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Dynamic Industrial Change Through the Popularization of Front-End ICT

Yukinori Nakano

This study analyzed the Employment Matrix Tables (industrial sectors and occupations) extracted from the linked Input-Output Tables in order to identify the trends of the socio-industrial state of operators and technicians of wireless technology. In contrast with the increasing number of licensees of wireless operators and technicians, the number of in-house operators and technicians started declining rapidly after the 1990s, except within the broadcast industry. This indicates that the popularization of front-end ICT, such as easy-to-use wireless technology, has led to the reduction in the number of well-qualified and knowledgeable operators and technicians. In the future, new non-professional technicians, who have comprehensive wireless and informatics literacy, will be the core people developing a more user-friendly advanced ICT society.

Key Words: Popularization of front-end ICT; User-friendly; Wireless operators and technicians; Advanced ICT society

1. Introduction

We observe contradictory trends between the increasing number of license-holding radio operators or technicians and the decreasing number of in-house wireless communication operators and technicians in mobile service or communication industries except within the broadcast industry.

Where are the radio license holders working?

The answer is that they are working everywhere, but they are not hired as radio operators or technicians. They are the policemen who operate the radar to control traffic circulation, the pilots of airplanes who communicate with the control tower, the first mate of a ship who operates the semi-automatic communication radio system, etc. This indicates that the proliferation of sophisticated front-end ICT incorporated in wireless technology has led to the reduction of well-qualified and skillful communication operators and technicians. Thus, the industries profit from the depression of higher labor costs and this results in changes in industrial structure.

2. Overview

(1) The diffusion of new ideas which increases social accumulation of knowledge: The popularization of wireless communication technology depends on the degree of awareness and interest among senders and receivers who are not certain that an emerging front-end ICT represents an improvement on the previous skillful technicians, as proposed by Rogers1 in 1962. It is also worth noting that he states “rejection, discontinuance, and
reinvention frequently occur during the diffusion of an innovation\textsuperscript{2}.

(2) Popular culture and populist technology: Some types of technology become populist technology. These are well diffused among the younger generation because they utilize them for entertainment in unanticipated ways. This popular culture helps to introduce the next generation, especially amateurs, to a profit promised market as professionals and/or consumers. This is an idea of Susan J. Douglas\textsuperscript{3} (1987) and it is related to the social system of Rogers.

(3) Endogenous technological change: sustainable economic growth is driven only by sustainable improvement in productivity. Only research activity can increase productivity through the accumulation of human capital and knowledge stock. But the expected return is too small to compensate for the expenditure of maintaining the research activity. Subsidies can encourage this expected return and reduce the expected risk. This is an aspect of the theory of Paul Romer\textsuperscript{4} (1990) and Charles I. Jones\textsuperscript{5} (1998).

(4) The social role of amateurs: Patrice Flichy\textsuperscript{6} (2010) maintains that amateurs play an important social role in creating the emerging culture or new social activities. They establish their expertise outside of professional fields or schools and show their ability to create populist culture, technical performance, practical know-how, political protest, etc.

(5) The social role of unofficial sectors in achieving scientific and technological literacy: Through the observation of the rapid growth of the Japanese electronics industry after the Second World War (World War II), Yuzo Takahashi\textsuperscript{7} (2011) found that the informal sectors contributed to the development of the emergence of new industries with the cooperation and support of formal sectors. Informal publishing in the chaotic market just after World War II disseminated scientific and technical knowledge and created the enthusiasm for radio technology among young people.

These arguments are persuasive in themselves but weak in two regards:

First, they are not demonstrated by a quantitative model analysis.
Second, they do not address the degeneration or discontinuance process of certain technologies.

3. Working Hypotheses

Our Working Hypotheses are:

(1) The diffusion of front-end ICT devalues highly-trained mono-competence operators or technicians, and opens higher professional opportunities to multi-competence operators or technicians.

(2) The diffusion of front-end ICT encourages the out-sourcing of core competence activities and/or collaboration with informal amateur activities.

(3) The diffusion of front-end ICT results in a reduction of the labor cost and a change in industrial structure.

4. Method

This article aims to show the results of a quantitative analysis model.

We call man-machine interface technology “front-end ICT”.

To show empirical results with robust data, we use Employment Matrix Tables (101 x 269) to find out the number of wireless radio operators or technicians and system engineers.

To observe changes in industrial structure, we use the Input-Output coefficients matrix and the final demand matrix.


5. Quantitative analysis model

5.1. Technology Diffusion Model

Fig 1 demonstrates the typical information diffusion process as described by Rogers. We can see a life-cycle model of a technology by a curve expressed here in the number of shipments of a product.
The period of the life-cycle of the Japanese word processor was so short that we can see the whole life-cycle at a glance. But in general, the life-cycle of a piece of technology is much longer. In respect of wireless communication or ICT technology in general, it is difficult to show such a life-cycle curve with the trends of product shipments because the use of these products started many years ago and is ongoing.

