is high, on the other hand, L is more worried about the future, and, if F is expected to catch up fast enough $\left(\frac{a}{b} > \left(\frac{a}{b}\right)^*\right)$, nothing may be able to dissuade L from starting a pre-emptive war. When this is the case, the probability that war actually happens is higher, the higher is $\frac{a}{b}$. In terms of Proposition **??**, $\Phi > 0$, and is increasing in $\frac{a}{b}$.

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

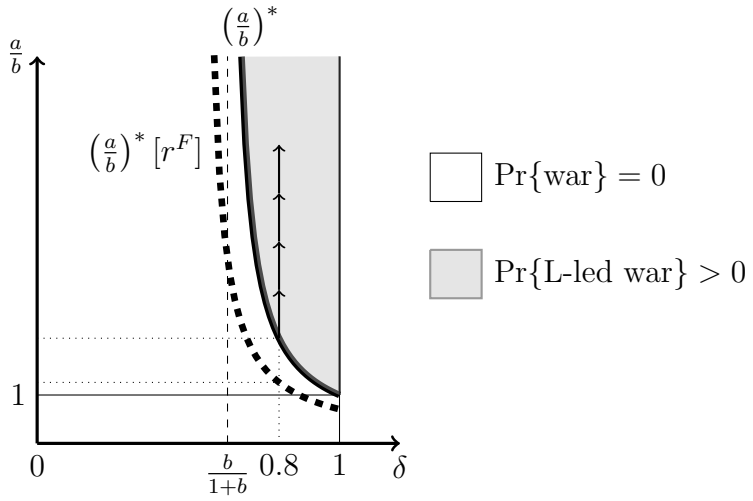

Figure 4: Equilibrium when L does not have the capacity to blockade.

One important point that emerges from Figure **??** is that, for $\delta < 1$, 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* **??** *and Corollary* **??**.

- *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:*

$$k < \Gamma \equiv \frac{\frac{g_y}{g_x}\left[\frac{r^F+1}{r^F}\left(\delta - \frac{1}{1+r^F}\right)\right] - 1}{\frac{g_y}{g_x} + r^F(1-\delta) - \delta}. \tag{14}$$

The capacity to blockade is a valuable military tool in L's hands, but only if F's imports are strategic. If not, relative power still depends on industrial catching up alone, and the equilibrium is as in Proposition **??**. If imports are strategic, on the other hand, Proposition **??** 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 grows at a rate g_y. Thus, it may now be the follower that wants to defeat the leader before it is too late.

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, this probability is increasing in* $\frac{g_y}{g_x}$*.*

Corollary **??** relates the probability of an F-led war 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 δ is low. If δ is high, on the other hand - 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 **??**, $\Gamma > 0$, and 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 **??**.

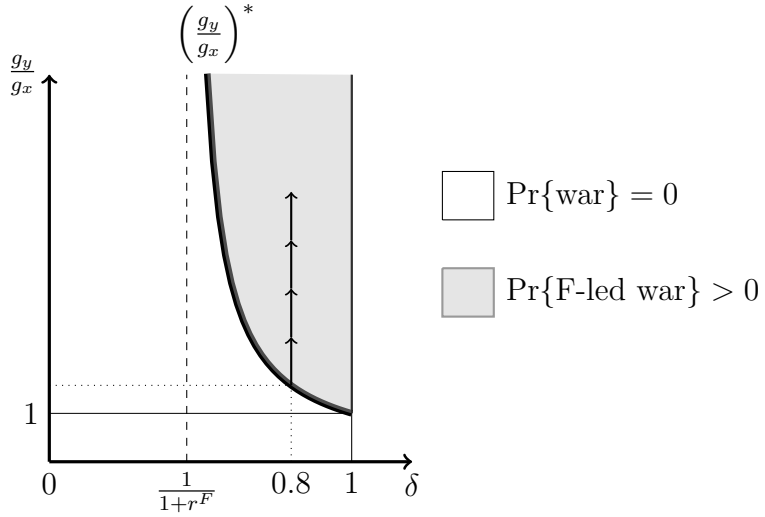

Figure 5: Equilibrium when L has the capacity to blockade, and $\alpha = 1$.

These results suggest that a growing dependence on international trade over time can make war more likely, at least if the hegemonic country has the capacity to blockade and imports are strategic. This is because it makes follower nations more militarily vulnerable over time, and thus more likely to start a pre-emptive war.

