Kidney Exchange

Mini course on market design
Al Roth
Sao Paulo, July 2014
Pre-kidney history: some abstract theory


House allocation

• Shapley & Scarf [1974] housing market model: n agents each endowed with an indivisible good, a “house”.

• Each agent has preferences over all the houses and there is no money, trade is feasible only in houses.

• Gale’s top trading cycles (TTC) algorithm: Each agent points to her most preferred house (and each house points to its owner). There is at least one cycle in the resulting directed graph (a cycle may consist of an agent pointing to her own house.) In each such cycle, the corresponding trades are carried out and these agents are removed from the market together with their assignments.

• The process continues (with each agent pointing to her most preferred house that remains on the market) until no agents and houses remain.
Theorem (Shapley and Scarf 74): the allocation \( x \) produced by the top trading cycle algorithm is in the core (no set of agents can all do better than to participate)

Proof: Let the cycles, in order of removal, be \( C_1, C_2, \ldots C_k \). (In case two cycles are removed at the same period, the order is arbitrary.)

- Suppose agent \( a \) is in \( C_1 \). Then \( x_a \) is \( a \)'s first choice, so \( a \) can’t do better at any other allocation \( y \), so no \( y \) dominates \( x \) via a coalition containing \( a \).

- Induction: suppose we have shown that no agent from cycles \( C_1, \ldots C_j \) can be in a dominating coalition. Then if \( a \) is in cycle \( C_{j+1} \), the only way that agent \( a \) can be better off at some \( y \) than at \( x \) is if, at \( y \), \( a \) receives one of the houses that originally belonged to an agent \( b \) in one of \( C_1, \ldots C_j \). But, by the inductive hypothesis, \( y \) cannot dominate \( x \) via a coalition that contains \( b \)…
Theorem (Shapley and Scarf 74): the allocation $x$ produced by the top trading cycle algorithm is in the core (no set of agents can all do better than to participate)

- When preferences are strict, Gale’s TTC algorithm yields the *unique* allocation in the core (Roth and Postlewaite 1977).
Theorem (Roth 1982): if the top trading cycle procedure is used, it is a dominant strategy for every agent to state his true preferences.
Theorem (Roth 1982): if the top trading cycle procedure is used, it is a dominant strategy for every agent to state his true preferences.

Sketch of proof: Cycles and chains
The cycles leave the system (regardless of where i points), but i’s choice set (the chains pointing to i) remains, and can only grow.
Allocating dormitory rooms

• Abdulkadiroğlu & Sönmez [1999] studied the housing allocation problems on college campuses, which are in some respects similar:
  • A set of houses (rooms) must be allocated to a set of students. Some of the students are existing tenants each of whom already occupies a room and the rest of the students are newcomers. In addition to occupied rooms, there are vacant rooms. Existing tenants are not only entitled to keep their current houses but also apply for other houses.
Transplants—some background

• Transplantation is the best treatment for a number of diseases
• For kidneys both deceased and live donation is possible
• For most organs, deceased donation is the only possibility
• But there’s a big shortage of organs compared to the need
More than 1,000 kidney transplants in a single year by the "Hospital do Rim" Group in Sao Paulo - Brazil. Medina-Pestana JO.

Abstract

We describe the organization of a high-volume Brazilian kidney transplant program that performed 7,833 transplants in 12 years fulfilling government expectations without compromising the care of the patients. The annual number of kidney transplants increased from 428 in 1999 to 1,048 in 2010. In our Organ Procurement Organization (6.1 million inhabitants) brain death notifications increased from 196 to 468 in 2010 and 35% became actual donors. There are 5,011 patients on the waiting list and recipient selection is based on HLA matching.
Kidneys

• More than 100,000 people on the waiting list for deceased-donor kidneys in the U.S.
  – The wait can be many years, and many die while waiting.
  – (In 2012, 4,543 died, and 2,668 became too sick to transplant…)

• Transplantable organs can come from both deceased donors and living donors.
  – In 2013 there were 5,732 transplants from living donors
  – Now including more than 10% from kidney exchange

• Sometimes donors are incompatible with their intended recipient.

