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# U JEDNOJ GODINI TRI NOBELOVE ZVEZDE IZ EKONOMIJE - II DEO

*Rajnhard Zeltén*

*Nobelova nagrada za 1994.*

## **Rezime**

Nobelovu nagradu iz ekonomije za 1994. godinu „za pionirsku analizu ravnoteže u teoriji nekooperativnih igara“ dobili su Džon Čarls Haršanji, Džon F. Neš i Rajnhard Zeltén. Ono što je zajedničko za ovu trojicu nobelovaca jeste oblast rada iz ekonomije i teška životna iskušenja kroz koja su prošli i uspešno ih prebrodili. Zeltén je Nobelovu nagradu dobio za svoj rad u definisanju koncepta racionalne i iracionalne odluke u predviđanju ishoda nekooperativnih igara. Takođe, dopunjava i Nešov koncept istraživanja igara u kojima su prisutne dinamičke strategijske interakcije.

**Ključne reči:** Rajnhard Zeltén, Nobelova nagrada, igrač, teorija igara, kredibilne pretnje, nekredibilne pretnje, koncept, savršena ravnoteža podigara, informacioni skup, greška, izbor

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*Reinhard Selten*

*Nobel Prize for 1994*

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### Summary

**Abstract:** 1994 Nobel Prize in Economics “for their pioneering analysis of equilibrium in the theory of non-cooperative games” was awarded to John Charles Harsanyi, John F. Nash, and Reinhard Selten. What these three Nobel Prize winners have in common is the field of economics they studied, as well as the hardships that they had undergone and successfully overcome during their lifetime. Selten won the Nobel Prize for his work on defining the concept of rational and irrational decisions in predicting the outcome of non-cooperative games. Also, he refined the Nash equilibrium concept of researching games which involve dynamic strategic interactions.

**Key words:** Reinhard Selten, Nobel Prize, player, game theory, credible threats, non-credible threats, concept, perfect subgame equilibrium, information sets, error, choice

**JEL Classification:** B31, C72, C81

IN ONE YEAR  
THREE NOBEL  
STARS IN  
ECONOMICS  
- PART TWO

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## Od rođenja do svetske slave

Rajnhard Zelten je rođen 1930. godine u Breslau (današnji Vroclav), gradu koji je pre Drugog svetskog rata pripadao Nemačkoj, a danas Poljskoj. Iako je njegov otac bio slep od mladosti, imao je knjižaru, ali je sa ovim poslom morao da prestane sredinom tridesetih godina jer je Jevrejima bilo zabranjeno da se bave biznisom koji je povezan sa izdavaštvom. Zbog političkih (ne)prilika kršten je u protestantskoj crkvi, jer mu je majka bila ove veroispovesti. Otac mu je umro 1942. godine ne doživевši holokaust svojih sunarodnika.

Veoma je bilo teško Rajnhardu da odraste pod Hitlerovim režimom. Sa 14 godina morao je da napusti srednju školu, ali ova agonija nije dugo trajala jer je zajedno sa majkom, braćom i sestrom uspeo da ode iz Nemačke iskoristivši verovatno poslednju šansu koja im se ukazala. Do 1947. godine promenili su mnoga mesta, kada su se skrasili u gradiću Melsungenu gde je do 1951. Rajnhard pohađao srednju školu. Kako je sa porodicom živeo u selu u blizini Melsungena, svakoga dana je morao da pešači tri i po sata do škole. Tokom pešačenja vreme je kratio rešavanjem problema iz geometrije i algebre.

