

Crude Calculations: Productivity and the Profitability of Conquest

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ONLINE APPENDIX

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A. WHAT IF ATTRACTIVENESS OF CONQUEST DRIVES INVESTMENT IN MILITARY INNOVATION?

Our theory supposes that, if investment in innovation is primarily devoted to civilian rather than military uses, then the opportunity cost per productive asset used in conquest will rise faster than the quantity of productive assets needed for conquest falls, so that the profitability of conquest declines. In other words, the allocation of innovation investment has a causal effect on the attractiveness of conquest. However, it is easy to imagine that there might also be a causal effect in reverse: the more attractive conquest is, the more investment in innovation shifts toward military (that is, conquest) uses.

This could potentially invalidate our explanation for the decline in conquest. Suppose conquest initially became unattractive for some reason—call it “X”—other than the one we have theorized. Then investment in innovation would be increasingly allocated to civilian uses because military uses had become less attractive, and so our theorized effect would at best reinforce the unattractiveness of conquest, rather than causing it to become unattractive in the first place. If, by contrast, X had been absent, then conquest would initially remain attractive, so investment in innovation would be heavily devoted to military uses, and as a result conquest would only become even more attractive over time as productivity rose. Does our theory put the cart before the horse, and so misidentify the moving force for the decline of conquest?

Here, we show that there are exogenous limits on how much reverse causation could be occurring, so that our theorized effect would still reduce the profitability of conquest even if X was absent. Put another way, even if conquest had initially remained profitable for some reason other than productivity, so that military prowess and investment in improving it remained equally valuable, rising productivity would still be expected to erode conquest’s profitability over time, as we have theorized. As we will explain, this is because exogenous limits on the relative sizes of the markets for military and civilian innovation in modern economies constrain how much the attractiveness of conquest could shift the allocation of investment in innovation toward military uses.

We consulted the economic literature on “directed technical change,” which investigates the question of why innovation of one kind rather than another happens. The main finding of that literature is that investments in innovation tend to be concentrated where the market for those innovations is largest, because this generates the highest expected profits for the investor.¹ Thus, in theorizing about what determines the composition of investment, we have to think about the size of the market for military innovation relative to the market for civilian innovation. Obviously, the more a country is anticipated to engage in or profit from conquest, the larger the potential market for military innovation will be. However, in the modern economies where most innovation (whether civilian or military) happens, the size of the market for military innovation is constrained by exogenous limits on the size of government budgets.

¹ See, in particular, Acemoglu 1998; 2002a; 2002b.

These limits ensure that the market for military innovation is generally smaller than the market for civilian innovation, regardless of how attractive conquest is.

In any country, the size of the market for military innovation is constrained by the size of the government's overall budget, from which military spending is drawn. The size of this budget relative to the civilian economy is in turn constrained by the distortionary effects of actions taken to fund the budget, whether printing money, taxing, or borrowing. Although governments can temporarily neglect these economy-shrinking distortions, such as in wartime, in the steady-state they impose strong limits on how large the budget can be as a share of the economy. Sustained investment in innovation should be driven by steady-state expectations, and hence the steady-state limits on the government budget also limit the size of the market for military innovation.

What is the limit on a government's budget as a share of the economy? Empirically, most governments in most years are unable to sustain a government budget that is greater than half the overall economy.² The few instances of a government budget regularly above 50% of GDP occur in just a handful of countries, and only since the 1970s. In most of those instances, the budget is just slightly above 50%.

Moreover, governments' budgets are not entirely devoted to military spending, even in extremis. For instance, during World War II, when the United Kingdom faced an existential military threat, government and military spending as a share of GDP reached unprecedented highs. And yet even then, non-military spending still consumed about one-quarter of the government budget.³ Even if conquest is anticipated to be extremely profitable, its value seems unlikely to be as high to the conqueror as fighting World War II was to the UK. We would therefore expect that military spending would almost always be substantially less than total government spending.

Because sustained government spending almost never exceeds half of GDP, and then only by a very small amount, and military spending is always substantially less than total government spending, then steady-state military spending almost never exceeds half a country's economy. We conclude that, in modern economies, the market for military innovation will almost always be smaller than the market for civilian innovation regardless of how attractive conquest is.⁴

² We used the International Monetary Fund Public Finances in Modern History database, which has government expenditure as a share of GDP for most countries, going back to 1800 for the developed economies. See Mauro et al. 2013.

³ The figures are drawn from the UK Public Spending website, which itself compiles data from British Historical Statistics by B. R. Mitchell. See Chantrill 2021.

⁴ We should stress that the qualification "in modern economies" is important here. If the civilian economy is not market-based (e.g. in a pre-modern economy composed primarily of subsistence agriculture with little domestic commerce), or if military innovations are profitable but civilian ones are not (e.g. because governments reward military innovation but do not enforce intellectual property rights for civilian innovation), then the market for civilian innovation may be smaller than that for military innovation even if the civilian economy is much larger than military spending. In modern economies, markets for civilian goods and services are extensive and intellectual property rights are enforced for civilian innovation.

Thus, while reverse causation from the attractiveness of conquest to investment in military innovation surely exists, it is not large enough to invalidate our claims in the paper. Rising productivity in modern economies will still independently reduce the profitability of conquest, even if investment in military innovation reaches its exogenous upper limit.

B. PGR IS THE MOST TEMPTING TARGET FOR CONQUEST OF SUBSTANTIAL SIZE

We will explain why PGR ought to be the most tempting target of substantial size for any militarily-able conqueror on the basis of potential profitability. The chance that conquering any particular target will be profitable should be greatest for the target that offers the highest benefits to a conqueror per cost of invading and occupying it. To determine this most tempting target, we need to specify a list of targets and the metrics by which we will assess the benefits per cost offered by each target on the list, and then measure each target on the list.

We restrict our attention to targets of substantial size. As we explain in the paper, in a world with high economic inequality across individuals there is always a sufficiently small target (e.g., the world's richest person) that would offer a high benefit-to-cost ratio to a conqueror. However, such targets also offer relatively small profits on an absolute scale, and so we discard them from the list. We will operationalize "substantial size" to mean country-scale targets, so that our list of targets is comprised of all the world's countries. (Specifically, we look at the countries that existed in 1990 and 2003 since these are the years in which our conquerors are presumed to engage in conquest, but our results would be essentially the same if we instead choose almost any other year in the post-World War II era.)

