

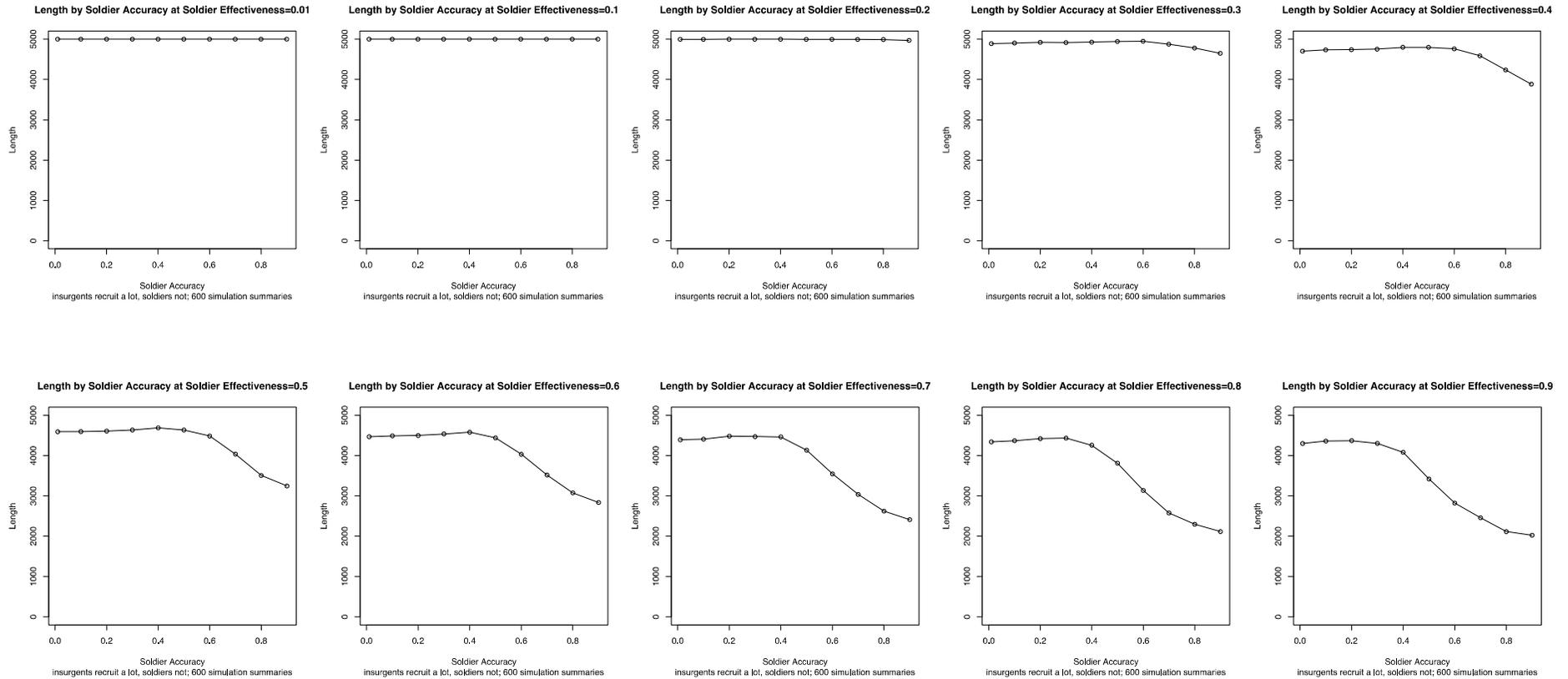


Web Appendix for “Violent and Non-Violent Strategies of Counterinsurgency”, by Anna O. Pechenkina and D. Scott Bennett, published on 31 October 2017 in JASSS-Journal of Artificial Societies and Social Simulation, 20(4), 11: <http://jasss.soc.surrey.ac.uk/20/4/11.html> [doi: DOI: 10.18564/jasss.3540]

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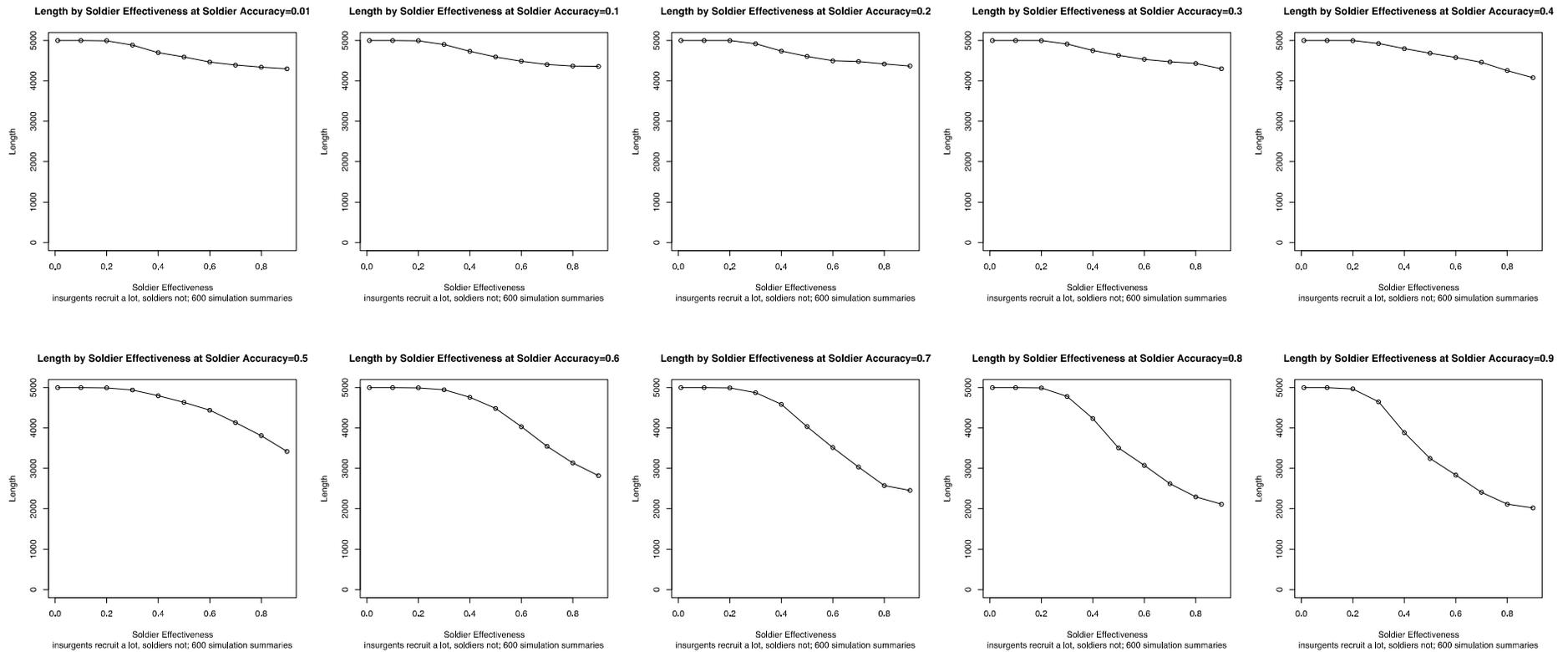
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## Section 1: Figures 1a-4b



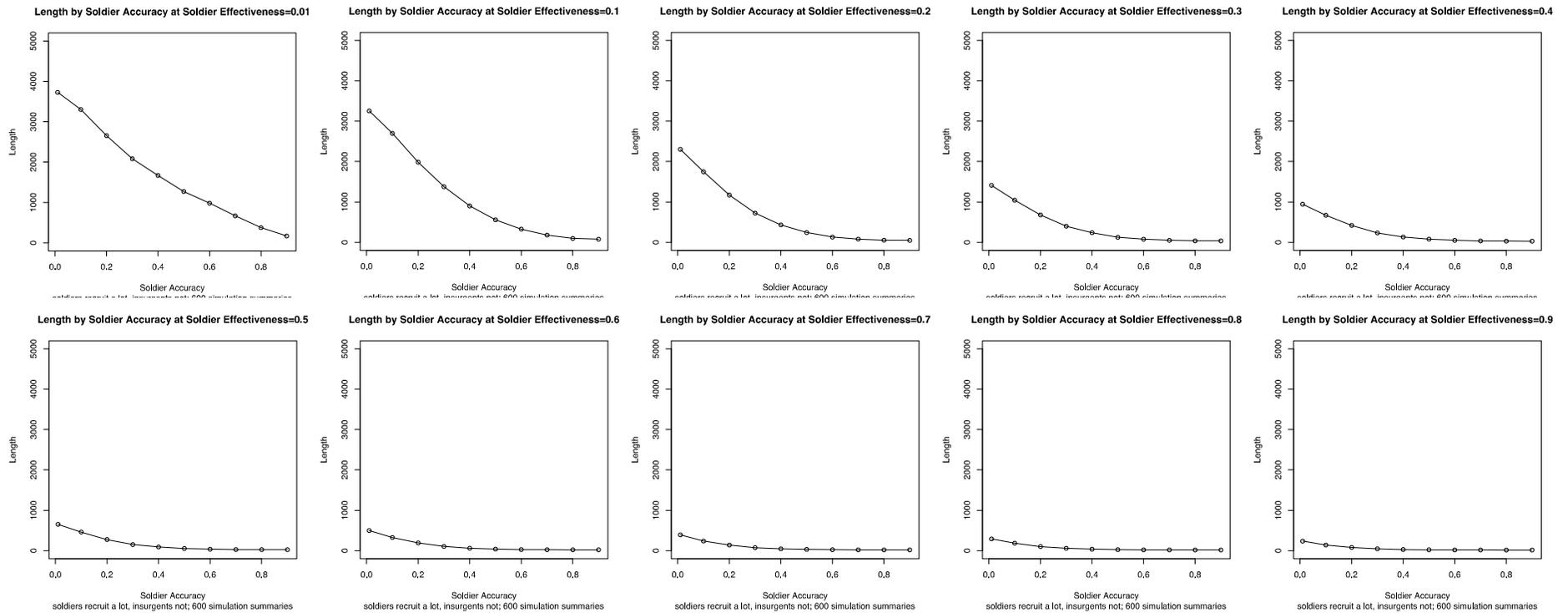
**Figure 1a: Average insurgency duration by the quality of the military strategy (various values of effectiveness by accuracy), if soldiers use an ineffective aid but insurgents use an effective aid**

Background Scenario:  $P_{GR} < 0.5$ ; Number civilians recruitable by government = 1; Anger change given government recruitment = -0.05;  $P_{IR} > 0.5$ ; Number civilians recruitable by insurgents = 9; Anger change given insurgent recruitment = 0.25.



**Figure 1b: Average insurgency duration by the quality of the military strategy (various values of accuracy by effectiveness), if soldiers use an ineffective aid but insurgents use an effective aid**

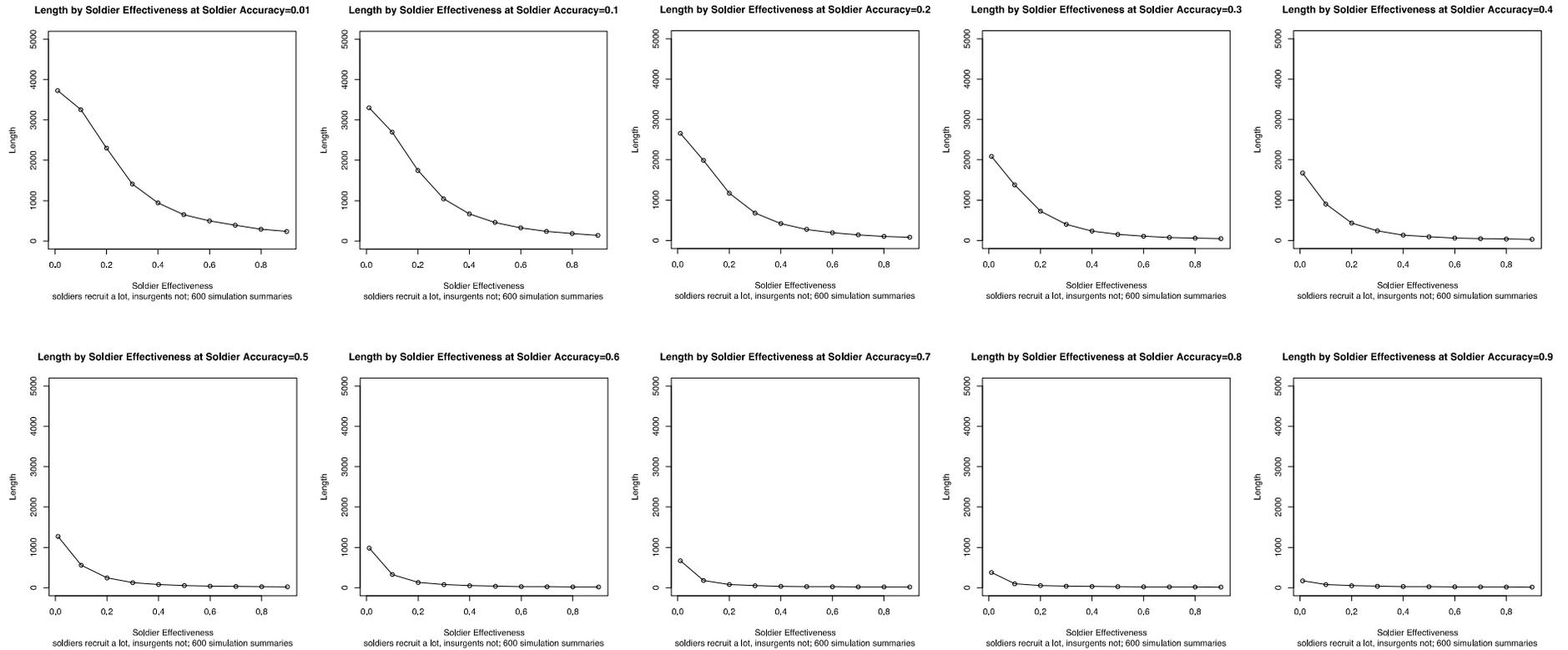
Background Scenario:  $P_{GR} < 0.5$ ; Number civilians recruitable by government=1; Anger change given government recruitment=-0.05;  $P_{IR} > 0.5$ ; Number civilians recruitable by insurgents =9; Anger change given insurgent recruitment=0.25.



