Web economics I

Economy after the Web: knowledge and networks

version 1.0

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4/3/2010
The course
• Digital goods
• The Web
• Economy after the Web
• Web economics
• Knowledge in existing economic theory
• The 3rd industrial revolution - New economic theory needed
• Microeconomic foundations
• Knowledge
• Economics of Digital goods
• Network externalities
• The demand function for network goods
• Economic analysis of network externalities
Course outline

• Research question: the economy after the Web

Last decade, digital goods and the Web have transformed the patterns of production, exchange and consumption. The value creation mechanisms in this new economy are based on knowledge, creating the so called "knowledge-based" economy. In the "Economics and Business in the Web" course we identify the fundamental elements of this new economic environment in micro and macro level.
Digital goods – definition [Quah]

• bitstrings, sequences of 0s and 1s, which have economic value or
• a set of economically valuable instructions

• examples
Ideas and knowledge, computer software, visual images, music, databases, videogames, blueprints, recipes, DNA sequences, codified messages etc
Digital goods - characteristics

• **nonrival**
  
  use by one agent does not degrade its usefulness to any other agent [ideas, mathematical theorems, S/W, opposite: water]

• **infinitely expansible**
  
  its quantity can be made arbitrarily large arbitrarily quickly at (almost) no cost [mp3 songs, digital pictures]

• **discrete**
  
  instantiate only to quantity 1 - indivisibility

• **aspatial**
  
  they are both nowhere/everywhere at the same time [Virtualization, Lévy]

• **recombinant**
  
  cumulative and emergent/ new digital goods that arise from merging antecedents have features absent from the original
Web widens these characteristics...

by promoting the following activities at low cost:

• Communication
• Collaboration
• Knowledge Representation
• Reasoning & inference (not yet ?)

The result is changes in:

• Time
• Space
• Quantity & quality of options
Web creates “unlimited” options

“unlimited” opportunities, i.e.
• innovative technologies
• social inclusion
• regional development
• collaborative research...

and “unlimited” threats:
• identity theft
• frauds
• addictions...
Economy after the Web

• Knowledge-based economy
• Massive use of ICT all over economy
• Digital goods
• Network and knowledge: the dominant factors
• Self-powered knowledge creation, search and distribution
• Collective production and control
Web economics

1. Knowledge in existing economic theory
2. Micro-economic foundations
3. Network externalities
Knowledge in existing economic theory I

Classical

Marx [theory of exploitation and accumulation]

Schumpeter [innovative entrepreneurship]

placed technological progress at the centre-stage of capitalist development.
Knowledge in existing economic theory II

Classical
Malthus, Smith, Ricardo, Stuart Mill, Marshall

technological change as an instrument for achieving *scale economies* and improved productivity.
Modern

Solow and Swan [exogenous economic growth model]

technical change is exogenous to economic activity, contribution of factors which already exist within an economy (the production function), paradoxical conclusion: rate of growth of income per capita in a long-term balanced economy can be explained only by technological progress.
Knowledge in existing economic theory IV

Modern
Arrow, Romer, Lucas [endogenous economic growth model]

knowledge and technology are no longer the “manna from Heaven” and their use in production is directly linked to production factors.

learning by doing models
increases in productivity are a by-product of economic activity and the acquisition of knowledge is the result of normal investment and production which end up generating accumulated experience

human capital theories
increases in productivity are the result of intentional investment in education and research by economic agents, making technological progress a costly process
3rd industrial revolution

knowledge-based economy and society

1. Knowledge the basic I/O of production
2. Very dynamic in time and space
3. Massive synergic effects (relational)
New economic theory needed I

1. a new philosophy of production, i.e. the incorporation of a new (or several new) productive resources, which results in
   a) a variation of relative costs
   b) an increase in production efficiency
   c) a change in entrepreneurial organisation
   d) the appearance and consolidation of new economic activities
   e) the use of these new goods and services by the other economic activities and agents.
New economic theory needed II

2. a new philosophy for the production of knowledge is also required.