Studirao je matematiku na Univerzitetu u Frankfurtu od 1951. do 1957. godine. U tom periodu bio je zainteresovan i za druga područja studija kao što su psihologija, fizika i astronomija. Jedan članak u časopisu *Fortune Magazine*, koji je pročitao tokom poslednje godine srednje škole, zainteresovao ga je za teoriju igara. U biblioteci je pronašao o tome

knjigu Fon Nojmana i Morgenšterna što ga je još više uputilo na područje istraživanja teorije igara. Poznanstvo sa profesorom Evaldom Burgerom, izuzetnim matematičarem i učiteljem, bilo je od velikog značaja za Rajnhardovu dalju naučnu karijeru. Od 1957. je asistent profesora Hajnca Zauermana koji se bavio povezivanjem teorije igara i ekonomske analize. Iz ove oblasti radio je i doktorski rad koji je odbranio 1961. godine i od tada jača njegov ugled među naučnicima koji se bave ovom vrstom ekonomije i matematike. Kako Zelten sam ističe, Zauerman je bio izuzetan čovek koji je uvek imao dobar osećaj za izbor problematike kojom se u istraživanju treba baviti. Bio je jedan od prvih ekonomista u Nemačkoj koji je propagirao **kejnzijanizam**, odličan organizator koji je mnogo učinio na popularisanju eksperimentalne ekonomije i kome prema sopstvenom priznanju Zelten mnogo duguje.

Zajedno sa Zauermanom 1959. godine napisao je članak „Eksperimentoligopol“ u kojem iznosi rezultate bavljenja eksperimentalnom ekonomijom. Zainteresovanost za psihologiju dok je studirao matematiku bila mu je od pomoći jer se na ovim predavanjima upoznao

Od najznačajnijih radova i studija Rajnharda Zeltena izdvajamo sledeće:

1. Zelten, R. 1973. Jednostavni model nesavršene konkurencije u kome je 4 učesnika malo, a 6 previše. *Međunarodni žurnal teorije igara*, 2 (3): 141-201.
2. Zelten, R. 1977. Oligopolske ekonomije kao igre sa ograničenim informacijama (sa Tomasom Maršakom). *Zeitschrift für die gesamte Staatswissenschaft*, 133 (oktobar): 385-410.
3. Zelten, R. 1983. Model oligopolske veličine, strukture i profitabilnosti. *Evropski ekonomski pregled*, 22 (jun): 33-57.
4. Zelten, R. 1988. Evolutivna stabilnost u ekstenzivnim igrama sa dva učesnika, korekcije i dalji razvoj. *Matematičke i društvene nauke*, 16 (3) (decembar): 223-266.
5. Zelten, R. 1994. Teorija igara i evolutivna biologija (sa Piterom Hamerštajnom). 929-993, u: *Priručniku za teoriju igara*, 2, R.J. Ojman and S. Hart (ur.), Amsterdam-Njujork: Elsevier Science B.V.

In 1994 the Nobel Prize in Economics was awarded to John Charles Harsanyi, Reinhard Selten and John F. Nash, “for their pioneering analysis of equilibrium in the theory of non-cooperative games”. What these three Nobel Prize winners have in common is the field of economics they studied, as well as the hardships that they had undergone and successfully overcome during their lifetime.

Selten won the Nobel Prize for his work on defining the concept of rational and irrational decisions in predicting the outcome of non-cooperative games. Also, he refined the Nash equilibrium concept of researching games which involve dynamic strategic interactions.

### From birth to world fame

Reinhard Selten was born in 1930 in Breslau (today’s Wrocław), a town which before the World War Two belonged to Germany, and is now Polish. His father, despite being blind since his young years, owned a bookshop, but was forced to close it in mid 1930s, since all Jews were forbidden to run a business connected to the press. Under the prevailing political

From the numerous articles and studies authored by Reinhard Selten, we hereby select the following:

1. Selten, R. 1973. A Simple Model of Imperfect Competition where 4 are Few and 6 are Many. *International Journal of Game Theory*, 2 (3): 141-201.
2. Selten, R. 1977. Oligopolistic Economies as Games of Limited Information (with Thomas Marschak. *Zeitschrift für die gesamte Staatswissenschaft*, 133 (October): 385-410.
3. Selten, R. 1983. A Model of Oligopolistic Size, Structure, and Profitability. *European Economic Review*, 22 (June): 33-57.
4. Selten, R. 1988. Evolutionary Stability in Extensive Two-Person Games, Correction and Further Development. *Mathematical Social Sciences*, 16 (3) (December): 223-266.
5. Selten, R. 1994. Game Theory and Evolutionary Biology (with Peter Hammerstein). 929-993, in *Handbook of Game Theory*, 2, R.J. Aumann and S. Hart (eds.), Amsterdam-New York: Elsevier Science B.V.

circumstances, he was baptized in a protestant church, because his mother was a protestant. His father died in 1942, not having witnessed the holocaust of his compatriots.

