

Orange, François Jeanjean

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Static and dynamic causes of the decline in the price of mobile telecommunication services

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Static and Dynamic Causes of the Decline in the Price of Mobile Telecommunication Services.

François Jeanjean Orange

September 9, 2013

Abstract

Telecommunication industry is characterized by a sharp fall in unit price which highly benefits to consumers. This article aims to identify the main parameters that lead to such a fall. Using a 13-countries wireless market dataset, it shows that investment actually drives the exponential growth of traffic. As the growth of revenues are much lower, the price of MByte decreases sharply. Telecom operators need some margin to invest. The increased margin increases subscription price, however, in the same time, it also increases investment. The paper shows that the impact on investment highly outweighs the impact on subscription price. As a result, the overall impact of increased margin is the fall of Mbyte price.

1 Introduction

Prices of telecommunication services is a key issue for competition and regulatory authorities. They have a high impact on the whole economy and influence the rate of growth (Röller, 2001) (Datta, 2004) (Wavermann & Meschi, 2005). To compare prices of telecommunication services across countries and over time, it seems more appropriate to consider the price of a unit of consumption than simply comparing the subscription prices. Indeed, the services offered in a subscription can vary widely over time, across countries and even between consumers while a unit of consumption (minute of communication or quantity of data) is much more suited to the comparison. Usage (in minutes or MBytes) better characterizes the amount of useful service for users than subscription, either as intermediate consumption for business, or as final consumption for households. A minute of communication or a Megabyte has the same meaning for each consumer regardless the time or the country.

The unit prices of telecommunications services fall sharply over time, which benefits consumers that highly increase their consumption. What are the causes of such a fall? Is this the result of increased competition? or drastic reduction in operating costs? or rather the effect of technological progress embodied in the network through investment? All these reasons may contribute to lower prices,

but not all in the same proportions. To what extent each of them contributes? This paper attempts to answer this question from both a theoretical and an empirical point of view. The paper shows that the impact of investment in successive generations of network technologies is predominant in the permanent trend of price reduction of telecommunication services, over time. Using a 13 national mobile markets dataset provided by the "World Cellular Information Services" database from 2008 to 2012, empirical evidence from mobile markets stresses that the impact of competitive intensity and operating costs are almost negligible compared to the impact of investment in a period of just five years.

The fact that investment is the main driver of unit-price reduction leads to important policy implications. In particular, the price cost margin issue is particularly relevant. On the one hand, the current margin has a direct and increasing impact on unit price, on the other hand, the expected margin spurs investment and tends to increase traffic which has a decreasing impact on unit price. Empirical evidence shows that, as expected, the dynamic impact on traffic dominates the static impact on price in the data which have been studied. As a result, higher margin tends to accelerate the decrease of unit-price. Therefore, the level of competition that reduces margin should be carefully settled in order to allow the required investments that reduce unit prices.

Information Technologies in general and telecommunication industry in particular experience a high technological progress for more than a century. According to Koh and Magee the yearly technical progress rate is relatively steady around 20 to 30% for the Information technologies (Koh H. &., 2006), highly above that of energy sector which is around 6% (Koh H. &., 2008). This high technical progress spurs investment. Doms highlights that the sharp increase in telecommunication service providers' investments, in the late 1990s, corresponds to an acceleration of the technical progress rate (Doms, 2004). Technical progress generates opportunities to improve the quality of service for consumers and encourages telecom operators to invest. (Jeanjean, Competition through Technical Progress, 2011). Competition has an ambiguous impact on investment incentives. On the one hand, competition encourages investment with the "escape competition effect", and on the other hand, it deter investment reducing the future expected profits. As a result, there is an inverted U relationship between competition and investment in the telecommunication industry. This relationship highlighted by (Aghion, Bloom, Blundell, & griffith, 2005) between competition and innovation has been extended between competition and investment in several empirical studies (Friederiszick, Grajek, & Röller), (Kim, Kim, Gaston, Lestage, & Kim Y & Flacher, 2011).

The rest of the paper is organized as follows. The second section presents the dataset, the third section shows that traffic growth is mainly driven by investment. Contrary to what is typically observed in many industries where technological progress is lower, the empirical analysis shows that the causality runs from investment to growth in traffic, rather than the reverse. The fourth section explains the evolution of price per Megabyte according to margin, costs and traffic growth and concludes that traffic growth highly dominates margin and costs. The fifth section discuss on the margin ambiguous impact and the

sixth section is the conclusion and the policy implications.

2 Data set

The dataset gathers annual financial information from 13 countries around the world between 2008 and 2012.

Total revenues and Ebitda per country in millions \$US are provided by Informa database WCIS "World cellular Information Service". WCIS is on a quarterly basis thus the data have been annualized. In the rest of the paper, Ebitda is treated as profit.

Traffic per country in millions of Mbytes is provided by Informa Intelligence Center on an annual basis. The years 2008 to 2010 from the report Global mobile network traffic, BTS & subscriber forecasts 2010-2014 and the years 2011 and 2012 from the report Global BTS, traffic and Subscriber forecasts 2011-2016. In both cases, the core scenario has been chosen.

Capex per country in millions \$US are provided by Yankee group on an annual basis. Four report have been used according to the world area of the country: "EMEA Mobile Carrier Monitor", "North America Mobile Carrier Monitor", "Latin America Mobile Carrier Monitor" and "Asia-Pacific Mobile Carrier Monitor". In the rest of the paper Capex are treated as Investment.

The number of users per country is provided by Strategy Analytics "World-wide Cellular User Forecasts 2012-2017". The number of users seems more relevant than the number of subscribers because the number of subscription per user highly varies across country. The table below (Table.1) represents the descriptive statistics for the whole sample of 13 countries. (The detail for each country is in the annexes.)

Country	Variable	Revenus	Ebitda	Capex	Costs	Traffic	Users	Price/Mbyte
	unit	millions \$US	millions \$US	millions \$US	millions \$US	millions Mbytes	millions	\$US
All	Mean	50 655	18 036	8 179	32 619	224 453	151,99	0,5747
	Median	30 032	11 098	3 442	21 391	130 444	70,40	0,2992
	Std dev	48 441	17 622	9 309	32 174	351 883	181,88	0,5612
	Min	14 633	3 819	1 787	8 644	8 263	18,37	0,0583
	Max	216 043	70 410	41 701	145 633	2 159 005	821,67	2,4104
	CAGR 2008-2012	2%	1%	6%	3%	71%	10,8%	-40%
	Observations	65	65	65	65	65	65	65

Table.1: Descriptive Statistics

In all the countries, during the studied period, traffic increases almost exponentially, while the variations of the other variables are much more moderate. Revenues and Ebitda tend to decrease in Europe and to increase in the other countries (excepted Ebitda in India). The growth in the number of users is largely due to emerging countries, particularly China and India, it is much lower in developed countries. Traffic growth is much higher than the revenue growth, therefore the price of Mbyte decreases very sharply.