We propose using the number of operators or technicians who were licensed or certified by the national government since the emergence of these technologies instead of using the number of shipments of products.

Here is a typical example which shows a life-cycle of an Information Technology.

A certification system for system engineers was introduced in 1969. It covers software products and services for main-frame computers until the 1980s. We can see the discontinuance of the curve indicating system engineers at 1994 in Fig 2, when the target of the national certification system was changed. The curve on the right hand side in Fig 2 shows, between 1988 and 1994, a fluctuation in the number of certified system engineers.

The government changed certification in response to dramatic changes in information technology from stand-alone main-frame systems to network connected client–server systems and user-oriented systems in 1994. They have introduced the system administrator and network control technician certification.

5.2. Production function and Input-Output Model

Ronald E. Miller and Peter D. Blair state, "In input-output work, a fundamental assumption is that the interindustry flows from \( i \) to \( j \) – recall that these are for a given period, say a year – depend entirely on the total output of sector \( j \) for the same time period.\(^{10}\) They call \( a_{ij} \) a technical coefficient. When \( j \) industry doubles the volume of its product, it must consume double the amount of \( i \) product as intermediate consumption purchased from \( i \) industry. From this assumption, this type of production function, called Leontief production function, used in Input-Output Analysis requires "inputs in fixed proportion where a fixed amount of each input is required to produce one unit of output."\(^{11}\)"

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9 It should be noted that Japanese word processors were not personal computers. Rather they were a kind of typewriter designed to input and print out the complex Japanese sentences ordinarily written by hand.

10 Ronald E. Miller and Peter D. Blair (2009), Input-Output Analysis, P.15 1.7-5 from the bottom of the page. Cambridge University Press

11 Id. P.19 1.7-9
This fixed proportional input structure is called the technical structure of industry. Although abrupt changes in the technical structure, or production function, are not supposed to be observed in a given short period, technological progress such as front-end ICT may change technical coefficients of some industries. If we observe the changes of the input coefficients of certain industries, it may be a trace of the diffusion of innovation.

To determine the quantitative degree of influence of the diffusion process of certain technology by using this Input-Output Model, we choose an appropriate industry where the production function would be changed by introducing emerging products. Personal computers or smart phones etc. are typical examples of this. But as we proposed above, we have chosen the number of people who obtained their certifications of a technology and the industries where these people worked.

More concretely, we have chosen the number of license holders of wireless technology in order to highlight the appropriate industries where front-end ICT allows the substitution of well-trained people with advanced semi-automatic or fully automatic digital communication equipment.

We observe the change of technical coefficients in fishery, transport, telecommunication and broadcasting in this model, where wireless communication is essential and required by law.

6. Results

6.1. Number of communication operators or technicians

(1) Number of telephone exchange operators

Fig 3 shows the clear decrease in the number of telephone operators in five major industries in Japan: commerce, finance and insurance, communication, public administration, and the subtotal of other services. In 1970, the largest proportion of telephone operators was working in the telecommunication industry, but in 2000, other service activities comprised the largest part. The total number was about 20,000 in 2000. About 90,000 operators quit their posts between 1970 and 2000.

Fig. 3: Number of telephone operators in five major industries (1970-2000)

(2) Number of wired communication operators

As fig 4 shows, the number of wired communication operators decreased in all major industries except within rail-road transport in which the number of operators increased before 1990 but decreased after this point. In commerce, and finance and insurance, wired communication operators had disappeared by 1990. This may have been the result of the disappearance of the telex system in these industries. In broadcasting, the number of wired communication operators slightly increased after 1990 and further expanded from 1995 to 2000. This may be the result of the introduction of new cabled broadcasting or cabled communication technologies.

Fig. 4: Number of wired communication operators in major industries (1975-2000)
(3) Number of wireless communication operators or technicians

Wireless communication technology has been mainly used for mobile communication since its inception. Marconi’s Wireless Telegraph Company Limited\(^{12}\) established wireless telegraph communication over the Atlantic in 1901, and this trial revolutionized mobile communications between ships and land, and ships and ships. Until then, a ship had no way to make off-shore communication. After the disaster of Titanic in 1912, the installation of a wireless telegraph station on board was made obligatory for most shipping in 1914. The occupation of wireless telegraphist on board became popular and was a dream for many of the younger generation. Mobile communication expanded to air communication and ground communication, such as railway and road transport after World War I. The utilization of electromagnetic wave expanded to television, RADAR, data gathering, remote control of machines, etc. In addition to the increasing use of electro-magnetic technology, after World War II, as a result of the demands of mass production and mass consumption, the technology was simplified so that many people were able to use it.