We narrow this list down using GDP per capita as a first, rough metric for the benefit-to-cost ratio each country offers a conqueror. A country's GDP is equal to the total income its economy produces annually, and hence forms a natural upper bound on the economic benefits a conqueror might be able to extract each year. Once the initial invasion is over and the conqueror has begun to extract benefits, one of the most important determinants of the long-run cost of conquest is the size of the population the conqueror must deal with.

Using inflation-adjusted GDP data from the World Bank, the countries with the highest GDP per capita fit into three categories: small island states that are tax havens, gambling centers, or prime tourist attractions; members of the OECD; and countries with economies dominated by the production of oil and gas. Each category derives its high income from a different source of wealth: regulatory arbitrage or serene beauty in the case of the island states; human capital in the OECD; and reserves of oil and gas. Theoretically, these sources of wealth vary substantially in the ease with which they could be extracted by a conqueror.

The island states live off the willingness of outside actors to stash capital there or visit them for vacation. This willingness should depend strongly on the perceived safety of these states' territory: wealthy individuals and tourists alike would go elsewhere if one of these states were

to become perceived as financially or physically insecure. A conqueror's invasion and subsequent occupation, especially if resisted by the native population, would severely undermine this sense of safety. In response, capital would flee and tourists would stay away, drastically reducing the benefits a conqueror would actually realize from seizing one of these island states. Thus, these states' wealth should be very hard for a conqueror to extract, even given a successful invasion and occupation.

OECD countries' income is generated primarily by owners of human capital—skilled workers. These workers might flee an invading conqueror, but even if they are kept in the occupied territory, they might devote their efforts to resisting the occupation rather than generating income. Perhaps most likely, rather than flee or resist they could simply shirk: work less hard and invest less effort into generating and implementing economically valuable innovations. Over time, this would seriously reduce the benefits a conqueror could extract, relative to the unconquered GDP of these countries. Liberman finds that even a relatively rapacious conqueror, Nazi Germany, was able to extract only a modest fraction—less than half and in some cases less than a third—of the pre-conquest income of France and Belgium after occupying them in the second World War.⁵ Brooks argues that the difficulty a conqueror would face in extracting benefits from the advanced economies has only risen since World War II, as production has become increasingly dispersed over the globe, making it easier for outside consumers, investors, and businesses to substitute away from a conquered economy.⁶ We assume that Brooks is right, so that the difficulty of extracting their wealth makes OECD countries relatively less tempting targets.

By contrast, oil states sit atop a source of wealth that cannot flee, hide, resist, or shirk. Regardless of such a state being in the middle of a war, being invaded, being occupied, or suffering a civil war as a result of insurgency and counterinsurgency, outside consumers will happily purchase its oil and gas. And the production of oil or gas from a given field cannot be dispersed to far-flung locations. We are aware of no arguments in the literature for why this source of wealth would be difficult for a conqueror to extract, in contrast to those of the previous two categories of countries. We therefore conclude that, among states with high GDP per capita, oil states are the most promising pool in which to find the target for conquest that has the highest chance of being profitable.

Among the countries whose income derives heavily from oil and gas production, those in PGR have the lowest production costs and the highest total income. The sole exception is Norway, which has a much higher GDP per capita than PGR. However, this difference derives entirely from Norway's deep pool of human capital: Norway actually produces less oil per capita than most of the PGR countries. Among other oil states, Brunei has a GDP per capita comparable to PGR, but its economy is tiny even relative to that of Bahrain, which is by far the smallest-income country in PGR. Oman, Equatorial Guinea, Gabon, and Venezuela are the next richest major oil/gas producers, but they all have substantially lower GDP per capita than PGR.

⁵ Liberman 1996, 50, 66.

⁶ Brooks 2005, 9–10, 57–71, 162–206, 209–219.

Moreover, among these major oil and gas producers, only PGR is located on flat, coastal desert terrain, making it relatively easy to invade since resistance to occupation would have less in the way of a defensible natural sanctuary. From a conqueror's perspective, this is preferable to, for instance, Norway's mountains, Venezuela's jungles and mountains, or the rain forests of Brunei, Equatorial Guinea, and Gabon.

We therefore conclude that PGR is plausibly the most tempting country-scale target for conquest in the world in 1990 and 2003.

C. THE POTENTIAL FOR OIL MARKET MANIPULATION REINFORCES OUR FINDINGS

In the paper, we set aside the possibility that either the US in 2003 or Iraq in 1990 might, having conquered PGR, employ control over its oil and gas reserves to manipulate the oil market. Here, we show that this kind of manipulation would likely increase the net-unprofitability of conquering PGR for the US, but would substantially increase the net-profitability of conquering PGR for Iraq. This possibility would therefore strengthen our findings.

Because PGR represented about 15% of the world's oil production in 1990 and 20% of it in 2003, its consolidation under a conqueror in either year would offer considerable scope for market manipulation. In particular, a conqueror might lower production in PGR: if the world price of oil rises by a greater proportion than the decrease in PGR's production, then the net profits from oil sales will be higher. In effect, the conqueror would be exerting (partial) monopoly control over oil supplies to extract additional profits. This manipulation would increase the benefits to either the US or Iraq of conquering PGR, making conquest more attractive.

However, manipulating the oil market to raise the price of oil also imposes a cost on the conqueror. This is because consumers of oil in each conqueror's domestic economy, and in any economy that is integrated with the conqueror's, will have to pay a higher price for oil. Hence, some of the extra benefits the conqueror realizes from a higher oil price will come out of the pockets of its own consumers. Moreover, the higher oil price also imposes costs on other economies that are net-consumers of oil. To the extent that these other economies are integrated with the conqueror's, damage to them will also inflict additional damage on the conqueror's economy.⁷ For example, consumers in these other integrated economies might buy more of the conqueror's exports or invest more in its economy if they did not instead have to pay a higher price for oil. Manipulation of the market thus increases the costs of conquest through a direct effect on a conqueror's own consumption of oil and also through an indirect effect on the consumption of integrated economies.

⁷ Stiglitz and Bilmes 2008, 221-3 discusses this "global general equilibrium" effect of increased oil prices on the US.

