Collective Defense by Common Property Arrangements: the Rise and Fall of the Kibbutz

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Abstract

Common property arrangements have long been considered inefficient and short lived, since they encourage high-productivity individuals to leave and shirking among those who stay. In contrast, kibbutzim — voluntary common property settlements in Israel — have lasted almost a century. Recently, about 75% of kibbutzim abandoned their equal-sharing rule and paid differential salaries to members based on their contributions. To explain the long persistence of the kibbutzim, as well as the recent privatization of income, a model of public defense is developed, which predicts that defense depends on equal sharing, and that income privatization depends on external threats. Using settlement and Kibbutz level data, it is shown that kibbutzim made the largest contributions to expanding and defending the Jewish territory under the attacks of local Arabs and surrounding Arab countries. When the external threats went away, the kibbutzim in safer areas abandoned equal sharing.

1 Introduction

Common property arrangements, where resource users share rewards and duties, have long been considered inefficient.[1] The inefficiency comes from two sources: low-productivity individuals tend to remain in the regime, while high-productivity individuals tend to leave (adverse selection); and equal income sharing, regardless of contributions, encourages shirking (moral hazard). As a result, most common property arrangements are either short lived, such as early collectivized settlements at Jamestown, Plymouth, and Salt Lake City (Ellickson 1993), or based on coercion, such as the people's communes in China. In contrast, kibbutzim — voluntary common property settlements in Israel — have lasted for a century.[2]

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[1]Common property arrangements are often confused with common-property resources (see Ostrom and Hess, 2007). Among various cases, I focus on common property arrangements where output is equally shared, as commonly practiced in gold mines (Umbeck 1977), alpine pastures, fishing grounds (Ostrom 1990), marriages (Allen 1992), and pirate organizations (Leeson 2007).

[2]Kibbutz Gan Shmuel, established in 1913, was still a common property community by 2014.

The kibbutzim started in 1910, flourished during the 1936-1939 Arab revolt, and started to decline after 1979 (Near 1999, pp. 1–9). Traditionally, kibbutz members hold common ownership over all properties and receive an equal share of total kibbutz output, regardless of individual productivity. From the late 1990s to the early 2010s, about 75% of kibbutzim abandoned this equal-sharing rule and introduced a "safety net" budget, which paid differential salaries to members based on working hours and the market value of jobs (see Appendix B for details of kibbutz institutions).

The long persistence and recent income privatization of the kibbutzim has been the research subject of sociologists, economists, and historians. Sociologists typically view the kibbutz as a social experiment fuelled by the Zionist movement, and attribute the recent income privatization of Kibbutzim to the decline of a "pioneering spirit," and the rise of individualism among kibbutz members (Rosner and Getz 1996; Russel et al. 2013, pp. 5).

Certainly, one should not underplay the important role of ideology in constructing kibbutzim. However, ideology-based explanations are rarely testable and subject to concerns of reverse causality: high level of cooperation or altruism may be the consequence of the equal sharing rule in kibbutz through self-selection. In a recent field experiment kibbutz members, when paired with city residents, were found to be as uncooperative as city residents. Kibbutz members demonstrated a higher level of cooperation only when they were paired with anonymous kibbutz members (Ruffle and Sosis 2006). The experiment results suggest that the kibbutz institution is the cause, rather than the consequence, of the ideologies of kibbutz members.

To the limited extent they have given kibbutzim attention, economists have viewed them as risk-sharing communities to provide insurance against fluctuations of income across its members, when the insurance market was under-developed in early years. The fluctuations could result from "illness, unemployment, disability and occupation-specific demand shocks" (Abramitzky, 2008; Abramitzky, 2011). However, it is not clear why equal-sharing was still maintained, once the market or the state could provide life and unemployment insurance. Some elements of the traditional kibbutz are also inconsistent with the objectives of full risk sharing. For example, members develop similar skills through rotating positions, and gain similar knowledge through collective education within the kibbutzim. The kibbutzim neither allow members to work outside, nor hire outside workers. As a result, the low diversification of the human capital within the kibbutz hampers the efficacy of the insurance. The risk-sharing argument also fails to explain the rarity of the kibbutzim.

The moshavim, an individually owned settlement, outnumbered the kibbutzim after the independence of Israel, and became the dominant type of Israeli rural settlement. Yet these settlements did not adopted the equal sharing rule. The difference could be due to different constraints, or because moshav members were different from kibbutz members. Abramitzky (2011) suggests the latter and attributes the differences to ideology, arguing that "the presence of ideologically committed members is important for maintaining equal sharing, while mitigating brain drain and moral hazard." Once again, a back door reliance on an unobservable ideology is not a satisfactory explanation.

Historians, on the other hand, are on the right track in pointing out that the kibbutzim were the most appropriate type of settlement in defending against an enemy attack, as they were placed by the Jewish agency in strategic areas to form first defence lines, and played an important role in the war of independence (Near 1999, pp. 58; Bowes 1990; Ben-David 2015, pp. 58; Weintraub 1969, pp. 30). They attribute the high defensive abilities of the kibbutzim to the member characteristics — solidarity, discipline and ideologies (Near 1999, pp. 397). To the extent those personal characteristics are hard to measure, the explanation based on them is hardly testable.

To explore a falsifiable explanation for the existence of kibbutzim and the timing of kibbutz income privatization, I develop a model that relates the high defense function to the equal-sharing arrangements. The model highlights the tradeoff between the high level of public defense and the incentive to stay. In a private income community, public defense is under-provisioned, as the members tend to free ride on the contribution of others. Common property communities, on the other hand, can induce a first-best level of public defense, since the sharing rule can be used to align the private benefit of each resident with the aggregate benefit of the village — any choice that maximizes the wealth of the village is also the one that maximizes the wealth of each individual resident. Thus, common property arrangements solve the free riding problem on the production of the public good.

The model makes two prediction: (1) other things equal, kibbutzim have higher defensive capacity than private income communities. Consequently, they were placed by the Jewish Agency in strategic areas to enhance legal recognition of the Jewish territory, and defend the territory against foreign invasions; (2) kibbutzim in safer environments shift away from equal sharing. When the threat faced by kibbutzim faded away, the benefit of higher public defense was outweighed by the cost of low productivity in private goods. Under the pressure of members, especially those of high

productivity, kibbutzim introduced a differential wage system and abandoned the equal-sharing rule.

To test prediction (1), a settlement dataset is constructed that contains the year of establishment and the locations of different types of settlements. The empirical results show that kibbutzim had a larger chance of being placed in peripheral areas that defined the legal boundary of the Jewish state proposed in the 1947 UN partition plan. They were also more likely to be placed on highlands, and at the frontier of the invasion routes of the surrounding Arab countries before the independence of Israel. Two placebo tests also confirm the prediction: the location pattern is less salient after the independence of Israel in 1948, since Israel had established a standing army; the pattern disappears after the Israel-Egypt treaty in 1979, since the two strongest Arab neighbours — Egypt and Jordan — recognized the existence of Israel and no longer imposed military threats.

The independent and asymmetric timing of income sharing reform across various kibbutzim allows a test of prediction (2).[3] A kibbutzim-level panel dataset is constructed that contains the terrorist attacks near each kibbutz and the institutional status (preserving the equal-sharing rule or not) of each kibbutz in the years from 1986 to 2014. Using rainfall variation at the nearby refugee camp as an instrument for terrorist attacks, the empirical results show that a decrease in the number of Israeli deaths near a kibbutz significantly increases the probability that the kibbutz abandons its equal sharing rule. The results are robust to various measures for external threats.

The theoretical and empirical analysis of the kibbutz sheds light on the functions of common property arrangements. In the current property rights literature, common ownership has a lower cost of excluding outsiders in managing existing resources such as fisheries, oil pools, and forests, since it involves more owners than private ownership (Lueck 1994, Ostrom and Hess 2010). However, there were no valuable natural resources near kibbutzim, as most kibbutzim were located in "substandard, poorly developed or undeveloped tracts of marsh, swamp, or sand dune..." (Anabtawi 1972). Instead, kibbutz members deliberately pooled all their output together through banning private assets, thereby inducing a high level of public defense aiming at protecting the whole community, instead of a low level of public defense aiming at protecting individual property.

This paper is related to a growing literature on state building under external threats. While

[3]Historically, kibbutzim were affiliated with several kibbutz federations, and mutually responsible for each other's debts. The kibbutz federations in 1989 formally permitted their member kibbutzim to introduce reforms, and ensured that each kibbutz was fully responsible for its own debt (Russel et al. 2013, pp. 42).

recent theoretical models emphasizes the resources allocation between the military sector and the production sector (Tilly 1990, Besley and Persson 2009, 2011, Gennaioli and Voth 2015), this paper focuses on the economy-defense tradeoff embodied in the equal-sharing rule and the militarily important but economically inconvenient locations of kibbutzim. To the extent that those property regimes are long lasting, it suggests the cost of defending external threats involves not only the transfer of economic resources in the short run, but also the distortions in institutions in the long run.

Finally, this paper illustrates an empirical method of testing defensive capacity of different institutions. To the extent that combat results hinge on many unobserved variables, directly measuring the military strength is difficult. Instead, this paper theoretically ranks rural settlements of different income arrangements by their defensive capacity. Assuming that a central planner allocates the strongest institutions to the most dangerous places, it then tests their locations relative to the planned invasion routes constructed topographically. To the best knowledge of the author, the only other paper use the same method is Matranga (working paper), which tests the defensive capacity of Russian serfdom against the optimal invasion routes.[4]

2 Brief History of Arab-Israeli Conflicts

Although many states have been involved in conflicts, few have faced the repeated wars and persistent hostilities from all surrounding neighbours as Israel has since its creation. Despite being the victor in six wars, Israel for most of the twentieth century made little progress in negotiating peace treaties with neighbouring Arab countries. When Israel finally made peace with Egypt in 1978 and Jordan in 1994, it was still caught in a guerrilla war with armed Palestinian groups. Still today, it faces missiles fired by Hamas (Islamic Resistance Movement) from the Gaza Strip.

2.1 Palestine during the British Mandate or Jewish Land policy

Facing a rising anti-semitism in Europe, the Jews in the nineteenth century initiated Zionism, a movement aiming to re-establish a Jewish state. For a state, a territory is essential. The Jewish

[4]The working paper titled "All Along the Watchtower: Linear Defenses and the Introduction of Serfdom in Russia" was accessed on Nov 24, 2019 from
https://economics.ucdavis.edu/events/papers/copy2_of_1029Matranga.pdf

leadership understood this principle from the beginning, and strove for consolidating the economic and legal property rights of the Palestine land held by the Jewish people.[5] In 1897, the first Zionist Congress established the Jewish National Foundation to purchase, develop and settle lands as the property of the Jewish people (Weintraub 1968, pp. 5–7).

However, the chaotic land system in the Ottoman Empire prevented the Jewish National Foundation from purchasing lands with clean titles. In some cases, Arab tenants, according to their customary land system, claimed partial property rights of the lands they had worked for decades. In other cases, the real owners, fearing the tax and conscription imposed by the Ottoman Empire, left the lands unregistered, or registered by local elites (Abu-Lughod 1971, pp. 120–124). Consequently, even if the Jewish National Foundation legally purchased the lands, they usually did not own the *complete* property rights. Local Arabs treated the Jewish rural settlers as squatters, and sought to drive them out of the lands the moment settlements were established (Lieblich 1981, pp. 22).

In 1920, the Arabs struck three Jewish settlements on the north of Lake Hula, and forced settlers to abandon the settlements temporarily (Morris 2000, pp. 92–93). In 1929, the Arabs burned seven Jewish settlements near Jerusalem, and attacked settlements in the Jezreel, Jordan and Beisan Valleys (Morris 2000, pp. 115). But the Jewish land purchases kept growing at the cost of thousands of landless Arab families.

To find a solution to the uprising by Palestinian Arabs, the Peel Commission appointed by the British government in 1937, for the first time, recommended to partition the territory.[6] The Jewish state, according to the plan, was entitled to one-fifth of the Palestine region. The Arab state was entitled to the rest of the areas, except a small enclave, including Jerusalem and a path to the sea at Jaffa (Morris 2000, pp. 139).

Disappointed with the partition plan, the Arabs resumed the uprising and escalated into the Great Arab Rebellion from 1936 to 1939 (Morris 2000, pp. 123–124). Although the British succeeded in pushing the Arab militants out of the towns, they failed to disarm the rural bands. Consequently, the armed bands had launched about 800 attacks against Jewish targets and claimed more

[5]The legal property rights in this context refer to the support of other countries. Other things being equal, the more countries formally recognize the territory claimed by the Jews, the more legitimate the territory claim is.

[6]The British government appointed Lord Robert Peel to "ascertain the ... causes of the disturbances... to ascertain whether ... either the Arabs or the Jews have any legitimate grievances ... and to make recommendations for their removal." (Morris 2000, pp. 138)

than 300 Jewish deaths, by the end of the rebellion (Near 1999, p302; Morris 2000, pp. 144–157).

In response to the revolt, the British Mandate issued "The MacDonald White Paper" in 1939, limiting the Jewish immigrants to 75,000 over the next five years (Hadawi 1967, pp. 64).[7] After fruitless protests to the "White Paper", the Jewish agency, anticipating the upcoming conflicts with the Arab states, went out of its way to smuggle arms from abroad, and organize illegal Jewish immigration to Palestine.[8] Most of the illegal immigrants, however, were intercepted by the Royal Navy, and were sent to internment camps.[9] Albeit cautiously hidden in several young kibbutzim, 33 arms caches containing over 500 weapons and a large quantity of munitions (a significant part of Jewish armouries) were confiscated by the British Mandate during the Operation Agatha (Charters 1998; Wagner 2008).

Various Jewish groups retaliated by attacking British targets, including bombing the south wing of the King David Hotel, which was the headquarters of the British government in Palestine (Morris 2000, pp. 175–179). The Jewish violence and reprisal became too big a burden for post-war Britain, which was weak and short on soldiers, and forced the British to relinquish the mandate.[10]

In response to the request of the British, United Nations Special Committee on Palestine (UNSCOP) in 1947 made a partition recommendation in UN Resolution 181 (Klausner and Bickerton 2007, pp. 83).[11] The resolution recommended a partition of the Israel-Palestine region into a Jewish State, an Arab State and a small internationally administered zone including Jerusalem and Bethlehem (see Figure 8).[12] The Jews, owning only 6 percent of the land of Palestine and making up a third of the population, were entitled to 56 percent of the land under the partition plan (Yusuf 2002, Asadi 1976).[13]

[7] Britain was granted a Mandate for Palestine in 1920 by the League of Nations.

[8] Against the backdrop of the Arab revolt, Ben-Gurion, the head of the Jewish Agency, had wrote in his diary: "The danger we face is not riots—but destruction. Because the attackers will not be only the Arabs of Palestine but perhaps [also] Iraq and Saudi [Arabia], and they have aircraft and artillery. And we must draw a political and military conclusion [from this]." (Morris 2008, pp. 199)

[9] During 1946-1949, 51,510 Jews were intercepted by the British and interned in Cyprus detention camps (Tucker and Roberts 2008, pp. 280). In the meantime, the total Jewish population in the region of Palestine was 630,000 (Morris 2008, pp. 81).

[10] The British sent almost 100,000 troops to Palestine, five times the amount of troops sent during the 1936–1939 Arab Revolt.

[11] The UN charter required the resolution passed by a two-thirds majority. 33 countries voted in favour of the partition plan, 13 against, and 10 abstentions. The two superpowers, United States and Soviet Union, both supported the plan.

[12] United Nations General Assembly Resolution 181, assessed on Sep 2, 2019 from https://avalon.law.yale.edu/20th_century/res181.asp

[13] In contrast, the Arabs were entitled to 44 percent of the land, while occupying 48.5 percent of the land of Palestine.

As before, the Arabs rejected any partition plan. If they could not establish an Arab state in the whole of Palestine through diplomatic negotiations, they would establish it through military operations.

2.2 Middle-East Wars

On 15 May 1948, Egyptian, Syrian, Iraqi, and Jordanian armies invaded Israel. In the first three weeks of the war, the Haganah troops, inferior in manpower and firepower, managed to halt and contain the four-pronged assault.[14] During the truce from June 11 to July 8, the Haganah transformed from a paramilitary group into a regular army. They bypassed the embargo, purchased foreign arms, and almost doubled their manpower with the arrival of immigrants. The Israelis had gained the strategic initiative since then, and retained it until the end of the war (Morris 2008, pp. 263).

Alongside the clear victory for Israel, the 1948 war also left some 700,000 Palestinian refugees — former inhabitants of Arab villages conquered by the Jewish State. Starting in June 1948, thousands of refugees crossed the border lines into Israel, in order to resettle in their native villages. Egypt and Jordan took the opportunity to send infiltrators called "fedayeen" (self-sacrificers) to attack Israelis. From 1949 to 1956, infiltration resulted in the death of some two hundred Israeli civilians (Morris 2011, pp. 271; Morris 1993, pp. 99–101).

To completely secure the borders, Israel fought another two wars in 1956 and 1967 with neighbouring Arab countries. The end of the Six-Day War in 1967 found Israel's occupation of the Sinai, the Golan Heights, the West Bank, and the Gaza Strip. The new territories provided Israel with strategic depth and more defensible borders. Israel offered withdrawal from the newly occupied regions in exchange for peace treaties with the neighbouring Arab countries, but the answer they received was "no peace, no recognition, and no negotiations" (Klausner and Bickerton 2007, pp. 150–153).

The military defeat of 1967, along with the loss of territory, left Arab countries with a driving urge for revenge, and made another round of conflict a certainty. Equipped with modern weaponry and guided by thousands of military advisors from the Soviet Union, Egyptian and Syrian armies jointly launched a surprise attack on the Israeli forces in Oct 6, 1973. On the Golan Heights, the

[14] See Morris (2008, pp. 204–206) for a comparison of the military forces from both sides.

Syrian armour broke through the Israel defense lines, forcing Israel to send the strategic reserve originally to be deployed to the Sinai front. Just as the Israeli defenses were almost at the point of collapse, the Syrians met fresh Israeli armour, broke first, and withdrew.[15] In the Sinai Peninsula, the Egyptian armour demolished almost all Israeli fortifications, and breached the Israeli defence lines along the Suez Canal. On Oct 24, the Soviet-American cease-fire proposal put an end to the 1973 war, without a decisive result (Morris 2011, pp. 347–p440; Klausner and Bickerton 2007, pp. 163–171)

Israel turned the tide, but only at the edge of collapse. The narrow victory convinced many Israelis that the Sinai Peninsula could not be held indefinitely. On the other hand, the 1973 war restored the honor of the Arabs, thus enabling their leaders to contemplate peace with Israel. With the help of American mediation, Egypt and Israel signed a peace treaty in 1979 (Morris 2011, pp. 484–486).[16] Within three years, Israel withdrew all armed forces and civilian settlements from the Sinai, effectively handing over the territory back to Egypt. In return, Egypt became the first Arab country to officially recognize Israel, and established a "normal relationship" with Israel.[17] The peace treaty won Israel a far less dangerous Middle East. Since then, no Arab states have waged a regular war against Israel.

2.3 The Rise of The Palestine Liberation Organization

While Israel and Arab states were shelling each other, the Israeli occupation of the Gaza Strip and the West Bank instilled a growing sense of nationalism among the Palestinians. The Palestine National Liberation Movement, or Fatah, gained enormous popularity among the Palestinians, and took over the Palestine Liberation Organization (PLO). In the 1970s, PLO guerrillas launched rocket attacks and cross-border raids against northern Israeli towns from Lebanese forward bases, killing more than one hundred, and forcing thousands of border settlers to leave their homes (Morris 2011, pp. 507–517).

[15] Colonel Ben-Gal, a Israel brigade commander, said: "I was already set to order all [my] forces to withdraw. I had already picked up the radiotelephone. But I said to myself: Let's wait a little longer.... I was sure we had lost the battle. Had it gone on for another half an hour, an hour, we would have lost. For some reasons, the Syrians broke first and decided to retreat."

[16] The peacemaking momentum was interrupted by the collapse of the Nixon Administration as a result of the Watergate affair.

[17] The normal relationship means "full recognition, diplomatic, economic and cultural relations, termination of economic boycotts and discriminatory barriers to the free movement of people and goods."(Morris 2011, pp. 484)

To silence the PLO guns and rocket launchers, the Israel Defence Forces besieged PLO's base in Lebanon on 6 June 1982, and successfully forced its guerrillas to evacuate the base. But the destruction of numerous apartment houses, the loss of hundreds of Palestinian and Lebanese lives, and the seemingly indefinite occupation stirred bitterness among the Lebanese Shi'ites. A group of devout families, led by a handful of Shi'ites clerics, organized themselves into Hizbollah, or the "Party of God", and took over the guerrilla war from spring 1983. Holding the belief that their sacrifice would send them straight to Heaven, the Hizbollah proved themselves to be far more deadly and determined than the PLO. Along with ambushes and roadside explosions, suicide bombers also emerged as a regular weapon in the Shi'ite armory. In 1985, Israel was forced to retreat to the security zone, and completely withdrew from Lebanon in 2000, leaving some 650 dead and close to 3,000 wounded in the Lebanon War (Morris 2011, pp. 518–566).

The successful Shi'ite guerrilla campaign boosted the morale of Palestinians in the occupied territories — the West Bank and the Gaza Strip. In 1987, the first Intifada (popular uprising) arose in the occupied territories with the aim to end Israeli occupation. During the first eighteen months of the Intifada, the Israel government registered 41,000 violent incidents. It was the Madrid conference that eventually ended the first Intifada. In the conference, the State of Israel and the Palestine Liberation Organization (PLO) formally recognized one another, and initiated the Oslo Process to negotiate a solution to their decades-long conflict (Morris 2011, pp. 575–592).

Figure 1 shows estimates of Israeli deaths in this history (the numbers come from various sources, see Appendix C).[18] Using the death number as an approximation for the threats faced by the Israelis, it is clear that the Israelis faced constant military threats from hostile Arabs within and surrounding Palestine in the early years. Against this threat, the country used an arsenal of defenses, one of which was the kibbutzim. The threats from regular wars vanished after the Israel-Egypt peace treaty in 1979. Although the compromise of the Arab countries led Palestinians to carry out terrorist attacks starting in the late 1980s, the threats from terrorist attacks were not comparable to regular wars. Consequently, the kibbutzim spontaneously abandoned their traditional form, and adopted income privatizations in relatively safe areas.

[18]This paper focuses on one side (Israel) of the conflict because the main interest is in the Kibbutz. It does not take sides on the Israeli-Palestinian conflict.

Figure 1: Israeli Death Numbers

3 The Theoretical Framework

Here the kibbutz is modelled as an institutional defense strategy. Consider a community with N members. Each member allocates the effort e_i between producing a private good (food), and a public good (public defense).[19] The total effort available is normalized to 1. The community foresees an expected damage S sabotaged by surrounding enemies.[20] The damage can be mitigated by the aggregate public defense contributed by all members, and remaining damage is equally shared among the members. To avoid making any structural assumption on the utility function, the damage S is measured in the loss of food. Correspondingly, public defense is produced to preserve food.

Defense involves patrolling, digging trenches, building fences, manufacturing and laying mines, standing sentry, etc. Members are heterogeneous in their food productivity. However, it is assumed that members are homogeneous in the productivity of public defense, as every member receives the same military training and holds a gun on guard duty.[21]

[19] A private good refers to a rival and excludable good, in contrast to a public good. It does not imply private ownership.

[20] Members are assumed to be risk neutral, so that the focus is on public good provision rather than on risk sharing.

[21] Observations in California gold mines support that the miners has small variance in the ability of using pistols (Umbeck 1981).

Member i's production function for food and public defense are $z_i F(1-e_i)$ and $G(e_i)$ respectively, where z_i is a shift parameter in food productivity to capture the heterogeneity, and follows a uniform distribution $z_i \sim U(0,1)$. Both production functions are increasing and concave in effort, with $F(0) = 0$, $G(0) = 0$. To ensure an interior solution, it is assumed that the marginal productivity is zero when a member is exhausted: $F'(1) = 0$ and $G'(1) = 0$.

3.1 First-Best Solution

In terms of a benchmark, consider the first-best solution (the zero transaction cost solution). Here, the objective of the community is to maximize the food surviving from the damage caused by enemies. To simplify the model, the damage S is assumed to be sufficiently large such that effort on public defense can always mitigate damage and preserve food (for a rigorous proof in Appendix K, this assumption will be relaxed to show the effect of decreasing damage S on institution choices). Thus, the community maximizes the total food surviving damage:

$$\max_{e_1, e_2 \ldots e_N} \quad \sum_{i=1}^{N} z_i F(1-e_i) - [S - \sum_{i=1}^{N} NG(e_i)] \tag{1}$$

The optimal effort e_i^* of each member equates the individual marginal product of food with the marginal product of public defense for the *whole community*:

$$\frac{dz_i F(1-e_i^*)}{d(1-e_i)} = \frac{NdG(e_i^*)}{de_i} \tag{2}$$

Figure 2 gives a geometric interpretation of the effort allocation by member i. The optimal choice for the whole community is at e_i^*. At this effort level, the marginal product curve of food ($z_i F'(1-e_i)$) intersects with the marginal product curve of public defense for the whole community ($G'(e_i)$), and the sum of food (in Figure 2) and public defense (in Figure 2) is maximized.

Of course, the first-best solution does not exist in a positive transaction costs world, where the allocation of effort is costly to measure. Members may save effort on public defense by reducing the frequency of patrolling the community border, taking a nap while standing sentry, building low

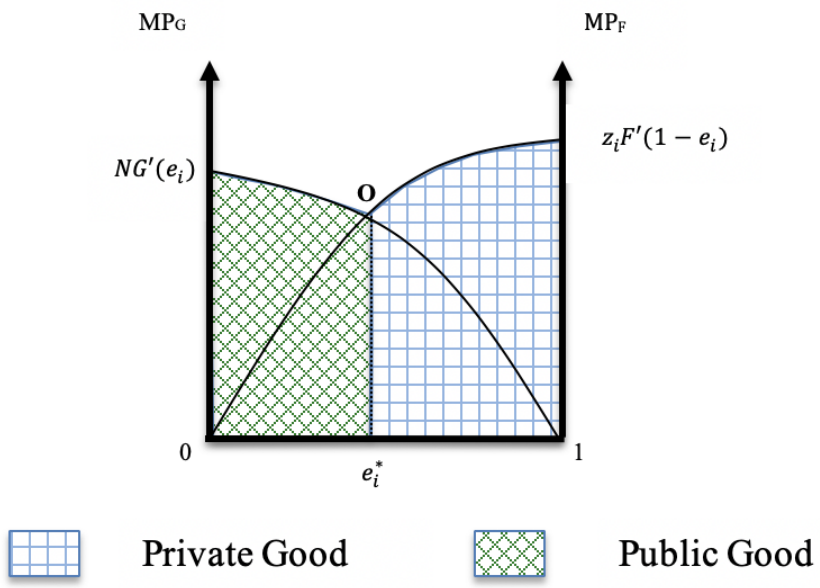

Figure 2: First-best effort e^*

quality fences, or simply carrying one's duty absently. Whenever the community incurs unexpected damage, everyone knows the public defense is under-provided, but it is hard to assign blame to any specific member. Since every member's effort on the public defense is mixed together, no one can be solely held accountable for the under-provision of the public defense.

In the presence of transaction costs — in this case, the cost of monitoring and enforcing other members' effort on public defense — economic outcomes differ under various types of income arrangements. I analyze two income arrangements: the private income arrangement, under which each member consumes the food produced by himself, and the equal-sharing income arrangement, under which each member equally shares the aggregate food produced by all members.

3.2 Private Income Solution

Under a private income arrangement, each member maximizes the sum of the food produced by him and survives damage:

$$\max_{e_i} \quad z_i F(1-e_i) - \frac{1}{N}[S - \sum_{i=1}^{N} NG(e_i)] \tag{3}$$

The equilibrium effort $\hat{e}_i$ of each member equates the marginal product of food and the marginal product of the public defense for *himself*:

$$\frac{dz_i F(1-\hat{e}_i)}{d(1-e_i)} = \frac{dG(\hat{e}_i)}{de_i} \tag{4}$$

Proposition 1

Under a private income arrangement, public defense is under provided while food is over provided, as $G(e_i^*) \geq G(\hat{e}_i)$, and $F(1-e_i^*) \leq F(1-\hat{e}_i)$.

This is the classic public goods problem where public defense is under provided, because members only consider their own benefit and ignore the positive externality on the whole community. Yet, a contract over the level of effort on the public defense is not feasible, as the effort allocation is not observable.

