Testing the “waterbed” effect in mobile telephony

Christos Genakos (University of Cambridge and CEP) and Tommaso Valletti (Imperial College London, University of Rome and CEPR)
A “waterbed” effect

- Mobile telephony largely unregulated, with the important exception of termination (MTR).
- The “bottleneck” monopoly problem.
- Mobile customers bring a termination “rent”.
- Competition for customers might exhaust this rent.
- Intervention to cut MTR -> can it cause other prices to go up? The waterbed!
Regulation and the waterbed effect

- Most regulators have established the need to intervene in F2M calls.
- MTR are regulated in many countries (one of the EC markets recommended for *ex ante* regulation).
- Intervention has large welfare implications.
- Waterbed is mentioned (since first 1997 MMC investigation), but never assessed too carefully.
- Only anecdotal evidence
  - Ofcom in UK (2006): it exists but is incomplete
  - CC in New Zealand (2005): first did not believe it exists, then convinced it exists but not sure about practical relevance
• France, medium user
• Evidence of no waterbed?
This paper

The aim of this paper is to:

- Examine theoretically the market structure conditions that give rise to the waterbed effect.
- Document empirically the existence and magnitude of this effect, using a uniquely constructed quarterly panel of mobile operators’ prices and profit margins across more than twenty countries over six years.
Why do we care?

1. Existence and magnitude of the waterbed effect is key to understanding the social costs and benefits of regulation of MTR.
2. Our analysis has implications for the current debate about regulation of “roaming charges” within EU.
3. Mobile industry exhibits typical features of two-sided markets. The structure of prices (who pays for what) is fundamental for the development of these markets.
A simple model of a waterbed: competition

- **Profit:** \[ \pi = (P - c)N + \frac{TQ_I}{\text{bill}} \]

- Imagine there is perfect competition
- Then price is: \[ P = c - \frac{TQ_I}{N} = c - \tau \]
- The lower the termination rent, the higher the price
- In elasticity terms: \[ \varepsilon_W = \frac{\partial P}{\partial T} \frac{T}{P} = \frac{1 + \varepsilon_I}{1/\lambda + \varepsilon_N} \]

- This elasticity can be below or above -1 even with a “full” waterbed effect (assumed here).
A simple model of a waterbed: monopoly

- Similar logic: change in marginal cost
- The lower the termination rent, the higher the marginal cost and the higher the price
- In elasticity terms: \[ \varepsilon_W = \frac{\partial P}{\partial T} \frac{T}{P} = \frac{1+\varepsilon_I}{-c/\tau + 1} \]
- Difference 1. Effect on profits: \[ \varepsilon_\pi = \frac{\partial \pi}{\partial T} \frac{T}{\pi} = \varepsilon_W (1 - |\varepsilon_N|) \]
- Difference 2. Waterbed at work when market is “growing”, but much less when market is fully covered.
Hypotheses and Empirical Strategy

• Is there a waterbed effect?
  – MTR down -> retail prices up?
• Is it “full”?
  – Market competitive enough, so just a rebalancing of structure of prices, or mobile operators have significant market power, so negative impact on their profits?
• Is there a significant interaction of the waterbed effect with competition and market saturation?
• Empirical Strategy: exploit differential timing of introduction of regulation between countries and differential intensity, within countries, between operators
Data

- MTR from Cullen International
- Teligen (2002-2006):
  - Total bill paid by consumers with a given calling profile (fixed weights)
  - High/medium/low user
  - Pre-paid/post-paid
  - ARPU (consists of all revenues, including MTR)
  - EBITDA
Is there a waterbed effect?

• We estimate the following diff-in-diff regression:

\[
\ln P_{ujct} = \alpha_{ujc} + \alpha_t + \beta_1 \text{Regulation}_{jct} + \epsilon_{ujct}
\]

\[
\ln \text{EBITDA}_{jct} = \alpha_{jc} + \alpha_t + \beta_1 \text{Regulation}_{jct} + \epsilon_{jct}
\]

where \( u = \) usage profile, \( j = \) operator, \( c = \) country, \( t = \) time.

• “Treated” group: countries that introduced regulation
• “Control” group: non-reforming countries
Is there a waterbed effect?

- In the second step, our analysis is based on the following instrumental variable regression models:

\[
\ln P_{ujct} = \alpha_{ujc} + \alpha_t + \beta_1 \ln (MTR)_{jct} + \varepsilon_{ujct}
\]

\[
\ln EBITDA_{jct} = \alpha_{jc} + \alpha_t + \beta_1 \ln (MTR)_{jct} + \varepsilon_{jct}
\]

- \( MTR_{jct} \) is instrumented using Regulation

- Very good instrument!
Regulation

- We use different indexes:

\[ \text{Regulation}_{jct} = 0/1 \]

\[ \text{MaxMTR index }_{jct} = \begin{cases} 0 \text{ if } MTR_{jct} \text{ is unregulated} \\ \frac{\text{MaxMTR}_{ct} - MTR_{jct}}{MTR_{jct}} \text{ if } MTR_{jct} \text{ is regulated} \end{cases} \]

\[ \text{UnregulatedMTR index }_{jct} = \begin{cases} 0 \text{ if } MTR_{jct} \text{ is unregulated} \\ \frac{\text{UnregulatedMTR}_{ct} - MTR_{jct}}{MTR_{jct}} \text{ if } MTR_{jct} \text{ is regulated} \end{cases} \]
Empirical Concerns

