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## Conference Paper

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24th European Regional Conference of the International Telecommunications Society (ITS): "Technology, Investment and Uncertainty", Florence, Italy, 20th-23rd October, 2013

### Provided in Cooperation with:

International Telecommunications Society (ITS)

*Suggested Citation:* Okamoto, Yoshikazu; Nakamura, Akihiro (2013) : The influence of local loop unbundling on investment by incumbent telecommunications operators in the OECD member countries, 24th European Regional Conference of the International Telecommunications Society (ITS): "Technology, Investment and Uncertainty", Florence, Italy, 20th-23rd October, 2013, International Telecommunications Society (ITS), Calgary

This Version is available at:

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# The influence of local loop unbundling on investment by incumbent telecommunications operators in the OECD member countries

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## Abstract

This paper examines the influence of local loop unbundling (LLU) on incumbent telecommunications operators' investment in their respective telecommunications networks in OECD countries. In addition, the background of the influence is analyzed from both qualitative and quantitative aspects. The study uses panel data (1995–2011) of capital expenditure (capex) and revenues to derive an investment function. The results indicate that LLU had a positive impact on investment by incumbent telecommunications operators in the United States, but a negative impact in Japan. These results echo those of previous empirical studies, which indicate that LLU can impact investment in various ways.

## 1. Introduction

Information and telecommunications networks can achieve economies of scale relatively easily, and local loop networks, typically owned by an incumbent telecommunications operator, can become a bottleneck. For this reason, some countries have introduced local loop unbundling (LLU), which aims to promote competition by allowing new service providers with access to the unbundled local loops. LLU aims to promote service competition in the short term and infrastructure competition in the long term. Some OECD countries first introduced LLU in the late 1990s, although most began adopting LLU around 2000. Therefore, it has been well over ten years since LLU was first introduced.

According to Spulber and Yoo (2009), there are two main perspectives on the negative impact of LLU. The first is that the incumbent telecommunications operator loses the incentive to invest in the network, because it is required to share the network elements with competitors. The second is that LLU dampens the incumbent telecommunications operator's motivation to pursue and invest in technical innovation and new transmission technologies. Both perspectives focus on the decrease in investment by the incumbent telecommunications operator. Grajek and Röller (2012), among others, also point out that LLU negatively affects investment by the entire telecommunications industry, and so does not result in infrastructure competition. On the other hand, the idea that both the incumbent and new telecommunications operators can continue to invest in the network without LLU is well

established, particularly in the United States. As a result, a number of empirical studies have investigated the pros and cons of adopting LLU.

Most previous empirical studies on LLU analyze data covering a relatively short period, typically less than ten years. This period is based on the aforementioned LLU adoption timeline and the accompanying development of broadband networks, covering the time prior to the impact of the institution settling down. However, network development takes time to complete after introducing LLU, so it is necessary to analyze long-term data that include the LLU adoption period. It has been over ten years since many OECD countries adopted LLU, making it possible to conduct more precise analysis. This analysis empirically examines changes in annual investment data from 1995 to 2011 of the incumbent telecommunications operators in the OECD member countries.

The paper is organized as follows. Section 2 provides an overview of previous studies and discusses how the analysis in this paper is positioned among them. Section 3 establishes hypotheses regarding the impact of LLU on investment by incumbent telecommunications operators. Section 4 discusses the estimation model, using panel data, and explains how the estimation results verify the hypotheses. Section 5 discusses the estimation results, and Section 6 concludes the paper, including possible further research.

## 2. Previous Studies and the Characteristics of This Paper

The majority of previous studies examine LLU while analyzing the factors driving broadband penetration in OECD countries or European countries (see Table 1). These studies use the penetration rate of broadband as their dependent variable because they are explaining broadband penetration. In terms of the impact of LLU, the reality is that results can vary, and may be positive and significant, negative and significant, or positive or negative but not significant, and so on. To date, empirical results have not been consistent.

Table 1: Previous Studies

Study	Countries	Period	Number of observations	Independent variables	Significant variables (#)
Garcia-Murillo, M. (2005)	Approximately 100 countries	2001	18-92 (Observations vary depending on the model)	GDP per capita, Population, Price, Number of broadband providers, Percentage of domestic Internet hosts, Percentage of Internet users, Broadband competition, Privatization, Unbundling, etc.	GDP per capita, Population, Price, Number of broadband providers, Percentage of domestic Internet hosts, Unbundling
Cava-Ferruella, I. and A. Alabau-Munoz (2006)	OECD 30 countries	2000-2002	90	GNI (Gross National Income), Competition between technologies, Percentage of urban population, Number of UMTS operators, Number of dial-up Internet users, Regulations of LLU, Number of unbundled local loops, etc.	GNI, Competition between technologies, Number of dial-up Internet users, [The following two did not show strong significance] Percentage of urban population, Number of UMTS operators [Regulations of LLU and Number of unbundled local loops were not significant]
Grosso, M. (2006)	OECD 30 countries	2001-2004	117	HHI (Herfindahl-Hirschman Index), Real GDP per capita, Fixed Internet penetration (previous year), Broadband penetration (previous year), LLU	(Based on the estimation using a fixed cross-section effect) HHI (negative), Real GDP per capita, Fixed Internet penetration (previous year), Broadband

