Supporting Information (SI)

“Group Segregation and Urban Violence”
Bhavnani, Donnay, Miodownik, Mor, and Helbing

1.0 Empirical Data

1.1 Data Sources
The dataset used in this study covers acts of violence involving Secular/Moderate Orthodox Jews, Ultra-Orthodox Jews, Palestinians and (Israeli) security forces from January 2001 to December 2009 within the municipal boundaries of Jerusalem. It also includes data on several permanent checkpoints in the outskirts of the city, which are used to control population flows between the West Bank and the city. The data has daily resolution and events are geo-coded by statistical districts of Jerusalem. In addition to the geographical location and the type of event, the dataset contains detailed information on the identities of both perpetrators and victims.

Raw data was collected from various sources: The Israeli Police, particularly the Statistics and Mapping division operating within the police’s Planning and Organization Branch;1 B’Tselem, the Israeli Information Center for Human Rights in the Occupied Territories, an organization whose activities include the documentation of assorted human rights violations, including the restriction of movement, expropriation of land, discrimination in planning and building, administrative detention, and fatalities;2 OCHA oPT, the UN Office for the Coordination of Humanitarian Affairs, an office established to monitor the humanitarian situation in the Occupied Territories (East Jerusalem notwithstanding), to enhance inter-agency coordination, and affect policy making through the collection and dissemination of information and facts;3 AIC, Alternative Information Center, an Israeli-Palestinian organization devoted, among other things, to the collection, analysis, and dissemination of information pertaining to human rights violations in the Israeli-Palestinian context;4 and lastly data was collected through a thorough content analysis of all the daily issues of Yediot Aharonot, Israel’s highest circulation newspaper.5

1.2 Data Reliability and Availability
These data sources were used with several goals in mind: (1) to assemble a wide universe of events of deadly and non-deadly violence in Jerusalem; (2) to cross-check and validate the coding of events across various sources; and (3) to compensate for biases in the data that

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5 Access to the Yediot Aharonot archive was provided by the Jewish National & University Library in Jerusalem http://jnul.huji.ac.il/eng/.
may have been introduced by relying on only one or a limited set of sources. In the context of Jerusalem, Palestinians for example are less likely to use the police to file complaints on violence but more likely to express grievances in front of a representative of a human rights organization. Using multiple sources we cross-validate and account for potential biases wherever possible—nonetheless we are conscious that there may still be systematic biases remaining in the data.

Police records available for the entire period of research include events with information on the perpetrators and victims, and particular information on the type of violent act committed; B’Tselem’s data includes high quality reports on deadly violence occurring in the city of Jerusalem for the entire period; OCHA’s data includes weekly reports that cover information on deadly violence (mostly obtained from B’Tselem), and on non-deadly violence for the period between October 2003 to November 2009; Yediot Aharonot provided information on murders, attempted murders, minor assaults and riots for the entire period; and, finally, the AIC holds some information on minor assaults and mobilization events between Jews and Palestinians.

1.3 Coding Violence
Data were coded into three types of events: murders, which includes cases of deadly stabbing, gunfire, and suicide bombing; attempted murders, including events with injuries incurred as a result of stabbing, gunfire, or suicide bombings; and minor assaults, or cases that involved beating, and either stone or Molotov cocktail throwing. Overall the dataset includes 286 cases of minor assaults, 173 events of attempted murders (116 of the reported attempted murders and violent assault events occurred during riots or collective clashes), and 85 deadly events incurring 253 causalities. Descriptions of typical events in our data include:

- On January 26, 2008, a Palestinian working in the Atarot industrial zone in the northern part of the city stabbed a Jewish fellow worker and then was fired at and killed.
- On October 26, 2009, a Palestinian woman stabbed an Israeli security guard at Qalandiya checkpoint, injuring him. A few weeks later on November 19, 2009, an Israeli settler stabbed and moderately injured a Palestinian man while he was standing at a bus station.

For purposes of comparison, we treat events from all three categories as “incidents of violence.”

1.4 Population and Settlement Data
The geography and the initial population setup of the simulations are based on data from Israel’s Central Bureau of Statistics and include: (1) detailed information on the geography of all of Jerusalem’s neighborhoods, including the locations of residential areas; and (2) population statistics and information on natural population growth (births, deaths,

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6 Implicit selection bias in the collection of empirical data is a known issue (see, for example, Davenport & Ball 2002).
immigration) on a neighborhood basis for the years 2001–09 (note that for the Ultra-
Orthodox population only estimates for the year 2005 are available—the other years are
extrapolated from those estimates). The geography and the initial population setup of the
model are based on polygons that were made available through Israel’s Central Bureau of
Statistics, the Jerusalem Institute for Israel Studies8 and the HUGIS (The Hebrew University
GIS Center),9 and Shaul Arieli, a retired colonel, publicist and member of the Geneva
Initiative, who has been collecting geo-spatial data on proposed peace initiatives and
settlements.10

