

Discussion of “The College Admissions Problem
with a Continuum of Students” and “Stability and
Competitive Equilibrium in Trading Networks”

Eric Budish

May 6, 2011

“The College Admissions Problem with a Continuum of Students”

Eduardo Azevedo and Jacob Leshno

- ▶ Setting: many-to-one matching (colleges / students, firms / workers)

“The College Admissions Problem with a Continuum of Students”

Eduardo Azevedo and Jacob Leshno

- ▶ Setting: many-to-one matching (colleges / students, firms / workers)
- ▶ Key insight: the Gale-Shapley deferred acceptance algorithm can be interpreted as discovering a small set of statistics – “prices” – that parameterize the resulting allocation

“The College Admissions Problem with a Continuum of Students”

Eduardo Azevedo and Jacob Leshno

- ▶ Setting: many-to-one matching (colleges / students, firms / workers)
- ▶ Key insight: the Gale-Shapley deferred acceptance algorithm can be interpreted as discovering a small set of statistics – “prices” – that parameterize the resulting allocation
- ▶ Modeling trick: students/workers are a continuum. So the “many” in many-to-one is many indeed

“The College Admissions Problem with a Continuum of Students”

Eduardo Azevedo and Jacob Leshno

- ▶ Setting: many-to-one matching (colleges / students, firms / workers)
- ▶ Key insight: the Gale-Shapley deferred acceptance algorithm can be interpreted as discovering a small set of statistics – “prices” – that parameterize the resulting allocation
- ▶ Modeling trick: students/workers are a continuum. So the “many” in many-to-one is many indeed
- ▶ Allows us to think of each college c as having a “price” p_c , the minimum score required for admission at college c

“The College Admissions Problem with a Continuum of Students”

Eduardo Azevedo and Jacob Leshno

- ▶ Setting: many-to-one matching (colleges / students, firms / workers)
- ▶ Key insight: the Gale-Shapley deferred acceptance algorithm can be interpreted as discovering a small set of statistics – “prices” – that parameterize the resulting allocation
- ▶ Modeling trick: students/workers are a continuum. So the “many” in many-to-one is many indeed
- ▶ Allows us to think of each college c as having a “price” p_c , the minimum score required for admission at college c
- ▶ This technique yields some nice new results:

“The College Admissions Problem with a Continuum of Students”

Eduardo Azevedo and Jacob Leshno

- ▶ Setting: many-to-one matching (colleges / students, firms / workers)
- ▶ Key insight: the Gale-Shapley deferred acceptance algorithm can be interpreted as discovering a small set of statistics – “prices” – that parameterize the resulting allocation
- ▶ Modeling trick: students/workers are a continuum. So the “many” in many-to-one is many indeed
- ▶ Allows us to think of each college c as having a “price” p_c , the minimum score required for admission at college c
- ▶ This technique yields some nice new results:
 - ┆ Unique stable matching (core convergence)

“The College Admissions Problem with a Continuum of Students”

Eduardo Azevedo and Jacob Leshno

- ▶ Setting: many-to-one matching (colleges / students, firms / workers)
- ▶ Key insight: the Gale-Shapley deferred acceptance algorithm can be interpreted as discovering a small set of statistics – “prices” – that parameterize the resulting allocation
- ▶ Modeling trick: students/workers are a continuum. So the “many” in many-to-one is many indeed
- ▶ Allows us to think of each college c as having a “price” p_c , the minimum score required for admission at college c
- ▶ This technique yields some nice new results:
 - | Unique stable matching (core convergence)
 - | This matching is “well behaved” in some appealing ways: continuous wrt primitives, limit of the sequence of finite economy

“The College Admissions Problem with a Continuum of Students”

Eduardo Azevedo and Jacob Leshno

- ▶ Setting: many-to-one matching (colleges / students, firms / workers)
- ▶ Key insight: the Gale-Shapley deferred acceptance algorithm can be interpreted as discovering a small set of statistics – “prices” – that parameterize the resulting allocation
- ▶ Modeling trick: students/workers are a continuum. So the “many” in many-to-one is many indeed
- ▶ Allows us to think of each college c as having a “price” p_c , the minimum score required for admission at college c
- ▶ This technique yields some nice new results:
 - ┆ Unique stable matching (core convergence)
 - ┆ This matching is “well behaved” in some appealing ways: continuous wrt primitives, limit of the sequence of finite economy
- ▶ It also seems of intrinsic intuitive appeal; and may be a useful input into subsequent work

