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Bonus-Malus System in Iran: An Empirical Evaluation

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Abstract: The aim of this paper is to represent the Bonus-Malus System (BMS) of Iran, which is a mandatory scheme based on Insurance act number 56. We examine the current Iranian BMS, using various criteria such as elasticity and time of convergence to steady state with respect to the claim frequency as well as financial balance. We also find the closed form of stationary distribution of the Iranian BMS that plays a key role in study of BMSs. Moreover, we compare the results with the German and Japan BMS. Finally we give some hints that can be used to improve the performance of the current Iranian BMS.

Key words: Claim frequency, Iranian Bonus Malus System, stationary distribution.

1. Introduction

The consequences of car accidents are often very severe, therefore insurance for car owners is compulsory in most countries. For instance in Iran, according to the provisions of Article One of the Law of Compulsory Third Party Liability Insurance (TPLI), all owners of land transport motor vehicles and all kinds of tuggers and trailers attached to the said vehicles, and railway trains, are liable for personal injuries and property damage incurred by third parties as a result of accidents, and are obligated to insure their liability with one of the Iranian insurance companies. Looking at the following factors show the importance of TPLI in Iran:

- Number of road deaths: Figure 1 shows the mortality rates from road traffic injuries per 1,000,000 population, for several countries in 2008[1]. This figure indicates that the highest rate is for Iran.

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[1]http://www.internationaltransportforum.org/statistics/GlobalTrends/Accidents.pdf

Iranians driver's behavior has been blamed for the high accident rates. Indeed, an Iranian official in an interview published online attributed about 70 percent of road accidents to reckless driving, 15% to car failures and the remaining 15% due to the poor state of some of the roads. This official cited illegal overtaking and high speed driving as prime causes of accidents on Persian roadways[2].

- Contribution of TPLI to non-life premiums: In most developed countries, TPLI represents a considerable share of the yearly non-life premium collection. In Iran, the share was more than 40% during the years 2008 and 2009[3].
- Share of TPLI in paid losses: Market statistics of Iran show that the share of TPLI in paid losses was more than 64% in 2008 and decreased to around 60% in 2009[3], which shows that a high percentage of paid loss is related to TPLI. According to official statistics of the Central Insurance of Iran, there were around 11 million policies of TPLI in 2007 which increased to around 14 million in 2008. In this period the annual number of claims did not change and remained around 1.47 million, which show a decrease in loss frequency. The mean frequency claim diminished from 13.3% in 2007 to 10.5% in 2008.

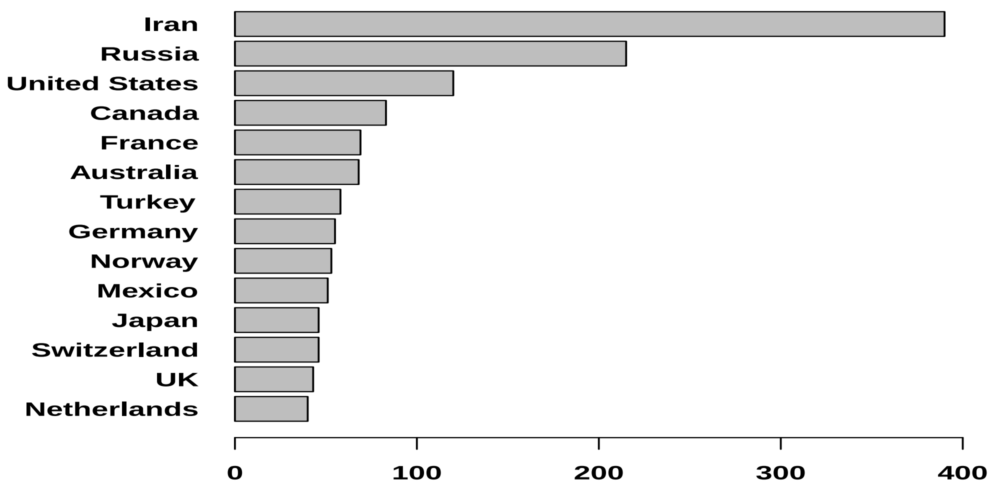

Figure 1: Mortality Rates from Road Traffic Injuries per 1,000,000 population

Many attempts have been made in the actuarial literature to find good models for calculating the premiums; for a review of the existing literature, we refer the interested reader, e.g., to Mahmoudvand and Hassani, 2009; Frangos and Vrontos

