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IS INEQUALITY HARMFUL FOR BROADBAND DIFFUSION AND ECONOMIC GROWTH?

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ABSTRACT

Some say that the digital gap adds new inequalities to the economic and social inequalities and help amplify them. However, others think that this gap is simply the effect of the existing social and economic inequalities. Although the first opinion has been studied by a fair number of empirical studies, the second has not had much luck in the existing literature. In this work, we try to examine the impact of inequality on the proliferation of broadband Internet and on the change of its relationship with economic growth. The implementation of two empirical models on panel data for 19 countries covering the 2000-2012 period identified two main original results. The positive impact of broadband on economic growth is reduced by the digital divide, which strengthened by the presence of income inequality and hampers economic growth. The second model emphasizes the blocking effect that income inequality could have on broadband proliferation.

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Contribution/ Originality: This study is one of very few studies which have investigated the trilateral relationship between broadband (and ICT in general) inequality and growth, and allows studying the inverse relationship between broadband and inequality (i.e. how inequality affects the broadband proliferation).

1. INTRODUCTION

Recently, the growing internal inequalities in the world, and specifically in the advanced countries, has caused a renewed interest in the study of the impact of inequality on economic growth as well as the factors explaining this increase (Chan *et al.*, 2014; Javier and Montiel, 2014; OCDE, 2014; Ostry *et al.*, 2014; Daniel *et al.*, 2015). The technological change has long been regarded as the main factor behind this increase (Aghion and Howitt, 1998; Galor and Maov, 2000; Acemoglu, 2002). Further studies, such as that of Lloyd-Ellis (1999) argue that the diffusion of information and communication technology can increase labor productivity and might tend to reduce income inequality. Meanwhile, a large amount of research was conducted in the United States and other countries

throughout the world emphasized the importance of income in the explanation of the disparities in ICT diffusion, and therefore, the digital gap which is inconvenient for economic growth.

This critical perspective suggests that the analysis of the ICT impact and mainly of the broadband, on economic growth requires the consideration of the interaction between the broadband and income inequality and a better understanding of the relationship between inequality and growth. In fact, as presented in figure 1, countries with low (or average) income inequality show a higher diffusion of the broadband than other countries. Noh and Yoo (2008) argue that the adoption of the Internet does not necessarily enhance economic growth. Actually, the presence of a digital gap impedes economic growth and therefore may reduce it.

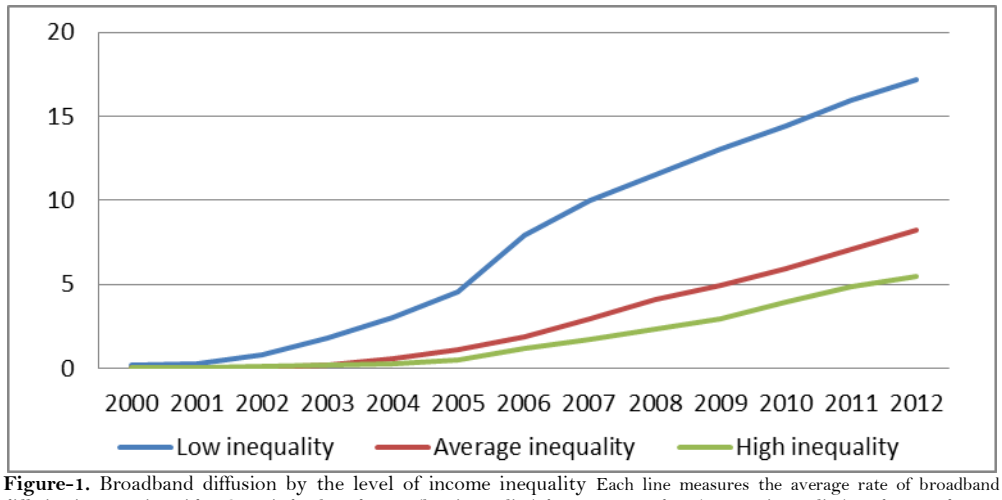

Figure-1. Broadband diffusion by the level of income inequality Each line measures the average rate of broadband diffusion in countries with a GINI index less than 35 (low inequality), between 35 and 46 (average inequality), and upper than 46 (high inequality).
Source : Auteur sur données de la Banque Mondiale

By joining a theoretical framework which combines three complementary fields of economic literature, such as the contribution of the broadband to economic growth, the impact of ICT diffusion on income inequality and the effect of the latter on economic growth, this paper is twofold. The first objective consists in examining the impact of the broadband penetration on economic growth as well as trying to know whether the digital gap linked to income inequality hinders economic growth associated with the adoption of the broadband, whereas the second aim is to analyze the causal relationship between broadband, and inequality.