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. We assume that L may offer to surrender the capacity to blockade as part of its period 1 proposal. More precisely, it may do so immediately before deciding whether or not to offer π_1. If L does surrender the capacity to blockade, and then makes an offer π_1 that F accepts, the capacity to blockade is dismantled by the beginning of period 2, and, from that period onwards,

no country has it.[22] As a tie-breaking rule, we assume that L does not surrender the capacity to blockade unless doing so strictly increases its payoff. Importantly, the capacity to blockade is assumed to be indivisible: either L surrenders it, or not.[23][24] 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 $t > 1$. If imports are not strategic, this has no effect on the path of relative power, which remains as in the right hand panel of Figure 2 (case $\alpha = 0$). If imports are strategic, however, we have a new path of relative power. This is illustrated in Figure **??**, which modifies the right hand 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 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 (left hand panel of Figure 2), since now F gets stronger both because of catching up, and because L relinquishes the capacity to blockade.

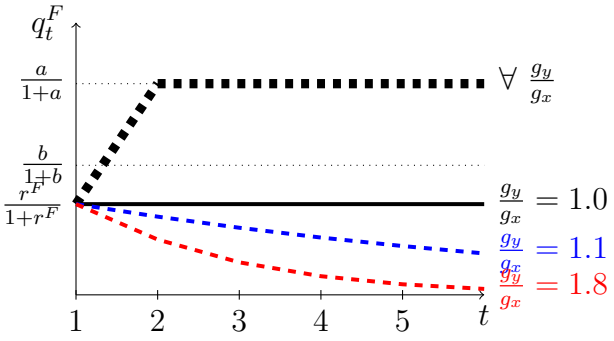

Figure 6: Evolution of relative power, case $B_1 = 1$, $\alpha = 1$.

If L does not surrender the capacity to blockade, the evolution of relative power remains the

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

[23] 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.

[24] 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.

same as in the previous section. Thus, Result **??** still applies. If L surrenders the capacity to blockade, however, we need the following (proof in the online Appendix):

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.*

Result **??** implies that we only need to ascertain whether or not war happens in period 1. Thus, independently of whether or not L surrenders the capacity to blockade, (**??**) and (**??**) are still the relevant conditions for war.

By surrendering the capacity to blockade, L may be able to determine q_2^F, and thus the occurrence of war. When will it want to do so? This is clarified in the following:

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* **??** *and Corollary* **??**.
- *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*

$$\Phi[r^F] \equiv b\frac{\frac{a}{b}(1+r^F)\left(\delta - \frac{r^F}{1+r^F}\right) - \frac{r^F}{b}}{1 + \frac{a}{b}b(1+\delta+\delta r^F)} \tag{15}$$

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. [25]

Proposition **??** modifies Proposition **??** 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,

[25] 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.

an F-led war is unavoidable - there is now a range of parameters, $k \in (\Phi(r^F), \Gamma)$, such that war is avoided. This is because L offers to surrender the capacity to blockade, and this is enough to induce F to accept L's offer. An F-led war may still be unavoidable, however. Intuitively, L would like to avoid an F-led war, and realises that it could do so by surrendering the capacity to blockade. But doing so 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.[26][27]

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

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 $\Phi[r^F] > \Gamma$.*

As with Proposition **??**, an F-led war can only occur if δ is high, and dependence on imported raw materials grows 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 $\left(\frac{a}{b} > \left(\frac{a}{b}\right)^* \left[r^F\right]\right)$. In terms of Proposition **??**, we 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 $\frac{a}{b}$ is low, L remains strong even after surrendering the capacity to blockade, and is therefore willing to do so to avoid an F-led war ($k \in (\Phi(r^F), \Gamma)$). If $\frac{a}{b}$ is high, on the other hand, 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 ($k \leq \Phi(r^F)$).

The new threshold, $\left(\frac{a}{b}\right)^* \left[r^F\right]$, is represented by the dashed, thick curve in Figure **??**.[28] For $\delta = 0.8$, Figure **??** represents the equilibrium in $\left(\frac{a}{b}, \frac{g_y}{g_x}\right)$ space. If negotiations about the capacity

[26] 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.

[27] 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 **??**.

[28] 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 $(\frac{a}{b})^*$. For $r^F = b$, the two thresholds coincide.

to blockade were impossible, there would be an F-led war whenever $\frac{g_y}{g_x} > \left(\frac{g_y}{g_x}\right)^*$. The ability 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.