**Figure 2a: Average insurgency duration by the quality of the military strategy (various values of effectiveness by accuracy), if soldiers use an effective aid but insurgents use an ineffective aid**

Background Scenario:  $P_{GR} > 0.5$ ; Number civilians recruitable by government = 9; Anger change given government recruitment = -0.25;

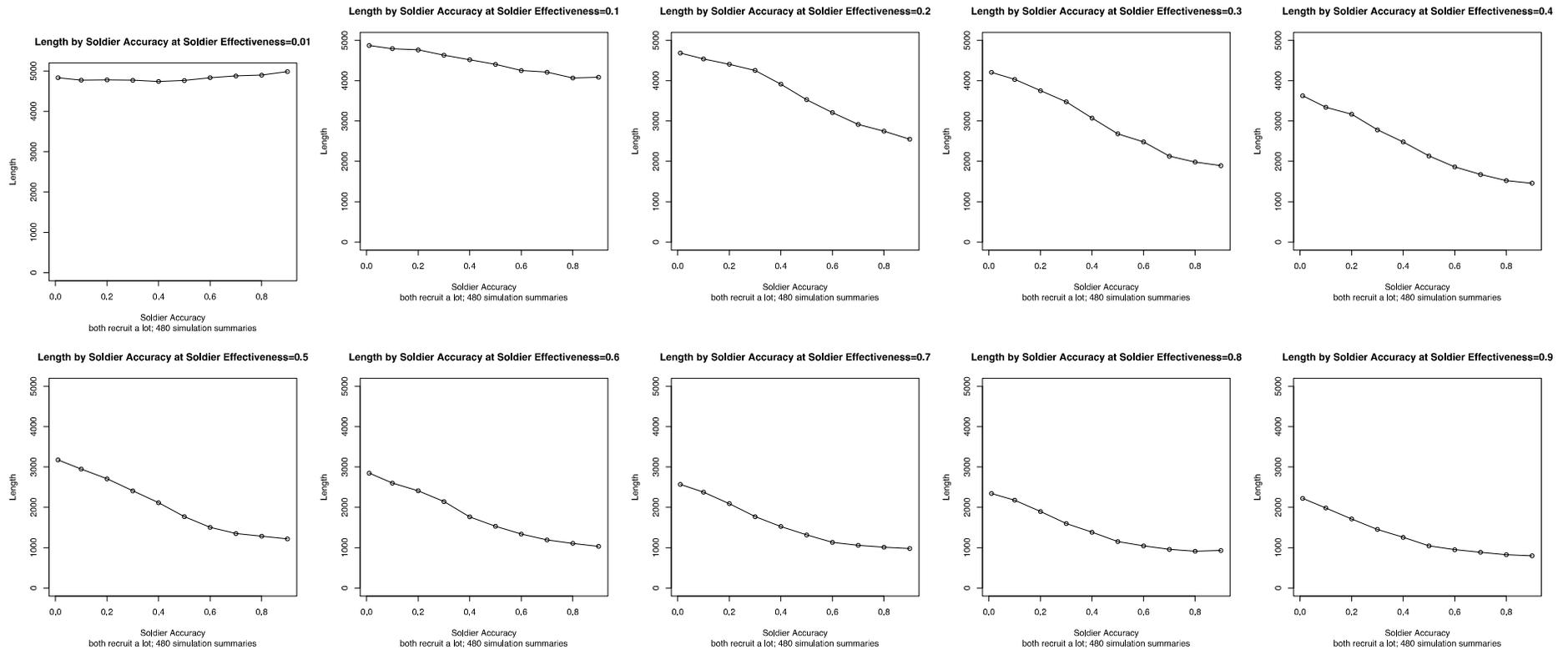
$P_{IR} < 0.5$ ; Number civilians recruitable by insurgents = 1; Anger change given insurgent recruitment = 0.05.



**Figure 2b: Average insurgency duration by the quality of the military strategy (various values of accuracy by effectiveness), if soldiers use an effective aid but insurgents use an ineffective aid**

Background Scenario:  $P_{GR} > 0.5$ ; Number civilians recruitable by government = 9; Anger change given government recruitment = -0.25;

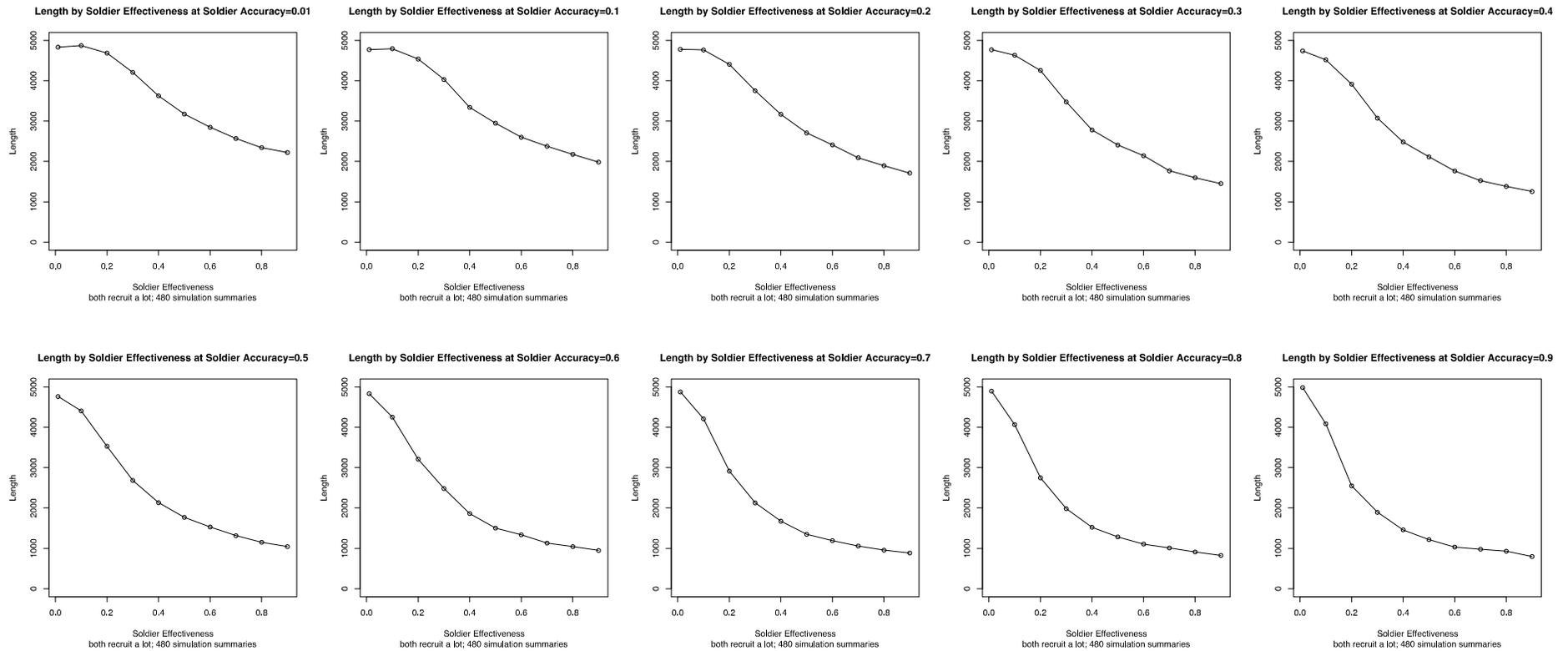
$P_{IR} < 0.5$ ; Number civilians recruitable by insurgents = 1; Anger change given insurgent recruitment = 0.05.



**Figure 3a: Average insurgency duration by the quality of the military strategy (various values of effectiveness by accuracy), if both soldiers and insurgents use an effective aid**

Background Scenario:  $P_{GR} > 0.5$ ; Number civilians recruitable by government = 9; Anger change given government recruitment = -0.25;

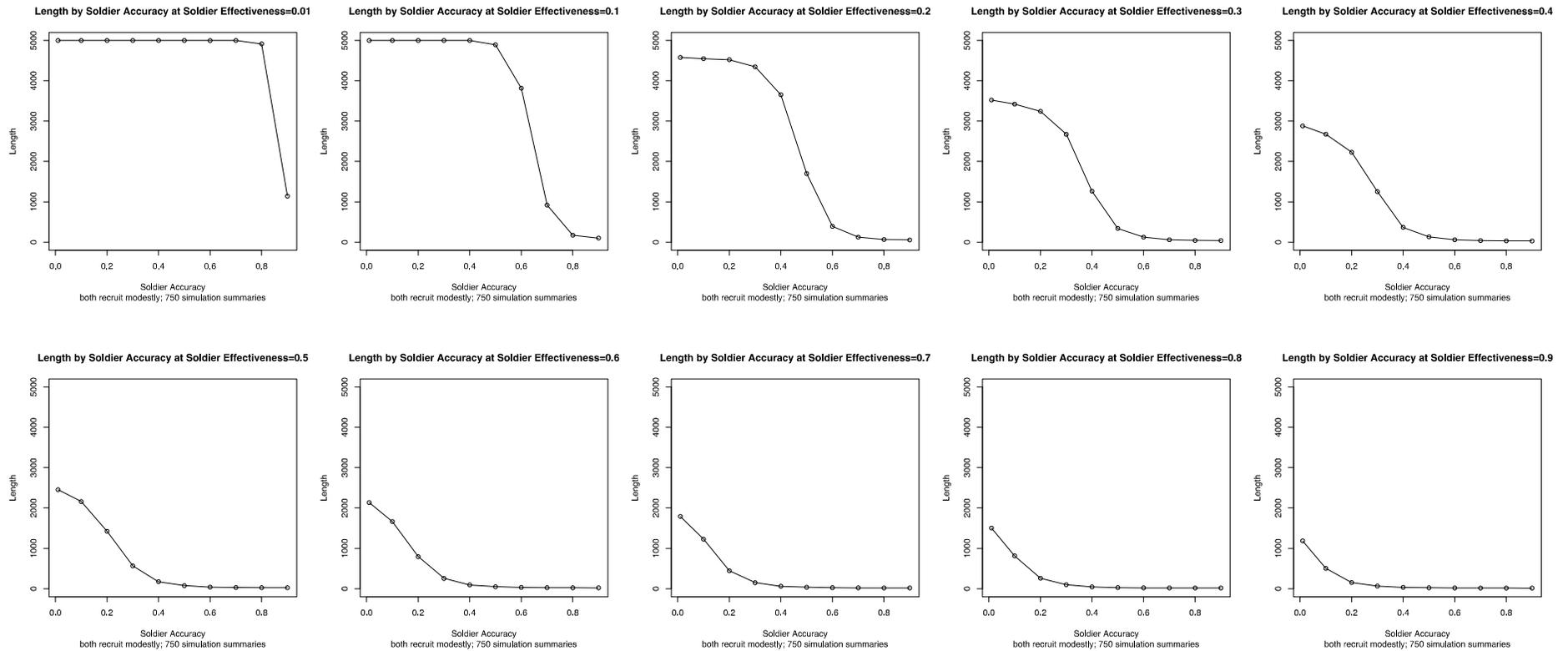
$P_{IR} > 0.5$ ; Number civilians recruitable by insurgents = 9; Anger change given insurgent recruitment = 0.25.



