The impact of regulated toll highway price policies on the Consumer Price Index

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Introduction

- The presentation suggests a first exploratory analysis of the impact of price policies in regulated toll highways as a specific case of revenue management in transportation services.
- Its aim is twofold
  - Analyse the impact of Revenue Management policies on the Consumer Price Index in Toll Highways with the hypothesis that it brings about adverse consequences as compared to other transportation services.
  - Describe the price behaviour of a highway operator and suggest a formal framework to study it.
- Very few papers exist on this topic and the work is still in progress.
What is Revenue Management?

- A price policy that seeks to optimize the revenue of a company.
- The ordinary objective is to saturate the available capacities by discriminating customers' demand.
- It especially works in industries where the output is not storable and customers can be identified = services producing activities.
- Consists usually in offering discount fares to attract new customers.
- New fares are affixed to specific requirements.
What is the likely impact of RM on the Consumer Price Index?

- The presentation refers to standard practice for CPI:
  - Laspeyre's index for two periods \((0, 1)\) and \(n\) products
    \[
    \frac{\sum_{i=1}^{n} (P_{i1} \cdot q_{i0})}{\sum_{i=1}^{n} (P_{i0} \cdot q_{i0})}
    \]
    (Prices are evolving but the quantities are held constant)
  - Quantities refer to the constant use which is approximated by the distance covered by a given number of customers.
  - The price is the average price paid for a unit of production (seat)
  - Revenue Management ordinarily intends to bring in new customers that pay less for the same travelled distance, thus the average customers price tends to decrease.
The specificities of the Highway Industry

A quasi monopolistic situation, where direct competition is often missing and low intermodal competition.

A high share of fixed costs, mainly due to the building of the network. Economists (Ekelund Jr et al. 2003), commonly view the function of production of the road industry as the one of a natural monopoly.

Competition for the market rather than within the market: public contracts set up for a definite period the requirements that the highway operator should fulfil. The specification requirements ordinary include a price cap.
Revenue Management in Toll Highways: optimising revenue and saturating capacities (?)

- In highways, saturating capacities is not about seats, but kilometres.
- Maximising price per unit of production = price per vehicle/kilometre. Highways are split in several toll sections that determine routes. Operators optimise the kilometric income per route.
- Because of their quasi monopolistic situation, the rise of the average kilometric revenue per route may be reached by increasing the average kilometric price, rather than by attracting new customers using discount fares.
How to measure average kilometric price? Price cap versus CPI rationale

- prices are regulated and must comply with specified formulas (Cour des Comptes 2008; Odeck 2008).
  - In Spain Matas & Raymond (2003 p. 94): in the 1990’s “toll increases equal to 95% of annual CPI growth”.
  - In France, the approved increase for the APRR company (Autoroutes Paris Rhin Rhône) was for the duration of the last contract (2004-2008): 0.85% of annual CPI growth + 0.845.
- two main concerns:
  - The price cap links motorways prices to the CP Index.
  - The capping scheme may not fit to the Consumer Price Index principles. Companies may raise the actual average consumer toll above the regulated toll level.
the regulated kilometric ratio ($T$)

In France the *kilometric ratio*, is used by authorities to regulate highways prices (Cour des Comptes 1992, 2008). Its formula is to be found in the contract that ties the State and the operators. It is defined as the ratio of the sum of all the separate tolls divided by the sum of the length of all the routes.

$$
\frac{\sum_{i=1}^{N} p_{i,0}}{\sum_{i=1}^{N} k_{i}}
$$
Table 1: Kilometric ratio (kilometric toll) for several highway companies in France in 2006

<table>
<thead>
<tr>
<th>Highway companies</th>
<th>APRR</th>
<th>ASF</th>
<th>SANEF</th>
<th>ATMB</th>
<th>AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilometric ratio, class 1 vehicles; cts €/km, (VAT Included)</td>
<td>6.57</td>
<td>6.9</td>
<td>6.74</td>
<td>9.7</td>
<td>9.09</td>
</tr>
</tbody>
</table>

*Autoroutes Paris Rhin Rhône (APRR). Autoroutes du Sud de la France (ASF); la Société du Nord et de la France (SANEF); société des Autoroutes Rhône Alpes (AREA); autoroute tunnel du Mont-Blanc concédée à la société (ATMB); (Cour des Comptes 2008 report).*

The regulator sets the approved value of the toll increase (price cap) for the kilometric ratio $T$, let $\Delta T = c\%$ (price cap in %) or $\frac{T_1}{T_0} = 1 + c$. For instance, the approved increase for the APRR Company (Autoroutes Paris Rhin Rhône) was up to 0.916 in 2007.
The real kilometric toll ($T_{KM}$)

- The latter ratio is quite notional and merely “seeming” since it does not take into account the actual kilometres covered by customers.
- Let us call $t_i$ the traffic related to the $i$th segment; $t_i$ is the number of times a route is travelled during a reference period.