The next section of this article presents a theoretical framework for the study of the relationship between broadband, inequality and economic growth. In the third section, we discuss the empirical part of the relationship between Broadband, inequality and economic growth.

2. THEORETICAL ANALYSIS OF THE RELATIONSHIP BETWEEN BROADBAND, INEQUALITY AND ECONOMIC GROWTH

This section attempts to provide a theoretical framework for the analysis of the relationship between the broadband, income inequality and growth by presenting three different fields of literature. The first consists in presenting a literature review about the contribution of the broadband to economic growth.

2.1. Broadband and Economic Growth

Recently, and with the widespread deployment of the broadband service, the systematic empirical exploration of the relationship between the broadband Internet and economic growth has been gaining much significance (Thompson and Garbacz, 2008). Using a model of simultaneous equations for 22 OECD countries during the 2002-2007 period, Koutroumpis (2009) showed that the broadband Internet positively and significantly contributes to economic growth especially when a critical level of infrastructure is available. In countries with a high broadband

Internet penetration (over 30%), an increase of this penetration by 10% contributes to the increase of economic growth by about 0.23%. However, in countries with a low Internet penetration, (less than 20%), an increase of the broadband penetration by 10% leads to the rise of the economic growth rate by about 0.08%. For countries with an average adoption, the impact on economic growth is 0.14%. Czernich *et al.* (2009) confirmed the results achieved by Koutroumpis (2009) using a more sophisticated econometric approach. Their results showed that a 1% increase of the broadband penetration drives up the GDP growth rate from 0.09 to 0.15%.

Using cross-sectional data covering the 1980-2006 period, Qiang and Rossotto (2009) used a model of endogenous growth (Barro, 1991) to test the effect of the broadband penetration (measured by the number of subscribers to the broadband per 100 inhabitants) on economic growth for 120 developed and developing countries. Their results showed that there is a significant association between both variables and showed that a 10% increase of penetration raises the economic growth rate by 1.21% for high-income countries and 1.38% for low-income countries. However, this effect is more significant for the first group of countries than for the second. The authors explained this difference in the coefficient significance by the fact that the broadband has not yet reached critical mass in the developing countries because it is a recent phenomenon for them and therefore cannot generate global effects as strong as it can in the developed countries. The International Telecommunication Union (2012) validated the results for a group of developing countries. Actually, using a multivariate regression analysis, the report showed that a 10% increase of the broadband penetration increases economic growth by 0.15% for 25 countries of Latin America and by 0.2% for 17 Arab countries. Due the lack of data, an analysis of the broadband impact on the Asia Pacific region was conducted for some countries (country by country). This analysis showed a positive and statistically significant sign only for Chile, India and Malaysia. However for Malaysia, the impact was overestimated because of the data used in the adoption of the broadband (per household and not by population). The ITU report also emphasized the significant role of the broadband in the creation of employment in those regions by consolidating the results of some previous studies (Katz *et al.*, 2008; Liebenau *et al.*, 2009).

2.2. Causal Link between ICT and Inequality

The causal relationship in the first direction between ICT and income inequality (the effect of ICT on inequality) has its origins in two economic research lines: the thesis of Skill-biased technological change (SBTC) and the role of the ICT in the Nations' convergence. The idea of the first line is that the technological change favors the most skilled workers by accelerating their productivity and disadvantages the uneducated by causing their disqualification. Therefore, the acceleration of the pace of the technological change led to an increase of wage inequality (Acemoglu, 1998). The second line is interested in the impact of the introduction of ICTs on the macroeconomic performance of the nations. In fact, the countries that are unable to invest in innovation, have a state of knowledge lagging behind that of the other countries and which suffer from several structural problems (infrastructure, political instability, the pretty average quality of the educational system) cannot, of course, have the same impact on economic growth as that of the developed countries after the introduction of ICT. Hence, the gap in terms of economic growth is widening between the two (Aissaoui, 2017).