3. new patterns of expenditure and investment are needed, which in our case is a demand-based boost (consumer activity, investment and foreign relations) in production based on the input of knowledge.

Microeconomic foundations

from scale to network economies
Knowledge

1. Data
2. Information
3. Knowledge
4. Wisdom

Knowledge: the human and dynamic process which consists of justifying a personal belief to the point of certainty
Types of Knowledge I

1. know-what (facts)
2. know-why (scientific knowledge)
3. know-how (skills)
4. know-who (networks)

1, 2 easily reproducible
3, 4 not easily reproducible
4 more important in the Web era
Types of Knowledge II

facility of reproduction leads us to the following grouping:

1. explicit, observable or codifiable knowledge
   expressed in a formal/systematic language,
   easily processed, transmitted and stored.

2. tacit or implicit knowledge
   associated with the work factor and includes technical
   and cognitive elements (practical experience, skill
   and qualifications)
   difficult to list.
Knowledge at the Web era

a) increase in the supply of observable knowledge

b) the transformation of tacit knowledge into observable knowledge

c) the development of new abilities within the workforce / generating a virtuous circle between the production of knowledge and its economic and social uses.
1. easily-reproducible knowledge commodities (know-what and know-why)
   a) *Infinitely expansible*
   b) *Experience goods*
   c) *Decreasing marginal usefulness*
   d) *High costs of changing (lock-in)*
   e) *Network externalities*
a) Infinitely expansible

- high fixed costs and very low marginal costs (with a trend towards zero)
- increasing returns to scale (increases in output are higher than the increases in the productive supply of inputs)
- pricing not connected with cost but in differentiation strategies
b) Experience goods

end user cannot determine whether they are useful until he/she consumes them.

From the company's perspective, as experience in production increases, the cost per unit produced falls.

Experience economies

circular flow of perceptions of observable knowledge commodities between entrepreneurs and consumers as the two economic agencies' experience grows.
c) Decreasing marginal usefulness

saturation generates a sensation of accessible and observable knowledge overload.

consumer satisfaction decreases as the sensation of saturation increases together with the cost structure explain differentiation strategies

[semantic web effect?]
d) High costs of changing (lock-in)

- high costs of changing digital goods providers (lock-in)
- technological dependency of users
- expense of changing technology
- Standards
- ...

[what is the role of the Web?]
e) Network externalities

usefulness for consumers grows exponentially as their numbers increase (i.e. Metcalfe's Law, Reed’s Law etc)

[more on this issues in the following sections]
Economics of Digital goods II

2. difficult to reproduce or tacit in nature
   (know-how and know-who)
   a) marginal costs are higher (less intense increasing returns)
   b) Experience goods
   c) Lower consumer saturation (excess of demand)
   d) Network externalities (classical + intrinsic)
economic characteristics of observable knowledge and tacit knowledge commodities

<table>
<thead>
<tr>
<th>Type of knowledge</th>
<th>Ease of reproduction</th>
<th>Type of good</th>
<th>Economic properties</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Know-what</td>
<td>Observable knowledge</td>
<td>No rival</td>
<td>High increasing returns</td>
<td>Digital content, Media, Hardware, telecommunications and machinery, Software and services</td>
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<td></td>
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<td>Experience good</td>
<td>Decreasing marginal usefulness</td>
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<td>Capacity for exclusion</td>
<td>High barriers to release</td>
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<td>Use network externalities</td>
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<tr>
<td>Know-why</td>
<td>Observable knowledge</td>
<td>No rival</td>
<td>High increasing returns</td>
<td>Scientific knowledge, Research and development, Patents, Innovation systems</td>
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<td></td>
<td></td>
<td>Experience good</td>
<td>Decreasing marginal usefulness</td>
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<td>Average exclusion</td>
<td>High barriers to release</td>
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<td></td>
<td>Use network externalities</td>
<td></td>
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<tr>
<td>Know-how</td>
<td>Tacit knowledge</td>
<td>No rival</td>
<td>Average increasing returns</td>
<td>Internal labour markets, Internet job sites, Wetware, Digital competition</td>
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<td></td>
<td>Experience good</td>
<td>Decreasing marginal usefulness</td>
<td></td>
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<td>Low exclusion</td>
<td>Few barriers to release</td>
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<td>Use network externalities</td>
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<tr>
<td>Know-who</td>
<td>Tacit knowledge</td>
<td>No rival</td>
<td>Average increasing returns</td>
<td>Capital and social networks, Relational wetware, Professional networks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experience good</td>
<td>Increasing marginal usefulness</td>
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<td>Low exclusion</td>
<td>Few barriers to release</td>
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<td></td>
<td>Intrinsic network externalities</td>
<td>Use network externalities</td>
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</tbody>
</table>
Network externalities
Externality