- We do not allow for joint country-time effects BUT split countries in macro regions and allow region-time effects
- Heteroskedasticity and autocorrelation
- Exogeneity of regulation:
  - Theory: all countries should be regulated sooner or later.
  - In practice: EC. Timing and severity varied unsystematically.
  - However: what if countries and operators which have witnessed slower decrease in prices (including F2M prices) than comparable countries, were more likely candidates for regulation?
Average Price around the introduction of Regulation

Quarters around the introduction of Regulation (T)

Average price paid (PPP adjusted euros/year) per usage profile (time and country-operator-usage demeaned)
## Waterbed Effect Through MTR

<table>
<thead>
<tr>
<th>Estimation method</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
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<td>ln(P_{uijt})</td>
<td>ln(P_{uijt})</td>
<td>ln(P_{uijt})</td>
<td>ln(\text{EBITDA}_{ijct})</td>
<td>ln(\text{EBITDA}_{ijct})</td>
<td>ln(\text{EBITDA}_{ijct})</td>
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<td>ln(MTR)(_{ijct})</td>
<td>-1.207*** (0.411)</td>
<td>1.127* (0.603)</td>
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<td>MaxMTR index(_{ijct})</td>
<td>-0.938*** (0.278)</td>
<td>0.070 (0.392)</td>
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<tr>
<td>UnregulatedMTR index(_{ijct})</td>
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<td></td>
<td>-0.334** (0.133)</td>
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<td>0.620 (0.862)</td>
</tr>
<tr>
<td>1st Stage Coef.</td>
<td>-0.110*** (0.024)</td>
<td>-0.310*** (0.035)</td>
<td>-0.382*** (0.028)</td>
<td>-0.111*** (0.037)</td>
<td>-0.335*** (0.051)</td>
<td>-0.239** (0.098)</td>
</tr>
<tr>
<td>1st Stage R(^2)</td>
<td>0.044</td>
<td>0.127</td>
<td>0.523</td>
<td>0.045</td>
<td>0.112</td>
<td>0.137</td>
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<tr>
<td>1st Stage F-test</td>
<td>21.83*** [0.000]</td>
<td>78.85*** [0.000]</td>
<td>188.24*** [0.000]</td>
<td>8.90*** [0.004]</td>
<td>43.88*** [0.000]</td>
<td>5.90** [0.028]</td>
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# WATERBED EFFECT THROUGH MTR (Regional-Time Controls)

<table>
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<tr>
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<tr>
<td>Dependent variable</td>
<td>ln(P_{ujct})</td>
<td>ln(P_{ujct})</td>
<td>lnEBITDA(jct)</td>
<td>lnEBITDA(jct)</td>
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<tr>
<td>ln(MTR)(jct)</td>
<td>-1.529***</td>
<td>1.415*</td>
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<tr>
<td></td>
<td>(0.496)</td>
<td>(0.757)</td>
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<td>MaxMTR index(_{jct})</td>
<td>-1.076***</td>
<td>0.187</td>
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<td></td>
<td>(0.283)</td>
<td>(0.473)</td>
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<td>1st Stage Coef.</td>
<td>-0.100***</td>
<td>-0.294***</td>
<td>-0.098**</td>
<td>-0.288***</td>
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<td>(0.023)</td>
<td>(0.032)</td>
<td>(0.038)</td>
<td>(0.052)</td>
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<tr>
<td>1st Stage R(^2)</td>
<td>0.038</td>
<td>0.123</td>
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<td>1st Stage F-test</td>
<td>18.15***</td>
<td>85.18***</td>
<td>6.47**</td>
<td>30.43***</td>
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<td>[0.000]</td>
<td>[0.000]</td>
<td>[0.013]</td>
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<td>Clusters</td>
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<td>67</td>
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Results

- The waterbed effect on prices exists and is always significant.
- The magnitude of the effect varies from 3%-15%.
- Negative effect on profit margins (also on ARPU) indicating that the effect is not full or that firms have some significant market power (there is not “neutrality”). Noisier estimates.
- Price (Teligen) vs. profit (ML) dataset.
Caveats

- No data on handset subsidies (though should not affect results with EBITDA).
- No country-time dummies (though we did include regional-time joint effects).
- Results may be biased if a country, which is regulated with low MTR is concentrated and compared with another country not regulated but competitive.
Additional Findings

- Interaction of competition and subscriber penetration
- Timing and impact of regulation
- Differential impact on pre- and post-paid customers:
  - Strong results on post-paid customers, not so much on pre-paid
    (Receive less calls? Expectation of receiving less future incoming revenues? Loss leaders to fight unregulated rivals?)
## COMPETITION AND WATERBED EFFECT