3.3 Equal-Sharing Income Solution

Under an equal-sharing income arrangement, each member only gets one Nth of the food produced. Each member maximizes an equal share of the food surviving damage:

$$\max_{e_i} \quad \frac{1}{N}\sum_{i=1}^{N} z_i F(1-e_i) - \frac{1}{N}[S - \sum_{i=1}^{N} NG(e_i)] \tag{5}$$

The equilibrium effort $\tilde{e}_i$ of each member equates the marginal product of one Nth of the food produced by himself and the marginal product of public defense for *himself*:

$$\frac{1}{N}\frac{dz_i F(1-\tilde{e}_i)}{d(1-e_i)} = \frac{dG(\tilde{e}_i)}{de_i} \tag{6}$$

Notice that once Equation 5 is normalized by N, it is equivalent to Equation 1. Equilibrium equation 6 can also be rearranged to equilibrium equation 2. It naturally leads to Proposition 2:

Proposition 2

Under an equal-sharing income arrangement, the provision of the public defense and food is at the first-best level, as $G(\tilde{e}_i) = G(e_i^*)$ and $F(1-\tilde{e}_i) = F(1-e_i^*)$

Under an equal-sharing income arrangement, the incentive to produce food is suppressed, as each member only gets a share of his own food production. This moral hazard problem decreases the food effort level and increases the effort level on the public good. As a result, the effect of the moral hazard counteracts the effect of the positive externality on the public good. Thus, an equal-sharing income arrangement brings back the provision of the public good to the first-best level.[22]

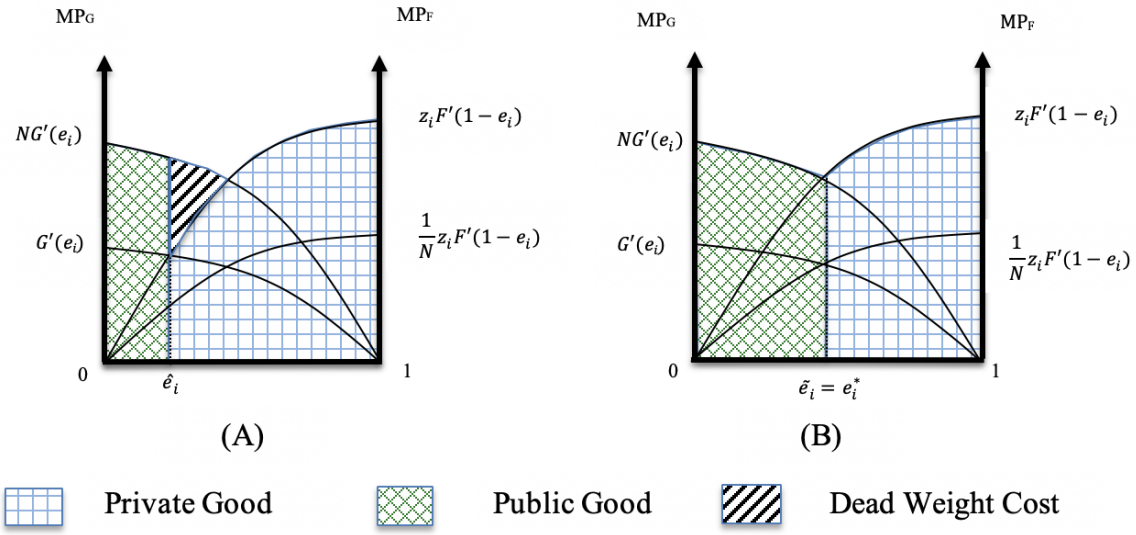

Figure 3: On Figure (A), the equilibrium effort under private income arrangements is $\hat{e}_i$. On Figure (B), the equilibrium effort under equal-sharing income arrangements is $\tilde{e}_i$.

In Figure 3(A), the equilibrium effort under a private income arrangement is $\hat{e}_i$, where the marginal product curve of food ($z_iF'(1-e_i)$) intersects with the marginal product curve of public defense for oneself ($\frac{1}{N}G'(e_i)$). The effort on public defense is under-provisioned, which leads to a dead weight cost (in Figure 3).

[22]Since the members cannot consume leisure, the problem of shirking does not enter the model. In reality, the shirking problem was minimized by the distinct rules of traditional kibbutzim (See Section 4.1).

In Figure 3(B), the equilibrium effort under an equal-sharing income arrangement is $\hat{e}_i$, where the marginal product curve of one-Nth food ($\frac{1}{N} z_i F'(1-e_i)$) intersects with the marginal product curve of public defense for oneself ($\frac{1}{N} G'(e_i)$). The equal-sharing income arrangement restores the equilibrium effect back to the first-best level, and avoid the dead weight cost.

3.4 The Choice over Income Arrangements

Though an equal-sharing income arrangement induces the first-best effort on the public good, it is not a free lunch. Otherwise, kibbutzim would not have privatized the income in the 1990s, and equal-sharing income arrangements would not have been so rare. The cost is adverse selection — the high productivity (in food) members incur a loss when sharing food with others. The severity of the adverse selection increases in the degree of heterogeneous in food productivities among the members, and the total amount of food produced.

The members thus have to choose between the lesser of the two evils: (1) adopting an equal-sharing income arrangement, thereby inducing a high provision of public defense, but allowing high productivity members to leave, or (2) adopting a private income arrangement, thereby avoiding the adverse selection problem, but suffering an under-provision of public defense. The optimal choice depends on the security situation faced by each community.

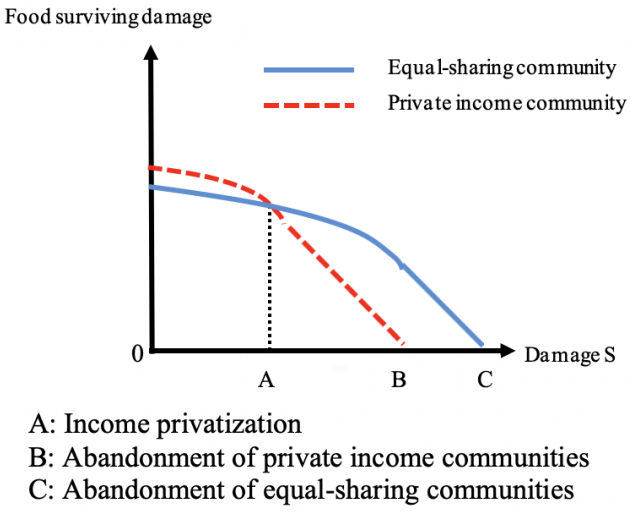

Figure 4: Total food remaining for the median voter

Assume the income arrangement of the community is determined by a simple majority vote, as

the mechanism used by kibbutzim in the 1990s. A member will vote for the income arrangement under which his food surviving damage is larger. When a community locates in a dangerous area, and foresees a large damage, the members choose the equal-sharing income arrangement to maintain a high level of public defense. As the damage to the community decreases, the benefit of the additional public defense provided by the equal-sharing income arrangement diminishes. Also, the adverse selection problem gets worse, because the members shift effort from producing public defense to producing food. As a result, the most productive member will vote for the private income arrangements, then the second most productive one, then the third... Eventually, the median voter will vote for the private income arrangements increases, and the community will abandon the equal sharing rule and privatize income (see Appendix K.4 for the proof).

Figure 4 illustrates the food remaining for the median voter. when the damage is large, equal-sharing arrangements can induce a higher public defense, and hence preserve more food (from Proposition 2). As the damage decreases, all members shift their effort from producing public defense to producing food. As a result, the benefit of the higher public defense under equal-sharing arrangements reduces, while the cost of equal-sharing the food for the median voter increases. Once the damage is below point A, the median voter will vote for the equal-sharing community, and the community will privatize the income.

Prediction 1

Communities maintain equal-sharing income arrangements in relatively dangerous environments, while privatizing income when the external threats decrease .

The analysis so far is based on the survival of communities. However, the external threats can be so large, that communities are abandoned.[23] To be consistent, assume that a member will vote for abandoning the community when his food surviving damage is lower than zero (this survival threshold can be interpreted as the value of an outside option).

As just shown in Figure 4, when the damage increases, the median voter will vote for abandoning the community at point B under a private income community, while at point C under an

[23] For example, several kibbutzim were evacuated when they faced overwhelming attacks during the 1948 Israel-Arab war.

equal-sharing community. Hence, equal-sharing communities can hold longer under enemy attacks than private income communities. If there is a central planner, like Jewish agency before the independence of Israel, it will place equal-sharing income communities at dangerous areas, thereby deterring the attack of enemies as long as possible .

Prediction 2

Other things being equal, a central planner places equal-sharing communities at dangerous areas, while placing private income communities at safe areas.

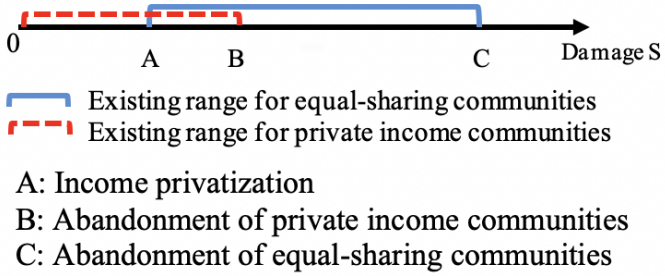

Figure 5: Range of the existence for different communities

Extending Figure 4, Figure 5 summarizes the range of the existence for different communities over the damage S. Private income communities abandon their settlements at point B, while equal-sharing communities abandon their settlements at point C. Also, equal-sharing communities privatize the income once the damage S falls below point A.[24]

Before presenting the dataset against which the predictions are tested empirically, I first provide institutional evidences to show the explanatory power of the model.

[24]While point C always lies to the right of point B, the relative position of A depends on the outside option (see Appendix K.5 for all possible situations). However, only the situation illustrated in Figure 5 is relevant to Israeli settlements, since kibbutz and non-kibbutz co-existed a long time.

4 Institutional Evidences

4.1 Kibbutzim Institutional Confirmations

In the light of the model, the distinct rules of traditional kibbutzim become reasonable and even necessary. In order to provide high levels of public good, the incentive on all private consumption has to be constrained. While the model argues that equal sharing can constrain the incentive on producing food, the constraint has to be applied to other consumptions, leisure and childrearing.

To prevent members from hiding in their rooms and spending effort on private hobbies, kibbutzim abolish private property along with privacy. Kibbutz members can go straight into a living place without knocking the door.[25] Kibbutz do not even allow private teakettle to be used in living rooms. According to Kerem (1962, pp. 105), "Social activity was supposed to be conducted in the dining room — with the whole kibbutz family — and the private drinking of tea in rooms would undermine the whole concept, leading inevitably to a return to privacy in all fields." What Kerem does not mention is that privacy increases the difficulty of prohibiting consuming leisure, and in turn impairs the provision of public defense.

Similarly, to relieve women from child rearing and allow them to equally contribute to kibbutz defense, the kibbutzim invented "communal sleeping".[26] Instead of sleeping with their parents, children spent their nights in children's houses, which include sleeping quarters, play areas, dining faculties, washrooms and classroom facilities for children five years old and up. Children live, eat, sleep and study together. Members are assigned to take care of the children as part of their work (Kerem 1962, pp. 78–81; Near 1999, pp. 237–245).

Homogeneous members along with rules designed to constrain private incentives together facilitate a high provision of public goods. While only public defense requires persistent provision, kibbutzim also use their comparative advantage in producing public good on providing other collective services: housing, laundry, mending, tailoring, childrearing, newspapers, wedding celebrations, and dining halls where members can eat for free. Compared to other communities, kibbutzim also have a higher provision of local public facilities such as swimming pools, basketball and tennis

[25] One member "recounted hanging red handkerchiefs on the door if privacy for sexual relations was desired" (Rayman 2014, pp. 52)

[26] Although the system was designed due to the limited housing capacity, it became "part of the ideology of most of the kibbutz movements", according to Near (1999).

courts, cultural centers, and parks (Gavron 2000, pp. 2).

4.2 The Performance of Kibbutzim in Civil Conflicts

Among all the public goods, the high provision of public defense is the fundamental purpose of the kibbutz institutions. During the 1936–1939 Arab revolt, rural settlements had to defend by themselves with limited support from the Jewish leadership (Near 1999, pp. 309). Kibbutzim, thanks to their institutions, quickly adapted to the dangerous environment.

Kibbutz Hulda increased the number of night guards to 18, almost reaching the limit for a settlement of 66 members.[27] Although the Jewish Agency leased extra land, including a citrus grove, and rationed water to the kibbutz, it was the kibbutz members who defended against the harassment from snipers, repulsed the storm from an organized band, and held the territory until the end of the revolt (Near 1999, pp. 313–314).

Kibbutz Makom, with a total population of 40, had 6 to 8 people on duty every night. Since the kibbutz bordered on hostile Arab villages, working on the field while exchanging fires with the Arab neighbours became the daily life of the kibbutz members. All adults, men and women, received training in the use of weapons. Even children were responsible for communication to the regional headquarters, in cases of emergency (Leiblich 1981, pp. 60–63). Chaim Weismann, the first president of Israel, described the life during the period of tension:"The rifle has become a working tool. We don't move without it." (Near 1999, pp. 312)

Defending the Jewish land against intermittent raids, and sometimes sieges, from Arab bands was not easy. Expanding the Jewish land to contested places within the range of Arab rifles was even harder. Yet, the kibbutzim made it by inventing a novel strategy — "Tower and Stockade".

At the night before the day of settlement, the members of kibbutz Tel Amal departed from the nearest settlement with all their equipment loaded on trucks. Before dawn, they had arrived at the appointed land for their home, under the protection of Jewish police and volunteers from nearby settlements. At first light, they started to build the defense structures — a double wall, a tower with a searchlight, two barbed-wire fences, trenches, and defense posts. By evening, the settlement was ready to defend against the attack of the Arab neighbours. Kibbutz Tel Amal thus became the first Jewish settlement in the Beit She'an Valley, one of the invasion routes of neighbouring Arab

[27]The four policemen, sent to the kibbutz as official guards, were not trusted by the kibbutz members.

armies (Near 1999, pp. 316–318).

The success of kibbutz Tel Amal convinced the Jewish leadership that kibbutzim were the most appropriate type of settlement at a time of tension. The Jewish leadership thus tilted resources from other settlements to kibbutzim, and accelerated the rate of expansion in the strategic areas.

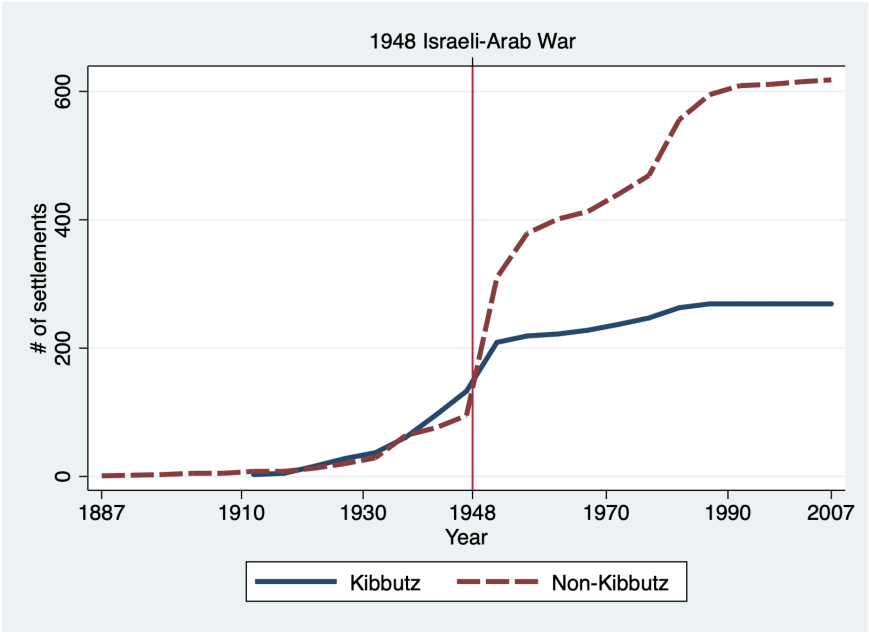

Figure 6: Number of Israeli settlements

Figure 6 illustrates the number of kibbutzim and non-kibbutzim over time. While the kibbutzim accounted for 50% of all settlements (46 out of 92) established before the revolt, the percentage increased to 74% (39 out of 53) during the 1936–1939 Arab revolt, and remained the same until the independence of Israel in 1948.[28]

4.3 The Performance of Kibbutzim in Military Conflicts

The Performance of Kibbutzim in the 1948 Israeli-Arab War exceeded expectations. On the eastern front, Kibbutz Gesher, with the help of one Israeli brigade, withstood the attack from the Iraqis for five days, and forced them to withdraw and redeploy in Samaria (Morris 2008, pp. 245–248). Kibbutz Degania Aleph and Degania Bet, with limited help from Jewish troops, halted the advance of two Syrian infantry battalions, along with twelve tanks and twenty armoured cars. They even immobilized two tanks by grenades and Molotov cocktails. After fighting grimly for two

[28]Kibbutzim accounted for 72% of the settlements (53 out of 74) established during 1940 to 1947.

days, the kibbutzniks beat back the Syrians (Morris 2008, pp. 254–257).

On the southern front, one Egyptian battalion attacked Kibbutz Kfar Darom. After dozens of casualties, the battalion withdrew and bypassed the kibbutz. The next target was Kibbutz Yad Mordechai. Unlike Kfar Darom, the Egyptians had to conquer Yad Mordechai, as it is located on on a hill, dominating the coastal road. The Jewish leaders also understood the importance of the kibbutz, ordering the defenders to withhold the attack and delay the Egyptians for as long as possible. On May 20th, 110 kibbutz members (twenty of them were women) and two squads of Jewish soldiers, resisted seven joint assaults from two Egyptian battalions, inflicting dozens of dead on the Egyptian side. The Egyptians added another battalion, and resumed attack on May 23rd. By nightfall, the toll of kibbutz casualties had exceeded 50 percent, but their reinforcement had been blocked by the Egyptian air force. They had no choice but to disobey the orders and retreat (which was criticized by the Jewish prime minister, Ben-Gurion). The Egyptians conquered Kibbutz Yad Mordechai, but their advance was delayed by at least four days. The delay gave the Israeli Giv'ati Brigade enough time to rally, and eventually halt the Egyptians at Isdud. The Egyptians lost the initiative from then on (Morris 2008, pp. 235–242).

In all cases, kibbutz members, with inferior weapons, fought with the Arab armies. Although the battle results were affected by many unobserved factors, the actual performance of the kibbutzim provides strong anecdotal evidence for the claim that kibbutzim can induce a high public defense and survive under fierce attacks. It is also evident that the Jewish National Foundation and the Jewish government fully understood the strong defensive capacity of the kibbutzim, purposefully placed them at the frontiers to delay the enemies, and purchased enough time for the eventual victory.

In addition to the anecdotal evidence, two datasets are compiled to test the predictions of the model in the context of Israeli kibbutzim: 1, kibbutzim maintain equal-sharing income arrangements in relatively dangerous environments, while privatizing income when the external threats decrease; 2, the Jewish leadership places kibbutzim at dangerous areas, while placing non-kibbutzim at safe areas.

5 Data

To test Prediction 1, I compile a kibbutz-level dataset covering 223 kibbutzim over the 20 years from 1986 to 2014. For each kibbutz, the dataset includes the year of income privatization, the number of terrorist attacks nearby, and other control variables. Rainfall data at Palestine refugee camps are used as an instrument variable to establish the causal relationship between the number of terrorist attacks nearby and the income privatization decisions.

To test Prediction 2, I compile a settlement dataset covering 851 Jewish rural settlements (kibbutzim and non-kubbtzim) since 1900. For each settlement, the data includes the location, type, and year established. I then use Geographic Information System (GIS) to construct the attacking routes of surrounding Arab countries based on topography, and measure the threats faced by different forms of settlements by the their locations relative to the attacking routes. The data sources are explained below (see Appendix A for the summary statistics and the definitions of the variables).

5.1 Kibbutz Data

The kibbutz reform data were compiled by Ran Abramitzky (Abramitzky 2018),[29] and contain information for 223 secular kibbutzim, which accounts for 83% of the 268 existing kibbutzim in total. Kibbutzim were excluded if they were religious or had not yet decided on whether to adopt reforms by 2014. Variables include the year in which the differential wage system has been adopted, the age of the kibbutz, the population in 1995, the average household size in 1995, whether the kibbutz belonged to the more ideological movement Artzi, the economic strength assessed by the banks and the government in 1995, regional employment rate, and regional population.[30]

5.2 Terrorist Attacks

After the peace treaties with Egypt and Jordan, Israel alleviated the military threats from its two most powerful Arab neighbours. The terrorist attacks from Palestinian armed groups, which caused thousands of civilian casualties, then became the major threat to Israeli settlements. Since

[29] Retrieved on March, 2018 from https://ranabr.people.stanford.edu/sites/g/files/sbiybj5391/f/data-on-kibbutzim.docx

[30] Regional employment rate, and regional population are compiled from Statistical Abstract of Israel 1990-2017.

terrorist attacks directly targeting kibbutzim were scarce, the analysis measures the threats faced by a kibbutz by the number of Israeli civilian deaths under terrorist attacks near each kibbutz. [31] A large number of civilian deaths near a kibbutz means the kibbutz located in a place vulnerable to terrorist attacks, and requires a high level of local public defense, in addition to the security service provided by the government.

The terrorist attacks are obtained from Global Terrorism Database (GTD)[32]. This database contains data on more than 180,000 terrorist attacks from 1970 to 2017, and is the most complete source of data on terrorist attacks currently available. It includes attack types (assassination, explosion, shooting, etc.), attack dates, and characteristics of the victims. As specified in the GTD guidebook, the analysis only includes incidents that meet the three criteria for terrorist attacks: 1) the act must be aimed at attaining a political, economic, religious, or social goal; 2) there must be evidence that the act had an intention to coerce, intimidate, or convey some other message to a larger audience than the immediate victims; and 3) the act must be outside the context of legitimate warfare activities.

To focus on the incidents of most concern to Israeli civilians, the analysis restricts the sample to attacks happening in Israel and targeting Israeli civilians. All projectile attacks (mortars, missiles, and rockets) are excluded, as they are not defendable by a settlement. This leaves a sample of 1259 terrorist attacks resulting in 1128 civilian deaths from 1986 to 2014. The threat level faced by each kibbutz in each year is then measured by the total number of civilian deaths within 30 kilometres of each kibbutz in the previous six years [33]. A large number of civilian deaths near a kibbutz may occur simply because that kibbutz is located in a densely populated area, and that one death in a remote town can be more worrisome than two deaths in a large city. Therefore, the death number is divided by the population density at the incidence locations, to take the population density into account.[34]

[31] Only two terrorist attacks happened in kibbutzim: five civilians were killed in Kibbutz Metzer in 2002, and one civilian was killed in kibbutz Nir-Oz in 2008.

[32] National Consortium for the Study of Terrorism and Responses to Terrorism (START). (2018). Global Terrorism Database [globalterrorismdb_0718dist.xlsx]. Retrieved from https://www.start.umd.edu/gtd

[33] The number of Israeli civilian deaths within 10km, 20km, and 40km of the kibbutz is also used for robust tests.

[34] The population density data is obtained from Gridded Population of the World. Incidents before 2000 are normalized by the population density in 2000; Incidents between 2000 and 2005 are normalized by the population density in 2005; Incidents between 2005 and 2010 are normalized by the population density in 2010.
Center for International Earth Science Information Network - CIESIN - Columbia University. 2016. Gridded Population of the World, Version 4 (GPWv4): Population Density. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H4NP22DQ. Accessed DAY MONTH YEAR.

Since terrorist attack data in 1993 is missing, the number of civilian deaths in 1993 is imputed by the average of 1992 and 1994 data. To address concerns regarding potential imputation errors, the analysis includes an imputation dummy variable in all regressions.[35]

5.3 Refugee Camp and Rainfall Data

The death of civilians could be correlated with some unobserved factors. For example, kibbutzim were largely identified with the Labor Party. The rise to power of the Likud party, known for its support of Israeli settlements in the West Bank and Gaza Strip, may provoke the terrorist attacks of Palestinians, while at the same time reduced the official support for kibbutzim.

To address this concern, the analysis uses an instrument for the number of civilian deaths under terrorist attacks near each kibbutz. The instrument is the total rainfall surplus in the previous six years at the nearest refugee camp to each kibbutz, multiplied by the camp population, and then divided by the distance between each kibbutz and the nearest camp.

Under the harsh and often brutal occupation of Israel, Palestine refugee camps were the breeding ground for terrorist attackers. The First Intifada (the Palestinian's war for independence from Israel) started with a mass demonstration in the Jibalya refugee camp, and soon spread to the other refugee camps in the Gaza Strip and in the West Bank (Morris 2011, pp. 573-574). In the following years, Palestine refugee camp residents were more supportive of military operations against Israeli targets than residents in cities and villages (Bloom 2004). They were represented among the suicides at more than twice their share of the general population (Yufit and Lester, 2004).

One of the main factors that fuels the resentment of Palestinians is the water crisis arising from the over-extraction by Israel settlements and the constraints on the water supply and sanitation infrastructure imposed by the occupying power.

Most of the West Bank's natural water resources lie beneath its soil in three shared aquifers collectively known as the "Mountain Aquifer". The three aquifers derive most of their recharge from rainfall and snowmelt. While the Palestinians extract 20% of the estimated aquifer potential lying beneath the West Bank, which is in line with its allocation in the Oslo agreement, the Israelis

[35] Corresponding estimates without terrorist attack data in 1993 are in Appendix 2. They are qualitatively very similar to the estimates in Table 8.

over-extract by more than 50%, in addition to the balance of the estimated potential.[36] The over-extraction of the aquifers has lowered water levels in the West Bank, and reduced Palestinian extraction from 138 MCM (Million Cubic Metre) in 1999 to 113 MCM in 2007. As a result, more than 200,000 people in West Bank are served by rainwater and expensive tanker water (World Bank, 2009).

The water supply coverage in the Gaza Strip is better than in the West Bank, but the quality of water has been deteriorating, due to high concentrations of salts and nitrates. In the past three decades, heavy over-drafting of groundwater and a decline in the rainfall, the main source of groundwater recharge, has led to the groundwater quality decline and seawater intrusion (Baalousha 2006). Consequently, agriculture productivity is harmed, and less than 10% of water supplied through the network in Gaza Strip meets potable standards (World Bank, 2009; UNOCHA, 2010).

Water supply and sanitation infrastructure could have mitigated the water crisis in the West Bank and the Gaza Strip. The 1995 Oslo agreement aimed to provide a stable framework for investment in water infrastructure, and improve water and sanitation services, but the actual outcome has been the opposite. It is often impossible for Palestinians to obtain Israeli permits to construct or repair water infrastructure, including digging new wells, restoring old wells and constructing water collection structures (UNCTAD, 2015). Only 38 out of the 202 well-drilling projects and 3 out of the 16 waste water projects submitted by the Palestinians were eventually implemented. No agricultural water applications, whether linked to drilling of new or replacement wells or mobilization of surface water streams, have been approved (World Bank, 2009). Israeli governments have also denied the establishment of small and medium-sized dams that could have been used to store water and release it at appropriate times throughout the year (UNCTAD, 2015); at the same time, numerous dams on the Israeli side cut the upstream water supply, drying the Wadi coastal wetlands in Gaza Strip (Shomar, 2011).

Given the low coverage and the poor quality of the water network, rainfall in Palestine is vital for those who live there to recharge groundwater and prevent seawater incursion. Though the amount of rainfall is exogenous, the Palestinians have good reasons to blame the Israelis for their low living standard in a dry year, and direct their rage on nearby Israeli settlements. Thus, it is

[36] In 1995, the Government of Israel and the Palestine Liberation Organization signed the Oslo II agreement. In the Article 40, the aggrement recognized Palestinian water rights, and assigned 20% of estimated rechargeable potential of West Bank aquifers to the Palestinians, 80% to the Israelis.

expected that variation in rainfall at the nearest refugee camp of a kibbutz is strongly correlated with the number of civilian deaths under terrorist attacks near the kibbutz in a given year.

The Palestinian Central Bureau of Statistics provides the population of 19 Palestinian refugee camps in West Bank and 8 in Gaza Strip in 1996.[37] The analysis then links each kibbutz to its nearest refugee camp, as well as the rainfall at the camp in each year. The rainfall information is obtained from the daily gridded observational dataset for precipitation, temperature and sea level pressure in Europe (E-OBS). [38] Using the ECA&D blended daily station data, the E-OBS daily gridded dataset provides rainfall estimates at 0.1 degree (11km at the equator) latitude longitude intervals. Considering the small size of Israel, this high spatial resolution data is crucial to obtain reasonable rainfall variation.

5.4 Settlement data

Settlement data containing the location and year of establishment, are compiled from various resources. The location of all existing rural settlements are obtained from Google Map API. The year of establishment are obtained from the Israel government.[39] Among the existing settlements, three of them are formed by an ideological split in 1952.[40] They are included in the kibbutz level data for income privatization analysis, as they make reform decisions independently since 1989. But they are excluded from the settlement level data for location analysis, to avoid double counting the establishment of the same settlements.

