

*Lojd Šepi*

*Nobelova nagrada za 2012.*



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# TEORIJA STABILNIH RASPOREDA

## Rezime

Švedska Kraljevska akademija nauka dodelila je 2012. godine Nobelovu nagradu za ekonomiju Lojdu Šepiju i Elvinu Rotu za teoriju stabilnih raspodela i praksu tržišnog dizajna. Ova dvojica američkih istraživača radila su nezavisno jedan od drugog kombinujući osnovnu teoriju i empirijska istraživanja, i uz eksperimente i praktičan dizajn doprineli su izuzetnom razvoju polja istraživanja i unapredili performanse mnogih tržišta. Šepi, rođen 1923. godine u Kembridžu, Masačusets, doktorirao je na Princeton univerzitetu 1953. godine. Dugo godina radio je u RAND-u, a više od trideset godina bio je profesor na UCLA univerzitetu. Objavio je brojne naučne radove sam ili u saradnji sa drugim ekonomistima.

**Ključne reči:** Švedska Kraljevska akademija, 2012. godina, Nobelova nagrada za ekonomiju, Lojd Šepi, Elvin Rot, teorija stabilnih raspodela, istraživanje, praktičan dizajn, teorija igara, UCLA, Princeton univerzitet, RAND

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*Lloyd S. Shapley**Nobel Prize for 2012*

# THEORY OF STABLE ALLOCATIONS

## Summary

The Swedish Royal Academy awarded the 2012 Nobel Prize in Economics to Lloyd Shapley and Alvin Roth, for the theory of stable allocations and the practice of market design. These two American researchers worked independently from each other, combining basic theory and empirical investigations. Through their experiments and practical design they generated a flourishing field of research and improved the performance of many markets. Born in 1923 in Cambridge, Massachusetts, Shapley defended his doctoral thesis at Princeton University in 1953. For many years he worked at RAND, and for more than thirty years he was a professor at UCLA University. He published numerous scientific papers, either by himself or in cooperation with other economists.

**Keywords:** Swedish Royal Academy, 2012, Nobel Prize in Economics, Lloyd Shapley, Alvin Roth, theory of stable allocations, research, practical design, game theory, UCLA, Princeton University, RAND

**JEL:** B31, C71, C78

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Švedska Kraljevska akademija nauka dodelila je 2012. godine Nobelovu nagradu za ekonomiju Lojdu Šepliju i Elvinu Rotu za teoriju stabilnih raspodela i praksi tržišnog dizajna. Šepli, profesor emeritus na Univerzitetu Kalifornija u Los Anđelesu (UCLA), dao je početni teoretski doprinos ovom polju istraživanja, a Rot, profesor na Harvard Univerzitetu u Bostonu, razvio je i unapredio ova teorijska istraživanja primenivši ih na američko tržište lekara. Naime, njihova istraživanja pomažu u objašnjavanju tržišnih procesa, na primer pri radu na raspodeli lekara u bolnice, učenika u škole i ljudskih organa za transplataciju pacijentima.

### Strast prema matematici i istraživanju - recept za uspešnu karijeru

Šepli i Rot su četvrta grupa ekonomista koja je dobila Nobelovu nagradu na temelju istraživanja unutar teorije igara. Pre njih ovu nagradu dobili su: 1994. godine Neš, Harsani i Selten; 2005. godine Auman i Šeling i 2007. godine Hurvic, Maskin i Majerson. Očigledno, teorija igara postala je jedna od najtrofejnijih grana ekonomije zajedno sa finansijama i makroekonomijom, ali ih prevazilazi svojom sveprisutnošću i moćima koje nude njeni analitički alati.

Ova dvojica američkih istraživača radila su nezavisno jedan od drugog kombinujući osnovnu teoriju i empirijska istraživanja, i uz eksperimente i praktičan dizajn doprineli su izuzetnom razvoju polja istraživanja i unapredili performanse mnogih tržišta.

Neš, savremenik Šeplija, takođe se bavio teorijom igara. Postao je poznat po nekooperativnom delovanju unutar teorije igara, a Šepli po njegovom kooperativnom pandanu. Šepli je izgradio teoriju čije je konture Neš izneo u radu "Problem pregovaranja" koji je objavio u časopisu Ekonometrika 1950. godine. Ovo dvoje ekonomista ne veže samo grana ekonomije kojom su se bavili već i istraživanje u RAND korporaciji koja je bila vodeća u definisanju vojnih strategija SAD.