3 Traffic is driven by investment

The wireless data traffic is experiencing almost exponential growth for several years (Cisco Networking Index). One wonders what is driving this growth? Investment by mobile operators or the increasing use of consumers over time, driven by experience and imitation? Obviously, both are necessary. Investment is necessary to install the capacity required to carry the traffic and consumers' demand is necessary to increase the traffic. What is the relative importance of time and investment in traffic growth? This question is even more difficult because the investment is relatively stable over time, making the cumulative investment strongly correlated with the time.

In order to disentangle this problem, let us consider first the two extreme opposite cases that may generate an exponential growth of traffic, then let us build the intermediate cases between the two initial cases.

The first case explains the traffic by the time only. The traffic increases because the consumers' demand follows an imitation process which is not limited by capacity constraints. The imitation process means that the growth of traffic is proportionnal to the current traffic:

$$\frac{dT}{dt} = \alpha_t T \quad (1)$$

where α_t represents the coefficient of imitation, T , the traffic and t , the time. In that case, investment merely adapts network capacities to the growing traffic. This avoids the capacity constraints.

The second case explains the traffic by investment only. Investment improves the quality of service for the customers, encouraging them to increase their consumption. In that case, the growth of traffic generated by an investment is proportionnal to the current traffic:

$$\frac{dT}{dK} = \alpha_K T \quad (2)$$

where K represents the cumulative investment. At time t , $K_t = \sum_{i=0}^t I_i$, I_t is the amount invested at year t and α_K , the coefficient of sensitivity to improved quality.

Remark: If investment is constant over time, $\forall t, I_t = I$, the cumulative investment increases steadily: $K_t = (t+1)I$, therefore $dK = Idt$ and $\frac{dT}{dt} = \alpha_K IT$ which means that equation 2 becomes similar to equation 1 with $\alpha_t = \alpha_K I$. On the contrary, if the investment varies highly over time, the two equations becomes very different.

Let us assume λ is the coefficient of the contribution of the variations in investment to the traffic such that : $I'_{t+1} - I'_t = \lambda(I_{t+1} - I_t)$. I' represents the effective impact of the variations in investment on traffic. If $\lambda = 0$, this is the first case, time explains entirely the traffic, if $\lambda = 1$, this is the second case, Investment entirely explains the traffic.

Let us denote $K'_t = \sum_{i=0}^t I'_i$. The general case writes similar to the second, replacing K by K' . The differential equation of general case is

$$\frac{dT}{dK'} = \alpha_{K'} T \quad (3)$$

Data should allow us to choose the value of λ that best explains the traffic.

We assume the initial conditions in the year 2008: $t_0 = 0$, Traffic for the year 2008 is $T = T_0$ and $I_0 = I'_0$. Resolution of equation 3, according to the initial conditions yields: $\ln(\frac{T}{T_0}) = \alpha_{K'}(K' - K'_0)$ and $K'_t - K'_0 = \lambda(K_t - K_0) + (1 - \lambda)K_0 t$ (see annexes for the proofs). Therefore:

$$\ln(\frac{T}{T_0}) = \alpha_{K'} [\lambda(K - K_0) + (1 - \lambda)K_0 t] \quad (4)$$

We can check that when $\lambda = 0$, traffic depends only on time, in this case, $\alpha_t = \alpha_{K'} K_0$ and when $\lambda = 1$, traffic depends only on investment, in that case, $\alpha_K = \alpha_{K'}$. We can test equation 4 for each country and different values of λ using the OLS regression to estimate the coefficient $\alpha_{K'}$:

$$\ln(\frac{T_{i,t}}{T_{0i,t}}) = \alpha_{K'_i} [\lambda(K_{i,t} - K_{0i}) + (1 - \lambda)K_{0i} t] + \varepsilon_{i,t} \quad (5)$$

i indexes the country and t the time in year. ε is the error term. The results are reported in the following table below (Table 2)