The information of settlements that once existed but were later deserted are compiled from various archives. During the 1948 Israel-Arab War, 8 settlements were destroyed by the Arab armies.[41] In 1982, as part of the Israel-Egypt treaty, Israel evacuated 13 rural settlements from the Sinai.[42] In 2005, Israel unilaterally disengaged from the Gaza Strip and North Samaria. As a result, 16 rural settlements in the Gaza Strip and 4 rural settlements in the North Samaria were

[37] Accessed on April 9, 2019 from http://www.pcbs.gov.ps/Downloads/book31.pdf

[38] I acknowledge the E-OBS dataset from the EU-FP6 project UERRA (http://www.uerra.eu) and the Copernicus Climate Change Service, and the data providers in ECA&D project (https://www.ecad.eu)

[39] Accessed on May 11, 2018 from http://www.cbs.gov.il/webpub/pub/text_page?publ=47&CYear=2006&CMonth=1.html

[40] Ein Harod split into Ein Harod (Ihud) and Ein Harod (Meuhad). Ashdot Ya'akov split into Ashdot Ya'akov (Ihud) and Ashdot Ya'akov (Meuhad). Giv'at Hayyim split into Giv'at Hayyim (Ihud) and Giv'at Hayyim (Meuhad).

[41] The established years and types of those settlements are obtained from Fischbach (2003, p157). The locations are obtained from Lorch and Moshe (2007).

[42] The established years, types, and the locations of those settlements are obtained from Lesch (1977) and MERIP Reports (1977).

evacuated.[43]

5.5 Geographic Information

The invasion of foreign armies was the major threat faced by the Jewish settlements before the peace treaties with Egypt and Jordan. In order to measure that, I use QGIS to construct the optimal invasion routes based on geographic information, including the elevation and impassable places like lakes in the Israel-Palestine region.

The elevation data comes from the Global Multi-resolution Terrain Elevation Data (GMTED2010) developed by the National Geospatial-Intelligence Agency.[44] Elevations in GMTED2010 are spaced at 7.5 arc-seconds, or 225 meters at the equator, across the entire surface of the Earth.

Vilnay (1968) records the location of the two large lakes (the Lake Kinneret and the Dead Sea) at the Israel-Jordan border. The map is digitalized, and the area covered by the two lakes is marked as impassable in the GIS system. The maps of the partition plans are obtained from United Nations.[45]

Apart from the military pressure, the Jewish National Foundation may also place the settlements in fertile land to maximize the economic benefit. To control the land fertility, the analysis uses the wheat cultivation potential, which is obtained from the Global Agro-Ecological Zones (GAEZ) project run by the Food and Agriculture Organization (FAO).[46] GAEZ estimates the upper bound for individual crop yields at a resolution of 30 arc-seconds, or 900 meters at the equator, based on detailed grid cell-level data on agro-climatic (precipitation, temperature, wind speed, sunshine exposure and rainfall), soil types, elevation, terrain slopes.[47] This analysis uses the agro-climatically attainable yield for intermediate input level irrigated wheat, because it is largely consistent with

[43]The established years and types of those settlements are obtained from the Israel government central bureau statistics 2004 locality list file, cross checked with the changes in localities from 1948 to 2016 file. The two files are accessed on Aug 27th, 2019 from
https://www.cbs.gov.il/he/publications/doclib/2019/ishuvim/index2004.xls
https://www.cbs.gov.il/he/publications/doclib/2019/ishuvim/change2016.xls
The locations are obtained from Israel Ministry of Foreign Affairs, which is accessed on Aug 27th, 2019 from:
https://mfa.gov.il/MFA/AboutIsrael/Maps/Pages/Israels%20Disengagement%20Plan-%202005.aspx.

[44]Danielson, J.J., and Gesch, D.B., 2011, Global multi-resolution terrain elevation data 2010 (GMTED2010): U.S. Geological Survey Open-File Report 2011–1073, 26 p. http://pubs.usgs.gov/of/2011/10pdf/of2011-1073.pdf

[45]The 1947 UN partition plan: https://www.un.org/unispal/document/auto-insert-208958/
The 1937 Peel Commission partition plan https://www.un.org/unispal/document/auto-insert-207683/

[46]FAO/IIASA, 2011. Global Agro-ecological Zones (GAEZ v3.0). FAO Rome, Italy and IIASA, Laxenburg, Austria. The data is downloaded from http://gaez.fao.org/Main.html on May 4, 2019

[47]Documentation on GAEZ data is available on http://pure.iiasa.ac.at/id/eprint/13290/1/GAEZ_Model_Documentation.pdf

the land quality classification, based on a soil survey carried out in 1946 by the Departments of Agriculture, Lands, Irrigation and Statistics for the Anglo-American Committee of Enquiry (Hadawi 1957, pp. 6; see Appendix D for a comparison).

6 Expanding the Jewish Territory by Rural Settlements

6.1 Legal Recognition of the Jewish Territory

Starting with holding 0.8 percent of the Palestine land in 1900, the Jews were entitled 20 percent of the Palestine land under 1937 Peel Commission plan, and 56 percent under the 1947 UN plan (Yusuf 2002, Asadi 1976, Bisharat 1993). The main factor considered by both committees were the facts created on the ground — Jewish rural settlements.

According to the Peel Commission report, "the natural principle for the Partition of Palestine is to separate the areas in which the Jews have acquired land and settled from those which are wholly or mainly occupied by Arabs..." (Peel Commission Report, pp. 382).[48] Most frontiers were drawn along the rural settlements, while the northern part was considered as "a reasonable allowance ... for the growth of [Jewish] population and colonization..." (Peel Commission Report, pp. 383). The UN partition plan follows the similar principle. It allocated areas with "no Jews" or "only a very small minority of Jews" to the Arab State, while increased "the proportion of Arabs to Jews in the Jewish State" so that the Jewish State can include a "a larger number of Jews as well as a larger land area" (UN Resolution 181). Fair or not, the two committees assigned the Jewish State mainly the lands that the Jews had already settled .

The Jewish leadership understood this from the beginning, and strove to link the Jewish people to the land by establishing rural settlements. However, the Jewish rural settlements were under constant attacks the moment they were established (as introduced in Section 2.1). Hence, it was crucially for the Jewish National Foundation to allocate the lands purchased to settlements of high defense capacity — kibbutzim, especially in areas far away from the heartland. Fortunately, as the monopoly owner of Jewish land, the Jewish National Fund acted as the central planner in allocating land to rural settlements.[49] The fact that the Jewish National Fund knew the type of settlement

[48] the full report of Peel Commission is accessed on Oct 2, 2019 from https://unispal.un.org/pdfs/Cmd5479.pdf

[49] Organized in 1901, the Jewish National Fund held 90 percent of land purchased by the Jews by 1930 (Abu-Lughod 1971, pp. 128).

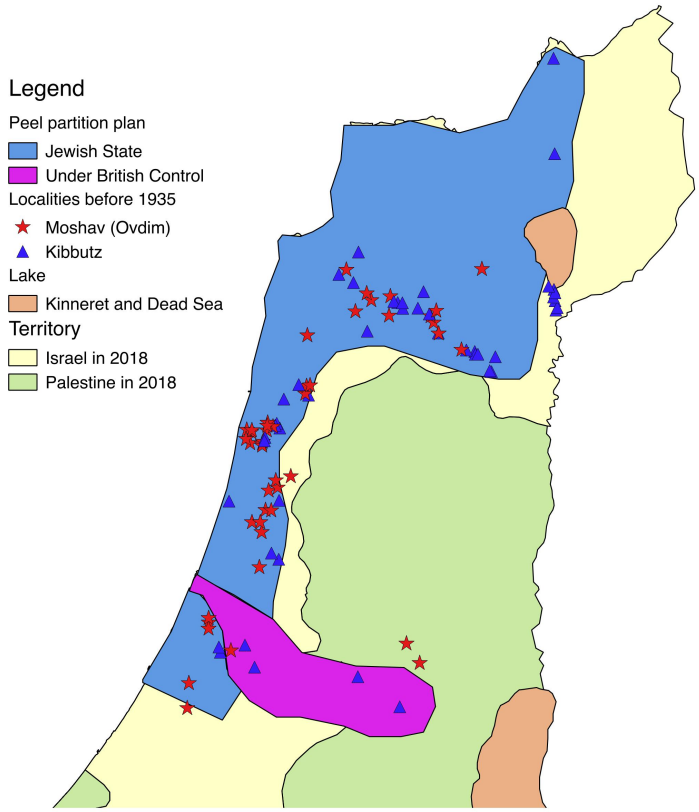

Figure 7: The partition plan proposed by the Peel Commission in 1937

that settlement members intended to establish when they apply for land grants, allowed it to assign the land to settlements according to their defensive capacity.

Figure 7 shows the relationship between the Jewish rural settlements in 1935 and the Jewish territory (the blue area) recommended in the Peel partition plan.[50] Though not obvious in Figure 7, kibbutzim made a greater contribution than other forms of settlement (see the following subsections).

Figure 8 shows the relationship between the rural settlements in 1947 and the Jewish territory (the blue area) recommended in the UN partition plan.[51] Once again, the borders of the Jewish state in the partition plan were mainly defined by the kibbutzim established at the frontiers (see the following subsections).

Had the Arabs accepted the UN partition plan, the Jews would have established the Israel

[50]The Peel Commission wrote report mainly based on Settlement patterns in 1935 (Near 1999, p320).

[51]The UNSCOP made the partition recommendation mainly based on their investigation in the summer of 1947 (Morris 2000, pp. 182–184).

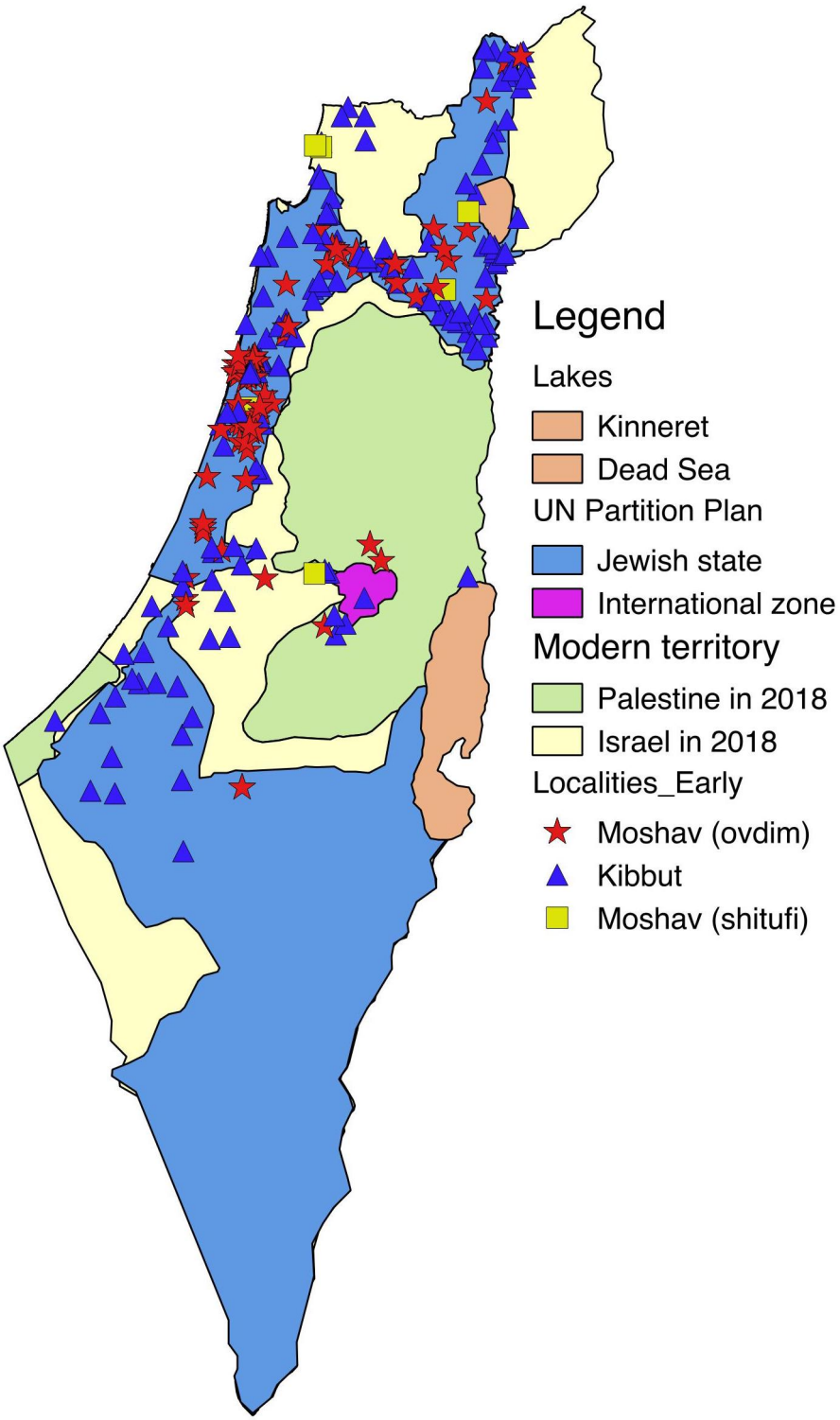

Figure 8: The partition plan approved by the United Nations General Assembly in 1947

state without fighting a bloody war. Even when the flat rejection from the Arab states made the partition plan non-binding, the partition plan still had tremendous legal and economic ramifications in the following decades. In 1948, the partition plan was taken as "a legal justification for both Israel's existence as a state and its subsequent admission to the United Nations" (Elaraby 1968).[52] In 1988, when the Palestine National Council declared independence of the State of Palestine, they also invoked the UN partition plan as a legal basis (Khalidi 1990).[53] Palestinian President Mahmoud Abbas in 2011 even acknowledged that rejecting the 1947 UN proposal that would have created a Palestine state was "our mistake".[54] It is reasonable to believe that the UN partition plan would be a reference point for the territory claims made by the Palestinians, should they negotiate with the Israelis to recognize a Palestine State.

Apart from the long-run legal consequences, the UN partition plan also had an immediate impact on the unfolding of the 1948 Israel-Arab War. Throughout the war, the Jordan army "avoided attacking the territory of the UN partition plan Jewish state" (Morris 2008, pp. 231), while the Jewish leadership felt it was legitimate to conquer the Arab area dubbed "the Little Triangle" south of Haifa, because "this will be a police action... as their area is ours [that is, inside Israeli territory as defined by the UN partition resolution] and they [the Arabs] are inhabitants of the [Jewish] state," as argued by the Jewish leader, Ben-Gurion (Morris 2008, pp. 296).

6.2 Regression Specifications and Results on Settlement Locations

As discussed in the previous subsections, settlements, especially kibbutzim, shaped the boundaries of the Jewish state proposed in the Peel commission partition plan in 1937 and the UN partition plan in 1948. The above observation can be verified by the following Logit regression

[52] "Recalling its resolutions of 29 November I947 [where the partition plan was approved by the UN majority] and 11 December 1948 and taking note of the declarations and explanations made by the representative of the Government of Israel before the ad hoc Political Committee in respect of the implementation of the said resolution" (United Nations General Assembly Resolution 273 accessed on Oct 8, 2019 from https://www.securitycouncilreport.org/un-documents/document/unmembers-ares273-iii.php)

[53] In the independence declaration, the Palestine National Council stated:" Despite the historical injustice done to the Palestinian people by their dispersion and their being deprived of the right of self-determination after UN General Assembly Resolution 181 of 1947, which partitioned Palestine into two states, one Arab and one Jewish, that resolution still provides the legal basis for the right of the Palestinian Arab people to national sovereignty and independence." (Khalidi 1990)

[54] See the news report from Reuters accessed on Oct 8, 2019 from https://www.reuters.com/article/us-palestinians-israel-abbas/abbas-faults-arab-refusal-of-1947-u-n-palestine-plan-idUSTRE79R64320111028

Table 1: Peripheral settlements in the 1937 Peel partition plan

Dependent variable:	Peripheral Settlement			
	(1)	(2)	(3)	(4)
Kibbutz	2.327*	2.106	1.891	1.711
	(1.026)	(0.995)	(1.014)	(0.936)
Water Distance		0.930		0.941
		(0.0790)		(0.0948)
Agriculture Potential		0.0871		0.261
		(0.166)		(0.402)
Observations	92	92	76	76

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a settlement being a peripheral settlement. A settlement is a defensive settlement if it is located within 3km of the boundary of the partition plan. The results are robust for 1km, 2km, or 4km (see Appendix E).

specification:

$$Peripheral\ settlement_i = \beta_1 Kibbutz_i + \gamma X_i + \epsilon_i \tag{7}$$

where $Peripheral\ settlement_i$ is a binary variable: equal to 1 if the distance to the boundary of the Jewish state in the partition plan is less than 3km, 0 otherwise (the results are robust for 1km, 2km, or 4km. See Appendix E); $Kibbutz_i$ is a binary variable: equal to 1 if the settlement i is a kibbutz, 0 otherwise; X_i is a set of control variables, including the distance to the nearest source of water, and the agriculture potential (see Table 10 in Appendix A for the summary statistics).

Table 1 presents the Logit regression results on the probability of each settlement being a peripheral one. One issue in analyzing the effect of settlements on the proposed Jewish state is how to deal with the 16 settlements that were located outside the boundary. In column (1) and (2), all settlements established up to 1935 are included in the analysis. Settlements that were located outside the proposed Jewish State were assumed to have zero distance to the boundary of the state. In column (3) and (4), only settlements that were located inside the boundary were included in the sample. No matter which method is adopted, the results are biased against the contribution of kibbutzim, as there are more kibbutzim (11) than non-kibbutzim (5) among the settlements located outside the proposed Jewish State (see Figure 7).

In all specifications, kibbutzim had a larger chance of being a peripheral settlement that shaped the boundary of the Jewish state proposed in the 1937 Peel partition plan. Taking column 2 for

Table 2: Peripheral settlements in the 1947 UN partition plan

Dependent variable:	Peripheral Settlement			
	(1)	(2)	(3)	(4)
Kibbutz	3.401***	3.556***	3.197***	3.350***
	(1.040)	(1.136)	(1.132)	(1.216)
Water Distance		0.919***		0.915**
		(0.0267)		(0.0332)
Agriculture Potential		0.407***		0.691
		(0.119)		(0.299)
Observations	219	219	184	184

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a settlement being a peripheral settlement. A settlement is a defensive settlement if it is located within 3km of the boundary of the partition plan. The results are robust for 1km, 2km, or 4km (see Appendix E).

example, the odds ratio of **Kibbutz** means kibbutzim were 2.1 times as likely to be peripheral settlements as non-kibbutzim. The odds ratios are not significant, except in column (1), since the Jewish leadership had not fully realized the defense capacities of kibbutzim by 1935.

But once kibbutzim had fully demonstrated their defense capacities during the Arab revolt from 1936 to 1939, they were increasingly likely to become peripheral settlements. Using settlements established up to 1947 and the proposed Jewish state in the 1947 UN partition plan, previous Logit regression is conducted again (see Table 11 in Appendix A for the summary statistics).

Table 2 presents the Logit regression results on the probability of each settlement being a peripheral one in the 1947 UN partition plan. The analysis deals with 35 settlements that were located outside the boundary in the same way. In column (1) and (2), all settlements established up to 1947 are included in the analysis. Settlements that were located outside the proposed Jewish State are assumed to have zero distance to the boundary of the state. In column (3) and (4), only settlements that were located inside the boundary were included in the sample. Similarly, the results are biased against the contribution of kibbutzim, as there are more kibbutzim (31) than other settlements (4) (see Figure 8).

In all specifications, kibbutzim had a larger chance of being a peripheral settlement that shaped the boundary of the Jewish state proposed in the 1947 UN partition plan. The odds ratios of **Kibbutz** are larger than one, and significant at the one percent level across all specifications, which means that kibbutzim were more likely to become peripheral settlements. Taking column 2 for

example, the odds ratio means kibbutzim were 3.6 times as likely to be peripheral settlements as non-kibbutzim. Interestingly, the odds ratios of both **Water Distance** and **Agriculture Potential** are significantly less than one in column (2), which means peripheral settlements were located on barren fields, and were further from water sources. To the extent that most peripheral settlements were kibbutzim, kibbutz members sacrificed their economic returns and living standards, in order to expand the Jewish territory before the independence.

6.3 Regression Specifications and Results on the Number of Jewish Settlements Nearby

One of the reasons why kibbutzim were more likely to become peripheral settlements, was that they needed less support from other Jewish settlements. Geographically, they were located sparsely, while non-kibbutzim were clustered (see Figure 8). This observation can be verified by the following linear regression.

$$Number\ of\ Jewish\ Settlements_i = \beta_1 Kibbutz_i + \gamma X_i + \epsilon_i \tag{8}$$

where $Number\ of\ Jewish\ Settlements_i$ is the logarithmic number of other Jewish settlements within 3km (similar results for 1km, 2km or 4km), when settlement i is established; $Kibbutz_i$ is a binary variable: equal to 1 if the settlement i is a kibbutz, 0 otherwise; X_i is a set of control variables, including the distance to the nearest source of water and the agriculture potential (see Appendix A for the summary statistics).

Table 3 presents the linear regression results. The dependent variable in column 1, 2, 3, and 4 is the number of nearby Jewish settlements within 1, 2, 3, and 4 km respectively. In all specifications, the coefficients of **kibbutz** is negative, which means kibbutzim established before the independence have a lower number of nearby friendly settlements than non-kibbutzim. Taking column 3 for example, the coefficient -0.247 means kibbutzim have 25 percent fewer Jewish settlements within 3km than non-kibbutzim. The coefficients are significant at the one percent level across all specifications, except in column 1, due to the small number of Jewish settlements within 1km. In contrast, when the same regression is conducted on all settlements before 1936 (see Table 4), the coefficients of **kibbutz** are smaller and not significant, which means that kibbutzim were placed

Table 3: Number of nearby Jewish settlements before 1948

Dependent variable:	Number of Jewish settlements within			
	(1)	(2)	(3)	(4)
	1km	2km	3km	4km
Kibbutz	-0.0670	-0.268***	-0.247***	-0.269**
	(0.0436)	(0.0738)	(0.0933)	(0.105)
Water Distance	-0.00673**	-0.0152***	-0.0221***	-0.0236***
	(0.00330)	(0.00559)	(0.00707)	(0.00792)
Agriculture Potential	-0.0237	-0.00549	0.0107	0.0292
	(0.0299)	(0.0505)	(0.0639)	(0.0716)
Constant	0.369*	0.783**	1.036**	1.245***
	(0.192)	(0.325)	(0.411)	(0.461)
Observations	219	219	219	219

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Number of nearby Jewish settlements before 1936

Dependent variable:	Number of Jewish settlements within			
	(1)	(2)	(3)	(4)
	1km	2km	3km	4km
Kibbutz	0.0133	-0.152	-0.105	-0.101
	(0.0779)	(0.121)	(0.148)	(0.166)
Water Distance	-0.0329**	-0.0372*	-0.0472*	-0.0441
	(0.0133)	(0.0206)	(0.0251)	(0.0283)
Agriculture Potential	0.0320	-0.0435	0.0408	0.0759
	(0.0767)	(0.119)	(0.145)	(0.164)
Constant	0.169	1.154	1.000	1.059
	(0.485)	(0.752)	(0.919)	(1.036)
Observations	92	92	92	92

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

further away from other Jewish settlements only after the Arab revolt in 1936.

Consistent with the theoretical prediction, the Jewish leadership placed kibbutzim in the peripheral areas to shape the boundaries of the Jewish state, because they realized kibbutzim had a higher defense capacity, and were able to hold longer in barren lands without supports from other Jewish settlements. The settling strategy was more salient after 1936, both because the Jewish leadership had to accelerate the territory expansion when a territory partition was more likely than ever, and because the threats faced by peripheral settlements were higher due to the deteriorating relationship between the Arabs and the Jews.

The kibbutzim, in turn, enhanced the legal property rights of the Jewish territory, through the partition plans proposed by Britain and the United Nations. The legal recognition by the international societies divided the surrounding Arab countries over their invasion plan — at the eve of the 1948 Arab-Israel War, Jordan unilaterally changed its attacking route in order to avoid attacking the proposed Jewish state in the partition plan, while Lebanon quitted the invasion. The military pressure faced by the nascent Jewish state had thus reduced significantly. But the rest of the Arab countries — Syria, Egypt, and Iraq — resolved to ignore the UN resolution, and nip the Jewish state in the bud. Kibbutzim, once again, demonstrated the institutional strength of equal-sharing income arrangements, through delaying, or even halting the invasion, and bringing precious time for the Jewish army.

7 Defending the Jewish Territory by Rural Settlements

Most modern independent countries have a regular army for civil security and national defense. However, the Jews, under the close surveillance of the British Mandate before 1948, could only use a paramilitary organization — Haganah — which was both outmanned and outgunned by the Arab invading armies at the eve of the 1948 Arab–Israeli War. Therefore, they had to rely on rural settlements to defend *strategic areas*, which are defined to be areas along the invasion routes of neighbouring Arab countries, and delay the advance of their enemies.

Based on the model, kibbutzim are expected to yield the highest level of public defense, since they are the most equalitarian settlements among all types. Consequently, the Jewish National Fund, given the limited resources before the Independence War, was expected to implement two

related strategies: (a) placing settlements in *strategic areas*, and (b) placing kibbutzim in the most strategically important areas such that they can hold as long as possible in the face of enemy attacks, thereby consolidating the economic property rights of lands purchased, through deterring, or even repelling impending invasions of its Arab neighbours.[55]

After the independence of Israel in 1948, such a pattern of settlement locations was predicted to be less salient, because the rural settlements were no longer exposed to the direct attack of foreign invasions, thanks to the formation of the Israel Defense Force. However, the deep hostility from surrounding Arab countries continued, as none of them was willing to negotiate with Israel. The possibility of invasions still posed a threat, though smaller than in the pre-independence period, to the rural settlements. Consequently, those *strategic areas* were less dangerous, and became habitable for less equalitarian communities of a lower defending capacity, like moshavim (ovdim).

Once Israel and its strongest neighbour — Egypt — had signed the peace treaty, such a pattern of settlement locations was predicted to be almost unidentifiable. Because the rest of the Arab armies could not break through Israel's border defenses, the *strategic areas* were suitable to communities of the lowest defending capacity. Consequently, private income communities like community settlements were predicted to be placed more often in those areas.

7.1 The Invasion Routes

To formally test the above idea, one may attempt to measure the strategic importance of various areas in the Israel-Palestine region by the actual invasion of the Arab armies during the Arab-Israeli War. But such an attempt suffers from two problems. First, the actual progress of a war is highly unpredictable. Unexpected events, like natural disaster, plague, or even a change in the wind direction, may drastically change the course of one decisive battle, and in turn, change the result of a war. Second, the actual invasions are endogenous to the strength of the defenders. The defenses in strategic areas may be so strong that the enemy has no choice but to take a detour, and conquer less valuable land, as happened in Israel (the actual performance of kibbutzim in the war will be examined in Section H). Therefore, the actual invasion routes can deviate from the original plan wildly, and hence are not a good measure for the optimal invasion routes.

[55] Following Allen (1991), I define economic property rights as the range of choices can be freely exercised over these lands.

To overcome those problems, I exploit the terrain of the Israel-Palestine region. The region is 470 km in length and 135 km at the widest point, which can be crossed by armored cars within several hours, in the absence of resistance (see Figure 9).[56] The region bordered by Lebanon to the north, Syria to the northeast, Jordan to the east, Egypt to the southwest and the Mediterranean Sea to the west. The region can be roughly divided into four geographic areas: The Mediterranean coastal plain, The Central Hills, the Jordan Valley, and the Negev Desert. The Mediterranean coastal plain stretches from the Lebanese border in the north to the Egypt border in the south. The Central Hills is a mountainous region parallel to the coastal plain, but interrupted by the Jezreel Valley. The Jordan Valley lies at the Israel-Jordan border. In the valley runs the Jordan River, flowing from north to south through the Lake Kinneret and emptying into the Dead Sea. Except in the winter rainy season, the river is usually quite shallow. The southern half of the region lies in the Negev Desert, at the tip of which is Red Sea.[57]

It is hard to defend the whole region, especially when the attackers hold the initiatives consisting of the tactical surprise by choosing when and where to attack, and the strategic advantage of attacking simultaneously at several borders, as happened in the 1948 Arab-Israeli war. But it is not impossible to defend part of the region, with adequate preparation. The priority of defending is the population center, weapon factories, and the major port for importing weapons — Haifa and its surrounding areas, as the weapons and the manpower are essential for halting the advance of enemies, and organizing a counterattack. Thanks to the central hills, Haifa is only accessible through a handful of pathways: the coastal corridor from the southern Egypt-Israel or the northern Lebanon-Israel border, and the Jezreel Valley from the western (Jordan and Syrian) border. So long as the defenders can block these pathways, and force the invaders to march in the mountainous areas, they can buy enough time for the Jewish agency to mobilize the army, wait for international aid, establish new defense lines, and hopefully turn the tide of the war.

To verify the above observations, I construct the optimal invasion routes based on the terrain elevations. The main advantage of this approach is that both the attackers and the defenders have common knowledge about the terrain. The target towards which the attackers will march is also

[56] Though the border of Israel is controversial, the border of the region ruled by the British Mandate was clearly delineated, and recognized by the surrounding Arab countries. Jordan, for example, refused to cross the border before the British left, when planning the invasion with other Arab countries (Morris 2008, pp. 182).