Let the real average kilometric toll (or price) for the period n°0 be

\[ T_{KM0} = \frac{\sum_{i=1}^{N} p_{i0} \cdot t_{i0}}{\sum_{i=1}^{N} k_{i} \cdot t_{i0}} \]

- This ratio is the one to be used for the computation of the CPI.
- The same ratio called “weighted average toll” is the kilometric price the 2006 directive Eurovignette asserts that should serve to control the coverage of highway infrastructure costs for lorries.
Under what circumstances these two ratios may be equals?

\[
T_0 = \frac{\sum_{i=1}^{N} p_{i,0}}{\sum_{1}^{N} k_i} \quad T_{KMO} = \frac{\sum_{1}^{N} p_{i,0} \cdot t_{i,0}}{\sum_{1}^{N} k_i \cdot t_{i,0}}
\]

The two ratios produce equal results in the following particular circumstances:

1) When there is only one section.

2) When all the kilometric prices \( \frac{p_{i,0}}{k_i} \) are equal to \( T_0 \). For instance when the price of any route is a multiple (mathematical product) of its length (in kilometres), i.e. when \( p_{i,0} = \beta \cdot k_i; \beta > 0 \).

3) If by chance the linear combination of the tolls by the effective traffic, divided by the traffic kilometres is equal to \( T_0 \).

Therefore there are few chances that in ordinary circumstances the two ratios can produce the same result.
The real kilometric ratio $T_{KM0}$ is more likely to be above or under the legal kilometric ratio $T_0$, depending on whether the average consumer uses more or less routes with a kilometric price respectively above or under $T_0$.

In fact the result of the comparison ultimately depends on the highways price policy.

However intuitively Revenue Management should tend to drive $T_{KM0}$ above the controlled $T_0$ ratio.
An illustrative example: the A 36 highway

- The A 36 is a rather typical medium traffic size motorway, operated by the APRR Company, one of the major French highway operators. It goes from the south-west German border to the so-called “sun highway” going to the “Côte d’Azur”.
- For practical and statistical reasons the stretch under scrutiny is the west part that goes between Montbéliard to Beaune.
- Several toll segments have been merged in order to keep only four sections and ten routes compatible with available traffic data.

<table>
<thead>
<tr>
<th>Km</th>
<th>Montbéliard</th>
<th>East Besançon</th>
<th>West Besançon</th>
<th>Dole</th>
<th>Beaune</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montbéliard</td>
<td>0</td>
<td>59</td>
<td>82</td>
<td>115</td>
<td>173</td>
</tr>
<tr>
<td>East Besançon</td>
<td>24</td>
<td>57</td>
<td>113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Besançon</td>
<td>32</td>
<td>89</td>
<td>53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006 average daily traffic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>0</td>
<td>1500</td>
<td>1750</td>
<td>7000</td>
<td>5000</td>
</tr>
<tr>
<td>East Besançon</td>
<td>0</td>
<td>0</td>
<td>350</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>West Besançon</td>
<td>0</td>
<td>2000</td>
<td>0</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Dole</td>
<td></td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual overall traffic on each section (figure n°3)</td>
<td>17340</td>
<td>15890</td>
<td>18000</td>
<td>8040</td>
<td></td>
</tr>
</tbody>
</table>
Present highway network in France
The A 36 Highway stretch under scrutiny
Table 3: Tolls for the routes between Montbéliard and Beaune in Euros