“Stability and Competitive Equilibrium in Trading Networks”

Hatfield, Kominers, Nichifor, Ostrovsky, Westkamp

- ▶ Setting: bilateral trade on a general trading network

“Stability and Competitive Equilibrium in Trading Networks”

Hatfield, Kominers, Nichifor, Ostrovsky, Westkamp

- ▶ Setting: bilateral trade on a general trading network
- ▶ Trade is mediated via *contracts* (a la Hatfield and Milgrom, 2005) each contract specifying:

“Stability and Competitive Equilibrium in Trading Networks”

Hatfield, Kominers, Nichifor, Ostrovsky, Westkamp

- ▶ Setting: bilateral trade on a general trading network
- ▶ Trade is mediated via *contracts* (a la Hatfield and Milgrom, 2005) each contract specifying:
 - | A buyer
 - | A seller
 - | A specific good or service
 - | A monetary transfer

“Stability and Competitive Equilibrium in Trading Networks”

Hatfield, Kominers, Nichifor, Ostrovsky, Westkamp

- ▶ Setting: bilateral trade on a general trading network
- ▶ Trade is mediated via *contracts* (a la Hatfield and Milgrom, 2005) each contract specifying:
 - | A buyer
 - | A seller
 - | A specific good or service
 - | A monetary transfer
- ▶ Assumptions: quasi-linearity, full substitutability
 - | N.B. paper’s discussion of various substitutes conditions in the literature, and how they relate, is a valuable contribution in its own right. In part a reminder of how strong an assumption substitutability is.

- ▶ The model yields familiar-sounding results, but in a very rich setting (e.g. “cycles” of trading partners)

- ▶ The model yields familiar-sounding results, but in a very rich setting (e.g. “cycles” of trading partners)
 - | Existence of competitive equilibria
 - | First welfare theorem
 - | Second welfare theorem
 - | Competitive equilibria are stable
 - | Stable allocations can be supported by comp eqm prices
 - | Substitutability necessary for existence
- ▶ What does all this teach us?

- ▶ The model yields familiar-sounding results, but in a very rich setting (e.g. “cycles” of trading partners)
 - | Existence of competitive equilibria
 - | First welfare theorem
 - | Second welfare theorem
 - | Competitive equilibria are stable
 - | Stable allocations can be supported by comp eqm prices
 - | Substitutability necessary for existence
- ▶ What does all this teach us?
 - | One possible takeaway: indivisibilities *per se* simply aren't that problematic for the competitive equilibrium approach to efficient resource allocation

- ▶ The model yields familiar-sounding results, but in a very rich setting (e.g. “cycles” of trading partners)
 - | Existence of competitive equilibria
 - | First welfare theorem
 - | Second welfare theorem
 - | Competitive equilibria are stable
 - | Stable allocations can be supported by comp eqm prices
 - | Substitutability necessary for existence
- ▶ What does all this teach us?
 - | One possible takeaway: indivisibilities *per se* simply aren't that
proble of com'tettiveapTds ren'trich..efficientd(Fiingourcd(Stable)-(a

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s
- ▶ *Budgets* however are not

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s
- ▶ *Budgets* however are not
 - ┆ Each student θ has a score e_s^θ at each college s

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s
- ▶ *Budgets* however are not
 - | Each student θ has a score e_s^θ at each college s
 - | This score vector determines his choice set, in a highly personalized way

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s
- ▶ *Budgets* however are not
 - | Each student θ has a score e_s^θ at each college s
 - | This score vector determines his choice set, in a highly personalized way
 - | Put differently: each student has a different budget for each college, depending on how highly the college values him

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s
- ▶ *Budgets* however are not
 - | Each student θ has a score e_s^θ at each college s
 - | This score vector determines his choice set, in a highly personalized way
 - | Put differently: each student has a different budget for each college, depending on how highly the college values him
- ▶ Prices in Hatfield et al, too, are at surface very simple: monetary transfer from seller to buyer