Table A1. Neighborhoods of Jerusalem

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>ID</th>
<th>Name</th>
<th>ID</th>
<th>Name</th>
<th>ID</th>
<th>Name</th>
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<tbody>
<tr>
<td>1</td>
<td>Atarot, Kafr ‘Aqab, Industrial Zone</td>
<td>21</td>
<td>Givat Shaul industrial Zone</td>
<td>41</td>
<td>Armenian Quarter</td>
<td>61</td>
<td>Ramat Sharett and Ramat Denya</td>
</tr>
<tr>
<td>2</td>
<td>Beit Hanina</td>
<td>22</td>
<td>Givat Shaul</td>
<td>42</td>
<td>Talbiya</td>
<td>62</td>
<td>Teddy Stadium, Zoo</td>
</tr>
<tr>
<td>3</td>
<td>Neve Yasqov</td>
<td>23</td>
<td>Har Nof</td>
<td>43</td>
<td>Rehavia</td>
<td>63</td>
<td>Malha</td>
</tr>
<tr>
<td>4</td>
<td>Pisgat Ze’ev</td>
<td>24</td>
<td>Kiryat Moshe</td>
<td>44</td>
<td>German Colony</td>
<td>64</td>
<td>Sharatf</td>
</tr>
<tr>
<td>5</td>
<td>Shuafat</td>
<td>25</td>
<td>Beit Hakerem</td>
<td>45</td>
<td>Katamonim</td>
<td>65</td>
<td>Gilo</td>
</tr>
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<td>6</td>
<td>Ramot Haredi</td>
<td>26</td>
<td>Givat Ram</td>
<td>46</td>
<td>Katamon</td>
<td>66</td>
<td>Beit Safafa</td>
</tr>
<tr>
<td>7</td>
<td>Ramot Alon</td>
<td>27</td>
<td>Kiryat Hale’om</td>
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<td>Givat Mordechai</td>
<td>67</td>
<td>Givat Hamatos</td>
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<tr>
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<td>Nachlat</td>
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<td>Nayot</td>
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<td>Har Homa</td>
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<td>9</td>
<td>Motza</td>
<td>29</td>
<td>Mekor Baruch</td>
<td>49</td>
<td>Bayit VeGan</td>
<td>69</td>
<td>Sar Baher, Um Tuba</td>
</tr>
<tr>
<td>10</td>
<td>Har Hotzvim</td>
<td>30</td>
<td>Mea Shearim</td>
<td>50</td>
<td>Yefeh Nof</td>
<td>70</td>
<td>Um Lison</td>
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<td>11</td>
<td>Sanhedria</td>
<td>31</td>
<td>City Center</td>
<td>51</td>
<td>Herzl Mount</td>
<td>71</td>
<td>Talpiot</td>
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<td>12</td>
<td>Ramat Eshkol</td>
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<td>Musrara</td>
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<td>Ein Karem</td>
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<td>East Talpiot</td>
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<td>French’s Hill</td>
<td>33</td>
<td>Bab A zahara</td>
<td>53</td>
<td>Ein Karem Hospital</td>
<td>73</td>
<td>Talpiot Industrial Zone</td>
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<tr>
<td>14</td>
<td>Mount Scopus</td>
<td>34</td>
<td>Sheikh Jarrah</td>
<td>54</td>
<td>Ramat Hadassah (unbuilt)</td>
<td>74</td>
<td>Baka</td>
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<td>Wadi Joz</td>
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<td>Abu Tor</td>
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<td>A-Tur</td>
<td>56</td>
<td>Kiryat Hayovel</td>
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<td>Jabel Mukaber</td>
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<td>17</td>
<td>Shmuel Hanavi</td>
<td>37</td>
<td>Silwan</td>
<td>57</td>
<td>Kiryat Mennahem</td>
<td>77</td>
<td>Ras al-Amud</td>
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<td>18</td>
<td>Geula</td>
<td>38</td>
<td>Muslim Quarter</td>
<td>58</td>
<td>Givat Massuah</td>
<td>5555</td>
<td>(unbuilt)</td>
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<td>Romema</td>
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<td>Christian Quarter</td>
<td>59</td>
<td>Lavan Ridge</td>
<td>7777</td>
<td>(unbuilt)</td>
</tr>
<tr>
<td>20</td>
<td>Lifta</td>
<td>40</td>
<td>Jewish Quarter</td>
<td>60</td>
<td>Shalmon Mount</td>
<td></td>
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</tr>
</tbody>
</table>

2.0 The Agent-Based Model
The computational model is implemented in JAVA using the GIS functionality of the
REPAST Simphony multi-agent simulation toolbox.11 The model dynamics, the statistical
analysis of the simulation results, and output and input functionality are implemented in
custom JAVA code. All simulation results are fully reproducible knowing the exact
parameter configuration of the respective scenario and the random seed used. Every
simulation run returns detailed statistics on the simulated events (location, time, size,
asassinant/victim identity) and the population distribution in the simulated neighborhoods.
Note that each simulated violent event is marked by an event ID—incidents that occur

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9 The Hebrew University GIS Center: http://hugis.huji.ac.il/.
during the same simulation time step and involve individuals from the same pairing of perpetrator and victim groups are treated as part of the same event.\footnote{In a typical simulation run most episodes of violence correspond to single incidents while episodes consisting of several related incidents account for only \( \sim 20\% \) of the simulated events.}

\subsection{Model Dynamics}

To define time progression from repeated pair-wise interactions, we assume a time step to be the period after which 10 percent of the agent population has been updated. We compensate for the arbitrariness in this definition by exclusively considering time-aggregated simulation results for our analysis and rescaling the total number of simulated events to the total number of empirical events. Effectively, this amounts to comparing relative frequencies of simulated events to the corresponding empirical data. In order to improve computational performance, the agent population in the simulation was scaled down from the empirical population size;\footnote{In the simulation runs reported here, the empirical population was scaled down by a factor of 100.} as long as the relative population sizes and characteristics of the population distributions are maintained, the rescaling can be absorbed in the time step definition without altering the simulation outcomes. The (empirical) population growth rates for each neighborhood are explicitly time-dependent and have been rescaled to reflect the difference in time progression between model and empirical time. In the simulations reported here the time scaling is such that 30 simulation steps correspond to one year; this represents model dynamics that lead to sufficiently large (representative) simulated event samples.

In every time step, an agent migrates and interacts—the order of migration and interaction does not have a systematic influence on the model dynamics.\footnote{Changes in simulated model dynamics arising from inverting this order are negligible since they are no larger than those arising from a different random simulation seed.} Agents relocate with probability \( m_G \) (the group specific mobility) if the local level of violence \( v_R \) exceeds the average level of violence in neighborhood \( N \). If they relocate, they only migrate to neighborhoods where they are not in the minority; if they cannot find such a location, they leave the city.

The logistic function used in the definition of the event probability has a finite value on both sides of the transition point where social distance equals the threshold. We believe such a smooth, graduated transition from non-violence to violence represents a more plausible escalation dynamic than a step function with a sharp transition from non-violence to violence at a certain point. When the value of \( \lambda \) is small (large), the curve is steep (shallow) and \( p_{ij}(t) \) goes to zero and 1 on the respective sides of the transition point at a faster (slower) pace. As part of the formal model estimation, we evaluate the dependence of the model results on the value of \( \lambda \).

Interaction dynamics in the simulation model are residence-based, i.e., only members of the three population groups (Secular/Moderate Orthodox Jews, Ultra-Orthodox Jews, Palestinians) may perpetrate violence;\footnote{Security forces may nonetheless be the targets of violence.} comparing the model to empirical data we therefore exclude violent events perpetrated by security forces. In the 2001–04 (2005–09) period, security forces can be held accountable for 17 (67) violent incidents, yet the overall pattern of violence is very similar with and without those events (Figure A1), mainly because they
are concentrated in quarters of the city with the highest levels of violence. Note that security force violence may both occur in response to violence but also incite further violence. We do account for this potentially adverse effect of policing and police violence in our modeling framework (see also section 4): high levels of policing correspond to more contact with security forces thus increasing the risks of violence when tension is high. In line with the empirical observations but without explicitly matching incidents perpetrated by security forces, our model then exhibits high levels of (potentially violent) policing in violent city quarters—both as a result of and a reason for high levels of violence.