New technology was developed in higher radio frequencies and it was diffused in wireless communication in the late 1960s. The downsizing of wireless communication equipment started in the 1970s by introducing transistors. Semi-automatic or fully automatic radio communication systems with friendly and easy-to-use man-machine interfaces could be operated not only by skillful operators but also by radio technicians, as it was no longer necessary to hire well-trained radio operators.

We focused on eleven major industries in which we observed employment of wireless operators or technicians. Their number was ranked in ascending order for the year 1990. The rank was listed by order; “printing, plate making and book binding”, “household electrical appliances”, “building construction”, “electricity”, “commerce”, “other industries”, “public administration”, “transport”, “fisheries”, “communication” and “broadcasting”.

Tab 1 shows the change in the number of wireless operators and technicians from 1970 to 2005. The total number of wireless operators and technicians in intermediate activities decreased from 39,116 in 1970 to 13,519 in 2005. We can see the three periods of this decline in Fig 5-a. They seem to correspond to the three different technology diffusion processes: first, usage of higher frequency technology, VHF or UHF, driven by the use of transistors; second, satellite communication technology using SHF; third, digitalization and the front-end ICT revolution. The communication appliances became easy-to-use and semi- or fully automatic after 1995 through the use of advanced and sophisticated micro-processor units which replaced or built-in the knowledge and skill of former operators or technicians.

| Table 1. Number of wireless operators and technicians in major 10 industries (1970-2005) |
|--------------------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Printing, plate making and book binding           | 338        | 521        | 78         | 195        | 87         | 0          | 0          | 0          |
| Household electric appliances                      | 1183       | 182        | 82         | 184        | 126        | 0          | 0          | 0          |
| Building construction                              | 310        | 110        | 104        | 107        | 235        | 0          | 0          | 0          |
| Electricity                                       | 238        | 149        | 161        | 181        | 366        | 653        | 245        | 230        |
| Commerce                                          | 1167       | 415        | 286        | 521        | 507        | 0          | 0          | 0          |
| Public administration                             | 3770       | 3257       | 3333       | 2971       | 2411       | 0          | 0          | 0          |
| Transport                                         | 10556      | 7185       | 7504       | 9250       | 3117       | 3444       | 1645       | 797        |
| Fisheries                                         | 6206       | 4072       | 4630       | 3679       | 3205       | 3996       | 1182       | 850        |
| Communication                                     | 6026       | 5943       | 3824       | 5414       | 4360       | 9876       | 3268       | 3364       |
| Broadcasting                                      | 8113       | 3998       | 4087       | 6170       | 5087       | 6579       | 14017      | 8013       |
| Total of intermediate industrial activities        | 39116      | 25565      | 32730      | 21481      | 24516      | 20672      | 13519      |


In stark contrast to the decrease in the number of wireless operators and technicians in public administration, transport and fishery shown in Fig 5-b, we notice the opposite tendency within broadcasting. Well-trained and license-holding personnel in broadcasting has increased even recently.

In mobile wireless communication industries, such as fishery, transport and public service, the number of license-holding wireless operators were in decline from 1970 until 1990 and almost disappeared in 1995. Administration services provided meteorological information and accurate standard time sig-

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12 This company changed its name in 1900 from its original name “Wireless Telegraph & Signal Company Limited” established in 1896.
nal radio diffusion commenced in the early twentieth century and disappeared before the twenty-first century.

Fig. 5-a: Total number of wireless operators and technicians in intermediate industrial activities (1970-2005)

Fig. 5-b: Number of wireless operators and technicians in major industries (1970-2005)

6.2. Number of certified operators and technicians

(1) Number of radio operator and technician licensees

To operate a wireless communication station, it is obligatory to obtain a radio operator or radio technician national license. Tab 2 and Fig 6, and also Fig 7 show the number of radio operators and radio technicians between 2003 and 2012.

The most popular license is the radioamateur’s license. The number of license holders is more than 3.36 million but the rate of increase is low (0.3% annual rate). It is believed that the diffusion of cellular phones has diminished interest in applying for the national radioamateur license examination in Japan. The second most popular license is for special ground radio technicians numbering 1.75 million and expanding faster than any other radio license (11.9% annually). The number of holders of marine radio operator and special marine radio operator licenses is about 63,000 and 749,000 in 2012 respectively, and increasing at a modest annual rate of 0.5-0.6%. The number of holders of air radio operator and special air radio technician licenses is about 50,000 and 75,000 in 2012 respectively and increasing at rather a high annual rate of 1.4%. These annual rates of growth are not so small, if we take into account the fact that the Japanese population is decreasing.