[2] http://www.car-accidents.com/country-car-accidents/iran-car-accidents.html
[3] http://www.centinsur.ir/frmHome_en-IR.aspx

(2001). Generally speaking, insurers partition all policies into risk classes with the help of a priori variables such as age, sex, location of driving and so on. However, some important factors may not be taken into account and therefore risk classes are still quite heterogeneous. To solve this problem, adjustment of the premium amount on basis of the individual claims experience can be applied. Adjustment of the premium amount on basis of the individual claims is called a posteriori ratemaking.

Bonus-Malus systems (BMS) are the most common form of a posteriori ratemaking in automobile third-party liability insurance. BMSs are mostly based on the number of policyholder claims. However there are also other complicated versions of BMS which are based on the frequency component, severity component and individual characteristics that affect on the distribution of the frequency and severity components (see for example Mahmoudvand and Hassani (2009); Frangos and Vrontos, 2001). In the simpler BMS, which are considered here, the policyholder moves around the classes of the BMS according to his annual number of claims. Claim-free years are rewarded by premium discounts or bonuses; at-fault accidents are penalized by surcharges called maluses. Such systems were firstly used in the United Kingdom in 1910. Grenander (1957) studied actuarial aspects of applying BMS and after that many studies were published on the theoretical and methodological aspects of BMS.

Lemaire and Zi (1994) studied BMSs of 22 countries. In order to compare these systems with one another, they used different criteria such as stationary average premium level, the elasticity with respect to the claim frequency and the magnitude of the hunger for bonus.

The idea of this paper was originally motivated by the work of Lemaire and Zi. In this paper, we examine the analogous questions in Iranian BMS. It is noticeable that the Iranian BMS has not been the topic of scientific investigations to date in the actuarial literature. This paper aims to analyze this system in details. Despite its apparent simplicity, it will be seen that it leads to nontrivial mathematical problems.

The outline of this paper is as follows: A brief description of the Iranian BMS will be presented in Section 2. Section 3 includes the results of analysis the Iranian BMS and comparison with other countries. Finally, some conclusions will be given in Section 4 and a new modified version of Iranian BMS that has higher performance will be introduced.

2. Iranian BMS

In 1969 the Iranian Parliament passed the act of mandatory automobile third party liability insurance, establishing the a unique a priori premium. This act has been changed and readjusted since its inception. As of 1969 the first BMS of Iran allowed the amount of premium to increase or decrease depending on the past claim records of the insurers. Based on the history of claims, the insured individual would be classified in a bonus category lowering the premium, or a malus category increasing the premium. These categories are shown in Tables 1 and 2. Now, according to Article 1 of Law No. 56 of the Central Insurance of Iran (including Tables 1 and 2), we can rewrite Iranian BMS in a formal representation. Iranian BMS has 11 classes, with premium levels ranging from 50 to 200. The starting level is 100, in class 6. Transition rules are described in Table 3.

Table 1: Discount rates in the premiums

years of no claim	1	2	3	4	5	5+
discount	5%	10%	15%	25%	35%	50%

Table 2: Penalty rates in the premium

claims	1	2	3	4	4+
penalty rate	0	20%	40%	60%	100%

Table 3: Iranian BMS (Starting class: 6)

Class	Relativities	Class after $\cdots$ claim					
		0	1	2	3	4	4+
10	200	5	6	7	8	9	10
9	160	5	6	7	8	9	10
8	140	5	6	7	8	9	10
7	120	5	6	7	8	9	10
6	100	5	6	7	8	9	10
5	95	4	6	7	8	9	10
4	90	3	6	7	8	9	10
3	85	2	6	7	8	9	10
2	75	1	6	7	8	9	10
1	65	0	6	7	8	9	10
0	50	0	6	7	8	9	10

Table 3 shows that each claim-free year results in a one-class discount and k claims ($k \geq 1$) will transferred policyholder to the class $\min\{10, 6 + (k-1)\}$. Looking to the transition rules in Table 3, shows that the current Iranian BMS is not fair for policyholders with claims. For more explanation consider two cases:

- Assume a policyholder is in class k, ($k \leq 6$) and has one claim, then the policyholder will be transferred to class 6 and all premium reductions will be lost.
- On the other hand assume a policyholder is in class k, ($k > 6$), then he/she also will be transferred to class 6, which means that all penalties will be neglected.