2.2 Model Geography
We seed the geography of Jerusalem and its neighborhoods using shape files such that agents interact on a virtual landscape that mirrors the actual physical geography of the city. In order to reduce the computational complexity of the simulations, agent locations are defined on an underlying regular grid that is dynamically generated using actual settlement locations and their associated densities. This corresponds to a (fine-grained) discretization of geographical space, i.e., the model rests on a finite number of geographical sites or settlement locations.

The grid size of 100 m used in this study is roughly equivalent to the size of settlement or housing blocks. In order to account for both low and high neighborhood population densities, we use a grid of medium granularity to specify agent locations on the model topology and “stack” agents, i.e., locate more than one agent at a given grid point, to capture denser population distributions. The immediate surrounding \( R \) of an agent is operationalized in terms of a Moore neighborhood, a concept drawn from the theory of cellular automata: it consists of all agents located on positions on the regular grid within range \( r \) from the agent. The stacking of agents ensures that within the same range \( r \) an agent has more direct neighbors in a densely compared to a more sparsely populated area. For every neighborhood the largest (empirical) population in the time period considered defines the maximal number of possible agent locations.\(^{16}\)

As noted in the previous section, only agents who belong to the civilian groups are explicitly represented on the model landscape while state authorities are assigned to each neighborhood \( N \) in numbers proportional to the level of policing \( s_N \). Assigning fixed positions to security forces is not realistic: they are typically deployed to a neighborhood and within a short time span may reach any point in the locality. The interaction partners for any agent \( i \) are then randomly drawn from: (1) all civilian agents within local surroundings \( R \), and (2) the security forces. If violence against a civilian agent \( j \) ensues, the violence memory of all affected neighbors in the victim’s immediate surroundings increases; for violence against security forces all neighbors in the perpetrator’s surroundings are affected. An agent’s individual violence memory ranges from 0 (no memory of violence) to 1 (very high exposure to violence); for every experience of violence it increases to 1 and then decays exponentially on a characteristic time scale \( t \). We further assume that memory is not private information but shared by neighbors subjected to violence. The number of security forces interaction

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\(^{16}\) In the case of new housing developments (only relevant for the counterfactual analysis), the projected housing capacities are also considered for the housing capacity.
The probability of civilian violence directed at security forces is then calculated exactly as for interactions with (other) civilian groups since both are driven by local conflict drivers and contact in a given location.\textsuperscript{17}

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2.3 Empirical Parameters
The values for the mobility parameters $m_c$ are developed based on results from the Israel Social Survey (2002–07) conducted by the Central Bureau of Statistics, according to which about 10 percent of the Ultra-Orthodox Jewish population, 20 percent of the Secular Jewish population and 30 percent of the Palestinian population are not satisfied with their current residential location. We take these figures as a measure of the motivation to migrate, then factor in that at any given point only a fraction of the population—assumed to be 10 percent—considers or is capable of moving, before translating the values to a unit interval scale. The agent population, the corresponding natural population growth, and the housing capacity of each neighborhood are given as empirical inputs for both the 2001–04 and 2005–09 period; in the counterfactual analysis they are based on the specific provisions of each scenario.

3.0 Model Estimation
The simple heuristic methodology we employ enumerates the model’s parameters and identifies parameter combinations for which the model best approximates the empirical data along the specified dimensions of agreement. First, the full parameter space is covered in a coarse-grained sweep; the parameter region of interest where the model exhibits the best agreement in all dimensions is then subjected to a fine-grained analysis. In the first sweep, the minimal conditions for qualifying a parameter vector as having “good agreement” are set for the 2001–04 (2005–09) period as 0.75 (0.8) location of violence match, 0.3 (0.5) Pearson’s correlation for the number of violent events per neighborhood, and 0.9 (0.9) Pearson’s correlation for the attack targets by group. In the fine-grained parameter sweep, the latter condition is increased to a 0.95 Pearson’s correlation allowing only for very good (city-wide) representations of the violence dynamics. Note that the coarse-grained sweep already reliably identifies the parameter ranges leading to good agreement with data. The subsequent fine-grained analysis simply yields even better quantitative agreement—it more precisely identifies the parameter ranges of parameter combinations with the best agreement to data (see also Figure 5 and A4). In order to define a reference scenario for each period, we then identify within this subset of “best agreement” the parameter combination for which the simulation model most reliably exhibits the maximal agreement (see Table A2 for an overview).\textsuperscript{18}

<table>
<thead>
<tr>
<th>Table A2. Reference Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>period</strong></td>
</tr>
<tr>
<td>2001-2004</td>
</tr>
<tr>
<td>2005-2009</td>
</tr>
</tbody>
</table>

L: location of violence; D: number of violent events per neighborhood; T: attack targets by group * p<0.005 (Pearson's correlation)
S: Secular/Moderate Orthodox Jews; U: Ultra-Orthodox Jews; P: Palestinians and F: Security Forces

\textsuperscript{18} The run that “most reliably” agrees with the data is the one with the highest average quantitative agreement in all three dimensions of agreement for 100 simulation runs.
In order to guarantee that our specific choice of $\lambda$, $r$ and $t$—the scale of the logistic threshold function, the size of the local surroundings $R$, and the time scale for memory decay—does not impact the estimation of the social distance and discrimination parameters, we simultaneously also vary these parameters in three discrete steps each ($\lambda \in \{0.02, 0.05, 0.08\}$; $r \in \{2, 5, 8\}$; $t \in \{20, 30, 40\}$). Figure A2 shows the occurrence of these parameter values in the subset of “best agreement.” The majority of parameter combinations with excellent agreement to data assumes $\lambda = 0.05$, $r = 5$ and $t = 30$, though the model’s agreement to data is more strongly dependent on the choice of $\lambda$ and $r$ than on $t$. Note that in contrast to social distance and discrimination these parameters do not have clear empirical referents, however, we may nonetheless check their face validity. For $r = 5$ the local surroundings in the model have a radius of 500m, this is larger than the immediate neighborhood but smaller than the size of an average residential quarter—in this sense it captures well the geographical unit at which local contact takes place. The violence memory time scale of $t = 30$ simulation steps corresponds in our scaling to one year; in other words, after one year, given no further exposure to violence, the memory of a violent incident will have mainly faded. While for major incidents this may appear too short it nonetheless adequately captures the notion that the memory of exposure to violence lingers for a considerable time. The threshold scale value of $\lambda = 0.05$ simply implies that the transition from non-violent to violent behavior is not too abrupt (for $\lambda = 0.02$ the probability, $p$, takes a form much closer to a step function); at the same time the specification ensures that it is very unlikely that for low social distances violence ensues (this is much more likely at $\lambda = 0.08$ or larger; see also Figure 1 in the manuscript). In that sense, the value of $\lambda$ we find in the estimation yields plausible threshold dynamics.