λ	0	0	0.2	0.2	0.4	0.4	0.5	0.5	0.6	0.6	0.8	0.8	1	1
VARIABLES	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO	lnTTO
France	0.000313*** (1.36e-05)	0.000301*** (1.32e-05)	0.000312*** (1.35e-05)	0.000301*** (1.31e-05)	0.000311*** (1.34e-05)	0.000300*** (1.29e-05)	0.000309*** (1.33e-05)	0.000299*** (1.28e-05)	0.000308*** (1.33e-05)	0.000298*** (1.27e-05)	0.000304*** (1.33e-05)	0.000295*** (1.27e-05)	0.000299*** (1.37e-05)	0.000292*** (1.29e-05)
Germany	0.000159*** (7.22e-06)	0.000153*** (7.00e-06)	0.000159*** (7.17e-06)	0.000153*** (6.95e-06)	0.000157*** (7.05e-06)	0.000151*** (6.81e-06)	0.000155*** (6.98e-06)	0.000150*** (6.73e-06)	0.000154*** (6.93e-06)	0.000149*** (6.65e-06)	0.000150*** (6.87e-06)	0.000145*** (6.53e-06)	0.000144*** (6.92e-06)	0.000141*** (6.51e-06)
Italy	0.000220*** (1.04e-05)	0.000211*** (1.01e-05)	0.000220*** (1.03e-05)	0.000211*** (1.00e-05)	0.000220*** (1.03e-05)	0.000212*** (9.95e-06)	0.000220*** (1.03e-05)	0.000212*** (9.92e-06)	0.000221*** (1.03e-05)	0.000213*** (9.91e-06)	0.000221*** (1.05e-05)	0.000214*** (1.00e-05)	0.000222*** (1.10e-05)	0.000216*** (1.04e-05)
Spain	0.000286*** (1.33e-05)	0.000274*** (1.29e-05)	0.000286*** (1.33e-05)	0.000275*** (1.29e-05)	0.000288*** (1.33e-05)	0.000277*** (1.29e-05)	0.000289*** (1.33e-05)	0.000278*** (1.29e-05)	0.000290*** (1.34e-05)	0.000280*** (1.29e-05)	0.000294*** (1.38e-05)	0.000285*** (1.32e-05)	0.000299*** (1.47e-05)	0.000291*** (1.38e-05)
UK	0.000228*** (1.00e-05)	0.000219*** (9.74e-06)	0.000228*** (1.00e-05)	0.000219*** (9.70e-06)	0.000220*** (9.95e-06)	0.000220*** (9.62e-06)	0.000228*** (9.94e-06)	0.000220*** (9.58e-06)	0.000228*** (9.95e-06)	0.000220*** (9.57e-06)	0.000228*** (1.01e-05)	0.000221*** (9.64e-06)	0.000228*** (1.05e-05)	0.000223*** (9.93e-06)
Russia	0.000119*** (5.83e-06)	0.000114*** (5.66e-06)	0.000118*** (5.79e-06)	0.000113*** (5.62e-06)	0.000117*** (5.71e-06)	0.000113*** (5.52e-06)	0.000117*** (5.66e-06)	0.000112*** (5.46e-06)	0.000116*** (5.62e-06)	0.000112*** (5.41e-06)	0.000113*** (5.60e-06)	0.000110*** (5.34e-06)	0.000110*** (5.67e-06)	0.000108*** (5.36e-06)
USA	2.45e-05*** (1.23e-06)	2.35e-05*** (1.19e-06)	2.45e-05*** (1.22e-06)	2.34e-05*** (1.18e-06)	2.44e-05*** (1.21e-06)	2.34e-05*** (1.17e-06)	2.43e-05*** (1.20e-06)	2.34e-05*** (1.16e-06)	2.42e-05*** (1.20e-06)	2.33e-05*** (1.15e-06)	2.40e-05*** (1.21e-06)	2.32e-05*** (1.15e-06)	2.37e-05*** (1.24e-06)	2.31e-05*** (1.17e-06)
Canada	0.000367*** (1.67e-05)	0.000353*** (1.62e-05)	0.000362*** (1.64e-05)	0.000348*** (1.59e-05)	0.000346*** (1.56e-05)	0.000333*** (1.51e-05)	0.000334*** (1.50e-05)	0.000322*** (1.45e-05)	0.000321*** (1.45e-05)	0.000310*** (1.39e-05)	0.000292*** (1.34e-05)	0.000284*** (1.28e-05)	0.000261*** (1.25e-05)	0.000255*** (1.18e-05)
Brazil	0.000111*** (4.67e-06)	0.000107*** (4.53e-06)	0.000111*** (4.67e-06)	0.000108*** (4.53e-06)	0.000113*** (4.71e-06)	0.000109*** (4.55e-06)	0.000114*** (4.75e-06)	0.000110*** (4.58e-06)	0.000116*** (4.82e-06)	0.000112*** (4.63e-06)	0.000119*** (5.07e-06)	0.000116*** (4.82e-06)	0.000125*** (5.51e-06)	0.000122*** (5.19e-06)
Japan	3.59e-05*** (1.92e-06)	3.39e-05*** (1.86e-06)	3.55e-05*** (1.91e-06)	3.39e-05*** (1.86e-06)	3.54e-05*** (1.90e-06)	3.39e-05*** (1.84e-06)	3.53e-05*** (1.90e-06)	3.39e-05*** (1.83e-06)	3.53e-05*** (1.90e-06)	3.39e-05*** (1.82e-06)	3.51e-05*** (1.92e-06)	3.39e-05*** (1.83e-06)	3.49e-05*** (1.99e-06)	3.39e-05*** (1.88e-06)
Korea	0.000184*** (1.02e-05)	0.000176*** (9.93e-06)	0.000181*** (1.00e-05)	0.000173*** (9.74e-06)	0.000173*** (9.53e-06)	0.000165*** (9.22e-06)	0.000167*** (9.20e-06)	0.000160*** (8.88e-06)	0.000160*** (8.85e-06)	0.000154*** (8.52e-06)	0.000145*** (8.17e-06)	0.000140*** (7.80e-06)	0.000129*** (7.59e-06)	0.000125*** (7.18e-06)
China	1.68e-05*** (1.21e-06)	1.58e-05*** (1.17e-06)	1.67e-05*** (1.19e-06)	1.57e-05*** (1.16e-06)	1.63e-05*** (1.16e-06)	1.53e-05*** (1.12e-06)	1.60e-05*** (1.14e-06)	1.51e-05*** (1.10e-06)	1.56e-05*** (1.11e-06)	1.48e-05*** (1.07e-06)	1.48e-05*** (1.07e-06)	1.41e-05*** (1.02e-06)	1.38e-05*** (1.05e-06)	1.33e-05*** (9.89e-07)
India	0.000170*** (1.10e-05)	0.000161*** (1.07e-05)	0.000169*** (1.09e-05)	0.000160*** (1.06e-05)	0.000166*** (1.07e-05)	0.000158*** (1.03e-05)	0.000164*** (1.05e-05)	0.000156*** (1.02e-05)	0.000161*** (1.04e-05)	0.000154*** (9.98e-06)	0.000155*** (1.02e-05)	0.000148*** (9.68e-06)	0.000147*** (1.01e-05)	0.000142*** (9.50e-06)
Constant	-0.0769** (0.0327)		-0.0758** (0.0326)		-0.0722** (0.0323)		-0.0695** (0.0322)		-0.0662** (0.0321)		-0.0577* (0.0324)		-0.0466 (0.0334)	
Observations	65	65	65	65	65	65	65	65	65	65	65	65	65	65
R-squared	0.9769	0.9902	0.9771	0.9903	0.9774	0.9905	0.9775	0.9906	0.9775	0.9907	0.9769	0.9906	0.9751	0.9901
F	166,15	405,27	167,31	408,95	169,7	417,7	170,45	422,04	170,3	424,93	165,6	421,71	153,79	401,13

Standard errors in parentheses

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

Table.2: Impact of Investment on Traffic per Country

The value of λ that best explains the growth of traffic is close to 0.6. Indeed, the Fisher statistic as well as the R-squared are maximum around this value. This means that both investment and time are necessary to explain the traffic. They both contribute to traffic growth. The contribution of Investment seems to be slightly higher than that of time. The constant term is not significant in all cases, and in any case, never above the 5% level. Even when the constant term is significant, it is quite lower than the Root-Mean square error and may be neglected as in the equation 5. The coefficients $\alpha_{K'}$ are all highly significant for all the countries, and the R-squared are all quite close to 1 which means that the model has a high explanatory power. In all the countries, coefficient $\alpha_{K'}$ is moderately sensitive to λ , this is a consequence of the correlation between time and cumulative investment. The value of λ between 0 and 1 suggests that a part of investment may not directly contribute to the growth in traffic and also that there is a certain inertia between investment and the growth in traffic. Indeed, there is a time between the installation and the use of traffic capacities.