<table>
<thead>
<tr>
<th></th>
<th>East Besançon</th>
<th>West Besançon</th>
<th>Dole</th>
<th>Beaune</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montbéliard</td>
<td>6,1</td>
<td>7,3</td>
<td>9,8</td>
<td>13,5</td>
</tr>
<tr>
<td>East Besançon</td>
<td>1,6</td>
<td>3,9</td>
<td>7,2</td>
<td></td>
</tr>
<tr>
<td>West Besançon</td>
<td>2,7</td>
<td>6,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dole</td>
<td></td>
<td></td>
<td>4,1</td>
<td></td>
</tr>
</tbody>
</table>

Source APRR 2008, 2009 documents

Table 4: Kilometric ratio, HCPI and their deviations between 2008-2009

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>Deviation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilometric ratio for merged sections €/km,</td>
<td>0.0788</td>
<td>0.0802</td>
<td>1.75</td>
</tr>
<tr>
<td>Real Highway Consumer Price and deviation Index for merged sections €/km</td>
<td>5.126 $10^{-05}$</td>
<td>5.218 $10^{-05}$</td>
<td>1.79</td>
</tr>
<tr>
<td>Full 8 sections kilometric ratio €/km</td>
<td>0.0776</td>
<td>0.0789</td>
<td>1.67</td>
</tr>
</tbody>
</table>

All results are computed VAT included.
Exploratory formal analysis: the Revenue function

The revenue function $R(p)$ depends for each trip $i$ on the toll $p_i$ and the traffic $t_i$, which in turn also react to the prices.

$$R(p_i) = \sum_{i=1}^{N} (p_i \cdot t_i)$$

Finally, all things being equal (especially the gasoline price and the economic growth), the traffic in $t_1$ is for the operator basically contingent upon the price deviation of the corresponding trip from period 0. It is thus contingent upon the average short term demand price elasticity of traffic for section $i$ ($\eta_i; \eta_i < 0$) applied to traffic $t_0$.

$$R(p_i) = \sum_{i=1}^{N} (p_i \cdot \theta_i(p_i))$$

with

$$\theta_i(p_i) = t_{i,0} (1 + (\frac{P_{i,1}}{P_{i,0}} - 1) \cdot \eta_i)$$

$$R(p_i) = \sum_{i=1}^{N} (p_i \cdot t_{i,0} \cdot ((1 - \eta_i) + \frac{P_{i,1}}{P_{i,0}} \cdot \eta_i))$$
Exploratory formal analysis: short term elasticity of demand

The elasticity of demand in highway is noticeably lower than in railway or air transportation. It depends on several factors such as the length of the trip and the potential access to good alternative free roads. It is also conditional on the regularity of the trips.

Table 6: Demand consumer price short term elasticity in selected tolled circumstances

<table>
<thead>
<tr>
<th>Mode of transport</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highways France (trips &gt; 100km)</td>
<td>-0.22 to -0.35</td>
</tr>
<tr>
<td>Highways France very long distance trips</td>
<td>~ 0</td>
</tr>
<tr>
<td>Bridges and tunnels</td>
<td>-0.09 to -0.50</td>
</tr>
<tr>
<td>Highways, Spain</td>
<td>-0.21 to -0.83</td>
</tr>
<tr>
<td>Railway passengers, France</td>
<td>-0.7 to -0.9</td>
</tr>
<tr>
<td>Air transportation</td>
<td>-0.8 to -2.7</td>
</tr>
</tbody>
</table>

(1) INRETS 1997 (in Matas 2003)
(2) Conseil de la concurrence (1994)
(3) six bridges and two tunnels, New York city area in Matas 2003
(4) Matas 2003
(5) Services des Etudes et de la Statistique France
(6) OACI
Two sections exploratory analysis case

Three sections already means six unknown variables... A genuine theoretical analysis produces an infinite number of unknown variables.

![Diagram of routes between City A and City B]

\[
R(p_i) = (p_1 \cdot \theta(p_1)) + (p_2 \cdot \theta(p_2)) + (p_3 \cdot \theta(p_3))
\]

with \(\theta_i(p_i) = t_{i,0}(1 + \left(\frac{P_{i,1}}{P_{i,0}} - 1\right)\eta_i)\) or \(\theta_i(p_i) = t_{i,0}(1 - \eta_i) + t_{i,0}\eta_i \frac{P_{i,1}}{P_{i,0}}; \eta_i \leq 0\)

**Constraints**

Only three constraints are taken into consideration.