					penetration (previous year), LLU
Wallsten, S. (2006)	OECD 30 countries	1999-2003	179	Full unbundling, Bitstream access, Sub-loop unbundling, Collocation, Main telephone lines per 100 people, GDP per capita, etc.	(Based on a two-way fixed effects estimation) Full unbundling, Bitstream access, Sub-loop unbundling (negative), Collocation [these depend on estimation criteria; there is no strong significance] Main telephone lines per 100 people, GDP per capita, etc.
Hoffler, F. (2007)	16 western European countries	4Q2000 -1Q2004	195-210 (Estimation with LLU price)	Market share of the cable companies, Price of the LLU, Number of ISDN lines divided by all households, Final consumer expenditure per capita, Population density, etc.	Market share of the cable companies, Price of the LLU (negative), Number of ISDN lines divided by all households (negative), Final consumer expenditure per capita, Population density, etc.
Bouckaert, J., T. van Dijk and F. Verboven (2010)	OECD 20 countries	2003.12-2008.3	344, 326	Inter-platform competition, Facility-based competition, Service-based competition, Population density, GDP, etc.	Inter-platform competition (negative), [Service-based competition may be positive or negative, depending on the estimation criteria; no strong significance], GDP, etc.
Lee, S., J. S. Brown and S. Lee (2011)	OECD 30 countries	2001-2008	238	Income, Education, Population density, Platform competition (1 for different fixed-broadband platforms are available, 0 for otherwise), Previous fixed broadband penetration, PC infrastructure, LLU(1) (1 for with full unbundling, line sharing, bitstream access, no LLU price regulation, 0 for otherwise), LLU(2) (1 for with full unbundling, line sharing, no bitstream access, with LLU price regulation, 0 for otherwise)	Income, Education, Platform competition, Previous fixed broadband penetration [LLU(1) and LLU(2) are not significant]
Shinohara, Akematsu and Tsuji (2012)	OECD 30 countries	2001-2010 (Quarterly)	184-234	Broadband subscription, Broadband price, Broadband speed, HHI, CATV subscription, Dry copper unbundling (full unbundling), FTTx unbundling, Operator's business decision	(Based on the estimation of 16 countries classified as DSL type) DSL price (negative), FTTx price, Broadband speed (FTTx) (negative), CATV subscription (negative), Dry copper unbundling, FTTx unbundling (negative)

(#) Only 5% significance level variables are described. Only results that are negative are marked (negative).

When the broadband penetration rate is used as a proxy variable for investment, as in previous studies, the variable reflects the investment of both incumbent and new telecommunications operators. As shown in Figure 1, there are four possible types of investments in an information and telecommunications network based on the type of technology (existing vs. new technology) and the type of investor (incumbent vs. new operator). The studies listed in Table 1 verified types (1) through (4) in Figure 1 without breaking them down. The one exception was the study by Hoffler (2007), which added “LLU price” as an explanatory variable for the cost incurred by new operators and focused on types (2) and (4) in Figure 1. In contrast, this paper focuses on types (1) and (3) in Figure 1, as it analyzes the impact of LLU based on the investment data of incumbent telecommunications operators in the OECD member countries. However, since there was almost no investment in new transmission technology (e.g., fiber optics) in many OECD countries during this period, this study focuses mainly on type (1).

Figure 1: Scope of the Analysis

Investment in existing transmission technology		Investment in new transmission technology	
Incumbent operator (1)	New operator (2)	Incumbent operator (3)	New operator (4)

In addition, as mentioned earlier, many previous studies used data from the early 2000s onwards. In some cases, these analyses only cover the period after LLU was introduced, which obscures any influence LLU may have had on the penetration of broadband. In contrast, this paper uses annual data from 1995 to 2011, which includes the period before OECD countries adopted LLU, enabling us to study and understand how the adoption of LLU influenced investment behavior.

Since we are using real investment data, this paper estimates an investment function, which, to the best of our knowledge, no previous studies on LLU have done. The estimated investment function is of the acceleration principle type, a traditional principle that has been studied since the early 20th century. This type of function suffers from an insufficient economic theoretical basis, but is still often used as a macro econometric model to explain investment demand because it produces sound quantitative analysis results (Zhu, 1995; Nakamura, 2003; etc.). Although the function was replaced by Tobin's q theory in the field of empirical study in the early 1980s, the acceleration principle still has strong explanatory power in situations in which companies overinvest (excess capacity) (Miyagawa and Tanaka, 2009; Miyagawa et al., 2005; etc.). In the 1990s, because the period of weak capital investment continued in countries such as Japan and the United States, researchers began considering models based on the premise that there was excess debt rather than excess capacity from the perspective of the real economy in the acceleration principle. They believed that these excess debts were behind the weak capital investment and were restricting new capital investment (Miyagawa et al., 2005; etc.) These models included approaches such as demonstrating liquidity constraints (cash flow). However, recent estimates, such as those of Fazzari, Ferri and Greenberg (2010), take both cash flow and the acceleration principle into account. In this paper, we estimate the investment function of a simpler acceleration principle type because of data constraints.