**Figure A2. Interaction Parameter**

In the model estimation procedure the number of scenarios to be simulated increases with the number of parameters varied; it also grows as the step size of the parameter variations decrease. Therefore, even for a model with a small number of parameters scanning the whole parameter space at a reasonable resolution is computationally very intensive. The multi-step procedure we employ here helps to mitigate this issue: a coarser initial parameter resolution allows enumerating the full parameter space at an acceptable computational cost, whereas the subsequent fine-grained analysis of the parameter subset that leads to good agreement with data guarantees that the parameter values leading to the best agreement with data are precisely identified.

The model enumeration procedure has a few limitations: (1) it only reliably detects regions of good agreement with data that are larger than the resolution of the first coarse-
grained parameter sweep; however, making the steps in the coarse-grained analysis sufficiently small mitigates this problem; (2) using a finite step size for the parameter variations the procedure implicitly requires that there are no extreme changes in the fit measures for small parameter variations—this limitation is inherent to procedures using finite step sizes; (3) among the parameter regions with good agreement to empirical data, only the largest region is reliably identified. We are confident, however, that these limitations do not affect the optimization results in the present case: the coarse-grained enumeration is using relatively small step sizes and an analysis of the fit measures as a function of the model parameters in this coarse-grained parameter sweep indicates that only one general parameter region leads to a good fit along all three fit dimensions; there also do not appear to be sudden changes in the fit measures for small parameter variations.

3.1 Measures for Quantitative Agreement

The quantitative model optimization requires clear criteria for identifying if a simulated scenario is consistent with the empirical observations or not and to what degree. We compare the simulation results to the empirical data along three dimensions:

- a neighborhood is violent or non-violent (location of violence)
- the exact number of violent events in each neighborhood
- the attack targets by group, i.e., which population group is responsible for which fraction of attacks on which other population group(s)

It is possible to have good agreement in the location of violence while at the same time the quantitative agreement in the number of events per neighborhood is quite poor and vice versa. The attack targets by group are considered on the city-level, guaranteeing that the violence dynamics are (globally) representative of the empirical violence dynamics.

The comparison between simulated and empirical data in each of the three dimensions is formalized using standard measures: the agreement for the location of violence may be compactly expressed as the percentage of neighborhoods for which “violence” or “no violence” is correctly predicted in the simulated data. In order to test if two patterns of violent/non-violent neighborhoods are significantly different we use a non-parametric McNemar test (McNemar 1947). The number of violent events per neighborhood statistics may be cast in the form of a data series where each entry corresponds to the number of attacks in a specific neighborhood. The degree of agreement between the empirical and simulated series may then be quantified using different measures: we use standard Pearson’s correlation and several root mean square deviation (RMSD) measures. Used for example in bioinformatics, RMSD measures are well suited to quantify how precisely a predicted data series corresponds to an empirical reference series. The common definition of the root mean square deviation is:

\[ \text{RMSD} = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (x_i - y_i)^2} \]

where \( \{x_i\} \) and \( \{y_i\} \) for \( i=1\ldots n \) are two data series representing the empirical and predicted distributions of violence respectively; \( n \) is the number of neighborhoods. The measure returns the number of attacks by which the simulation and the empirical data are (on
average) not agreeing. It may also be normalized to the average number of attacks per neighborhood and is then referred to as the coefficient of variation of the root mean square deviation (CVRMSD); normalizing with the maximal range of values in the data series yields the normalized root mean square deviation (NRMSD). Note that the measures are generally quite consistent in estimating the per neighborhood agreement; in the optimization procedure we relied on Pearson’s correlation as the quantitative criterion.

The attack targets by group statistics may also be formalized as a data series, the entries corresponding here to the nine interaction pairings between actor groups that may lead to violence: Secular/Moderate Orthodox Jews attacking Palestinians, Ultra-Orthodox Jews or security forces; Palestinians attacking Secular/Moderate Orthodox Jews, Ultra-Orthodox Jews or security forces; and Ultra-Orthodox Jews attacking Secular/Moderate Orthodox Jews, Palestinians or security forces. The quantitative agreement between the simulated and empirical distribution of violence targets may then again be estimated using a simple Pearson’s correlation, analogous to the measure for the per neighborhood agreement in the distribution of violence.

4.0 Validation
The validation procedures detailed below indicate that the simulation model has a high degree of internal validity and can thus serve as a reliable basis for the counterfactual analysis conducted. To this end we first analyze the model’s predictive power, in-sample and compared to a base line model; the analysis focuses on the 2005–09 period since the counterfactual analysis is based on the dynamics of this period. We then verify that parameter values for social distance and discrimination obtained through formal optimization are consistent and reflect observed levels of intergroup tension and discrimination in Jerusalem—a strong indication of the internal validity of the individual (micro) level model mechanisms.

4.1 In-Sample Validation
The in-sample validation performed here replaces an out-of-sample prediction test: we train the model on geographically and temporally sliced subsets in the 2005–09 period and then test its predictive power on the remaining subsets. Splitting the data geographically, the neighborhoods constituting the “training set” are selected by randomly drawing half of the non-violent and half of the violent neighborhoods; the “test set” covers the remaining neighborhoods.\(^{19}\) The corresponding training and test datasets then cover all incidents in the 2005–09 period for their respective subset of neighborhoods (we generated training and test datasets for 20 different random geographical slices). Slicing temporally, the following five splits of the data set (training vs. test dataset) were analyzed: (1) 2005–06 vs. 2007–09; (2) 2005–07 vs. 2008–09; (3) 2005–08 vs. 2009; (4) 2005–06, 2009 vs. 2006–07; (5) 2005, 2009 vs. 2006–08. In the first validation step, the simulation model is optimized for the training set with the same procedure used to obtain the reference scenarios.\(^{20}\) Testing its predictive

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\(^{19}\) Independently drawing from the violent and non-violent neighborhoods ensures that the training and test set have similar numbers of violent and non-violent neighborhoods.

\(^{20}\) For the spatial slices, the matching in both the training and in the testing stage is done only for the neighborhoods that are part of the respective subset; the spatially sliced datasets by definition do not contain data on the neighborhoods outside of the sample.
power, the optimized model is run on the test dataset. This step is repeated 100 times with different random simulation seeds to obtain confidence intervals for the quantitative agreement.