This example indicates that the current system gives more rewards to bad drivers than good drivers. Table 3 shows that knowledge of the number of claims for the present year suffices to determine the next class and especially it does not depends on the current class. In the next section we will take a look at inefficiency of this system confirms by using actuarial tools.

Let $p_k, k = 0, 1, \cdots$ denote the distribution of the number of claims of a policyholder during one year. Then the transition probability matrix of the Iranian BMS is represented as follow:

$$\boldsymbol{P} = \begin{bmatrix} p_0 & 0 & 0 & 0 & 0 & 0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ p_0 & 0 & 0 & 0 & 0 & 0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & p_0 & 0 & 0 & 0 & 0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & 0 & p_0 & 0 & 0 & 0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & 0 & 0 & p_0 & 0 & 0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & 0 & 0 & 0 & p_0 & 0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & 0 & 0 & 0 & 0 & p_0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & 0 & 0 & 0 & 0 & p_0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & 0 & 0 & 0 & 0 & p_0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & 0 & 0 & 0 & 0 & p_0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \\ 0 & 0 & 0 & 0 & 0 & p_0 & p_1 & p_2 & p_3 & p_4 & p_{4+} \end{bmatrix} \quad (1)$$

where $p_{4+} = 1 - \sum_{j=0}^{4} p_j$. Assume that $\boldsymbol{\pi} = [\pi_0, \pi_1, \cdots, \pi_{10}]^T$ denotes the vector of stationary probability distribution. Let us now explain how to compute the π_j's. First recall that the vector $\boldsymbol{\pi}$ is the unique probabilistic solution to the system of linear equations:

$$\begin{cases} \boldsymbol{\pi}^T = \boldsymbol{\pi}^T \boldsymbol{P}, \\ \boldsymbol{\pi}^T \boldsymbol{e} = 1, \end{cases} \quad (2)$$

where, $\boldsymbol{e}$ is a column vector of 1's. Applying (2) and transition probability of the Iranian BMS, given by (1) we have:

$$\pi_j = \begin{cases} (\pi_0 + \pi_1) p_0, & j = 0, \\ \pi_{j+1} p_0, & j = 1, 2, 3, 4, \\ (\pi_6 + \cdots + \pi_{10}) p_0, & j = 5, \\ p_{j-5}, & j = 6, 7, 8, 9, \\ p_{4+}, & j = 10. \end{cases} \quad (3)$$

By solving (3) we have:

$$\pi_j = \begin{cases} p_0^6, & j = 0, \\ p_0^{6-j}(1-p_0), & j = 1,2,3,4,5, \\ p_{j-5}, & j = 6,7,8,9, \\ p_{4+}, & j = 10. \end{cases} \tag{4}$$

3. Evaluation of the Current Iranian BMS

As we mentioned the main goal of a BMS is to divide policies into homogeneous classes and to set premiums proportional to their risks. Considering the importance of third party liability automobile insurance in the insurance market, setting correct premiums is one of the most important problems both for insurers and regulators. Lemaire (1995) has provided actuarial tools for the design and evaluation of BMSs. To study and compare the current Iranian BMS with other BMS, we use following tools.