### 3. Defining Hypotheses

Prior to conducting the empirical analysis, this section organizes the investment behavior of incumbent telecommunications operators after introducing LLU. This paper organizes the determinants of this investment behavior by focusing on the interconnection fees imposed on these operators after adopting LLU, as well as the vertical corporate structure of bottleneck facilities and retail services.

With respect to the investment in bottleneck facilities, new operators are generally able to suspend making a decision on whether to fund the investment on their own or through other means

until all uncertainties related to the investment are resolved. On the other hand, incumbent operators are required to make the investment prior to resolving those uncertainties (Armstrong, 2007). With respect to the interconnection fee, because there is a risk related to recovering the investment in the bottleneck facilities, it is essential that the fee accurately reflect the investment cost, including this risk. Under these circumstances, if the usage fee (interconnection fee) per unbundled network element is too low, this reduces the profitability for the incumbent telecommunications operator and their subsequent level of investment will be too low (Fuke, 2007; Lehr and Pupillo, 2009). In contrast, the incumbent operator's level of investment will be too high in the opposite situation. In addition, Vareda (2007) points out that investment in facility enhancement (e.g. fiber optic networks that would improve transmission speed and capacity) will also decrease, because lower interconnection fees will promote retail market competition.

In terms of the relationship between the vertical corporate structure and the interconnection fee, the following differences can be envisioned. In the case of a vertically integrated structure (i.e., the upstream incumbent telecommunications operator and the downstream retail operators are affiliated), a relatively high interconnection fee<sup>1</sup> means that the retail prices offered by new operators as well, and the retail market share of the incumbent operator expands. If the incumbent telecommunications operators can profit by expanding the downstream market (retail market) share in this manner (Yamamoto, 2010), we can assume that adopting LLU would lead to increased investment by the incumbent operators. On the other hand, this type of incentive will not work in a vertically separated structure. In this case, the investment level would decrease from the levels prior to LLU adoption, even if the interconnection fee becomes relatively expensive. However, it should be noted that capital expenditure could stay the same or decline, depending on the situation of each incumbent operator. For example, some researchers believe that the capital expenditure of an incumbent operator that dominates the local network in a vertically integrated structure would fall below the socially optimized level, even if access regulations are not imposed (Kotakorpi, 2006). However, others believe that the capital expenditure of an incumbent operator exposed to network competition in a vertically integrated structure would also drop below the socially optimal level (Valletti and Cambini, 2005).

Figure 2 illustrates the general implications, for the sake of simplicity. It is difficult to definitively determine the direction of changes in capital expenditure, particularly in the cases of [a] and [f] shown in Figure 2, because the direction changes based on the level of factors i and ii. As described, LLU might have a positive or negative impact on the investment level of incumbent operators. We will examine this point in the next section.

Figure 2: Determinants of Investment Behavior of Incumbent Telecommunications Operators after Adopting LLU

		ii	
		Vertically separated type 【↓】	Vertically integrated type 【↑】
i	Higher interconnection fee 【↑】	[a] High or low capital expenditure	[b] High capital expenditure
	Appropriate interconnection fee 【→】	[c] Low capital expenditure	[d] High capital expenditure
	Lower interconnection fee 【↓】	[e] Low capital expenditure	[f] High or low capital expenditure

(Note) The arrow shown in 【】 indicates the increase and decrease of capital expenditure by incumbent telecommunications operators.

#### 4. Estimation

##### (1) Estimation Model and Data

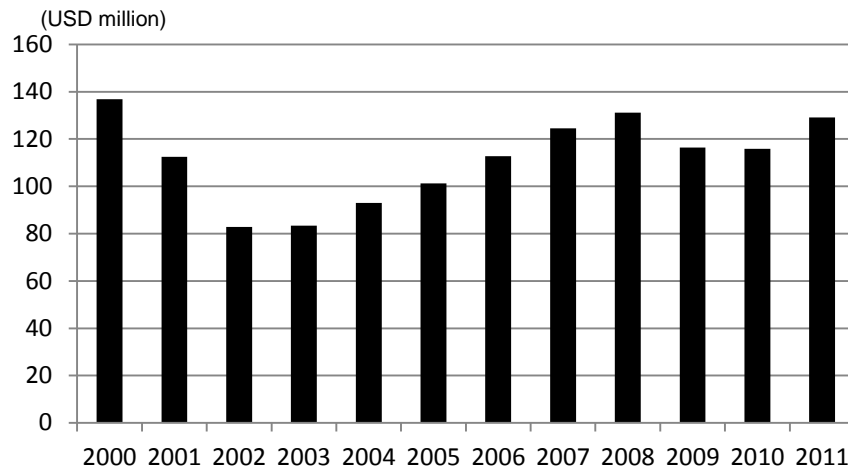
To test the hypotheses described in the previous section, we formulate the following estimation model:

$$Inv_{it} = \alpha_0 + \alpha_1 (Rev_{it} - Rev_{it}(-1)) + \sum \beta_i (LLU_{it} * Cdummy_i) + \varepsilon_{it}$$