Regarding the causal relationship in the opposite direction between the ICTs and inequality, to our knowledge, there is no study that has been conducted in this field. However, there is a field of relatively new adjacent literature, which is the thesis of the digital divide. The studies that are part of this field often point out to an association between the income and the technology dissemination. They agree on the fact that the income is a key factor in the reduction the digital inequalities (Kiiski and Pohjola, 2002; Crenshaw and Robison, 2006; Chinn and Fairlie, 2010; Gulati and Yates, 2012) since it is linked to other explanatory factors that can significantly affect the inequalities of the ICT use in a country or in a region, such as telecommunication infrastructure, human capital and demographic characteristics of the population (Billon *et al.*, 2010; Chinn and Fairlie, 2010; Fairlie *et al.*, 2010). It follows that income inequality at the national and international level can have a significant effect on the technological diffusion.

Gulati and Yates (2012) support this idea and stipulate that a low level of income inequality enhances the spread of broadband Internet.

2.3. Inequality and Growth

The analysis of the impact of inequality increase on economic growth has been for a long time a loa subject of a controversy in the literature.

Using panel data, Barro (2000) could not detect a significant direct effect of inequality in the presence of the control variables related to human and physical capital and fertility. This suggests that inequality has an effect on economic growth only via the transmission channels referred to by the modern perspective. In the absence of the fertility variable, Barro's model detected a negative and significant impact of inequality on growth. Easterly (2007) also found a negative effect of inequality on human capital formation and economic growth. He explains this by the fact that inequality is a barrier to education and economic prosperity. For Ostry *et al.* (2014) inequality can have a negative effect on economic growth because it plays a role at the expense of health and the accumulation of human capital of the poor, adversely affects economic stability, reduces investment, and therefore, leads to inadequate shocks by preventing the social consensus. Moreover, inequality can play a role in promoting economic growth by encouraging innovation, increasing investment and savings (of the rich), as it may enable some individuals in poor countries to accumulate the minimum needs to have a good education and start a business. On their part, Halter *et al.* (2011) focused on the methodological aspects by indicating that the estimators in cross-section variation showed a negative effect of inequality on economic growth whereas the estimators in variation of time series showed a positive impact. More recently, Sabaouelgi and Boulila (2013) have used the cointegration techniques to explore the causal problem between inequality and economic growth in the short and long term for 9 countries of the MENA zone during the 1960-2011 period. They found that long term Granger causality exists for some countries, such as Morocco, Iran and Tunisia, whereas the short-term one exists for many other countries, such as Algeria and Jordan. Using the same econometric technique on data from 46 countries covering the 1970-1995 period, Herzer and Vollmer (2012) showed that inequality has long-term a negative effect on economic growth whether the country is rich or poor, democratic or non-democratic.

3. EMPIRICAL STUDY

The empirical part of this research study consists in estimating two empirical models. The first aims at analyzing the simultaneous effect of inequality and the broadband Internet on economic growth, whereas the second is used to examine the impact of inequality on the proliferation of the broadband. This section presents the estimated models, the econometric methods, the data, the used variables, the results, and the discussion.

3.1. Econometric Methodology

In order to test the impact of the high-speed Internet and income growth inequality, we build the following econometric model:

$$z_{i,t} = \alpha_0 + \alpha_1 \Delta HD_{i,t} + \alpha_2 inequality_{i,t-1} + \alpha_3 (inequality_{i,t-1} \times \Delta HD_{i,t}) + \alpha_4 Y_{i,t}\theta + \beta_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

With: $z_{i,t}$, ΔHD, $inequality_{i,t-1}$, $(inequality_{i,t-1}*\Delta HD)$, $Y_{i,t}$, β_i, δ_t and $\varepsilon_{i,t}$ are the economic growth rate, the change of the number of subscribers to the (fixed) broadband between two successive periods (t and t-1), the interaction between the income inequality and the flow of the Internet subscription broadband, the vector of the control variables (such as: the investment, the inflation rate, the human capital (labor with primary, secondary and university education)), the specific effect observed for each country and the temporal specific effect, respectively.