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s
- ▶ *Budgets* however are not
 - | Each student θ has a score e_s^θ at each college s
 - | This score vector determines his choice set, in a highly personalized way
 - | Put differently: each student has a different budget for each college, depending on how highly the college values him
- ▶ Prices in Hatfield et al, too, are at surface very simple: monetary transfer from seller to buyer
- ▶ But the *contract space* is incredibly rich, allowing for quite complex pricing patterns

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s
- ▶ *Budgets* however are not
 - | Each student θ has a score e_s^θ at each college s
 - | This score vector determines his choice set, in a highly personalized way
 - | Put differently: each student has a different budget for each college, depending on how highly the college values him
- ▶ Prices in Hatfield et al, too, are at surface very simple: monetary transfer from seller to buyer
- ▶ But the *contract space* is incredibly rich, allowing for quite complex pricing patterns
 - | Each contract specifies a unique buyer-seller pair: “doubly personalized” prices

Discussion topic: nature of the prices

- ▶ Prices in Azevedo and Leshno are simple: price of college s
- ▶ *Budgets* however are not
 - | Each student θ has a score e_s^θ at each college s
 - | This score vector determines his choice set, in a highly personalized way
 - | Put differently: each student has a different budget for each college, depending on how highly the college values him
- ▶ Prices in Hatfield et al, too, are at surface very simple: monetary transfer from seller to buyer
- ▶ But the *contract space* is incredibly rich, allowing for quite complex pricing patterns
 - | Each contract specifies a unique buyer-seller pair: “doubly personalized” prices
 - | Each contract specifies a unique good/service: allows e.g. for non-linear prices

Discussion topic: nature of the prices

- ▶ In neither paper do prices have the feel of Hayek (1945): economizing, in a simple set of statistics, the data individuals need to make efficient resource-allocation decisions on a decentralized basis:

Discussion topic: nature of the prices

- ▶ In neither paper do prices have the feel of Hayek (1945): economizing, in a simple set of statistics, the data individuals need to make efficient resource-allocation decisions on a decentralized basis:
 - | Azevedo and Leshno: budgets too complicated (but: maybe there's a decentralization argument?)

Discussion topic: nature of the prices

- ▶ In neither paper do prices have the feel of Hayek (1945): economizing, in a simple set of statistics, the data individuals need to make efficient resource-allocation decisions on a decentralized basis:
 - | Azevedo and Leshno: budgets too complicated (but: maybe there's a decentralization argument?)
 - | Hatfield et al: too many prices! (but, sometimes there is a commodification argument?)

Discussion topic: nature of the prices

- ▶ In neither paper do prices have the feel of Hayek (1945): economizing, in a simple set of statistics, the data individuals need to make efficient resource-allocation decisions on a decentralized basis:
 - ┆ Azevedo and Leshno: budgets too complicated (but: maybe there's a decentralization argument?)
 - ┆ Hatfield et al: too many prices! (but, sometimes there is a commodification argument?)
- ▶ Yet, in both papers prices play a familiar kind of role: identify and support efficient allocations (are prices / budgets informationally efficient in the sense of Nisan and Segal?)

Discussion topic: nature of the prices

- ▶ In neither paper do prices have the feel of Hayek (1945): economizing, in a simple set of statistics, the data individuals need to make efficient resource-allocation decisions on a decentralized basis:
 - ┆ Azevedo and Leshno: budgets too complicated (but: maybe there's a decentralization argument?)
 - ┆ Hatfield et al: too many prices! (but, sometimes there is a commodification argument?)
- ▶ Yet, in both papers prices play a familiar kind of role: identify and support efficient allocations (are prices / budgets informationally efficient in the sense of Nisan and Segal?)
- ▶ And in both papers the price-theoretic approach yields new theoretical intuitions and insights
 - ┆ Azevedo and Leshno: give a genuinely eye-opening take (to me at least) on the classical deferred acceptance algorithm.
 - ┆ Hatfield et al is an impressive work of unification, highlights some assumptions that really matter and some that are more dispensable for markets with indivisibilities

Discussion topic: nature of the prices

So, the question I would like to pose for discussion is:

- ▶ How do works like these change one's basic thinking about the price system?
- ▶ How do “complex prices” fit into classical price theory?