Here, *Inv* represents the capital expenditure (in USD) of incumbent telecommunications operators in 30 OECD member countries, while *Rev* represents the (operating) revenue (in USD) of the same group of operators. The data used here are sourced from documents including annual reports and the Form 20-F, which each operator files with the United States Securities and Exchange Commission (SEC). *LLU* is a dummy variable that reflects when LLU was introduced<sup>2</sup> in the OECD member countries. Note that capital expenditure and revenue were deflated based on the annual GDP deflator in each country.

This paper uses panel data to examine two-way fixed effects (individual effects) of the cross-section variable (by country) and time series variable. By doing so, the differences attributed to factors other than global economic trends and LLU in each country are controlled. The subscripts *i* and *t* represent each OECD country and year, respectively. The analysis period this paper covers (1995 to 2011) is the same period during which factors such as liquidity constraints could have had explanatory power, because investments were sluggish consequent to events such as the collapse of the IT bubble. However, by 2008, the capital expenditure for the OECD countries had returned to similar levels to 2000, prior to the collapse of the IT bubble (See Figure 3). Therefore, this paper focuses on revealing the overall impact of LLU adoption by using only the acceleration principle.

Figure 3: Trends in Total Capital Expenditure of Incumbent Telecommunications Operators in Each OECD Country (30 Countries)



Source: Form 20-F and other documents of incumbent telecommunication operators in each country

Note: The data for Ireland is missing for 2010 and 2011.

We selected the difference in revenue between the current period and the previous period as the term for induced investment after considering that investment in information and communications aims for an immediate effect. Regarding the use of revenue data, previous studies, such as Nagahata and Sekine (2002), conducted empirical analyses of the acceleration principle investment function using companies' revenue (sales) data. It is also possible, for example, to use the number of subscribers to the Internet or broadband services as a proxy variable instead of using revenue (sales). However, the available international data combines the figures for new and incumbent telecommunications operators. Since this paper sets the revenue of incumbent telecommunications operators as the dependent variable, we decided that it was more appropriate to use incumbent operators' revenue (sales) as an explanatory variable.

With respect to the dummy variable for LLU, this paper does not differentiate between full unbundling, line sharing, and bit stream access, or the three categories that make up LLU. Doing so would complicate the estimation model. In addition, when LLU was introduced in the EU countries, one of the three types often dominated, while the remaining types did not play a role (De Bijl and Peitz, 2005).<sup>3</sup> In other words, even if these three types were institutionalized, the analysis would be biased if the level of system usage varied. In fact, this is probably one reason the studies of Wallsten (2006) and Lee, Brown, and Lee (2011) did not produce significant results when they attempted estimations that reflected the different categories. In the estimation in this paper, we handle LLU as a whole, because we do not have detailed timing information of when each system was used in each country. However, because it is conceivable that the impact of LLU varies by country in this manner, we attempt an estimation that includes a coefficient dummy variable for each country (using Japan as a reference) to test this possibility. This coefficient dummy variable will control for differences



that reflect the type of LLU adopted in each country.

However, some countries have missing values, and it is not possible to perform an estimation that includes the coefficient dummy variable by country for countries that introduced LLU early. As a result, we excluded the data of Ireland, Mexico, the Netherlands, and Turkey, and used the data of the remaining 26 countries.

Note that we used the instrumental variable method in the estimation because there was a possibility that the explanatory variables would become endogenous variables in the estimate of the investment function. With respect to the instrumental variables, population size (ages 55 to 59), population size (ages 75 to 79), and the difference in the capital expenditure for road infrastructure between the current and previous periods were used as variables that were correlated with the induced investment term. The first two variables assume that the usage of telecommunications services increases and leads to increased revenue as the population size increases. The third variable assumes that as more money is invested in roads, which are a more basic form of infrastructure than telecommunications, economic activities in general will be stimulated. This in turn will lead to increased use of telecommunications services and increased revenue.

As described above, this study adopts static analyses. However, there are cases that estimate the investment function using a dynamic model using GMM. However, doing so would have to introduce lag variables for multiple periods. When lag variables are used for multiple periods in this way, data constraints arise in relation to the dummy variable that represents the period LLU was introduced, making it difficult to conduct an estimation that covers most of the incumbent telecommunications operators in the OECD countries. Therefore, we chose being able to analyze most of the OECD countries over being able to conduct a dynamic model estimation using GMM.

