

Analysis on Soviet armaments and heavy Industry

Preliminary version

Introduction and overview

The aim of the article is to determine the minimum amount of armaments and heavy industry the Soviet player has to evacuate to avoid a shortage on armaments points after 06.1942 and of supply during the entire war.

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1. Abbreviations and Constants

1.1 Abbreviations

1.2 Constants and facts

Lend-lease

Year	SPs
1941 (T1-T28)	1000 (from T8, 07.08.1941)
1942 (T29-T81)	3000
1943 (T82-T133)	5000
1944 (T134-T185)	7000
1945 (T186-T224)	6000

Industry multipliers

Year	Multiplier AI	Multiplier HI
1941 (T1-T28)	250	500
1942 (T29-T81)	325	550
1943 (T82-T133)	325	650
1944 (T134-T185)	325	725
1945 (T186-T224)	325	775

No production takes place on the first turn, 22.06.1941. Repair of factories takes place after the factory has produced for that turn at a rate of 3% per turn.

The evacuated part of a factory is damaged by $50\% + \frac{\text{not evacuated factory points}}{\text{factory points in city before evacuation}} \cdot 50\%$

Factories produce nothing if damage is above 50% damage and $\text{multiplier} \cdot \frac{50\% - \text{damage}}{50\%}$ if below 50%.

1.2 Variables

	Armaments Industry and Heavy Industry multiplier for each year
	Armaments/Heavy Industry production as a function of the date
	Armaments/Heavy Industry production in a certain year
	Armament/Heavy Industry points with a description: $_{ev} = \text{evacuated}$; $_{des} = \text{destroyed}$; $_{ar} = \text{at risk}$; $_{nar} = \text{not at risk}$; $_{ne} = \text{not evacuated and not destroyed}$
	Armament /supply points
$Turns_{year}(Date)$	Number of turns that fall into a certain year for given date
$LL(Date)$	Lend-Lease deliveries as a function of the date
LL_{year}	Weekly deliveries from Lend-Lease for a certain year
	Armament points consumed/Supply points consumed

	Armament points and supply points before the campaign
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2. Assumptions made

To simplify calculations, an assumption on the average time of factory evacuation and destruction is made, expecting both events to take place after the logistics phase of turn 11 (28.08.1941) as a mean. One expects most evacuations to take place during the summer of 1941, so their temporary loss of production falls into a time when multipliers are lower than in later years. Further evacuations could take place from late 1941 to mid 1942, depending on the course of the game, but it is assumed that no factories will be destroyed after 1941.

Furthermore, factories are expected to be not further damaged after the first evacuation, which could happen through strategic bombing or a second evacuation.

Not always can a factory be evacuated as a whole, the initial damage of an evacuated factory is estimated to be 62%.

Only a portion of the Soviet industry is at risk of being overrun and therefore subject to destruction or evacuation. By counting the factory points in cities considered to be safe over the course of a normal game, one obtains the number of factories that are at risk, for this analysis 257 armaments industry points and 129 heavy industry points.

The considerations lead us to the following model including three fates every factory point can have:

- 1) Destroyed in 1941: The factory point is destroyed at some point in 1941, produces until that moment no more afterwards.
- 2) Evacuated in 1941: The factory point is evacuated at some point in 1941, produces up to this moment, then gradually repairs at the new location and is never evacuated again, or even destroyed
- 3) Never evacuated nor destroyed: The factory point is neither evacuated nor destroyed and continues production through the whole war.

Every possible fate requires somewhat altered formulas for our model.

Note that every factory point can only have one of the three fates and will remain there for the rest of the game!

3. Formulas

$$APr(Date) = APr_{1941} + \sum_{i=2}^5 APr_{194i}(date)$$

Undamaged production

$$APr_{1941} = APr_{ev_{1941}} + APr_{des_{1941}} + APr_{ne_{1941}}$$

Evacuated factories take four turns to go online (need to repair from 62% to 50%), thus restart production in T16 and produce 12 more turns in 1941 until 1942 is reached. There is no production on the first turn.