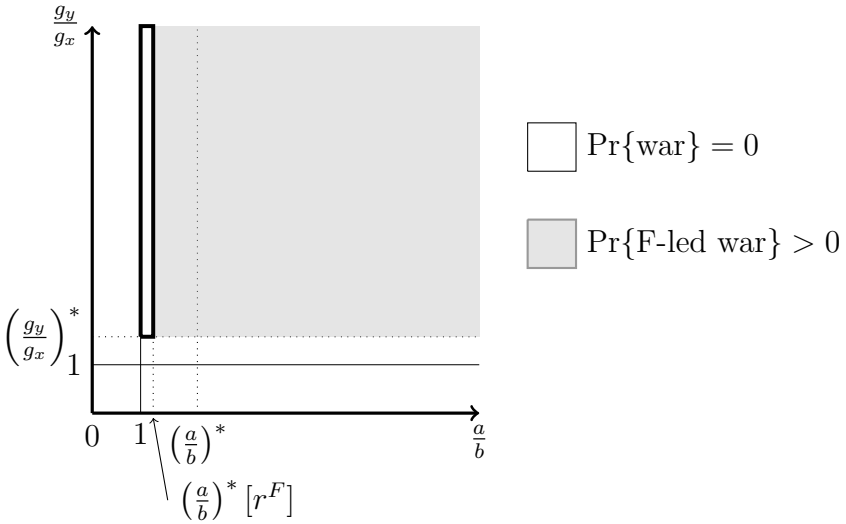

Figure 7: Equilibrium when L has the capacity to blockade and can choose to surrender it, and $\alpha = 1$ (case $\delta = 0.8$).

One interesting point that emerges from Figures **??** and **??** 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 needed 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 (when bargaining over the capacity to blockade is possible) the more rapidly the follower is catching up on the leader (Corollary 3). There is a substantial body of historical literature which suggests that this mechanism was 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.

To repeat: the world is much more complicated than the simple structure envisaged in our model, or any other, and we do not argue that our mechanism can "explain" the Second World War in some monocausal way. However, our model provides useful insights into the origins of this war, especially in the Pacific. It is much less useful in understanding the origins of the First World War, which lie elsewhere, but does provide insights into the Anglo-German naval rivalry which preceded it, and which helps explain Britain's decision to join the war once it had started. We therefore provide a very brief account of the build-ups to the First World War, the Second World War in Europe, and the Second World War in Asia. In each case, we indicate how the mechanisms identified by our model are relevant in understanding the episode in question, as well as some of the ways (certainly not all) in which reality was more complex than allowed for in the theoretical discussion above.

5.1 Anglo-German naval rivalry and World War I

Towards the end of the eighteenth century, Britain started to experience very rapid population growth and industrialisation. Population growth created the need for food imports, 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 increasingly dependent on international trade (Clark et al. 2014), and naval supremacy became a strategic imperative.

British hegemony could not last for ever, as the Industrial Revolution spread to Continental Europe. 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). Germany's 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 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, and made 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 (Offer 1989, p. 322). Germany, like Britain, was 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, rose (Fischer 1967, p. 12).

According to Avner Offer (1989), a key factor underlying Anglo-German naval rivalry 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).

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). 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 trading system [in the event of war] appeared to offer Britain a strategic opportunity as well as a strategic danger... 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 was not the cause of World War I, but the strategic considerations underlying it were one reason why Britain chose to enter the conflict (Howard 1991). 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 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. At a conference 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). As he later 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).[29]

The failure to make any headway in challenging Britain's naval superiority, 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). 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. This was also unacceptable 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. This would have weakened or eliminated Britain's capacity to blockade Germany in the event of a conflict. As 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 continental entanglements. Paradoxically, Britain's traditional maritime orientation meant that it was *more* likely that she would intervene in a war in which France risked being destroyed by Germany.

[29]Thus, Britain could not tolerate the establishment of a German port in Morocco, and thus sided decisively with France in 1911 during the Second Moroccan Crisis (Strachan 2001, p. 25, Clark 2012, p. 209).

There are several ways in which our model resonates with the history of this period. Germany was 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 growth made Britain unwilling to concede this, again as our model predicts. But Germany did not declare war on Britain, and the First World War did not happen as a result of Anglo-German naval rivalry.

It arose, 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 Austro-Hungary. 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. 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. 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. 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). More importantly, German military planners in the 1920s drew the lesson from World War I 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 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 growing German population: exporting manufactures and using the proceeds to import primary products; or acquiring new soil through violence. 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. As he put it in his memorandum of August 1936, which became the

basis for the 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."[30] 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,[31] 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 Reich, than overseas..."[32]

The problem for Hitler was that creating *Lebensraum*, necessary in his view in the event of war, itself required war, and waging war required access to foreign raw materials. 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,

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

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

[32]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).

p. 246). During the 1930s, therefore, as the Nazis geared up for war, they embarked on a series of interim policies designed to lessen German dependence on raw material imports, in advance of the final struggle. The 1934 New Plan and 1936 Four Year Plan tried to construct an increasingly autarkic economy: in terms of our model, increasing r^F and g_x. 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). However, 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 (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."[33] 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, the ultimate prize, Russian resources, 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 crucial 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

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

the first months of the war, as a result of Franco-British efforts to limit them. Hitler thus felt that he had no alternative but to gamble on an all-out assault on the West (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 particular, it was heavily dependent on imports from 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 gave Stalin more and more leverage *vis à vis* the Nazis, which he was not slow to exploit. 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).