[57] The geographic information is obtain from Israel Ministry of Foreign Affairs on Aug 9th, 2019. https://mfa.gov.il/mfa/aboutisrael/land/pages/the%20land-%20geography%20and%20climate.aspx.

the target to be guarded by the defenders. The procedures are described below:

1. Calculate the least-cost paths by Dijkstra algorithm (Dijkstra 1959), using each cells on Israel-Lebanon border as the starting point and Haifa as the destination (see Appendix G for parameters for traveling costs).
2. Label the lowest least-cost path obtained in step 1.
3. Add a penalty of 20 percent to the traveling cost of all cells that are within 5km of the optimal invasion route obtained in step 2.
4. Iterate over steps 1–3, until three best optimal invasion routes are generated. However, the same cell can only be penalized once.
5. Repeat steps 1–4 for Egypt-Israel, Jordan-Israel, and Syria-Israel borders.[58]

Step 3 allows multiple attacking routes, because the attackers would not always take the shortest path, especially when the multiple routes are of similar travelling costs. However, given the constraint on the logistics, and the intermittent arriving of Jewish men of military age and weapons at the Haifa port, the attackers still had to keep a somewhat direct route towards Haifa, or risk losing their temporary local superiority in manpower and weaponry. Therefore, a penalty of 20 percent in step 3 is imposed to allows a secondary, and a third best attacking route, so long as they take less than 1.2 times of the travelling cost of the primary attacking route.

The final result is displayed in Figure 10. Several invasion routes from Egypt in the south have similar traveling costs, since the large plain allows an army to bypass local strongholds and outflank its target. In contrast, constrained by the narrow pathway, the route from the Lebanon in the north is unique (see Appendix H for a comparison with the actual historical invasion routes).[59]

It is then expected that most settlements were along the invasion routes before the independence. Among the various types of settlement, kibbutzim were predicted to be placed in more strategically important areas.

[58] Iraq army crossed Jordan and invaded Israel, as Iraq and Israel do not border each other.

[59] For settlements that once existed on the Sinai Peninsula, but evacuated in 1982, the invasion routes were constructed from the Suez Canal to the Gaza Strip (see Figure 14).

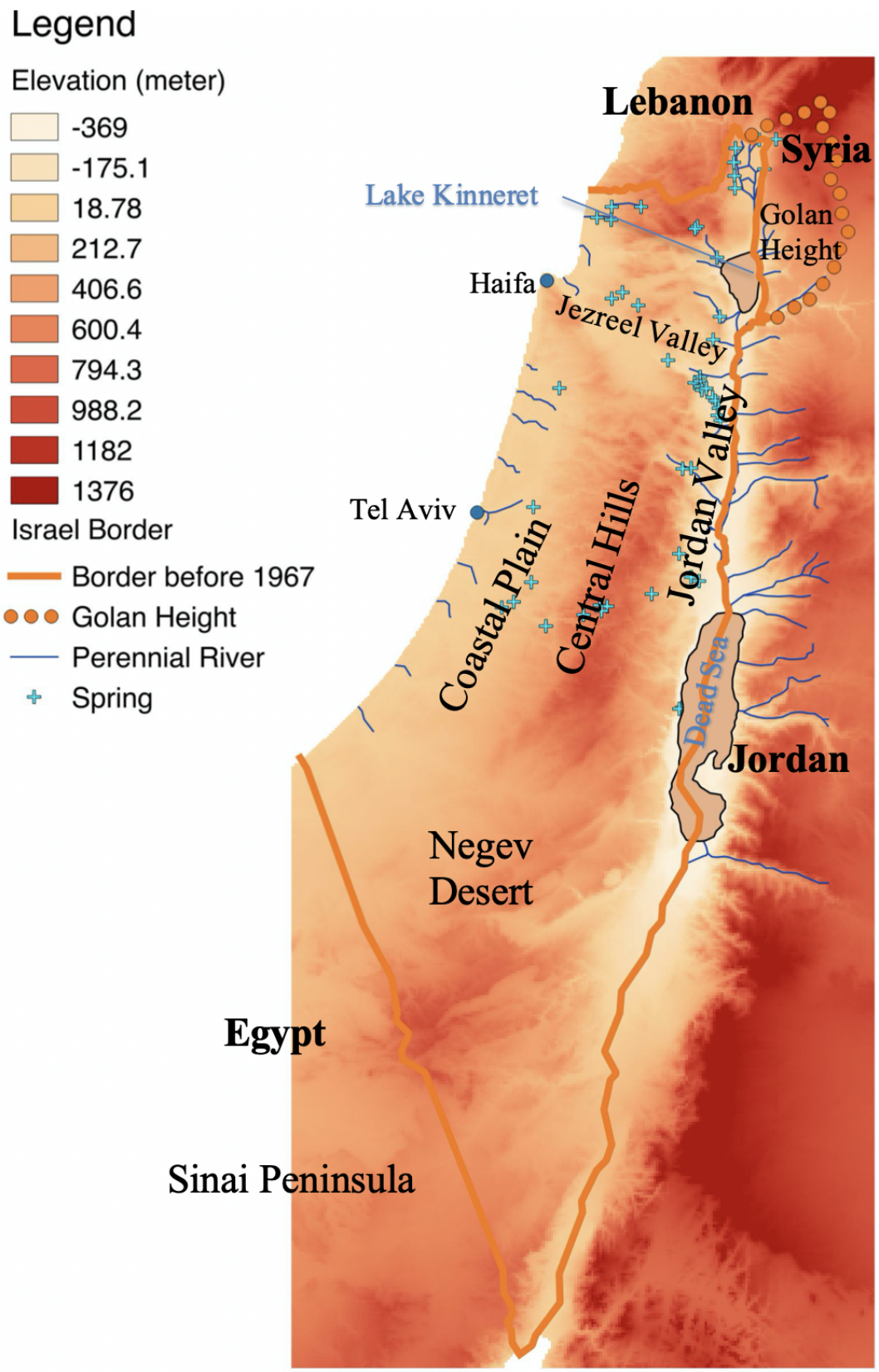

Figure 9: Israel geography

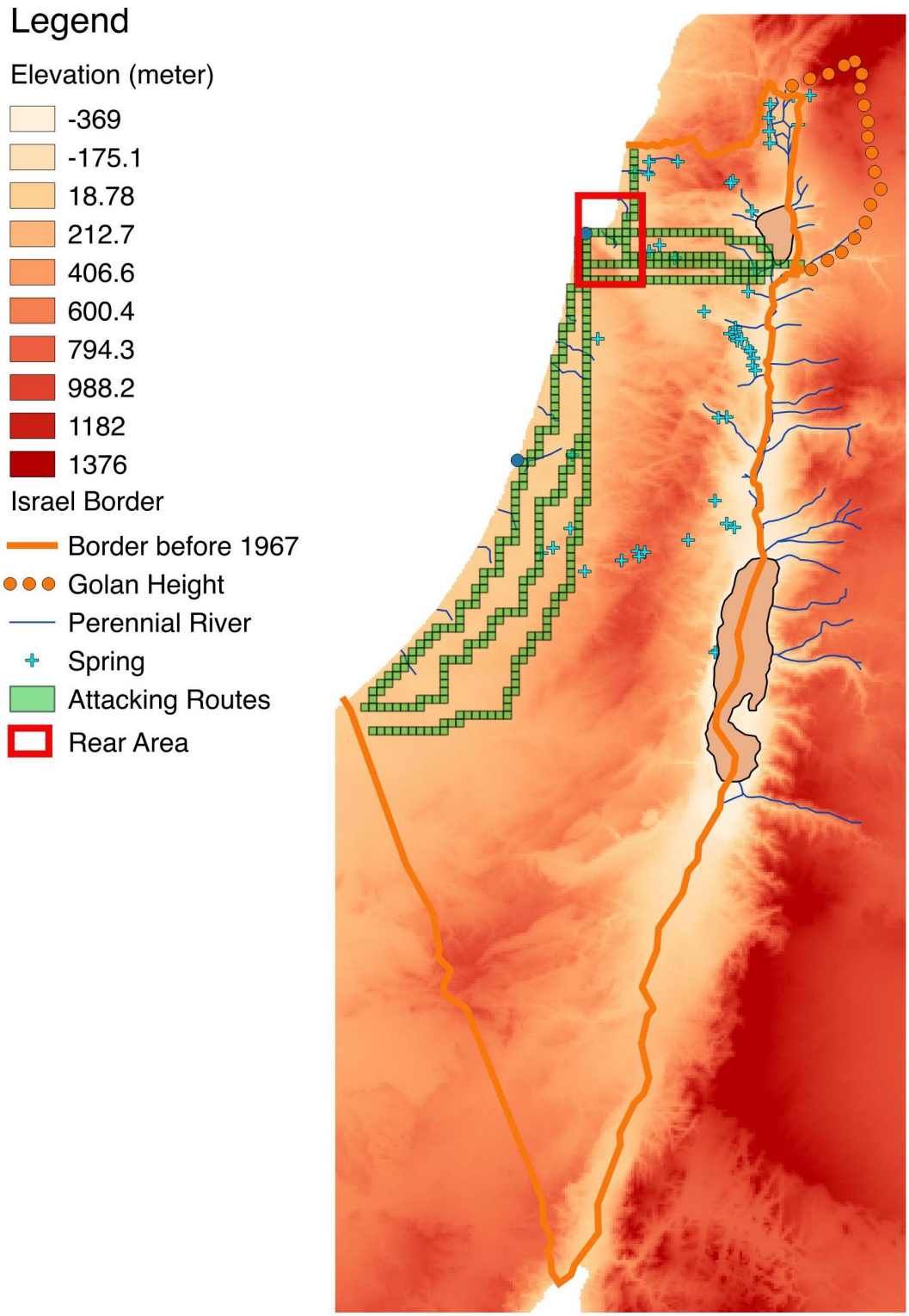

Figure 10: Least cost routes from the borders to Haifa

7.2 The Settlement Location Pattern

Indeed, the majority of settlements established before the independence were located along the attacking routes (see Figure 11). Among various types of settlements, kibbutzim were placed in the frontiers to defend against the first wave of attacks. In the south, settlements, especially kibbutzim, were spread out across the whole plain, to block the multiple invasion routes from the southern border. At the eastern frontier, settlements gathered along the Jordan Valley and Jezreel Valley, so that they can support each other in the times of war. At the northern frontier, they were sparsely placed along the invasion route, probably because Lebanon had the weakest army among all the neighbouring Arab countries.[60] In contrast, the majority of moshavim (ovdim) were located at the hinterland, under the protection of kibbutzim.[61]

After the independence, such a pattern is less salient (see Figure 12). Many settlements were still placed along the attacking routes, but a significant number of them were located in other places. More importantly, moshavim (ovdim) were also constantly located at the frontiers, along with kibbutzim.

The pattern becomes almost unidentifiable, once Israel signed the peace treaty with Egypt in 1979 (see Figure 13). In fact, the opposite seems true: settlements were no longer placed along the attacking routes. The private income settlements — community settlements emerged and were occasionally placed at the frontiers.

7.3 Regression Results on Settlement Locations

The above observed results can be verified by regression results. Specifically, I first measure the threats faced by the settlements, by the distance of the settlement to the invasion routes. To capture the difference in the threat level of each neighbouring Arab country, I then group settlements according to the nearest attacking route from Egypt, Lebanon, or the west (including Syria, Jordan and Iraq). All settlements close to the rear area are excluded (the red frame in Figure 10), as it is hard to identify which invasion route they are close to. Finally, the following Logit

[60] According to Morris (2000, pp. 217), there were only "a handful of Lebanese" out of the 28,000 Arab troops.

[61] Since the degree of equality in moshav (shitufi) is lower than that in kibbutz but higher than that in moshav (ovdim), the model predicts that moshavim (shitufi) will be placed behind kibbutz but in front of moshav (ovdim). Though casual observation seems support the prediction, the result is inconclusive due to the small umber of moshavim (shitufi).

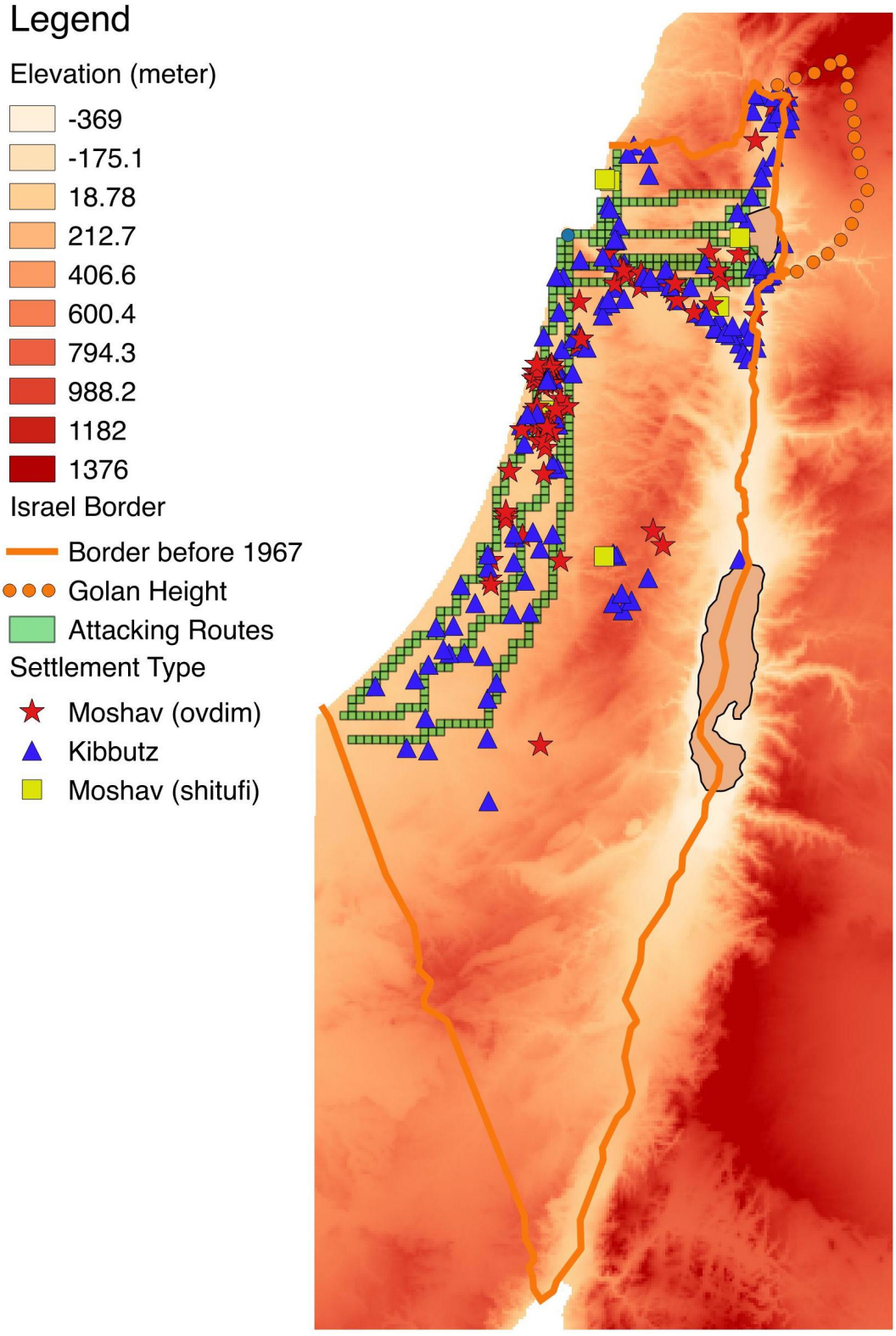

Figure 11: Settlements established before the independence in 1948

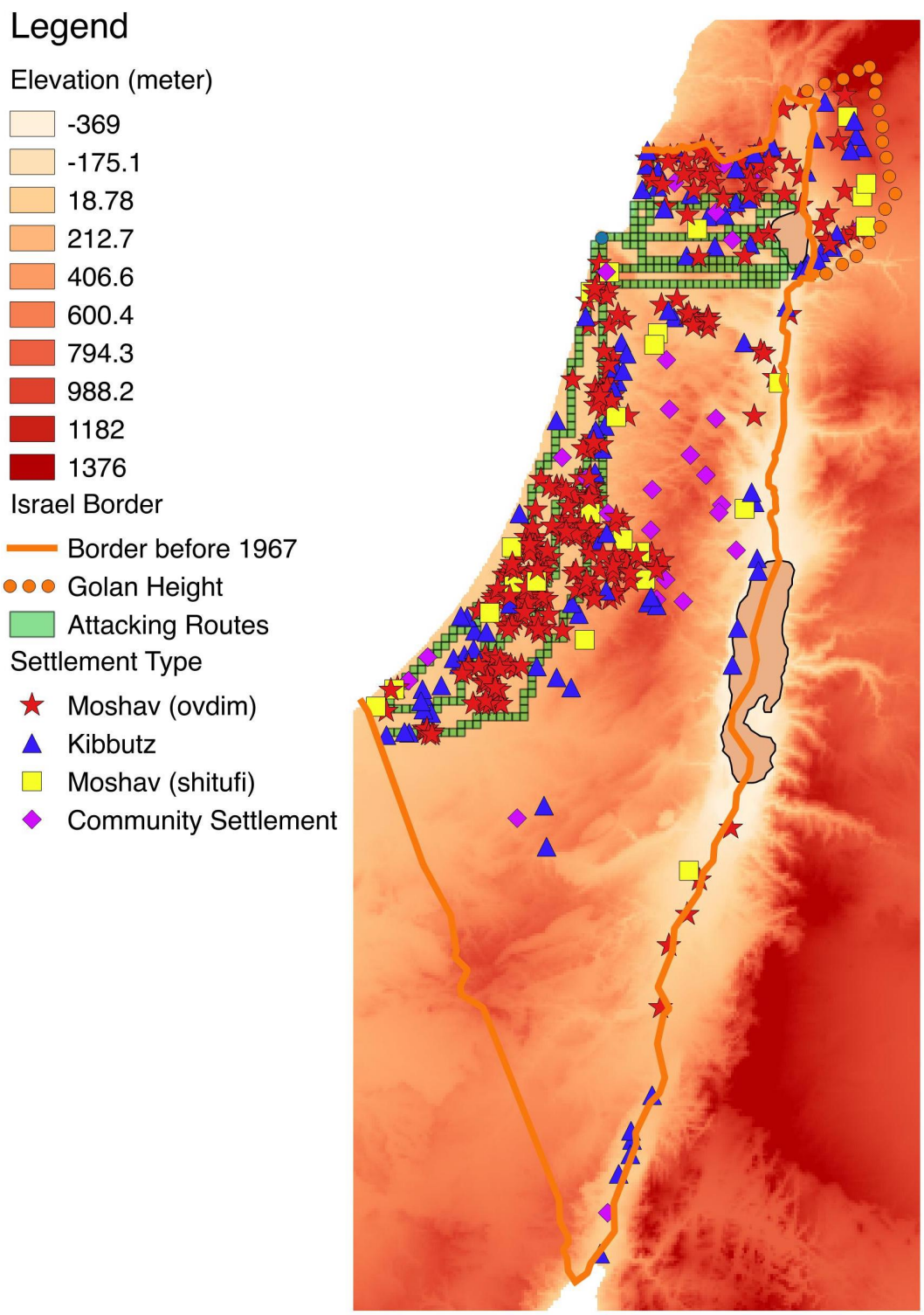

Figure 12: Settlements established between the independence in 1948 and the Israel-Egypt peace treaty in 1979

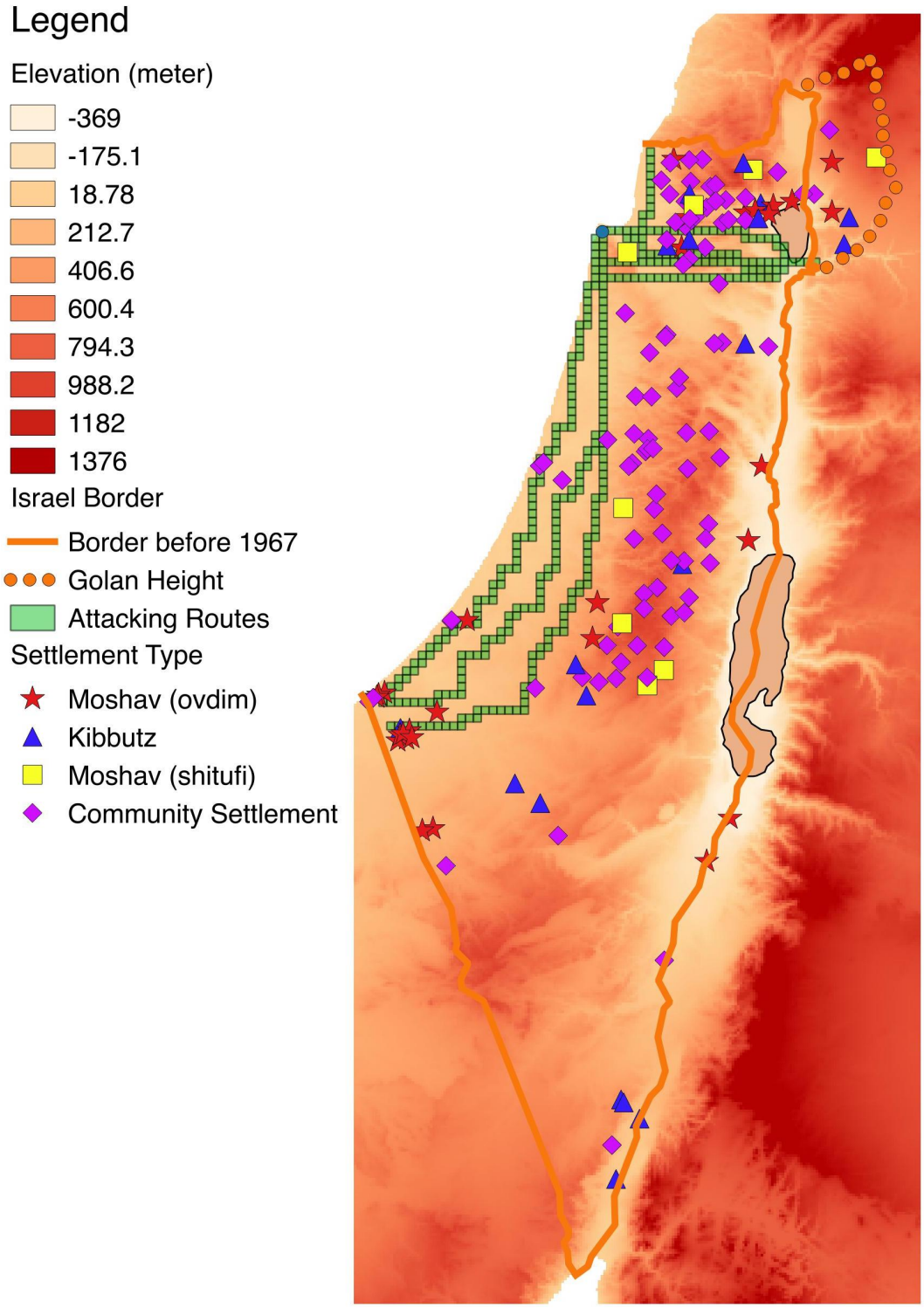

Figure 13: Settlements established after the Israel-Egypt peace treaty in 1979

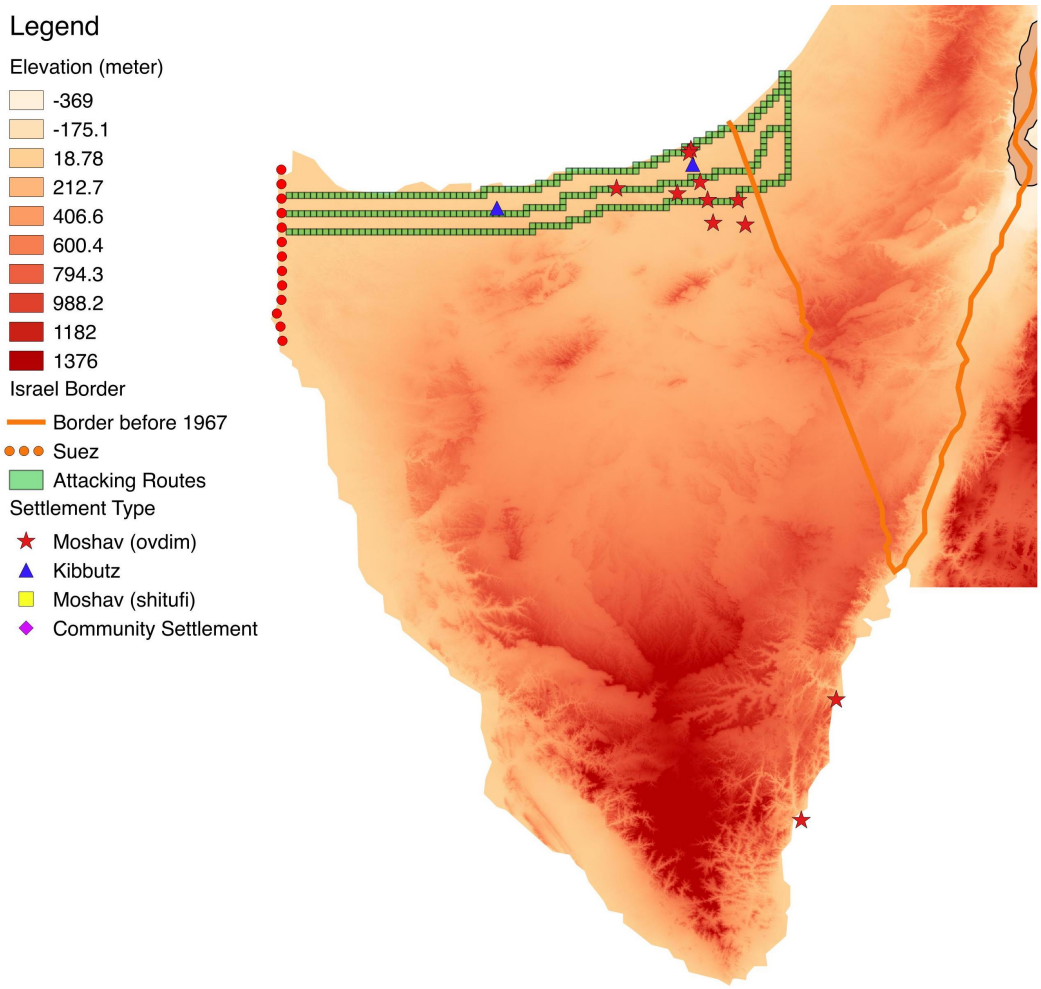

Figure 14: Settlements evacuated in 1982 on the Sinai Peninsula

Table 5: Settlement Locations in Different Times

Dependent variable: Defensive Settlement				
	(1)	(2)	(3)	(4)
	within 2km	within 3km	within 4km	within 5km
After Independence	0.694**	0.564***	0.540***	0.542***
	(0.119)	(0.102)	(0.101)	(0.103)
After Treaty	0.607**	0.549***	0.508***	0.488***
	(0.123)	(0.109)	(0.100)	(0.0964)
Attacking Route FE	Yes	Yes	Yes	Yes
Observations	828	828	828	828

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is Defensive Settlement. A settlement is a defensive settlement if it is located within 2km in **Column 1**, 3km in **Column 2**, 4km in **Column 3**, or 5km in **Column 4**; **Independence** is a binary variable: equal to 1 if the settlement is established after the independence of Israel, 0 otherwise; **Treaty** is a binary variable: equal to 1 if the settlement is established after the Israel-Egypt treaty, 0 otherwise; **Attacking routes FE**: Settlements are grouped according to the nearest Attacking route from Egypt, Lebanon, or the west (including Syria, Jordan and Iraq). All settlements close to the rear area are excluded (the red frame in Figure 10)

regression is conducted :

$$Defensive\ Settlement_{ij} = \beta_1 Independence_{ij} + \beta_2 Treaty_{ij} + Routes_j + \epsilon_i j \tag{9}$$

where $Defensive\ Settlement_{ij}$ is a binary variable: equal to 1 if the settlement i located within 5 kilometres of the invasion route j, 0 otherwise (results for 2km, 3km, or 4km are similar); $Independence_{ij}$ is a binary variable: equal to 1 if the settlement is established after the independence of Israel, 0 otherwise; $Treaty_{ij}$ is a binary variable: equal to 1 if the settlement is established after the Israel-Egypt treaty, 0 otherwise; $Routes_j$ is the invasion route fixed effect. No geographic control variables are included in the regression, since the invasion routes are mainly on the plain, and are highly correlated with geographic measures.

Table 5 presents the Logit regression results on the probability of each settlement being a defensive one. The odds ratios on **Independence** are smaller than one, meaning that the settlements established after the independence of Israel are less likely to be located near the invasion routes, compared to the settlements established before the independence. The odds ratios on **Treaty** are also smaller than one, meaning that the settlements established after the treaty have a smaller chance of being defensive settlements, even compared to the settlements established between the

independence and the Israel-Egypt treaty. They are all significant at the 95 percent confidence level, meaning that the above results are robust to different definitions of defensive settlements.