In short, the population of radio operator licensees is expanding less than radio technicians. There is a shift from operators to technicians, but neither is in decline. Surprisingly, the number of special ground radio technicians is currently still expanding rapidly.

Table 2. Number of wireless licensees according to their license category (2003-2012)

<table>
<thead>
<tr>
<th>License Category</th>
<th>2003</th>
<th>2005</th>
<th>2007</th>
<th>2010</th>
<th>2012</th>
<th>average growth rate (%)</th>
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<tr>
<td>Marine Radio Operator</td>
<td>55241</td>
<td>56407</td>
<td>57915</td>
<td>61129</td>
<td>63031</td>
<td>0.6</td>
</tr>
<tr>
<td>Comprehensive Radio Operator</td>
<td>62576</td>
<td>62859</td>
<td>63131</td>
<td>63562</td>
<td>63845</td>
<td>0.1</td>
</tr>
<tr>
<td>Air Radio Operator</td>
<td>38044</td>
<td>40591</td>
<td>43272</td>
<td>47827</td>
<td>50238</td>
<td>1.4</td>
</tr>
<tr>
<td>Ground Radio Technician</td>
<td>59104</td>
<td>61063</td>
<td>63114</td>
<td>67054</td>
<td>70140</td>
<td>0.8</td>
</tr>
<tr>
<td>Special Marine Radio Technician</td>
<td>682320</td>
<td>693841</td>
<td>706290</td>
<td>731699</td>
<td>748933</td>
<td>0.5</td>
</tr>
<tr>
<td>Special Air Radio Technician</td>
<td>56145</td>
<td>60470</td>
<td>64937</td>
<td>71066</td>
<td>74843</td>
<td>1.4</td>
</tr>
<tr>
<td>Special Ground Radio Technician</td>
<td>1375516</td>
<td>1443990</td>
<td>1521681</td>
<td>1661681</td>
<td>1757779</td>
<td>1.2</td>
</tr>
<tr>
<td>Radioamateur</td>
<td>3153789</td>
<td>3192744</td>
<td>3254491</td>
<td>3319709</td>
<td>3361904</td>
<td>0.3</td>
</tr>
</tbody>
</table>

(compiled by the author from the data published at the web-site of Soumusyo; http://www.soumu.go.jp/johotsusintokei/field/denpa04.html)
Fig 6 shows the overview of these trends of radio operators or technicians. The red bar shows that the number of comprehensive radio operators remained stable. This comprehensive license is the highest license category at the international level.

**Fig. 6: Number of wireless licensees according to their license category (2003-2012)**

(compiled by the author from the data published at the web-site of Soumusyo; http://www.soumu.go.jp/johotsusintokei/field/denpa04.html)

Fig 7 shows the recent annual differential number (an increasing number) of the national radio license holders according to their category. The speed of growth of the number of license holders is significantly higher among First Class Special Ground Radio Technicians and First Class Ground Radio Technicians.

**Fig. 7: Annual differential number of Radio Operators or Technicians (2003-12)**

(compiled by the author from the same data as Fig 6)

(2) Number of system engineers and system administrators

Now, we are going to look at the number of system engineers in the IT field. Front-end IT development and its diffusion changed the man-machine interface in general. As a consequence, office machines and electronic typewriters were substituted by networked personal computers, connected to the back-end global network system. This is one typical example of out-sourcing of core office work such as keeping data secure. The back-end system, such as
main-frame computers, have disappeared from in-house offices.

The number of system engineers in commerce increased from 13,096 in 1980 to 54,141 in 1995, but started to decrease thereafter to 37,782 in 2005. The peak number of 18,002 in finance and insurance services was reached in 1990, as we can see in Fig 8-a. There seems to be a rapid evolution of Information Technology (IT) in general. This evolution has caused downsizing and the erosion of the bigger computers market such as the main-frames and mini-computers market. Most system engineers were trained for managing main-frames and subsequently have lost their jobs.

Fig. 8-a: Number of system engineers in commerce and finance (1980-2005)

In contrast to Fig 8-a, there are no inverse U-curves in Fig 8-b. The curve is linear in this case. The number of system engineers, system administrators and network control technicians who were hired in communication, research, other business services and information services, increased steadily even after 1995. The number of system engineers in information service technologies is the highest. It rose from 48,137 in 1980 to 502,311 in 2005. The annual growth rate reaches 4.8% and 4.2% in research and information services respectively, as a result of work outsourcing from manufacturing or other service activities.

Table 3. Number of system engineers in major industries.