Sistem uparivanja na kojem je radio Šepli, odnosno istraživanja koja treba da ponude perfektan sistem koji besprekorno funkcioniše

doveo je do rešenja u vidu Gejl - Šeplijevog algoritma. On je primenjen i na "probleme stabilnog braka" i učinio je da Šeplijeva istraživanja postanu uspešna jer funkcionišu čak i kada postoji mogućnost istopolnog uparivanja. Zadatak se sastojao u tome da je bilo potrebno spojiti žene i muškarce na takav način da ne postoji muškarac ili žena koji bi radije imali neke druge partnere nego one koje već imaju - ako takvi muškarac ili žena ne postoje, brakovi su stabilni. Šepli je rešenje video na sledeći način: svaki naznačeni muškarac zaprosi partnerku koju je izabrao. Ona pak onome koga sama izabere odgovara sa – možda, te postaje provizorno verena za njega, a ostalima odgovara sa – ne. Muškarci potom ponavljaju proces, preseći sve partnerke bez obzira da li su već zaprosene ili ne. Ženama je u tom rešenju dozvoljeno da odbace svog sadašnjeg partnera ako naiđe osoba koja će ih zaprositi, a koja im više odgovara.

Šepli objašnjava zašto je ovaj algoritam važan: (1) osigurava da svi muškarci i žene konačno završe u braku i to nakon konačnog broja rundi; (2) osigurava stabilnost brakova. Ovakav način uparivanja generiše raspodelu koja je Pareto efikasna i stabilna i predstavlja fundamentalni koncept u ekonomiji.

### Obrazovanje

Harlou, otac Lojda Šeplija bio je astronom i radio je na teleskopu od 100 inča u Mt. Vilson opservatoriji, Pasadena (Kalifornija). Prvo troje dece Harloua i Marte rođeno je u Pasadeni. Iz ovog grada porodica odlazi kada je Harlou 1920. godine postao direktor Harvardske



The Swedish Royal Academy awarded the 2012 Nobel Prize in Economics to Lloyd Shapley and Alvin Roth, for the theory of stable allocations and the practice of market design. Shapley, a professor emeritus at the University of California in Los Angeles (UCLA), provided the fundamental theoretical contribution to this field of research, whereas Roth, a professor at the Harvard University in Boston, developed and upgraded these theoretical investigations by applying them to the American market of medical doctors. Namely, their research helps explain the market processes at work, for instance, when doctors are assigned to hospitals, students to schools and human organs for transplant to recipients.

### Passion for Math and Research - Formula for a Successful Career

Shapley and Roth are the fourth group of economists who won the Nobel Prize based on their research in the field of game theory. Before them, the Prize was awarded to: Nash, Harsanyi and Selten in 1994; Aumann and Schelling in 2005; and Hurwicz, Maskin and Myerson in 2007. Evidently, game theory has become one of the most rewarded branches of economy alongside finance and macroeconomics, which she surpasses owing to its comprehensiveness and powers enabled by its analytical tools.

These two American researchers worked independently from each other, combining basic theory and empirical investigations. Through their experiments and practical design they generated a flourishing field of research and improved the performance of many markets.



Lojđ Šepļi prima Nobelovu nagradu od kralja Gustava XVI Lloyd S. Shapley receiving his Prize from His Majesty King Carl XVI Gustaf of Sweden at the Stockholm Concert Hall, 10 December 2012

Nash, Shapley's contemporary, also dealt with the game theory. He became famous for a solution concept for non-cooperative game theory and Shapley for its cooperative counterpart. Shapley developed a theory contoured by Nash in his paper "The Bargaining Problem" published in *Econometrica* in 1950. These two economists are tied not only by the branch of economy they investigated, but also by their research at RAND Corporation, the leader in defining the US military strategies.

The matching system developed by Shapley, i.e. his investigations aimed at ensuring a perfect system functioning flawlessly, led him to the solution in the form of the "Gale-Shapley algorithm". It was applied to the "stable marriage problem", and made Shapley's research a success, given that it functions even when there is a possibility of same-sex matching. The task was to match men and women in such a way as to achieve that no man or woman would rather choose a partner other than the one they already have - if there are no such men or women, the marriages are stable. Shapley perceived the solution in the following way: each designated man would propose to a woman of his choosing. She, on the other hand, responds to the man she herself has chosen with a "maybe", hence becoming provisionally engaged to him, and with a "no" to the remaining men. After that, the men repeat the process, proposing to all women regardless of whether they have already been proposed to or not. According to Shapley's solution, the women are allowed to reject their present partner if another person that they find more suitable proposes to them subsequently.