4 The price of the Mbyte

Unit price, up , may be expressed as the ratio between Revenue, R , and traffic, T : $up = \frac{R}{T}$. Unit price is thus inversely proportional to the traffic. The relationship between Ebitda, E , operating costs, C , and revenues writes $E = R - C$, the Lerner index L is defined by $L = \frac{E}{R}$. As a result, the Revenue is: $R = \frac{C}{1-L}$, where $(1 - L)$ represents a proxy of competition intensity. Equation 4 provides the traffic expression: $T = T_0 e^{\alpha_{K'}(\lambda(K-K_0)+(1-\lambda)K_0 t)}$

Therefore, Unit price writes:

$$up = \frac{C}{T_0(1-L)} e^{-\alpha_{K'}(\lambda(K-K_0)+(1-\lambda)K_0 t)} \quad (6)$$

The contribution of each variable to the unit price is driven by the elasticities:

$$\begin{aligned} \varepsilon_C &= \frac{\partial up}{\partial C} \frac{C}{up} = 1 \\ \varepsilon_{(1-L)} &= \frac{\partial up}{\partial(1-L)} \frac{(1-L)}{up} = -1 \\ \varepsilon_K &= \frac{\partial up}{\partial K} \frac{K}{up} = -\lambda \alpha_{K'} K \\ \varepsilon_t &= \frac{\partial up}{\partial t} \frac{t}{up} = -(1-\lambda) \alpha_{K'} K_0 t \end{aligned} \quad (7)$$

It is noteworthy that the elasticities of operating costs and competition are constant while the elasticities of investment and time depend negatively on time with an increasing absolute value.

The sign of the elasticity of operating costs is positive. An increase in operating costs, all things being equal increases the unit price. The sign of the elasticity of competition is negative. An increase in competition intensity, all things being equal, reduces the Ebitda margin and then the unit price. The signs of Investment and time elasticities are negative because both investment and the imitation process over time increase traffic which reduces unit price. However, the impacts of operating costs and competition are static. Their elasticities remain equal to unity. The impacts of investment and imitation process are dynamic, they increase over time. As a consequence, the impact of dynamic effects becomes predominant after a while. Moreover, operating costs and competition can increase or decrease over time while cumulative investment always increase and time always flows in the same direction. Specifically, the dynamic effects outweigh the static effects after only a few months. On the entire 5-year period between 2008 and 2012, the static effects appear almost negligible compared to the dynamic effects.

Using the dataset, it is possible to determine the actual contribution of each parameter to the fall in unit price during the period 2008-2012. After some transformations (see annexes), equation 6 yields:

$$\ln \left(\frac{up_4}{up_0} \right) = \ln \left(\frac{C_4}{C_0} \right) - \ln \left(\frac{(1-L)_4}{(1-L)_0} \right) - \alpha_{K'} [\lambda(K_4 - K_0) + 4(1-\lambda)K_0] \quad (8)$$

The value of each term represents the relative change of one parameter during 2008 and 2012. The value of λ is set to 0.6, as it maximizes the explanation power of equation 5, however, given the strong correlation between the cumulative investment and time, the results are not very sensitive to changes in λ . The following table provides the results for each country:

Country	Unit price (Observed)	Operating Costs	Competition	Investment	Time	Unit price (Calculated)
France	-290%	-3%	-11%	-161%	-105%	-280%
Germany	-278%	-32%	11%	-153%	-99%	-273%
Italy	-268%	-40%	13%	-142%	-98%	-267%
Spain	-286%	-30%	-12%	-140%	-100%	-283%
UK	-287%	-29%	4%	-159%	-105%	-288%
Russia	-238%	11%	-8%	-154%	-92%	-242%
USA	-219%	19%	1%	-143%	-91%	-214%
Canada	-225%	36%	-5%	-191%	-89%	-249%
Brazil	-249%	19%	4%	-151%	-115%	-243%
Japan	-203%	5%	-2%	-128%	-84%	-209%
Korea	-165%	36%	-3%	-163%	-72%	-202%
China	-145%	33%	-11%	-111%	-59%	-148%
India	-149%	49%	-26%	-110%	-67%	-154%

Table.3: Contributions to the fall in unit price

In the table above, Unit price (observed) is given by the left term of equation (8), ie $\ln\left(\frac{up_4}{up_0}\right)$. The Operating costs are $\ln\left(\frac{C_4}{C_0}\right)$, Competition, $-\ln\left(\frac{(1-L)_4}{(1-L)_0}\right)$, Investment $-\alpha_{K'}\lambda(K_4 - K_0)$ and Time $-4\alpha_{K'}(1 - \lambda)K_0$. Unit price calculated is given by the left term of equation (8), ie $\ln\left(\frac{C_4}{C_0}\right) - \ln\left(\frac{(1-L)_4}{(1-L)_0}\right) - \alpha_{K'}[\lambda(K_4 - K_0) + 4(1 - \lambda)K_0]$. The fit between right and left term is $R^2 = 0.947$. Contributions of static effects (operating costs and competition) are relatively low compared to contributions of dynamic effects. In the case of France, for example, the decrease of operating costs have entailed a decrease by 3% of MByte price, the increase of competitive intensity 11%, while investment and time entailed respectively a decrease by 161% and 105%. the graph below (figure.1) compares the contributions of static and dynamic effects.