<table>
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<tr>
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<th></th>
<th></th>
<th></th>
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</thead>
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<tr>
<td>Communication</td>
<td>3390</td>
<td>4113</td>
<td>12187</td>
<td>12472</td>
<td>28460</td>
<td>29603</td>
<td>3.8</td>
</tr>
<tr>
<td>Research</td>
<td>2534</td>
<td>8675</td>
<td>13371</td>
<td>11407</td>
<td>33459</td>
<td>38485</td>
<td>4.8</td>
</tr>
<tr>
<td>Other business services</td>
<td>3023</td>
<td>6431</td>
<td>16901</td>
<td>16464</td>
<td>24867</td>
<td>27227</td>
<td>3.9</td>
</tr>
<tr>
<td>Information services</td>
<td>48137</td>
<td>161921</td>
<td>319162</td>
<td>255944</td>
<td>437107</td>
<td>502311</td>
<td>4.2</td>
</tr>
<tr>
<td>Total</td>
<td>129078</td>
<td>334562</td>
<td>547203</td>
<td>549179</td>
<td>698256</td>
<td>716089</td>
<td>3</td>
</tr>
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</table>

The qualification system for system engineers was changed by the central government in 1994 to adapt to market needs. Two categories have been added: system administrators and network control technicians who demonstrate user-oriented and network management ability.

Fig 2 shows the number of system engineers certified by the national qualification system, which was amended in 1994. The number of newly certified system engineers after this amendment reached 186,984 in 2000. The total number under the old qualification system was 486,420 from 1969 to 1994. However, from 1994 to 2000, a period of only six years under the amended system, the number rose to 947,896. This abrupt change was successful because it helped the market move towards downsizing, personalizing
and networking.

As a result of the diffusion of new ICT in offices, the number of system engineers decreased in commerce and finance and the system engineers qualifications could not adapt to these market changes. In response to the new social needs, the government changed its qualification system and encouraged outsourcing service industries, such as information services, research services and other business services where the re-qualified system engineers and newly-trained system administrators and network managers started to work.

From these observations, we can conclude that the diffusion of front-end ICT devalues highly-trained mono-competence operators or technicians, and opens higher professional opportunities to multi-competence operators or technicians to adapt to the market change.

6.3 Technical structure changes of Input-Output Model

We have checked the number of wireless operators and technicians in major industries since the 1980s and found that new licensees of radio technologies could not find posts in the major industries such as fishery, transport and communication. Only the broadcasting industry continued to hire these operators. This caused a mutation in the occupational-employment structure.

Now we are going to check if the industrial structure changes in the Input-Output Model.

Fig. 9: Final Demand Expenditure of major industries related to wireless communication activities (unit: million yen, current price) (1990-2005)
The case of air transport is slightly different because of its dependency on final consumption. The administration may intervene to maintain the price of air transport in order to protect the air transport industry.

Railroad transport is less under threat from international competition and it is possible to keep in-house skillful people. Road transport, communication and broadcasting do not depend on final consumption and have fewer trade opportunities with foreign countries. They have to negotiate with business partners to conclude their communication policy.

(2) Value-Added structure

As shown in Fig11-a, which indicates the input coefficients of wages and salaries (compensation of employees), the coefficients declined continuously in broadcasting, communication and fishery. The trends in air (koku), land and water transport indicate an inverse U. These coefficients reflect the labor cost in general.

Fig 11-b shows the input coefficients of depreciation of fixed capital. The coefficients of depreciation of fixed capital is related to the capital cost. These coefficients increase in broadcast and water transport but decrease in communication and fisheries.

The changes in coefficients of each industry could be classified by two axes: labor cost and capital cost with which axes we can draw Tab 4.

Fig. 10: Characteristics of industries observed in Fig 9

<table>
<thead>
<tr>
<th>Higher trade activity</th>
<th>Intermediate output</th>
<th>Final output</th>
<th>Lower trade activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water transport</td>
<td>Road transport</td>
<td>Railway transport</td>
<td></td>
</tr>
<tr>
<td>Fishery</td>
<td>Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Broadcasting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Fig. 11-a: Input coefficients of wages and salaries (compensation of employees) and Fig 11-b Input coefficients of depreciation of fixed capital (1985-2005)

Tab 4. Classification of the coefficients changes of observed industries (1985-2005)

<table>
<thead>
<tr>
<th></th>
<th>broadcast</th>
<th>Communication</th>
<th>fisheries</th>
<th>air transport</th>
<th>land transport</th>
<th>water transport</th>
<th>railway transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>labor cost</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>inv.U</td>
<td>inv.U</td>
<td>inv.U</td>
<td>→</td>
</tr>
<tr>
<td>capital cost</td>
<td>↑</td>
<td>U</td>
<td>↓</td>
<td>→</td>
<td>→</td>
<td>↑</td>
<td>↑</td>
</tr>
</tbody>
</table>
(3) Input coefficients structure or technical structure

(a) Communication industry

It is obvious that the input coefficients of the communication industry changed between 1985 and 2005. This industry was privatized in 1985. The total intermediate consumption coefficient increased significantly from 0.20 to over 0.35 and, in contrast to this, the coefficient for compensation of employees (wages and salaries, expenditure on labor cost) and depreciation of fixed capital were reduced by half from 0.43 to 0.21 and by a third from 0.3 to 0.2 respectively. The reduction of the coefficient of depreciation of fixed capital is important because it is related to former investments.