**Figure 3b: Average insurgency duration by the quality of the military strategy (various values of accuracy by effectiveness), if both soldiers and insurgents use an effective aid**

Background Scenario:  $P_{GR} > 0.5$ ; Number civilians recruitable by government = 9; Anger change given government recruitment = -0.25;

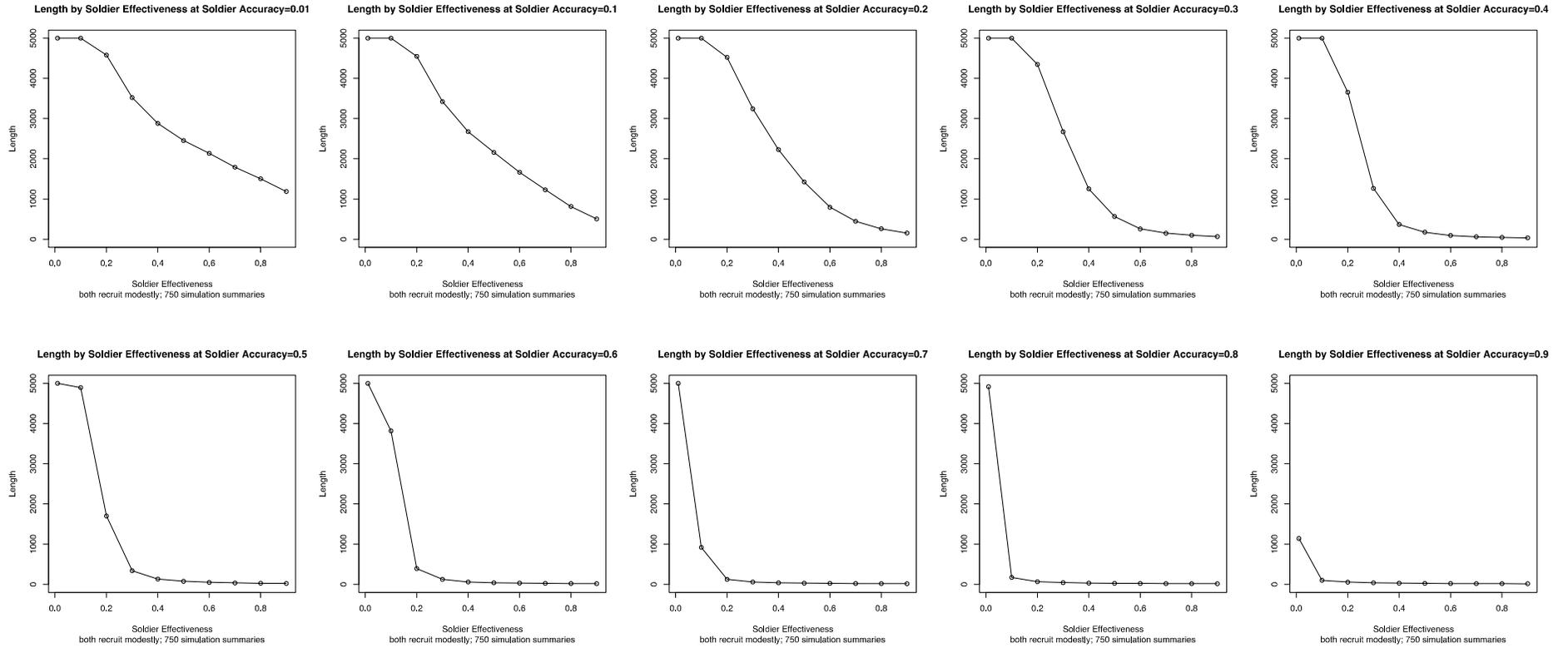
$P_{IR} > 0.5$ ; Number civilians recruitable by insurgents = 9; Anger change given insurgent recruitment = 0.25.



**Figure 4a: Average insurgency duration by the quality of the military strategy (various values of effectiveness by accuracy), if neither soldiers nor insurgents use an effective aid**

Background Scenario:  $P_{GR} < 0.5$ ; Number civilians recruitable by government=1; Anger change given government recruitment=-0.05;

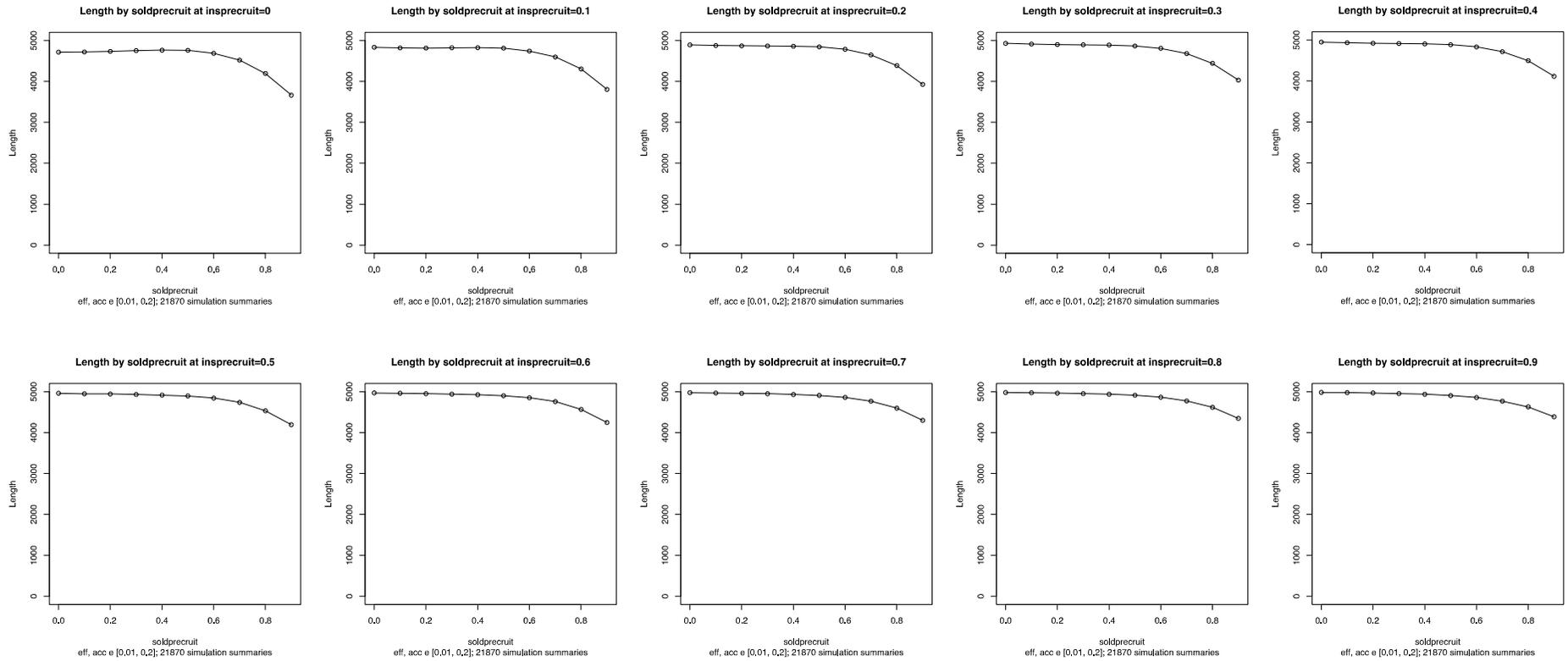
$P_{IR} < 0.5$ ; Number civilians recruitable by insurgents=1; Anger change given insurgent recruitment=0.05.



**Figure 4b: Average insurgency duration by the quality of the military strategy (various values of accuracy by effectiveness), if neither soldiers nor insurgents use an effective aid**

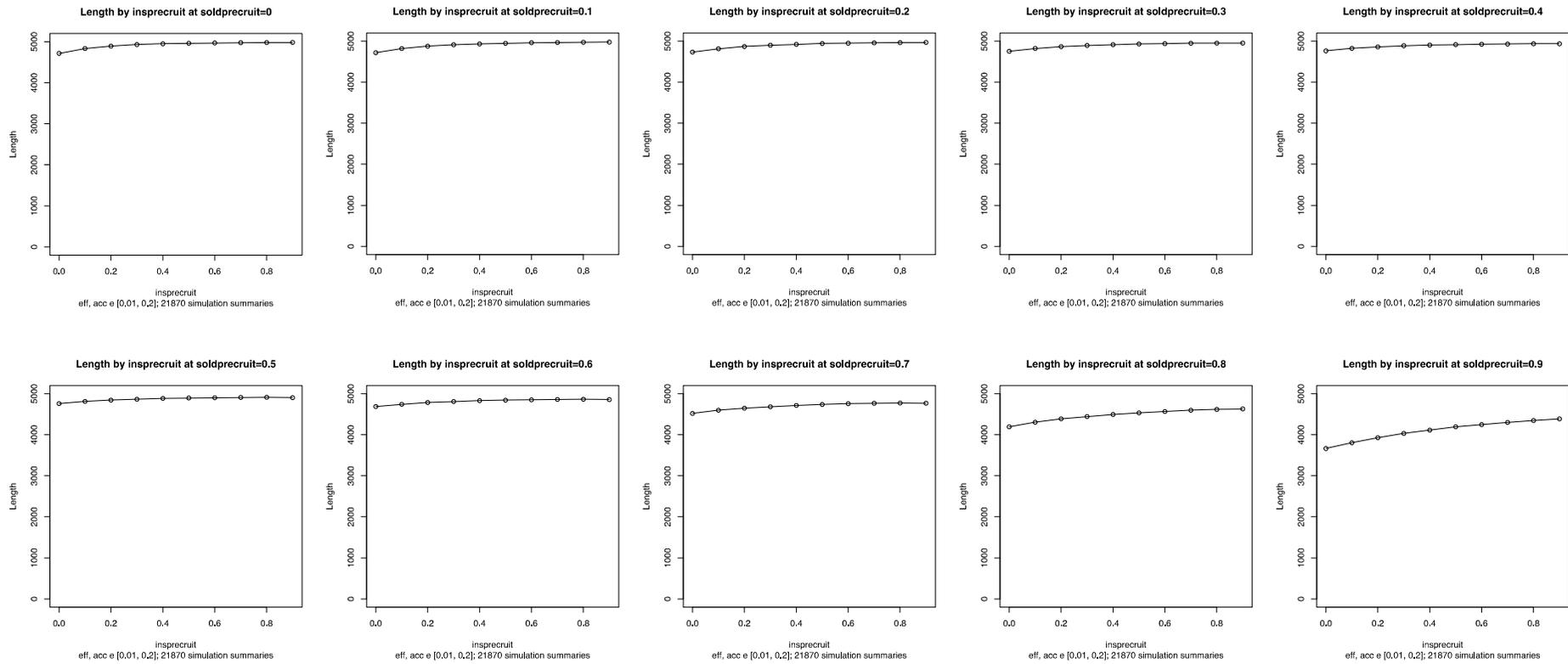
Background Scenario:  $P_{GR} < 0.5$ ; Number civilians recruitable by government = 1; Anger change given government recruitment = -0.05;  $P_{IR} < 0.5$ ; Number civilians recruitable by insurgents = 1; Anger change given insurgent recruitment = 0.05