The descriptive statistics of the data are summarized in Table 2.

Table 2: Descriptive Statistics

	Observation	Mean	Standard Deviation	Minimum	Maximum
Inv	421	41.61513	68.59898	0.167341	355.9776
Rev	421	230.7371	369.2136	1.363527	2324.190
LLU	421	0.608076	0.488761	0.000000	1.000000

## (2) Analysis Results

The estimation results are as summarized in Table 3.

Table 3: Estimation Results

Estimation model	Fixed effect (two-way) Instrumental Variables Method [26 countries]	Remarks (Actual estimated value of LLU and <i>t</i> -value in the fixed effect (two-way) model)
Constant	33.49337** (9.646158)	
Rev-Rev(-1)	0.386315** (4.678173)	
LLU	-48.60353** (-4.007177)	
LLU*Australia	49.06501** (3.110864)	0.46148 (0.039306)
LLU*Austria	53.42300** (3.010210)	4.81947 (0.343601)
LLU*Belgium	53.00303** (3.365561)	4.39950 (0.373335)
LLU*Canada	60.58833** (3.141430)	11.98480 (0.740265)
LLU*Czech Republic	43.61031** (2.852026)	-4.99322 (-0.462125)
LLU*Denmark	55.20634** (3.491718)	6.60281 (0.553175)
LLU*Finland	52.21095 (2.149643)	3.60742 (0.164828)
LLU*France	72.92447** (4.400994)	24.32094 (1.898488)
LLU*Germany	61.02950** (3.339741)	12.42597 (0.874272)
LLU*Greece	60.91241 * (2.414265)	12.30888 (0.543966)
LLU*Hungary	52.91761** (3.425961)	4.31408 (0.382723)
LLU*Iceland	52.97160** (3.374526)	4.36807 (0.370602)
LLU*Italy	49.12065** (3.159838)	0.51712 (0.044748)
LLU*Korea	50.69324 (2.001014)	2.08971 (0.093002)
LLU*Luxembourg	54.92890** (3.564015)	6.32537 (0.557510)
LLU*New Zealand	42.33399* (2.534201)	-6.26954 (-0.513627)
LLU*Norway	65.01575** (4.189068)	16.41222 (1.455130)
LLU*Poland	39.50536* (2.500772)	-9.09817 (-0.810923)
LLU*Portugal	55.94610** (3.141017)	7.34257 (0.515894)
LLU*Slovak Republic	43.14950** (2.631713)	-5.45403 (-0.466132)
LLU*Spain	48.52340* (2.402837)	-0.08013 (-0.004850)
LLU*Sweden	55.25752** (3.565560)	6.65399 (0.589688)
LLU*Switzerland	44.36309* (2.486251)	-4.24044 (-0.311446)
LLU*UK	50.52907** (3.285759)	1.92554 (0.168488)
LLU*US	112.6272** (4.609683)	64.02367 ** (2.924323)
Observations	373	
J statistics	0.919296	

(Note 1) The value listed in parentheses under the estimated value is the *t*-value. The figure on the J statistics line is the *p*-value.

(Note 2) \* and \*\* indicate that the figure is statistically significant at the 3% and 1% level, respectively.

The computation of the estimation formula uses the instrumental variable method, as described above. The *p*-value for the J statistic related to this estimation is 0.919296 and the null hypothesis that the instrumental variable is appropriate is not rejected. Therefore, the estimation is appropriate.

The estimation results showed that the induced investment term was positive and significant, and

that LLU was significant for the United States and Japan (positive for the United States and negative for Japan). Note that the LLU parameter in the estimation results represents the situation in Japan without including the cross term for Japan in the explanatory variables. In other words, because the cross term  $LLU*[country]$  represents the difference in the LLU effect in the specified country and Japan, the estimations and  $t$ -values shown in Table 3 only indicate whether the difference in the LLU effect compared to Japan is significant. Therefore, the actual impact of LLU in each country, other than Japan, is calculated<sup>4</sup> by adding LLU and the estimated value of  $LLU*[country]$ , and using this estimated effect and the variance-covariance matrix to derive the  $t$ -value (See the remark column in Table 3 for the results).