3.1 Elasticity

The elasticity of a BMS measures the response of the system to a change in the claim frequency. More rigorously, denote $P(\lambda)$ the mean stationary premium associated with a claim frequency λ. Ideally, an increment $d\lambda/\lambda$ of the claim frequency should lead to an equal change, $dP(\lambda)/P(\lambda)$, of the premium. The elasticity concept was defined for BMS, under the name of efficiency, by Loimaranta (1972) as follows:

$$Ef_{Loi} = E\left\{\frac{dP(\lambda)/P(\lambda)}{d\lambda/\lambda}\right\}. \tag{5}$$

According to this index, a BMS is called perfectly efficient if $Ef_{Loi} = 1$. In what follows we consider the Poisson distribution for the claim number and compute Ef_{Loi} for several BMS. Figure 2 shows the efficiency of the BMS for Iran, Germany and Japan (German and Japan systems, which used here, are given in the Appendix). As one can see in Figure 2, the efficiency of the Iranian BMS is very low in comparison with other BMS and the reference value 1. It is noticeable that the elasticity of the Iranian BMS is close that of other two systems and even is higher than that of Japan for $\lambda \leq 0.10$, however it is diminished by increasing the claim frequency.

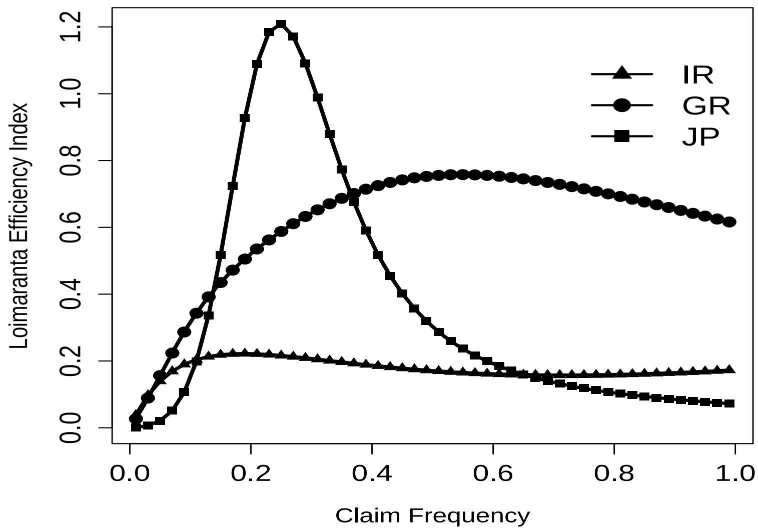

Figure 2: Elasticity index for Iran, Germany and Japan

3.2 The Rate of Convergence

Evaluation of the convergence rate of BMSs toward their steady-state condition is of great importance, because many of the tools defined here assume that stationarity has been reached (Lemaire and Zi, 1994). Let $p_{ij}(\lambda)$ be the one-step transition probabilities of the Markov chain associated with each BMS, and $p_{ij}^{(n)}(\lambda)$ the n step transition probabilities. The formula given bellow, defined by Bonsdorff (1992), which is called total variations

$$TV_n(i) = \sum_j |p_{ij}^{(n)} - \pi_j| \tag{6}$$

is a measure of the degree of convergence of the system after n transitions. Computation of the transition probability distributions of the chain related to the Iranian BMS shows that $TV_n(i) > 0$ for all i and $n = 1, 2, 3, 4, 5$ and becomes zero after that, which means that the Iranian system reaches full stationarity after only 6 years.

Figure 3 displays the behaviour of the index $TV_n(i)$ over a period of 30 years for Iran, Germany and Japan, when $\lambda = 0.1, 0.3$ and i is the starting class of the BMS. The plots show that the total variation of both BMS of Germany and Japan tend to zero for more than 30 years. Whereas the Iranian BMS reaches full stationary after only 6 years. Furthermore, comparison of curves in the left and right corner of the Figure 3 indicate that the time of reaching full stationary decline for the Germany BMS by increasing λ from 0.10 to 0.30, whereas this is vice versa for the Japan BMS.