If the world price of oil increases, the conqueror will realize a fraction of the total increase in global oil revenue that is equal to his share of global oil production—the rest will be realized by other states that also produce oil. Analogously, and ignoring the effects of integration with other economies, the conqueror will suffer a fraction of the total extra cost of oil purchases that is equal to his share of global oil *consumption*—the rest will be suffered by other states that also consume oil. Thus, we can compare the shares of oil production and consumption represented by the US in 2003 and Iraq in 1990, when combined with the shares of PGR in the corresponding years, to determine the net effect of a higher oil price on the profitability to each of conquering PGR. If a conqueror, combined with PGR, would consume more of the world's oil than it would produce, then the net direct effect of a higher oil price would be to reduce the profitability of conquest. If instead the combined entity would consume less of the world's oil than it produced, then the net direct effect of a higher oil price would be to increase the profitability of conquest. We then examine the additional indirect effect on profitability caused by the integration of each conqueror's economy with other states' economies. We draw data on the shares of world oil production and consumption from the US Energy Information Administration.⁸

First consider the US. In 2003, the US produced 11% of the world's supply of oil, and PGR produced another 20% of the total. However, in the same year the US also consumed 25% of the world's oil and PGR consumed another 3%. Hence, if the US had conquered PGR, the combined entity would realize 31% of the benefits of a higher oil price but pay 28% of the costs. This implies that market manipulation is very unlikely to change our conclusion that conquering PGR in 2003 would not be profitable for the US. To see why, suppose that the US, having conquered PGR, were able to manipulate the market to raise the revenue it received from oil sales *by a factor of ten*. The resulting increased costs to US consumers would amount to over 90% ($28 / 31 * 100$) of the increased benefits. Thus, even given this quite implausible degree of market manipulation, the net benefits of conquest for the US would only double the figure offered in the paper, which assumed no market manipulation. This increase would still leave conquest substantially net-unprofitable for the US.

Moreover, in computing the cost to the US of raising the price of oil, we considered only the direct cost to US consumers. The economies of Canada, the EU, Japan, and Mexico—which are those most closely integrated with the US economy—are, in aggregate, a large net-consumer of oil and so would also suffer a net cost from a higher oil price.⁹ These economies would produce fewer goods and services due to the higher cost of a crucial input, which would result in less commerce with the US, which would inflict further costs on the US economy. These negative feedback effects might make it so that a higher oil price actually made conquest of PGR even more unprofitable for the US than it would be in the absence of market manipulation.¹⁰

⁸ Energy Information Administration 2021.

⁹ In 2003 Canada, the EU, Japan, and Mexico produced 12% of the world's oil, but consumed 28% of it.

¹⁰ Since 2003, US oil production has risen greatly with the exploitation of shale deposits, to the point that the US might become a net exporter of oil. This means that the US share of world oil production will begin to exceed its share of world oil consumption. However, US integration with major oil consumers in Europe and East Asia has also increased over time, so that the negative feedback from integrated economies of higher oil prices has grown.

Next consider Iraq. In 1989, Iraq produced about 5% of the world's supply of oil, and PGR produced another 15% of the total.¹¹ However, in the same year, Iraq consumed 0.53% of the world's oil and PGR added another 2.1%. Hence, if Iraq had conquered PGR, the combined entity would realize 20% of the additional benefits of a higher oil price and only pay about 2.6% of the additional costs. This implies that market manipulation would be highly appealing for Iraq once it had conquered PGR, and would strengthen our conclusion that conquering PGR in 1990 would be highly profitable for Iraq. Suppose that Iraq, having conquered PGR, were able to manipulate the market to double the revenue it received from oil sales, a not implausible factor given historical fluctuations in price of oil due to supply disruptions. The resulting increased costs to Iraq's consumers would amount to only 13% ($2.6 / 20 * 100$) of the increased benefits. Thus, this plausible degree of market manipulation would raise the net benefits of conquest for Iraq by 87% relative to the figure offered in the paper, which assumed no market manipulation. This would amplify the already-large net profits of conquest we found for Iraq.

Of course, in computing the cost to Iraq of raising the price of oil, we considered only the direct cost to Iraqi consumers. A higher price of oil would also inflict costs on most other states' economies. However, almost all of Iraq's commerce with the outside world in 1989 was based on oil, with oil responsible for 95% of its foreign exchange earnings.¹² There are therefore few channels for damage to the world economy caused by a higher oil price to affect Iraq's economy. We conclude that our result that Iraq's net profits from conquest would increase from market manipulation is robust to the potential for negative feedback from other economies.

D. WHAT IF WE HAD CHOSEN YEARS OTHER THAN 1990 AND 2003 FROM WHICH TO CALCULATE EXPECTED BENEFITS OF CONQUERING PGR?

In the paper, we chose 1990 and 2003 as the years for which to calculate the expected benefits for Iraq and the US (respectively) from conquering PGR. We chose 1990 and 2003 because these were the years in which our (counterfactual) cases (are presumed to have) occurred. Our cases are a counterfactual in which Iraq's 1990 invasion of Kuwait is extended to all of PGR and tolerated by the international community, and a counterfactual wherein the US invades PGR instead of Iraq in 2003. The choice of these particular cases instead of others is driven by the very limited availability of comprehensive cost assessments that can serve as bounds for the

Studies of the total effect of higher oil prices on the US economy suggest that this feedback effect is quite large, perhaps 4-12 times the direct cost of higher oil prices paid by US consumers. See Stiglitz and Bilmes 2008, 222. To overcome this feedback and be left better off on-net from a higher oil price, the US would need to produce much more oil than it consumes, not just a small percentage.

¹¹ Because Iraq's invasion of Kuwait in 1990 and the sanctions subsequently imposed on Iraq disrupted the oil market, we use oil production and consumption figures from 1989. However, instead using the figures from 1990 yields nearly identical results.

¹² Central Intelligence Agency 1990.

(unobserved) cost of conquest. In other words, given a need to pick years at which to calculate expected benefits, choosing years that matched our counterfactual cases, whose choice was determined by other concerns, seemed natural.

Of course, just because the conclusions came out one way—profitable for Iraq, but not for the US—for the natural but arbitrary choice of 1990 and 2003, doesn’t guarantee they would come out the same for other choices of the years from which to calculate the expected benefits of conquering PGR. Here, we determine how robust our conclusions are to choosing different years at which to calculate expected benefits for the US and Iraq.

Our data on oil and gas production and prices cover all of the years from 1965 to 2018. For each of those years, we compute expected benefits based on the benefits observed in the 10, 15, 20, 25, or all previous years, and then check whether this level of expected benefits would change our conclusions for either Iraq (conquest profitable) or the US (conquest unprofitable).