Shapley explains why this algorithm is so important: (1) it ensures that all men and women ultimately end up in a marriage, after a finite number of rounds; and (2) it ensures the stability of marriages. This matching technique generates a Pareto-efficient and stable allocation and represents a fundamental concept in economics.

### Education

Harlow Shapley, Lloyd's father, was an astronomer and worked at the 100-inch telescope on Mt. Wilson in Pasadena,



opservatorije. Lojd se rodio 2. juna 1923. godine u Kembridžu, Masačusets kao četvrto od petoro dece. Od ranog detinjstva pokazivao je svoj talenat za matematiku i unutar porodice je uživao reputaciju "matematičkog čarobnjaka". Lojd je posle završetka Akademije Filips Egzeter upisao studije na Harvardu gde je bio odličan u matematici, ali ne i u drugim predmetima. Međutim, prekida studije i odlazi 1943. godine u vojsku gde ostaje tri godine.

Maštovit i originalan, radi bezbednosti prepiske sa porodicom o poverljivim vojnim putovanjima napisao je šifrovano pismo koje je njegov brat Vilis uspeo da rastumači i tako sazna da se Lojd nalazi u Kini. U vojsci dobija i medalju "bronzana zvezda" i veću platu jer je zbog potreba vojne avijacije pronikao u vremensku prognozu SSSR-a na osnovu koje je na raspolaganju bilo daleko više podataka.

Po povratku iz vojske nastavlja studije na Harvardu sve do 1947. godine. Te godine fakultet je završavala klasa iz 1944. godine koja je dala šest nobelovca, a među njima i Šeplija. Tokom studija Lojd je uzeo sve matematičke predmete koji su na fakultetu postojali, međutim i pored toga nije bio među najboljima. Na kraju studija nije znao čime bi voleo da se bavi i zaposlio se u RAND-u što je za njega bilo idealno radno mesto jer nije bio naročito disciplinovan kada je u pitanju vreme dolaska na posao. RAND je za zaposlene bio otvoren 24 sata. Osnovna delatnost RAND-a bilo je istraživanje i razvoj kompanija. Posao u RAND-u bio je poput neke vrste otvorenog ugovora sa vojnim vazduhoplovstvom zemlje, te Lojd time objašnjava svoje zapošljavanje: "Zato su i zaposlili jednog ludog studenta sa matematičkog odseka - mene!" Istraživanja koja su rađena u RAND-u bazirala su se na teoriji igara i ekonomskom ponašanju objedinjenim u knjizi koja je prvobitno izdata 1944. godine.

Zahvaljujući ovoj knjizi sa matematičarem Rodžerom Snouom radio je na tome kako pronaći sva rešenja za "matriks igru". To je bio i početak njegove karijere u teoriji igara. U RAND-u je proveo oko dve godine, a potom je otišao na Princeton univerzitet ali je i dalje preko leta radio za RAND kao konsultant. Za njegov dalji profesionalan razvoj Princeton je bio od velikog značaja. Ovde je izdao nekoliko svojih radova od kojih je najznačajniji "Vrednost igara sa  $n$ -tim brojem učesnika". Na ovom fakultetu je i doktorirao 1953. godine.

## Teorija igara

Nakon sticanja diplome pred njim je bio akademski rad, ali nije bio zainteresovan za posao predavača, te se vratio u RAND. Tu dobija pismo od Dejvida Gejla sa postavljenim problemom: kako izabrati cimera. Pismo je stiglo u podne, a Gejl je odgovor, odnosno kako da se do rešenja dođe, dobio posle podne. Rešenje je bilo u uparivanju logaritama i objavljeno je 1962. godine u radu sa naslovom "Upis na koledž i stabilnost u braku". Interesantan je podatak da su ovaj rad izdavači dva puta odbili da objave jer im se učinilo da je rešenje previše jednostavno.

## Autorski radovi

1. Vrednost igara sa  $n$ -tim brojem učesnika [1953], *Doprinosi teoriji igara*, br. II, H.V. Kun i A.V. Taker (ur.).
2. Stohastičke igre [1953], *Zbornik Nacionalne akademije nauka*, br. 39, str. 1095–1100.
3. Upis na koledž i stabilnost u braku [1962], (sa Dejvidom Gejлом), *Američki mesečnik za matematiku*, br. 69, str. 9–15.
4. Jednostavne igre: Pregled deskriptivne teorije [1962], *Bihevioralna nauka*, br. 7, str. 59–66.
5. O tržišnim igrama [1969] (sa Martinom Šubikom), *Žurnal ekonomske teorije*, br. 1, str. 9–25.
6. *Vrednosti neatomskih igara* [1974] (sa Robertom Aumanom), Princeton University Press.