As mentioned in the literature cited above that ICT, and particularly broadband, enables to increase economic growth as well as accentuate the existing disparities and give rise to new forms of inequality (the digital divide),

which hampers economic growth. According to our theoretical model, it is expected that countries with different levels of inequality will differently respond to a variation of the broadband penetration and vice versa. To easily and clearly formulate this idea, we have chosen to introduce an interaction variable between inequality and the broadband penetration ($inequality_{i,t-1}$*ΔHD) in our econometric model.

The fact that this interaction term reduces or reinforces the individual impact of the broadband and inequality on economic growth, the omission of such a variable necessarily leads to a specification bias. In the absence of the interaction term, the change of economic growth caused by a variation of the broadband penetration will be measured using the α_1 coefficient. Moreover, in the presence of this term, this variation will be dependent on the level of income inequality at date t-1:

$$\frac{dz_{i,t}}{d\Delta HD_{i,t}} = \alpha_1 + \alpha_3 inequality_{i,t-1} \quad (2)$$

Moreover, due to the variation of the inequality level, the variation of economic growth will depend on the rate of the broadband penetration.

$$\frac{dz_{i,t}}{dinequality_{i,t-1}} = \alpha_2 + \alpha_3 \Delta HD_{i,t} \quad (3)$$

Therefore, the marginal effects of the broadband penetration and inequality are not constant but respectively vary according to the level of income inequality and the broadband penetration.

Furthermore, in order to complete our analysis and consider the impact of inequality on the spread of the broadband Internet, we have opted for a second empirical modeling based on the work of Conceicao *et al.* (2003):

$$HD_{i,t} = \gamma_0 + \gamma_1 inequality_{i,t-1} + \gamma_2 prim_{i,t-1} + \gamma_3 sec_{i,t-1} + \gamma_4 tert3_{i,t-1} + \alpha_i + \delta_t + \varepsilon_{i,t} \quad (4)$$

With: HD, prim, sec, tert are, respectively, the number of subscribers at time t, labor force with primary, secondary and tertiary education. This specification helps test the hypothesis that a highly unequal distribution inhibits the proliferation of the broadband. Actually, a high inequality causes a weak purchasing power for a large part of the population and therefore a lower access to the broadband.

The panel data estimation method enables to deal with biases related to the omitted variables. The general approach used in this case consists in testing whether there is a specification with homogeneous or heterogeneous data. The application of the preliminary tests promotes the estimation of a static relationship having individual fixed effects for either of the specifications (see tables 1 and 2). These results confirm those of Pirotte (1996) who emphasizes that the "Within" estimator helps account for the short term effects. The identification of the existence of heteroscedasticity by applying the Breusch- Pagan's test led us introduce the dummy variables for each country in both models using OLS instead of transforming the data into differences compared to the individual average of removing fixed effects.

3.2. The Data and the Variables

The statistical data used in this work are acquired from two different sources. The data about the income inequality (measured by the Gini index), the growth rate, education (primary, secondary and university), the workforce by education level (primary, secondary and university), investment and inflation are collected from the World Bank (WDI). The data about broadband Internet are obtained from the International Telecommunication Union (ITU).

Our panel covers 19 developed and developing countries, such as (Armenia, Bolivia, Colombia, Costa Rica, Dominican Republic, Ecuador, Estonia, Georgia, Hungary, Lithuania, Moldova, Panama, Peru, Poland, Paraguay,

Romania, El Salvador, Turkey, and Uruguay) covering the 2000-2012 period. The used variables, their definitions and descriptive statistics are presented in the following table.

Table-1. Definitions and Descriptive Statistics of Variables

Variables	Definition	Obs	Mean	Standard-deviation	Min	Max
Z	The GDP growth rate	247	4.4	4.5	-14.81	21.02
HD	The variation in the number of broadband subscribers per 100 people	228	0.88	1.10	-0.49	5.44
Inequality	Gini index (in %)	227	43.33	9.73	23.71	63.88
(Inequality*ΔHD)	The multiplicative term of Broadband and Gini	227	33.87	40.81	-16.55	233.37
TS1	School enrollment rate, primary	182	28.94	17.65	1.8	71.4
TS2	School enrollment rate, secondary	179	46.20	17.43	1.4	72.1
TS3	School enrollment rate, tertiary	175	20.59	7.36	2.4	42.5
Prim	Labor force with primary education (% of total workforce)	227	105.78	7.23	92.38	122.22
Sec	Labor force with secondary education (% of total workforce)	225	84.27	13.95	53.79	109.37
Tert	Labor force with tertiary education (% of total workforce)	195	43.66	15.85	15.71	83.32
Inflation	The consumer price index (%annual)	228	7.78	10.20	-1.14	96.09
Investment	Gross fixed capital formation (% de GDP)	228	20.83	5.04	11.68	36.74