We check conquest profitability using two different sets of cost figures. The first set is our cost bounds for Iraq and the US as reported in the paper. However, as we argue extensively in the paper, these are bounds on costs, not unbiased estimates of them, and are likely to be very conservative: that is, the real cost for Iraq is much lower, and the real cost for the US is substantially higher. This has an important implication for our robustness analysis. Just because, say, the benefits for the US are higher in a given year than our lower bound on the cost for the US doesn’t mean we should conclude that conquest would be profitable for the US in that year: it means we cannot be as confident that conquest would be *unprofitable*. We therefore also check conquest profitability using cost figures that are 1/3 lower for Iraq and 1/3 higher for the US than our bounds. Our arguments in the paper about why the Iraq bound is too high and the US bound is too low lead us to think these are still very conservative numbers.

The results of our robustness analysis are in Table 1 below. Each cell contains the share of years for which our conclusion about Iraq’s conquest profitability would still hold, and the fraction for which our analogous conclusion about the US would still hold. The higher the numbers are in each cell, the more robust our conclusions are to the choice of year (and also to the choice of retrospective window) from which to calculate expected benefits.

Table 1: Share of Years in Which Main Conclusions Hold Given Alternate Assumptions

	Previous Years of Oil and Gas Profits Used:				
Costs used:	10	15	20	25	All
Bounds from paper	Iraq: .57 US: .61	Iraq: .67 US: .77	Iraq: .76 US: .79	Iraq: .79 US: .79	Iraq: .31 US: 1.00
Less conservative figures	Iraq: .68 US: .80	Iraq: .85 US: .82	Iraq: 1.00 US: .85	Iraq: 1.00 US: .93	Iraq: .74 US: 1.00

According to this analysis, our conclusions generally hold in the majority of years we could have chosen. Using a longer (and so probably more realistic) retrospective window, and/or less conservative cost figures against which to check profitability, our conclusions generally hold in 68-100% of the years we could have chosen. The sole exception is when we use all previous years to compute expected benefits for Iraq and our cost bounds, where our conclusions hold only 31% of the time. This is because the earliest years in our data generate the lowest figures for expected benefits, and so render conquest unprofitable for Iraq.

We draw two lessons from the analysis. First, our chosen years of 1990 and 2003 are broadly representative, in that the same conclusions about conquest profitability would follow from most other choices of years, under most other plausible retrospective windows. Second, it is nonetheless true that our conclusions are not independent of the choice of years, and so our claims in the paper are accordingly qualified.

E. COULD THE US CONQUEST OF PGR BE CHEAPER THAN THE IRAQ WAR?

In the paper we noted that a skeptical reader might suspect that the US could pursue its conquest of PGR in a very different fashion from the Iraq War, and that this would reduce the cost of conquering PGR below that of the Iraq War. We examine what seem like the most salient possibilities here, and show that none of these would alter our conclusion that conquering PGR would be unprofitable for the US.

Recall the possibilities we listed in the paper. The US could rely heavily on mercenaries, who might be cheaper to use than the US military. It might make fewer mistakes than some have argued occurred in Iraq: it could use far more US forces and make better decisions on occupation policy, so that an insurgency does not form or is weaker. The US could seek to occupy just the oil and gas fields and the infrastructure (e.g., refineries and pipelines) needed to bring them to market, which would reduce the area and perhaps population that would need to be occupied. Finally, the US could “take the gloves off”, allowing its troops to use whatever amount of force was necessary to pacify PGR, instead of trying to limit civilian casualties as it did in Iraq.

We deal with each of these in turn. First, the US *already* relied very heavily on mercenaries to augment its own military in Iraq, with contractors making up over half the personnel the US deployed there and in Afghanistan.¹³ Increasing that percentage might lower the cost, but it would also create problems of control—mercenaries would have strong incentives to siphon off some of the oil and gas revenues. Ensuring the mercenaries’ loyalty might require more US forces or sharing revenues, either of which would lower the profits from conquering PGR.

¹³ Avant and De Nevers 2011.

Second, even given that the US made serious mistakes in Iraq, it is not clear that it would avoid making the same or different mistakes in PGR. Military campaigns usually involve mistakes, often serious ones. It has been argued that the US also made major mistakes in the Vietnam War, the Korean War, and World War II.¹⁴ And the US is not uniquely prone to mistakes in foreign occupation: Germany's occupation of Russia in World War II, France in Indochina, the British and later the Soviet Union and NATO in Afghanistan—the list goes on.¹⁵ The fog of war is thick, and wars of conquest are no exception.

Third, we show in more detail in the next section of this appendix that even if the US were to occupy only the oil and gas fields and associated infrastructure, this would not cut the cost of conquest by much. The resulting area of occupation would still be larger than Iraq, and the population to be occupied would still be at least two-thirds of Iraq's. The region's oil and gas fields, refineries, and pipelines are spread throughout much of its territory and are often located in or very near densely-populated areas. Thus, conquering these assets would require conquering and governing most of the local population. Moreover, the population of the "rump" territory not occupied by the US would still have lost the main source of their livelihoods, and would therefore likely still be fiercely hostile to the US and contribute to the resistance against its occupation.

Finally, while the US could "take the gloves off," this would not necessarily reduce the cost of conquest. A substantial share of the US population, and of its military, would find a rapacious occupation of PGR morally repugnant. This would radically increase the cost of recruiting and retaining soldiers, as well as the cost of caring for veterans after the war, who would find it harder to re-integrate into civilian life and be more likely to suffer mental illness. Moreover, rapacity itself is sometimes not sufficient to end the resistance to occupation, as Russia in Chechnya, Iraq in Kuwait, and the Assad regime in Syria all experienced.

Of course, the US could attempt to simply expel or kill the resistant population, which might drastically lower the cost of conquest. However, no conqueror has ever eliminated an occupied population of this size. In the largest forced migration of all time, fifteen million people were moved across all the theaters of conflict in World War II (including internally displaced persons).¹⁶ PGR had a population nearly twice as large as this in 2003. In perhaps the most efficient mass killing in history, the Nazis murdered 5-6 million Jewish residents of German-occupied territory during 1941 to 1945, achieving an average rate of 1.5 million killed annually using death camps and chemical weapons.¹⁷ Assuming the US managed the same rate, it would take a full decade to expunge only half the population of PGR. Given that a mass expulsion or killing of this size is unprecedented, neither we nor the US could confidently conclude that it would seriously reduce the cost of conquering PGR.

¹⁴ Cohen and Gooch 1990, 10.

¹⁵ David 1998, 1, 192, 278.