California. The first three children of Harlow and Martha were born in Pasadena, but in 1920, when Harlow was appointed director of the Harvard Observatory, the family left the town. Lloyd was born on 2 June 1923 in Cambridge, Massachusetts, as the fourth of five children. He showed an early talent in mathematics and enjoyed a family reputation of being the “math whiz”. After attending Phillips Exeter Academy, Lloyd enrolled at Harvard where he did well in mathematics and less well in other subjects. However, his studies were interrupted when he was drafted in 1943 to spend three years in the army.

Imaginative and original, for the sake of a safe correspondence with his family about his confidential military trips, he wrote a coded letter that his brother Willis figured out, realizing that Lloyd was in China. In the army he received a Bronze Star and a raise in salary after he managed to break the Soviet weather code, which provided the military aviation with a lot more reliable data.

Upon his return from the army Lloyd continued his studies at Harvard and graduated in 1947. Shapley was the sixth member of the Harvard class of 1944 to receive a Nobel Prize. During his studies, Lloyd attended all



Lojd Šepeli (desno) sa sinom Piterom  
Lloyd S. Shapley (right) and his son Peter Shapley (left) at the Nobel  
Banquet, 10 December 2012.

subjects related to mathematics, yet despite that, he was not among the top students. Not being sure about what he was going to do upon graduation, he accepted a job offer at RAND, which was an ideal working place for him given that he was not very disciplined in getting to work on time. RAND was open for its employees all the time, twenty-four hours. The main activity of RAND was research and company development. Working at RAND was a kind of wide-open contract with the US Air Force, which is how Lloyd explains his hiring: “And that’s why they hired a crazy student from the math department - me!” The investigations at RAND were based on game theory and economic behavior, summarized in a book originally published in 1944.

Thanks to this book, Lloyd spent some time working with Roger Snow on how to find all the solutions to a matrix game. This marked the beginning of his career in game theory. He spent two years at RAND, after which he went to Princeton, though during the summers he still worked at RAND as a consultant. Princeton was vital to his further professional development. It was there that he published several papers, the most important of which was “A Value for  $n$ -person Games”. He gained his PhD at this University in 1953.

## Game Theory

Once he had his degree, he was set for doing academic work, yet he was not really interested in teaching, so he returned to RAND. One day he received a letter from David Gale framing a problem of choosing roommates. The letter arrived at noon, and Lloyd mailed the solution

## Selected works:

1. A Value for  $n$ -person Games [1953], *Contributions to the Theory of Games* volume II, H.W. Kuhn and A.W. Tucker (eds.).
2. Stochastic Games [1953], *Proceedings of National Academy of Science* Vol. 39, pp. 1095-1100.
3. College Admissions and the Stability of Marriage [1962] (with David Gale), *The American Mathematical Monthly* Vol. 69, pp. 9-15.
4. Simple Games: An Outline of the Descriptive Theory [1962], *Behavioral Science* Vol. 7, pp. 59-66.
5. On Market Games [1969] (with Martin Shubik), *Journal of Economic Theory* Vol. 1, pp. 9-25.
6. *Values of Non-Atomic Games* [1974] (with Robert Aumann), Princeton University Press.

Od 1952. godine do kasnih sedamdesetih bio je u stalnom kontaktu sa Šubikom. Radili su na aplikaciji za teoriju igara u ekonomiji. Rezultate istraživanja nazvali ga "Strateškim tržišnim igrama". Sa Irvinom Manom 1962. godine izučavao je glasačku moć u nekoliko saveznih država u igri glasanja sa 51 učesnikom, poznatoj kao "Electoral College", koja je korišćena za izbor američkog predsednika. Šepi je imao tezu da je glasanje igra sa nekoliko miliona glasača. Rezultati su pokazali da glasači iz država srednje veličine imaju najmanju glasačku moć. Osim ove dvojice ekonomista sarađivao je i sa Giljermom Ovenom oko glasanja o političkoj situaciji i koristio je tezu koja se zove "prostorne igre".

Pred kraj sedamdesetih godina prošlog veka, svestan da je ostao usamljen u RAND-u na istraživanju teorije igara, Šepi shvata da je krajnje vreme da promeni posao i instituciju ili da se penzionise. Imao je ponudu iz UCLA i Stenforda te je 1981. godine otišao u UCLA da studentima predaje matematiku. Nakon Nobelove nagrade brojni svršeni student ovog fakulteta izneli su pohvale za njegov profesorski rad istakavši posebno njegova briljantna predavanja i lična angažovanja u pružanju



različite (od savetodavne do materijalne) pomoći. Mnogi su tom prilikom izneli i svoje mišljenje da je ovu nagradu odavno zaslužio i da je stigla sa zakašnjenjem, ali "bolje i sa zakašnjenjem nego nikad".