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).

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. There are clearly echoes of our model here, although this case does not fit our model insofar as 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. A key difference from our model thus lies in the fact that he attempted to do so by attacking countries to his East that were, in terms of our model, followers to his leader. 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 it also in part reflected a fear of being dependent on imports from a potential enemy.

5.3 World War II in Asia

Meanwhile, population growth and industrialisation in another archipelago, at the opposite end of Eurasia, meant that Japan was now becoming increasingly dependent on imported primary products. 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, 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 very high. Indeed, 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). In 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.

Yasuba (1996) argues that the militarists' argument that Japan needed to invade Manchuria in order to secure vital natural resources was flawed, since natural resources only became scarce once war had started (given that modern warfare required the rapid development of heavy industry with large raw materials requirements). The argument may 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 required for purely civilian purposes can never be a cause of war; only raw materials essential for warfare itself can prompt follower countries to go to war, and this seems to be largely what happened.[34]

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. The US response 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 different matter, and was seen as a *de facto* declaration of

[34]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).

war.[35] 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 2007), since it implied that $q^F_{t+1} < q^F_t$.

This case seems the one that best fits our model. 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 gave them an ability to blockade which was 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, 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 trying to achieve such self-sufficiency was a high risk gamble, since it 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 of the links between growth, trade and military power 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 future military strength if it is accompanied by increased dependence on imported raw materials, and 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 access to strategic raw materials before it is too late.

A classic example of a follower country catching up on and overtaking a leader, without provoking a war, is the United States' ascent relative to Britain. Our mechanism could not have been at work in this instance, since the United States was a vast continental economy abundant in raw materials, and impossible to blockade. Nor did Russia, or the Soviet Union, launch pre-

[35] 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).

emptive wars against Germany in 1914, 1939 or 1941. Again, our mechanism would not have been expected to work in this instance, since Russia was another vast, resource-abundant country that was impossible to blockade. Germany and Japan, on the other hand, were resource-scarce and worried about the dependence on imports of strategic materials that this implied.

Several historians have noted that there was a circularity to some of the strategic and military logics 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." Ralph Hawtrey (1952, p. 72) 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 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 (although one hopes that the costs of war have now become so enormous as to make it unthinkable): if strategic considerations were ever allowed to gain an upper hand, globalization would become more fragile, and the world would become a much more dangerous place.

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Appendix

Proof of Proposition ??. (??), (??)-(??), and (??) imply $q_1^F = \frac{b}{1+b} \leq \frac{\frac{a}{b}b}{1+\frac{a}{b}b} = q_2^F$. Thus, only (??) can be true, and iff:

$$k < \frac{\delta\frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{b}{1+b}}{1+\delta\frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{b}{1+b}} = b\frac{\frac{a}{b}(1+b)\left(\delta - \frac{b}{1+b}\right) - 1}{1+\frac{a}{b}b(1+\delta+\delta b)}. \tag{16}$$

■

Proof of Corollary ??. The first part follows from inspection of (??). To see that the probability of an L-led war is, for given b, increasing in $\frac{a}{b}$, define $D \equiv \delta\frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{b}{1+b}$. Clearly, for given b, D is increasing in $\frac{a}{b}$. But we can re-write the RHS of (??) as $\frac{D}{1+D}$, which is increasing in D. ■

Proof of Proposition ??. If $\alpha = 0$, $q_1^F = \frac{b}{1+b} \leq \frac{\frac{a}{b}b}{1+\frac{a}{b}b} = q_2^F$ as before. If $\alpha = 1$ (??), (??)-(??) and (??) imply $q_1^F = \frac{r^F}{1+r^F} \geq \frac{r^F}{\frac{g_y}{g_x}+r^F} = q_2^F$. Thus, only (??) can be true, and iff:

$$k < \frac{\frac{r^F}{1+r^F} - \delta\frac{r^F}{\frac{g_y}{g_x}+r^F} - (1-\delta)}{\frac{r^F}{1+r^F} - \delta\frac{r^F}{\frac{g_y}{g_x}+r^F}} = \frac{\frac{g_y}{g_x}\left[\frac{r^F+1}{r^F}\left(\delta - \frac{1}{1+r^F}\right)\right] - 1}{\frac{g_y}{g_x} + r^F(1-\delta) - \delta}. \tag{17}$$