In terms of the magnitude, taking Column 4 for example, the odds ratio on **Independence** means that a settlement established after the independence of Israel but before the peace treaty is 54.2 percent as likely to be a defensive settlement as a settlement established before the independence. The odds ratio on **Treaty** means that a settlement established after the peace treaty is 48.8 percent as likely to be a defensive settlement as a settlement established after the independence of Israel but before the peace treaty.

The above regression results confirm the observation that the rural settlements established before the independence of Israel were located along the invasion routes, mainly to deter the enemy attacks. As the threats of invasion decreased after the independence, more settlements were located in strategically less important areas. Once the threats went away with the signature of the Israel-Egypt peace treaty, the settlements were no longer placed along the invasion routes. The results also eliminate an alternative explanation — settlements may be located along those routes to facilitate trading with neighbouring countries, to the extent that the optimal invasion routes can also be the optimal trading routes. While there is no trading data to directly rule out this alternative explanation, it is inconsistent with the fact that the settlements established in time of wars were closer to the routes, and the settlements established in time of peace were further away to the routes.

7.4 Regression Results on Kibbutz Locations

As discussed in the previous sections, kibbutzim can theoretically induce the highest public defense, among different types of settlements. The maps above shows that they are indeed placed at the frontiers of the invasion route. To formally verify the observation, I use the subsample of all defensive settlements within 4km of the attacking routes, and conduct the following Logit regression:[62]

$$Kibbutz_{ij} = \beta Border\ Distance_{ij} + \gamma X_{ij} + Routes_j + \epsilon_i \tag{10}$$

[62]Results are robust for different definitions of defensive settlements. See Appendix F.

Table 6: Kibbutz vs. non-Kibbutzim Locations

Dependent variable: Kibbutz			
	(1)	(2)	(3)
	Pre Independence	Independence to Treaty	Post Treaty
Border Distance	.972***	.99	1.00
	(.00885)	(.00649)	(.031)
Local Highland Index	3.07**	2.54**	1.20
	(1.36)	(.965)	(1.51)
Water Distance	.201	.000238**	5.51e-09
	(1.07)	(.000842)	(8.15e-08)
Agriculture Potential	.0525	.836	.543
	(.151)	(.207)	(.503)
Attacking Route FE	Yes	Yes	Yes
Observations	142	287	59

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a defensive settlement being a kibbutz. The sample is restricted to the settlements within **4km** of the attacking routes, and further restricted to the settlements established before the independence in **Column 1**, between the independence and the Israel-Egypt peace treaty in **Column 2**, and after the treaty in **Column 3**; **Attacking routes FE**: Settlements are grouped according to the nearest attacking routes from Egypt, Lebanon, or the west (including Syria, Jordan and Iraq). All settlements close to the rear area are excluded (the red frame in Figure 10)

where $Kibbutz_{ij}$ is a binary variable: equal to 1 if the settlement i is a kibbutz, 0 otherwise; $Border\ Distance_{ij}$ is the distance of each settlement to the borders of the country (Lebanon, Egypt, or Syria/Jordan) in which the invasion routes starts; X_{ij} is a set of control variables, including distance to water resources, local highland index, and agriculture potential, measured by the attainable yield for intermediate input level irrigated wheat where the settlement is located; $Routes_j$ is the attacking route fixed effect.

Table 6 presents the Logit regression results. The odds ratio on **Border Distance** in Column 1 is significant at the 99 percent level and smaller than one, meaning that the pre-independence settlements that are located closer to the borders are more likely to be kibbutzim. Specifically, when the distance of a settlement to the borders increases by 1 km, the settlement is 2.8 percent less likely to be a kibbutz. The gap reduces to 1 percent in Column 2 for the settlements established between the independence and the peace treaty, and completely disappears for the settlements established after the Israel-Egypt treaty. The results confirm the prediction of the model that the Jewish National Fund placed kibbutzim at the frontiers of the invasion routes to withstand the first wave of attacks, while placing less equalitarian communities like moshavim (ovdim) behind the

protection of kibbutzim. As the threats of invasion decreased after the independence, the locations of different forms of settlements no longer depends on the distance to the borders.

The coefficient on **Local Highland Index** in Column 1 is significant at the 99 percent level and larger than one, meaning that the pre-independence settlements that are located on hills are more likely to be kibbutz. Specifically, the settlements located above the surrounding terrain are 3.1 times as likely to be kibbutzim as the settlements located below the surrounding terrain. The odds ratio is still significant, but reduces to 2.5 times for the settlements established after the independence. The odds ratio further reduces to 1.2 times for the settlements established after the Israel-Egypt treaty, and is no longer significant. Highlands, especially those along the attacking routes, are hotly contested spots in the warring times, because holding highlands provides the defenders several military advantages: a wider field of view which allows them to spot the attackers earlier, a better firing position, a safer shelter, and easier communication with nearby friendly forces.

The contrast among the kibbutz locations established before the independence, after the independence, and after the peace treaty shows that kibbutz were systematically placed on highlands only when the threats of invasion were high, consistent with the prediction that kibbutzim were placed in strategic areas to make the full use of their defensive capacity.

Due to the data limitation, the above analysis cannot control the composition of the settlement members, which raises the concern that the strong kibbutz defense capacity may be attributed to the quality of members, instead of the equal-sharing income arrangement. In fact, it was very likely that members who voluntarily formed a kibbutz in the early years tended to be single, young, and share the same cultural background. Those characteristics of kibbutz members certainly led to a better performance in defending against enemies. But there are two reasons why this concern does not pose a threat to the casual relationship between the institutions of the kibbutzim and their high defense capacity.

First, although demographic variables are not controlled in the analysis of settlement locations, they are controlled in the kibbutz privatization process in Section 8.5. After controlling the age of each kibbutz and the average household size, the threat levels faced by each kibbutz still have a significant impact on the income privatization decisions. Also, the impact is much larger than those of demographic control variables.

Second and more importantly, the personal characteristics of kibbutz members and the equal-sharing income arrangement are inseparable. On the one hand, kibbutzim were mainly appealing to single youths. Families found it much harder to give up their privacy, in order to fully enforce the equal-sharing income arrangement in the kibbutzim. However, most single youths enjoyed the social life in kibbutzim, due to the close interaction with peers. Individual hobbies were discouraged, group activities became the daily entertainments — hiking, singing and listening to music, reading poetry and literature, playing games, and dancing in the dinning hall (Leiblich 1981, pp. 45–46). On the other hand, kibbutzim need a homogeneous group of members, in order to facilitate the equal-sharing income arrangement, as well as the rotation of work during the day and guard duties during the night. Single youths who received the same training in youth movements became the natural candidates.

8 The Income Privatization of Kibbutzim

The victory did not bring peace to Israel immediately. Israel annexed the Sinai Peninsula from Egypt and the Golan Heights from Syria through three major wars: the Sinai campaign in 1956, the Six-Day war in 1967 and the Yom Kippur war in 1973. The strategic depth gained through the annexation, and the increasingly powerful Israel Defense Forces greatly improved the security situation in Israel. Under this background, the kibbutzim gradually adopted reforms in child rearing, consumption decisions and eventually income distribution.

8.1 Kibbutz Transformation

Starting in the 1950s, a growing number of kibbutzim abandoned communal childrearing — children slept with their parents instead of in the children's houses (Russell et al. 2013, pp. 27).[63] As explained in Section 4.1, the children's houses could be used to forbid the private consumption of childrearing, and sustain an efficient level of effort on public defense. As the external military threats decreased, the collective child rearing went away with the closure of the children's houses.

Some kibbutzim also switched from strict equal distribution of consumption goods to a personal budget system. Under the system, the members were endowed with a certain amount of money in

[63]The first kibbutz to abandon communal childrearing was Gesher Haziv in 1949 Near (1997, pp. 303)

each category of consumption — clothing, furniture, toilet articles, etc. The members were free to allocate the money within each category, but could not spend money in the category of furniture for clothes or recreation. The category restriction was gradually loosened. In the 1970s, kibbutzim started to adopt comprehensive budgets with a lump sum of money for each member to spend without restriction (Russell et al. 2013, pp. 26–27).

Despite the privatization of consumption decisions and childrearing, kibbutzim in the 1980s still preserved most of the traditional practices. The members rotated their job, including managerial positions, and received equal pay. Their demands for electricity, meals, housing, medical care, travels, and education, were collectively provided.

It was the Camp David Accords in 1978 and the peace treaty with Egypt in 1979 that made Israeli borders secure. At about the same time, the Labor party and its labor zionism ideology lost to the Likud party, which was entirely opposed to the kibbutz movement (Bowes 1990). Cuts in financial subsidies, along with an economic crisis, hit the kibbutzim heavily in the late 1980s, and led to a net outflow of 2000 to 3000 kibbutz members per year (or 6–10 residents per kibbutz per year). Without the financial support from the government, kibbutz federations were forced to allow individual kibbutz to adopt more aggressive reforms, and be responsible for their own debt (Russell et al. 2013, pp. 42; Ashkenazi and Katz 2009).[64] In the following years, the reforms made by kibbutzim can be roughly divided into three categories: involvement of nonmembers, decision making process and privatization of consumption and services.[65]

Kibbutz increasingly allowed the members to work outside, and pursue a career of their own choice. Kibbutzim established pension plans and began to purchase health insurance for their members. Individual members were responsible for more consumption expenses, including electricity, recreation, travel, meals, health services, laundry, higher education, etc, which was described as "privatization of kibbutz expenditures" (Russell et al. 2013, pp. 58–62).

Correspondingly, outsiders became involved in kibbutz operations as workers, managers, investors, and consumers. Nonmembers sometimes even held the position of committee chairs. Stocks and raised capital were issued by some kibbutzim publicly. Kibbutz education system were open

[64] In 1989, each kibbutz was officially given the right to determine which reforms it would or would not adopt (Russell et al. 2013, pp. 42)

[65] From 1990 to 2001, University of Haifa's Institute for Research of the Kibbutz and the Cooperative Idea conducted yearly surveys on the reforms adopted by each kibbutz (see the tables in Russell et al. 2013, Chapter 2).

to children of nonmembers. Houses, initially vacant ones and later newly built ones, were rented out to generate profits (Russell et al. 2013, pp. 49–58).

To enhance economic efficiency, the general assembly was replaced by independent boards of directors consisting of knowledgeable members in governing kibbutz industrial ventures. Managers served longer terms, and were not required to be rotated out of the positions. To limit the power of the managers, internal control committees were also formed. In accounting, kibbutzim recorded kibbutz members' "shadow wages", wages that were calculated based on the general labor market (Russell et al. 2013, pp. 44–49).

Among all the reforms, the most fundamental one was the adoption of the safety net budget. Kibbutz members received *differential*, contribution-based wages, but were taxed progressively to maintain a minimal living standard for older and weaker members (Palgi 2002). Of course, such a major decision can not be made lightly. Since 75 percent of votes in the general assembly was required to adopt the differential pay reform, intense debates, with members of both sides threatening to leave, could take years. However, once the reform was made, it was never reversed in any kibbutz (Russell et al. 2013, pp. 85–89). The "privatization" of income (in an economic sense as well as in kibbutz jargon, see Russell et al. 2013, pp. 99) started in Kibbutz Gesher Haziv and Kibbutz Naot Mordechai in 1995 (Russell et al. 2013, pp. 84). By 2014, 75% of non-religious kibbutzim were privatized.[66]

Thanks to Abramitzky (2008), the dates of income privatization of kibbutzim are well recorded, allowing an empirical test against the prediction: communities privatize income when the external threats decrease. The threats are measured by the number of civilian deaths under terrorist attacks near each kibbutz, since the terrorist attacks became the major threat to Israeli civilians in the 1990s. The death number over previous six years is used instead of one year, because it usually takes several years for the kibbutz members to negotiate and make the decision on income privatizations.

8.2 Effect of Terrorist Attacks

The kibbutzim income privatization can be best described as a survival process, in the sense that once a kibbutz abandoned its equal sharing rule, it never readopted the rule. Therefore, a Cox

[66] After wage reforms, several kibbutzim went further to privatize profitable assets, by distributing shares of profit-making business to the members (Russell et al. 2013, pp. 116–117).

proportional survival model is used to analyze the probability of kibbutz income privatization.[67] The Cox model assumes that the probability of a kibbutz i after s years since 1989 (when kibbutzim were formally permitted by kibbutz federations to introduce reforms) is:

$$h_{ijt}(s) = h_0(s) \exp\left(\beta_D \log\left(Death_{ijt}\right) + \beta_X X_i + \theta_j + \eta_t\right) \tag{11}$$

where h_{ijt} is the hazard rate of kibbutz i in district j, in year t; h_0 is the baseline hazard function; $Death_{ijt}$ is the number of civilian deaths under terrorist attacks within 30 kilometres of the kibbutz over the six years ending in year t, (the measure for the threats faced by kibbutz i in district j);[68] θ_j is the district fixed effect; η_t is the year fixed effect; and X_i is a vector of kibbutz specific control variables, including the age of the kibbutz, the population in 1995, the average household size in 1995, whether the kibbutz belonged to the more ideological movement Artzi, the economic strength assessed by the banks and the government in 1995, the regional population, and the regional employment (see Appendix A for the summary statistics and the definitions of the variables).

8.3 Cox Model Result

Table 7 reports the regression results of the Cox model, where external threats are measured by the number of Israeli civilian deaths in the previous six years within 10 km (Column 1,2), 20 km (Column 3,4), 30 km (Column 5,6), or 40 km (Column 7,8) of each kibbutz, normalized by the population density at the attack location. Control variables are included in Columns 2, 4, 6, and 8.

The negative coefficients of **Civilian deaths** mean an increase in the number of civilian deaths in the previous six years near each kibbutz reduces the probability of the income privatization of the kibbutz across all specifications, which is consistent with the prediction of the model. Because a large number of civilian deaths means the kibbutz is located in a dangerous area, the kibbutz maintains the equal sharing rule, thereby inducing a high level of public defense from its members.

Regarding the magnitude, the point estimate of -3.21 (Column 4 in Table 7) shows that a one standard deviation increase in the number of civilian deaths within 20km in the previous six

[67] Corresponding estimates based on the Logit model are in Appendix J. They are qualitatively very similar to the estimates in Table 8.

[68] Results are robust to civilian deaths within 10, 20, or 40 km

Table 7

Hazard Rate	(1) 10km	(2) 10km	(3) 20km	(4) 20km	(5) 30km	(6) 30km	(7) 40km	(8) 40km
Civilian deaths	-7.84*	-5.25	-4.96***	-3.21*	-1.71	-.0949	-.742	.554
	(4.17)	(4.87)	(1.41)	(1.87)	(1.22)	(.336)	(1.58)	(.906)
Population in 1995		-.00102		-.000976		-.000988		-.000993
		(.000826)		(.000814)		(.00083)		(.000832)
Average Household Size		.0337		.022		.0655		.0803
		(.661)		(.668)		(.655)		(.644)
Movement Affiliation		-.414*		-.438*		-.437*		-.44**
		(.24)		(.229)		(.228)		(.223)
Economic Strength		-.267***		-.277***		-.263***		-.256***
		(.0898)		(.0908)		(.0927)		(.0881)
Regional Population		.000288		.000426		.000173		.00011
		(.00105)		(.00105)		(.00109)		(.00113)
Regional Employment Rate		2.12		2.17		2.35		2.4
		(2.24)		(2.2)		(2.08)		(2.07)
Established before Independence		.594***		.595***		.604***		.609***
		(.161)		(.128)		(.14)		(.138)
Age in 1989		-.0268**		-.0266**		-.0283**		-.0291***
		(.0127)		(.0112)		(.0111)		(.0106)
[1em] District fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Number of observations	3297	1849	3297	1849	3297	1849	3297	1849
Number of subjects	223	189	223	189	223	189	223	189
Number of failures	173	149	173	149	173	149	173	149

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Kibbutzim were exposed to the decision of income privatization in 1989, when they were formally permitted by kibbutz federations to introduce reforms. A failure happens when the kibbutz privatizes income (adopts the partial payment reform). **Civilian deaths**: the number of Israeli civilian deaths in the previous six years within 10 (**column1,2**), 20 (**column3,4**), 30 (**column5,6**), or 40 (**column7,8**) km of the kibbutz, normalized by the population density at the attack location. Control variables are described in Table 12. Standard errors are clustered at district level. All regressions include an imputation dummy for years affected by the imputed terrorist attacks in 1993.

years reduces the income privatization probability of a kibbutz by $1 - \exp(-2.6 \times 0.0426) = 12.8$ percent.[69].

The coefficients are significant at the 95 percent level for civilian deaths within 20km (Column 4 in Table 7), when controlling for a number of other factors that potentially affect the income privatization. The number of civilian deaths within 30km and 40km (Column 6 and 8 in Table 7) has diminished explanatory power, while the number of civilian deaths within 10km (Column 2 in Table 7) is too noisy to yield a significant result, due to the small number of terrorist attacks (see Table 9 for the average number of civilian deaths).

8.4 Instrumental-Variables Strategy

Even after including a large set of controls, the death of civilians could be correlated with some components of the error term. As discussed in Section 5, this analysis uses the following instrument: the total rainfall surplus in the previous six years at the nearest refugee camp to each kibbutz, multiplied by the camp population, and then divided by the distance between each kibbutz and the nearest camp.

A valid instrument needs to satisfy the exclusion restriction that absent terrorist attacks, distance to the nearest refugee camp interacted with the rainfall variation at the camp, and the population of the camp has no effect on the timing of kibbutz income privatization. This is unlikely to be true, as the instrument, determined by the relative location of kibbutzim and refugee camps, and the local climate, is probably correlated with a kibbutz's access to Palestinian labour and the productivity of rain-fed products within each kibbutz. These characteristics may in turn affect the income privatization decision.

To address these concerns, the analysis only uses the rainfall deviation from the long-term (from 1980 to 2017) average rainfall at refugee camps. Furthermore, the analysis controls for the rainfall deviation at *each kibbutz*, the distance between each kibbutz and its nearest refugee camp, the population at the nearest refugee camp, and the interaction between the distance and the population. In the following analysis, these are called "refugee controls". To control for broad geographic characteristics, the analysis also includes six district fixed effects. Identification then only stems from short-term variation in rainfall at the nearest refugee camp, which is arguably

[69]The standard deviation of civilian deaths within 20km is 0.0426 (see Appendix A)

exogenous and only affects the number of civilian deaths.

The analysis uses a two-step control function approach as in Blundell and Powell (2003).[70] The approach requires running a first-step regression of the endogenous variable on the instrument plus the other explanatory variables, and computing the residuals. Specifically, the following first-stage regression is estimated:

$$Death_{ijt} = \beta_{IV}(Rainfall_{ijt} \times Pop_{ij} \div Dist_{ij}) + \beta_X X_i + \theta_j + \eta_t + \epsilon_{ijt} \tag{12}$$

where $Death_{ijt}$ is the number of civilian deaths under terrorist attacks within 30 kilometres of the kibbutz i in district j over the six years ending in year t;[71] θ_j is the district fixed effect; η_t is the year fixed effect; X_i is a vector of kibbutz specific control variables, explained above; $Rainfall_{ijt}$ is the total rainfall surplus above the historical average over the six years ending in year t at the nearest refugee camp to kibbutz i; Pop_{ij} is the population at the nearest refugee camp to kibbutz i in 1996; $Dist_{ij}$ is the distance between kibbutz i and its nearest refugee camp; ϵ_{ijt} is the error term.

In the second stage, the hazard is estimated, including the residual from the first step as a regressor, to control for the endogeneity of the main regressor:

$$h_{ijt}(s) = h_0(s)\exp(\beta'_D Death_{ijt} + \beta_X X_i + \theta_j + \eta_t + \hat{\epsilon}_{ijt}) \tag{13}$$

where $\hat{\epsilon}_{ijt}$ is the residual from the first stage. The coefficient β'_D captures the causal effect of civilian deaths on kibbutz income privatization under those terrorist attacks affected by rainfall variation at the nearest refugee camp.

8.5 Instrumental-Variables Results

Table 8 reports results of the Cox model under the control function approach, where external threats is measured by the number of Israeli civilian deaths in the previous six years within 10 km (Column 1,2), 20 km (Column 3,4), 30 km (Column 5,6), or 40 km (Column 7,8) of each kibbutz, normalized by the population density at the attack location. Control variables are included in

[70] The usual Two-Stage Least Squares method generally yields inconsistent estimates of the structural parameters, when the second stage is nonlinear (Blundell and Powell 2003).

[71] Results are robust to civilian deaths within 10, 20, or 40 km

Table 8: First Stage and Main Effects

A.Dependent variable:	First Stage							
Civilian deaths	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	10km	10km	20km	20km	30km	30km	40km	40km
Rainfall× Pop÷ Dist	-.126***	-.5***	-.206***	-1.09***	-.253**	-1.57***	-.166	-1.8***
	(.0103)	(.0165)	(.0534)	(.0311)	(.0928)	(.121)	(.125)	(.232)
Refugee Control	yes	yes	yes	yes	yes	yes	yes	yes
Kibbutz Control	no	yes	no	yes	no	yes	no	yes
District fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
N	6021	4158	6021	4158	6021	4158	6021	4158
F-statistics on the IV	151.4	915.3	14.91	1236.7	7.424	169.5	1.761	60.51
B.Dependent variable:	Main Effect							
Hazard Rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	10km	10km	20km	20km	30km	30km	40km	40km
Civilian deaths	-204***	-75***	-126***	-35.1***	-107***	-23.5***	-167***	-20.1***
	(38)	(10.4)	(26.6)	(5.26)	(21.8)	(3.45)	(34.5)	(2.83)
Population in 1995		-.00185**		-.00126		-.0011		-.00133
		(.000745)		(.000809)		(.00085)		(.000827)
Average Household Size		-.541		.0671		.109		.155
		(.666)		(.733)		(.744)		(.73)
Movement Affiliation		-.435**		-.528***		-.582***		-.498**
		(.207)		(.185)		(.19)		(.194)
Economic Strength		-.212**		-.193**		-.24**		-.216**
		(.0852)		(.0829)		(.0961)		(.0923)
Regional Population		.00162		.00202*		.00171		.00174
		(.00112)		(.00108)		(.00106)		(.00107)
Regional Employment Rate		-5.37***		-1.36		.467		-.907
		(1.31)		(1.76)		(1.73)		(1.56)
Established before Independence		.475***		.618***		.577***		.533***
		(.118)		(.115)		(.124)		(.124)
Age in 1989		-.00666		-.0148***		-.0176***		-.0142**
		(.00571)		(.00511)		(.00566)		(.00557)
Refugee Control	yes	yes	yes	yes	yes	yes	yes	yes
District fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
N	3297	1849	3297	1849	3297	1849	3297	1849

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Kibbutzim were exposed to the decision of income privatization in 1989, when they were formally permitted by kibbutz federations to introduce reforms. A failure happens when the kibbutz privatizes income (adopts the partial payment reform). **Civilian deaths**: the number of Israeli civilian deaths in the previous six years within 10 (**column1,2**), 20 (**column3,4**), 30 (**column5,6**), or 40 (**column7,8**) km of the kibbutz, normalized by the population density at the attack location. Control variables are described in Table 12. Standard errors are clustered at district level. All regressions include an imputation dummy for years affected by the imputed terrorist attacks in 1993.

Columns 2, 4, 6, and 8.

The first-stage relationships between the rainfall surplus, augmented by the population of and the distance to the nearest refugee camp, and civilian deaths under terrorist attacks are negative at the 99 percent confidence level across all specifications when control variables are included (Columns 2,4,6,8 in Table 8). The instrument variable is strong, since the F-statistic among those specifications are much larger than 10.

Regarding magnitude, the point estimate of -0.5 (Column 2 in Table 8) shows that the civilian deaths within 10km of a kibbutz in the previous six years reduces by $0.00824 \times 0.5 = 0.00412$, about 50.4 percentage of the average civilian deaths (0.00817), following a one standard deviation decrease (0.00824) in the instrument variable.[72] The magnitude decrease to 42.6 percent for civilian deaths within 20km, 33.3 percent for civilian deaths within 30km, and 26 percent for civilian deaths within 40km, showing a diminishing explanatory power of the instrument for civilian deaths further away from the kibbutz.

The instrumental-variables point estimates are much larger than the analogous estimates without instrument variables: a one standard deviation increase in the number of civilian deaths within 20km in the previous six years reduces the income privatization probability of a kibbutz by $1 - \exp(-35.1 \times 0.0426) = 77.6\%$.[73] The impact of the civilian deaths on kibbutz income privatization are much bigger than that of any other variable, showing that safe environments are the main driven factor behind the kibbutz income privatization. The results are robust and significant at the 99 percent confidence level across all specifications.

This finding once again supports the theoretical prediction that equal-sharing income arrangements are better at coordinating the public defense, and are maintained in relatively dangerous environments. Furthermore, the negative coefficients of **Movement affiliation** and **Economic Strength** mean that wealthier kibbutzim and kibbutzim that belong to Artzi, the more ideological movement, are less likely to privatize income, which is consistent with findings in Abramitzky (2008, 2011).

To further ensure the validity of the instrument, the analysis reruns the first stage regression

[72] The standard deviation of the instrument variable, Rainfall$\times$ Pop$\div$ Dist, is 0.00824 (see Appendix A)

[73] The result should be interpreted with cautious. The cox proportional model does not estimate the base line hazard rate. While the relative hazard rate increases for a kibbutz experiencing average level of terrorist attacks compared to a kibbutz experiencing zero terrorist attacks, it says nothing about their absolute hazard rates.

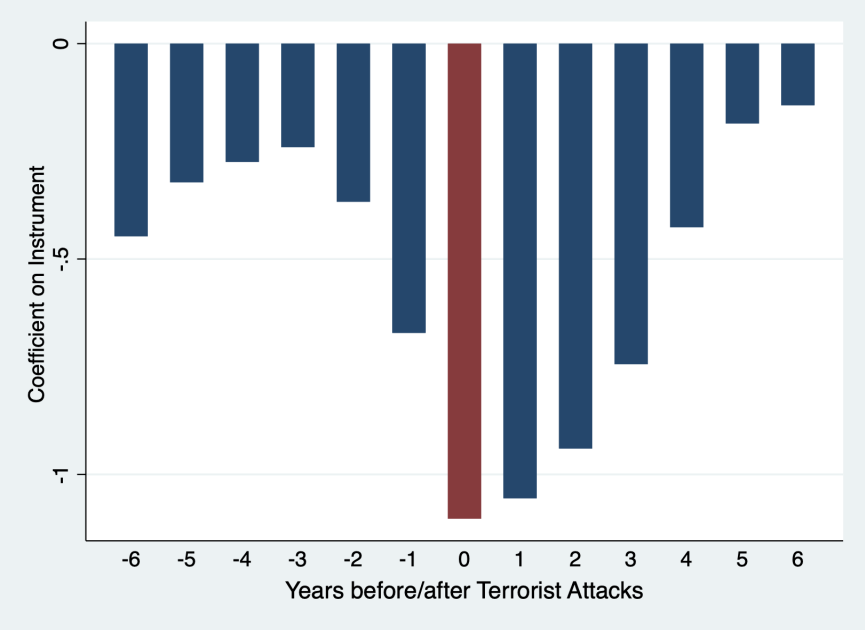

Figure 15: Placebo Check of Instrument — Different Time Windows
The x-axis gives the total rainfall surplus over six years at the nearest refugee camp measured in the number of years after (before) the civilian deaths. To illustrate, 5 on the x-axis means that the rainfall 5 years after the terrorist attacks is used as the instrument of the civilian deaths. Similarly, -3 means that the rainfall 3 years before the terrorist attacks is used as the instrument of civilian deaths.

in Table 8. Instead of using the total rainfall surplus over the same six year period as the instrument for the civilian deaths, it shifts the total rainfall surplus by x years. The coefficient of the instrument when x equals zero is the largest among all cases (see the red bar in Figure 15), thereby eliminating the concern that the strong correlation between rainfall and civilian deaths is due to some measurement errors.

Although the instrument used in this analysis is valid in time and space, an alternative channel through which a low rainfall at the nearest refugee camp can increase probability of kibbutz income privatization may still violate the exclusion restriction. For example, droughts might decrease labour demand in nearby Palestine region, thereby increasing labour supply to the kibbutzim. In order to hire external workers, the income of kibbutzim were privatized.

While data on the number of employed Palestinian in Israel is unavailable at the district level, the general trend since 1990 is downward, due to the closures on the West Bank and Gaza Strip and new Israeli policies that aimed to reduce the dependency on Palestinian unskilled labour (Mansour 2010; Miaari and Sauer 2011).[74] Miaari and Sauer (2011) also find that between the years 1999

[74]Employed Palestinians in the Israeli business sector decreased from 10 percent in 1990 to 3 percent in 2005 (Mansour 2010). Foreign non-Palestinian workers increased from 8,000 In 1991 to 120,000 in 1995 and 180,000 in

and 2004, Israeli-Palestinian conflict increased the labour supply of foreign non-Palestinian workers, and reduced Israeli employers' reliance on Palestinian labor. Therefore, a higher Palestinian labour supply induced by rainfall is unlikely to the be the reason behind the income privatization of the kibbutzim.