The results of the in-sample predictions are summarized in Figure A3. In the case of spatial slicing (Figure A3a), the model optimized for the training set predicts violence in the test dataset with on average 0.75 location match, 0.45 correlation for the number of violent events per neighborhood and 0.75 for the attack targets by group. This quantitative agreement is in the range of the optimized scenarios for the training sets. Note, however, that a number of splits deviate substantially for one of the measures—this can be attributed to a substantial difference between training and test datasets: if the two sets are too different it is not possible that the parameter vector optimized for the training set matches the test set with high precision. This is most noticeable for the attack targets by group for which a few
of the splits (split 4, 6, 9 and 13) show comparably lower agreement. For the temporal slices of the dataset (Figure A3b) the model optimized for the training datasets predicts violence in the test datasets on average with 0.72 location match, 0.36 correlation for the number of violent events per neighborhood and 0.7 for attack targets by group. The degree of agreement for the attack targets by group again varies, which may be attributed to the fact that training and test set when splitting temporally may in fact be quite different; in particular, the distribution of attack targets by group changes substantially over time. Overall, however, the generally strong quantitative agreement with the test datasets is a strong indication that the simulation model has substantial in-sample predictive power. Note further that optimized parameter vectors for both spatial and temporal subsets are very similar to the parameter vector of the reference scenario; this points to a high consistency of the model mechanisms in predicting the empirical violence patterns (see also section 4.3).

### 4.2 Comparison to Baseline Model

We further verified that the simulation model has added explanatory value compared to a simple statistical baseline model. Our data indicates a strong regularity in the location and intensity of violence in the 2005–09 period; consequently, we expect past violence to be an excellent predictor for future violence within that period. We construct the model’s prediction for the number of violent events in a neighborhood $N$ by assuming that $\text{violence}_{N}(\text{year}) = \text{violence}_{N}(\text{year-1})$. The predictive power of our simulation relative to the statistical model is estimated by regressing the empirical number of violent events per neighborhood against the predictions of the two models. We find that the predictions of both models are significant (Table A3)—in the combined model, the simulated results significantly increase the explanatory value compared to the baseline model.\(^{21}\) Note that the statistical baseline model is intentionally kept simple.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Past Violence Model</th>
<th>Simulation Model</th>
<th>Past Violence &amp; Simulation Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Events per neighborhood constructed from past violence</td>
<td>1.084*** (0.117)</td>
<td>0.795*** (0.109)</td>
<td></td>
</tr>
<tr>
<td>Simulated events per neighborhood</td>
<td>0.924*** (0.116)</td>
<td>0.595*** (0.101)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.948** (0.230)</td>
<td>0.112 (0.354)</td>
<td>0.099 (0.292)</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>79</td>
<td>79</td>
<td>79</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.526</td>
<td>0.443</td>
<td>0.667</td>
</tr>
</tbody>
</table>

Note: Linear regressions, dependent variable: empirical number of violent events per neighborhood for the 2005–09 period. Standard errors are given in parentheses. Two-tailed significance test: * $p<0.05$ ** $p<0.01$ *** $p<0.001$

\(^{21}\) F-test: $F=34.93$, $p<0.001$. 

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\(^{21}\) F-test: $F=34.93$, $p<0.001$. 

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4.3 Consistency of Parameter Values in the Subset of Good Fits

The distribution of the social distance and discrimination parameter values in the subset of parameter combinations that generate the best agreement with empirical data for the 2001–04 period is shown in Figure A4 (the corresponding figure for the 2005–09 period is Figure 5 of the manuscript). The distribution of parameter values for each parameter is an important indicator of model fit and parsimony—in this analysis we follow Weidmann and Salehyan (2013). The more similar the parameter combinations in the subset, the more reliably the model approximates empirical data. In particular, a low spread in values for each parameter is a strong indicator that each parameter is necessary for generating model fit. In Figure A4 a circle represents the occurrence of a given parameter value for the 2001–04 period; the larger the circle the more often this parameter value is assumed in the subset. The parameter values of the reference scenario are marked with a black circle. As in the 2005–09 period, all parameters in the subset of good fits are very consistent, featuring a low spread around the values assumed in the reference scenario.

Figure A4. Distribution of Parameter Values in the Subset of Good Fits (2001–04)

4.4 Empirical Plausibility of Parameter Values

In this section, we assess the plausibility of parameter values generated by the calibration exercise, specifically inter-group tension and discrimination, to the empirical situation. In the 2001–04 period, the only recorded incidents of violence perpetrated by Secular/Moderate Orthodox Jews are carried out against Palestinians; in the reference scenario, this is correctly represented by a vanishing (or close to vanishing) social distance of Secular/Moderate Orthodox Jews towards all groups but Palestinians. Similarly, Ultra-Orthodox Jews in that time period only engage in violence towards Palestinians reflected in the large social distance towards this group. Palestinians perpetrate the majority of events, which in the reference scenario translates to non-zero social distances to the other population groups; in particular, the relationship with Secular/Moderate Orthodox Jews is very strained during the second
Intifada. Note that both Secular/Moderate Orthodox and Ultra-Orthodox Jews in that time period do not perceive to be strongly discriminated by the state security forces, whereas Palestinians are subject to strict security measures and certainly perceive the resulting limitations in everyday life as (state) discrimination. The situation is consistently reflected in the discrimination variables of the reference scenario.

In the 2005–09 period there is close to no recorded violence of Secular/Moderate Orthodox Jews towards Ultra-Orthodox Jews and no violence towards security forces. Compared to the 2001–04 period there is also less Secular/Moderate Orthodox violence towards Palestinians. This again is reflected in the social distance as the tension proxy of the model, in particular a smaller social distance represents the decrease in Secular/Moderate Orthodox violence against Palestinians. In contrast to the 2001–04 interaction dynamics, Ultra-Orthodox Jews primarily engage in violence with security forces; this is representative of the increasing estrangement from the Israeli state and radical opposition towards government involvement in Ultra-Orthodox affairs. In the reference scenario, this development is both reflected in the increased social distance towards security forces and the higher perception of (state) discrimination. Similar to the 2001–04 period, Palestinians carry out most recorded attacks; the observable shift in violence targets towards security forces is represented by a corresponding shift in the social distance parameters in the best fit vector.

Consistent with the model mechanisms, the limiting case of no violence in the simulated data corresponds to parameter vectors with vanishing social distance. The location of violence match for the 2001–04 (2005–09) period in this case is 0.32 (0.57) and the Pearson’s correlation for the number of violent events per neighborhood and the attack targets by group simply vanishes. The non-zero value for the location of violence measure arises from the fact that in the 2001–04 (2005–09) period 24 (44) of 77 neighborhoods are empirically non-violent. Note that the 2001–04 reference scenario has a poor quantitative agreement with the 2005–09 empirical data, verifying that parameter vectors representing different interaction dynamics lead to poor agreement in the fit measures.