• This opens the possibility of exchange.
Simple two-pair kidney exchange

Donor 1
Blood type A

Recipient 1
Blood type B

Donor 2
Blood type B

Recipient 2
Blood type A
• The very first kidney exchanges were (as far as I know) carried out in S. Korea in the early 1990’s (where the percentage of blood types A and B are roughly equal)

• The first kidney exchange in the U.S. was carried out at the Rhode Island Hospital in 2000
  – Pre 2004: only 5 in the 14 transplant centers in New England
A classic economic problem: 
Coincidence of wants 
(Money and the Mechanism of Exchange, Jevons 1876)

Chapter 1: "The first difficulty in barter is to find two persons whose disposable possessions mutually suit each other's wants. There may be many people wanting, and many possessing those things wanted; but to allow of an act of barter, there must be a double coincidence, which will rarely happen. ... the owner of a house may find it unsuitable, and may have his eye upon another house exactly fitted to his needs. But even if the owner of this second house wishes to part with it at all, it is exceedingly unlikely that he will exactly reciprocate the feelings of the first owner, and wish to barter houses. Sellers and purchasers can only be made to fit by the use of some commodity... which all are willing to receive for a time, so that what is obtained by sale in one case, may be used in purchase in another. This common commodity is called a medium, of exchange..."
Only one country in the world has a legal cash market for kidneys

- The Islamic Republic of Iran
- Virtually everywhere else it is illegal to buy or sell kidneys
A general market design framework to keep in mind:

• To achieve efficient outcomes, marketplaces need to make markets sufficiently
  – Thick
    • Enough potential transactions available at one time
  – Uncongested
    • Enough time for offers to be made, accepted, rejected, transactions carried out…
  – Safe
    • Safe to participate, and to reveal relevant preferences

• Some kinds of transactions are repugnant…and this can constrain market design.
Section 301, National Organ Transplant Act (NOTA), 42 U.S.C. 274e 1984:

“it shall be unlawful for any person to knowingly acquire, receive or otherwise transfer any human organ for valuable consideration for use in human transplantation”.

Charlie W. Norwood Living Organ Donation Act

Public Law 110-144, 110th Congress, Dec. 21, 2007

• Section 301 of the National Organ Transplant Act (42 U.S.C. 274e) is amended-- (1) in subsection (a), by adding at the end the following:

• "The preceding sentence does not apply with respect to human organ paired donation."
Kidney exchange clearinghouse design

_________started talking to docs_________


multi-hospital exchanges become common—hospitals become players in a new “kidney game”


[Additional text not shown]
And in the medical literature


Modeling kidney exchange, when it was new

• Players: patients, donors, surgeons
• Incentives: Need to make it safe for them to reveal relevant medical information
• Blood type is the big determinant of compatibility between donors and patients
• The pool of incompatible patient-donor pairs looks like the general pool of patients with incompatible donors
• Efficient exchange can be achieved in large enough markets (but not infinitely large) with exchanges and chains of small sizes

• Top trading cycles and chains…
Top Trading Cycles and Chains

• The mechanism we propose relies on an algorithm consisting of several rounds. In each round
  – each patient $t_i$ points either towards a kidney in $K_i \cup \{k_i\}$ or towards $w$, and
  – each kidney $k_i$ points to its paired recipient $t_i$.

• A *cycle* is an ordered list of kidneys and patients $(k_1, t_1, k_2, t_2, \ldots, k_m, t_m)$ such that
  – kidney $k_1$ points to patient $t_1$,
  – patient $t_1$ points to kidney $k_2$…
  – kidney $k_m$ points to patient $t_m$, and
  – patient $t_m$ points to kidney $k_1$..

• Note that no two cycles can intersect.
There can be *w-chains* as well as cycles

- A *w-chain* is an ordered list of kidneys and patients \((k_1, t_1, k_2, t_2, \ldots k_m, t_m)\) such that
  - kidney \(k_1\) points to patient \(t_1\),
  - patient \(t_1\) points to kidney \(k_2\),
  - kidney \(k_m\) points to patient \(t_m\), and
  - patient \(t_m\) points to \(w\).
- Unlike cycles, *w-chains* can intersect, so a kidney or patient can be part of several *w-chains*, so an algorithm will have choices to make.

![Diagram showing w-chains and cycles](image-url)
Lemma

Consider a graph in which both the patient and the kidney of each pair are distinct nodes, as is the waitlist option \( w \).
Suppose each patient points either towards a kidney or \( w \), and each kidney points to its paired recipient.
Then either there exists a cycle or each pair is at the end of a \( w \)-chain.
Kidney Exchange

For incentive reasons, all surgeries in an exchange are conducted simultaneously, so a 2-way exchange involves 4 simultaneous surgeries.
Suppose exchanges involving more than two pairs are impractical?