$$APr_{ev_{1941}} = (10 + 0.06 \cdot (1 + 2 + 3 + 4 + \dots + 12)) \cdot AIM_{1941} \cdot AIP_{ev} \left(10 + 0.06 \cdot \left(12 \cdot \frac{12 + 1}{2} \right) \right) \cdot AIM_{1941} \cdot AIP_{ev}$$

$$APr_{des_{1941}} = 10 AIM_{1941} \cdot AIP_{des}$$

$$APr_{ne_{1941}} = 27AIM_{1941} \cdot AIP_{nar}$$

$$APr_{1942}(Date) = APr_{ev_{1942}}(Date) + APr_{nar_{1942}}(Date)$$

Evacuated factories start 1942 with 72% damage. The factor $\left(4 \cdot \frac{4+1}{2}\right)$ equals $(1 + 2 + 3 + 4)$ (Gaussian sum).

$$APr_{ev_{1942}}(Date) = \left(4 \cdot 0.72 + 0.06 \cdot \left(4 \cdot \frac{4+1}{2}\right) + Turns_{1942}(Date) - 4\right) \cdot AIM_{1941} \cdot AIP_{ev}$$

$$APr_{ne_{1941}} = Turns_{1942}(Date) \cdot AIM_{1941} \cdot AIP_{nar}$$

For $3 \leq i$

$$APr_{194i} = Turns_{194i}(Date) \cdot AIM_{194i} \cdot (AIP_{ne} + AIP_{ev})$$

With the exception the AIM 's, AIP_{ev} , AIP_{des} and AIP_{ne} , which must be replaced by their equivalent for the branch of heavy industry, the formulas to calculate the production of supplies are identical.

$$LL(Date) = 21 \cdot LL_{1941} + \sum_{i=2}^5 Turns_{194i}(Date) \cdot LL_{194i}$$

By replacing AIP_{des} and HIP_{des} with

$$AIP_{des} = AIP_{ar} - AIP_{ev} \text{ and } HIP_{des} = HIP_{ar} - HIP_{ev}$$

and considering the equations

$$AP(Date) = AP_0 + APr(Date) - AP_{cons}$$

$$SP(Date) = SP_0 + HIPr(Date) + LL(Date) - SP_{cons}$$

, it turns out that the equation can be solved for AIP_{ev} and HIP_{ev} . The resulting formula is too long to be shown here but is included in the spreadsheet.

4. Results

Demanding a minimum reserve of 150 000 AP and 600 000 SP , one obtains the following numbers for the minimum amount of AIP and HIP that the Soviet Union should have overall to fulfil it's needs in each game at the given turn.

Game	Turn	Minimum AIP	Minimum HIP
1. Dessauer vs. Oerty	66	366	No data
1. Dessauer vs. Oerty	109	356	156
2. Stelteck vs. Steph78	180	263	156
3. Timmyab vs. Smokindave	192	212	147
4. Topeverest vs. AdmiralKamikaze	160	283	175

Game 1 is an outlier, because it saw the Soviets holding very many manpower centres while suffering repeated massive encirclements, which caused a massive demand for armament points (the Soviets had the manpower to use the armaments points and the need to do so).

Games 2-4 are much better representations of common games between experienced players.

The conclusion is that shooting for 280 *AIP* and 170 *HIP* should be sufficient for most games, with the possibility to go lower for *HIP*, because there were no *SP* saving measures in any of the analysed games (only produce what is really needed, e.g. stopping production of excess aircraft and AFVs) which could reduce demand further.

The result is supported by the 8MP multiplayer game, where the Soviets were positive in terms of *AP* from January 1942 onwards with only 261 *AIP*. Having more *AIP* than the necessary long term minimum is desirable because there tends to be an *AP* shortage in early 1942 which can be shortened by having more factories.

Having some reserve factories can be useful in case re-evacuation is necessary or strategic bombing damages them.

Knowing the necessary amount of *AIP* and *HIP* is very helpful, because you will not waste rail capacity to evacuate excess factories of this type, and can focus on railing units and evacuating AFV and vehicle factories. The calculated numbers are lower than the old estimation of 300*AIP* and 200*HIP*, giving the Soviet player more leeway.

The used method is somewhat rough and only calculates the minimum amount of factories needed at a certain point in the game, not the amount of factories needed to fulfil the needs at every point in the game. Nevertheless, consistency of results from different turns, and cross-checking with the 8MP supports the conclusions.