The most important change of the input coefficients from 1985 to 2005 was that observed in communication and in other business services. They increased rapidly and constantly. This means inter-industrial relations were strengthened by outsourcing of core competence services in communication.

The reduction of compensation of employees started after 1990. It was 0.44 in 1990 and fell to 0.21 in 2005. The labor cost was reduced by a half. Corporate consumption increased from 0.01 to 0.08, an eight-fold increase.

(b) Broadcasting

In the broadcasting industry, we can see the increase of the total intermediate consumption coefficient except 2005. The coefficient of compensation of employees reduced from 0.30 in 1985 to 0.19 in 2005 in contrast to the increase of operation surplus from 0.06 to 0.13. The coefficient of depreciation of fixed capital also increased steadily from 0.06 to 0.09 between 1985 and 2005.

The input coefficient from within broadcasting was augmented from the order of 0.001 to 0.02 and the input coefficient from other business services to broadcasting was also augmented from the order of 0.01 to 0.06 between 1985 and 2005. This means inter-industrial relations were strengthened by the outsourcing of core competence services in broadcasting, such as in communication.

There is a relevant change of value added vector in broadcasting. The coefficient of the payment of salary decreased slightly from 0.26 to 0.19 in contrast to the expansion of capital depreciation costs from 0.06 to 0.09 and business surplus from 0.8 to 0.14.

The outsourcing of communication services from 0.02 to 0.04 is also observed and this pushes up the coefficient of total intermediate consumption from 0.51 to 0.53. The input to the amusement service in 1990 was shifted to the input to the new category of contents service which was introduced in 1995. This is a technical shift and there is no clear change of outsourcing policy of contents in broadcasting activities.

The comparison in input coefficients between communication and broadcasting showed us some interesting points as follows:

(1) The broadcasting industry is much more labor intensive than the communication industry because the ratio of input coefficients between compensation of employees and depreciation of fixed capital is bigger in broadcasting. They are about 3.3 (0.23/0.07) in the broadcasting industry and...
1.4 (0.28/0.2) in the communication industry in average figures from 1985 to 2005 period. This suggests that the broadcasting industry continued to employ more highly qualified in-house wireless operators or technicians than communication industries.

(2) The broadcasting industry depends on the inter-industrial dealings structure much more than the communication industry. The input coefficients in total among intermediate sectors were from 0.2 to 0.35 in the communication industry and 0.46 to 0.55 in the broadcasting industry. Two major inter-industrial dealing partners of the broadcasting industry were image information, character information production services and amusement recreational services. This means that the broadcasting industry bought many contents from outsourcing services and, in contrast, there is no need to buy any contents in the communication industry. The key competence of broadcasting industry is to secure the transmission of its contents. This is ensured by the highly trained professional radio operators and technicians.

(c) Fishery

In fishery, the input-coefficients in compensation of employees declined from 0.2 in 1985 to 0.17 in 2005 and there was no evident change in input coefficients in other professional services (this figure was so small that it was omitted in Fig 14). This suggests that many professional radio operators were made redundant because of the diffusion of front-end ICT for fishery boats led to a decrease in the number of crew and someone took the place of the radio operator’s competence. Thus, the input coefficients of operation surplus slightly increased from 0.21 to 0.23 between 1985 and 2000.

The input coefficients in total of intermediate sectors showed some tendency of increase from 0.41-0.38 to 0.39-0.44 in 1985-90 and 2000-05 respectively. This is very clear in ships and the repair of ships, and in finance and insurance, of which input coefficients showed steady increase between 1985 and 2005. This means the increase of repairs or improvements of on board equipment such as radar, communication equipment etc. In contrast, the input coefficients in depression of fixed capital in fishery decreased from about 0.13 to 0.09. This suggests that in fishery the number of proper boats decreased.

(d) Water transport

Before testing the input coefficient changes in the water transport industry, we summarize the change in the number of wireless operators in water transport because the effect of the front-end ICT diffusion in transport industry was strongest in water transport.

Fig 16 shows that there are two trends; (1) the disappearance of wireless operators between 1995 and 2000 and the rebound curve of total output (turn-over) of the water transport industry after 2000.