- Our New England surgical colleagues had (as a first approximation) 0-1 (feasible/infeasible) preferences over kidneys.
- Initially, exchanges were restricted to pairs.
  - This involves a substantial welfare loss compared to the unconstrained case
  - But it allows us to tap into some elegant graph theory for constrained efficient and incentive compatible mechanisms.
Pairwise matchings and matroids

- Let \((V,E)\) be the graph whose vertices are incompatible patient-donor pairs, with mutually compatible pairs connected by (undirected) edges.
- A matching \(M\) is a collection of edges such that no vertex is covered more than once.
- Let \(S = \{S\}\) be the collection of subsets of \(V\) such that, for any \(S\) in \(S\), there is a matching \(M\) that covers the vertices in \(S\).
- Then \((V, S)\) is a matroid:
  - If \(S\) is in \(S\), so is any subset of \(S\).
  - If \(S\) and \(S'\) are in \(S\), and \(|S'|>|S|\), then there is a point in \(S'\) that can be added to \(S\) to get a set in \(S\).
Pairwise matching with 0-1 preferences

Theorems:
- All maximal matchings match the same number of couples.
- If patients have priorities, then a “greedy” priority algorithm produces the efficient (maximal) matching with highest priorities.
- Any priority matching mechanism makes it a dominant strategy for all couples to
  - accept all feasible kidneys
  - reveal all available donors
- So, there are efficient, incentive compatible mechanisms
- Hatfield 2005: these results extend to a wide variety of possible constraints (not just pairwise)
Representation with Graphs

Problem:

Subproblem for \(\{1,2,6,7,8\}\):
odd component

even component
Gallai-Edmonds Decomposition
Gallai-Edmonds
Decomposition Lemma

Let $\mu$ be any Pareto efficient matching for the original problem $(N, R)$ and $(I, R_I)$ be the subproblem for $I = N \setminus N^O$.

1. Any overdemanded patient is matched with an underdemanded patient under $\mu$.

2. $J \subseteq N^P$ for any even component $J$ of the subproblem $(I, R_I)$ and all patients in $J$ are matched with each other under $\mu$.

3. $J \subseteq N^U$ for any odd component $J$ of the subproblem $(I, R_I)$ and for any patient $i \in J$, it is possible to match all remaining patients with each other under $\mu$. Moreover under $\mu$
   (a) either one patient in $J$ is matched with an overdemanded patient and all others are matched with each other,
   (b) or one patient in $J$ remains unmatched while the others are matched with each other.
Who are the over-demanded and under-demanded pairs?

- We can ask this even for the more general problem of efficient exchange (i.e. once we surmounted the constraint of just 2-way exchanges).
- By 2006 we had successfully made the case for at least 3 way exchanges
Factors determining transplant opportunity

- **Blood compatibility**

So type O *patients* are at a disadvantage in finding compatible kidneys—they can only receive O kidneys. And type O *donors* will be in short supply.

- **Tissue type compatibility**. Percentage reactive antibodies (PRA)

  - Low sensitivity patients (PRA < 79): vast majority of patients
  - High sensitivity patients (80 < PRA < 100): about 10% of general population, somewhat higher for those incompatible with a donor

  Relevance: patient antibodies to donor HLAs
<table>
<thead>
<tr>
<th>A. Patient ABO Blood Type</th>
<th>Frequency</th>
</tr>
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<tbody>
<tr>
<td>O</td>
<td>48.14%</td>
</tr>
<tr>
<td>A</td>
<td>33.73%</td>
</tr>
<tr>
<td>B</td>
<td>14.28%</td>
</tr>
<tr>
<td>AB</td>
<td>3.85%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Patient Gender</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>40.90%</td>
</tr>
<tr>
<td>Male</td>
<td>59.10%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Unrelated Living Donors</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spouse</td>
<td>48.97%</td>
</tr>
<tr>
<td>Other</td>
<td>51.03%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D. PRA Distribution</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low PRA</td>
<td>70.19%</td>
</tr>
<tr>
<td>Medium PRA</td>
<td>20.00%</td>
</tr>
<tr>
<td>High PRA</td>
<td>9.81%</td>
</tr>
</tbody>
</table>
Compatibility graphs: An arrow points from pair i to pair j if the kidney from donor i is compatible with the patient in pair j.
Random Compatibility Graphs

n hospitals, each of a size c>0
D(n) - random compatibility graph:
1. n pairs/nodes are randomized –compatible pairs are disregarded
2. Edges (crossmatches) are randomized