## Section 2: Figures 5a-8b



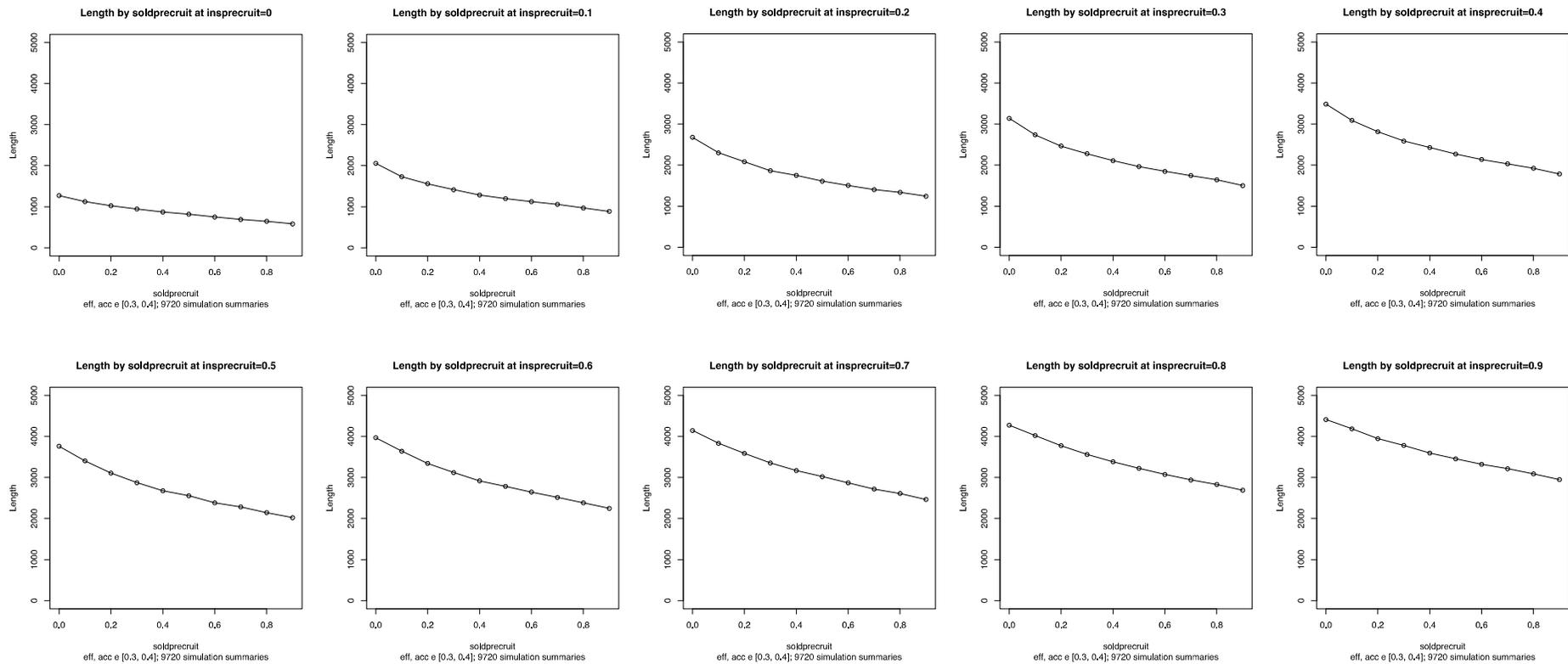
**Figure 5a: Average insurgency duration by the frequency of use of the aid strategy (various values of insurgent use of aid by soldier use of aid), if soldiers implement a low-quality military strategy**

Background Scenario: *accuracy*<0.3; *effectiveness*<0.3.

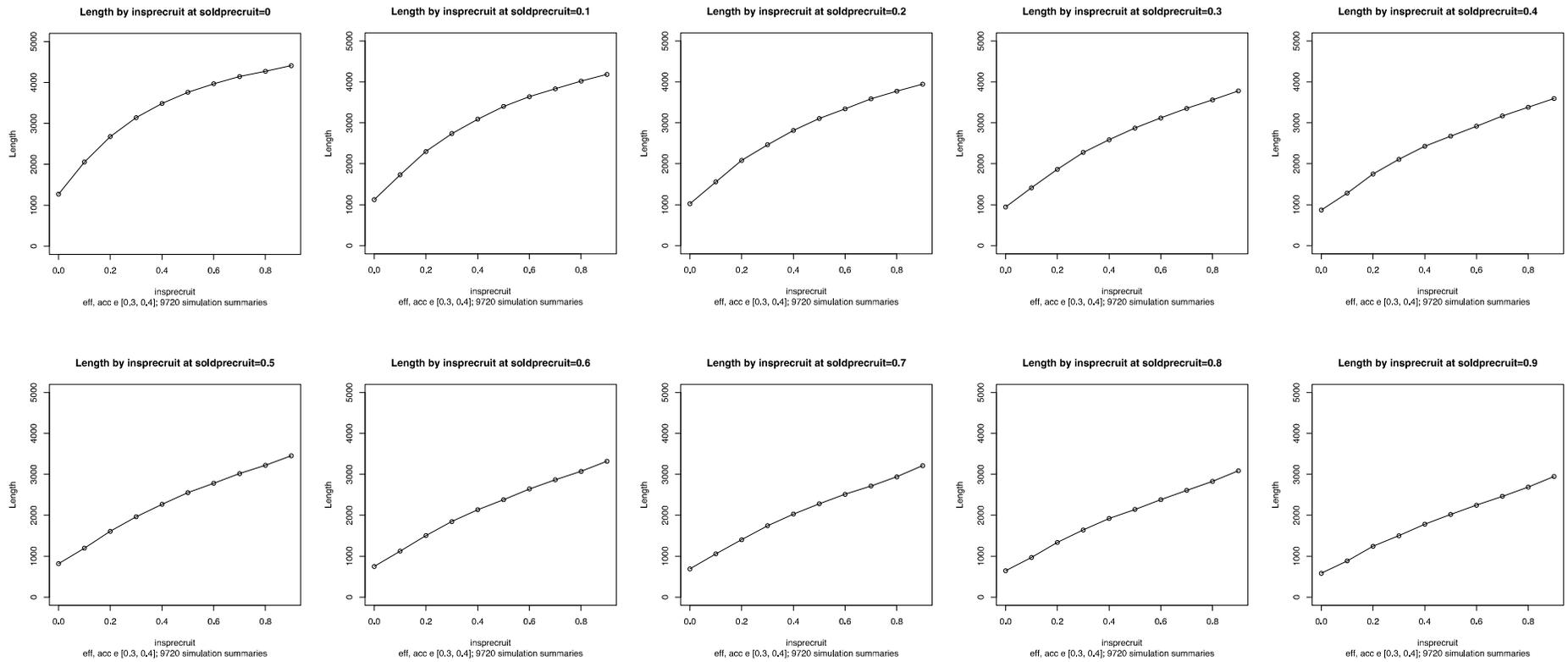


**Figure 5b: Average insurgency duration by the frequency of use of the aid strategy (various values of solder use of aid by insurgent use of aid), if soldiers implement a very low-quality military strategy**

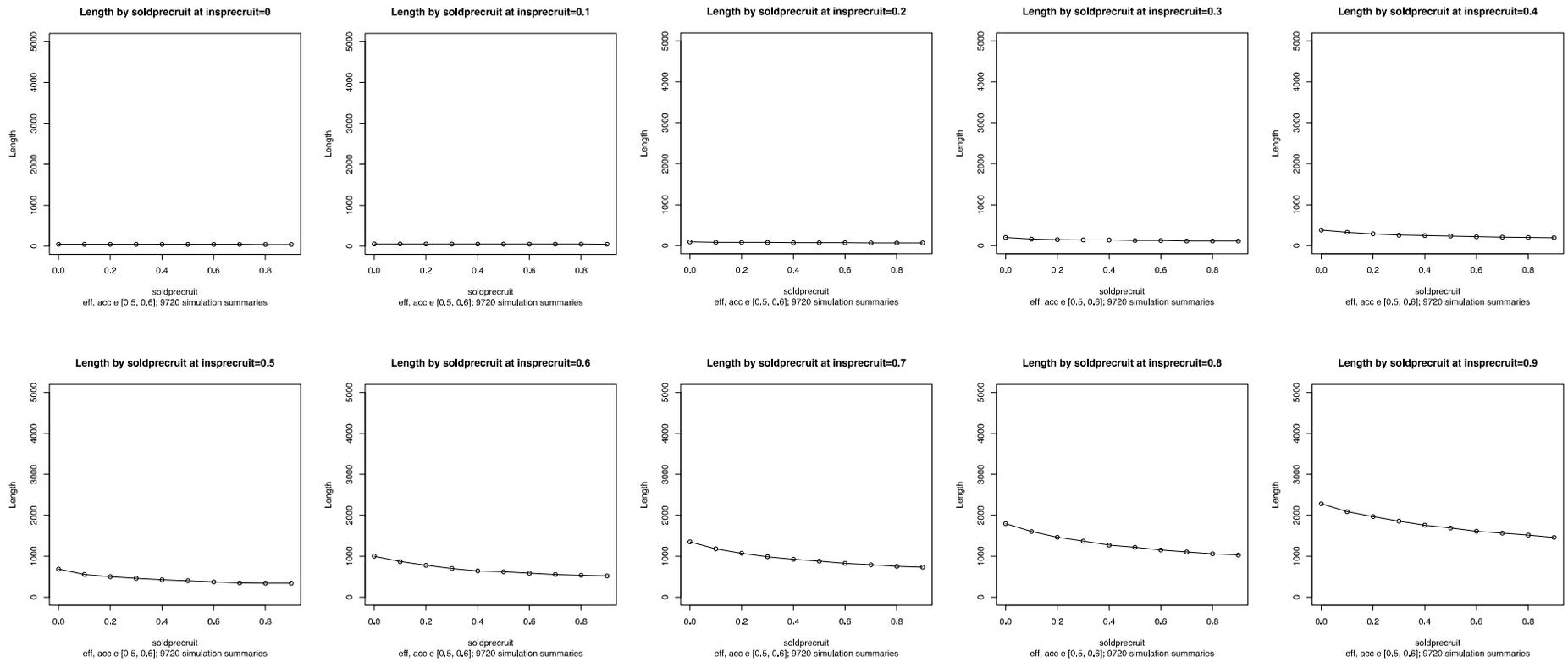
Background Scenario: *accuracy* < 0.3; *effectiveness* < 0.3.



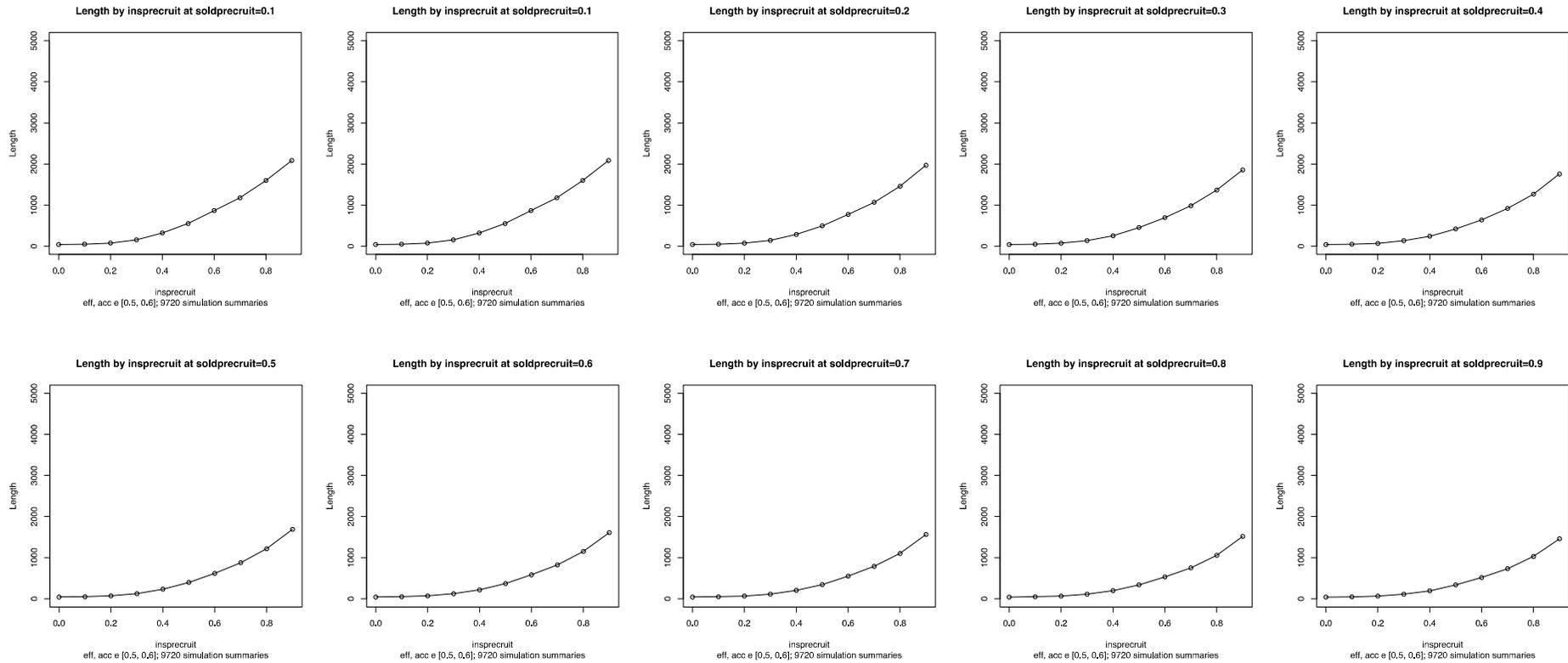
**Figure 6a: Average insurgency duration by the frequency of use of the aid strategy (various values of insurgent use of aid by soldier use of aid), if soldiers implement a low-quality military strategy**  
 Background Scenario:  $accuracy \in [0.3; 0.4]$ ;  $effectiveness \in [0.3; 0.4]$