Source: Author

3.3. Results and Discussion

The estimation results of the first model (equation (1)) are presented in table 1. The first two estimates evaluate the impact of the different variables without considering the effect of the interaction between broadband dissemination and inequality. This effect will be evaluated in the last two specifications.

The introduction of human capital (measured by the school enrollment rates) reduced the sample size by 53 observations. Nevertheless, this reduction did not affect the general nature of the obtained coefficients which show overall signs consistent with the literature mentioned above. Four key results can be drawn from table 2 below:

Tableau-2. Estimation results of the first model (equation (1))

Specifications	Dependent variable: Economic Growth			
	With interaction		Without interaction	
	(1)	(2)	(3)	(4)
HD	0.1179*** (0.0307)	0.0566** (0.0249)	0.1090 (0.1210)	0.1919** (0.0931)
Inequality	-0.0674*** (0.0073)	-0.0614*** (0.0102)	-0.0667*** (0.0074)	-0.0630*** (0.0102)
(Inequality*ΔHD)	---	---	0.0002 (0.0030)	-0.0035* (0.0020)
TS1	---	-0.0066*** (0.0020)	---	-0.0066*** (0.0020)
TS2	---	0.0063** (0.0031)	---	0.0067** (0.0031)
TS3	---	0.0196*** (0.0074)	---	0.0191*** (0.0072)
Inflation	-0.0082*** (0.0029)	-0.0168*** (0.0024)	-0.0082*** (0.0030)	-0.0166*** (0.0024)
Investment	0.0321*** (0.0081)	0.0276*** (0.0084)	0.0330*** (0.0083)	0.0279*** (0.0087)
_constant	10.5097*** (0.4320)	10.0321*** (0.5466)	10.4585*** (0.4364)	10.0851*** (0.5586)
Fisher test	48.30	45.53	47.73	46.24
Hausman test	19.10	20.46	16.42	22.43
Preusch Pagan test	45158	33838	81962	47854
R2	0.86	0.89	0.86	0.90
Observation	226	173	225	172

***, ** and * means that the coefficient is significant at an error risk of 1%, 5% and 10% respectively.

Values in brackets correspond to the robust standard deviations.

Source: Author, output Stata

Firstly, the secondary and university school enrollment rates, inflation and investment are all significant and have the expected signs. Therefore, the human capital positively affects economic growth. Moreover, the coefficient associated with the tertiary school enrollment rate is higher than that of the secondary school enrollment rate. Nevertheless, like Chambers (2007) it was found that the primary school enrollment rate has a negative and highly significant impact on economic growth. It was also found that there is a strong negative association between inflation, which is an indicator of macroeconomic stability, and economic growth. However, investment positively and significantly affects growth. These two results are consistent with those obtained by Noh and Yoo (2008).

Secondly, the factors associated with income inequality are highly significant and negative in all the specifications. Actually, an increase of the Gini index by 10% reduces economic growth by a little more than 0.6%. This result confirms the work of Perotti (1996); Chambers (2007); Herzer and Vollmer (2012); Noh and Yoo (2008) and Easterly (2007). The inequality adverse effect on both production and growth is often described in the literature as the fact that an unequal distribution negatively affects the investment in the human and physical capital and then reduces economic growth. Other explanations, such as political instability, the oppressive institutions,... have been proposed.

Thirdly, the variation of the broadband penetration has a positive and highly significant impact on economic growth, with the exception of the third specification. In fact, the introduction of the interaction term between inequality and broadband specification (3), without including human capital, resulted in a non significant effect of both the broadband Internet and the interaction term. The latter showed a negative and significant effect in the fourth specification. This result can be explained by the fact that due to the lack of human capital, the interaction term fully offsets the positive effect of the broadband on economic growth and therefore both coefficients become insignificant. Since the interaction term represents the digital divide, human capital plays a crucial role in determining the cleavage.