<table>
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<tbody>
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<td>lnP&lt;sub&gt;u&lt;/sub&gt;ct</td>
<td>lnP&lt;sub&gt;u&lt;/sub&gt;ct</td>
<td>lnP&lt;sub&gt;u&lt;/sub&gt;ct</td>
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<tr>
<td>ln(MTR)&lt;sub&gt;j&lt;/sub&gt;ct</td>
<td>-1.580**</td>
<td>-1.282**</td>
<td>-0.775***</td>
<td>-0.585***</td>
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<tr>
<td></td>
<td>(0.587)</td>
<td>(0.525)</td>
<td>(0.235)</td>
<td>(0.223)</td>
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<tr>
<td>ln(competitors)&lt;sub&gt;c&lt;/sub&gt;t</td>
<td>-0.289*</td>
<td>-0.522***</td>
<td>-0.344**</td>
<td>-0.344**</td>
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<tr>
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<td>(0.173)</td>
<td>(0.178)</td>
<td>(0.173)</td>
<td>(0.173)</td>
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<tr>
<td>ln(mkt penetration)&lt;sub&gt;c&lt;/sub&gt;t</td>
<td>-0.768</td>
<td>-1.785***</td>
<td>-3.228***</td>
<td>-3.228***</td>
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<tr>
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<td>(0.483)</td>
<td>(0.563)</td>
<td>(0.840)</td>
<td>(0.840)</td>
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<tr>
<td>ln(MTR)&lt;sub&gt;j&lt;/sub&gt;ct × ln(competitors)&lt;sub&gt;c&lt;/sub&gt;t</td>
<td>0.168*</td>
<td>0.098</td>
<td>0.098</td>
<td>0.098</td>
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<tr>
<td></td>
<td>(0.087)</td>
<td>(0.083)</td>
<td>(0.083)</td>
<td>(0.083)</td>
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<tr>
<td>ln(MTR)&lt;sub&gt;j&lt;/sub&gt;ct × ln(mkt penetration)&lt;sub&gt;c&lt;/sub&gt;t</td>
<td>0.168</td>
<td>1.422***</td>
<td>1.422***</td>
<td>1.422***</td>
</tr>
<tr>
<td></td>
<td>(0.141)</td>
<td>(0.364)</td>
<td>(0.364)</td>
<td>(0.364)</td>
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<tr>
<td>ln(competitors)&lt;sub&gt;c&lt;/sub&gt;t × ln(mkt penetration)&lt;sub&gt;c&lt;/sub&gt;t</td>
<td>0.962**</td>
<td>2.346***</td>
<td>2.346***</td>
<td>2.346***</td>
</tr>
<tr>
<td></td>
<td>(0.441)</td>
<td>(0.557)</td>
<td>(0.557)</td>
<td>(0.557)</td>
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<tr>
<td>ln(MTR)&lt;sub&gt;j&lt;/sub&gt;ct × ln(competitors)&lt;sub&gt;c&lt;/sub&gt;t × ln(mkt penetration)&lt;sub&gt;c&lt;/sub&gt;t</td>
<td>-0.895***</td>
<td>-0.895***</td>
<td>-0.895***</td>
<td>-0.895***</td>
</tr>
<tr>
<td></td>
<td>(0.248)</td>
<td>(0.248)</td>
<td>(0.248)</td>
<td>(0.248)</td>
</tr>
</tbody>
</table>

| ΔP/Δcompetitors     | -1.282     | -0.345     | -0.263     | -0.263     |
| ΔP/ΔMTR             | -0.289     | -0.583     | -0.498     | -0.498     |
| ΔP/Δmkt penetration  | -0.768     | -0.256     | 0.269      | 0.269      |

Observations

<table>
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<th>Observations</th>
<th>1371</th>
<th>1371</th>
<th>1371</th>
<th>1371</th>
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<td>Clusters</td>
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</table>

Sargan-Hansen test of overidentifying restrictions

| Sargan-Hansen test of overidentifying restrictions | [0.220] | [0.108] |
The Evolution of the Waterbed Effect

Quarters around the introduction of Regulation (T)

Regression coefficients

95% confidence interval

Regression Coefficient

T-6 T-5 T-4 T-3 T-2 T-1 T T+1 T+2 T+3 T+4 T+5 T+6
The Evolution of the Waterbed Effect (Pre-Paid)

Regression coefficients

95% confidence interval

Regression coefficient

95% confidence interval

Quarters around the introduction of Regulation (T)

T-6 T-5 T-4 T-3 T-2 T-1 T T+1 T+2 T+3 T+4 T+5 T+6

Imperial College London
Conclusions and Policy Implications

- Evidence of a significant waterbed effect, but not “full”.
- Waterbed stronger the more intense competition is in markets with high levels of market penetration and high termination rates.
- This has antitrust implications: market for subscription and outgoing interlinked with market for incoming calls.
- Welfare analysis of regulation of termination rates cannot ignore the presence of waterbed effect.
- Concentrate more efforts on understanding behaviour of marginal users.
- Beware of the waterbed from regulation of roaming charges!
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