It was very difficult for Reinhard to live under the Hitler regime. When he was 14, he had to leave high school, but this agony did not last too long, because together with his mother, brothers and a sister, he managed to leave Germany, having seized probably the last opportunity that presented itself to them. They moved a lot, living in many towns, until in 1947 they finally settled in Melsungen, where Reinhard went to high school until 1951. Given that they actually lived in a village near Melsungen, each day he had to walk to school for three and a half hours. During these walks he occupied himself by solving problems in elementary geometry and algebra.

He studied mathematics at the University of Frankfurt from 1951 to 1957. In this period he was also interested in other fields of study, such as psychology, physics and astronomy. It was an article in *Fortune Magazine*, which he read in his last high school year, that raised his interest in game theory. In the library he found a book on the subject by Von Neumann and Morgenstern, which additionally turned his attention to the field of research within game theory. His acquaintance with Professor Ewald Burger, exquisite mathematician and mentor, was of huge importance for Reinhard’s further scientific career. In 1957 he was hired as assistant to Professor Heinz Sauermann, who investigated the connection between game theory and economic analysis. It was in this field that Reinhard wrote his doctoral paper, defended in 1961, which boosted his reputation among the scientists dealing with this field of economy and mathematics. As underlined by Selten himself, Sauermann was an amazing man who always had a good feeling for the trends in the field, suggesting the right problems to be further investigated. He was one of the first to propagate **Keynesianism** in Germany, an excellent organizer, who did much for the propagation of experimental economics, and whom Selten, according to his own words, owes a lot.

Together with Sauermann in 1959 he wrote an article titled “An Oligopoly Experiment”, in

sa eksperimentalnim tehnikama. Nakon doktorata učestvuje na konferenciji posvećenoj teoriji igara na Princetonu. Ova konferencija je Zeltenu bila od velikog značaja jer je tom prilikom upoznao Ojmana i Mašlera koji su bili članovi istraživačke grupe Morgenštern. Sledeći njegov članak iznosi rezultate istraživanja koje je uradio zajedno sa Zauermanom i objavio ga 1962. godine. Tri godine kasnije štampan je još jedan njegov članak „Model oligopola sa inercijom tražnje“, koji je veoma dobro primljen u stručnoj javnosti i mnogo puta citiran, naročito zbog definicije savršenstva podigara. Vrlo brzo, kako ističe Zelten, postalo je jasno da ovaj koncept ne rešava u potpunosti problem savršenstva, te je u članku objavljenom 1975. definisao rafinisaniji pojam savršenstva.

Skup u Jerusalimu 1965. godine posvećen teoriji igara imao je 17 učesnika, među njima i najvažnije ekonomiste koji su se bavili teorijom igara. Na ovom skupu Džon Haršanji je izložio svoju teoriju igara sa nepotpunim informacijama koja je podstakla prisutne na žučnu raspravu. To je bio početak Zeltenove dugogodišnje saradnje sa Haršanijem. Od 1969-1972. godine radio je na Slobodnom univerzitetu u Berlinu kao redovan profesor ekonomije, a potom na Univerzitetu u Bilefeldu. Ovaj fakultet ga je privukao jer je bilo u planu stvaranje velikog Instituta matematičke ekonomije, ali se to nije obistinilo iz finansijskih razloga. U malom institutu koji je osnovan umesto toga radio je zajedno sa Rozenmulerom i Albersom. Koncentracija profesora koji se bave teorijom igara u ovom institutu dala mu je šansu da stekne svetsku reputaciju. Godine u Bilefeldu bile su produktivne, jer je nastavio sa eksperimentalnim istraživanjem, uglavnom na teoriji igara. Intenzivno je saradivao i sa Haršanijem i nakon 18 godina rada izgradili su opštu teoriju ravnotežne selekcije u igrama i potom izdali knjigu 1988. godine.