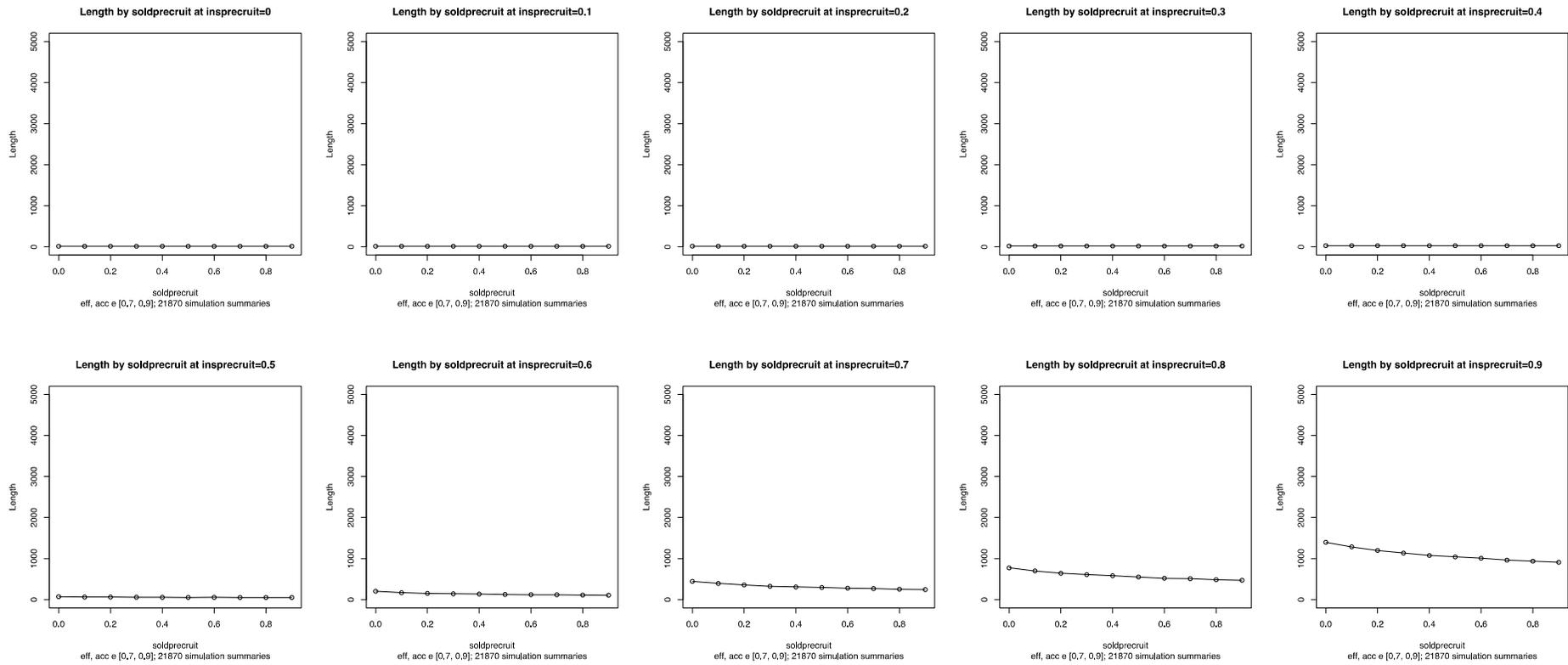
**Figure 6b: Average insurgency duration by the frequency of use of the aid strategy (various values of soldier use of aid by insurgent use of aid), if soldiers implement a low-quality military strategy**  
 Background Scenario:  $accuracy \in [0.3; 0.4]$ ;  $effectiveness \in [0.3; 0.4]$



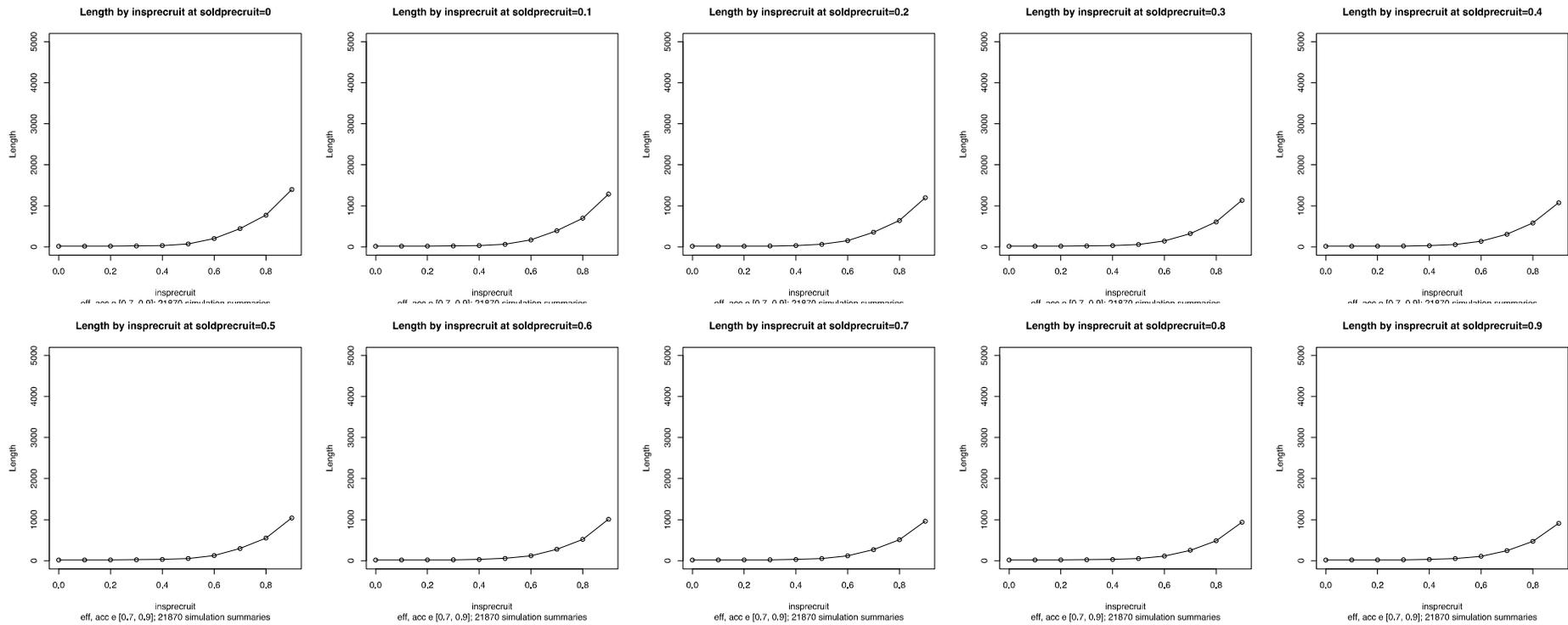
**Figure 7a: Average insurgency duration by the frequency of use of the aid strategy (various values of insurgent use of aid by soldier use of aid), if soldiers implement a low-to-medium-quality military strategy**  
 Background Scenario:  $accuracy \in [0.5; 0.6]$ ;  $effectiveness \in [0.5; 0.6]$



**Figure 7b: Average insurgency duration by the frequency of use of the aid strategy (various values of soldier use of aid by insurgent use of aid), if soldiers implement a medium-to-high-quality military strategy**  
 Background Scenario:  $accuracy \in [0.5; 0.6]$ ;  $effectiveness \in [0.5; 0.6]$

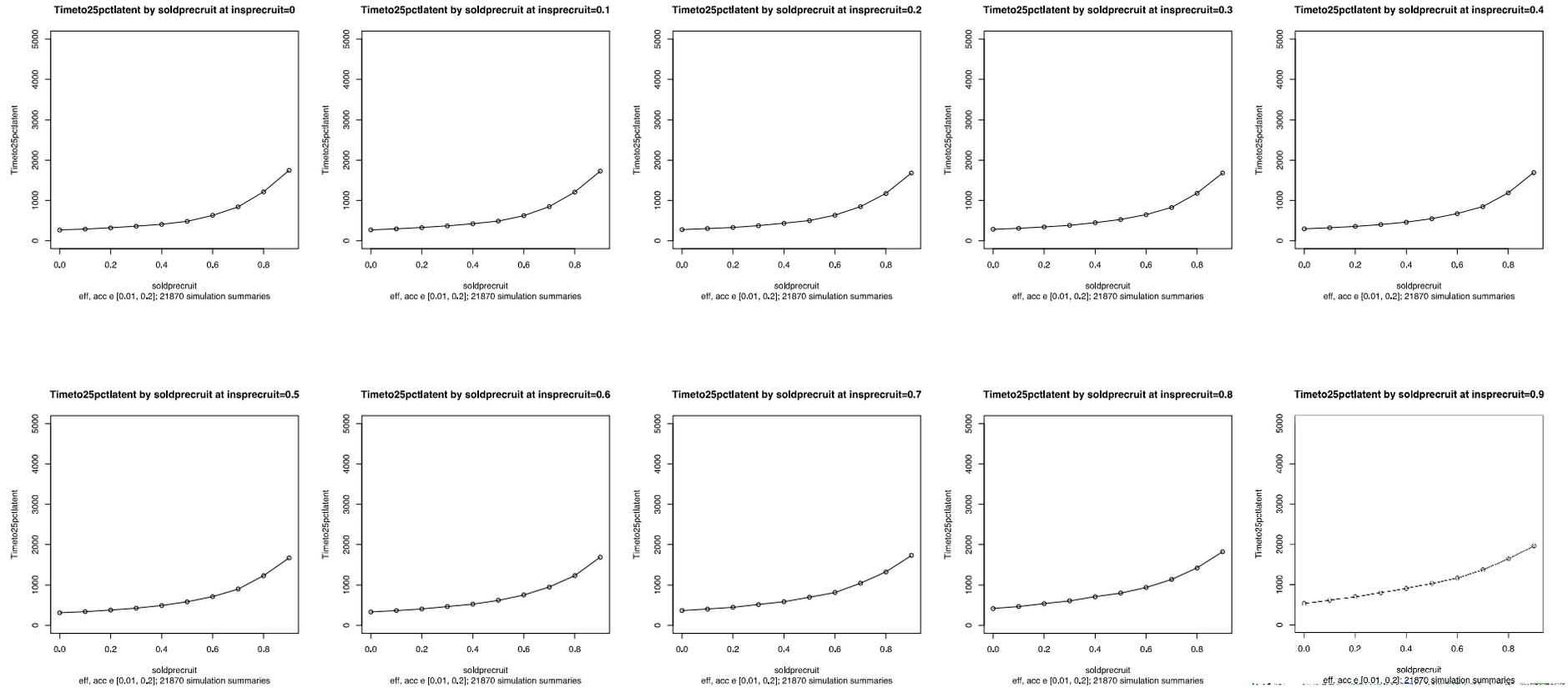


**Figure 8a: Average insurgency duration by the frequency of use of the aid strategy (various values of insurgent use of aid by soldier use of aid), if soldiers implement a very high-quality military strategy**  
 Background Scenario:  $accuracy \in [0.7; 0.9]$ ;  $effectiveness \in [0.7; 0.9]$



**Figure 8b: Average insurgency duration by the frequency of use of the aid strategy (various values of soldier use of aid by insurgent use of aid), if soldiers implement a very high-quality military strategy**  
 Background Scenario:  $accuracy \in [0.7; 0.9]$ ;  $effectiveness \in [0.7; 0.9]$