4.5 Adverse Effect of Policing

The effect of policing is conditional on the level of inter-group tension. It tends to mitigate violence for small social distances towards security forces but may incite violence if tensions are high (see also section 2.1). We validate that this aspect is correctly represented in our framework analyzing a stylized scenario identical to the 2005–09 reference scenario but with social distances between civilian population groups set to zero, i.e., we exclusively model violence directed at the police. The simulations demonstrate that if social distance between a population group (in this case Ultra-Orthodox Jews and Palestinians) and the police is high, violence is self-perpetuating with levels of violence directed at the police nearly as high as in the reference scenario. We then confirm that this adverse effect vanishes for social distances towards the police below a critical value of around 0.4.

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22 The no violence case then also sets the natural base line for the fit measures.
23 The location of violence match in this case is below 0.61 and it has a Pearson’s correlation of 0.28 for the distribution of violence and of 0.57 for the distribution of violence targets.
24 We initialize the model with different levels of policing and let the scenario develop endogenously afterwards; as long as this initial level is sufficiently high (> 0.2), the resulting violence dynamics are comparable.
5.0 Counterfactual Scenarios

The potential “futures” of Jerusalem are characterized by specific provisions concerning the city’s population structure and migration dynamics. The inter-group relations underlying the violence mechanism are those of the reference scenario—any deviations in violence patterns from those of the reference scenario may therefore be fully attributed to the provisions of the “futures”. We report average statistics for the trends in the number of affected neighborhoods and total number of events generated from 100 runs that only differ in their random seed—this accounts for the influence of the probabilistic nature with which violence ensues. The futures are then illustrated using representative (or ideal typical) runs, i.e., simulation runs that have the most similar number of total events and violent neighborhoods compared to the average values of the scenario they represent. In order to draw conclusions regarding a relative increase/decrease in violence, the event distributions are rescaled relative to the total number of events in the reference scenario.\(^{25}\) Correspondingly, the violence categories used to visualize the results of the counterfactual analysis are comparable to those of the reference scenario; the use of qualitative categories emphasizes that the figures demonstrate forecasts of general trends and not precise predictions for expected numbers of violent incidents per neighborhood. The detailed provisions of the four “futures” discussed in the manuscript are given below. In order to develop an intuition for the degree to which trends in the scenarios are contingent on changes in inter-group relations, we explored a “worst” and “best” case realization of each of the four futures (see Table A6 for an overview). These worst and best case scenarios are of course highly stylized but may still serve to illustrate how specific (political) developments would affect the simulated violence dynamics. The specific assumptions we make with regard to potential changes in social distance between population groups and perceptions of discrimination are informed by a number of public opinion polls.\(^{26}\) Additionally, we introduce two stylized scenarios—Uniform Mixing and Localized Segregation—that illustrate the effect of neighborhood composition.

\(^{25}\) The event distributions become comparable to the reference scenario by rescaling with the same scaling factor: the number of events in the reference scenario divided by the total number of empirical events.

\(^{26}\) List of sources:


5.1 Business as Usual

The most similar to the reference scenario, this “future” reflects trends in the population dynamics already visible at present and believed to impact the dynamics in the city in the near future. The initial population in the scenario is based on the empirical distribution of the year 2008. Palestinians are assumed to have a strong preference to reside in East Jerusalem and only consider moving to neighborhoods in the East.\textsuperscript{27} The Ultra-Orthodox population growth is set to 4 percent annually, reflecting the empirical trend of an increased population growth compared to the remainder of the population. Capturing the fact that Ultra-Orthodox tend to move to neighboring Secular/Moderate Orthodox quarters, those areas are considered to have a 50 percent probability for Ultra-Orthodox in-migration. The scenario further reflects the substantial Ultra-Orthodox migration to the three neighborhoods Ramat Shlomo, Kiryat Hayovel and Har Homa by introducing a (small) bias in every Ultra-Orthodox migration decision towards a move to those neighborhoods. The Muslim, Christian and Armenian Quarter see additional Jewish population growth as a consequence of right-wing Jewish groups pushing to obtain property and establish settlements in the holy basin.

As the “worst” case situation, we assume that Israel would continue to expand settlements in East Jerusalem, partly in currently unsettled locations (e.g., Givat Hamatos in the south, Ramat Shlomo in the north), and partly by claiming/re-claiming property arguably owned by Jews in the past (e.g., Sheikh Jarrah north of the old city, Silwan south of the old city, Ras el-Amud east of the old city). This would create more points of friction, undoubtedly increase feelings of discrimination among Palestinians (in general and specifically in these locations) and contribute to increased social distance towards the Jewish population groups. In the model, these developments are reflected by an increase in the Palestinian perception of discrimination (+0.05 compared to the reference scenario) and an increase of social distance of Palestinians toward the two Jewish population groups (+0.05 towards each faction).

In a “best” case scenario, Israel might stop expansion toward the East and invest heavily in improving Palestinian infrastructure (roads, building permits, educational system, employment/business centers in the East, etc.). Overall, this should significantly reduce feelings of discrimination and Palestinian social distance towards Israelis and security forces—we represent this by a decrease in the Palestinian perception of discrimination (−0.1) and a significant decrease in social distance towards Secular Jews and security forces (−0.1 towards each faction). We assume that civic relations with Ultra-Orthodox Jews will remain as strained as before, with tension continuing to arise from conflict over access to holy sites in the old city and in East Jerusalem.

| Table A4: East Jerusalem Neighborhoods under Palestinian Authority |
|-------------------|-------------------|-------------------|
| **Return to 1967** | **Clinton Parameters** | **Palestinian Proposal** |
| 1, 2, 3, 4, 5, 6, 7, 8, 12, 13, 14, 15, 16, 33, 34, 35, 36, 37, 38, 39, 40, 41, 64, 65, 66, 67, 68, 69, 70, 72, 75, 76, 77 | 1, 2, 5, 15, 33, 34, 35, 36, 37, 38, 39, 41, 64, 66, 69, 70, 75, 76, 77 | 1, 2, 5, 15, 33, 34, 35, 36, 37, 38, 39, 64, 66, 69, 70, 75, 76, 77 |

\textsuperscript{27} The definition of East Jerusalem is in accordance with the boundaries of 1967 (Table A4).
5.2 Return to 1967