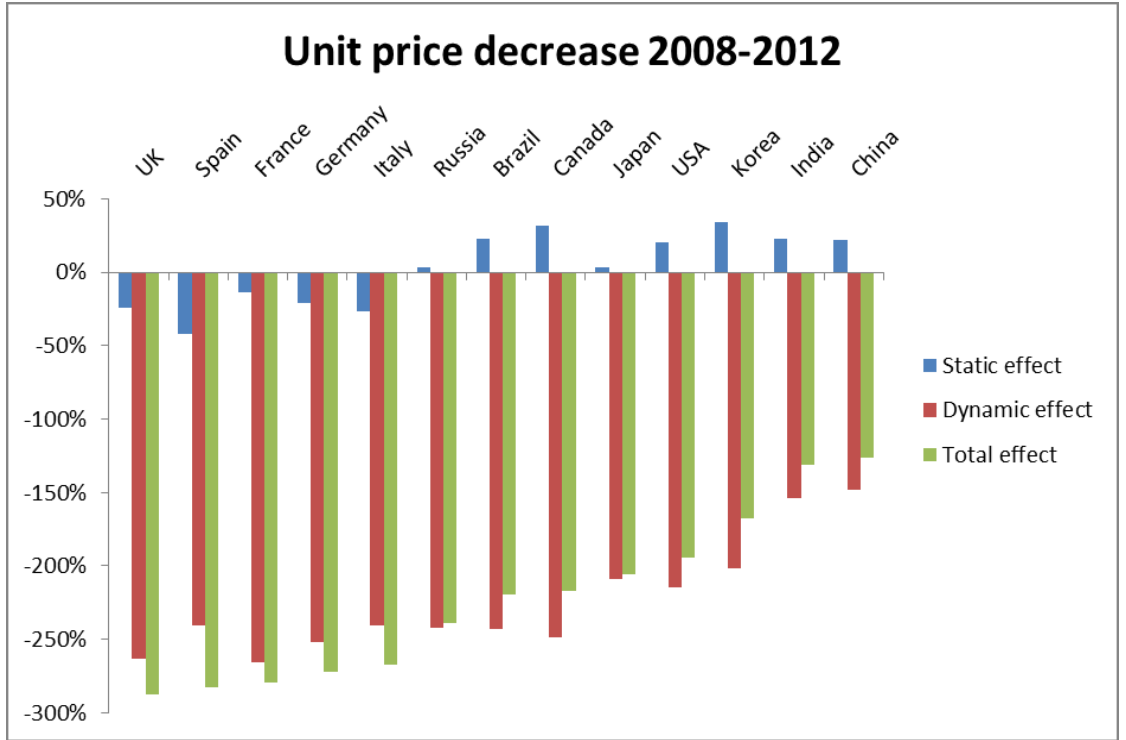


Figure.1: Comparison between Static and Dynamic effects

The contribution of static effects may be positive or negative. Indeed, during the period 2008-2012, competitive intensity has increased in some countries and decreased in others. Same for Operating costs (see Table.3). While static effects can increase or decrease unit prices, dynamic effects always contribute to decrease them. During the period 2008-2012, dynamic effects have had an impact more than five times higher than the static effects, and this difference

tends to increase over time. Indeed, the elasticities of dynamic effects increase over time while elasticities of static effects remain steady (see equation 7). Moreover, the potential for change of static effects are limited; indeed, it is not possible to increase competition intensity beyond perfect competition ($1 - L) = 1$, operating costs can not sustainably exceed revenues, and revenues can not exceed consumers' willingness to pay, while cumulated investment and time regularly increase. This is the reason why, on the long run, static effects become negligible compared to dynamic effects.

5 In Wireless Industry, increased margin tends to decrease unit price on the long run

In this regard, the impact of margin on unit price is particularly relevant because margin has not only a direct and increasing impact on price per user but also an indirect and increasing impact on investment. Investment increases the rate of growth of traffic and, as a consequence, accelerates the fall in unit price. The graph below (figure.2) compares the Margin/User and Investment/User in the dataset and highlights the relationship between margin and investment. The number of users is used to control for the different market size among countries. Each plot represents a national market during a year.

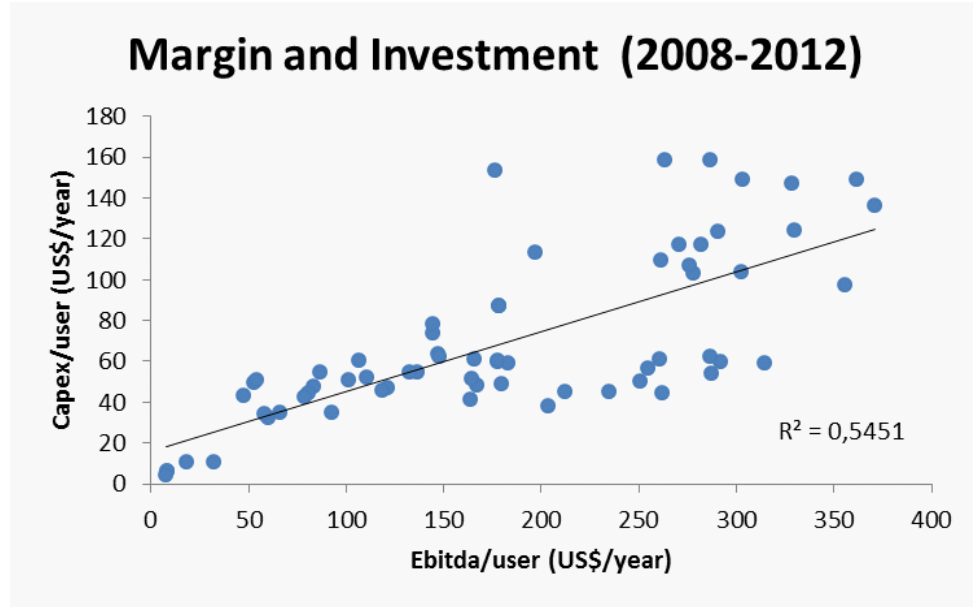


Figure.2: Margin and Investment relationship

The Figure.2, highlights a positive and very significant correlation ($R^2 = 0,545$) between Margin and Investment per User. Increased margin leads to increased

investment. Indeed, an increase in margin provides both more capabilities to Invest and, up to a certain threshold, more incentives to invest (Jeanjean, Incentives to Invest in Improving Quality in the Telecommunications Industry, 2013).

An increase in margin entails an increase in investment that in turn accelerates the growth of traffic. The growth of traffic accelerates the fall in unit prices. After a few months, as seen in the previous section, the impact on traffic which is dynamic, outweighs the impact on price, which is static. As a consequence, an increase in margin entails a decrease in unit price through the growth of traffic that outweighs the increase in price caused by increased margin. The following figure (Figure.3) compares the relative change in the rate of margin and the relative change in unit price between 2008 and 2012. The relative change means $\frac{up_4 - up_0}{up_0}$ for unit price and $\frac{L_4 - L_0}{L_0}$ for the rate of Margin.