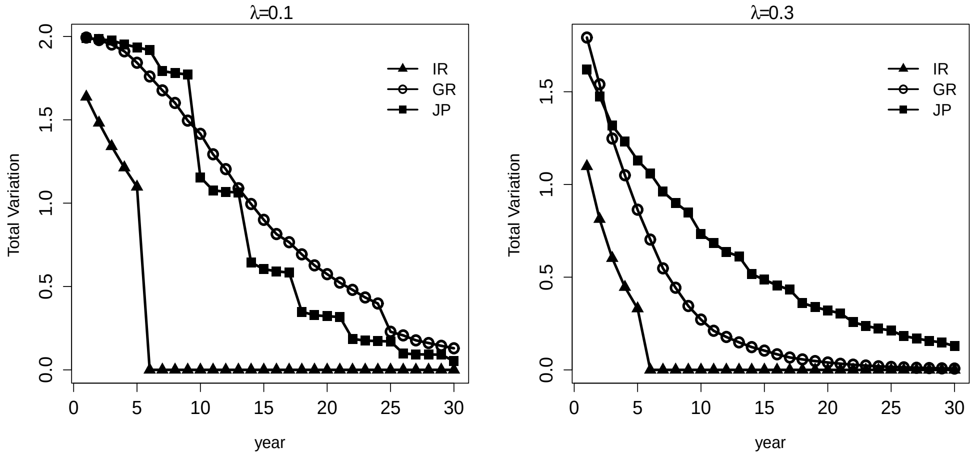

Figure 3: Convergence rate for Iran, Germany and Japan

3.3 Asymptotic Relativity

It is important that the relativities average to 100 %, resulting in financial equilibrium. This property is highly desirable: it guarantees that the introduction of a BMS has no impact on the yearly premium collection. The distribution of the amounts paid by the policyholders is modified according to the reported claims but on the whole, the company gets the same amount of money (Denuit *et al.*, 2007).

Let r_j denotes the relativity associated with level j; means that an insured occupying that level pays an amount of premium equal to $r_j\%$ of the priori premium determined on the basis of his observable characteristics. If $E[r_L] = 1$ for the cases that BMS reaches to steady state, then BMS is balanced. Using (4) for Iranian BMS we have:

$$E[r_L] = \sum_{j=0}^{10} r_j \pi_j = 0.5p_0^6 + (1-p_0)\big[\sum_{j=1}^{3}(0.55 + \frac{j}{10})p_0^{6-j} + 0.90p_0^2 + 0.95p_0] + \sum_{j=6}^{9}(\frac{j-1}{5})p_{j-5} + 2p_{4+}.$$

Assuming a Poisson distribution, $E(r_L)$ is depicted in the Figure 4 with respect to different values of claim frequency, for Iran, Germany and Japan. This figure shows that the value of $E(r_L)$ is less than 1 for all values of claim frequency, whereas we see that the German and Japan BMS attain $E(r_L)$ bigger than one for the value of claim frequencies more than 0.50 and 0.30 respectively. We notice that a low value of $E(r_L)$ indicates a high concentration of policies in the high-discount bonus-malus classes. A high value suggests a better spread among the risk classes.

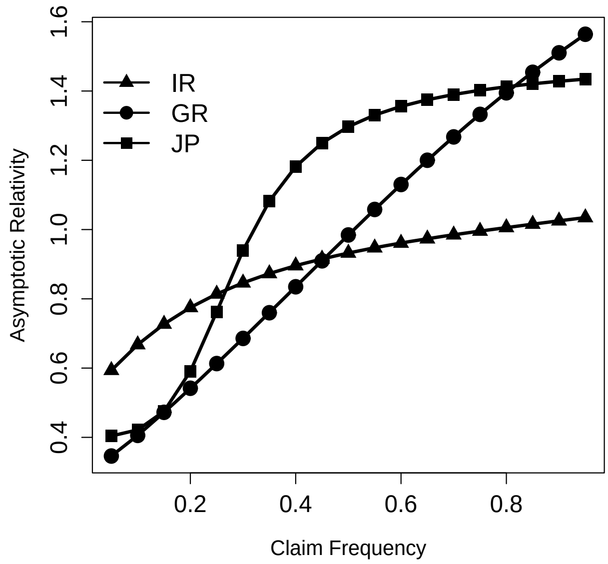

Figure 4: Asymptotic Relativity for Iran, Germany and Japan

4. Conclusions and Suggestions

In this paper, the Iranian BMS by Insurance act number 56, is evaluated by several actuarial tools. Elasticity, convergence rate of BMS to steady state and financial equilibrium of the BMS are considered to evaluate and compare the Iranian BMS with that of some other countries. According to these criteria we can conclude that the current Iranian BMS is not fair and needs to to be revised.