• analyzes the impact that individual decision-making has on the other agents
• comparison, of how decision-making involves others without exchange
• Positive (i.e. education) or
• Negative (i.e. pollution)
Network externalities or effects

Dogbert, look, I got the first video phone in the city!

Now we wait for somebody else to buy a compatible video phone and call us.

The amazing thing is that society couldn’t advance without people like you.

I think I saw something.
Network externalities

• "demand-side economies of scale" or "network economies"

• Some goods/services create more value when more users consume the same goods and services.

• They have little or even no value if they are used in isolation.

• The consumers using these products constitute networks in which the utility derived from consumption of these goods increases as additional consumers purchase the same goods.
Types of Externalities

1. direct network externalities
   increased or decreased usefulness of the network for the user as the number of nodes grows (Metcalfe’s Law, communication networks, Internet, Web etc)

2. indirect network externalities
   Change market conditions directly linked to standardisation (positive: price fall due to competition, negative: price increase due to competition restriction practices)

3. learning network externalities
   consolidation of a specific, expert knowledge as the network nodes increase (positive: Web, negative: barriers to expert knowledge)
Fundamental components of network externalities

1. Expectations
   when we choose BlueRay format we believe that it will become a standard

2. Coordination
   reduces the risk of choosing the wrong network. Difficult in big networks.

3. Compatibility
   two products are compatible when the cost of combining them to generate services is free

4. Switching Costs
   barriers to transfer from a network to another
• Positive feedback
• winner takes all [scale-free behavior?]
Metcalfe’s Law I

• Robert Metcalfe, inventor of Ethernet - founder of 3Com
• rule of thumb
• the value of a network can be measured by the number of connected objects
• where “n” is the number of objects (PCs, phones, people) connected, the value of the network is “n” squared

• is supported from the data in semiconductor industry
Metcalfes’s Law II

• After critical mass the benefits of a network grow larger than its costs \[C \times N = A \times N^2 \Rightarrow, \ N = C/A \text{ is critical mass}\]

\(N: \text{network size, } C: \text{cost per connection, } A: \text{value per connection}\)

• The value of a network can not always grow. It may actually starts going down after some size \(N' > N\)
Reed’s Law: Group Forming Networks I

- GFNs have functionality that directly enables & supports affiliations (i.e. interest groups, clubs, meetings, communities) among subsets of its customers.
- Group technologies with **common theme** (user-defined mailing lists, chat rooms, discussion groups, market makers & auction hosts etc)
- Aggregate value of a GFN is proportional to the number of non-trivial groups that can be constructed from $N$ nodes (users or members).
- $N$ users, construct a total of $2^N - N - 1$ non-trivial groups of sizes between 2 to $N$ members.
Reed’s Law: Group Forming Networks II

- total network value according to Reed’s Law scales exponentially with $N \cdot 2^N$

- Example eBay.com
  online auction market site where any subset can form an auction
### What about the Web?