■

Proof of Corollary ??. The first part follows from inspection of (??). 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 $\frac{g_y}{g_x}$. But the RHS of (??) can be written as $\frac{E-(1-\delta)}{E}$, an increasing function of E. ■

Proof of Proposition ??. Define an indicator variable $\mathcal{S}$, which is one if L surrenders the capacity to blockade. Thus, if $\mathcal{S} = 0$, $B_t = 1\ \forall t$; if $\mathcal{S} = 1$, $B_1 = 1$ but $B_t = 0$ for $t > 1$. Consider how L's payoff depends on $\mathcal{S}$. If $\alpha = 0$, $\mathcal{S}$ does not affect payoffs, since it does not affect q_t^F. Thus, L is indifferent as to the choice of $\mathcal{S}$, and sets $\mathcal{S} = 0$ at an optimum. If $\alpha = 1$, suppose $\mathcal{S} = 0$. By Proposition ??, there is (an F-led) war in period 1 iff $k < \Gamma$, and there is no war at any subsequent period. Suppose instead $\mathcal{S} = 1$. By Result ??, war can only happen in period 1. Furthermore, $q_1^F = \frac{r^F}{1+r^F} \leq \frac{\frac{a}{b}b}{1+\frac{a}{b}b} = q_2^F$, so only condition (??) can be satisfied. Thus, there is

(an L-led) war in period 1 iff:

$$k < \frac{\delta \frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{r^F}{1+r^F}}{1+\delta \frac{\frac{a}{b}b}{1+\frac{a}{b}b} - \frac{r^F}{1+r^F}} = b\frac{\frac{a}{b}(1+r^F)\left(\delta - \frac{r^F}{1+r^F}\right) - \frac{r^F}{b}}{1+\frac{a}{b}b(1+\delta+\delta r^F)} \equiv \Phi\left[r^F\right], \tag{18}$$

and there is no war at any subsequent period. To set $\mathcal{S}=1$ can only benefit L if it avoids war in period 1.[36] There are then two cases. If $k \geq \Gamma$, L optimally sets $\mathcal{S}=0$: this is because there is no war if $\mathcal{S}=0$. If $k<\Gamma$, there are three subcases. If $\Phi[r^F]<\Gamma$, $k \in (\Phi(r^F),\Gamma)$, L optimally sets $\mathcal{S}=1$. To see why, notice that there is war if $\mathcal{S}=0$, no war if $\mathcal{S}=1$. Furthermore, if $\mathcal{S}=1$, peace leaves L strictly better off than war. This follows from $k>\Phi[r^F]$, which implies $\overline{\pi}_1>0$ (L is willing to pay to avoid war). Since payoffs from war are the same independently of $\mathcal{S}$, it follows that to set $\mathcal{S}=1$ leaves L strictly better off than to set $\mathcal{S}=0$. If $\Phi[r^F]<\Gamma$, $k=\Phi[r^F]$, L optimally sets $\mathcal{S}=0$. This is because - although there is again war if $\mathcal{S}=0$, no war if $\mathcal{S}=1$ - L is now indifferent as to whether there is peace or war (since $k=\Phi[r^F]$ implies $\overline{\pi}_1=0$). Finally, if $\Phi[r^F]\geq\Gamma$, or $k<\Phi[r^F]<\Gamma$, L optimally sets $\mathcal{S}=0$, since there is war independently of $\mathcal{S}$. ■

Proof of Corollary ??. By Proposition **??**, there is a war if and only if $k<\min\left\{\Gamma,\Phi[r^F]\right\}$. The first part then follows from inspection of (**??**) and (**??**). 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 (**??**) 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 **??**. ■

[36] If war happens both with $\mathcal{S}=0$ and with $\mathcal{S}=1$, L's payoff does not depend on $\mathcal{S}$ (since $\mathcal{S}$ does not affect L's chances of winning a war in period 1). If war does not happen, either for $\mathcal{S}=0$ or for $\mathcal{S}=1$, setting $\mathcal{S}=1$ strictly decreases L's payoff, since it increases q_t^F for all $t>1$. Finally, if there is no war for $\mathcal{S}=0$, but there is a war for $\mathcal{S}=1$, to set $\mathcal{S}=1$ leaves L no better off than to set $\mathcal{S}=0$. To see this, notice that, for war not to occur when $\mathcal{S}=0$, it must be that war leaves L no better off than peace. Since L's payoff from war is the same independently of $\mathcal{S}$, to set $\mathcal{S}=1$ must then leave L no better off than to set $\mathcal{S}=0$.