There are many attempts for optimal designing a BMS in the literature, but generally speaking, three following components must be considered for this purpose:

- Number of classes
- Transition rules
- Relativities

For example, we studied the effect of changing the transition rule of the Iranian BMS. For this purpose we used a $-3/+1$ system, in which the discount per claim-free year is one level and penalty per claim is three levels. Figure 5 shows three measures of elasticity, convergence and financial balance of the systems, by considering this change. As it can be seen, this change would make a dramatic improvement to the Iranian BMS.

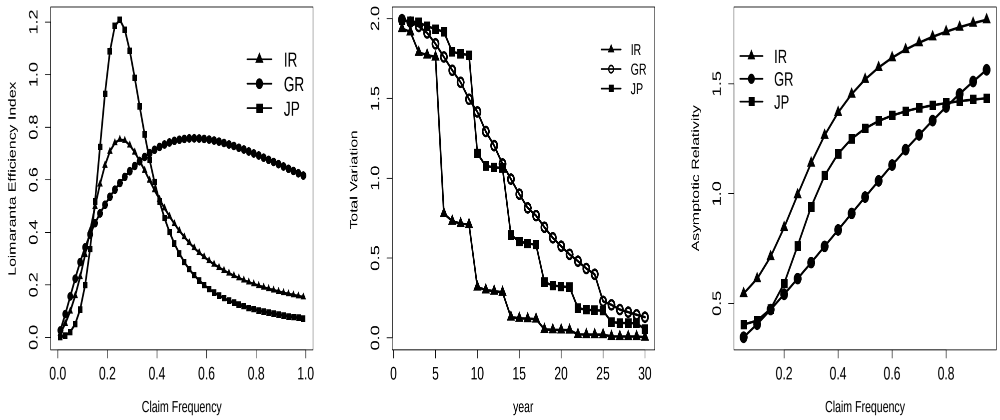

Figure 5: Three considered Index with considering a new revision in the structure of Iranian BMS

Appendix

Table 4: Germanian BMS (Starting class: 25)

Class	Relativities	Class after ··· claim					
		0	1	2	3	4	4+
28	245	24	28	28	28	28	28
27	230	24	28	28	28	28	28
26	155	24	28	28	28	28	28
25	140	24	26	28	28	28	28
24	100	23	25	28	28	28	28
23	85	22	24	26	28	28	28
22	75	21	23	26	28	28	28
21	60	20	23	25	26	28	28
20	55	19	22	25	26	28	28
19	55	18	22	25	26	28	28
18	50	17	21	25	26	28	28
17	50	16	21	24	26	28	28
16	45	15	20	24	26	28	28
15	45	14	20	24	26	28	28
14	40	13	20	24	26	28	28
13	40	12	19	24	26	28	28
12	40	11	19	23	25	28	28
11	40	10	18	23	25	28	28
10	40	9	16	23	25	28	28
9	35	8	16	23	25	28	28
8	35	7	16	23	25	28	28

Table 4: (continued) Germanian BMS (Starting class: 25)

Class	Relativities	Class after ··· claim					
		0	1	2	3	4	4+
7	35	6	16	22	24	28	28
6	35	5	16	22	24	28	28
5	35	4	16	22	24	28	28
4	30	3	15	21	23	28	28
3	30	2	15	21	23	28	28
2	30	1	15	21	23	28	28
1	30	0	14	21	23	28	28
0	30	0	14	21	23	28	28

Table 5: Japanian BMS (Starting class: 10)

Class	Relativities	Class after ··· claim					
		0	1	2	3	4	4+
15	150	14	15	15	15	15	15
14	140	13	15	15	15	15	15
13	130	12	15	15	15	15	15
12	120	11	15	15	15	15	15
11	100	10	14	15	15	15	15
10	100	9	13	15	15	15	15
9	90	8	12	15	15	15	15
8	80	7	11	14	15	15	15
7	70	6	10	13	15	15	15
6	60	5	9	12	15	15	15
5	50	4	8	11	14	15	15
4	45	3	7	10	13	15	15
3	42	2	6	9	12	15	15
2	40	1	5	8	11	14	14
1	40	0	4	7	10	13	13
0	40	0	3	6	9	12	12

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