Fourthly, the review of the latter specification helps assert that the presence of a significantly negative multiplicative interaction term (between inequality and broadband variation) changes the individual broadband effect on economic growth. Given that $\alpha_1>0$ and $\alpha_3<0$, the broadband positive contribution to economic growth is reduced by the unequal internal revenue. Therefore, a higher rate of broadband penetration reduces economic growth in countries where income distribution is very unequal. Meanwhile, since $\alpha_2<0$ and $\alpha_3<0$, the inequality negative effect on economic growth is magnified in countries with high rates of broadband penetration.

Table-3. Estimation results of the second model (equation (4))

	Dependent variable : Broadband		
	Total	**Inequality≤45**	**Inequality>45**
Specifications	**(1)**	**(2)**	**(3)**
Inequality	-0.1942 (0.1191)	-0.3024 (0.2841)	-0.2090*** (0.0764)
Prim	0.0629 (0.0657)	-0.0576 (0.1087)	0.1164*** (0.0406)
Sec	0.1465*** (0.0533)	0.3170*** (0.1134)	0.0409 (0.0281)
Tert	0.4478*** (0.0356)	0.4453*** (0.0517)	0.3111*** (0.0344)
_cons	-25.5504** (10.0729)	-28.1668 (22.1581)	-13.827** (5.9683)
Fisher test	7.65	8.43	10.17
Hausman test	47.25	34.16	31.50
Preusch-Pagan test	263.62	304.76	42.76
Observation	191	108	83
R^2	0.78	0.78	0.85

***, ** and * means that the coefficient is significant at an error risk of 1%, 5% and 10% respectively.

Values in brackets correspond to the robust standard deviations.

Source: Author, output Stata

Regarding the second model (equation (4)), which consists in examining the inequality impact on the spread of broadband, we chose to estimate three specifications. In the first one, we estimated equation (4) for all the other comments. Then, we assessed the same model when the Gini index is low and after that when it is high. The determination coefficients showed a good adjustment quality for the three specifications. Finally, the estimations of this model brought out the two following comments:

On the one hand, with the sole exception of the labor force with primary education, the human capital appears to have a significant and positive impact on the spread of the broadband Internet. This result is in line with that of the research that promotes the existence of a complementary relationship between information and communications technology and skilled labor or even the thesis of the technological bias (Berman *et al.*, 1994; Acemoglu, 1998; Greenan *et al.*, 2001; Aissaoui and Ben Hassen, 2016).

On the other hand, the Gini index in the first specification shows no significant negative effect on the spread of broadband Internet. Moreover, in the second specification when the Gini index is low, it has not been observed to have no significance. In fact, it is only in the third specification, when it is greater than 0.45, that it negatively and significantly affects the broadband dissemination. Inequality in this case represents an obstacle to the broadband Internet proliferation. A highly unequal distribution excludes a large part of the population from the access and the use of ICT and, particularly, the broadband.

4. CONCLUSION

In this article, we tried to examine the role of internal inequalities in the changes of the relationship between ICTs, mainly the broadband Internet, and economic growth. The starting point of our study was to expose three separate but complementary fields of literature in order to provide a theoretical framework basis for the analysis of the trilateral relationship that might exist between broadband, inequality and economic growth. The main point that emerges from this is that the effect of inequality on the causal relationship between ICTs and economic growth is often ignored in most of the research studies. Then, two empirical models were undertaken on panel data for 19 developed and developing countries for the 2000-2012 period. In the first model, a multiplicative interaction term of broadband and inequality was introduced to examine the simultaneous effect between them. The main result obtained through this model is that the broadband positive effect on economic growth is reduced by the digital gap, which is reinforced by the presence of income inequality and which hinders economic growth. The second model emphasizes the blocking effect that income inequality could have on broadband proliferation. As a consequence, it appears that inequality can have a negative effect on the spread of broadband Internet only when the Gini index is quite high. The redistributive policies which reduce the income inequality enable countries to accelerate the broadband proliferation, reduce the digital gap and enhance the broadband effect on economic growth.

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