¹⁶ The Economist 2016.

¹⁷ Stone 2019.

Finally, suppose that the US could successfully extract all the oil and gas profits from PGR with an occupation force of only 100,000 personnel. Given the population of PGR cited in the paper is 29.8 million, this would be a ratio of 3.36 occupiers per thousand. This is lower than the ratio of local law enforcement personnel to population in the United States, which was 3.5 per thousand in 2003.¹⁸ Such a small occupation force seems wildly implausible, but it is only slightly larger than the average number of US personnel maintained in Iraq over 2003 to 2017, which was cited in the paper at 116,000. Suppose also that, due to some combination of using more mercenaries, setting better occupation policy, and being more rapacious, the US could reduce the cost-intensity per troop deployed of conquering PGR by 50%. Then the new figure for the annual cost of conquering PGR would be:

Annual cost of conquest with 100k troops and 50% cost-intensity per troop = Annual cost of conquest with 116k troops * (100k / 116k) * 0.5 = \$85 billion

Thus, even assuming an implausibly small occupation force, that was twice as cost-effective in its occupation of PGR as the US military was in the Iraq War, the cost of conquering PGR in 2003 would *still* exceed the benefits of doing so for the US. We therefore conclude that our findings are robust to the various possibilities for the US to conquer PGR more cost-effectively than it did Iraq.

F. CONQUERING ONLY FIELDS AND INFRASTRUCTURE WOULD NOT QUALITATIVELY CHANGE OUR FINDINGS

We assumed in the paper that a conqueror must invade and occupy all of the territory of PGR, rather than just the territory relevant to oil and gas production and export. This begs the question: would the cost of conquering PGR be reduced if a conqueror sought only to occupy the oil and gas fields and the infrastructure (pipelines, refineries, and shipping terminals) needed to bring these fossil fuels to market? Here, we consider how much a fields-and-infrastructure-only (FIO) strategy would reduce the cost of conquest. If a FIO strategy reduced the cost of conquest, our finding that Iraq would profit from conquering PGR in 1990 would only be strengthened. We therefore focus here on the case of the US conquering PGR in 2003. We will show that even if the US employed a FIO strategy, conquering PGR would still be at least as costly for the US as the Iraq War, so that our finding that the US would not profit from conquering PGR is robust.

¹⁸ Federal Bureau of Investigation 2003, 364.



Figure 1: Oil and Gas Fields and Infrastructure in PGR

Figure 1 shows the location of the major oil and gas fields, pipelines, and terminals in PGR.¹⁹ We assume that a conqueror trying to take only these assets in the least costly way would still end up occupying additional territory, for two reasons. First, if a conqueror is to successfully extract the value contained in these assets, it must prevent hostile forces from routinely disrupting their operation. We therefore assume that the conqueror must occupy an exclusion zone around each of these assets of at least 30 kilometers. This range is sufficient to protect the assets from small arms, mortars, and simple rocket artillery such as the Qassam rockets used by Palestinians against Israel.²⁰ Second, a single contiguous land area is easier militarily to control than a set of occupied “islands” surrounded by hostile territory. This makes it easier to

¹⁹ Central Intelligence Agency 2007.

²⁰ HAMAS Rockets 2014.

assure the availability of supply lines and to move troops to areas being attacked. We therefore assume that the conqueror must occupy at least the smallest contiguous territory that includes the fields, pipelines, and terminals and a 30-kilometer exclusion zone around them.