1) \(\frac{P_{1,1} + P_{2,1} + P_{3,1}}{P_{1,0} + P_{2,0} + P_{3,0}} \leq (1 + c)\) \(\quad (C_1)\) capping constraint

2) \(P_{1,1} \leq P_{2,1} + P_{3,1}\) \(\quad (C_2)\) Direct route price constraint

3) Let \(\frac{P_{2,0}}{k_2} \geq \frac{P_{3,0}}{k_3} \Rightarrow \frac{P_{2,1} \cdot k_3}{P_{3,1} \cdot k_2} - 1 \leq 0.2\) \(\quad (C_3)\) Limitation of the kilometric price deviation between two contiguous sections.
Sometimes a broken (discontinuous) trip is cheaper than a direct one.

Table 5: Total tolls and spreads for various Montbéliard - Beaune dotted (discontinuous) routes (2009 tolls)

<table>
<thead>
<tr>
<th>Route</th>
<th>One stop</th>
<th>Two stops</th>
<th>Pure dotted route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via East Besançon</td>
<td>13.5 (-0.2)</td>
<td>14.5 (+0.8)</td>
<td>14.8 (+1.1)</td>
</tr>
<tr>
<td>Via West Besançon</td>
<td>14.1 (+0.4)</td>
<td>/</td>
<td>14.1 (+0.4)</td>
</tr>
<tr>
<td>Via Dole</td>
<td>14.2 (+0.5)</td>
<td>/</td>
<td>14.4 (+0.7)</td>
</tr>
</tbody>
</table>

The spreads between the corresponding route and the direct one are shown between brackets.
We look for the $p_{i,1}$ that maximise

\[
\mathcal{L}(p_i, \lambda_1, \lambda_2, \lambda_3) = p_{1,1} t_{1,0} (1 - \eta_1) + t_{1,0} \frac{p_{1,1}^2}{p_{1,0}} \eta_1 + p_{2,1} t_{2,0} (1 - \eta_2) + t_{2,0} \eta_2 \frac{p_{2,1}^2}{p_{2,0}} + \\
p_{3,1} t_{3,0} (1 - \eta_3) + t_{3,0} \frac{p_{3,1}^2}{p_{3,0}} \eta_3 - \lambda_1 \left( \frac{p_{1,1} + p_{2,1} + p_{3,1}}{p_{1,0} + p_{2,0} + p_{3,0}} - 1 - c \right) - \lambda_2 \left( p_{1,1} - p_{2,1} - p_{3,1} \right) - \\
\lambda_3 \left( \frac{p_{2,1} \cdot k_3}{p_{3,1} \cdot k_2} - 1 - 0.2 \right)
\]
First order conditions:

\[
\frac{\partial \Lambda}{\partial p_{1.1}} = 0 \iff t_{1.0} (1 - \eta_1) + 2 \cdot t_{1.0} \cdot \eta_1 \cdot \frac{p_{1.1}}{p_{1.0}} - \lambda_1 \cdot \frac{1}{p_{1.0} + p_{2.0} + p_{3.0}} - \lambda_2 = 0
\]

\[
\frac{\partial \Lambda}{\partial p_{2.1}} = 0 \iff t_{2.0} (1 - \eta_2) + 2 \cdot t_{2.0} \cdot \eta_2 \cdot \frac{p_{2.1}}{p_{2.0}} - \lambda_1 \cdot \frac{1}{p_{1.0} + p_{2.0} + p_{3.0}} + \lambda_2 - \lambda_3 \cdot \frac{k_3}{p_{3.1} \cdot k_2} = 0
\]

\[
\frac{\partial \Lambda}{\partial p_{3.1}} = 0 \iff t_{3.0} (1 - \eta_3) + 2 \cdot t_{3.0} \cdot \eta_3 \cdot \frac{p_{3.1}}{p_{3.0}} - \lambda_1 \cdot \frac{1}{p_{1.0} + p_{2.0} + p_{3.0}} + \lambda_2 + \lambda_3 \cdot \frac{p_{2.1} \cdot k_3}{k_2 \cdot p_{3.1}} = 0
\]

\[
\lambda_1 \geq 0
\]

\[
\frac{\partial \Lambda}{\partial \lambda_1} \geq 0 \iff \frac{p_{1.1} + p_{2.1} + p_{3.1}}{p_{1.0} + p_{2.0} + p_{3.0}} \cdot (1 - c) \leq 0
\]