Jezikom matematike služio se i u svakodnevnom govoru, čak i onda kada je želeo da slušaoc zabavi i nasmeje. U biografiji za Nobelovu instituciju koju je napisao

njegov sin Piter uz pomoć svoga brata Kristofera i Lojdovih bliskih saradnika zabeležena je jedna duhovita rečenica prilikom njegovog obraćanja prisutnima na konferenciji juna 1987. godine: "Juče mi je bio rođendan, osećam se kao da sam milion godina star, naravno, baza 2". Svi su se nasmejali jer su razumeli da je Lojd želeo da kaže da se oseća kao da ima dvadesetak godina.

Šepi je autor, sam ili sa drugim poznatim ekonomistima, brojnih stručnih radova i knjiga. Postao je član: Američke akademije za umetnost i nauku 1974; Nacionalne akademije nauka 1979; Američkog ekonomskog udruženja 2007. i Američkog matematičkog društva 2012. godine. Među najznačajnijim nagradama i priznanjima izdvajaju se: John von Neumann Theory Prize 1981. godine i Golden Goose Award 2013. godine, kao i mnoge druge.

## Literatura / References

1. "Lloyd S. Shapley - Biographical". Nobelprize.org. Nobel Media AB 2014. Web. 2 Dec 2014. <[http://www.nobelprize.org/nobel\\_prizes/economic-sciences/laureates/2012/shapley-bio.html](http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2012/shapley-bio.html)>
2. Amerikancima Nobelova nagrada za ekonomiju, Novi magazin, 15.10.2012.
3. Jednostavno objašnjenje zašto su Rot i Šepi dobili Nobela za ekonomiju, Biznis i finansije, 17.10.2012.
4. Noel Irwin: Nobel economics prize goes to two Americans: Lloyd Shapley, Alvin Roth, The Washington Post, Economy 15.10.2012.
5. Professor Lloyd Shapley wins the 2012 Nobel prize in Economics, [www.econ.ucla.edu](http://www.econ.ucla.edu)

back to Gale later that afternoon. This solution, the deferred matching algorithm, was published in 1962 in the paper "College Admissions and the Stability of Marriage". Interestingly enough, the paper was rejected by two reviewers before it was finally published, because it seemed to be too simple.

From 1952 until the late 1970s he had a considerable collaboration with Shubik. They worked on the application of game theory to economics. The results of their research were called the "Strategic Market Games". With Irwin Mann in 1962, he examined the voting power of the several states in the 51-party voting game known as the "Electoral College", used to elect American presidents. Shapley's thesis was that voting is a game with several million voters. The results showed that the voters of medium-sized states have the lowest voting power in the country. In addition to these two economists, Lloyd also cooperated with Guillermo Owen on analyzing voting in a political situation, using an approach called "spatial games".

By the late 1970s, Shapley realized that he was the only one left doing game theory at RAND, and that it was high time he either changed his job or retired. He received offers from UCLA and Stanford, hence in 1981 he moved to UCLA to teach mathematics to math students. After he won the Nobel Prize, many of his former students from this University praised

his professorship, particularly highlighting his brilliant lectures and personal engagements in providing various (from advisory to material) forms of help. On that occasion, many of them voiced their opinion that he had earned this Prize long time ago, and that it was a bit belated, yet "better late than never".

He used the language of math even in his everyday speech, when he wanted to entertain or amuse his audience. The biography written for the Nobel Prize Committee by Lloyd's son, Peter, with the help of his brother, Christopher, and Lloyd's close associates, contains a witty sentence that Lloyd uttered when addressing the participants in a 1987 conference: "Yesterday was my birthday. I feel like I'm a million years

old. Base two, of course." Everybody laughed because they understood that Lloyd was trying to say he felt like a 20-year old boy.

Shapley authored, by himself or in cooperation with other eminent economists, numerous scientific

papers and books. He became a member of the American Academy of Arts and Sciences in 1974; the National Academy of Sciences in 1979; the American Economic Association in 2007; and the American Mathematical Society in 2012. He is the recipient of many significant awards and recognitions, including John von Neumann Theory Prize in 1981, and Golden Goose Award in 2013.