The return to the boundaries of 1967 implies major changes to the population structure of the city, in particular, it assumes that the Jewish population in former Jewish East Jerusalem neighborhoods would be evicted and relocate to newly constructed dwellings in the West or, in the case of Ultra-Orthodox Jews, largely migrate to neighboring cities. The new Jewish dwellings are expected to be constructed in the neighborhoods of Ein Karem, Ein Lavan and in the area north of Ein Karem and west of Har Nof. The projected size of the new dwelling units is estimated from information on planned construction in those neighborhoods (Table A5). The scenario assumes that half of the Palestinian population in (former) East Jerusalem relocates to the vacated neighborhoods; within three years the neighborhoods are then again fully settled due to a substantial inflow of Palestinians from the West Bank. In this process the total population balance in the city shifts in favor of Palestinians. In particular, the Ultra-Orthodox population fraction declines significantly due to their out-migration, while their annual population growth assumed at 4 percent remains the largest in the city. The clear division into Israeli West and Palestinian East Jerusalem has two main implications: (1) The east of the city comes under Palestinian authority—analogous to the interaction of Secular/Moderate Orthodox Jews with the Israeli security forces in the West, there is no confrontation between the (almost exclusively Palestinian) population in the East and the Palestinian security forces. In the simulations this is captured by a vanishing social distance (tension) between population and security forces. (2) There are strict restrictions on mobility between the two parts, both for relocation within the city as well as for daily movement around the city: (a) Jewish citizens will only consider moving to neighborhoods in the West, Palestinian citizens only to neighborhoods in the East; (b) mobility across the East/West divide is reduced such that a person from the East (West) only has a reduced probability to interact with a person from the West (East). The scenario further reflects the special case of the Palestinian neighborhoods Sharafat and Beit Safafa where inhabitants are either Israeli citizens or Israeli residents but the identity of both groups is Palestinian. The two neighborhoods are among the richest in the East and their inhabitants are very unlikely to move to other Palestinian neighborhoods in East Jerusalem. At the same time, the scenario assumes no considerable in-migration of other Palestinians since there are very attractive (former Jewish) neighborhoods closer to the Palestinian city center. The simulation accounts for this special case by disallowing migration to and from the two referred neighborhoods. The “future” further assumes a special international regime for the holy basin and Mount Scopus: maintaining the status quo in particular implies no major shift in demographic balance. In the simulation, migration to and from neighborhoods in the holy basin is therefore subjected to the condition that the population fractions may not change by more than 5 percent compared to the status quo where the 2008 population in each quarter defines this status quo.

Dividing the city entails a massive relocation of the Jewish population from East Jerusalem—while it is safe to assume that they would be nicely compensated, a re-

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28 The empirical distribution of the year 2008 is taken as the base to which changes of the population structure are applied.
29 Adjusting for the different relationship of the population to the security forces in the East is the minimal generalization of the violence mechanism to the case where security forces represent two different state actors.
30 The value of the mobility restriction is chosen based on trial runs; at the selected value of the mobility restriction the observed dynamics are first noticeably affected.
partitioning of the city will in the “worst case” lead to strong resentments toward Palestinians across all segments of the Jewish population and also potentially increase distance between the Jewish population and the Israeli security forces (demonstrations, sabotage, violent attacks, etc.). Note that in particular ceasing control of the old city would contribute to the social distance of Jews towards Palestinians. The “worst case” scenario reflects these developments through an increase of social distance towards Palestinians (+0.05 for Ultra-Orthodox and Secular) and Israeli security forces (+0.05 Ultra-Orthodox, +0.1 Secular). In addition, dividing the city and re-settling Palestinians in the former Jewish enclaves in East Jerusalem might create intra-Palestinian frictions (Jerusalemites vs. newcomers) and increase social distance between Palestinians and Palestinian security forces (+0.1). If the agreement does not include specific provisions allowing Palestinians access to centers of employment in the West this would likely negatively affect Palestinian perceptions of discrimination (+0.05).

The effects of partition, however, could be moderated if specific provisions were to be introduced into the agreement. In such a “best case” scenario relatively free travel across the East/West divide would be possible allowing Palestinians easy access to employment centers (in the West), and Jews access to the old city and other holy and symbolic locations in the East. Overall this might lead to slight but visible improvements in civic relations both on the side of the Palestinians (−0.05 towards Secular Jews and −0.1 towards Israeli security forces) as well as on the side of the Ultra-Orthodox Jews (−0.05 towards Palestinians); moreover, it should positively affect perceptions of discrimination among Palestinians (−0.1).

Table A5: Housing Projects Relevant to the “Futures”

<table>
<thead>
<tr>
<th>Neighborhood ID</th>
<th>Neighborhood Name</th>
<th>Expected Residents</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>Ein Karem</td>
<td>9900</td>
</tr>
<tr>
<td>55</td>
<td>Ein Lavan</td>
<td>45000</td>
</tr>
<tr>
<td>5555</td>
<td></td>
<td>6750</td>
</tr>
</tbody>
</table>

5.3 Clinton Parameters

In comparison to Return to 1967, the changes to the population structure assumed here are less fundamental: the city remains integrated without exchange of territories or similar measures, however, the transfer of authority and the responsibility for maintaining security in East Jerusalem to the Palestinians again has a substantial impact on the projected violence dynamics. The city remains integrated but relocation is assumed to be strictly divided along ethnic lines: Jewish (Secular/Moderate Orthodox and Ultra-Orthodox) inhabitants’ migration is limited to Jewish neighborhoods and Palestinian migration to Palestinian neighborhoods. This also implies a slow out-migration of Jews from mixed neighborhoods in the East and of Palestinians from mixed neighborhoods in the West. The inhabitants of Sharafat and Beit Safafa are subject to the same migration restriction as in the previous scenario and the Ultra-Orthodox population growth rate is again set to 4% annually. There is no clear division into Israeli West and Palestinian East Jerusalem, but as a consequence of security concerns Palestinian access to Jewish neighborhoods is restricted; this is implemented analogous to the (general) East/West mobility restriction in the Return to 1967.

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31 The definition of neighborhoods constituting East Jerusalem in this scenario may be found in Table A4.
scenario. The “future” is further subject to a special international regime for the holy basin and Mount Scopus as detailed in Return to 1967.