\[
\lambda_1 \cdot \frac{\partial \Lambda}{\partial \lambda_1} \geq 0 \iff \lambda_1 \left( \frac{p_{1.1} + p_{2.1} + p_{3.1}}{p_{1.0} + p_{2.0} + p_{3.0}} \cdot (1 - c) \right) = 0
\]

\[
\frac{\partial \Lambda}{\partial \lambda_2} \geq 0 \iff p_{1.1} - p_{2.1} - p_{3.1} \leq 0
\]

\[
\lambda_2 \geq 0
\]

\[
\lambda_3 \cdot \frac{\partial \Lambda}{\partial \lambda_3} = 0 \iff \lambda_3 \left( \frac{p_{2.1} \cdot k_3}{p_{3.1} \cdot k_2} \cdot (1 - 0.2) \right) = 0
\]

\[
\frac{\partial \Lambda}{\partial \lambda_3} \geq 0 \iff \frac{p_{2.1} \cdot k_3}{p_{3.1} \cdot k_2} \cdot (1 - 0.2) \leq 0
\]

\[
\lambda_3 \geq 0
\]

The following computation remains especially strenuous and complex when the parameters are kept unknown. Nevertheless little calculation shows that solutions depend on cross elasticities. As a simplified first exploratory step let us apply the exploratory process to the illustration case already under analysis.
Using the data from the A 36 stretch

The previous maximisation function $\mathcal{L}(p_i, \lambda_1, \lambda_2, \lambda_3)$ becomes:

$$
\mathcal{L}(p_i, \lambda_1, \lambda_2, \lambda_3) = (p_{1.1} \cdot 9.100 - 2100 \times \frac{p_{1.1}^2}{9.8}) + (p_{2.1} \cdot 1.800 - 300 \times \frac{p_{2.1}^2}{6.1}) + (p_{3.1} \cdot 4.900 - 1400 \times \frac{p_{3.1}^2}{3.9}) - \lambda_1 \left( \frac{p_{1.1} + p_{2.1} + p_{3.1}}{19.8} - 1,022 \right) - \lambda_2 (p_{1.1} - p_{2.1} - p_{3.1}) - \lambda_3 \frac{p_{2.1} \times 56}{p_{3.1} \times 59} - 1 - 0.2
$$
Using the data from the A 36 stretch

First order conditions following Kuhn and Tucker method:

\[
\begin{align*}
\frac{\partial \Lambda}{\partial p_{1,1}} &= 0 \iff 9100 - 4200 \cdot \frac{p_{1,1}}{9.8} - \lambda_1 \frac{1}{19.8} - \lambda_2 = 0 \\
\frac{\partial \Lambda}{\partial p_{2,1}} &= 0 \iff 1800 - 600 \cdot \frac{p_{2,1}}{6.1} - \lambda_1 \frac{1}{19.8} + \lambda_2 - \lambda_3 \cdot \frac{56}{59 \cdot p_{3,1}} = 0 \\
\frac{\partial \Lambda}{\partial p_{3,1}} &= 0 \iff 4900 - 2800 \cdot \frac{p_{3,1}}{3.9} - \lambda_1 \frac{1}{19.8} + \lambda_2 + \lambda_3 \cdot \frac{56}{59 \cdot p_{3,1}} = 0 \\
\lambda_1 &\geq 0 \\
\frac{\partial \Lambda}{\partial \lambda_1} &\geq 0 \iff \left( \frac{p_{1,1} + p_{2,1} + p_{3,1}}{19.8} - 1.022 \right) \leq 0 \\
\lambda_1 \cdot \frac{\partial \Lambda}{\partial \lambda_1} &\geq 0 \iff \lambda_1 \left( \frac{p_{1,1} + p_{2,1} + p_{3,1}}{19.8} - 1.022 \right) = 0 \quad (C_1) \\
\frac{\partial \Lambda}{\partial \lambda_2} &\geq 0 \iff p_{1,1} \leq p_{2,1} + p_{3,1} \quad (C_2) \\
\lambda_2 &\geq 0 \\
\lambda_2 \cdot \frac{\partial \Lambda}{\partial \lambda_2} &= 0 \iff \lambda_2 \left( p_{2,1} + p_{3,1} - p_{1,1} \right) = 0 \\
\lambda_3 \cdot \frac{\partial \Lambda}{\partial \lambda_3} &= 0 \iff \lambda_3 \left( \frac{p_{2,1} \cdot 56}{p_{3,1} \cdot 59} - 1 - 0.2 \right) = 0 \quad (C_3) \\
\frac{\partial \Lambda}{\partial \lambda_3} &\geq 0 \iff \frac{p_{2,1} \cdot 56}{p_{3,1} \cdot 59} - 1 - 0.2 \leq 0 \\
\lambda_3 &\geq 0
\end{align*}
\]
Given the requirements of the maximisation program and the observed data not all the options have to be analysed. The interesting case is \((C_1)\) and \((C_3)\) saturated, \((C_2)\) not saturated \(\iff \lambda_1 \text{ and } \lambda_3 \neq 0 \text{ but } \lambda_2 = 0\). There is no optimal solution that saturates both the three constraints (further research needed).