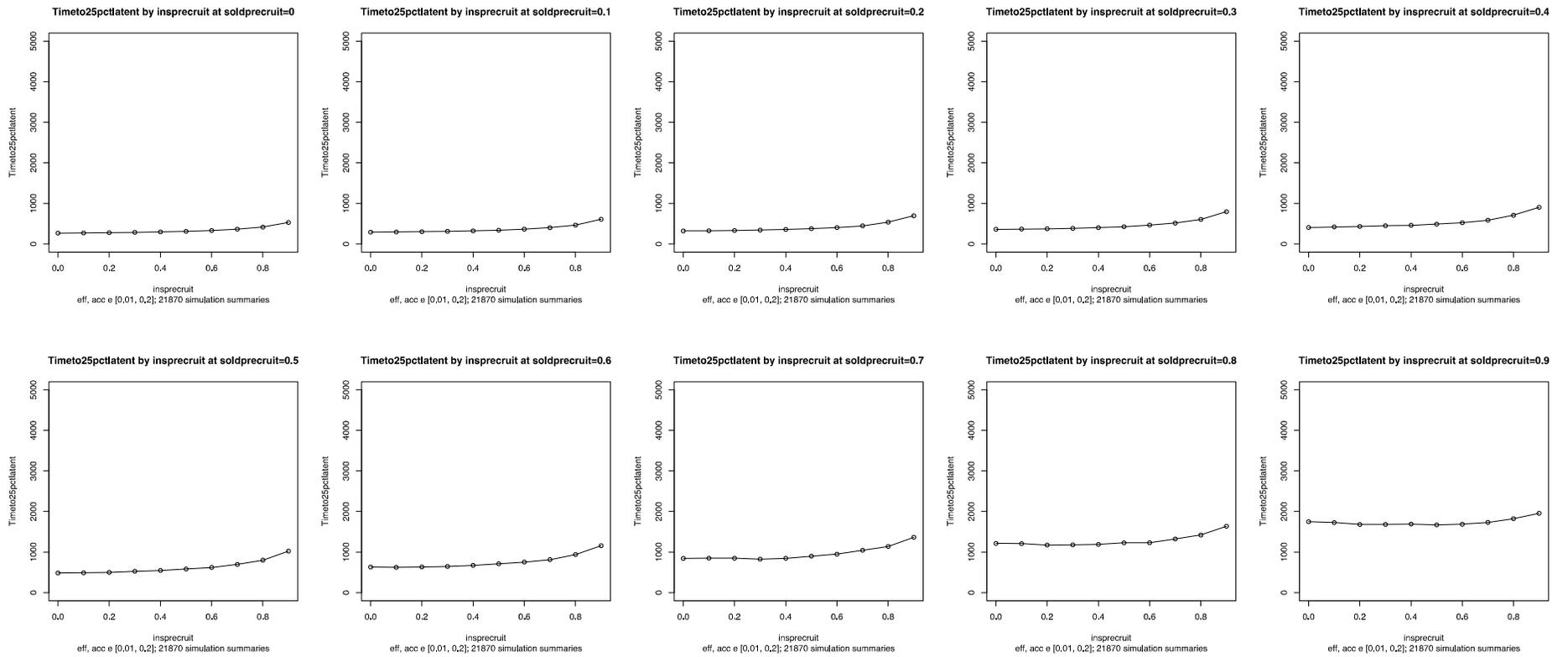
Section 3: Figures 9a-12b:



**Figure 9a: Average speed of growth\* by the frequency of use of the aid strategy (various values of insurgent use of aid by soldier use of aid), if soldiers implement a very low-quality military strategy**

Background Scenario:  $accuracy \in [0.1; 0.2]$ ;  $effectiveness \in [0.1; 0.2]$

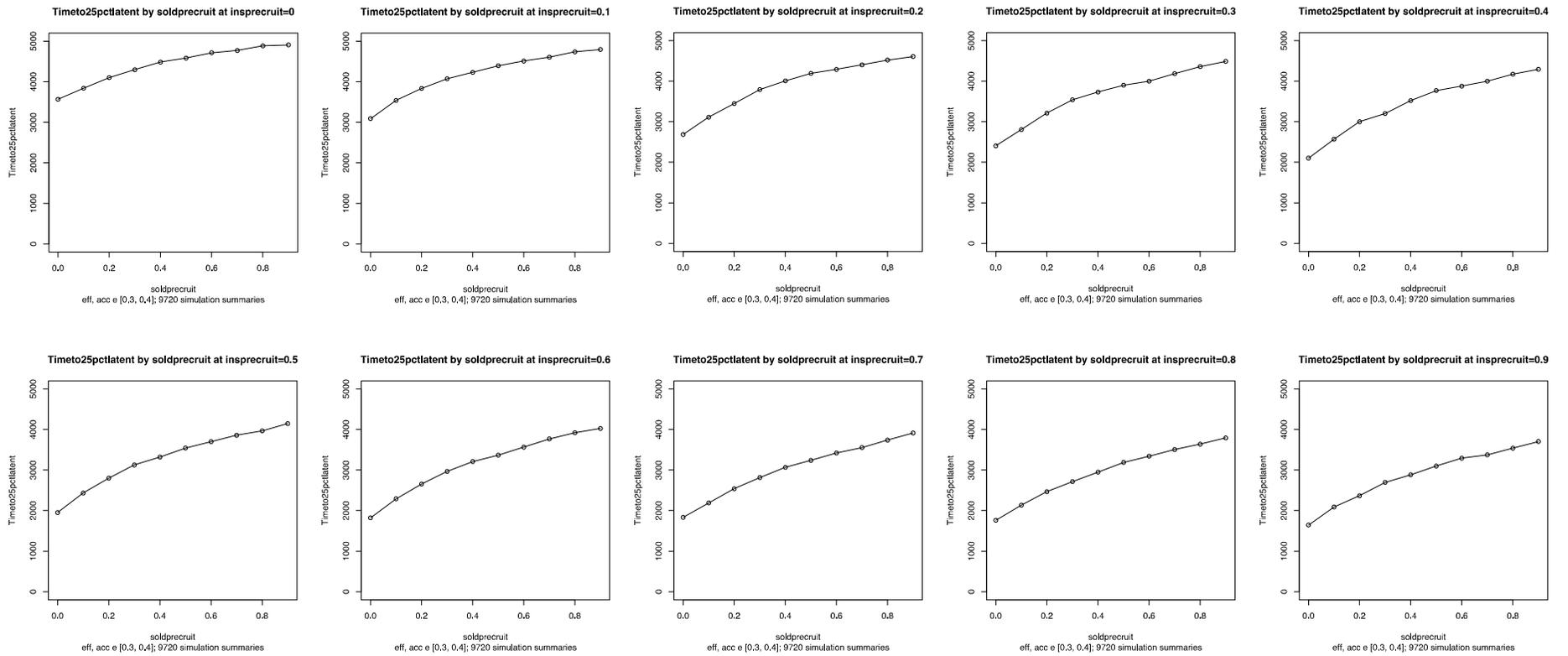
\*Speed of growth = simulation is stopped once 25% of the population become latent insurgents.



**Figure 9b: Average speed of growth\* by the frequency of use of the aid strategy (various values of soldier use of aid by insurgent use of aid), if soldiers implement a very low-quality military strategy**

Background Scenario:  $accuracy \in [0.1; 0.2]$ ;  $effectiveness \in [0.1; 0.2]$

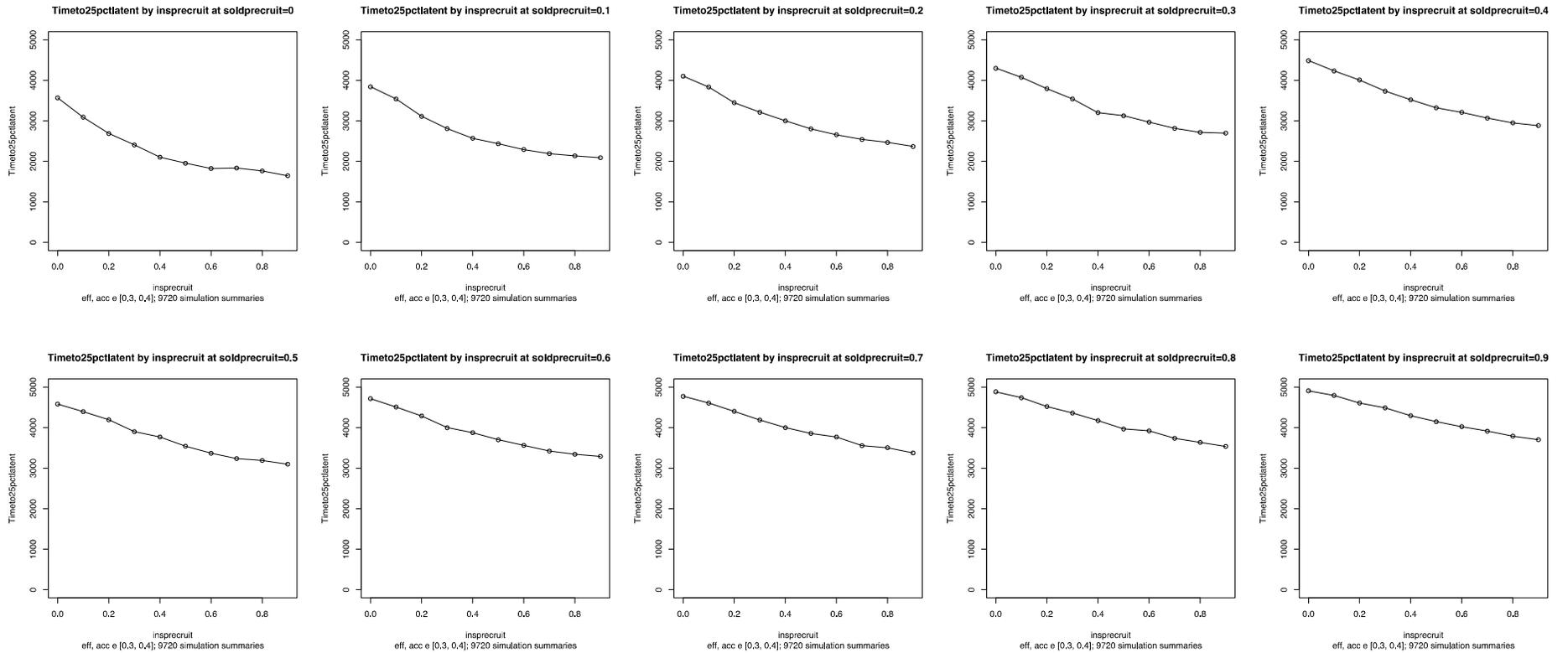
\*Speed of growth = simulation is stopped once 25% of the population become latent insurgents.



**Figure 10a: Average speed of growth\* by the frequency of use of the aid strategy (various values of insurgent use of aid by soldier use of aid), if soldiers implement a low-to-medium-quality military strategy**

Background Scenario:  $accuracy \in [0.3; 0.4]$ ;  $effectiveness \in [0.3; 0.4]$

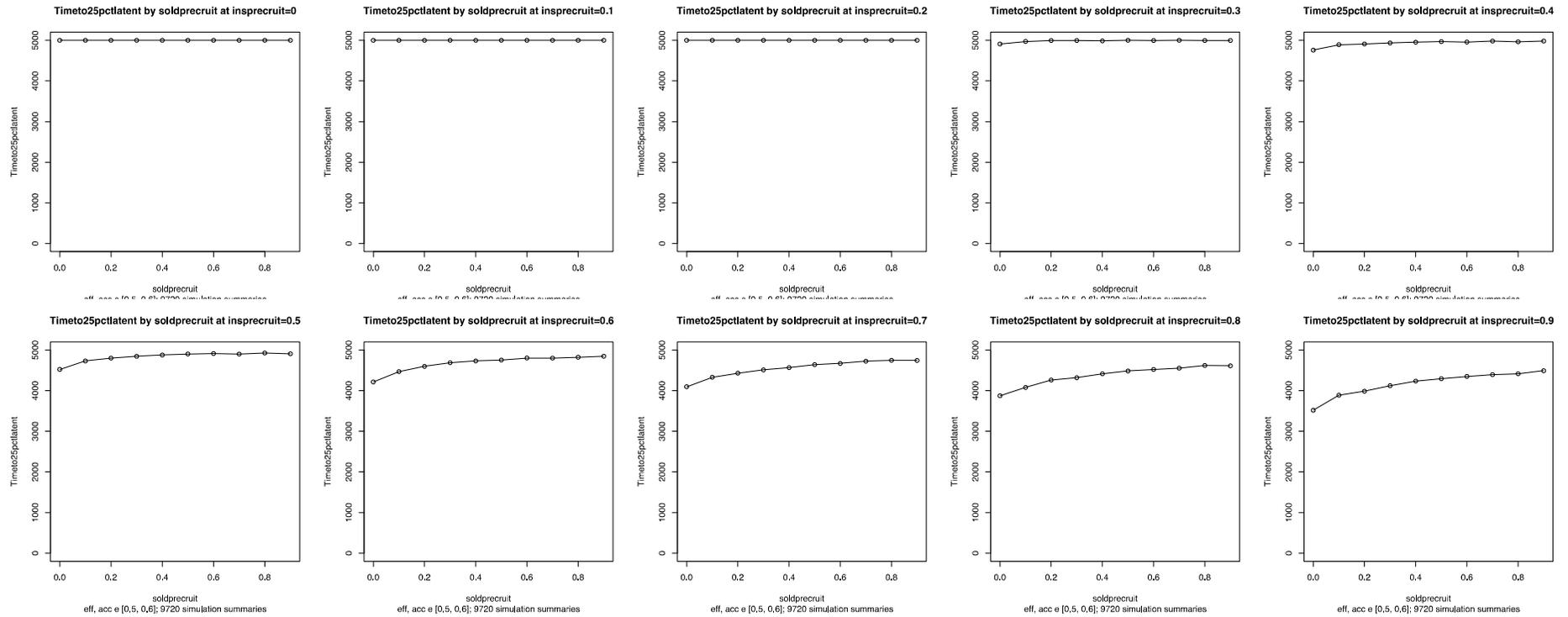
\*Speed of growth = simulation is stopped once 25% of the population become latent insurgents.