<table>
<thead>
<tr>
<th>eras</th>
<th>description</th>
<th>basic value source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Web 1980’s</td>
<td>The desktop is the platform</td>
<td>Computations [no network effect]</td>
</tr>
<tr>
<td>Web1.0:90’s</td>
<td>“Surfing” Web: The browser is the platform</td>
<td>hyper-linking of documents</td>
</tr>
<tr>
<td>documents</td>
<td></td>
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</tr>
<tr>
<td>Web2.0: 00’s</td>
<td>Social Web: The Web is the platform</td>
<td>social dimension of linkage properties</td>
</tr>
<tr>
<td>people</td>
<td></td>
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</tr>
<tr>
<td>Web3.0:10’s</td>
<td>Semantic Web: The Graph is the platform</td>
<td>URI-based semantic linkages</td>
</tr>
<tr>
<td>data</td>
<td></td>
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</tr>
<tr>
<td>Web4.0:20’s</td>
<td>Metacomputing: The network is the platform</td>
<td>+ processing power hyper-linking</td>
</tr>
<tr>
<td>abilities</td>
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</tbody>
</table>
Criticism

• In real life, Reed’s Law means that total value of a large network doubles every time a new person joins!
• No theory behind them
• This kind of valuation model ignores key factors—competition/saturation/complexity-burocracy.
• Each new connection or GF with same N adds the same value [false assumption]
• the smaller network gains considerably more than the larger one. This produces an incentive for larger networks to refuse to interconnect without payment, a very common phenomenon in the real economy [Odlyzko &Tilly]
• What about negative network effects?
Negative network externalities I

General
digital divide is becoming more expensive both in social and economic terms for people out of the network generating:

- **new democratic deficit** [Vafopoulos]: a metastasis of digital divide which possesses two dimensions:
  
  (a) the lack of effortless and free access to information and communication for all citizens and
  
  (b) unauthorized and no voluntary access to personal data from third parties.
Negative network externalities II

- security, trust
- privacy, identity theft, fraud
- personal data aggregation and exploitation from governments
- congestion externality
  “overuse” of network resources lowers performance (i.e. bandwidth)

**challenge**
- identify & model network effects in social, economic and policy terms
- [think about incorporating them in Web modeling]
## Fundamental value components of the Web

- Which are the “competitive” networks of the Web?
- [short essay]

<table>
<thead>
<tr>
<th>eras</th>
<th>Expectations</th>
<th>Coordination</th>
<th>Compatibility</th>
<th>Switching Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web 1.0</td>
<td>Very low</td>
<td>Low</td>
<td>Very low</td>
<td>Very high</td>
</tr>
<tr>
<td>Web 2.0</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Web 3.0</td>
<td>Very high</td>
<td>Very high</td>
<td>Very high</td>
<td>Very Low</td>
</tr>
<tr>
<td>Web 4.0</td>
<td>Very high</td>
<td>Very high</td>
<td>Very high</td>
<td>Very Low</td>
</tr>
</tbody>
</table>
The same comparison can be done for...

1. Communication
   i. Mobile phones
   ii. Language
   iii. ...
2. knowledge representation
3. Learning
   i. e-learning = failure (high switching costs)
4. Selection process
   i. e-voting = failure (high switching costs)

...
The demand function for network goods

[usually] Concave (not traditional) because:
- positive relation between the value of the network and the increase in the number of users
- marginal contribution to the smaller network from new users from a certain point on (congestion effects).

[analysis will follow]
Types of demand functions

1) the intrinsic value of the technology/product value that it provides to the network user (0=pure networked goods)

2) the marginal, or synchronisation value value that the addition of new users to the network generates for an existing user

3) the size of the network in relation to the size of the market
Types of demand functions