## 5. Discussion

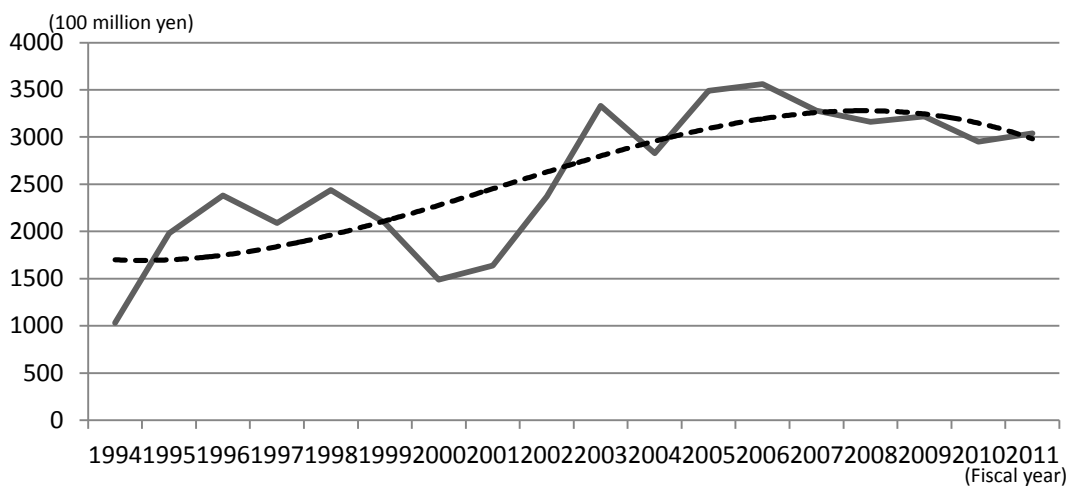
In this section, we examine the analysis results from the previous section and discuss which countries had a significant LLU dummy coefficient by country, based on the incumbent operators' investment behavior determinants, as listed in Figure 2 in Section 3. Note that all incumbent telecommunications operators that own the local loop network in each country were in charge of the regional communications service and had a vertically integrated structure to provide the service.<sup>5</sup>

A vertically integrated structure occurs in investment behavior categories [b], [d], and [f], as shown in Figure 2 in Section 3. The cases in which capital expenditure increases after adopting LLU would fall under these same categories. That is, in case [b], we assume that, even though a country-specific interconnection fee calculation system was introduced, the "higher interconnection fee" factor increased investment in conjunction with the "vertically integrated structure" factor. In case [d], a reasonable level of interconnection fee does not increase investment because it is on the border between higher interconnection fee and lower interconnection fee. However, the "vertically integrated structure" factor does increase investment. In case [f], the "vertically integrated structure" factor increases investment by overcoming the decreasing effect of the "lower interconnection fee" factor because of the country-specific interconnection fee calculation method in place. Based on the estimation results in this paper, we assume that the United States, which had a statistically significant increase in capital expenditure after adopting LLU, would fall within category [b], [d], or [f]. Note that the interconnection fee calculation system used in the United States was the total element long run incremental cost (TELRIC) method (Fujino, 2012).

Japan experienced a statistically significant decrease in capital expenditure after adopting LLU and also had a vertically integrated structure. Therefore, Japan falls within category [f]. In other words, we assume that the "lower interconnection fee" factor decreased investment by overcoming the "vertically integrated structure" factor, which would increase investment, because of the interconnection fee calculation method in place (the historical cost calculation method and LRIC method). However, in Japan, capital expenditure has to be examined separately for fiber optic networks and for the public switched telephone network (PSTN), unlike in other countries.

Specifically, NTT, the incumbent telecommunications operator in Japan, has a history of aggressive investment in fiber optic networks as a countermeasure to the controversy of NTT divestiture, and announced a plan to install fiber optic networks throughout the country during the period 1990 to 2015; the government later clarified that the basic plan was to complete the networks by 2010 (Ida, 2007).

Figure 4: Capital Expenditure for Laying Fiber Optic Access Network (Total for NTT East and NTT West)



Source: NTT

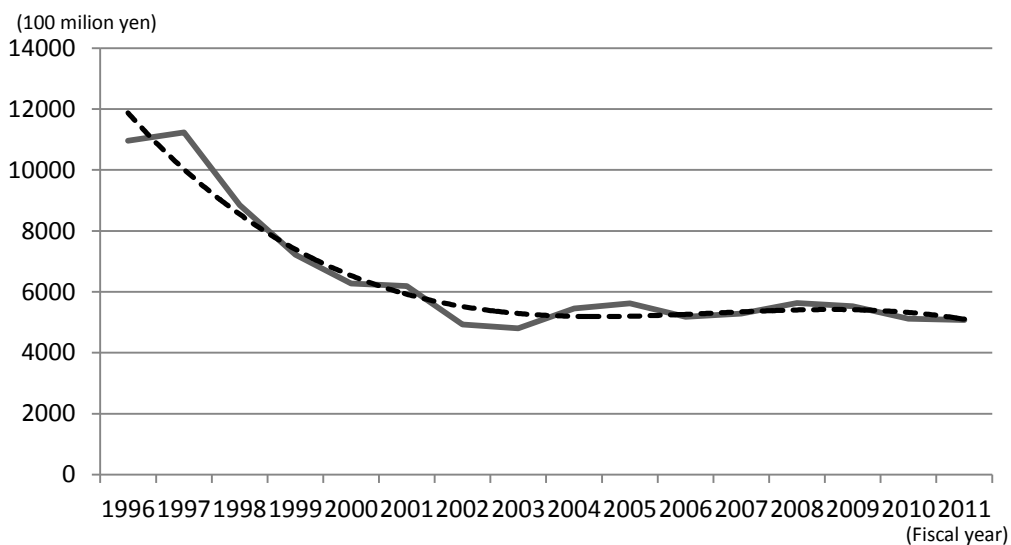
Note: The dotted line is an approximated curve (cubic function)