**Figure 10b: Average speed of growth\* by the frequency of use of the aid strategy (various values of soldier use of aid by insurgent use of aid), if soldiers implement a low-to-medium-quality military strategy**

Background Scenario:  $accuracy \in [0.3; 0.4]$ ;  $effectiveness \in [0.3; 0.4]$

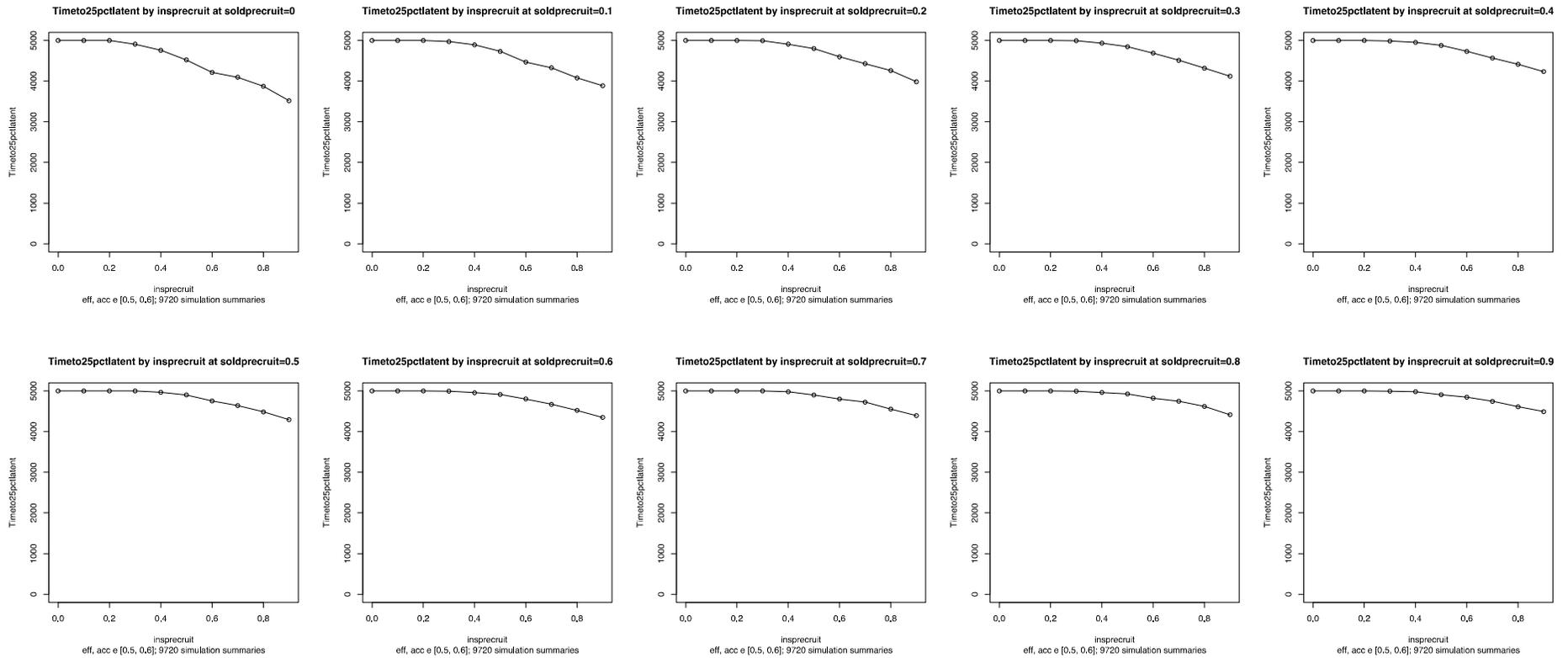
\*Speed of growth = simulation is stopped once 25% of the population become latent insurgents.



**Figure 11a: Average speed of growth\* by the frequency of use of the aid strategy (various values of insurgent use of aid by soldier use of aid), if soldiers implement a medium-to-high-quality military strategy**

Background Scenario:  $accuracy \in [0.5; 0.6]$ ;  $effectiveness \in [0.5; 0.6]$

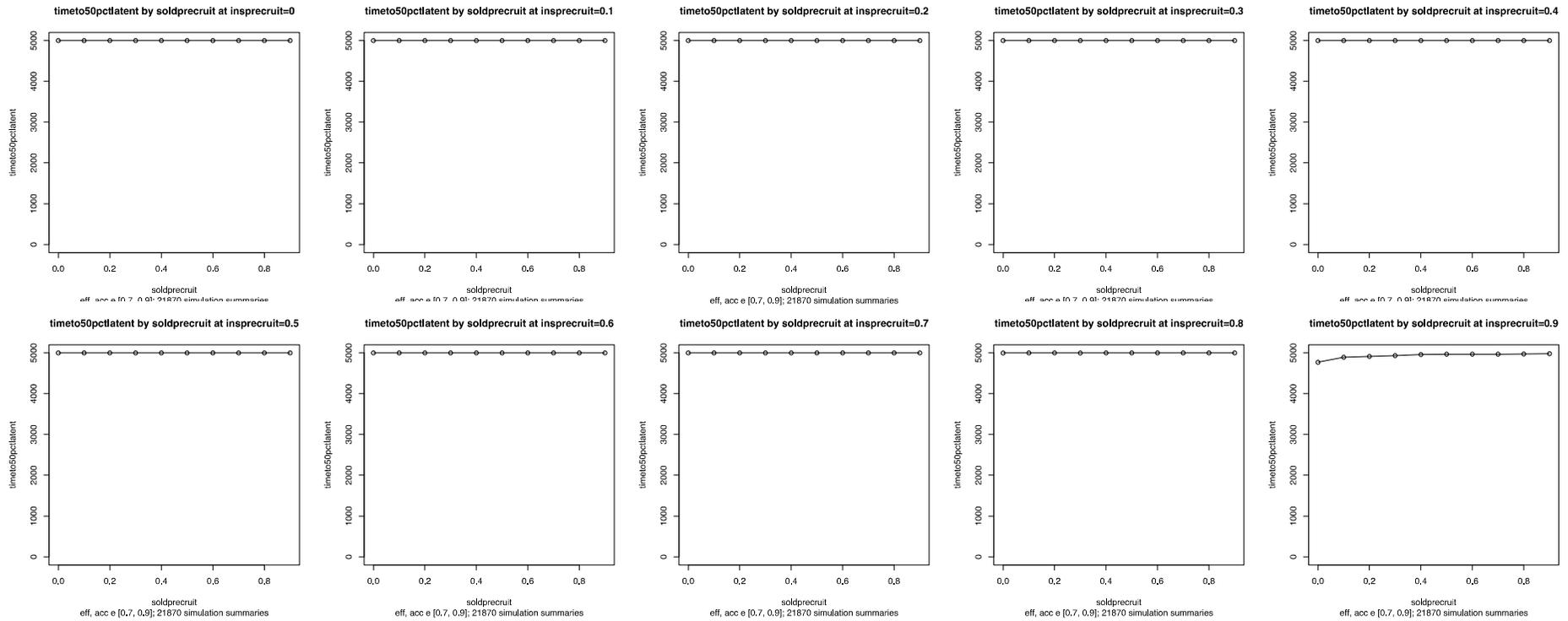
\*Speed of growth = simulation is stopped once 25% of the population become latent insurgents.



**Figure 11b: Average speed of growth\* by the frequency of use of the aid strategy (various values of soldier use of aid by insurgent use of aid), if soldiers implement a medium-to-high-quality military strategy**

Background Scenario:  $accuracy \in [0.5; 0.6]$ ;  $effectiveness \in [0.5; 0.6]$

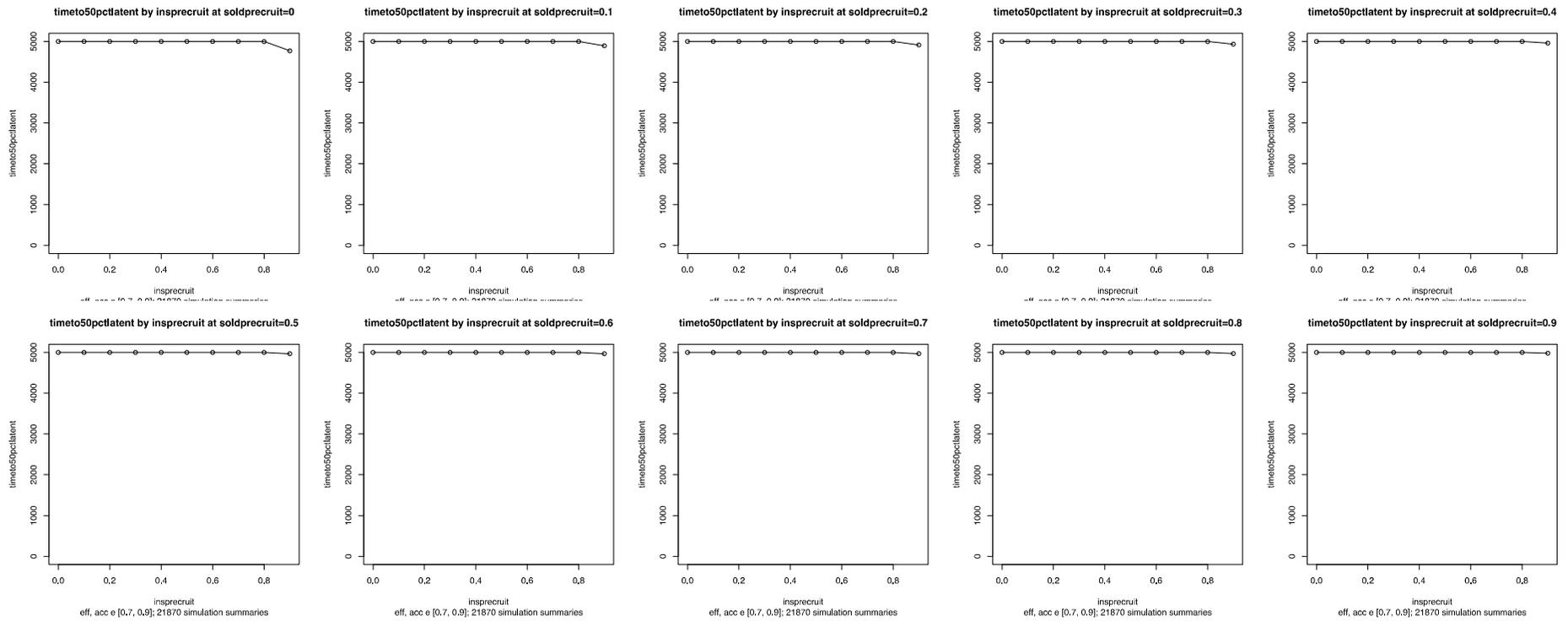
\*Speed of growth = simulation is stopped once 25% of the population become latent insurgents.



**Figure 12a: Average speed of growth\* by the frequency of use of the aid strategy (various values of insurgent use of aid by soldier use of aid), if soldiers implement a very high-quality military strategy**

Background Scenario:  $accuracy \in [0.7; 0.9]$ ;  $effectiveness \in [0.7; 0.9]$

\*Speed of growth = simulation is stopped once 25% of the population become latent insurgents.



**Figure 12b: Average speed of growth\* by the frequency of use of the aid strategy (various values of soldier use of aid by insrgent use of aid), if soldiers implement a very high-quality military strategy**

Background Scenario:  $accuracy \in [0.7; 0.9]$ ;  $effectiveness \in [0.7; 0.9]$

\*Speed of growth = simulation is stopped once 25% of the population become latent insurgents.