Random graphs will allow us to ask:
What would efficient matches look like in an “ideal” large world?
(Large) Random Graphs

**G(n,p)** – n nodes and each two nodes have a non directed edge with probability p

Closely related model: **G(n,M)**: n nodes and M edges—the M edges are distributed randomly between the nodes

**Erdos-Renyi**: For any p(n) ≥ (1+ε)(ln n)/n almost every large graph G(n,p(n)) has a perfect matching, i.e. as n→∞ the probability that a perfect matching exists converges to 1.

A natural case for kidneys is p(n) = p, a constant (maybe different for different kinds of patients), hence always above the threshold.

“Giant connected component”
Similar lemma for a random bipartite graph G(n,n,p).
Can extend also for r-partite graphs, directed graphs…
“Ideally” Efficient Allocations: if we were seeing all the patients in sufficiently large markets

Theorem 4.1 (Ashlagi and Roth (2011)). In almost every large (limit) graph without non-directed donors there exists an efficient allocation with cycles of size at most 3 whose structure is as described in Figure 1.

Patient-donor pairs by blood type.

Over-demanded (shaded) patient-donor pairs are all matched.
As kidney exchange has grown, we also have to worry about inefficient withholding of more complex exchanges

Why 4 way exchanges don’t help:
Computational notes

• Finding maximal 2-way exchanges is a computationally easy problem.
• Finding maximal 2- and 3-way exchanges is computationally complex.
  – But so far there hasn’t been a problem solving the necessary integer programs.
Next steps (circa 2006)

• Incorporate undirected donors, list exchange, and compatible pairs.

• Organize a national (UNOS sponsored?) kidney exchange.
  – Requires an amendment to the NOTA
Chains initiated by non-directed (altruistic) donors

Non-directed donation before kidney exchange was introduced.
Chains initiated by non-directed (altruistic) donors

Non-directed donation before kidney exchange was introduced

Non-directed donation after kidney exchange was introduced
A chain in 2007...

3-way chain
March 22, 2007
BOSTON -- A rare six-way surgical transplant was a success in Boston.

There are only 6 people in this chain.
Simultaneity congestion: 3 transplants + 3 nephrectomies = 6 operating rooms, 6 surgical teams…
Chains in an efficient large dense pool

It looks like a non-directed donor can increase the match size by at most 3.

Waiting list patient

Non-directed donor—blood type O
How about when hospitals become players?

- We are seeing some hospitals withhold internal matches, and contribute only hard-to-match pairs to a centralized clearinghouse.
- Mike Rees (APD director) writes us: “As you predicted, competing matches at home centers is becoming a real problem. Unless it is mandated, I'm not sure we will be able to create a national system. I think we need to model this concept to convince people of the value of playing together”.

Individual rationality and efficiency: an impossibility theorem with a (discouraging) worst-case bound

- For every $k \geq 3$, there exists a compatibility graph such that no $k$-maximum allocation which is also individually rational matches more than $1/(k-1)$ of the number of nodes matched by a $k$-efficient allocation.
Proof (for k=3)
There are incentives for Transplant Centers not to fully participate even when there are only 2-way exchanges

The exchange A1-A2 results in two transplantations, but the exchanges A1-B and A2-C results in four. (And you can see why, if Pairs A1 and A2 are at the same transplant center, it might be good for them to nevertheless be submitted to a regional match…)

Fig. 1a

Fig. 1b

(high priority)
PRA – probability for a patient to fail a “tissue-type” test with a random donor
Graph induced by pairs with **A patients and A donors**. 38 pairs (30 high PRA). Dashed edges are parts of cycles. 

*No cycle contains only high PRA patients.*

*Only one cycle *includes* a high PRA patient*
Cycles and paths in random dense-sparse graphs

\[ G \left( n, p_L, \frac{p_H}{n}, v \right) \]

- \( n \) nodes. Each node is L w.p. \( v \) and H w.p. \( 1 - v \)
- incoming edges to L are drawn w.p. \( \frac{p_L}{n} \)
- incoming edges to H are drawn w.p. \( \frac{p_H}{n} \)

L nodes have many incoming arrows
Case $v > 0$ (some low sensitized, easy to match patients. Why increasing cycle size helps

Theorem. Let $C_k$ be the largest number of transplants achievable with cycles $\cdot k$. Let $D_k$ be the largest number of transplants achievable with cycles $\cdot k$ plus one non-directed donor. Then for every constant $k$ there exists $\rho > 0$

$$\mathbb{E}[C_{k+1}] \geq \mathbb{E}[C_k] + \rho n \quad \text{and} \quad \mathbb{E}[D_k] \geq \mathbb{E}[C_k] + \rho n$$

Furthermore, $C_k$ and $D_k$ cover almost all $L$ nodes.
How to accomplish long chains when they’re optimal?