Figure 4 also suggests that NTT has been making a certain level of investment since the early 1990s. In addition, this level increased after the adoption of LLU in 2000 and 2001. It is possible that the investment in the PSTN decreased by more than the increase in the fiber optic investment over the same period. Unfortunately, no published data directly show capital expenditure for the PSTN. However, we can obtain similar data by deducting the capital expenditure for laying a fiber optic access network from the total capital expenditure related to the regional telecommunication business of NTT East and NTT West. These data support the aforementioned theory on the difference between the two levels of investment (see Figure 5). In addition, the data for the induced investment term (the difference in revenue between the current and previous periods) in the estimation model were generally trending up throughout the estimation period.

In terms of a contributory factor for this reduced investment in PSTN, it is conceivable that NTT's major strategic direction of discontinuing PSTN and transferring their management resources to fiber optic services had an impact.<sup>6</sup> In fact, shortly afterward, in 2004, NTT announced a plan to phase out metal access and fixed telephone networks and transition to fiber optic access and a

next-generation network.<sup>7</sup> In view of the above investment situation in Japan, it is also conceivable that a factor other than LLU adoption, namely, the long-term strategy related to the establishment of NTT network, had an impact. Therefore, it is necessary to consider these circumstances before concluding that adopting LLU has a negative impact on investment by the incumbent telecommunications operator.

Figure 5: Capital Expenditure for PSTN (Total for NTT East and NTT West, Approximate Amount)  
 [(Capital Expenditure for Regional Telecommunications Business) – (Capital Expenditure for Laying Fiber Optic Access Network)]

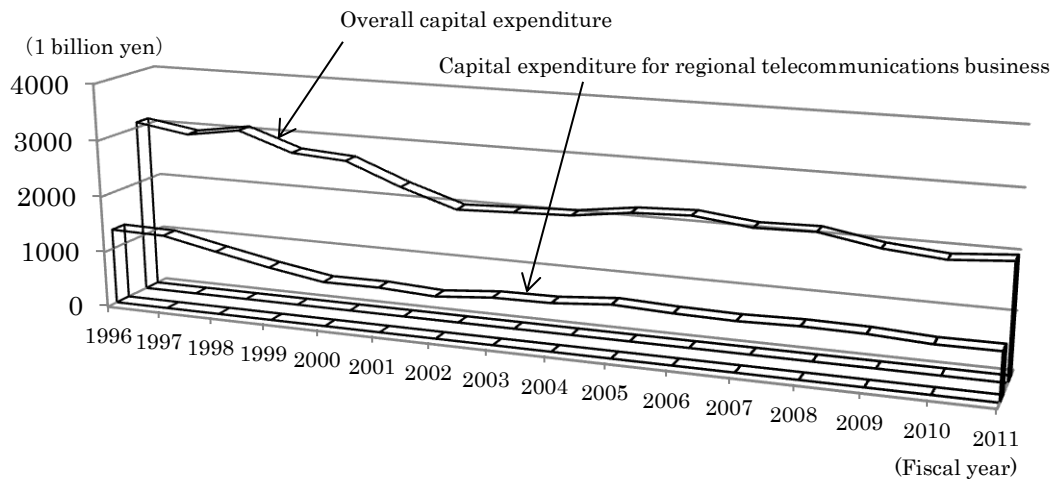


Source: NTT

Note: The dotted line is an approximated curve (cubic function)

Note that, while the estimates in this paper use overall capital expenditure in each country, the estimates for Japan use capital expenditure by regional telecommunications because that data was available, and would contribute to the examination. Therefore, one possible issue is that if the trends of the former and latter data are significantly different, the explanation by the latter data will be based on data that deviates from the estimation data in this paper. However, such a concern is almost negligible as the correlation coefficient of these two sets of data is 0.80 (see Figure 6).

Figure 6: Overall Capital Expenditure and the Capital Expenditure for Regional Telecommunications Business (Total of NTT East and NTT West)



Lastly, we touch on the group of countries in which the correlation between LLU adoption and the changes in capital expenditure were not statistically significant, according to the estimation results in this paper. These countries fall within categories [b], [d], or [f] in Figure 2 in Section 3, because the incumbent operators in these countries are vertically integrated, just as in the United States and Japan. However, in the case of category [f], for example, if the “lower interconnection fee” factor that reduces investment and the “vertically integrated structure” factor that increases investment cancel each other out, LLU adoption will not affect capital expenditure. In addition, the effect of the LLU variable at the time of the adoption might differ based on how far in advance the LLU adoption was accurately anticipated in each country. Furthermore, the amount of capital expenditure would differ if the LLU adoption began with the bit stream type, which is less of a burden on the incumbent operator, as opposed to full unbundling, which carries a far larger burden for the incumbent operator. It is also conceivable that whether an appropriate system for settling interconnection disputes was in place (including setting up the lead time for the incumbent telecommunications operator to implement unbundling upon a new operator’s request) from the beginning would have some kind of impact. Therefore, it is possible that these factors interacted in a complex manner in those countries where LLU adoption was not statistically significant to the level of investment.