9 Conclusion

This paper proposes a model which establishes the theoretical relationship between types of income arrangements and the level of external threats. Specifically, the equal-sharing income arrangement induces a first-best level of public defense, that would be under-provisioned under private income arrangements. However, the benefit of high defense capacity comes at the cost of adverse selection. When the threat level is high, the benefit dominates the cost, and the Jewish leadership subsidized equal-sharing communities like kibbutzim to expand and consolidate the territory. When the threat level decreases, the benefit is outweighed by the cost, and the kibbutzim eventually privatized income.

The timing of the establishment and the income privatization of kibbutzim is consistent with the model's prediction. The majority of kibbutzim were established either before or during Middle East wars. Only 22 out of the total 268 kibbutzim were established after the Israel-Egypt peace treaty in 1979, and none after the Israel-Jordan peace treaty in 1992.

Aside from the historical evidence, the predictions are also supported by evidence from empirical results. Under the British Mandate, the kibbutzim were placed at dangerous peripheral areas to expand the legal claim of Jewish territory. When the Arab invasions were imminent, the kibbutzim were placed at the frontiers of the attacking routes to delay the invasion of Arab armies. Also, those kibbutz locations are less fertile and are further away from the water resources, suggesting that the Israelis gave up the economic benefit in exchange for surviving the military conflicts.

After the peace treaties, the military threats from the neighbouring Arab countries decreased dramatically, and kibbutzim started to adopt various reforms. Specifically, those kibbutzim located in safe areas privatized their income once they observed a decrease in the civilian deaths under terrorist attacks nearby.

2004 (Miaari and Sauer 2011)

Kibbutzim illustrates the reason why equal-sharing communities are rare. The members in equal-sharing communities will privatize income when the damage is too low, and run away when the damage is too high. Also, for the presence of equal-sharing communities, the damage must also be stable in the foreseeable future. Since income privatization, or abandoning a community incurs a large fixed cost, the members will not build a community in a highly uncertain environment (in terms of the damage they anticipate).

While the results are based on a single case study of the kibbutzim in Israel, recent studies indicate that institutions play an important role in other areas of conflicts. Ellickson (1993) noticed that pioneers living in Jamestown, Plymouth and Salt Lake refused to parcel out land in the early years, partly to defend against Indian raids. However, pioneers in places without strong Indian threats established city lots and farmstead within a month of arrival. Allen (1999, 2019) argues that the United States in the mid-nineteenth century adopted the Homestead Act — giving away lands in the West for free — in order to defend the land in face of the competing land claims from Indians. Matranga and Natkhov (working paper) provide evidence consistent with the assertion of Hellie (1971, 1992) that Russian adopted serfdom to lock peasants in the southern frontier to defend against the raids of Crimean Tatars.[75]

These studies show that seemingly inefficient institutional arrangements can be attributed to incomplete land claims under external threats. They also suggest that collective defense are crucial in the survival and the expansion of states, and the institutions inducing collective defense are widely adopted and merit further study.

[75]The working paper titled "All Along the Watchtower: Linear Defenses and the Introduction of Serfdom in Russia" was accessed on Nov 24, 2019 from
https://economics.ucdavis.edu/events/papers/copy2_of_1029Matranga.pdf

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Appendix A: Summary Statistics and Variable Definitions

Table 9: Summary statistics

	Obs	Mean	Std. Dev.	Min	Max
Settlement Controls					
Distance to Attacking Routes	851	10.6	23.6	0	276
Border Distance	851	62.3	46.7	.00817	287
Local Highland Index	851	.711	.454	0	1
Water Distance	851	.0768	.0876	.0000817	1.09
Agriculture Potential	851	5.59	1.35	0	6.52
Civilians Deaths					
within 10km	6021	.00817	.0271	0	.447
within 20km	6021	.0211	.0426	0	.447
within 30km	6021	.0386	.0625	0	.447
within 40km	6021	.0571	.0823	0	.447
Refugee Controls					
Refugee Rainfall× Pop.÷ Dist.	6021	.000212	.00824	-.0686	.0986
Refugee Rainfall	6021	57.7	308	-534	772
Refugee Pop.	7136	.0159	.0245	.00148	.138
Refugee Dist.	7136	25.2	48.8	.0757	346
Kibbutz Rainfall	6021	38.7	285	-869	916
Kibbutz Controls					
Regional Population	4906	387	211	32	1397
Regional Employment Rate	4906	.51	.0668	.0905	.738
Before Independence	7136	.547	.498	0	1
Kibbutz Population	7136	454	225	27	1366
Average Household Size	7008	2.2	.325	1	3.5
Kibbutz Age	7136	43.7	14.9	2	80
Movement Affiliation	7136	.314	.464	0	1
Economic Strength	6144	2.38	.899	1	4

Table 10: Summary statistics for Peripheral Settlements in 1935

	Obs	Mean	Std. Dev.	Min	Max
Peripheral Settlement 1km	92	.217	.415	0	1
Peripheral Settlement 2km	92	.337	.475	0	1
Peripheral Settlement 3km	92	.38	.488	0	1
Peripheral Settlement 4km	92	.478	.502	0	1
Kibbutz	92	.5	.503	0	1
Neighbouring Jewish Settlements within 1km	92	.244	.375	0	1.39
Neighbouring Jewish Settlements within 2km	92	.66	.575	0	2.08
Neighbouring Jewish Settlements within 3km	92	1.01	.7	0	2.48
Neighbouring Jewish Settlements within 4km	92	1.3	.785	0	3.04
Water Distance	92	3.98	2.95	.175	14.5
Agriculture Potential	92	6.21	.504	3.97	6.47

Table 11: Summary statistics for Peripheral Settlements in 1947

	Obs	Mean	Std. Dev.	Min	Max
Peripheral Settlement 1km	219	.251	.435	0	1
Peripheral Settlement 2km	219	.329	.471	0	1
Peripheral Settlement 3km	219	.438	.497	0	1
Peripheral Settlement 4km	219	.534	.5	0	1
Kibbutz	219	.63	.484	0	1
Neighbouring Jewish Settlements within 1km	219	.147	.312	0	1.39
Neighbouring Jewish Settlements within 2km	219	.502	.546	0	2.08
Neighbouring Jewish Settlements within 3km	219	.831	.686	0	2.48
Neighbouring Jewish Settlements within 4km	219	1.13	.767	0	3.04
Water Distance	219	5.2	6.54	0	49.2
Agriculture Potential	219	6.08	.726	0	6.52

Table 12: Variable Definitions

Settlement Controls	
Peripheral Settlement 1, 2, 3, 4km	Binary variable indicating whether the settlement is located in peripheral areas 1 if the distance to the boundary of the Jewish state in the partition plan is less than 1, 2, 3, 4km 0 otherwise
Kibbutz	Binary variable indicating whether the settlement is a kibbutz: 1 if yes; 0 otherwise.
Distance to Attacking Routes	Distance of each settlement to the nearest constructed attacking route (km)
Border Distance	Distance of each settlement to the border of the country in 1947, in which the nearest attacking route starts (km)
Neighbouring Jewish Settlements within 1, 2, 3, 4km	Logarithmic Number of Jewish Settlements within 1, 2, 3 ,4km of the settlement
Local Highland Index	Binary variable indicating whether the settlement is located on the highland 1 if the elevation of the settlement is higher than the average elevation within 2 grids (about 500m) 0 otherwise
Water Distance	Distance to the nearest water resource, including perennial rivers, springs containing less than 500 mg chlorine per litres, and Lake Kinneret (km)
Agriculture Potential	Attainable yield for intermediate input level irrigated wheat (ton dry weight per ha)
Civilian Deaths within 10, 20, 30, 40km	Normalized number of Israeli civilian deaths within 10, 20, 30, 40km in the previous six years
Refugee controls	
Refugee Rainfall× Pop.÷ Dist.	Total Rainfall surplus at the nearest refugee camp in the previous six years, multiplied by the distance between the kibbutz and the nearest refugee camp, then divided by the population of the nearest refugee camp
Refugee rainfall	Total Rainfall deviation from the long-term (1980 to 2017) average at the nearest refugee camp to each kibbutz in the previous six years
Refugee Pop.	Population of the nearest refugee camp in 1996 (in millions)
Refugee Dist.	Distance to the nearest refugee camp
Kibbutz Rainfall	Total Rainfall deviation from the long-term (1980 to 2017) average at each kibbutz in the previous six years
Kibbutz controls	
Average Household Size	Average number of people in the household in each kibbutz
Kibbutz Population	Population of the kibbutz in 1995
Kibbutz Age	Number of years has passed since the establishment of the kibbutz
Before Independence	Binary variable for the established year of the kibbutz 1 if the kibbutz is established before the independence of Israel 0 otherwise
Movement Affiliation	Binary variable for the movement affiliation of the kibbutz 1 if the kibbutz belongs to the most ideological movement – Artzi 0 if the kibbutz belongs to the other movement – Takam
Economic Strength	Category variable for economic strength of the kibbutz in 1995 from 1 to 4, with 1 being the weakest and 4 being the strongest
Regional Population	Annual population of the subdistrict where the kibbutz is located from 1990 to 2017
Regional Employment Rate	Annual employment rate of the subdistrict where the kibbutz is located from 1990 to 2017

Appendix B: The Kibbutz Institution

In traditional kibbutzim, members hold common ownership of all properties, ranging from clothing and shoes to housings and tractors. The members work from 8.5 to 9.5 hours, six days a week, in fields assigned by a work coordinator.[76] All products and income, including German reparation, army pay, and royalties from copyright material, goes into a central treasury. To enforce the equal living standard among its members, the kibbutzim abolish private property. The moment newcomers arrive a kibbutz, they transfer all their belongings to the kibbutz treasury (Leiblich 1981, pp. 19 and 78), and should they leave, they take only personal effects such as pictures, books, and gifts (Weisman 1966).[77]

The kibbutzim, in turn, centrally sell all products in the market, and provide various goods and services, covering the needs of members, including clothing, food, concert tickets, razor blades, postage stamps, housing, laundering, mending, education, and medical care.[78] All members receive according to the principle: "equality of supply for equal needs".[79] In principle, every member lives to the same standard, regardless of the amount or the quality of a member's work (Weisman 1966).

The kibbutzim also claim the right to care for the children and educate them, thereby relieving women from child rearing. Instead of sleeping with their parents, children spent their nights in children's houses, which include sleeping quarters, play areas, dining faculties, washrooms and classroom facilities for children five years old and up. Children live, eat, sleep and study together. Members are assigned to take care of the children as part of their work. They graduate from one house to another as they grow up until the age of eighteen, by which time they become formal kibbutz members (Kerem 1962, pp. 78–81).

Economic equality is further secured by the political equality among the kibbutz members. The basic instrument of government is the weekly meeting, in which every member has an equal vote on determining policy, electing a secretariat, and controlling the general operation of the community. While the weekly meeting determines the general policy and rules, the secretariat implements

[76] Not every member gets their ideal jobs. Some boring jobs, like straight assembly line works in carpentry shops, rotate among the members (Kerem 1962, pp. 41).

[77] Those things are the kibbutz's property while they are still the members of the kibbutz.

[78] The living standard increased over time. Housing, for example, improved from tent to wooden shack without sanitary facilities to permanent housing with bathroom and shower (Kerem 1962, p138).

[79] The members take turns in using goods, if the goods cannot be divided equally. In one kibbutz, the members rotated watches every three months (Kerem 1962, pp. 107).

them. They are responsible for financing from banks, purchasing supplies, assigning daily work to the member, and selling kibbutz products (Kerem 1962, pp. 25–26). The managerial positions are rotated every two years to prevent the formation of a privileged class.[80]

[80] In fact, a leadership position gives no material benefit, as every member is entitled to the same consumption. Consequently, "kibbutz elections are often one long series of declinations: one candidate protesting that his wife is sick, another confessing his inability to cope with the task. Elections in which candidates actively campaign for positions are unknown."(Kerem 1962, pp. 116)

Appendix C: Israeli Death Tolls Sources

Table 13: Israeli Death Tolls Sources

Event	Year	Death Number	Reference
Battle of Tel Hai	1920	6	Segev 2001, pp. 124
Nebi Musa riots	1920	5	Segev 2001, pp. 138
Jaffa riots	1921	47	Segev 2001, pp. 183
Jerusalem riots	1921	5	Segev 2001, pp. 188
1929 riots	1929	133	Cohen 2015, pp. xxi
Arab revolt	1936–1939	547	Bowden 1975
Jewish insurgency	1945–1947	65	Charters 1989, pp. 205
1947 Civil War	1947	2000	Morris 2004, pp. 35
1948 Israel-Arab War	1948	4000	Morris 2004, pp. 35
Fedayeen attacks	1951–1956	450	Morris 1993, pp. 415
Sinai War	1956	190	Morris, pp. 296
Fedayeen attacks	1957–1967	135	Korn 1992, pp. 215
Six-day War	1967	983	Klausner and Bickerton 2007, pp. 147
War of attrition	1967–1970	750	Korn 1992, pp. 275
Terrorist attacks	1970–1979	160	Global Terrorism Database
Yom Kippur	1973	2838	Klausner and Bickerton 2007, pp. 170
Operation Litani	1978	18	Kober 2009
Terrorist attacks	1980–1989	120	Global Terrorism Database
First Lebanon War	1982–1985	657	Barzilai 2012, pp. 148
Terrorist attacks	1990–1999	267	Global Terrorism Database
Southern Lebanon Conflicts	1985–2000	319	Sela 2007
Terrorist attacks	2000–2009	817	Global Terrorism Database
Second Lebanon War	2006	157	Johnson 2011, pp. 78

Notes:

Death number that happens across two decades are assigned into each decade proportionally in Figure 1. For example, for 135 deaths due to fedayeen attacks from 1957 to 1967, 30 percent of deaths (40) is counted towards the total deaths in the 1950s, and 70 percent of deaths (95) is counted towards the total deaths in the 1960s.

Appendix D: Agriculture Potential

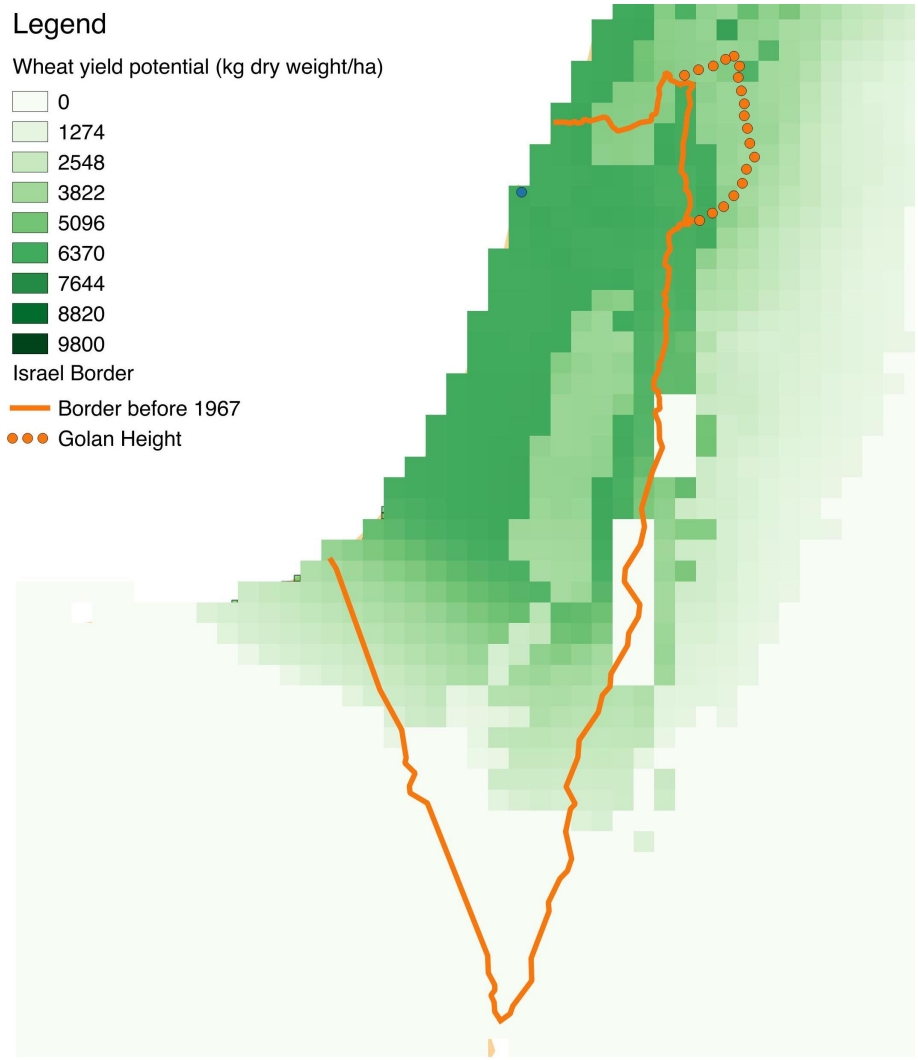

Figure 16: The soil survey reported in the Anglo-American Committee of Enquiry

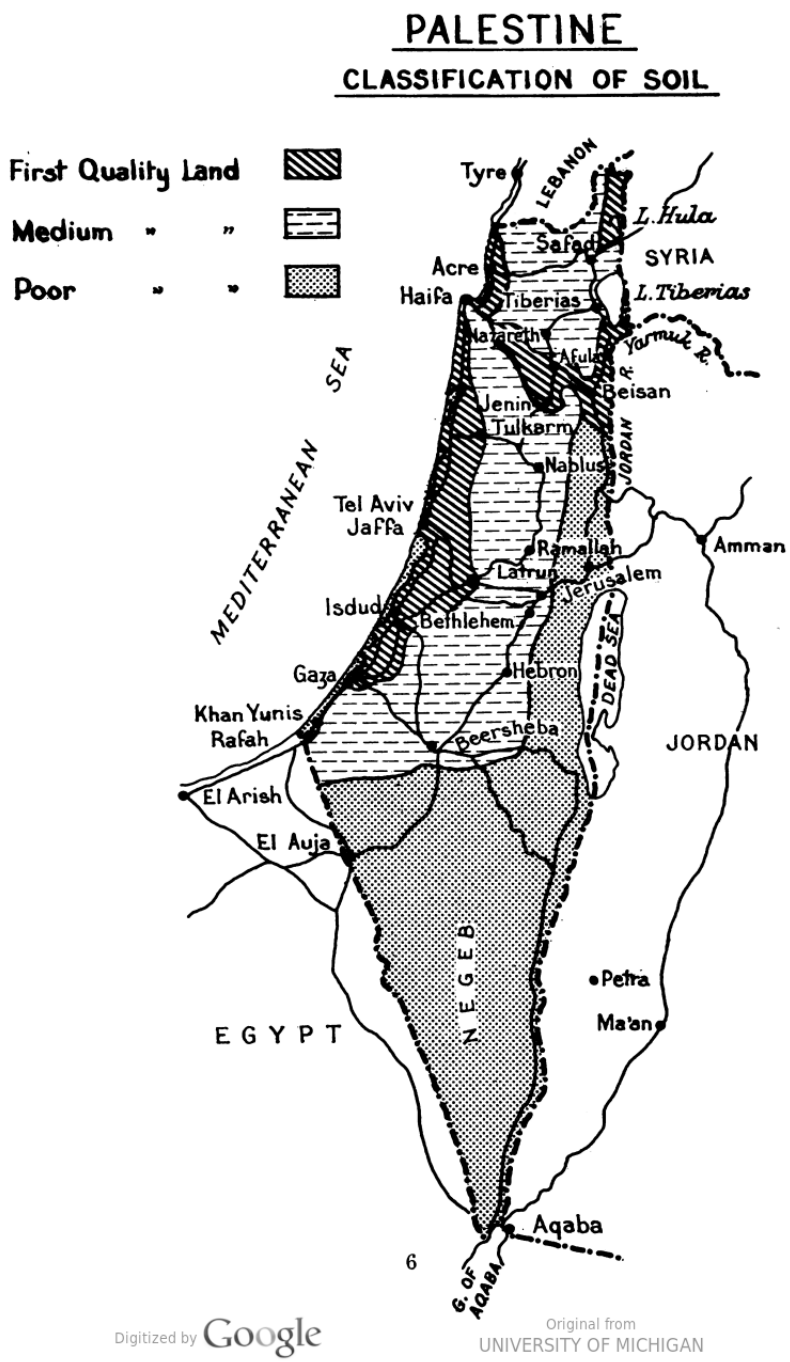

Figure 17: The attainable yield for intermediate input level irrigated wheat from FAO (Hadawi 1957, p6)

Appendix E: Robustness Checks for Peripheral Settlements

The Tables in this section replicates the results of Table 1, with slightly different definitions of peripheral settlements. The coefficients on *Kibbutz*, *Water Distance*, and *Agriculture Potential* are quantitatively similar.

Table 14: Peripheral settlements in the 1937 Peel partition plan

Dependent variable:	Peripheral Settlement			
	(1)	(2)	(3)	(4)
Kibbutz	2.92**	2.75*	3.75	3.6
	(1.58)	(1.64)	(4.42)	(4.43)
Water Distance		.894		.625
		(.0969)		(.239)
Agriculture Potential		.221***		3.92e+07
		(.127)		(4.37e+08)
Observations	92	92	76	76

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a settlement being a peripheral settlement. A settlement is a defensive settlement if it is located within **1km** of the boundary of the partition plan.

Table 15: Peripheral settlements in the 1937 Peel partition plan

Dependent variable:	Peripheral Settlement			
	(1)	(2)	(3)	(4)
Kibbutz	1.99	1.67	1.44	1.23
	(.897)	(.831)	(.832)	(.736)
Water Distance		.884		.875
		(.0846)		(.107)
Agriculture Potential		.0401		.171
		(.125)		(.326)
Observations	92	92	76	76

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a settlement being a peripheral settlement. A settlement is a defensive settlement if it is located within **2km** of the boundary of the partition plan.

Table 16: Peripheral settlements in the 1937 Peel partition plan

Dependent variable:	Peripheral Settlement			
	(1)	(2)	(3)	(4)
Kibbutz	2.92**	2.59**	2.58*	2.48*
	(1.26)	(1.19)	(1.26)	(1.25)
Water Distance		.859*		.834*
		(.0729)		(.0845)
Agriculture Potential		.156		.556
		(.198)		(.771)
Observations	92	92	76	76

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a settlement being a peripheral settlement. A settlement is a defensive settlement if it is located within **4km** of the boundary of the partition plan.

Table 17: Peripheral settlements in the 1947 UN partition plan

Dependent variable:	Peripheral Settlement			
	(1)	(2)	(3)	(4)
Kibbutz	3.44***	3.5***	4.33**	4.36**
	(1.32)	(1.41)	(2.79)	(2.85)
Water Distance		.928**		.866*
		(.0307)		(.0672)
Agriculture Potential		.342***		.732
		(.0951)		(.43)
Observations	219	219	184	184

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a settlement being a peripheral settlement. A settlement is a defensive settlement if it is located within **1km** of the boundary of the partition plan.

Table 18: Peripheral settlements in the 1947 UN partition plan

Dependent variable:	Peripheral Settlement)			
	(1)	(2)	(3)	(4)
Kibbutz	3.47***	3.57***	3.59***	3.68***
	(1.18)	(1.28)	(1.62)	(1.69)
Water Distance		.923**		.903**
		(.0286)		(.0429)
Agriculture Potential		.371***		.688
		(.104)		(.325)
Observations	219	219	184	184

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a settlement being a peripheral settlement. A settlement is a defensive settlement if it is located within **2km** of the boundary of the partition plan.

Table 19: Peripheral settlements in the 1947 UN partition plan

Dependent variable:	Peripheral Settlement			
	(1)	(2)	(3)	(4)
Kibbutz	3.75***	3.98***	3.49***	3.85***
	(1.11)	(1.22)	(1.13)	(1.29)
Water Distance		.924***		.93**
		(.0253)		(.0294)
Agriculture Potential		.51**		.975
		(.147)		(.41)
Observations	219	219	184	184

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a settlement being a peripheral settlement. A settlement is a defensive settlement if it is located within **4km** of the boundary of the partition plan.

Appendix F: Robustness Checks for Kibbutz vs. non-Kibbutzim Locations

The tables in this section replicate the results of Table 6, with slightly different definitions of defensive settlements. The coefficients on *Border Distance* and *Local Highland Index* are quantitatively similar.

Table 20: Kibbutz vs. non-Kibbutzim Locations within 2km of Attacking Routes

Dependent variable: Kibbutz			
	(1)	(2)	(3)
	Pre Independence	Independence to Treaty	Post Treaty
Border Distance	.968***	.993	1
	(.0108)	(.00794)	(.0303)
Local Highland Index	2.63*	2.62**	1
	(1.42)	(1.18)	(1.31)
Water Distance	.173	.0605	3.51e-08
	(1.08)	(.262)	(5.36e-07)
Agriculture Potential	.135	.777	.554
	(.414)	(.223)	(.492)
Attacking Route FE	Yes	Yes	Yes
Observations	106	218	47

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a defensive settlement being a kibbutz. The sample is restricted to the settlements within **2km** of the attacking routes, and further restricted to the settlements established before the independence in **Column 1**, between the independence and the Israel-Egypt peace treaty in **Column 2**, and after the treaty in **Column 3**; **Attacking routes FE**: Settlements are grouped according to the nearest attacking routes from Egypt, Lebanon, or the west (including Syria, Jordan and Iraq). All settlements close to the rear area are excluded (the red frame in Figure 10)

Table 21: Kibbutz vs. non-Kibbutzim Locations within 3km of Attacking Routes

Dependent variable: Kibbutz			
	(1)	(2)	(3)
	Pre Independence	Independence to Treaty	Post Treaty
Border Distance	.97***	.994	1
	(.00942)	(.00687)	(.0301)
Local Highland Index	2.9**	2.83**	1.27
	(1.32)	(1.17)	(1.64)
Water Distance	.00834	.00202*	1.90e-09
	(.0484)	(.00758)	(2.97e-08)
Agriculture Potential	.0384	.714	.492
	(.116)	(.186)	(.455)
Attacking Route FE	Yes	Yes	Yes
Observations	132	265	55

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a defensive settlement being a kibbutz. The sample is restricted to the settlements within **3km** of the attacking routes, and further restricted to the settlements established before the independence in **Column 1**, between the independence and the Israel-Egypt peace treaty in **Column 2**, and after the treaty in **Column 3**; **Attacking routes FE**: Settlements are grouped according to the nearest attacking routes from Egypt, Lebanon, or the west (including Syria, Jordan and Iraq). All settlements close to the rear area are excluded (the red frame in Figure 10)

Table 22: Kibbutz vs. non-Kibbutzim Locations within 5km of Attacking Routes

Dependent variable: Kibbutz			
	(1)	(2)	(3)
	Pre Independence	Independence to Treaty	Post Treaty
Border Distance	.973***	.993	1.01
	(.00868)	(.00606)	(.0303)
Local Highland Index	3.2***	2.2**	1.18
	(1.4)	(.779)	(1.49)
Water Distance	.16	.00017**	2.22e-09
	(.827)	(.000587)	(3.26e-08)
Agriculture Potential	.086	.846	.514
	(.217)	(.202)	(.465)
Attacking Route FE	Yes	Yes	Yes
Observations	146	298	61

Odds ratios; Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: the dependent variable is the probability of a defensive settlement being a kibbutz. The sample is restricted to the settlements within **5km** of the attacking routes, and further restricted to the settlements established before the independence in **Column 1**, between the independence and the Israel-Egypt peace treaty in **Column 2**, and after the treaty in **Column 3**; **Attacking routes FE**: Settlements are grouped according to the nearest attacking routes from Egypt, Lebanon, or the west (including Syria, Jordan and Iraq). All settlements close to the rear area are excluded (the red frame in Figure 10)

Appendix G: Constructing Optimal Attacking Routes between Two Points

The analysis constructs optimal travel routes based on elevation data from the Global Multi-resolution Terrain Elevation Data (GMTED2010) developed by the National Geospatial-Intelligence Agency (NGA).[81] The Palestine region is covered by a find grid (each pixel is 1.5 arc minutes, or about 2.5 km).[82] Based on this fine elevation grid, the analysis computes the travel times between any pixel and its four neighbours (North, South, East, and West). Following Barjamovic et al. (2019), the analysis uses the parameters from Langmuir (1984): it takes 0.72 seconds to travel 1 meter horizontally; going up hill adds an additional 6 seconds per vertical meter; going downhill on a gentle slope (less than or equal to 21.25%) saves 2 seconds per vertical meter; going downhill on a steep slope (more than 21.25%) adds an additional 2 seconds per vertical meter. Major lakes and the Mediterranean sea are assumed to be impassible for armies, since projecting force by ships was impracticable given the navel strength of the surrounding Arab countries. However, no penalty is imposed on crossing rivers, since the Iraqis easily crossed the Jordan river, the largest one in Palestine region (Morris 2008, pp. 247). Having defined travel times between any pixel and its four neighbours, the analysis applies Dijkstra's algorithm to compute the optimal travel paths between any two pixels (Dijkstra 1959).