What about the Web 1.0, 2.0 and 3.0?
<table>
<thead>
<tr>
<th>Type of knowledge</th>
<th>Basic network effects</th>
<th>Types (+/-) of network effects</th>
<th>Properties of demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observable knowledge</td>
<td>Direct network externalities</td>
<td>+ Increases in value&lt;br&gt; + Falls in pricing&lt;br&gt; + Increases in variety&lt;br&gt; + Improvement of conditions of&lt;br&gt; access and use&lt;br&gt; - Effects of congestion&lt;br&gt; - Saturation of information&lt;br&gt; - Dominant market positions&lt;br&gt; - Restrictions to competition</td>
<td>Low intrinsic value&lt;br&gt; High marginal value&lt;br&gt; Relatively large size&lt;br&gt; Function shape:</td>
</tr>
<tr>
<td></td>
<td>Indirect network externalities</td>
<td></td>
<td></td>
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<tr>
<td>Tacit knowledge</td>
<td>Learning network externalities</td>
<td>+ Accumulation and diffusion of knowledge&lt;br&gt; + Dilution of learning costs&lt;br&gt; - Barriers to gaining expert knowledge&lt;br&gt; - Changeover costs&lt;br&gt; - Learning opportunity costs</td>
<td>High intrinsic value&lt;br&gt; Low marginal value&lt;br&gt; Relatively small size&lt;br&gt; Function shape:</td>
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</table>
Critical mass of users and the technology adoption curve under external network effects
Economic analysis of network externalities

Based on Kleinberg et al 2010
The Economy Without Network Effects

assumptions

• consumers do not care how many other users of the good there are
• individual decisions without affecting the aggregate behavior [huge number of potential purchasers]
• consumers are represented in the set of all real numbers in \((0, 1)\).
• total mass of consumers is 1.
The Economy Without Network Effects

Assumptions
• Each consumer:
  • wants at most one unit of the good
  • has a personal intrinsic interest in obtaining the good that can vary from one consumer to another [willingness to pay] and
  • This the difference with network effects
The Economy Without Network Effects

Assumptions

• \textit{reservation price (r)}: the maximum amount she is willing to pay for one unit of the good. [inverse demand function]

• individuals are arranged in the \((0, 1)\) in decreasing order of reservation price, so that if consumer \(x\) has a higher reservation price than consumer \(y\), then \(x < y\).

• \(r(x)\) denotes the reservation price of consumer \(x\)
The Economy Without Network Effects

Assumptions

• \( r(\cdot) \) is continuous & no two consumers have exactly the same reservation price
• so the function \( r(\cdot) \) is strictly decreasing as it ranges over the interval from 0 to 1.
• market price for a unit of the good is \( p \): everyone who wants to buy the good can buy it at price \( p \), and no units are offered for sale at a price above or below \( p \).
The Economy Without Network Effects

Assumptions

• At \( p \), everyone whose \( r \geq p \) will actually buy the good, and everyone whose \( r < p \) will not buy it.

• at a price of \( r(0) \) or more, no one will buy the good; and at a price of \( r(1) \) or less, everyone will buy the good.
all consumers between 0 and x buy the product, and all consumers above x don’t — so an x fraction of the population buys the product.
The Equilibrium Quantity of the Good

- many potential producers of the good so that none of them is large enough to be able to influence the market price of the good
- this good can be produced at a constant cost of $p^*$ per unit
- $x^*$ the equilibrium quantity of the good
- socially optimal
The Economy With Network Effects

assumptions

a consumer’s willingness to pay is determined by:

• intrinsic interest - own reservation price
• the number of other people using the good — the larger the user population, the more she is willing to pay.
The Economy With Network Effects

Now two functions:

when a \( z \) fraction of the population is using the good, the reservation price of consumer \( x \) is equal to \( r(x)f(z) \)

- \( f(z) \) measures the benefit to each consumer from having a \( z \) fraction of the population use the good increasing in \( z \): it controls how much more valuable a product is when more people are using it.