## 6. Conclusion

In this paper, we used long-term cross-section data of 26 OECD countries and empirically analyzed the impact of adopting LLU on the investment behavior of incumbent telecommunications operators. When the differences between each country were controlled using panel data estimations, the results showed that there was a positive effect in the United States, and a negative effect in Japan, indicating that there were different effects in each country.

We conclude this paper by describing a few remaining issues with this paper. First, since each

operator's published capital expenditure data were often not broken down to fixed-line telecommunications business and mobile telecommunications business, we had to use the total figure for the operator data of the OECD countries for consistent estimation. It is possible that the total capital expenditure data (i.e., for both fixed-line and mobile telecommunications businesses) showed the same trend as the capital expenditure data for the fixed-line telecommunications business on its own in the United States, but differed in other countries. In addition, with respect to the capital expenditure for the fixed-line telecommunication business in Japan (the total capital expenditure for the regional telecommunications business) mentioned in the previous section, such data for the entire estimation period was only available for Japan. Obtaining similar data for the other countries will allow more accurate analyses in future.

In addition, this paper did not break LLU down into its three categories (full unbundling, line sharing, and bit stream) to estimate each effect. Although the estimation is performed using the LLU dummy variable per country for consistent control, once the institutions' adoption and their usage situations per country are closely investigated, it will probably be possible to analyze the level of impact of each LLU access method more accurately.

Furthermore, as briefly mentioned at the end of the previous section, this paper did not examine in detail countries in which the LLU dummy variable per country was not significant. This was purely because of a limitation of space, and we would like to address this point, along with the other issues in future studies.

### **Acknowledgment**

This work was partially supported by JSPS KAKENHI Grant Number 25380279 and 24330089.

List of incumbent telecommunications operators  
in the OECD member countries covered in the analysis

Country	Operator
Australia	Telstra
Austria	Telekom Austria
Belgium	Belgacom
Canada	BCE Inc., Telus
Czech Republic	Czech Telecom
Denmark	TDC
Finland	Elisa
France	France Telecom
Germany	Deutsche Telekom
Greece	OTE
Hungary	Magyar
Iceland	Siminn
Ireland	Eircom
Italy	Telecom Italia
Japan	NTT
Korea	Korea Telecom
Luxembourg	EPT
Mexico	Telmex
Netherlands	KPN Telecom
New Zealand	Telecom, NZ
Norway	Telenor
Poland	TPSA
Portugal	Portugal Telecom
Slovak republic	Slovak telekom
Spain	Telefonica
Sweden	TeliaSonera
Switzerland	Swisscom
Turkey	Türk Telekom
United Kingdom	BT
United States	AT&T, Verizon



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## Notes

- <sup>1</sup> This could occur when no rules are imposed. Although the fee could become expensive when only the duty to interconnect is imposed, this type of concern would fade once rules for calculating the interconnection fee using methods such as the long-run incremental cost (LRIC) are established.
- <sup>2</sup> Okamoto (2009): 14.
- <sup>3</sup> For example, Hungary is considered to have had no experience with full unbundling and line sharing as of 2004; however, the institutions have been in place since 2002 (OECD, 2005).
- <sup>4</sup> The standard deviation of  $LLU + LLU * [country]$  is  $\{(covariance\ between\ LLUs) + 2 * (covariance\ between\ LLU\ and\ LLU + LLU * [country]) + (covariance\ between\ the\ results\ of\ LLU + LLU * [country])\}^{1/2}$ . The *t*-value is calculated by dividing the estimate value of  $LLU + LLU * [country]$  by this standard deviation.
- <sup>5</sup> The cases such as the United Kingdom, where the BT Group has a division (Openreach (since January 2006)) to manage and market the local loop network and a separate retail division (BT Retail) running in parallel can be classified as being vertically separated. However, since LLU was introduced in the United Kingdom in 2001, this paper does not consider this situation.
- <sup>6</sup> For example, Shinohara, Akematsu, and Tsuji (2012) noted it is conceivable that NTT East and NTT West, having been on a par with Softbank (Yahoo BB) in terms of the DSL market share, gave up on DSL and indicated the possibility of discontinuing the metal subscriber line and redirected their management resources to FTTx.
- <sup>7</sup> NTT Group Mid-term Management Strategy (November 10, 2004).

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