[81] Danielson, J.J., and Gesch, D.B., 2011, Global multi-resolution terrain elevation data 2010 (GMTED2010): U.S. Geological Survey Open-File Report 2011–1073, 26 p. http://pubs.usgs.gov/of/2011/10pdf/of2011-1073.pdf

[82] Including Sinai Peninsula when constructing the invasion route from the Suez Canal.

Appendix H: Actual Attacking Routes and Kibbutz Performance

The planned attacking routes in the 1948 Arab-Israel war were largely consistent with the constructed invasion routes. But the actual unfolding of the war was quickly out of the Arab countries' control. Lebanon withdrew from the joint invasion at the last minute. Jordan unilaterally changed the plan from attacking the Jews to occupying the Arab area later known as the West Bank (Morris 2008, pp. 189). Syria and Iraq, fiercely resisted by the kibbutzim at the frontier, gave up the original plan of marching through Jezreel Valley, and conquered the West Bank instead. The Egyptian in the south were delayed by the Kibbutz Yad Mordechai, and was eventually halted by the Israeli army.

The 1948 Arab-Israeli war started on May 14th (see Figure 18 for the actual invasion routes). The goal of the Arab countries (Egypt, Lebanon, Syria, Jordan and Iraq) was "the elimination of the Jewish state" (Morris 2008, pp. 184). They initiated a four pronged invasion at the time and location of their choices, with a larger army (20,000 Arab combat troops vs. 16,500 Jewish combat troops) and heavy weapons (artillery, armour, and combat aircraft) that the Jews did not have (Morris 2008, pp. 197).

The Jewish goal was simply "surviving the onslaught and establishing a Jewish state" (Morris 2008, pp. 196). Although only 60 percent of the Jewish troops were under-equipped at the start of the war, large shipments would soon arrive by the start of June. Heavy weapons, including tanks, armored cars, three half-tracks, artillery pieces, antiaircraft or antitank cannon, and Czech-made air fighters, were on the way. The underground arms factories were also producing submachine guns, mortars, antitank projectiles, grenades, mines, and ammunition (Morris 2008, pp. 204). Aside from the weapons, thousands of volunteers from abroad, including hundreds of air and ground crew, would soon expand the Jewish army from nine brigades to twelve (Morris 2008, pp. 200–207). But all those reinforcements had to be accepted at the port, Haifa. If Haifa had been conquered, the Jews would not have reversed the war.

It came down to a race against time, and the Jewish leadership had to count on their rural settlements, especially kibbutzim, to delay the invasion and buy enough time. On the eastern front, Kibbutz Gesher, with the help of one Israeli brigade, withstood the attack from the Iraqis for five days, and forced them to withdraw and redeploy in Samaria (Morris 2008, pp. 245–248).

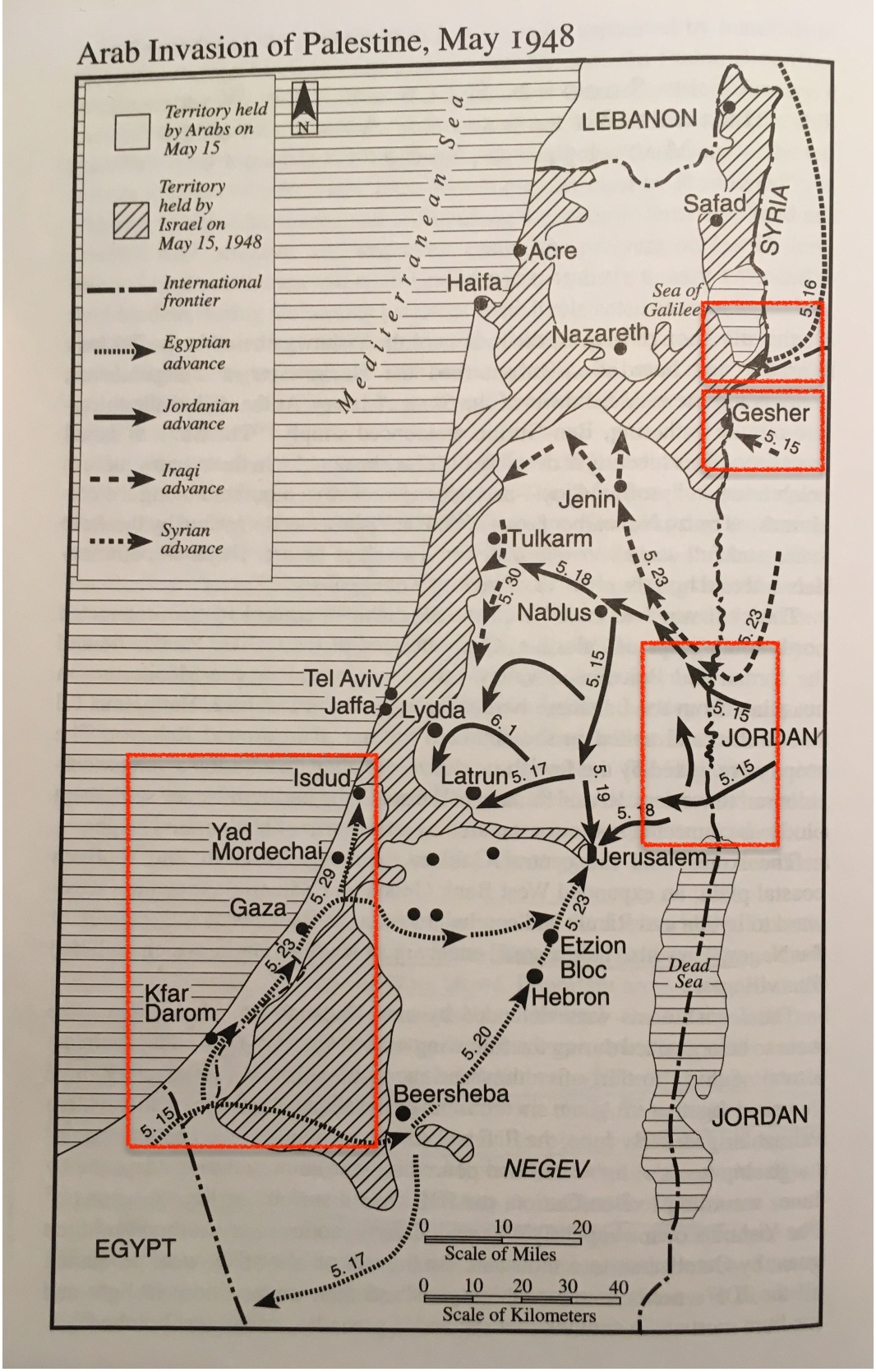

Figure 18: Actual Historical Attack Routes
The map comes from Morris (2000, pp. 216). The author labels the initial attack by the red frames.

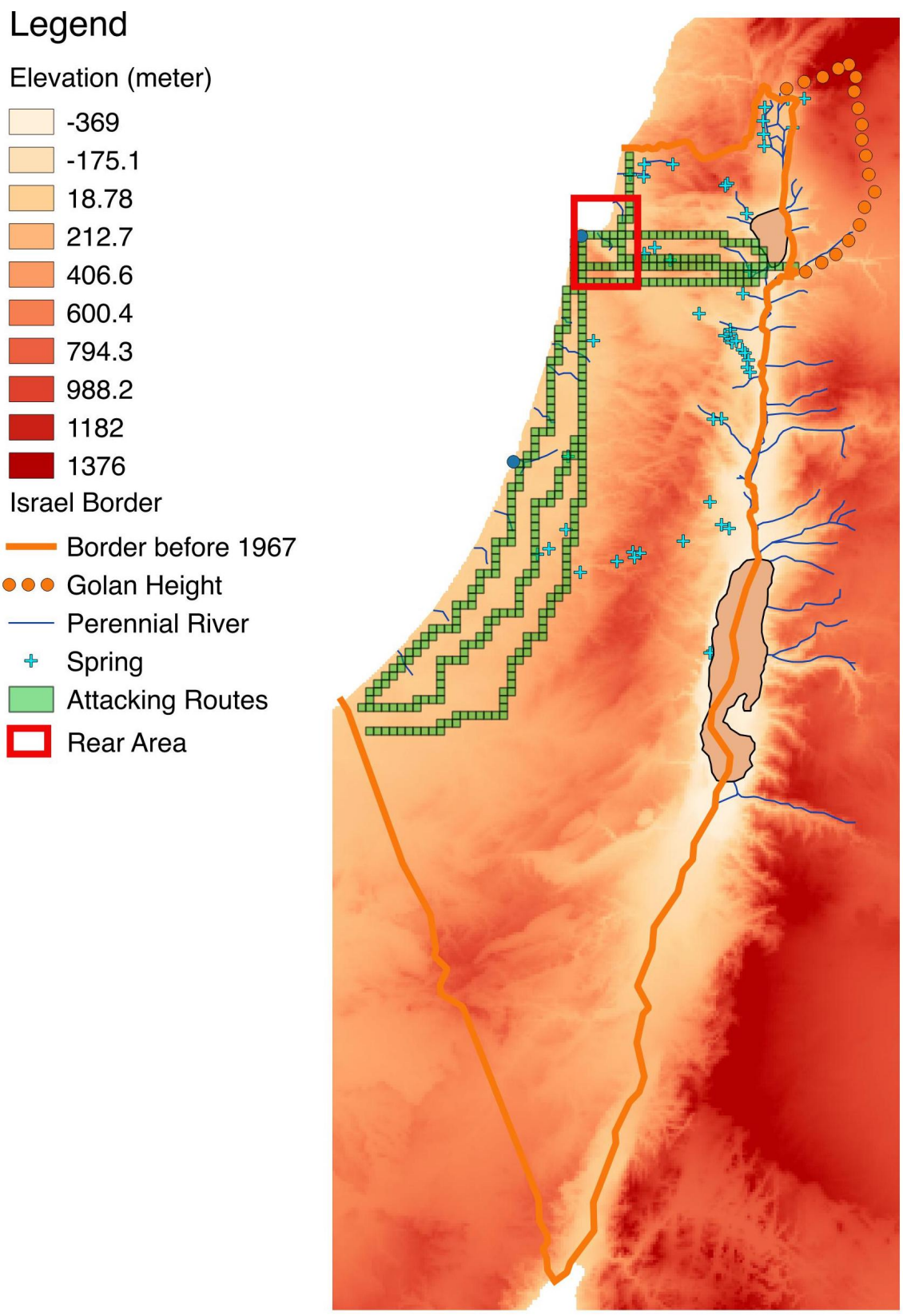

Figure 19: Constructed Optimal Invasion Routes

Kibbutz Degania Aleph and Degania Bet, with limited help from Jewish troops, halted the advance of two Syrian infantry battalions, along with twelve tanks and twenty armoured cars. They even immobilized two tanks by grenades and Molotov cocktails. After fighting grimly for two days, the kibbutzniks beat back the Syrians (Morris 2008, pp. 254–257).

On the southern front, one Egyptian battalion attacked Kibbutz Kfar Darom. After dozens of casualties, the battalion withdrew and bypassed the kibbutz. The next target was Kibbutz Yad Mordechai. Unlike Kfar Darom, the Egyptians had to conquer Yad Mordechai, as it is located on on a hill, dominating the coastal road. The Jewish leaders also understood the importance of the kibbutz, ordering the defenders to withhold the attack and delay the Egyptians for as long as possible. On May 20th, 110 kibbutz members (twenty of them were women) and two squads of Jewish soldiers, resisted seven joint assaults from two Egyptian battalions, inflicting dozens of dead on the Egyptian side. The Egyptians added another battalion, and resumed attack on May 23rd. By nightfall, the toll of kibbutz casualties had exceeded 50 percent, but their reinforcement had been blocked by the Egyptian air force. They had no choice but to disobey the orders and retreat (which was criticized by the Jewish prime minister, Ben-Gurion). The Egyptians conquered Kibbutz Yad Mordechai, but their advance was delayed by at least four days. The delay gave the Israeli Giv'ati Brigade enough time to rally, and eventually halt the Egyptians at Isdud. The Egyptians lost the initiative from then on (Morris 2008, pp. 235–242).

Appendix I: Robustness Checks for Kibbutz Privatization Regression

Table 23 replicates the results of Table 8, without the terrorist attack data in 1993. External threats is measured by the number of Israeli civilian deaths in the previous six years within 10 km (Column 1,2), 20 km (Column 3,4), 30 km (Column 5,6), or 40 km (Column 7,8) of each kibbutz, normalized by the population density at the attack location. Control variables are included in Columns 2, 4, 6, and 8. The results are qualitatively very similar to the estimates in Table 8.

Table 23: Robust check by dropping 1993 data

A.Dependent variable:	First Stage							
Civilian deaths	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	10km	10km	20km	20km	30km	30km	40km	40km
Rainfall× Pop÷ Dist	-169***	-75***	-93.7***	-35.1***	-73.9***	-23.5***	-89.8***	-20.1***
	(31.9)	(10.4)	(20)	(5.26)	(15.1)	(3.45)	(18.5)	(2.83)
Refugee Control	yes	yes	yes	yes	yes	yes	yes	yes
Kibbutz Control	no	yes	no	yes	no	yes	no	yes
District fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
N	5798	4158	6021	4158	5798	4158	6021	4158
F-statistics on the IV	250.2	915.3	30.27	1236.7	14.70	169.5	5.125	60.51
B.Dependent variable:	Main Effect							
Hazard Rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	10km	10km	20km	20km	30km	30km	40km	40km
Civilian deaths	-169***	-75***	-93.7***	-35.1***	-73.9***	-23.5***	-89.8***	-20.1***
	(31.9)	(10.4)	(20)	(5.26)	(15.1)	(3.45)	(18.5)	(2.83)
Population in 1995		-.00185**		-.00126		-.0011		-.00133
		(.000745)		(.000809)		(.00085)		(.000827)
Average Household Size		-.541		.0671		.109		.155
		(.666)		(.733)		(.744)		(.73)
Movement Affiliation		-.435**		-.528***		-.582***		-.498**
		(.207)		(.185)		(.19)		(.194)
Economic Strength		-.212**		-.193**		-.24**		-.216**
		(.0852)		(.0829)		(.0961)		(.0923)
Regional Population		.00162		.00202*		.00171		.00174
		(.00112)		(.00108)		(.00106)		(.00107)
Regional Employment Rate		-5.37***		-1.36		.467		-.907
		(1.31)		(1.76)		(1.73)		(1.56)
Established before Independence		.475***		.618***		.577***		.533***
		(.118)		(.115)		(.124)		(.124)
Age in 1989		-.00666		-.0148***		-.0176***		-.0142**
		(.00571)		(.00511)		(.00566)		(.00557)
Refugee Control	yes	yes	yes	yes	yes	yes	yes	yes
District fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
N	3076	1849	3076	1849	3076	1849	3076	1849

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Kibbutzim were exposed to the decision of income privatization in 1989, when they were formally permitted by kibbutz federations to introduce reforms. A failure happens when the kibbutz privatizes income (adopts the partial payment reform). **Civilian deaths**: the number of Israeli civilian deaths in the previous six years within 10 (**column1,2**), 20 (**column3,4**), 30 (**column5,6**), or 40 (**column7,8**) km of the kibbutz, normalized by the population density at the attack location. Control variables are described in Table 12. Standard errors are clustered at district level. All regressions include an imputation dummy for years affected by the imputed terrorist attacks in 1993.

Appendix J: Logit Regression

Table 24 runs a Logit model, where the dependent variable is whether the kibbutz privatized income in year i. It equals to 1 if the kibbutz privatized inocme in year i, 0 if not. The results are qualitatively very similar to the estimates in Table 8.

Specifically, the following first-stage regression is estimated:

$$Death_{ij,t,t-5} = \beta_{IV}(Rainfall_{ijt} \times Pop_{ij} \div Dist_{ij}) + \beta_X X_i + \theta_j + \eta_t + \epsilon_{ijt} \tag{14}$$

where $Death_{ijt}$ is the number of civilian deaths within 30 kilometres of the kibbutz in the previous six years; θ_j is a district fixed effect; η_t is a year fixed effect; X_i is a vector of kibbutz specific control variables, explained in detail above; $Rainfall_{ij,t,t-5}$ is the total rainfall surplus above the historical average in the previous six years at the nearest refugee camp to kibbutz i; Pop_{ij} is the population at the nearest refugee camp to kibbutz i in 1996; $Dist_{ij}$ is the distance between kibbutz i and its nearest refugee camp; ϵ_{ijt} is the error term.

In the second stage, the probability of income privatization is estimated by the following Logit regression, including the residual from the first step as a regressor, to control for endogeneity of the main regressor:

$$Privatization_{ijt} = \alpha + \beta'_D Death_{ij,t,t-5} + \beta_X X_i + \theta_j + \eta_t + \hat{\epsilon}_{ijt} + u_{ijt} \tag{15}$$

where $Privatization_{ijt}$ equals to 1 if the kibbutz i in district j privatized income in year i, 0 if not. $\hat{\epsilon}_{ijt}$ is the residual from the first stage. The coefficient β'_D captures the causal effect of civilian deaths on kibbutz income privatization under those terrorist attacks affected by rainfall variation at the nearest refugee camp. u_{ijt} is the error term.

Table 24: Logit Regression

A.Dependent variable:	First Stage							
Civilian deaths	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	10km	10km	20km	20km	30km	30km	40km	40km
Rainfall× Pop÷ Dist	-.126***	-.5***	-.206***	-1.09***	-.253**	-1.57***	-.166	-1.8***
	(.0103)	(.0165)	(.0534)	(.0311)	(.0928)	(.121)	(.125)	(.232)
[1em] Kibbutz Control	no	yes	no	yes	no	yes	no	yes
Refugee Control	yes	yes	yes	yes	yes	yes	yes	yes
District fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
N	6021	4158	6021	4158	6021	4158	6021	4158
F-statistics	151.4	915.3	493.4	1714.5	7.424	169.5	1.761	60.51
B.Dependent variable:	Main Effect							
Privitization	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	10km	10km	20km	20km	30km	30km	40km	40km
Civilian deaths	-227***	-86***	-141***	-40.5***	-118***	-26.9***	-185***	-22.9***
	(41.2)	(11.9)	(28.7)	(5.89)	(23.4)	(3.95)	(36.9)	(3.26)
Population in 1995		-.00217**		-.0015		-.00131		-.00157*
		(.000846)		(.00093)		(.000956)		(.000931)
Average Household Size		-.663		.0383		.0847		.134
		(.808)		(.881)		(.882)		(.873)
Movement Affiliation		-.539**		-.647***		-.707***		-.611**
		(.252)		(.229)		(.237)		(.238)
Economic Strength		-.264***		-.241**		-.296***		-.269**
		(.102)		(.0997)		(.115)		(.111)
Regional Population		.00184		.00233*		.0019		.00193
		(.00137)		(.00132)		(.00131)		(.00133)
Regional Employment Rate		-6.25***		-1.71		.412		-1.15
		(1.49)		(2.05)		(1.97)		(1.77)
Established before Independence		.578***		.743***		.7***		.65***
		(.161)		(.153)		(.166)		(.163)
Age in 1989		-.0101		-.0192***		-.0227***		-.0189***
		(.00705)		(.00657)		(.00712)		(.00674)
Constant	-2.97***	.623	-3.25***	-3.57	-1.98**	-3.8	.599	-3.29
	(.765)	(3.83)	(.764)	(4.27)	(.849)	(4.12)	(1.21)	(4.07)
[1em] Refugee Control	yes	yes	yes	yes	yes	yes	yes	yes
District fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
N	2061	1569	2061	1569	2061	1569	2061	1569

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The dependent variable is **Privatization**:1 if the kibbutz privatized income in this year, 0 if not. **Civilian deaths**: the number of Israeli civilian deaths in the previous six years within 10 (**column1,2**), 20 (**column3,4**), 30 (**column5,6**), or 40 (**column7,8**) km of the kibbutz, normalized by the population density at the attack location. Control variables are described in Table 12. Standard errors are clustered at district level. All regressions include an imputation dummy for years affected by the imputed terrorist attacks in 1993.

Appendix K: The Model

To provide a rigorous proof to Prediction 1 and 2, I have to relax the assumption that the damage S is sufficiently large such that effort on public defense can always mitigate damage and preserve food. Instead, a constraint is introduced that any public defense larger than the damage S will be wasted. This constraint will be used to derive the timing of income privatization.

K.1 First-Best Solution

In terms of a benchmark, consider the first-best solution (the zero transaction cost solution). Here, the objective is to maximize the total food surviving from the damage, subject to the constraint. Denote the total public defense by $D = \sum_{i=1}^{N} NG(e_i)$. The objective function is:

$$\begin{aligned} \max_{e_1, e_2 \ldots e_N} \quad & \sum_{i=1}^{N} z_i F(1-e_i) - [S - \sum_{i=1}^{N} NG(e_i)] \\ s.t. \quad & D = \sum_{i=1}^{N} NG(e_i) \leq S \end{aligned} \tag{16}$$

The socially optimal effort e_i^* of every member is one that equates the marginal product of the food and the public defense for the *whole community*:

$$\frac{dz_i F(1-e_i^*)}{d(1-e_i)} = \frac{N dG(e_i^*)}{de_i} \tag{17}$$

Let the aggregate public defense at this level be called *first-best defense*: $D^* = \sum_{i=1}^{N} NG(e_i^*)$. It should be noted that at the optimum, the constraint is not binding ($D^* \leq S$). In this case, there is some damage not mitigated by the *first-best defense*, since it is not worthwhile for members to exert any more effort on public defense.

Figure 20 gives a geometric interpretation of the effort allocation by member i. $z_i F'(1-e_i)$ is the marginal product of the private good; $\frac{1}{N} z_i F'(1-e_i)$ is the marginal product of the private good under equal sharing; $G'(e_i)$ is the marginal product of the public good for the member himself; $NG'(e_i)$ is the marginal product of the public good for the whole community. The optimal choice

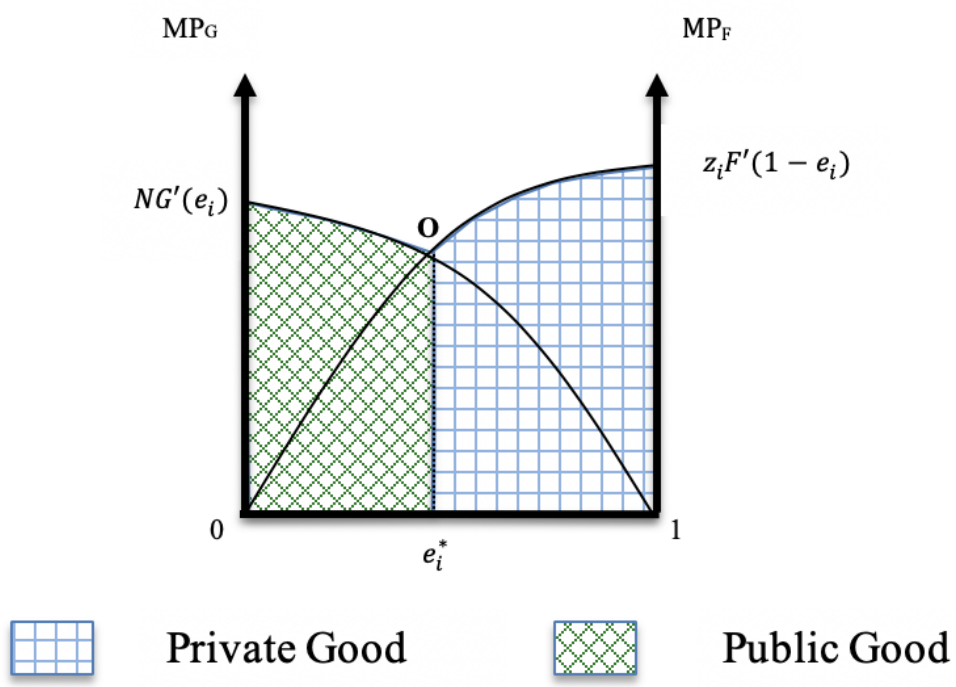

Figure 20: First-best allocation of effort between food and public defense

for the whole community is point O, which maximizes the sum of food (in Figure 20) and public defense (in Figure 20).

To provide a comparison between high productivity members (in food only) and low productivity members, consider a kibbutz called Doubletown, as illustrated in Figure 21. In Doubletown live two members ($N = 2$). Member H has a higher productivity in food than Member L ($z_H > z_L$), but their productivity in defense is the same. With zero transaction costs, they would maximize the total food surviving from the damage caused by enemies, and the social optimal choice for them would be the point O where the marginal productivity curve of food intersects the marginal productivity curve of public defense for the *whole community*. In this case, the total public defense D^* (the total in Figure 21) is less than the damage.

If the socially optimal public defense is larger than the damage caused by enemies ($D^* > S$), members will save effort on the public defense until $D = S$, and use the effort on private good instead. The equilibrium e_i^* then satisfies

$$\frac{dz_iF(1-e_i^*)}{d(1-e_i)} = \alpha(S)\frac{NdG(e_i^*)}{de_i} \tag{18}$$

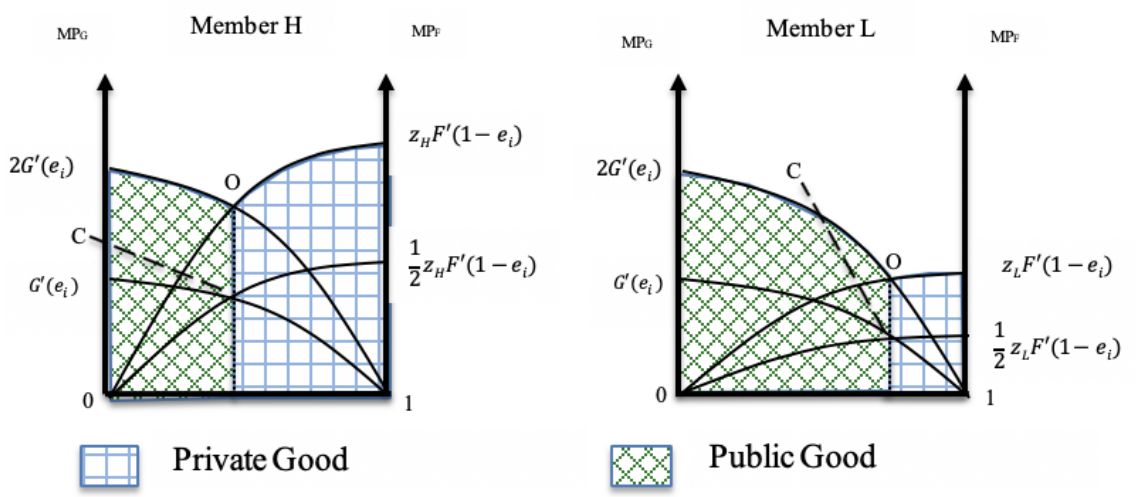

Figure 21: First-best allocation of effort in Doubletown

where $\alpha(S)$ is chosen such that the amount of public defense just mitigates the damage (i.e. $\sum_{i=1}^{N} NG(e_i^*) = S$).[83] Equation 18 states that for each member the ratio of the marginal product of food to public defense for the whole community must be equal to a constant $\alpha(S)$, when the constraint is binding (i.e. $S < D^*$).

The two members in Doubletown (see Figure 22) now face a damage lower than their total public defense (the total in Figure 21). They shift their effort from the public defense to the food, in the most efficient way — each member exerts effort at the point T in Figure 22, where they have the same ratio between food productivity to the public defense productivity ($\frac{TU}{QU}$ in Figure 22), and the total public defense (the total in Figure 21) is equal to the damage. Since the ratio is larger than one, any increase in the food production comes at a cost of a larger increase in the damage due to the lower public defense. Consequently, no one will decrease their effort on the public defense, which will yield a lower remaining food. No one will increase their effort on the public defense either, since the damage has already been fully mitigated, and any extra public defense will be wasted. Because no one wants to deviate from the status quo, exerting effort at point T in Figure 22 constitutes a Nash equilibrium.