Section 4: Table 1: Simulation outcomes (mean, standard deviation, minimum, and maximum values of insurgency duration, peak of latent insurgents, and peak of active insurgents) as a function of various model parameter combinations

Variable	Mean	SD	Min	Max
<b>I. No 'HM': <math>P_{GR}=0; P_{IR}=0</math></b>				
<b>1. All cases</b>				
Duration	1425.47	1855.79	9.6	5000
Peak of latent insurgents	81.82	102.01	8	406.5
Peak of active insurgents	42.97	74.53	0	333.32
<b>2. High quality of 'attrition': <math>\omega&gt;0.6; \varepsilon&gt;0.6</math></b>				
Duration	15.46	2.26	9.6	25.83
Peak of latent insurgents	8.37	.17	8	9.17
Peak of active insurgents	1.18	.50	0	2.67
<b>3. Medium quality of 'attrition': <math>\omega \in [0.4;0.6]; \varepsilon \in [0.4;0.6]</math></b>				
Duration	176.67	125.96	31.18	660.5
Peak of latent insurgents	16.66	5.86	8.73	38.75
Peak of active insurgents	6.73	2.53	2.45	15.5
<b>4. Low quality of 'attrition': <math>\omega \leq 0.3; \varepsilon \leq 0.3</math></b>				
Duration	4716.70	403.91	3895.32	5000
Peak of latent insurgents	279.43	49.78	190.87	406.5
Peak of active insurgents	179.58	74.52	83.32	333.32
<b>II. Both soldiers and insurgents use 'HM' frequently: <math>P_{GR}&gt;0.6; P_{IR}&gt;0.6</math></b>				
<b>1. All cases</b>				
Duration	2253.66	2040.13	9.5	5000
Peak of latent insurgents	71.03	65.18	7.8	333.09
Peak of active insurgents	58.27	53.63	.7	316.82
<b>2. High quality of 'attrition': <math>\omega&gt;0.6; \varepsilon&gt;0.6</math></b>				
Duration	522.37	1184.67	9.5	5000
Peak of latent insurgents	20.27	29.11	7.8	262.8
Peak of active insurgents	15.52	27.38	.7	240.1
<b>3. Medium quality of 'attrition': <math>\omega \in [0.4;0.6]; \varepsilon \in [0.4;0.6]</math></b>				
Duration	1657.9	1746.62	31.09	5000
Peak of latent insurgents	49.73	45.82	8.55	272.17
Peak of active insurgents	42.99	40.97	3.73	248.18
<b>4. Low quality of 'attrition': <math>\omega \leq 0.3; \varepsilon \leq 0.3</math></b>				
Duration	4638.19	803.08	490.33	5000
Peak of latent insurgents	166.38	58.47	21.7	328.41
Peak of active insurgents	127.08	46.34	18.23	261.14
<b>III. Both soldiers and insurgents use 'HM' at medium rates: <math>P_{GR} \in [0.4;0.6]; P_{IR} \in [0.4;0.6]</math></b>				
<b>1. All cases</b>				
Duration	1931.78	2021.14	10.3	5000
Peak of latent insurgents	71.56	73.34	7.9	333

Peak of active insurgents	54.96	57.26	.5	272.91
<b>2. High quality of ‘attrition’: <math>\omega &gt; 0.6</math>; <math>\varepsilon &gt; 0.6</math></b>				
Duration	62.1	162.36	10.3	3380.9
Peak of latent insurgents	10.09	4.81	7.9	85.73
Peak of active insurgents	4.91	4.95	.5	78.09
<b>3. Medium quality of ‘attrition’: <math>\omega \in [0.4; 0.6]</math>; <math>\varepsilon \in [0.4; 0.6]</math></b>				
Duration	1008.97	1310.99	39.18	5000
Peak of latent insurgents	36.14	32.86	8.82	171.75
Peak of active insurgents	29.68	30.16	4.64	138.83
<b>4. Low quality of ‘attrition’: <math>\omega \leq 0.3</math>; <math>\varepsilon \leq 0.3</math></b>				
Duration	4901.66	293.93	1765.13	5000
Peak of latent insurgents	211.81	47.19	62.90	333
Peak of active insurgents	152.88	41.89	48.55	272.91
<b>IV. If both soldiers and insurgents recruit at low rates (soldier <math>p(\text{good works}) \leq 0.3</math> &amp; insurgent <math>p(\text{recruit}) \leq 0.3</math>)</b>				
<b>1. All cases</b>				
Duration	1593.36	1936.07	9.6	5000
Peak of latent insurgents	77.86	92.59	7.9	406.5
Peak of active insurgents	48.78	69.89	0	337.68
<b>2. High quality of ‘attrition’: <math>\omega &gt; 0.6</math>; <math>\varepsilon &gt; 0.6</math></b>				
Duration	19.47	6.77	9.6	174.82
Peak of latent insurgents	8.56	.35	7.9	15.91
Peak of active insurgents	2.03	.87	0	9.45
<b>3. Medium quality of ‘attrition’: <math>\omega \in [0.4; 0.6]</math>; <math>\varepsilon \in [0.4; 0.6]</math></b>				
Duration	342.32	544.06	29.73	4819.6
Peak of latent insurgents	20.42	13.90	8.55	133.5
Peak of active insurgents	11.84	12.32	2.45	115.25
<b>4. Low quality of ‘attrition’: <math>\omega \leq 0.3</math>; <math>\varepsilon \leq 0.3</math></b>				
Duration	4809.35	321.77	3160.16	5000
Peak of latent insurgents	262.69	46.98	136.81	406.5
Peak of active insurgents	174.37	67.37	51.23	337.68
<b>V. If soldiers recruit at a high rate and insurgents recruit at a low rate (soldier <math>p(\text{good works}) &gt; 0.6</math> &amp; insurgent <math>p(\text{recruit}) \leq 0.3</math>)</b>				
<b>1. All cases</b>				
Duration	1180.65	1686.71	9.8	5000
Peak of latent insurgents	47.85	57.19	7.7	306.59
Peak of active insurgents	27.51	37.85	0	232.68
<b>2. High quality of ‘attrition’: <math>\omega &gt; 0.6</math>; <math>\varepsilon &gt; 0.6</math></b>				
Duration	19.35	6.52	9.8	314.73
Peak of latent insurgents	8.54	.33	7.7	16.45
Peak of active insurgents	2.04	.86	0	11.45
<b>3. Medium quality of ‘attrition’: <math>\omega \in [0.4; 0.6]</math>; <math>\varepsilon \in [0.4; 0.6]</math></b>				
Duration	210.27	330.94	24.73	4719.2

Peak of latent insurgents	16.35	8.56	8.64	117.17
Peak of active insurgents	9.02	7.56	2.45	105.5

#### 4. Low quality of ‘attrition’: $\omega \leq 0.3$ ; $\varepsilon \leq 0.3$

Duration	4356.1	1021.7	539.53	5000
Peak of latent insurgents	164.67	55.17	39.47	306.59
Peak of active insurgents	98.71	42.54	17.57	232.68

### VI. If soldiers recruit at a low rate and insurgents recruit at a high rate (soldier $p(\text{good works}) \leq 0.3$ & insurgent $p(\text{recruit}) > 0.6$ )

#### 1. All cases

Duration	2901.81	2124.33	10	5000
Peak of latent insurgents	111.31	94.28	7.9	361.18
Peak of active insurgents	94.17	82.72	.7	353.77

#### 2. High quality of ‘attrition’: $\omega > 0.6$ ; $\varepsilon > 0.6$

Duration	742.13	1478.78	10	5000
Peak of latent insurgents	27.1	43.58	7.9	284.36
Peak of active insurgents	21.92	40.99	.7	261.91

#### 3. Medium quality of ‘attrition’: $\omega \in [0.4; 0.6]$ ; $\varepsilon \in [0.4; 0.6]$

Duration	2485.02	1928.09	35	5000
Peak of latent insurgents	75.51	60.81	8.91	289.42
Peak of active insurgents	65.9	54.27	4.36	270.18

#### 4. Low quality of ‘attrition’: $\omega \leq 0.3$ ; $\varepsilon \leq 0.3$

Duration	4969.8	113.36	3403.48	5000
Peak of latent insurgents	258.77	51.59	51.29	361.18
Peak of active insurgents	213.34	59.87	46.29	353.77

Section 5: Note on the difference in assumptions made in our model and in Findley and Young (2007)

It may appear that our results differ significantly from Findley and Young’s conclusion that hearts and minds strategy leaves government always better off than an attrition strategy does. However, despite the differences between our model and Findley and Young’s (2007) model, it is important to underscore that when we initialize the Recruitment model with parameter values that approximate the pure hearts and minds strategy as described in Findley and Young (2007), our takeaway is that peaceful recruitment is very effective at containing the spread of insurgency through the population. The key difference between our models lies in what we assume that government troops can do to extract an insurgent from the population. Specifically, Findley and Young conceptualize pure hearts and minds strategy so that it allows “neutralization” of insurgents, which is an assignment of a new level of commitment to an insurgent, in other words turning an insurgent into a member of the population within one interaction.

Thus, to compare the models fairly we need to examine the scenario in our model of ‘HM’ complemented by high-quality ‘attrition.’ If we do this, then the results are almost identical to Findley and Young’s (2007): the government defeats an insurgency quickly. The regions in graphs 3b and 3c with effectiveness and accuracy of 0.7 and

higher show the regions within which Findley and Young’s (2007) description of the ‘hearts and minds’ strategy is satisfied.

Section 5: Table 2: OLS regression of insurgency duration

Covariate	beta	SE	p-value
Rate of insurgent recruitment	1716.29	4.15	0.000
Rate of government recruitment	-869.88	4.15	0.000
Probability of insurgent exposure	-466.57	2.92	0.000
Accuracy	-2964.43	3.77	0.000
Effectiveness	-4111.79	3.77	0.000
Insurgent recruitment anger change	3706.97	14.04	0.000
Govt recruitment anger change	1923.83	14.04	0.000
Insurgent number recruitable	101.60	0.36	0.000
Govt number recruitable	-79.14	0.36	0.000
Constant	4241.51	4.21	0.000
N obs		2,430,000	
Adj R <sup>2</sup>		0.72	
Prob > F		0.0000	

Section 6: Note on a narrowly constructed scenario under which the ‘hearts and minds’ strategy may compensate for a low-quality ‘attrition’ strategy.

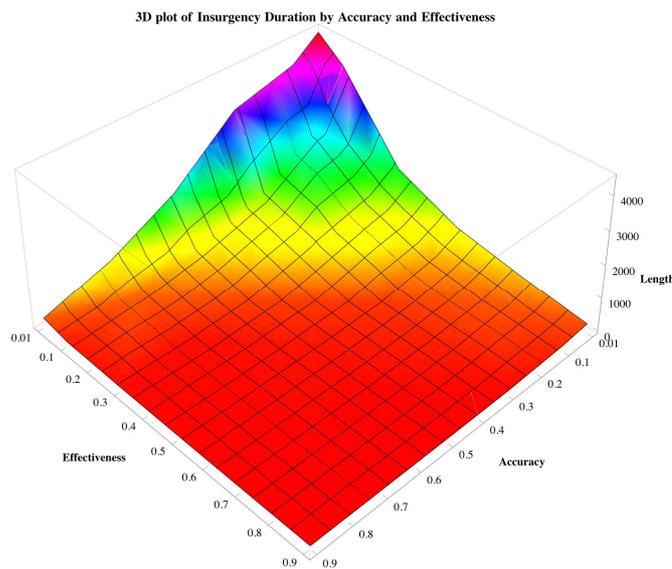
Government may compensate for its lacking attrition strategy by effectively recruiting the local population, only when insurgents recruit modestly. Figure 11 demonstrates this conclusion by presenting the surface of possible durations of insurgency for those cases when effectively recruiting soldiers counteract modestly recruiting insurgents. This surface includes the cases when government rate of recruitment is high (90% of the time) and insurgent rate is low (10-50% of the time). Furthermore, insurgents do not recruit many supporters at a time (1 to 5 people) and are not capable of increasing their newly recruited supporters’ anger at government by much (0.05 to 0.1 units), yet soldiers recruit many supporters (5 to 9 people) and are trained to lower newly gained supporters’ anger at government by a significant amount (0.1 to 0.25 units)]. Figure 13 shows that regardless of how disastrous soldiers’ attrition strategy is, insurgencies are always defeated when insurgents cannot recruit effectively but soldiers can. In other words, even for those cases when soldiers miss targets 90-99% of the time (effectiveness of 0.01 to 0.1) and when innocent civilians are hurt by soldiers’ response or attacks with probability 0.9-.99 (accuracy of 0.01 to 0.1), insurgencies still never spiral out of control and are always defeated by the government in 4,000 time units or less.<sup>1</sup> Furthermore, the militarily ill-prepared soldiers who miss targets 60-70% of the time and cause collateral damage 60-70% of the time, still will defeat insurgencies in 1,000 time units or less when they employ an active “hearts and minds” strategy and face insurgents

<sup>1</sup> In addition, see Figures 2a and 2b shown in pp. 4-5 of this web appendix that communicate this point in a more detailed fashion through a series of 2D graphs.

who recruit poorly. It is important to note, however, that this result is a function of very high counter-recruitment level. Comparable scenarios are summarized in rows 3 and 4 of Table 4 of the paper demonstrate that government recruitment at levels 70-90% of the time combined with disastrous military strategy most of the time cannot defeat insurgency.

While the major takeaway from Figure 1 of the paper about the inversely proportional relationship between military sophistication of the government and duration of insurgency holds true for all scenarios, the distribution of possible durations in Figure 3 is very different from Figure 1. In fact, Figure 13's surface of possible durations of insurgency rather closely resembles the scenario when insurgents do not recruit at all as shown in panel (a) of Figure 2 of the paper.

Figure 13: Insurgency duration when government recruits a lot and effectively, yet insurgents recruit modestly. Longest insurgency lasts 4,000 ticks.



*Note:* Rate of government recruitment=0.9; government number recruitable=5 to 9; government anger change=-0.15 to -0.25; rate of insurgent recruitment=0.1 to 0.5, insurgent number recruitable=1 to 5; insurgent anger change=0.05 to 0.15.