Economia e Dinamica Industriale

L’evoluzione strutturale: l’approccio History Friendly. Il caso dell’industria farmaceutica

24th October 2014
Evolutionary models of industrial dynamics

- When we consider "structural evolution" of the industry -> increased degree of **complexity**
  - Emergences of new products and technologies
  - Evolution of skills and firms competencies
  - Learning processes
  - Diversification and integration strategies
  - The emergence of networks and relations between actors
  - The role of public authorities
  - ...

- **Analytic approach** -> hard to deal with complexity, risk of an excessive simplification (eg. All firms with the same cost functions)

- **Simulation approach** -> allows economists to better account for the complexity of the economic system (eg. to account for heterogeneous characteristics of firms)
Evolutionary models of industrial dynamics

• **Agent-Based Model (ABM)** is a collection of autonomous decision-making agents. Each agent individually makes decisions on the basis of a given set of rules and interact with the other agents. Together, they determine the behavior of the system as a whole. E.g. consider an ABM where we define behaviors and characteristics of firms (micro-level) and we measure the industry concentration (macro-level).

• **Evolutionary simulation models (first generation)** are a kind of ABMs. They are rather abstract, with simple structure and the empirical basis are given by very broad phenomena. They aim at investigating generic properties of industry structures and dynamics that apply in many different industries.
History friendly models (1)

• **“History friendly” models (HF)** are a kind of ABMs.
  – HF contribute to the construction of formal evolutionary economic models aiming at capturing - in stylized form - qualitative theories about mechanisms and factors affecting industry evolution, technological and institutional change as suggested by empirical research.
  – The goal of HF models is to construct a *consistent and logically coherent model* in order to be able to explore and investigate which features are responsible for the evolution and functioning of the complex system under study.
  – Focus on evolution and dynamics! -> Also transitory is important, not only the equilibrium
  – Industry-specific and history-based
History friendly models (2)

• Analysis with HF models are usually structured as follows:
  1. Description of the historical phenomena and stylized facts to be explained
  2. Relevant theory believed to be crucial for explaining the historical phenomena
  3. Structure of the model
  4. Simulation runs and results

• Opportunities / advantages of using HF models
  – Possibility of running **counterfactual exercises**: once the model is able to replicate history, we can answer to questions like “what would happen if ...”
  – **Emergence** is due to the characteristic of ABMs of being “a representational mechanism that is distinguished by its capacity of generating relations that are not explicitly encoded”.
History friendly models (3)

While the first 3 steps are quite straightforward, the forth generates some concerns among the scholars (Drawbacks and still open questions):

- **How do we set the parameters (initial conditions) of the model?** -> *Calibration* based on empirically measured values of the input parameters (validation) or *calibration* driven by common sense and experience?

- **How do we test the model robustness?** -> *Sensitivity analysis*: It Aims at assessing the robustness of the simulation results conditional on different sets of inputs (MonteCarlo simulations)

- **How do we deal with the fact that we are trying to replicate a “typical” history** that is result of a series of casual events (it is only a set of the possible worlds)?
References


A History-friendly Model Of The Evolution Of The Pharmaceutical Industry

Technological Regimes and Demand Structure in the Evolution of The Pharmaceutical Industry

Journal of Evolutionary Economics, 2012

by Christian Garavaglia, Franco Malerba, Luigi Orsenigo, Michele Pezzoni
The Pharmaceutical Industry

An ideal subject for History-friendly analysis

- Pharmaceuticals are traditionally a highly R&D intensive sector, which has undergone a series of radical technological “shocks”

- This sector is strongly science-based, thus, the analysis of the industry lends itself to a study of a classical chapter of the economics of innovation, i.e. the relationships between scientific research and industrial innovation (linear model, chain model)

- The industry has been deeply affected by a large variety of institutional factors and policies. From this perspective, pharmaceuticals constitute an ideal case for studying the differential impact and the working of alternative policies
INDUSTRY EVOLUTION: Pharma is an R&D intensive sector in which the core of leading innovative firms has remained quite small and stable for a very long period of time, but the degree of concentration has been consistently low, whatever the level of aggregation is considered.

COMPETITION: fierce competition → innovation, imitation, marketing, patents!

RESEARCH: “random screening” -> compounds were randomly screened in test tube experiments and laboratory animals for potential therapeutic activity. Thousands of these compounds were analyzed before researchers could identify a promising lead.