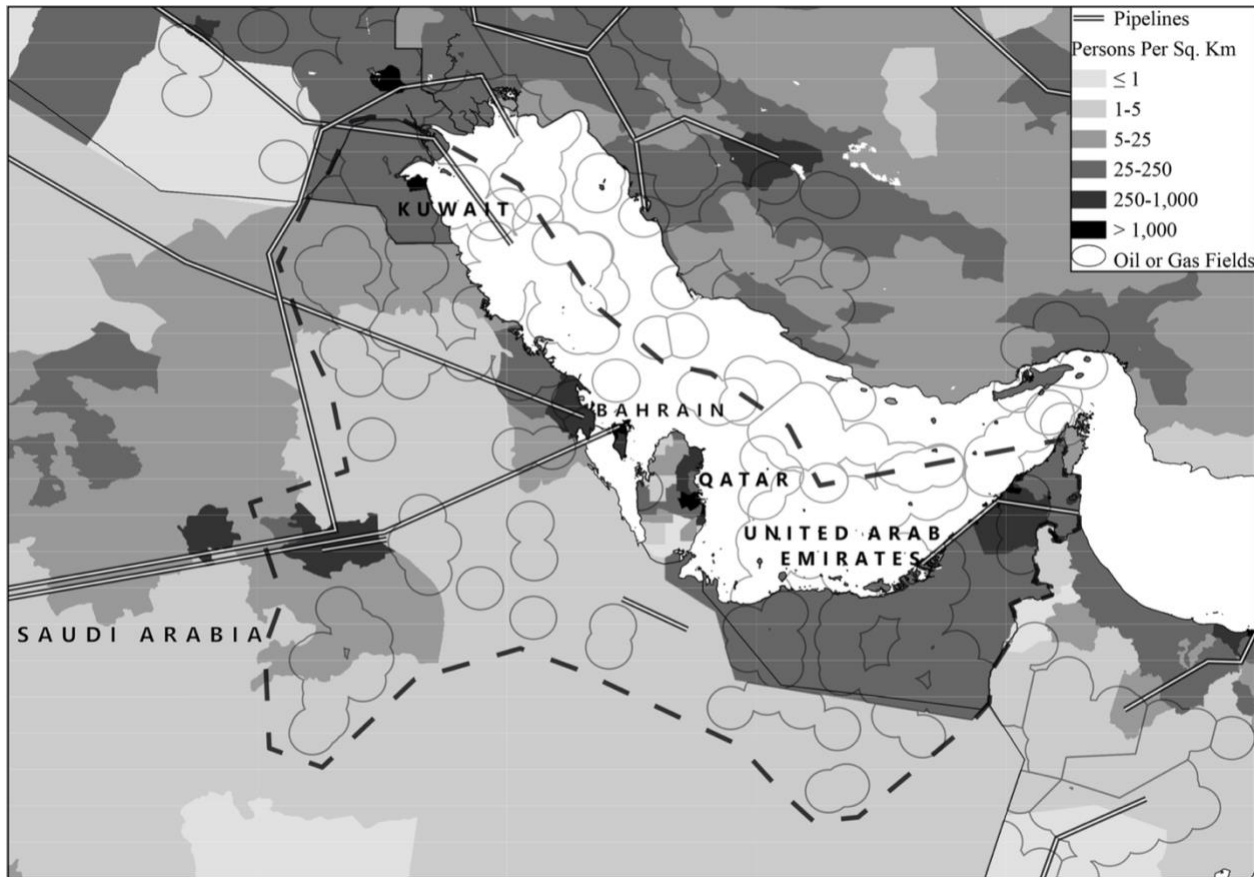


Figure 2: Minimum Territory within PGR to Capture Fields and Infrastructure

Figure 2 shows a rough approximation of the minimal territory to be conquered in PGR under these two assumptions. We refer to this territory as “FIO.” The circles have a radius of 30 kilometers and are centered on PGR’s oil and gas fields; for clarity, only the largest pipelines are included in the figure. The dashed line delineates the minimal territory to be taken. This territory includes the entirety of Bahrain, Kuwait, Qatar, and the United Arab Emirates, but only a small part of Saudi Arabia’s land area.

Note that this territory leaves out Saudi Arabia’s East-West pipeline and the large terminals at Al Mu’ajjiz, Rabigh, and Jiddah that this pipeline supplies, which represent roughly half of Saudi Arabia’s export capacity.²¹ If a conqueror did not conquer these assets, the benefits it could extract from Saudi Arabia’s fields would be smaller, at least until export facilities on the Gulf

²¹ We infer this from the capacities of the refineries located at these terminals, compared to the total capacity of all Saudi Arabia’s refineries, as marked on the map in Figure 1.

coast were expanded to compensate. We ignore this potentially serious reduction in the benefits of conquering FIO relative to PGR as a whole.

We proceed to compare FIO in 2003 to Iraq in 2003 on the seven indicators of the cost of conquest used in the paper: the target's proximity to the conqueror, terrain, area, population size and will to resist, and military size and quality. Five of these indicators would be unchanged, since FIO is just as far from the US as PGR, has the same terrain and will to resist, and the size and quality of military forces opposing the US conquest would be the same.

However, the land area and population size to be conquered would be smaller in FIO than PGR. Using ArcGIS, we estimate that the Saudi territory within FIO is approximately 18% of Saudi Arabia's land area. Even so, when this area is added to the full areas of Bahrain, Kuwait, Qatar, and the UAE, the resulting total land area of FIO is still greater than that of Iraq. The same area contained about 39% of the Saudi population in 2003, so that when added to the full populations of the other states, the total population residing in FIO is about 16 million.²² This is about 62% of the population of Iraq, suggesting that, according to this indicator only, occupying FIO might be cheaper than occupying Iraq. However, even if we assume that the annual cost of conquering FIO was reduced proportionately, to 62% of the annual cost of conquering Iraq, the resulting cost of \$123 billion would still exceed the benefits the US could expect to obtain in 2003.

Moreover, this calculation assumes that the remaining 61% of the Saudi population residing outside of FIO would impose no costs on the US. In reality, these people would have a very strong interest in resisting the US occupation, since they are as dependent on oil and gas profits for their economic livelihood as their compatriots residing in FIO. Insurgents drawn from their ranks would have little interest in respecting the new border the US would have to erect down the length of Saudi Arabia, and might use the "rump state" of western Saudi Arabia as a sanctuary, source of support, and base of operations from which to carry out attacks inside FIO. The availability of such havens for insurgents drastically raised the cost to the US of fighting the Iraq and Afghanistan Wars, and indeed led the US to invade Cambodia during the Vietnam War. Conquering only the part of Saudi Arabia that is in FIO would thus reduce the size of the population the US would have to control directly, reducing the cost of conquest, but would seriously increase the resources available to the resistance against US occupation, raising the cost of conquest.

We therefore conclude that conquering only the oil and gas fields and infrastructure of PGR would not reduce the cost of conquering it enough to make this profitable for the US in 2003.

²² Each country's total population in 2003 is drawn from the World Bank. We assume that the percentage of the Saudi population living in FIO is equal to the percentage living in the Eastern Province and Riyadh administrative regions of Saudi Arabia, whose territory corresponds roughly to the Saudi portion of FIO. We obtained the specified percentage from Sultan Abu Ashwan, Abdul Salam, and Mouselhy 2012, 42.

G. FIGURES FOR THE COSTS OF THE IRAN-IRAQ WAR FOR IRAQ

We first document the precise figures we use from Kamran Mofid's estimates and how we adjust these for inflation. We then document the calculations behind our estimate of the opportunity cost to Iraq of the personnel killed or wounded in the Iran-Iraq War.

Mofid provides a schedule of his estimated non-labor costs to Iraq of the war, including damage to Iraq's infrastructure, loss of Gross National Product (which includes both the loss of oil revenue and also the effect of any other war-induced disruption of Iraq's economy), and military spending on the war. These costs are computed on a monthly or annual basis for the course of the war from September 1980 through August 1988, a period of 95 months. Table 2 shows this schedule in billions of current-year US dollars, as well as our conversion of the figures into 2007 US dollars to match the inflation base-year used throughout our paper.

Table 2: Annual Non-Labor Costs to Iraq of the Iran-Iraq War

Year:	Infrastructure Damage ²³	Loss to Gross National Product ²⁴	Military Spending on War ²⁵	Total (current-year US dollars)	Total (2007 US dollars)
1980	2.4	13.9	0	16.3	41.02
1981	9.6	42.9	1.3	53.8	122.72
1982	9.6	43.4	4	57	122.47
1983	9.6	39.4	6.6	55.6	115.75
1984	9.6	32.2	10.3	52.1	103.97
1985	9.6	23.2	9.3	42.1	81.13
1986	9.6	15.1	8.5	33.2	62.81
1987-88	16	10.3	15.3	41.6	75.93

The grand total from the table comes to \$725.8 billion 2007 US dollars over the course of the war. Divided by the duration of the war in years (95 months / 12 = 7.92 years), we arrive at our annual figure of \$92 billion.

Next, we turn to our estimate of the opportunity cost to Iraq of the personnel killed or wounded in the Iran-Iraq War. Our approach is identical to that used in the Stiglitz and Bilmes assessments of the cost of the Iraq War to the US and therefore aids comparability between the two. We first document the numbers we use for the total count of Iraqi fatalities and wounded, then explain how we measure the economic value of an Iraqi life. We then convert

²³ Mofid (1990, 128) assumes that the damage to Iraq's infrastructure is \$0.8 billion current US dollars per month.