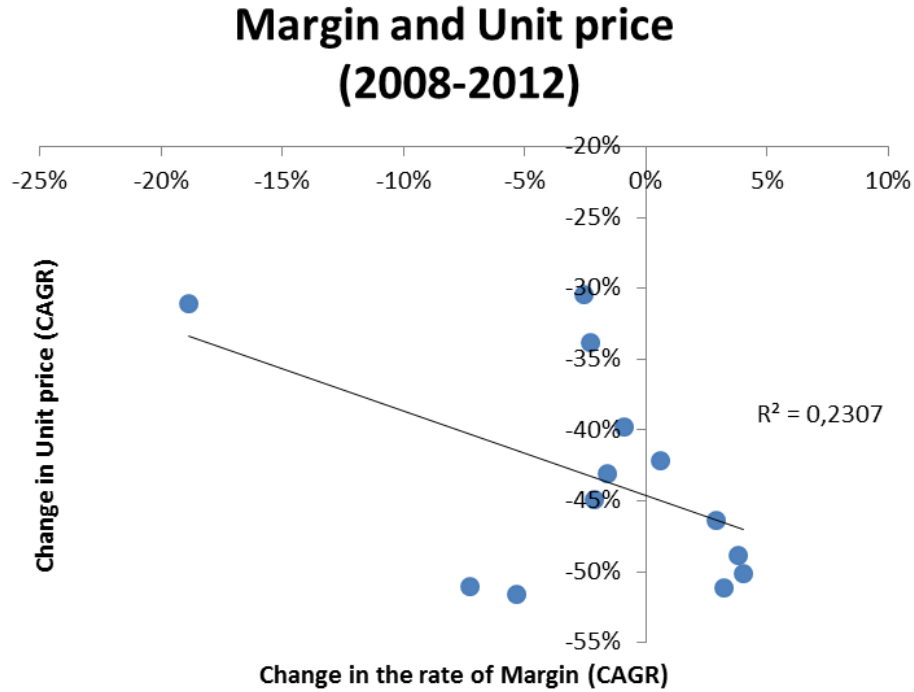


Figure.3: Margin accelerates the fall in unit price

Figure.3 highlights a negative and significant correlation between change in the rate of Margin and change in unit price. As expected, the countries where the Ebitda margin has grown the most are those where the fall in unit price has been the fastest. Although margin tends to increase price, its impact on investment and traffic is predominant and finally margin accelerates the fall in unit price.

Competition has a high negative impact on margin. This impact is both static and dynamic, however, as dynamic effects outweigh static effects within a few months, competition intensity tends to slow down the fall in unit price in the long run. However, it should be noted that this result is specific to the industry during the studied period characterized by a very high rate of technical progress, making investing so effective at improving the quality of service (speed, applications,...) In sectors with a lower technical progress, the dynamic effects are lower, it is then possible that they do not outweigh the static effects.

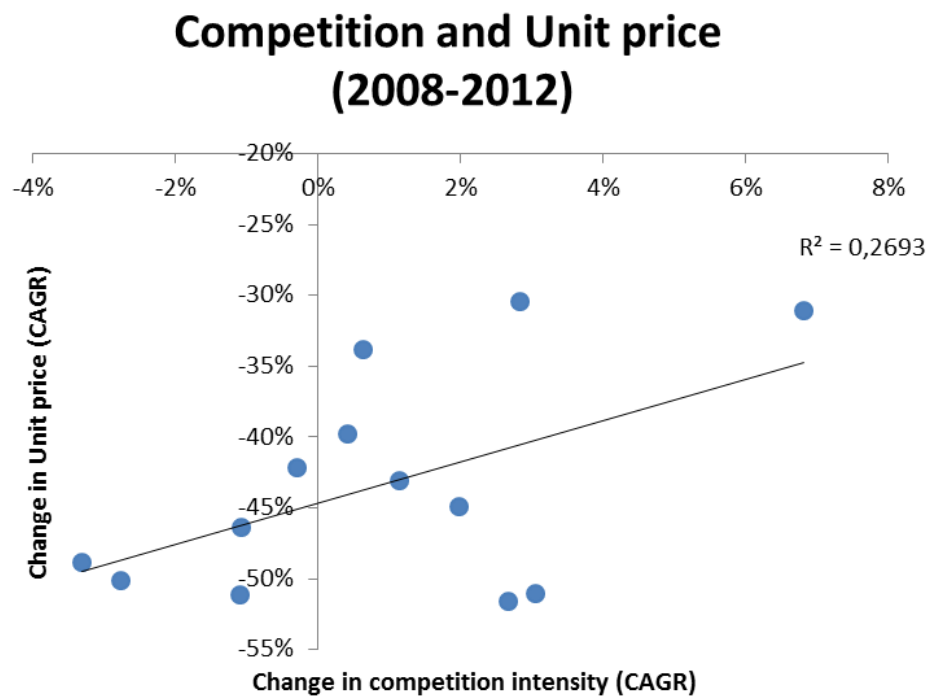


Figure.4: Competition intensity slows down the fall in unit price

The correlation between the intensity of competition and the unit price is positive and significant. Although competition tends to decrease the price per user, competition decreases margin and investment and as a result, competition slows down the fall in price of MByte.

Similarly, the increase in operating costs, causes both an increase in price/user and a decrease in margin and thus in investment. As a result, this slows down the traffic growth and the fall in unit price. As for operating costs both static and dynamic effects act in the same direction, the impact on unit price is very high.