Zelten je često posećivao Berkli univerzitet zbog saradnje sa Tomom Maršakom koja je rezultirala knjigom o multiproduktnim cenama 1974. godine. Sa Hogatom i njegovim mlađim saradnicima radio je na eksperimentalnom projektu o pregovaranju pod nepotpunim informacijama. Ono što svakako treba istaći jeste Zeltenova spremnost na saradnju sa naučnicima iz različitih oblasti nauke kao što su biologija, botanika, psihologija, filozofija, ali

i sa političarima. Profesor ekonomije postao je na univerzitetu u Bonu 1984. godine. Iako je bio oduševljen interdisciplinarnom atmosferom na Bilefeldu, želeo je da izgradi kompjuterizovanu laboratoriju za eksperimentalnu ekonomiju i Bon je bio spreman da ponudi najbolje uslove u tom pogledu.

Malo je podataka u javnosti iz Zeltenovog bračnog života sa Elizabet Langrajner. Poznato je samo da imaju skladan brak, da nemaju decu i da su veliki zaljubljenici u esperanto.

## Naučni rad

U istraživanjima igara na sreću Zelten je uopštio Nešov koncept u kojem su prisutne dinamičke strategijske interakcije. Pokazao je da u igrama u ekstenzivnoj formi igrači ne mogu da se unapred obavežu na određenu strategiju kao što je to u analizi igara u normalnoj formi. Na osnovu toga zaključio je da Nešove ravnoteže ne mogu da predstavljaju razumna rešenja igre. Odnosno, da je u takvim igrama moguće ostvariti mnoštvo ravnoteža i da je neophodno utvrditi i dodatni mehanizam „prečišćavanja“.

U teoriji igara neko obećanje ili pretnja smatraju se kredibilnim ukoliko je u interesu igrača da ih realizuju. Kada to nije slučaj, pretnje i obećanja su nekredibilni. Zelten je analizirao samo rešenja igre koja se zasnivaju na kredibilnim pretnjama. Tako je nastao koncept savršene ravnoteže podigara.

Nobelovac Herbert Sajmon je tvorac čuvenog koncepta ograničene racionalnosti. Ona predstavlja normalno stanje, dok je puna racionalnost samo jedan specijalni slučaj. Zbog toga je Zelten ovu pretpostavku o ograničenom racionalnom ponašanju uključio i u teoriju igara. Ovo pitanje već je bilo pokrenuto u knjizi Fon Nojmana i Morgenšterna. Istaknuta je činjenica da se može desiti da izbor nekog igrača bude neracionalan. Odnosno, utvrđivanje racionalnog ponašanja mora da uključi sve situacije, čak i one da se drugi igrači ponašaju neracionalno i da tako prave greške u izboru. I Zelten je ovako razmišljao i to upotrebio kao kriterijum za eliminisanje nesavršenih ravnotežnih tačaka. Njegova pretpostavka je bila da pri svakom izboru svaki igrač ima vrlo malu, ali pozitivnu verovatnoću da napravi grešku. U ovoj novoj, izmenjenoj igri nijedna strategija nije unapred

which he presented the results of his dealings with experimental economics. His interest in psychology while he studied mathematics was helpful, given that at these lectures he got acquainted with some experimental techniques. After he received his PhD, he took part in a game theory conference at Princeton. This conference meant a lot to Selten, because on that occasion he met Aumann and Maschler, who were members of Morgenstern's research group at the time. His next article, published in 1962, presented the results of a research conducted together with Sauerermann. Three years later, another one of his articles was published, titled "An Oligopoly Model with Demand Inertia". It was very well received by the professional public and often quoted, especially for its definition of subgame perfectness. According to Selten, very soon it became clear to him that this concept does not completely solve the perfectness problem, which is why, in a paper published 1975, he defined a refined notion of perfectness.