Seeing the next trends of input coefficients in compensation of employees in Fig 15, we observe that the expenditure of labor costs increased until 1995 and then decreased thereafter until 2005. As the number of radio operators in the transport industry decreased by two thirds from 9,250 to 3,444 between 1985 and 1995 and by a further half to 1,645 in 2000 and 797 in 2005, the increase of labor costs input
coefficients until 1995 in water transport could not be explained. This means that there were different factors in water transport in comparison with fishery.

It seems that the increase of labor costs from 1985 to 1995 were compensated by the reduction of the total intermediate consumption, such as petroleum refinery production and water transport. In other words, the decrease in the costs of total intermediate consumption pushed up the input coefficients in compensation of employees until 1995. After 1995, the input coefficients in compensation of employees in water transport decreased rapidly and reached below the level of 1985. The input coefficients from water transport to water transport (intra-industrial dealing) also increased very rapidly from 1995 to 2005.

(e) Air transport

The Labor cost of air transport is lower than any other transport industries. The input coefficients of the compensation of employees were 0.13 and 0.24 between 1985 and 2005 respectively. The operation surplus was also very small, near zero after 1990 (see Fig. 17).

The intensity of the intra-industrial dealing in air transport in Japan was very low at the level of 0.01 between 1985 and 2005.

In air transport, the relation between input coefficients in the depreciation of fixed capital and in the goods rental and leasing services was very simple: as one increased, the other decreased.

The consumption of service relating to transport in the air transport sector was higher than in any other transport sectors, their input coefficients were 0.31, 0.26, 0.3, 0.3 and 0.31 for 1985, 90, 95, 2000 and 2005 respectively. There was an inter-industrial connection. This means that there was a good opportunity to deal with corporate alliances or groups of closely related companies in air transport industrial structure.

It is possible that this service includes ICT related services, such as professional radio communication, in-flight entertainment services, airport cargo management services etc.

The comparison in input coefficients between fishery, water transport and air transport showed us some relevant points as follows:

(1) The water transport industry and the air transport industry are much more labor intensive than the fishery industry because the ratio of input coefficients between compensation of employees and depreciation of fixed capital is bigger in water transport and air transport than fishery. They are about 3 (0.2/0.07) in water transport industry, 3 (0.18/0.06) in air transport and 1.8 (0.18/0.1) in the fishery industry in average figures from 1985 to 2005. This suggests that the water transport or air transport industry could continue to employ more highly qualified in-house wireless operators or technicians than fishery industries.

(2) The water transport industry depends on much more intra-industrial dealing than other industries. The input coefficients within the water transport were between 0.25 (1995) and 0.36 (2005). In contrast, there is not a significant amount of dealing between fishery and fishery nor air transport and air transport. The input
coefficients of fishery intra-industrial and air transport were between 0.07 (1985) and 0.05 (2005) for fishery and below 0.01 in air transport.

(3) The air transport industry depends much more on professional inter-industrial dealing than the water transport industries or fishery. The average of input coefficients of the service relating to transport in the period of 1985-2005 were about 0.3 and 0.04 in the air transport and water transport industry respectively. The input coefficients in fishery from the ships and repair of ships was less than 0.05.

(f) Road transport

Labor costs in the road transport sector covers 50 or 60% of the total costs. The input coefficients of compensation of employees, shown in Fig16, were 0.51, 0.59, 0.58, 0.57 and 0.53 in 1985, 90, 95, 2000 and 2005 respectively. The input coefficients of total intermediate consumption were between 0.28 and 0.31 in 1990 and 2005. This large input for labor costs (compensation of employees) and small input for intermediate consumption was characteristic of all types of road transport (see Fig 18).

The utilization of radio equipment in this sector was spread after the proliferation of sophisticated user-friendly MCA radio transceivers in Japan after the 1980s and private MCA communication services were gradually digitalized and the Japanese government categorized this digital MCA service as a specific private radio communication service for which a radio license became much easier to obtain after the modification of radio regulation in 1997.

This type of front-end ICT diffusion in road transport service was not so evident that we could not observe any effects of the change of labor costs. However, the input coefficients of services relating to transport increased sharply from the order of 0.02 to 0.06 after 1985. MCA service for taxi companies started in 1982 and diffused step by step in the late 1980s until 2005. MCA was a typical outsourcing service.

It seems that fuel costs (input coefficients of petroleum refinery products), of which expenditure reached 0.05 or 0.08 in the period between 1985 and 2005, are directly reflected in the change of the expenditure for the input coefficients of compensation for employees.

This sector is not a heavy user of telecommunication services because the input coefficients of communication were consistently under 0.02.