Even with the workable results, the CPI amounts to 103.77 while the legal kilometric ratio stands still at 102.2, which ascertain that Revenue Management may push consumer prices above legal toll cap initiating an inflationist drift.
Table 7: Data for the maximisation process and results

<table>
<thead>
<tr>
<th>KM</th>
<th>East Besançon</th>
<th>Dole</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montbéliard</td>
<td>59</td>
<td>125</td>
</tr>
<tr>
<td>East Besançon</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td><strong>Traffic $t_0$</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>1500</td>
<td>7000</td>
</tr>
<tr>
<td>East Besançon</td>
<td>3500</td>
<td></td>
</tr>
<tr>
<td><strong>2008 actual tolls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>6,1</td>
<td>9,8</td>
</tr>
<tr>
<td>East Besançon</td>
<td>3,9</td>
<td></td>
</tr>
<tr>
<td><strong>2009 actual tolls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>6,2</td>
<td>10</td>
</tr>
<tr>
<td>East Besançon</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Elasticities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>-0,2</td>
<td>-0,3</td>
</tr>
<tr>
<td>East Besançon</td>
<td>-0,4</td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted $t_1$ traffic given 2009 tolls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>1490,16</td>
<td>6957,14</td>
</tr>
<tr>
<td>East Besançon</td>
<td>3464,10</td>
<td></td>
</tr>
<tr>
<td><strong>Kilometric ratios 2008</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>0,1034</td>
<td>0,0784</td>
</tr>
<tr>
<td>East Besançon</td>
<td>0,0696</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RESULTS</th>
<th>East Besançon</th>
<th>Dole</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximising rounded tolls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>5,6</td>
<td>10,1</td>
</tr>
<tr>
<td>East Besançon</td>
<td>4,5</td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted $t_1$ traffic with maximising tolls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>1524,59</td>
<td>6935,71</td>
</tr>
<tr>
<td>East Besançon</td>
<td>3284,62</td>
<td></td>
</tr>
<tr>
<td><strong>New kilometric ratios</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montbéliard</td>
<td>0,09492</td>
<td>0,08080</td>
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<tr>
<td>East Besançon</td>
<td>0,08036</td>
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<table>
<thead>
<tr>
<th>Revenue in €</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual tolls; $t_0$ traffic</td>
<td>91 400</td>
<td>93 300</td>
</tr>
<tr>
<td>Maximised tolls and $t_0$ traffic</td>
<td>94 850</td>
<td></td>
</tr>
<tr>
<td>Maximised $t_1$ tolls and adjusted traffic</td>
<td>93 369</td>
<td></td>
</tr>
<tr>
<td>Actual $t_1$ tolls and adjusted traffic</td>
<td>92 697</td>
<td></td>
</tr>
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</table>
Despite capping formulas, Revenue Management in toll highways may have adverse consequence on Consumer Prices.

The paper proposes a first simple formal framework to analyse highway pricing behaviour. The model shows that the behaviour depends on crossed elasticities between different tolled sections. However, even in the simplest case, two tolled sections, there is (apparently) no optimal solution to the maximisation problem. Furthermore study is needed to enhance and complete the analysis.

The quality issue has been discarded, and should deserve some observations. The capping scheme, as well as the consumer price index, should take into account quality enhancement, such as security improvement or better rest area services, or else an increase in daily accessibility... These quality upgrades should be interpreted as a real price decrease. However the valuation of these improvements raises particular strenuous and subtle questions that should be addressed in further research.