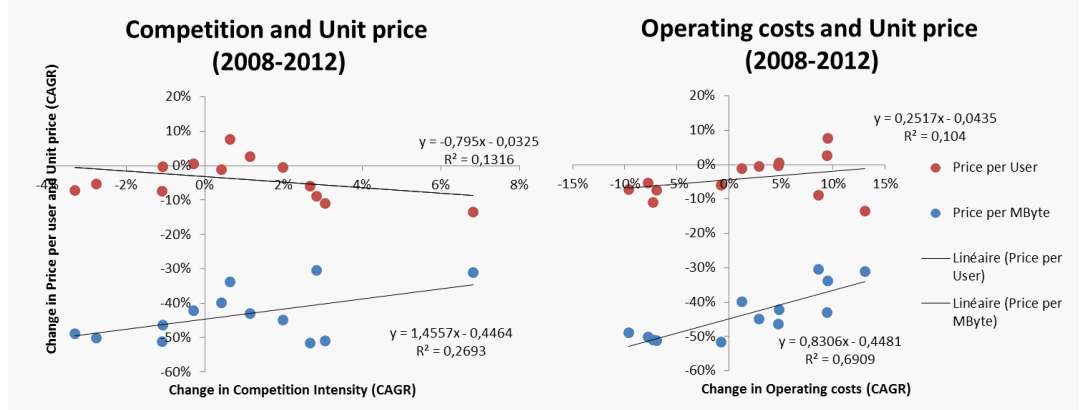


Figure.5: Compared impact on price per User and price per MByte

Figure.5 compares the impact of Competition and Operating costs on price per User (red) and Unit price, or price per MByte (Blue). It is clear that, as mentioned above, competition tends to decrease price per User and to slow down the fall in price per MByte, while Operating costs both increase price per User and Price per MByte, however, the slope is significantly higher for the price per MByte. This emphasizes the predominance of dynamic effects on the static effects.

6 Conclusion

In a highly innovative industry, like telecommunication and particularly wireless industry, where the technical progress is tremendous, investment becomes the key issue. Investment drives the growth of traffic while competition avoids such a growth of subscription price. As a result, price of Mbyte decreases sharply allowing consumers to benefit from a higher bit rate for a pretty steady price. This improvement also benefits to service and content providers that may provide more services and more contents.

However, There is a drawback. Investment requires some margin and the increased margin reduces consumer surplus. However, increased margin also allows increased investment which accelerates the fall in prices of MByte. Increased investment rapidly compensates for the reduced consumer surplus caused by increased margin, and, as a result, accelerates the fall in Mbyte price increasing ultimately the consumer surplus.

However, it should be noted that this result is specific to very innovative industry. In sectors with a lower technical progress, impact of investment is lower, it is then possible that it never outweighs the negative impact of increased margin.

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Annexes

Proof of $K'_t - K'_0 = \lambda(K_t - K_0) + (1 - \lambda)K_0t$
 We know that $I'_{t+1} - I'_t = \lambda(I_{t+1} - I_t)$ and $I'_t - I'_{t-1} = \lambda(I_t - I_{t-1})$
 therefore $I'_t = I'_{t-1} + \lambda(I_t - I_{t-1})$ and $I'_t = I'_{t-2} + \lambda(I_{t-1} - I_{t-2}) + \lambda(I_t - I_{t-1}) = I'_{t-2} + \lambda(I_t - I_{t-2})$
 As a result $I'_t = I'_0 + \lambda(I_t - I_0)$

$$K'_t = \sum_{i=0}^t I'_i = I'_0 + I'_0 + \lambda(I_1 - I_0) + I'_0 + \lambda(I_2 - I_0) + \dots + I'_0 + \lambda(I_t - I_0)$$

$$K'_t = (t+1)I'_0 + \lambda(I_1 + I_2 + \dots + I_t - tI_0) = (t+1)I'_0 + \lambda(\sum_{i=0}^t I_i - (t+1)I_0) =$$

$$(t+1)I'_0 + \lambda(K_t - (t+1)I_0)$$
 initial conditions are $I'_0 = I_0$ thus $K'_0 = I'_0 = K_0 = I_0$

We can write $K'_t = (t + 1)K'_0 + \lambda(K_t - (t + 1)K_0)$ and finally $K'_t - K'_0 = \lambda(K_t - K_0) + (1 - \lambda)K_0t$

Descriptive statistics for each country:

Country	Variable	Revenus	Ebitda	Capex	Costs	Traffic	Users	Price/Mbyte
	unit	millions \$US	millions \$US	millions \$US	millions \$US	millions Mbytes	millions	\$US
All	Mean	50 655	18 036	8 179	32 619	224 453	151,99	0,5747
	Median	30 032	11 098	3 442	21 391	130 444	70,40	0,2992
	Std dev	48 441	17 622	9 309	32 174	351 883	181,88	0,5612
	Min	14 633	3 819	1 787	8 644	8 263	18,37	0,0583
	Max	216 043	70 410	41 701	145 633	2 159 005	821,67	2,4104
	CAGR 2008-2012	2%	1%	6%	3%	71%	10,8%	-40%
	Observations	65	65	65	65	65	65	65
France	Mean	34 207	11 286	2 242	22 921	88 678	52,72	1,0391
	Median	34 909	11 208	2 269	22 986	38 036	52,79	0,8866
	Std dev	1 755	1 434	113	580	94 729	2,40	0,9395
	Min	31 409	9 106	2 070	22 303	14 921	49,54	0,1327
	Max	35 965	12 978	2 367	23 811	236 604	55,56	2,4104
	CAGR 2008-2012	-3%	-8%	1%	-1%	100%	2,9%	-52%
	Observations	5	5	5	5	5	5	5
Germany	Mean	29 663	12 457	4 246	17 206	105 301	70,28	0,6434
	Median	30 211	12 565	4 123	17 364	63 822	70,40	0,4755
	Std dev	2 241	406	1 121	1 995	100 358	0,30	0,6065
	Min	26 225	11 784	3 378	14 441	20 205	69,79	0,0994
	Max	32 358	12 847	6 144	19 933	263 951	70,53	1,6015
	CAGR 2008-2012	-5%	-1%	-5%	-8%	90%	0,3%	-50%
	Observations	5	5	5	5	5	5	5
Italy	Mean	28 849	14 082	2 804	14 768	95 877	49,23	0,6366
	Median	28 273	14 163	2 885	14 100	66 341	49,01	0,4247
	Std dev	2 896	998	225	2 227	83 504	0,65	0,6072
	Min	24 727	12 577	2 513	12 150	20 150	48,48	0,1100
	Max	32 357	15 385	3 079	18 194	224 720	50,14	1,6058
	CAGR 2008-2012	-7%	-3%	-3%	-10%	83%	0,8%	-49%
	Observations	5	5	5	5	5	5	5
Spain	Mean	24 506	7 183	2 118	17 323	69 812	38,05	0,7759
	Median	24 186	6 325	2 130	17 860	46 328	38,41	0,5220
	Std dev	3 692	2 300	244	1 918	61 289	0,74	0,7752
	Min	19 166	4 666	1 809	14 500	14 369	36,88	0,1170
	Max	29 259	9 627	2 441	19 632	163 786	38,67	2,0362
	CAGR 2008-2012	-10%	-17%	-5%	-7%	84%	1,1%	-51%
	Observations	5	5	5	5	5	5	5
UK	Mean	30 791	7 794	2 998	22 996	123 955	51,30	0,6191
	Median	29 917	7 838	2 977	21 808	64 945	51,28	0,4606
	Std dev	3 334	954	234	2 823	120 722	1,35	0,6286
	Min	28 675	6 785	2 752	20 838	22 255	49,63	0,0936
	Max	36 641	8 827	3 291	27 814	306 350	53,01	1,6464
	CAGR 2008-2012	-6%	-3%	3%	-7%	93%	1,7%	-51%
	Observations	5	5	5	5	5	5	5
Russia	Mean	26 114	12 207	5 613	13 907	102 883	115,19	0,5416
	Median	26 548	12 624	5 819	14 176	49 592	115,19	0,5208
	Std dev	2 575	1 076	1 164	1 714	99 958	2,51	0,4363
	Min	21 940	10 604	3 957	11 336	22 408	111,82	0,1093
	Max	28 724	13 258	7 095	15 827	251 931	118,25	1,1847
	CAGR 2008-2012	1%	-1%	8%	3%	83%	1,4%	-45%
	Observations	5	5	5	5	5	5	5