The advent of Biotechnology (not considered in this paper).
Puzzle

• **RQ1**: Why such a high R&D and marketing intensive industry has never been and it is still not highly concentrated?

• **Ancillary analysis**: We test, by means of a regression exercise, if the HF model reproduces a sector dominated by a handful of large firms, which entered early in the history of the sector
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### RQ1

**OTHER** R&D and Marketing intensive industries:

\[ C_4 = 43.50\% \]

- Goodyear: 15.5%
- Michelin: 12%
- Bridgestone: 8%
- Yokohama: 8%
- Kumho: 7.5%
- Hankook: 6.5%
- Falken: 5.5%
- BFGoodrich: 5%
- Continental: 4%
- Dunlop: 4%

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<td>18.8%</td>
<td>19.7%</td>
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<td>16.5%</td>
<td>16.4%</td>
<td>15.3%</td>
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<td>12.6%</td>
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<td>9.2%</td>
<td>8.8%</td>
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<tr>
<td>HONDA</td>
<td>9.7%</td>
<td>10.6%</td>
<td>11.1%</td>
<td>10.8%</td>
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Source: automakers

\[ C_4 = 59.0\% \]
RQ1

Market of Server operating systems (2008)

- 36.5% Windows Server
- 32.7% UNIX
- 13.4% Linux
- 11.8% z/OS
- 5.6% other

C4=94.4%
Ancillary analysis

ILC-REGULARITIES: EXIT BY AGE (COHORT)

% Survival by Entry Date of Automobile Producers

- Long-term survivors come from 1st entry cohort
- Survival chances declines with age of cohort
Other data on pharmaceutical industry: R&D Expenditures

Figure 4: Pharmaceutical R&D expenditure 1980 to 2003 in billion Euro (adjusted for inflation, 2000=100)

Other data on pharmaceutical industry:
New Molecular Entities

New Molecular entities approved by FDA, by country 1990 - 2006

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Three possible explanations of the puzzle

The literature is almost unanimous in suggesting three factors which may explain the patterns observed in pharmaceuticals:

1. **Imitation**: Innovative products of a bunch of innovative firms (the core) are imitated by a fringe of small firms producing generics (practice of “inventing around” existing molecules after the patent protection expires).

2. **Innovation process**: in this industry, the innovative process is characterized by extreme uncertainty and, above all, by the difficulty of leveraging the results of past innovative efforts into new products. In other words, economies of scope and cumulativeness of technological advances are limited (“lottery model”).

3. **Demand -> Market fragmentation**: even monopolistic positions in one submarket do not translate into overall concentration.
The main features of firms' competitive process in the pharmaceutical industry are:

- firms compete through R&D investments as well as imitative strategies;
- firms run parallel projects in product development;
- the Food and Drug Administration (FDA) follows strict approval procedures for new molecular entities;
- the pharmaceutical market is composed of a large number of independent submarkets, corresponding to different therapeutic categories (TCs), with little or no substitution between products;
- patents are a fundamental appropriability device;
- the process of drug discovery and development has long been based on an approach customarily labelled "random screening", in which researchers, lacking a precise knowledge of the causes of diseases and the mechanisms of action of drugs, randomly screen thousands of natural and chemically derived compounds in test tube experiments and on laboratory animals, looking for therapeutic activity;
- the innovative process is characterised by extreme uncertainty and, above all, by the difficulty of leveraging the results of past innovative efforts into new products: in other words, economies of scope and cumulativeness of technological advances are limited;
- firms compete through processes of "inventing around", the development of so-called "me-too drugs" and—after patent expiry—imitation and the entry of generics;
- firms also compete heavily through investments in advertising and marketing.

These relevant features represent the basic characteristics of our model structure. We call these features our model "inputs".
What emerges from these characteristics of competition among firms in this industry can be summarised in the following "stylised facts":

- the industry did not experience a significant rise in the degree of concentration in the global market;
- however, a stable core of leading firms emerged;
- firms diversify in many therapeutic categories;
- firms are able to gain monopoly positions in many therapeutic categories;
- monopolistic positions are short-lived and rarely observed because of the patterns of imitation;
- firms' size distribution is highly skewed;
- the R&D-sales ratio increased rapidly during these decades;
- hundreds of new chemical entities (NCEs) and several important classes of drugs were discovered and introduced, ranging from antibiotics to antidepressants to diuretics, etc.;
- correspondingly, the number of new molecular entities approved by the Food and Drug Administration (FDA) rose steadily from 25 in the decade of 1940-49 to 154 in the 1950s, 171 in the 1960s, and 264 in 1970s (Lichtenberg 2006);
- also, the number of imitative drugs increased significantly.