3-way chain
March 22, 2007

BOSTON -- A rare six-way surgical transplant was a success in Boston.

Why are there are only 6 people in this chain?
Simultaneity congestion: 3 transplants + 3 nephrectomies = 6 operating rooms, 6 surgical teams...
Compatibility graph: cycles and chains

Pair 1

Pair 2

Pair 3

Pair 4

Pair 5

Waiting list patient

Non-directed donor

Pair 6

Pair 7
Optimal choice of cycles and chains
Simultaneous cycles and Non-simultaneous extended altruistic donor (NEAD) chains

On day 1 donor D2 gives a kidney to recipient R1, and on day 2 donor D1 is supposed to give a kidney to recipient R2...

Conventional cycle: why always simultaneous?
Simultaneous cycles and Non-simultaneous extended altruistic donor (NEAD) chains

Since NEAD chains can be non-simultaneous, they can be long

A Nonsimultaneous, Extended, Altruistic-Donor Chain

Michael A. Rees, M.D., Ph.D., Jonathan E. Kopke, B.S., Ronald P. Pelletier, M.D.,
Dorry L. Segev, M.D., Matthew E. Rutter, M.D., Alfredo J. Fabrega, M.D.,
Jeffrey Rogers, M.D., Oleh G. Pankewycz, M.D., Janet Hiller, M.S.N.,
Alvin E. Roth, Ph.D., Tuomas Sandholm, Ph.D., M. Utku Ünver, Ph.D.,
and Robert A. Montgomery, M.D., D.Phil.

SUMMARY

We report a chain of 10 kidney transplantations, initiated in July 2007 by a single
altruistic donor (i.e., a donor without a designated recipient) and coordinated over
a period of 8 months by two large paired-donation registries. These transplan-
tations involved six transplantation centers in five states. In the case of five of the
transplantations, the donors and their coregistered recipients underwent surgery
simultaneously. In the other five cases, “bridge donors” continued the chain as
many as 5 months after the coregistered recipients in their own pairs had received
transplants. This report of a chain of paired kidney donations, in which the trans-
plantations were not necessarily performed simultaneously, illustrates the potential
of this strategy.
The First NEAD Chain (Rees, APD)

* This recipient required desensitization to Blood Group (AHG Titer of 1/8).
# This recipient required desensitization to HLA DSA by T and B cell flow cytometry.
THE KIDNEY CHAIN
How a single organ donation changed 20 lives and created the longest-running transplant chain

REYNALDO ESPINOZA, 59
Germantown, Md.

CLAUDIA ALAS, 52
Germantown, Md.

JEAN STAYLOR, 53
Charleston, S.C.

RAYMÖRD STAYLOR, 53
Charleston, S.C.

AVA ROBY, 54
Marysville, Ohio

GEORGE LECHNER, 51
Chillicothe, Ohio

LINDA JANISZEK, 42
Hammonton, Ohio

CECILIA JANISZEK, 71
Huber Heights, Ohio

MATT JONES, 50
Pittsfield, Mich.
First donor

BARBARA BUNNELL, 56
Phoenix

ROD BUNNELL, 56
Phoenix

ANGELA HECKMANN, 34
Toledo, Ohio

LAURIE SARVOS, 54
Toledo, Ohio

LAURIE SARVOS, 54
Toledo, Ohio

KATHRYN MUIRKEY, 29
Cincinnati
Donor in waiting

TIM SHAIN, 43
Lincolnton, N.C.

KURT BLEIKENGOPP, 41
Patchogue, N.Y.

LINDA BLEIKENGOPP, 41
Patchogue, N.Y.

HELENA MUIRKEY

BILL CORHAM, 55
Lincolnton, N.C.