- \( r(x)f(z) \) for \( r \) means that those who place a greater intrinsic value on the good benefit more from an increase in the fraction of the population using the good than do those who place a smaller intrinsic value on the good.
The Economy With Network Effects

\[ f(0) = 0: \text{if no one has purchased the good no one is willing to pay anything for the good} \]
\[ f \] is a continuous function.

\[ r(1) = 0: \text{as we consider consumers } x \text{ tending to } 1 \]
\[ (\text{the part of the population least interested in purchasing}), \text{ their willingness to pay is converging to 0}. \]
\[ x \text{ will want to purchase provided that } r(x)f(z) \geq p^*. \]
Equilibria with Network Effects

Assume: all consumers make *perfect* predictions about the number of users of the good (self-fulfilling expectations equilibrium)

If $p^* > 0$

and everyone expects a $z = 0$ fraction of the population to purchase, then the reservation price of each consumer $x$ is $r(x)f(0) = 0$, which is below $p^*$.

Hence no one will want to purchase, and the shared expectation of $z = 0$ has been fulfilled.
if consumer \( x' \) purchases the good and \( x < x' \), then consumer \( x \) will as well. Therefore, the set of purchasers will be precisely the set of consumers between 0 and \( z \). What is the price \( p^* \) at which exactly these consumers want to purchase, and no one else? The lowest reservation price in this set will be consumer \( z \), who — because of the shared expectation that a \( z \) fraction of the population will purchase — has a reservation price of \( r(z)f(z) \). In order for exactly this set of consumers, and no one else, to purchase the good, we must have \( p^* = r(z)f(z) \).
Equilibria with Network Effects

If the price $p^* > 0$ together with the quantity $z$ (strictly between 0 and 1) form a self-fulfilling expectations equilibrium, then $p^* = r(z)f(z)$.

Difference

In the market for a good with network effects the amount of the good demanded by consumers depends on how much they expect to be demanded — this leads $p^* = r(z)f(z)$ for the equilibrium quantity $z$ in contrast to $p^* = r(x^*)$. 
review

- Digital goods
  - Definition
  - Characteristics
- The Web
- Economy after the Web
- Web economics
- Knowledge in existing economic theory
  - Marx and Schumpeter
  - Malthus, Smith, Ricardo, Stuart Mill, Marshall
  - Solow and Swan
  - Arrow, Romer, Lucas
- The 3rd industrial revolution
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- Microeconomic foundations
review

• Knowledge
  – Types of Knowledge
    • know-what (facts)
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• Network externalities
  – Definition
  – Types of Externalities
    • Direct
    • Indirect
    • Learning
review

– Fundamental components
– Metcalfe’s Law
– Reed’s Law
– The Web
– Criticism
– Negative network externalities
– Fundamental value components of the Web

• The demand function for network goods
  – Types of demand functions

• Economic analysis of network externalities
  – The Economy Without Network Effects
  – The Economy With Network Effects
  – Equilibria with Network Effects
Issues for short essays

1. Εμπειρικοί νόμοι για την υποδειγματοποίηση των εξωτερικών οικονομιών δικτύου (Metcalfe’s Law, Reed’s Law κλπ)

2. Η ισορροπία στην αγορά με την ύπαρξη εξωτερικών οικονομιών δικτύου

3. Η οικονομική θεώρηση της τεχνολογίας στους Marx και Schumpeter και στους Malthus, Smith, Ricardo, Stuart Mill, Marshall

4. Η οικονομική θεώρηση της τεχνολογίας στους Solow and Swan και στους Arrow, Romer, Lucas

5. Οι θεμελιώδεις πηγές αξίας και οι εξωτερικές οικονομίες δικτύου του Web
Main readings

  http://www.uoc.edu/uocpapers/8/dt/eng/torrent.html

• Easley and Klienberg, 2010, Networks, Crowds, and Markets: Reasoning about a Highly Connected World, To be published by Cambridge University Press, chapter 17


• Βαφόπουλος (2010), Ψηφιακά αγαθά και Web
Further readings

Sources

  http://www.uoc.edu/uocpapers/8/dt/eng/torrent.html

• Easley and Klienberg, 2010, Networks, Crowds, and Markets: Reasoning about a Highly Connected World, To be published by Cambridge University Press, chapter 17