We call these aspects our model "output".
Theoretical explanations

• Sutton (1998) provides a simple and compact framework in a game theoretic.

• The key determinant is the “escalation parameter” $alpha$: how large is the profit that a firm outspending its current or potential competitors might gain?

• If such profit is large, then an escalation mechanism is set in motion which leads to high concentration.

• The degree of market fragmentation plays a crucial role: if the overall market is composed by many independent sub-markets, then the value of $alpha$ is necessarily lower.
• When the overall market is composed of several independent product groups, firms may pursue alternative research trajectories which have different relevance for the various submarkets.

• At one extreme, the same trajectory might be applicable to a wide range of products.

• At the other extreme, each trajectory is applicable only to one specific submarket.

• Thus, the effectiveness of an escalation strategy depends on two factors.

  1. First, it depends on the effectiveness of R&D investment on any single trajectory in raising consumers’ willingness to pay for the firm product within the associated submarket.

  2. Second, it depends also on the strength of the linkages between different R&D trajectories and their associated submarkets, i.e. on the economies of scope characterizing any one trajectory and on the degree of substitutability among products in the eyes of the consumers (Matraves 1999).

• A further prediction of the model is that an increase of the size of the market should lead to higher concentration: as market size grows, so does the value of the profits achievable through higher R&D spending, and the stronger becomes the escalation mechanisms.
• **Klepper’s approach** takes a different route. In the analysis of the life cycle patterns (Klepper 1996), the main engine is given by a process of dynamic increasing returns to R&D: larger firms benefit most from process R&D— and hence choose to invest more in R&D—because they apply the resulting unit cost reductions to the largest amounts of output.

• As entry and growth occur over time, industry output expands, causing price to fall. Over time, the requisite R&D capabilities to enter arise. Eventually, even the most capable potential entrants cannot profitably enter, and entry ceases. The convex costs of growth limit the ability of later entrants to catch up with earlier entrants in terms of size, and as price continues to fall, the smallest firms and least able innovators are forced to exit the industry. This leads to a shakeout of producers that continues until the entire output of the industry is taken over by the most capable early entrants.

• This model assumes homogeneous demand. Klepper (1997) suggests that product differentiation and demand fragmentation into many niches may prevent shakeouts and the emergence of concentration. Generalizing this intuition, Klepper and Thompson (2006) develop a formal model.
• A third approach focuses attention on the nature of the relevant technological regime (Nelson and Winter 1982; Winter 1984; Pavitt 1984; Breschi et al. 2000) in determining the patterns of innovation and the evolution of market structure.
Technological regimes

• [1] Imitation and [2] innovation process are determined by the nature of technological regime characterizing the industry.

• Technological regime is a mix of three elements:
  – opportunity conditions, two possible effects on concentration:
    • higher opportunities -> more products -> lower concentration
    • higher opportunities -> success-breeds-success -> higher concentration
  – appropriability conditions: higher app. -> less imitation -> higher concentration
  – cumulativeness of technological advancements: higher cum. -> advantages in research process -> higher concentration

• Mixes of particular interest are Schumpeter Mark1 and Schumpeter Mark2
  – SM2: high appropriability; high cumulativeness -> High concentration and large firms (expected)
  – SM1: low appropriability; low cumulativeness -> Low concentration and low firms (expected)

• We will assess the effect of technological regimes under different demand conditions [3]
THE MODEL

Market
Submarkets (TC)
Molecules (M)

Firms (F)
Research activity
Marketing activity

Products
Demand
The **industry environment** is constructed as a series of therapeutic categories (\(TC\)), each of which is characterised by a value (number of patients) and composed by several molecules (\(M\)) that firms can screen in order to develop a new drug.

![Diagram showing therapeutic categories and FDA Quality Check](image)
MARKET

TC = 200

- Number of patients (i.e. Value of TC) drawn from a normal distribution $N(600; \sigma=200)$

Molecules in each TC = 400

- Few molecules (3%) has a positive quality drawn from a normal distribution $N(30; \sigma=20)$, others are null (97%).
- The firms pay the same amount (960 if innovative; 480 if imitative products) to develop a product from a molecule, independently from its quality.
- Imitative products are developed faster than innovative
• In each TC (each characterized by a fixed number of patients) firms may sell products.