²⁴ This is the difference between the bracketed figures in the third and second columns of Table 10.5 (Mofid 1990, 130). The 1987-88 figure comes from the explanation lower on page 130.

²⁵ This is the difference between the bracketed figures in the sixth and third columns of Table 10.7 (Mofid 1990, 137). Mofid assumes that the war induced no excess spending in 1980 (presumably, since the war did not start until late that year), and provides a figure for 1987-88 on page 132.

fatalities and wounded into the total opportunity cost for Iraq of the lives lost or injured in the Iran-Iraq War, and annualize this to arrive at the estimate used in the paper. Finally, we show that the uncertainty inherent in this estimate nonetheless would not qualitatively alter our finding that conquering PGR would be profitable for Iraq.

To get numbers for dead and wounded suffered by Iraq in the Iran-Iraq War, we rely on the documentation to version 3.0 of the PRIO Battle Deaths Dataset.²⁶ For this war, the documentation characterizes an estimate of 100,000 to 150,000 fatalities as the “most widely used,” and also cites a figure of 400,000 wounded, for Iraq. To bias the results against our finding that conquest would pay for Iraq, we use the higher end of the fatality range: we assume Iraq suffered 150,000 fatalities in the war. Other, less widely-used estimates of Iraq’s death toll in the war range as high as 500,000, so we show at the end of this section that even such a high figure would not reverse our finding.

Stiglitz and Bilmes estimate the economic opportunity cost per person killed as the so-called “value of a statistical life” (VSL), a method commonly used by governments to estimate the economic value of a life for purposes of designing environmental, safety, and other regulations. For the US in 2003, this VSL is \$7.2 million in 2007 US dollars.²⁷ We cannot simply use the same number for Iraq, because labor productivity in Iraq in 1989 is much lower than in the US in 2003.²⁸ We conservatively use each country’s GDP per capita, taken from the World Bank, as a proxy for its labor productivity, so that we can obtain Iraq’s VSL from the US VSL by multiplying the latter by the ratio of Iraqi to US GDP per capita. Relative to the US, much more of Iraq’s GDP derives from resource extraction that requires very little labor, so that the ratio of the two countries’ GDP per capita likely overestimates the ratio of Iraqi to US labor productivity. This is conservative because it will lead us to overestimate the total opportunity cost of Iraqi labor lost due to the Iran-Iraq War, biasing our calculation against finding the conquest of PGR to be profitable for Iraq. We have:

$$\begin{aligned} \text{Iraq VSL} &= \text{US VSL} * (\text{Iraq GDP per capita in 1989} / \text{US GDP per capita in 2003}) \\ &= \$7.2 \text{ million} * (6,458 / 44,507) = \$1.0 \text{ million (all in 2007 US dollars)} \end{aligned}$$

This figure tells us the economic value of each Iraqi life lost in the Iran-Iraq War, but we must also assign an economic value to each Iraqi wounded in the war. Again following Stiglitz and Bilmes, we assume that each wounded person loses some fraction of their lifetime economic productivity as a result of being wounded in the war.²⁹ We assume that the average fraction lost across all those wounded is ¼. This is conservative because it assumes relatively severe

²⁶ Lacina and Uriarte 2009, 315–316.

²⁷ Stiglitz and Bilmes 2008, 94-95.

²⁸ As elsewhere in this appendix, we use economic statistics for Iraq from 1989 rather than 1990, because Iraq’s invasion of Kuwait in 1990 and the comprehensive economic sanctions it suffered thereafter caused anomalous, short-lived swings in those statistics.

²⁹ Stiglitz and Bilmes 2008, 97-98.

injuries: the average wounded person loses a quarter of their economic productivity.³⁰ Even so, we show below that assuming instead that every wounded person loses their *entire* lifetime economic productivity would not alter our finding that conquering PGR would be profitable for Iraq.

We can now calculate the total opportunity cost of Iraqi labor killed or wounded in the Iran-Iraq War. It is:

150,000 killed * \$1 million + 400,000 wounded * $\frac{1}{4}$ * \$1 million = \$250 billion (in 2007 US dollars)

Since the Iran-Iraq War lasted for about eight years, this implies an annual opportunity cost of labor lost of \$31 billion. Even if we have underestimated the deaths by a very implausible factor of three, or if each wounded person lost his entire lifetime economic productivity, the resulting true annual cost of no more than \$69 billion would only just suffice to render the conquest of PGR unprofitable for Iraq, since then the total cost would be \$161 billion, just over the total benefits of \$159 billion.

H. WHY WE CANNOT DETERMINE A THRESHOLD VALUE OF PRODUCTIVITY

It would be very valuable to be able to specify a threshold value of productivity, at which conquest has just become unprofitable. This would allow us to infer exactly which states at any point in time should anticipate profits from conquest, and which should not. However, it turns out that our empirical evidence doesn't enable us to estimate this threshold value with any useful level of precision.

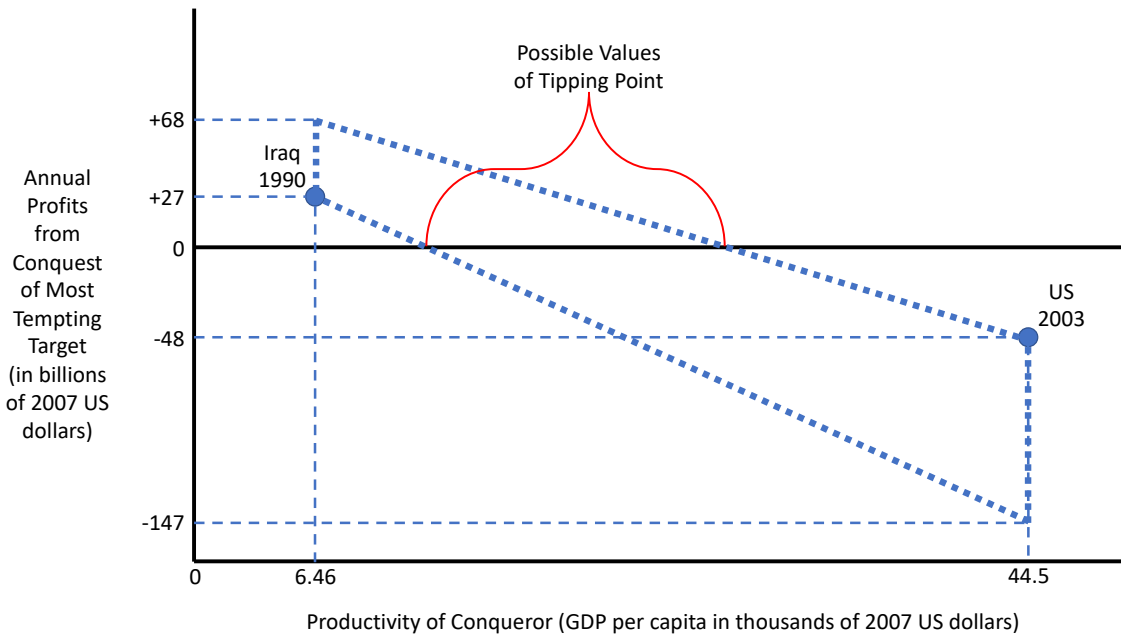
The threshold is the level of productivity at which profits are zero: the benefits of conquering the most tempting target just equal the costs. But all we know about the relationship between productivity and profits is that it is decreasing (more productivity leads to less profits), that at the productivity level of the US in 2003 the profit is negative by at least a certain amount, and that at the productivity level of Iraq in 1990 the profit is positive by at least a certain amount.