A 1965 game theory workshop in Jerusalem had only 17 participants, among them the most important economists in game theory. It was at this workshop that John Harsanyi presented his theory of games with incomplete information, which triggered some heated discussions among the participants. This marked the beginning of Selten's long cooperation with Harsanyi. In the period from 1969 to 1972, he worked as a full professor of economics at the Free University of Berlin, and then at the University of Bielefeld. This university attracted him by its plans to create a big Institute of Mathematical Economics, which could not be realized due to the lack of funding. In a small institute established instead, he worked together with Rosenmuller and Albers. The concentration of game theory professors

within this institute gave him a chance to get some international reputation. The years he spent at Bielefeld were productive, since he continued with his experimental research, mostly in the field of game theory. He intensively cooperated with Harsanyi, and after 18 years they constructed a general theory of equilibrium selection in games, which was followed by a book they jointly published in 1988.

Selten frequently visited Berkeley, due to his cooperation with Tom Marschak, which resulted in a book on multiproduct pricing published in 1974. He also did experimental work on bargaining under incomplete information together with Hoggatt and his younger associates. What certainly needs to be underlined is Selten's readiness to cooperate with scientists in various fields, including biology, botanics, psychology, philosophy, but also with politicians. In 1984 he became a professor of economics at the University of Bonn. Although he was thrilled by the interdisciplinary atmosphere in Bielefeld, he wanted to build a computerized laboratory for experimental economics, and Bonn was ready to offer him the best conditions in this respect.

Only a few things about Selten's marital life with Elisabeth Langreiner are available to the public. It is known that they enjoy a harmonious marriage, have no children, and that both of them are huge fans of Esperanto.

### Scientific work

Within his research of games of chance, Selten generalized Nash's concept involving dynamic strategic interactions. He proved that in extensive form games, players cannot oblige in advance to follow a certain strategy, as is the case in the analysis of normal form games. Based on this, Selten concluded that





isključena i njoj je pridružena neka pozitivna verovatnoća ostvarenja. Ako je, dakle, igra izmenjena na ovaj način, samo će savršeno ravnotežne tačke u originalnoj igri ostati to i u izmenjenoj igri. Tada će i nesavršeno ravnotežne tačke izgubiti status ravnotežnih tačaka.

Stav ovog nobelovca je da greška koju igrač napravi u jednom informacionom skupu u igri ne utiče na pojavljivanje greške u izboru u nekom drugom informacionom skupu igre ni od istog igrača ni od drugih igrača. Pored ovih istraživanja Zelten se bavio i specijalističkim problemima u teoriji igara.

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2. The Official Website of the Nobel Prize, [www.nobelprize.org](http://www.nobelprize.org)
3. Nobelpreisträger Reinhard Selten: "Den homo oeconomicus gibt es nicht" Ausgabe 3/2010, <http://www.institutional-money.com/magazin/theorie-praxis/artikel/test-4/> (pristupljeno 24.10.2012.)

Nash's equilibria cannot represent the reasonable game solutions. In other words, in such games it is possible to achieve multiple equilibria, which makes it necessary to determine an additional mechanism of "refinement".

In game theory, a promise or a threat are considered credible if it is in the player's interest to realize them. When this is not the case, the concerned promises or threats are non-credible. Selten analyzed only the game solutions based on credible threats. This is how he created the concept of perfect subgame equilibrium.

Another Nobel Prize winner, Herbert Simon, is the creator of the famous concept of bounded rationality. It supposes a normal condition, whereas full rationality refers only to one specific case. Therefore, Selten integrated this assumption on bounded rational behaviour into the game theory. This issue was already dealt with in a book by Von Neumann and Morgenstern. Thereby a fact was underlined that it might happen for the selection of a player to be irrational. This further implies that the determination of rational behaviour must include all situations, even those when other players are behaving irrationally, thus making selection errors. Selten followed this line of thought, using it as a criterion for eliminating imperfect equilibrium points. His assumption was that during each selection each player has a small, but positive probability of making an



error. In this new, altered game, none of the strategies are eliminated in advance, each of them being offered a positive probability of realization. If the game is thus altered, only the perfect equilibrium points in the original game would remain so in the altered game. Even the imperfect equilibrium points would then lose their status of equilibrium points.

The position of this Nobel Prize winner is that an error made by a player within one information set in a game does not impact the occurrence of selection errors within another information set in the game, neither those made by the same player nor those made by other players. In addition to this type of research, Selten also dealt with other more specific game theory issues.