In a “worst case” scenario this future might be perceived as a compromise that no side is actually content with—together with new points of frictions between Palestinians and Israelis we would thus generally anticipate additional strains on all inter-group relations. In the case of the Ultra-Orthodox faction the loss of control over symbolic sites like Mt. Olive and the old city would also contribute to the rising social distance towards Palestinians (+0.05). The general strain of civic relations would also be reflected in Palestinian relations with Secular and Ultra-Orthodox Jews (+0.05 towards both factions). The general dissatisfaction of Palestinians—due to substantial losses of areas in East Jerusalem as a consequence of the agreement, for example—might lead to increased tensions with Palestinian security forces (+0.05) and rising perceptions of discrimination (+0.05). Analogous to the Return to 1967 scenario, these negative effects could be moderated by introducing additional provisions to the agreement. The consequences of such a “best case” scenario with regard to social distances and perceptions of discrimination would be analogous to those detailed for Return to 1967.

5.4 Palestinian Proposal

This scenario reflects a number of concessions Palestinian negotiators are purported to have brought forward in May 2008 and that were first reported by The Guardian in January 2011: the sovereignty in the city would be largely divided along the lines specified by the Clinton parameters with a few marked exceptions. The Palestinian side would accept Israeli authority over the Jewish settlements in East Jerusalem with the exception of Har Homa (the neighborhood has a critical strategic importance as it provides Palestinians with direct access to Bethlehem and would be put under Palestinian authority). The scenario further assumes that the Israeli inhabitants of Har Homa relocate to new housing developments in Ein Karem and in the area North of Ein Karem and West of Har Nof; the neighborhood would initially be half settled by Palestinian citizens of East Jerusalem with the remainder of the dwellings occupied by Palestinians moving in from the West Bank over the course of the next three years. As a concession to Israeli interests, the Palestinians would in turn agree to give Israel control over two controversial areas: the Israeli settlement of Shimo’n Hatzadik in the Palestinian neighborhood of Sheikh Jarrah, including the nearby sacred graves, and the Armenian quarter in the old city. The Palestinian proposal also includes provisions regarding the other key points of conflict such as the status of the old city, operationalized here as the special international regime detailed in the Return to 1967 scenario. The “future” further assumes a clear division into Israeli West and Palestinian East Jerusalem with the same restrictions on mobility as outlined in the Return to 1967 scenario. Analogous to the previous scenarios, the Ultra-Orthodox population growth rate is set to 4 percent annually and the inhabitants of Sharafat and Beit Safafa are again subject to the same migration restrictions.

This scenario is very similar to the Clinton Parameters in its key structural changes and we assume its “worst case” and “best case” developments to be analogous, both

32 The Guardian (2011); the newspaper provides access to leaked internal documents and reports documenting the content of the talks at http://www.guardian.co.uk/world/palestine-papers-documents/browse (accessed August 8, 2012).
Table A6: Best and Worst Case Realizations of the “Futures”

<table>
<thead>
<tr>
<th>Counterfactual Scenario</th>
<th>Total number of violent events**</th>
<th>Number of violent neighborhoods**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>std.</strong></td>
</tr>
<tr>
<td>Business as Usual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best Case</td>
<td>-48%</td>
<td>9%</td>
</tr>
<tr>
<td>Status Quo*</td>
<td>+6%</td>
<td>8%</td>
</tr>
<tr>
<td>Worst Case</td>
<td>+39%</td>
<td>10%</td>
</tr>
<tr>
<td>Clinton Parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best Case</td>
<td>-60%</td>
<td>8%</td>
</tr>
<tr>
<td>Status Quo*</td>
<td>-33%</td>
<td>8%</td>
</tr>
<tr>
<td>Worst Case</td>
<td>+5%</td>
<td>9%</td>
</tr>
<tr>
<td>Palestinian Proposal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best Case</td>
<td>-67%</td>
<td>8%</td>
</tr>
<tr>
<td>Status Quo*</td>
<td>-42%</td>
<td>8%</td>
</tr>
<tr>
<td>Worst Case</td>
<td>-25%</td>
<td>11%</td>
</tr>
<tr>
<td>Return to 1967</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best Case</td>
<td>-75%</td>
<td>8%</td>
</tr>
<tr>
<td>Status Quo*</td>
<td>-52%</td>
<td>8%</td>
</tr>
<tr>
<td>Worst Case</td>
<td>-26%</td>
<td>8%</td>
</tr>
</tbody>
</table>

*Status Quo: counterfactual results based on 2005–09 parameter values without additional changes to social distance and discrimination
**relative increase/decrease compared to the total number of violent events (neighborhoods) in the reference scenario

with regard to expected developments and their operationalization via changes in social distance and perceptions of discrimination.

5.5 Uniform Mixing
In this stylized scenario the population of each neighborhood is recast to reflect the citywide ratio of the social groups in 2005 (41% Secular/Moderate Orthodox Jews, 25% Ultra-Orthodox Jews, 34% Palestinians). Uniform mixing is further achieved by randomizing the position of all agents within each neighborhood. The outcome of the simulation (Figure A5a) is a diffusion of violence to West Jerusalem, with a substantial increase in frequency in several neighborhoods, which contrasts with the 2005–09 reference scenario where the bulk of violence occurs in East Jerusalem. Consistent heterogeneity did not, however, result in the diffusion of violence to all parts of the city, and several neighborhoods remained unaffected, largely due to their small population sizes. Of note, the correlation between the frequencies of violence in the representative run of the complete mixing counterfactual and the reference scenario is high (0.44). However, the counterfactual yields the same prediction for the onset of violence as the reference scenario in only 50 of 77 neighborhoods (64.9%) and as the empirical data in 41 of 77 neighborhoods (53.2%).

5.6 Localized Segregation
This second stylized scenario represents the opposite case to Uniform Mixing. Locally segregated populations are designated by changing the demography of Jerusalem to create entirely homogeneous neighborhoods. For this purpose, in each neighborhood we maintain the total population from 2005 but only seed the majority group. A comparison of the representative run to the 2005–09 reference scenario indicates a reduction in violence in 13 East Jerusalem neighborhoods and 11 West Jerusalem neighborhoods (Figure A5b). The correlation between the frequencies of violence is high (0.65). Also, the simulation matches the reference scenario with respect to the occurrence of violence in 65 of 77 (84.4%) and the empirical data in 56 of 77 neighborhoods (72.7%).
The *Uniform Mixing* counterfactual represents the limiting case of maximum inter-group contact and produced a sharp increase in both the number of violent neighborhoods (+65%, relative to the reference scenario) and the frequency of violence (+240%). *Localized Segregation* on the other hand features minimal inter-group contact within each neighborhood and consequently sees a significant reduction in violence (−15% violent neighborhoods, −23% violent events). The two scenarios thus demonstrate the maximum extent to which neighborhood composition within each neighborhood influences levels of violence.

**Figure A5. Additional Counterfactual Results**

(a) Uniform Mixing  
(b) Localized Segregation
References