• The patients in each TC are grouped in a fixed number of submarkets (4), in which products can be sold if they reach an exogenous minimum level of quality (this means that low-quality products catch few patients, even if they are the only available drug).

![Diagram showing submarkets SubMKT1 to SubMKT4 with quality levels 30, 35, 40, and 45 respectively]
FIRMS

- The industry is populated of $F$ potential entrants.
- Each of them is endowed with a given initial budget $(B)$, equal for all firms.
- Firms are bounded rational and there is imperfect information.
- Firms engage in three activities:
  - **Research**
    - **Search** - can lead to patent protection if the molecule is promising
    - **Development**
  - **Marketing**
- Each firm has a given (innate) individual propensity to these activities. According to their own propensity, firms behave as innovators or imitators.
Search activity
(innovative firms only)

- Firms randomly screen the molecules, spending a given amount of money (a fixed share of the budget, 10%, is used for the search activity).
- The firm draws from the environment $n$ molecules and adds them to the array of (potential) projects.
- $n$ is given by:

$$n = \left( \frac{\text{Budget search}}{\text{draw cost}} \right)$$
Development activity
(run by both, innovative and imitative firms)

• All projects have the same cost of development.

• Firms, developing a project \((i)\) of an innovative or imitative product (or both), pay a fixed amount each period.

• Firms own a portfolio of potential “sleeping” projects, that is private when the firm innovates, and shared with the other firms when the firm imitates (i.e. is the portfolio of molecule with expired patents)

• A firm starts a new project (or multiple “parallel” projects according to \(n_{Proj}\)) if it has, in advance, enough money to finish it.

\[
n_{Proj} = \text{Int} \left( \frac{\text{Budget Research} - \sum_{i=1}^{n} (\text{TimeDevelop} - \text{state}_i) \cdot \text{cost}_{\text{inno/imi}}}{\text{TimeDevelop} \cdot \text{cost}_{\text{inno/imi}}} \right)
\]
Development activity
(run by both, innovative and imitative firms)

• Projects are selected according to the value of their TA: i.e. firms will select more likely a project whose **TA is high valued**.

• BUT: if the patent of the Molecule of the project is **close to expiration**, then firms are less attracted by this project and will not chose it very likely.

\[
index_{i,t} = \text{AvgEarnings}_{i,t} \left( \frac{PD - (t - Pstart_i)}{PD} \right)
\]
Marketing activity

• Once the project \((i)\) is developed the firm commercialize the product spending money for advertising; this amount has been saved up during the development period.

• The higher the value of a TC, the higher the amount spent in marketing for the product in that TC.
Innovation diagram

- **Project 1**
  - Draw
  - Development
  - Market
  - Profits
  - Profits support the activity of Drawing, Development and Marketing.

- **Project 2**
  - Draw
  - Development
  - Market
  - Profits

- **Project i**
  - Draw
  - Development
  - Market
  - Profits

!! Vector different for each firm, depends from drawings !!

Profits support the activity of Drawing, Development and Marketing.
Entry

• All firms start their research activity at time $= 0$.

• When a firm successfully develops its first product, then it enters the market!

• All firms start as innovators. After the first patent expired, then firms behave as innovators or imitators accordingly to their own firm-specific propension.
Product’s exit rule

Products with a market share lower than 5% exit the market.

i.e. Firms that own more than one product, then, might stop producing some of them without exiting the market.

Firm’s exit rules

1) If Firms have no more products and are not researching anymore, obviously exit the market.

2) If Budget < 0

3) If number of draw \( n \) is 0 more than a certain number of times
PRODUCTS

• If the development process is successful (pass quality check), then the firm markets its product

• The value of the $i$-th product $PQ_i$ is a function of the value $Q_i$ of the $i$-th molecule, according to the following relationship:

  \[ PQ_i = (1 + \alpha) Q_i \quad (\alpha \text{ is a noise term}) \]

• $PQ_i$ is one of the factors that defines the utility $U_{it}$ associated to a given product $i$:

  \[ U_{i,t} = PQ_i^a \cdot \left( \frac{1}{P_{i,t}} \right)^b \cdot A_{i,t}^c \]