ANONYMOUS DONOR

ANONYMOUS RECIPIENT

Dr. Mike Bees (center, left) and his team perform a kidney transplant.
The majority of exchange transplants, and the vast majority of those to the most highly sensitized patients are accomplished through chains.
Chains are important for hard to match pairs

• Why are chains essential? As kidney exchange became common and transplant centers gained experience they began withholding their easy to match pairs and transplanting them internally.

• This means that the flow of new patients to kidney exchange networks contain many who are hard to match

• So chains become important: many pairs with few compatible kidneys can only be reached through chains.
Feb 2012, NKR: a NDD chain of length 60 (30 transplants)
Behavioral issues: Motivation of donors?

- Standard live donors can have standard motivations: love of spouse, etc.
- Nondirected live donors are some flavor of altruist.
- Bridge donors?
  - A deal’s a deal?
  - More complicated?
- Also need to think about how to increase deceased donation:
Why do we have laws against simply buying and selling kidneys?

• I sure don’t know the answer to this one, but I think it’s a subject that social scientists need to study…

• It isn’t just about body parts…
Why can’t you eat horse meat in California?
Dwarf Tossing

The longest midget toss on record that we could find was made during the British Dwarf Tossing championships of 2002 when Jimmy Leonard of England tossed all 4'4" and 98 pounds of Lenny the Giant a giant 11 feet 5 inches.

Lenny The Giant
Ontario *Dwarf Tossing Ban Act, 2003*

- **Bill 97 2003 An Act to ban dwarf tossing**
- Her Majesty, by and with the advice and consent of the Legislative Assembly of the Province of Ontario, enacts as follows:

**Dwarf tossing banned**

1. (1) No person shall organize a dwarf tossing event or engage in dwarf tossing.

**Offence**

(2) A person who contravenes subsection (1) is guilty of an offence and on conviction is liable to a fine of not more than $5,000 or to imprisonment for a term of not more than six months, or to both.

**Commencement**

2. This Act comes into force on the day it receives Royal Assent.

**Short title**

3. The short title of this Act is the *Dwarf Tossing Ban Act, 2003.*
Dwarf tossing


Manuel Wackenheim began his fight in 1995 after dwarf tossing bans were upheld in France.

• The U.N. case report quotes Wackenheim to the effect that “there is no work for dwarves in France and that his job does not constitute an affront to human dignity since dignity consists in having a job.”

• The UN committee found for France, saying "the ban on dwarf-tossing was not abusive but necessary in order to protect public order, including considerations of human dignity."
Repugnance can be hard to predict

- Why is dwarf tossing widely regarded as repugnant?
- It’s not just the small size of the dwarfs
  - E.g. jockeys are small
Wife Carrying—Not Repugnant?

US champs 2005--traditional

World champs—Estonian position
Money and repugnance

• Often x+$ is repugnant, even when x alone isn’t.
  – E.g. interest on loans,
  – payments to birth mothers in adoption,
  – prostitution
“We didn’t have time to pick up a bottle of wine, but this is what we would have spent.”

(New Yorker)
Money and repugnance

• There seem to be three principal lines of argument about how adding money makes a non-repugnant transaction repugnant:
  – Objectification
  – Coercion ("exploitation")
  – Slippery Slope
Repugnant transactions

• 5 historically important repugnances
  – Sex (outside of marriage, incest, homosexuality, pornography, prostitution…)
  – Servitude: Slavery and serfdom and indentured servitude, women’s (lack of) rights (wasn’t so repugnant, now very much so)
  – Worship (Inquisitions, expulsions, heresy, religious wars, blasphemy)
  – Interest on loans (was repugnant, no longer so much)
  – Drugs (makes the list because of all the associated crime)

• Some are in flux right now
  – Same sex marriage
    • Don’t ask, don’t tell in U.S. military..
  – In-vitro fertilization (Nobel prize in 2010)
    • Other reproduction related transactions: surrogacy, eggs
  – Body parts for transplantation—compensation for donors (Kidneys, bone marrow, deceased donation…)
  – Assisted suicide (in England, re Switzerland)
  – Marijuana (in CA…and lots of crime in Mexico) or Finance(? E.g. securitized mortgages…)
Transactions between consenting adults

• Test yourself for repugnance: are you willing to contemplate the investigation (and perhaps eventual adoption) of carefully regulated sales of live:

  • Kidneys?
  • Hearts?
Kidney Exchange…

…achieves some of the benefits of a market, without using money, and thus without running into the barrier raised by the repugnance that kidney sales arouse.