USA	Mean	193 907	62 739	25 380	131 169	878 395	229,25	0,4456
	Median	190 145	63 055	24 502	126 804	428 385	229,40	0,4439
	Std dev	15 950	5 142	2 583	11 346	844 018	16,88	0,3322
	Min	177 002	56 256	22 375	120 746	197 984	208,03	0,1001
	Max	216 043	70 410	29 232	145 633	2 159 005	249,58	0,8940
	CAGR 2008-2012	5%	6%	5%	5%	82%	4,7%	-42%
	Observations	5	5	5	5	5	5	5
canada	Mean	17 449	6 787	2 414	10 662	43 311	20,54	0,8324
	Median	17 267	6 530	2 384	11 013	22 211	20,69	0,7774
	Std dev	2 643	1 044	495	1 765	42 147	1,71	0,6621
	Min	14 633	5 626	1 787	8 644	8 263	18,37	0,1934
	Max	20 757	8 378	3 077	12 379	107 334	22,60	1,8364
	CAGR 2008-2012	8%	6%	15%	9%	90%	5,3%	-43%
	Observations	5	5	5	5	5	5	5
Brazil	Mean	31 505	8 657	5 772	22 848	87 403	150,93	0,8078
	Median	32 280	9 349	5 686	22 931	46 562	155,64	0,6933
	Std dev	4 833	1 753	517	3 125	86 057	14,67	0,6905
	Min	26 673	6 752	5 060	19 921	14 270	129,79	0,1557
	Max	38 026	10 631	6 404	27 394	216 656	165,54	1,8790
	CAGR 2008-2012	6%	9%	-3%	5%	97%	6,3%	-46%
	Observations	5	5	5	5	5	5	5
Japan	Mean	97 269	31 841	15 714	65 428	302 817	103,14	0,5065
	Median	93 995	30 738	15 555	63 257	242 434	103,75	0,4138
	Std dev	10 946	4 305	715	6 750	222 970	3,32	0,3605
	Min	87 200	28 069	15 127	59 039	81 540	98,35	0,1405
	Max	114 759	38 186	16 919	76 573	641 109	106,64	1,0694
	CAGR 2008-2012	1%	0%	2%	1%	67%	2,0%	-40%
	Observations	5	5	5	5	5	5	5
Korea	Mean	29 528	6 843	4 118	22 684	159 318	40,59	0,2736
	Median	30 788	7 278	3 536	23 510	120 432	40,71	0,2556
	Std dev	5 137	1 039	1 422	4 214	115 816	0,76	0,1780
	Min	23 351	5 720	2 921	17 544	44 652	39,55	0,1073
	Max	35 092	8 095	6 366	27 774	326 933	41,44	0,5608
	CAGR 2008-2012	9%	6%	22%	9%	64%	1,2%	-34%
	Observations	5	5	5	5	5	5	5
China	Mean	88 469	47 216	29 980	41 253	601 047	630,75	0,2093
	Median	89 985	44 723	27 580	40 840	355 042	621,61	0,2565
	Std dev	13 251	6 574	6 905	7 280	445 595	145,10	0,1058
	Min	72 440	39 711	24 757	32 730	233 955	455,77	0,0723
	Max	107 944	56 908	41 701	51 035	1 244 625	821,67	0,3096
	CAGR 2008-2012	6%	3%	14%	9%	52%	15,9%	-30%
	Observations	5	5	5	5	5	5	5
India	Mean	26 256	5 380	2 928	20 876	259 098	423,88	0,1401
	Median	26 649	4 396	2 711	22 830	196 856	441,28	0,1354
	Std dev	3 496	1 792	419	5 031	174 123	129,45	0,0792
	Min	22 143	3 819	2 536	15 183	90 149	251,96	0,0583
	Max	30 000	8 078	3 558	25 735	501 194	566,98	0,2580
	CAGR 2008-2012	6%	-14%	-2%	13%	54%	22,5%	-31%
	Observations	5	5	5	5	5	5	5

Proof of equation (8):

From equation (6):

$$up = \frac{C}{T_0(1-L)} e^{-\alpha_{K'}(\lambda(K-K_0)+(1-\lambda)K_0t)}$$

$$\ln(up) = \ln(C) - \ln(1-L) - \ln(T_0) - \alpha_{K'}(\lambda(K-K_0) + (1-\lambda)K_0t)$$

For $t = 4$

$$\ln(up_4) = \ln(C_4) - \ln(1-L)_4 - \ln(T_0) - \alpha_{K'}(\lambda(K_4-K_0) + (1-\lambda)K_0t)$$

For $t = 0$

$$\ln(up_0) = \ln(C_0) - \ln(1-L)_0 - \ln(T_0)$$

$$\text{Therefore } \ln(up_4) - \ln(up_0) = \ln\left(\frac{up_4}{up_0}\right) = \ln\left(\frac{C_4}{C_0}\right) - \ln\left(\frac{(1-L)_4}{(1-L)_0}\right) - \alpha_{K'}(\lambda(K_4-K_0) + (1-\lambda)K_0t)$$

This is equation (8)