• In each TC we are able to compute the product market share and consequently the firms market share
**Products: Pricing**

\[ P_i = k \cdot (1 + mup_i) \]

\[ mup_i = (1 - \eta) \cdot mup_{i,t-1} + \eta \cdot \left( \frac{S_{TC,t-1}}{\eta + S_{TC,t-1}} \right) \]

**LEGEND:**
- \( S \): share of patients in a submarket (sub) and total share in a TC (TC) caught by a product
- \( n_{sub} \): number of submarkets reached
- \( S_{TC} \): total share of firm in the TC
- \( i \): product

\[ S_{TC} = \sum_{TC} S_{i,TC} \]

\[ S_{i,TC} = \sum_{sub=1}^{n_{Sub}} \frac{1}{n_{sub}} \cdot S_{i,sub} \]

\[ S_{i,sub} = \frac{U_{i,t}}{\sum_{j=1}^{n_{products.in.sub}} U_{j,t}} \]

\[ U_{i,t} = P Q_i^a \cdot \left( \frac{1}{P_{i,t}} \right)^b \cdot A_{i,t} \]
How does model work in practice?

• Let’s look at how the patient’s utility function is coded... (line 405)

\[ U_{i,t} = PQ_i^a \cdot \left( \frac{1}{P_{i,t}} \right)^b \cdot A_{i,t}^c \]

```csharp
m = 1+m*(1-erosionMarketing);
pos = Math.pow(qp,BioTech.TA[ta].a)
*Math.pow((1/(BioTech.costProd*(1+mup))),BioTech.TA[ta].b)
*Math.pow(m,BioTech.TA[ta].c);
```
How does model work in practice?

• Bandwagon variant 1 (total market share)

```java
if (BioTech.bandwagon1){
    m = 1+m*(1-erosionMarketing);
    pos = Math.pow(qp,BioTech.TA[ta].a)
    *Math.pow((1/(BioTech.costProd*(1+mup))),BioTech.TA[ta].b)
    *Math.pow(m,BioTech.TA[ta].c)
    *Math.pow((1+BioTech.F[firm].totShare[t-1]),BioTech.dw_exp);
}
```

• Bandwagon variant 2 (TA’s market share)

```java
if (BioTech.bandwagon2){
    m = 1+m*(1-erosionMarketing);
    pos = Math.pow(qp,BioTech.TA[ta].a)
    *Math.pow((1/(BioTech.costProd*(1+mup))),BioTech.TA[ta].b)
    *Math.pow(m,BioTech.TA[ta].c)
    *(1+BioTech.F[firm].shTA1[ta]);
}
```
How does model work in practice?

- Re-weighting marketing component

```java
if(BioTech.doubleMKTING){
    m = 1+m*(1-erosionMarketing);
    pos = Math.pow(qp,BioTech.TA[ta].a)
    *Math.pow((1/(BioTech.costProd*(1+mup))),BioTech.TA[ta].b)
    *Math.pow(m,(BioTech.TA[ta].c*2));
}
```
Average over 100 simulations

\[ x = (x_1, \ldots, x_m) \]

\[ \xi \]

\[ \text{Input vector} \]

\[ \text{Stochastic component} \]

\[ \text{Computer Model} \]

\[ y = (y_1, \ldots, y_n) \]

- We comment avg results of the model avg(y_i).
Herfindahl (100 sim)

Time 20 mean=0.042557 median=0.041858

Time 40 mean=0.079059 median=0.075252

Time 60 mean=0.15303 median=0.14356

Time 100 mean=0.21667 median=0.20156
Correlations

corr = 0.20022

corr = 0.94247

corr = -0.075093

corr = 0.74543
STANDARD SIMULATION: FIRST RESULTS

The model is encouragingly successful in reproducing the main **stylised facts** of the evolution of pharmaceutical industry

- In each submarket (TC), concentration (in terms of the Herfindahl index) tends to decrease quickly after an initial upsurge

- Overall market concentration is always much lower than in individual therapeutic categories
STANDARD SIMULATION: Number of Firms
Size distribution of the firms

(50 firms * 100 simulations)

A skewed distribution of firms’ size emerges

STANDARD SIMULATION

AVG number of TCs explored

(100 Sim)

The rate of discovery of new TC is quite high in the first part of the runs, but then it slows down
Innovative and imitative products increase in absolute terms (but the share of imitative products on the total increases continuously over time, as a consequence of imitation)

As time goes by, the prices of drugs decrease
Appropriability (patent duration)

We focus only on appropriability, see the paper for opportunities and cumulativeness

- Expected effect on Htc:
  - higher PD -> lower imitation -> higher H

- Unexpected effect on H, Inverted U:
  - lower patent duration -> lower H
  - higher patent duration -> lower H, why?