The first-best effort can be summarized by Equation 18, where the ratio between the marginal productivity in food and the marginal productivity in public defense $\alpha(S)$ is equal to one, when

[83] The Lagrange equation is $\max_{e_1,e_2\ldots e_N} \sum_{i=1}^{N} z_i F(1-e_i) - [S - \sum_{i=1}^{N} NG(e_i)] - \lambda \sum_{i=1}^{N} NG(e_i^*)$
The first order condition is $\frac{dz_i F(1-e_i^*)}{d(1-e_i)} / \frac{N dG(e_i^*)}{de_i} = \lambda$ for $\forall i$ and $\sum_{i=1}^{N} NG(e_i^*) = S$

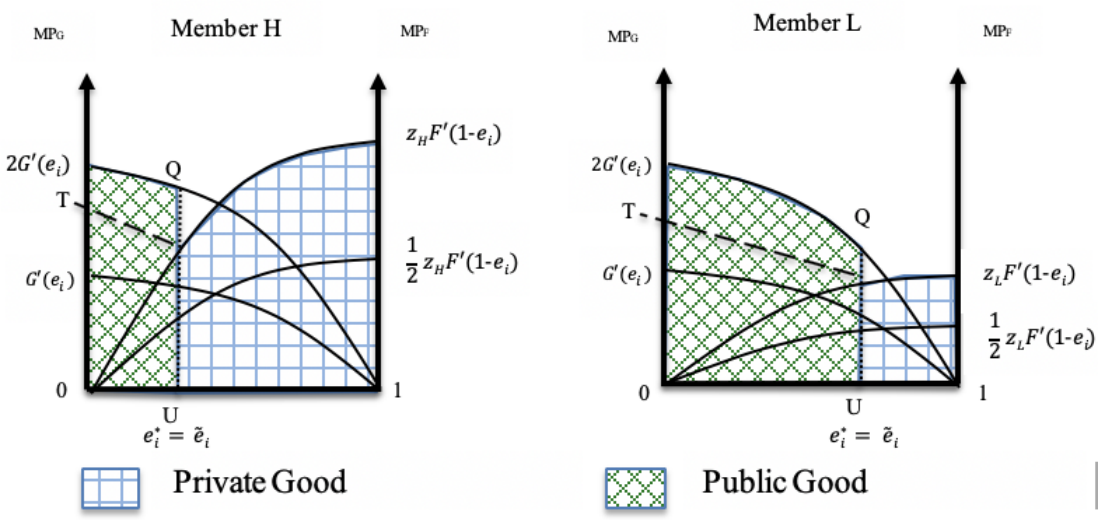

Figure 22: First-best allocation of effort in Doubletown, when the damage is less than D^*

the damage is larger than or equal to the *first-best defense* D^*. The ratio $\alpha(S)$ is less than one, when the damage is below the *first-best defense* D^*, and decreases as the damage decreases.

K.2 Private Income Arrangement Solution

Under a private income arrangement, each member maximizes the food that is produced by him, and survives from enemy damage, subject to the constraint that any public defense larger than the damage will be wasted:

$$\begin{aligned} \max_{e_i} \quad & z_i F(1-e_i) - \frac{1}{N}[S - \sum_{i=1}^{N} NG(e_i)] \\ s.t. \quad & \sum_{i=1}^{N} NG(e_i) \leq S \end{aligned} \tag{19}$$

The private optimal effort $\hat{e}_i$ of every member is one that equates the marginal product of the food and the public defense for *himself*:

$$\frac{dz_i F(1-\hat{e}_i)}{d(1-e_i)} = \frac{dG(\hat{e}_i)}{de_i} \tag{20}$$

Let the aggregate public defense at the current level be called *second-best defense* $\hat{D} = \sum_{i=1}^{N} NG(\hat{e}_i)$. It should be noted that at the optimum, the constraint is not binding ($\hat{D} \leq S$). In this case, there

is some damage not mitigated by the *second-best defense*, since it is not worthwhile for members to exert any more effort on the public defense (See Appendix L for a graphical illustration of the equilibrium).

When the damage caused by enemies is smaller than the *second-best defense* ($S < \hat{D}$), members will save effort on the public defense, and direct it to the private good. The equilibrium $\hat{e}_i$ then satisfies:

$$\frac{dz_i F(1-\hat{e}_i)}{d(1-e_i)} = \beta(S)\frac{dG(\hat{e}_i)}{de_i} \tag{21}$$

where $\beta(S)$ is chosen such that the amount of public defense just mitigates the damage ($\sum_{i=1}^{N} NG(\hat{e}_i) = S$). Equation 21 states that under a private income arrangement, for each member the ratio of the marginal product of the food to the public defense for *oneself* must be equal to a constant $\beta(S)$, given $\hat{D} > S$.

The equilibrium effort under private income arrangements can be summarized by Equation 21, where the ratio between the marginal productivity in food and the marginal productivity in public defense $\beta(S)$ is equal to one, when the damage is larger than or equal to the second-best defense $\hat{D}$. The ratio $\beta(S)$ is less than one, when the damage is below the second-best defense $\hat{D}$, and decreases as the damage decreases (See Appendix L for a graphical illustration of the equilibrium).

Proposition 1

Under a private income arrangement, public defense is under provided while food is over provided, as $G(e_i^*) \geq G(\hat{e}_i)$, and $F(1-e_i^*) \leq F(1-\hat{e}_i)$.

The public defense is under provided, because members only consider their own benefit and ignore the positive externality on the whole community. Yet, a contract over the level of effort on the public defense is not feasible, as the effort allocation is not observable.

K.3 Equal-Sharing Income Solution

Under an equal-sharing income arrangement, each member only gets one-Nth shares of the food produced. Therefore, each member maximizes an equal share of the food surviving from the

damage, subject to the constraint that any public defense larger than the damage will be wasted:

$$\begin{aligned} \max_{e_i} \quad & \frac{1}{N}\sum_{i=1}^{N} z_i F(1-e_i) - \frac{1}{N}[S - \sum_{i=1}^{N} NG(e_i)] \\ s.t. \quad & \sum_{i=1}^{N} NG(e_i) \leq S \end{aligned} \tag{22}$$

The equilibrium effort $\tilde{e}_i$ of every member is one that equates marginal product of one Nth of the food produced by himself and the public defense for *himself*:

$$\frac{1}{N}\frac{dz_i F(1-\tilde{e}_i)}{d(1-e_i)} = \frac{dG(\tilde{e}_i)}{de_i} \tag{23}$$

Now the public defense is $\tilde{D} = \sum_{i=1}^{N} NG(\tilde{e}_i)$. Again, the above equilibrium happens only when the constraint is not binding ($\tilde{D} \leq S$), and some damage is not mitigated (See Appendix M for a graphical illustration of the equilibrium).

When the damage caused by enemies is smaller than the above equilibrium public defense ($S < \tilde{D}$), members will save effort on the public defense, and direct it to the private good. The equilibrium $\tilde{e}_i$ then satisfies:

$$\frac{1}{N}\frac{dz_i F(1-\tilde{e}_i)}{d(1-e_i)} = \gamma(S)\frac{dG(\tilde{e}_i)}{de_i} \tag{24}$$

where $\gamma(S)$ is chosen such that the amount of public defense just mitigates the damage ($\sum_{i=1}^{N} NG(\tilde{e}_i) = S$). Equation 24 states that under a private income arrangement, for each member the ratio of one Nth of the marginal product of food to the public defense for *himself* must be equal to a constant $\gamma(S)$, given $\tilde{D} > S$ (See Appendix M for a graphical illustration of the equilibrium).

Proposition 2

Under a common property arrangement, the provision of the public defense and food is at the first-best level, as $G(\tilde{e}_i) = G(e_i^*)$ and $F(1-\tilde{e}_i) = F(1-e_i^*)$

Under a common property arrangement, the incentive to produce food is suppressed, as each member only gets a share of his own food production. This moral hazard problem decreases the food effort level and increases the effort level on the public good. As a result, the effect of the

moral hazard counteracts the effect of the positive externality on the public good. Thus, a common property arrangement brings back the provision of the public good to the first-best level.

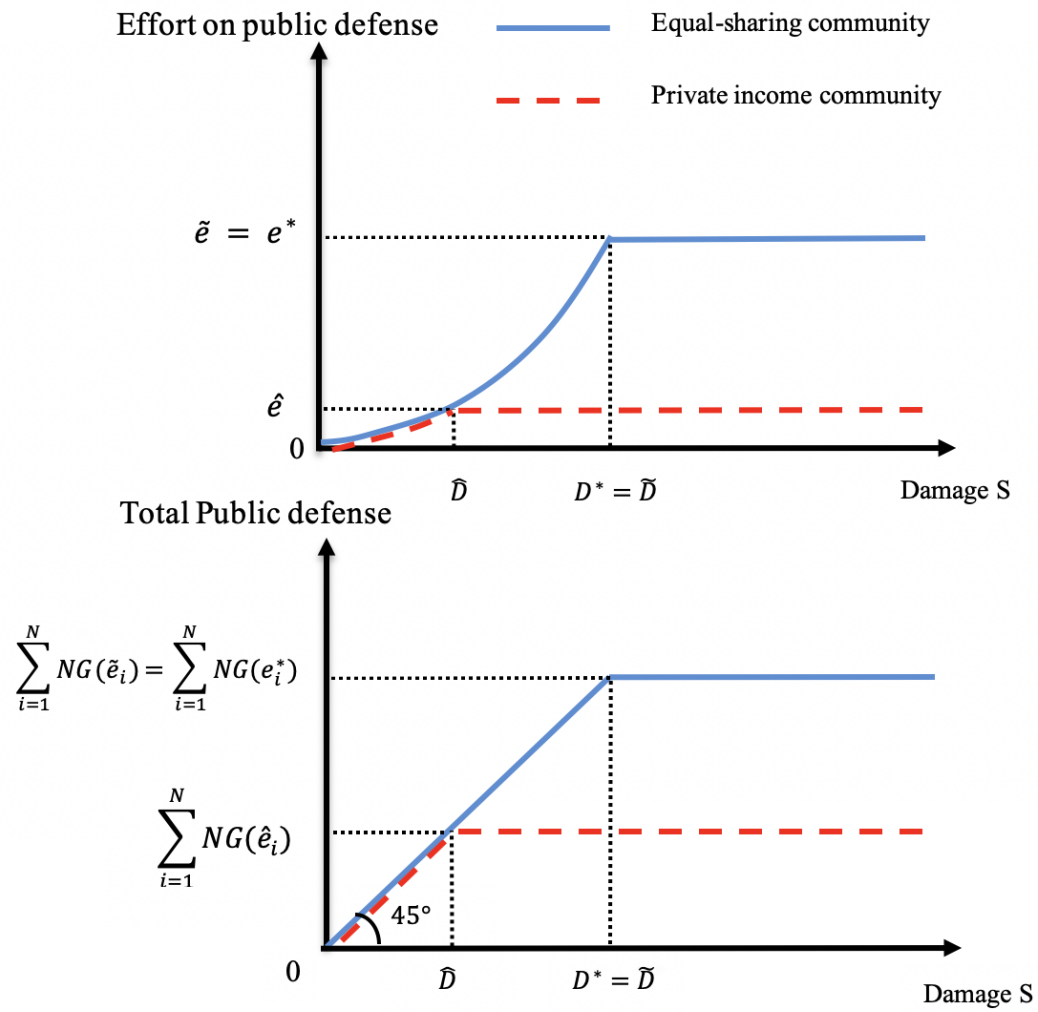

Figure 23: Public defense and corresponding effort under different income arrangements

Figure 23 compares the equilibrium effort levels under different income arrangements. When the damage faced by a community increases (the equilibrium points move to the right along the curves), members exert more effort on public defense, and aggregate public defense goes up. The public defense under private income arrangements (- - - in Figure 23) first hits the *second-best defence*: $\hat{D} = \sum_{i=1}^{N} NG(\hat{e}_i)$, and the members stop increasing their effort. In contrast, members in equal-sharing income arrangements continue to increase their effort on the public defense (—— in Figure 23), until the public defense hitting the *first-best defence*: $\tilde{D} = \sum_{i=1}^{N} NG(\tilde{e}_i)$.

K.4 The Choice over Income Arrangements

Assume members can vote to decide the income arrangement of the community. Once the approval rating for a certain income arrangement is greater than a threshold, the community adopts the income arrangement.

Consider the net benefit of staying in a equal-sharing community for member j:

$$\begin{aligned}\pi_j &= \frac{1}{N}\sum_{i=1}^{N} z_i F(e_i^*(S)) - \frac{1}{N}(S - \sum_{i=1}^{N} NG(1-e_i^*(S))) - z_j F_j(\hat{e_j}(S)) + \frac{1}{N}(S - \sum_{i=1}^{N} NG(1-\hat{e_i}(S))) \\ &= \frac{1}{N}\sum_{i=1}^{N} z_i F(e_i^*(S)) + \frac{1}{N}\sum_{i=1}^{N} NG(1-e_i^*(S)) - z_j F_j(\hat{e_j}(S)) - \frac{1}{N}\sum_{i=1}^{N} NG(1-\hat{e_i}(S))\end{aligned} \tag{25}$$

where $\frac{1}{N}\sum_{i=1}^{N} z_i F(e_i^*(S))$ and $\frac{1}{N}\sum_{i=1}^{N} NG(1-e_i^*(S))$ are the food and public defense received by member j at the equilibrium under equal-sharing arrangements; $z_j F_j(\hat{e_j}(S))$ and $\frac{1}{N}\sum_{i=1}^{N} NG(1-\hat{e_i}(S))$ are the food and public defense received by member j at the equilibrium under private income arrangements.

Prediction 1

(a) For $S \geq D^*$, π_j stays the same as damage S decreases.

(b) For $S \in (\hat{D}, D^*)$, π_j decreases as damage S decreases.

(c) $\pi_i > \pi_j$ whenever $z_i < z_j$

Prediction 1(a) and 1(b) (See Appendix N for the proof) state that as the community becomes safe, the net benefit of the common property arrangement over the private income arrangement decreases. Proposition 1(c) states that the more productive (in food) a member is, the smaller the net benefit he has.

When a community locates in a dangerous area, and foresees a large damage, members choose the common property arrangement to maintain a high level of public defense. As the damage to the community decreases, the benefit of the additional public defense provided by the common property arrangement diminishes; initially the most productive member, then the second most productive one, then the third ... will vote for the private income arrangements. As the number of members

voting for the private income arrangements increases, the community will, at one point, abandon the equal sharing rule and privatize income.

As the damage decreases, the total surplus receive by H under a common property arrangement will eventually be lower than that under a private income arrangement, and H will vote for the private income arrangement.

K.5 The Rarity of Equal-Sharing Communities

The analysis so far is based on the existence of communities. However, the external threats can be so large that communities cannot keep operating.[84] Assume that the members abandon their communities when the total food surviving from the damage is below certain threshold.

Figure 24, an extension of Figure 23, illustrates the total food under different income arrangements. As discussed in previous sections, when the damage is larger than the first-best defence level (D^* in Figure 24), equal-sharing arrangements can induce a higher public defense, and hence preserve more food. As the damage decreases, more food survives, and the total food remaining increases at a constant rate equal to one. Once the damage falls below the first-best defence level (D^* in Figure 24), no more food is damaged by the enemies, as the damage is completely mitigated by the public defense. The total food remaining still increases, but at a decreasing rate, since the members can substitute effort on the public defense into effort on the food at a decreasing rate.

The same pattern applies to the private income communities. The total food remaining grows at a constant rate equal to one, before the damage hits the second-best defence level ($\tilde{D}$ in Figure 24). Once the damage falls below the second-best defence level, the total food remaining still increases, but at a decreasing rate.

The abandonment thresholds B and C are ones at which the surviving threshold intersects the curves of total remaining food. Once the damage is larger than abandonment thresholds, the members have to run away. However, as the surviving threshold decreases in Figure 24, the abandonment thresholds B and C move to the right. That is, the more subsidy provided by the government, the larger damage the members can endure or the longer the members can hold out before abandoning their communities.

[84] For example, four isolated kibbutz were defeated by the Jordanian army during the 1948 Israel-Arab war.

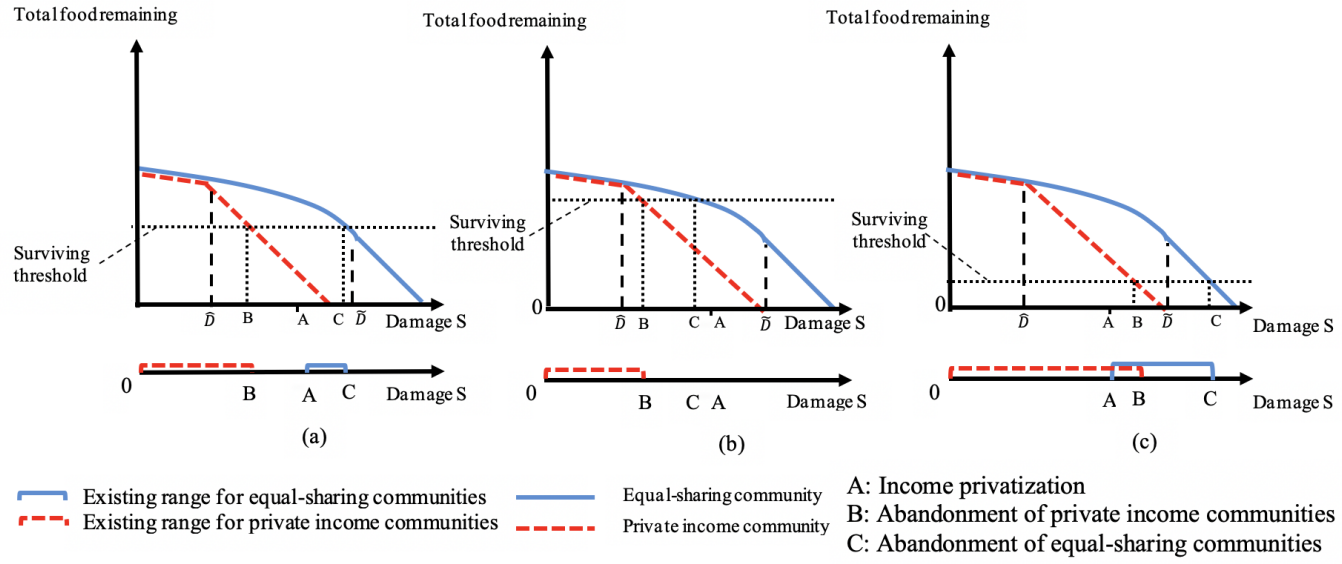

Figure 24: Range of the existence for different communities

Prediction 2

Other things being equal, a central planner places equal-sharing communities at dangerous areas, while placing private income communities at safe areas.

Threshold C always lies to the right of threshold B, as shown in Figure 24. But the relative position of the income privatization threshold A is uncertain, because it depends on the productivity of both goods and the surviving threshold. Therefore, I consider all three possible scenarios. (a) If A is located between B and C, equal-sharing communities can survive in dangerous environment, while private income communities can only survive in safe environment, but they can not survive at the same area. (b) If A is located to the right of C, equal-sharing communities are never present, while private income communities are present in safe environment. (c) If A is located to the left of B, equal-sharing communities are present dangerous environment, while private income communities are present in safe environment, and they co-exist at the same area.

It naturally follows that equal-sharing communities are rarer than private income communities, not only because equal-sharing communities are present in smaller number of scenarios, but mainly because the range of damage, in which equal-sharing communities are present, is more restrictive. The members in equal-sharing communities will privatize income when the damage is too low,

and run away when the damage is too high. Also, for the presence of equal-sharing communities, the damage must also be relatively stable in the foreseeable future. Since income privatization, or abandoning a community is so costly, the members will not build a community in a highly uncertain (in terms of the damage they anticipate) environment.

Appendix L: Illustration of Private Income Arrangement Solution in Doubletown

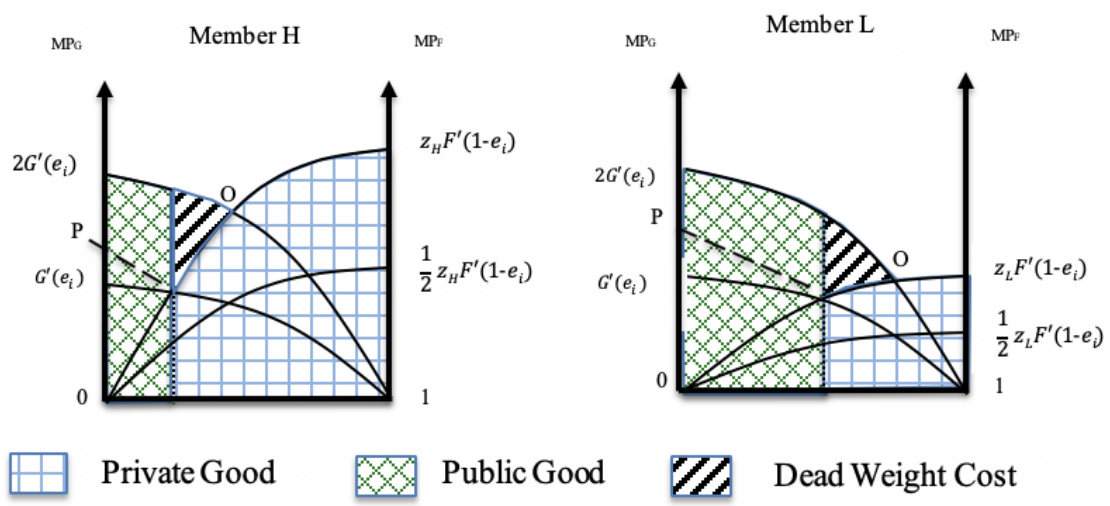

Figure 25: Allocation of effort in Double town under a private income arrangement

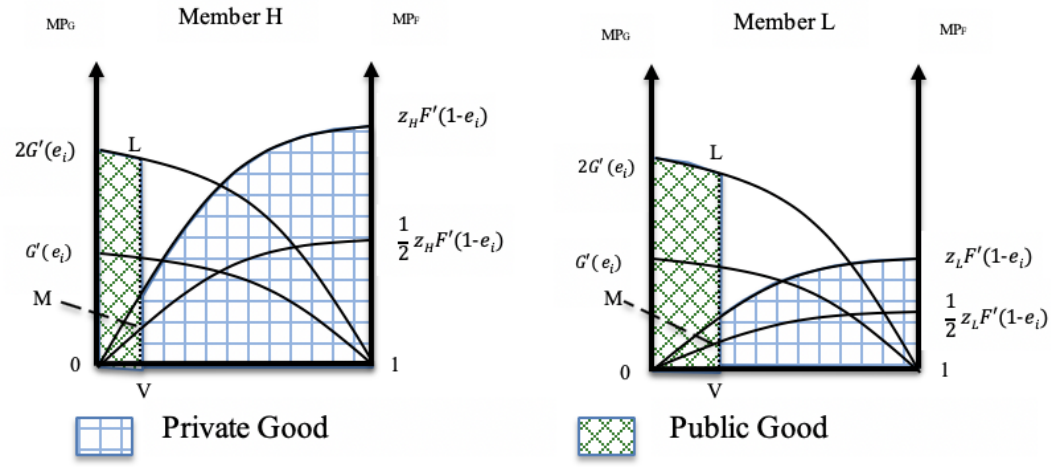

Figure 26: Allocation of effort in Double town under a private income arrangement, when the damage is low

Figure 25 illustrates the equilibrium in Doubletown in the present of positive transaction costs and private income. Every member maximizes their own food surviving from the damage caused by enemies, and exerts effort at the point P where the marginal productivity curve of food intersects the private marginal productivity curve of public defense. Even though they can exert effort level

at the point O, and get more food for *both of them* and avoid a dead weight cost ( in Figure 25), they are not able to sustain the equilibrium at the point O, as each of them has an incentive to deviate to the point P, and produce more food for *oneself*. In this case, the total public defense $\hat{D}$ (total  in Figure 25) is less than the damage.

The two members in Doubletown (see Figure 26) now face a damage lower than their total public defense (the total  in Figure 25). They reduce their effort on public defense and exert effort at the point M, where both members have the same ratio of marginal productivity of food to marginal productivity of public defense for *oneself* ($\frac{MV}{LV}$ in Figure 26), and the total public defense (the total  in Figure 26) just mitigates the damage.

Appendix M: Illustration of Equal-sharing Income Arrangement Solution in Doubletown

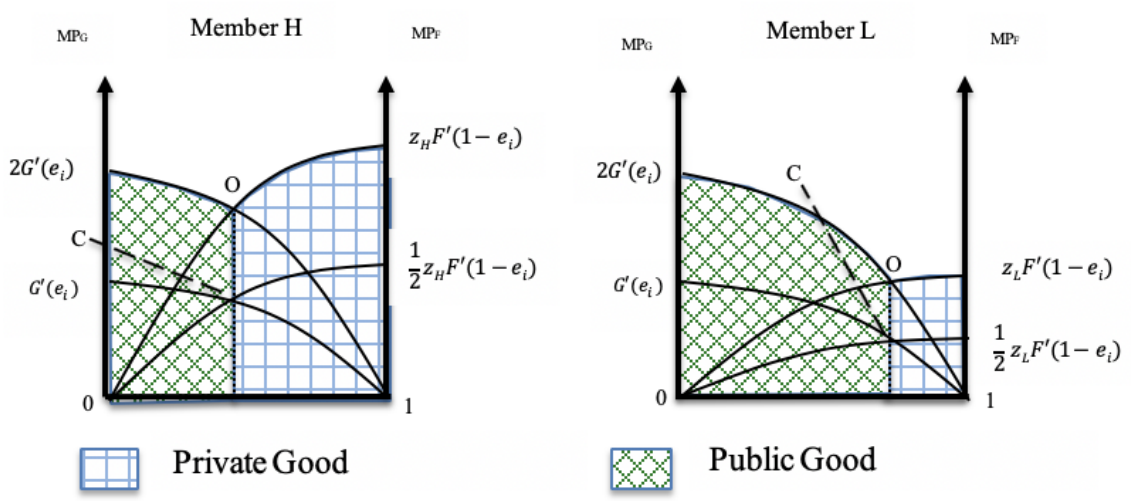

Figure 27: Allocation of effort in Double town under an equal-sharing income arrangement

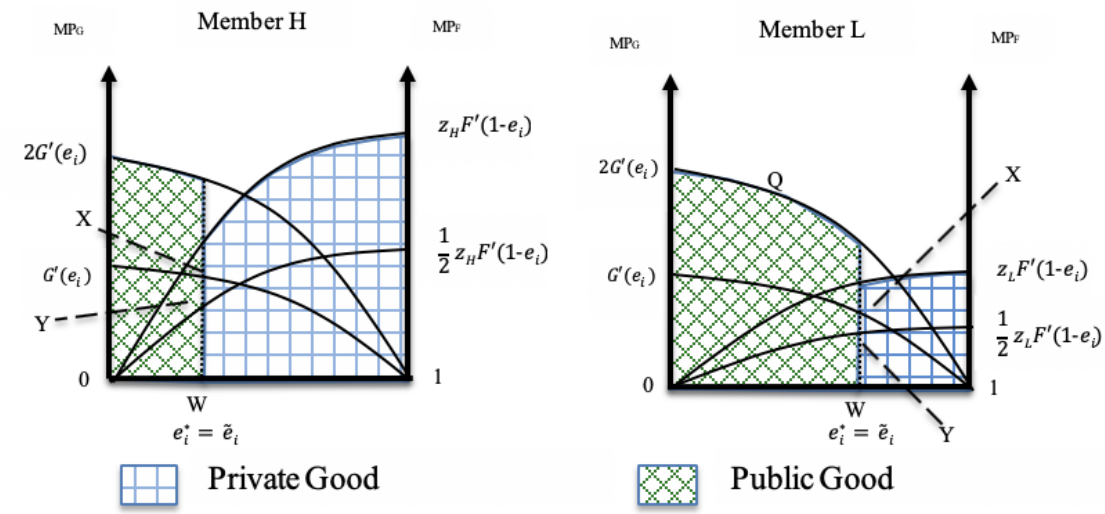

Figure 28: Allocation of effort in Double town under an equal-sharing income arrangement, when the damage is low

Figure 27 illustrates the equilibrium in Doubletown when food is equally shared between the two members. Every member maximizes their equal share of food surviving from the damage caused by enemies, and exerts effort at the point C where one Nth of the marginal productivity curve of

food intersects the marginal productivity curve of public defense for *himself*. In this case, the total public defense $\tilde{D}$ (the total  in Figure 27) is less than the damage.

The two members in Doubletown (see Figure 28) now face a damage lower than their total public defense (the total  in Figure 27). They reduce their effort on the public defense, and exert effort at the point B, where both members have the same ratio of half of the marginal productivity of food to marginal productivity of public defense for *oneself* ($\frac{DA}{BA}$ in Figure 28), and the total public defense (the total  in Figure 28) just mitigates the damage.

Appendix N: Proof of Proposition 3(b)

For $T \in (\hat{D}, D^*)$

$$\begin{aligned}
\pi_j =& \frac{1}{N}\sum_{i=1}^{N} z_i F(e_i^*(T)) + \frac{1}{N}\sum_{i=1}^{N} NG(1-e_i^*(T)) - z_j F(\hat{e_j}) \\
& - \frac{1}{N}\sum_{i=1}^{N} NG(1-\hat{e}_i) \\
\frac{d\pi_j}{dT} =& \frac{1}{N}\sum_{i=1}^{N} \frac{dz_i F(e_i^*(T))}{de_i^*(T)}\frac{de_i^*(T)}{dT} - \frac{1}{N}\sum_{i=1}^{N} \frac{NdG(1-e_i^*(T))}{d(1-e_i^*(T))}\frac{de_i^*(T)}{dT} \\
\frac{d\pi_j}{dT} =& \sum_{i=1}^{N} (\alpha(T)-1)\frac{NdG(1-e_i^*(T))}{d(1-e_i^*(T))}\frac{de_i^*(T)}{dT}
\end{aligned}$$

where the last equality comes from the envelope theorem.

$\frac{d\pi_j}{dT} > 0$, since $\alpha(T) - 1 < 0$, $\frac{NdG(1-e_i^*(T))}{d(1-e_i^*(T))} > 0$, $\frac{de_i^*(T)}{dT} < 0$