The figure below illustrates why this is not enough information to pin down the threshold value. It assumes expected annual benefits of \$150 billion, and that the annual costs to the US and Iraq are bounded by the values we estimated in the paper (greater than \$198 billion and less than \$123 billion respectively). If we suppose that both bounds could be off by as much as 50% (which seems plausible to us) from the actual costs, then the dotted parallelogram contains all the linear relationships between productivity and profitability that are possible under our uncertainty about the costs to the US and Iraq. This means that the tipping point could be

³⁰ By comparison, when Stiglitz and Bilmes needed to specify an average fraction lost across casualties suffered by non-US coalition forces in Iraq, they assumed a fraction of only 1/5 (145, fn 39).

anywhere along the zero-profit line within the dotted parallelogram: that is, anywhere from less than \$13k to more than \$28k GDP per capita.

Moreover, the uncertainty is actually wider than that, for two reasons. First, the expected annual benefits of conquering the most tempting target change from year to year: in our two cases, the benefits of taking PGR ranged from \$82 billion to \$159 billion, almost a factor of two. This means that the threshold value will also move substantially from year to year. Second, the parallelogram in the figure assumes that the relationship between productivity and profitability is linear, but there is no reason to think this must be so. This means that the edges of the parallelogram might be curved outward, increasing uncertainty about the tipping point further. These additional large sources of uncertainty mean we are unable to usefully narrow down the range within which the threshold value lies.



I. AVERAGE ANNUAL FORCES DEPLOYED FOR IRAQ IN IRAN-IRAQ WAR AND US IN IRAQ WAR

We do not have detailed over-time figures for the size of the force Iraq devoted to its war with Iran, but the total number of personnel in Iraq's military for each year of the war is given in the National Military Capabilities database, version 5.0. Averaging over the years 1980-88 gives 660,000 personnel. These personnel were not entirely devoted to the fight with Iran throughout the war. Only nine of Iraq's twelve active army divisions at the time were assigned to the invasion of Iran that began the war.³¹ Throughout the war, some of Iraq's military was

³¹ Pollack 2002, 182, 183.

assigned to protect Baghdad and Saddam Hussein from domestic enemies.³² And some forces were deployed at various points during the war to conduct internal conflicts with the Kurds in northern Iraq and with the Marsh Arabs in southern Iraq.³³ We conservatively assume that, on average over the course of the Iran-Iraq War, only 10% of Iraq's military personnel were not devoted to that war. Thus we obtain an average annual forces deployed for Iraq of $0.9 * 660,000 = 594,000$. This is conservative since the true figure is likely lower, and a lower figure would decrease the ratio of Iraq to US forces deployed, reinforcing our conclusion that productivity had a smaller effect on the quantity of productive assets used than on the opportunity cost per asset.

Determining the annual forces the US side devoted to the Iraq War also poses challenges. First, unlike Iraq in the Iran-Iraq War, the US made extensive use of private contractors, and these firms' personnel comprised a substantial share of the total US. Some of these contractors were US citizens; others were third-country nationals or Iraqis. On average, the number of contractor personnel was roughly equal to the number of US military personnel, while the number of contractors who were US citizens averaged about 32% of the number of US military personnel, over the course of the US deployment to Iraq.³⁴ Conceptually, it is clear that these contractors should be counted as forces deployed, since they were evidently perceived as necessary to the US invasion and occupation. However, it is less clear whether the non-US contractors should be regarded as having the same opportunity cost per person as US personnel. To be conservative, we include only contractor personnel who are US citizens in our count of forces deployed, since these clearly would have the same economic opportunity cost (on average) as US military personnel. This is conservative since the true figure is certainly higher (the opportunity cost of employing third-country and Iraqi contractors is not zero), and a higher figure would decrease the ratio of Iraq to US forces deployed, reinforcing our conclusion that productivity had a smaller effect on the quantity of productive assets used than on the opportunity cost per asset.

Second, a non-negligible fraction of the military forces deployed to Iraq came from non-US members of the coalition. As in the paper, we assume that these average 10% of the forces deployed, and that the US would have to supply these forces itself in an invasion of PGR.

Finally, we do not have figures for the actual number of US military personnel devoted to the invasion and occupation of Iraq. Instead we have over-time figures of the number of US military personnel *present in Iraq*. This represents a substantial undercount of US military forces, as it ignores, for example air and naval forces devoted to Iraq but operating out of bases in neighboring countries. This undercounting is conservative by the same logic outlined previously.

³² Pollack 2002, 219, 220.

³³ Murray and Woods 2014, 308-311.

³⁴ Authors' calculations from Peters and Plagakis 2019, 11-15.

We aggregated monthly US troop numbers in Iraq for March 2003 through June 2011 from McLean and Tse (2011) with quarterly US troop numbers in Iraq for July 2011 through February 2017 from Peters and Plagakis (2019). Averaging over this duration, the US deployed about 81,000 troops annually in Iraq. As described above, contractor personnel who were US citizens added another 32% or 26,000 personnel. Non-US coalition forces accounted for 10% of all forces, adding another 9,000 troops. This yields an average annual forces deployed of $81,000 + 26,000 + 9,000 = 116,000$.

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