Stronger patent protection extends the ability to maintain market power in each TC -> more profits -> more drugs -> more TCs discovered -> H declines
Appropriability + fragmentation

• Concentration depends much more on the degree of fragmentation (negligible appropriability effect)

• The effects of change of patent protection are constrained by the structure of demand

• In homogeneous markets concentration tends to be high anyway
How do we explain effect of fragmentation on market concentration?

• When market is fragmented the prize accruing to an innovator is limited. An early innovator gains only a modest advantage *vis-a-vis* competitors, who maintain their chances to discover a molecule, mainly by opening new TCs.

• Conversely when the prize is big (and TCs are few) early innovators gain disproportionate advantage, while competitors are left with little possibilities to invest and find new drugs.
Econometric analysis
(obs: 50 firms * 100 simulations)

We test with regression analysis:
1. The effect of “prize” for innovators [RQ1]
2. The relevance of innovative strategies (i.e. the presence of a core of large innovative firms) [Ancillary analysis]
3. The presence of a first mover advantage (i.e. the large firms are also the first firms entering the market) [Ancillary analysis]
Econometric analysis

Dependent variables:
- share: the firms’ market share at the end of simulation (time = 100);
- size: the firms’ profit at the end of simulation (time = 100);
- alive: status of firms if not exited before the end of simulation (time = 100);
- nTC: firms’ diversification, i.e. number of submarkets explored by each single firm at the end of simulation (time = 100);

Regressors:
- dummies for cohorts of entry: we construct 3 dummies relating to the period of entry of firms; cohort1 if the firm enters in the first 3 periods, cohort2 if the firm enters between periods 4 and 8, cohort3 if the firm enters after period 8;
- market_size: size of the market, in terms of patients, in which firms enter first;
- dummies for the propensity of firms to invest in research in comparison to marketing. We define 4 dummies, high_propensity, medium_propensity, weak_propensity, low_propensity, respectively if $h < 0.25$, $0.25 \leq h < 0.5$, $0.5 \leq h < 0.75$, $h \geq 0.75$. 
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) alive</th>
<th>(2) log(share)</th>
<th>(3) log(nTC)</th>
<th>(4) log(size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cohort1</td>
<td>0.87***</td>
<td>0.18**</td>
<td>0.23***</td>
<td>0.23***</td>
</tr>
<tr>
<td></td>
<td>(0.064)</td>
<td>(0.085)</td>
<td>(0.040)</td>
<td>(0.087)</td>
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<tr>
<td>cohort2</td>
<td>0.63***</td>
<td>0.057</td>
<td>0.18***</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>(0.073)</td>
<td>(0.093)</td>
<td>(0.044)</td>
<td>(0.096)</td>
</tr>
<tr>
<td>high propensity</td>
<td>0.062</td>
<td>1.47***</td>
<td>0.21***</td>
<td>1.58***</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.058)</td>
<td>(0.028)</td>
<td>(0.060)</td>
</tr>
<tr>
<td>medium propensity</td>
<td>-0.015</td>
<td>0.37***</td>
<td>0.24***</td>
<td>0.30***</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.059)</td>
<td>(0.028)</td>
<td>(0.060)</td>
</tr>
<tr>
<td>weak propensity</td>
<td>-0.031</td>
<td>0.12**</td>
<td>0.11***</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.060)</td>
<td>(0.028)</td>
<td>(0.061)</td>
</tr>
<tr>
<td>log(market size)</td>
<td>1.06***</td>
<td>0.35***</td>
<td>0.24***</td>
<td>0.36***</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.035)</td>
<td>(0.017)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>Constant</td>
<td>-6.42***</td>
<td>-6.35***</td>
<td>2.08***</td>
<td>2.55***</td>
</tr>
<tr>
<td></td>
<td>(0.20)</td>
<td>(0.22)</td>
<td>(0.10)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>(pseudo) 0.29</td>
<td>0.307</td>
<td>0.145</td>
<td>0.336</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

(1) probit, (2,3,4) OLS
Other exercises:
Interaction between PD and opportunities -> concentration (H)