(g) Railroad transport

The biggest nation-owned railroad transport service company in Japan, Kokutetsu, was privatized in 1987. As a consequence, there is some discontinuance of input coefficients between 1985 and 1990 because the debt was restructured by the decision of the government to restart privatized railroad transport service companies (see Fig 19).

The input coefficients in total intermediate consumption of railroad transport were not as high as in other transport industries and they declined from 0.51 to 0.38 between 1985 and 2005 after the privatization. The financial cost decreased thanks to the privatization law. The compensation of employees was reduced to 0.22 in 1990 from 0.33 in 1985 and it slowly recovered between 1990 and 2005.
The input coefficients of service related to transport in railroad transport decreased but not significantly. This service includes professional radio communication services.

The comparison in input coefficients between road transport and railroad transport showed us some relevant points as follows:

(1) The road transport industry is much more labor intensive than the railroad transport industry because the ratio of input coefficients between compensation of employees and depreciation of fixed capital is bigger in road transport than railroad transport. This is about eleven times as large as (0.55/0.05) in the road transport industry. In contrast, in railroad transport, this ratio is one (0.22/0.21) (0.22/0.21) from 1985 to 2005. This suggests that the road transport industry could continue to employ more highly qualified in-house radio operators or technicians than railroad transport, but the reality was the opposite.

(2) There is a common point in intra-industrial expenditure structure in the road and railroad transport industry. According to Fig 18 and 19, there was no significant intra-industrial dealing in these two land transport industries.

(3) There is also a common point in inter-industrial expenditure structure in the road and railroad transport industry. The input coefficients from services relating to transport were at the same level of 0.05 and 0.03 for road transport and railroad transport respectively. The professional radio communication services would be provided via services relating to transport in these similar transport services. They do not need to hire in-house professional radio operators.

7. Conclusions

This study proposes that policy makers should be aware of the diffusion process of certain technologies via emergence of amateurs, which will enrich human capital in industries. The earlier literature established that the diffusion of new ideas depends on the emergence of social groups of new amateurs who quickly take the place of the professionals. They destroy the old network and establish a new environment for new technological change. This innovation has come in ICT. However, old ICT until the 1990s was difficult to manage. Amateurs attended to become system engineers and professionally trained wireless operators, but new ICT has a new face. This is front-end ICT, a man-machine interface between complicated ICT appliances and untrained people.

(1) The diffusion of sophisticated front-end ICT reduced the number of in-house professional ICT engineers or radio operators. It increased amateur-level or multi-competence user-oriented technicians not only in ICT industries or mobile transport industries but also other professional service industries.

For instance, the steady decrease in the number of telephone operators and wired communication operators was caused by the evolution of the dial-up automatic telephone system, which was much more user-friendly, and made it possible to dial up someone directly. The professional competence of telephone operators was replaced by customers who were able to use the new automatic dialling system instead of the in-house telephone exchange operators.

(2) Industry structure moved dynamically toward the rapid expansion of out-sourcing activities and enforcing the network of international exchange.

This study analyzed the Employment Matrix Tables (industrial sectors and occupations) extracted from the linked Input-Output Tables in order to identify the trends of the socio-industrial state of operators and technicians of wireless technology under the rapid diffusion of sophisticated front-end information and communication technologies (ICT), such as wireless technology in onboard communication, fishery, water transport or air transport. The result of this discontinuance of human capital did not damage any industries where radio technology was essential, and the number of wireless license holders increased after the disappearance of professionals.

(3) Industry-occupation structure change was observed in certain professional activities.

Our results also show a dramatic industry-occupation structure change in several production activities, such as (1) an institutional decrease in the number of telegraphists in water and land transport activities in the 1980s, despite the increase in the number of wireless operators and technicians in the same activities, (2) an inverse U-curve change in the number of system engineers (SEs) employed in commerce, and finance and insurance activities in the last quarter of the twentieth century, despite the steady increase in the number of SEs in information service or research activities, (3) the rise in the number of special ground radio technicians, system-administrators and network control technicians who
work not only in communication or information services but also in any service activities.

This shows that the diffusion of front-end ICT devalues highly-trained mono-competence operators such as telephone operators or technicians, and opens professional opportunities to multi-competence operators or technicians such as network-oriented system engineers. The labor-cost also decreased in almost all ICT-related industries. Thus, industrial structure moved toward outsourcing and inter-industrial trade.

8. Discussion

The observed relationship between technological change and in-house well-trained operators or technicians shows us that endogenous technological change can be accomplished by the rich social power of amateurs or enthusiasts of technologies outside of companies. The social power of amateurs is often neglected by economists because of the difficulty of measurement. However, it is evident that “without amateurs there is no economic growth”.

(end of article)

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