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THE ROLE OF TELECOMMUNICATION SERVICE SECTOR IN INDIAN ECONOMY- AN ANALYSIS OF OUTPUT AND EMPLOYMENT LINKAGES

Prajeesh Karonnon* and Meenakshi Rajeev**

Abstract

The telecom services have remained as a major sub-sector within the communication sector over the years. The sector has attracted the attention of the policy makers evidently during post-2000 due to its widening demand. Whether the sector deserves adequate policy attention is an empirical question. This study aims at identifying the role of the sector in the growth of Indian economy by examining its linkage effects with the rest of the economy. It is carried out by using Input-Output (I-O) analysis. Further, the study also examines the employment linkages of the sector to assess the ability of the sector in generating employment in the economy. Through the Input-Output (I-O) analysis, it is found that the communication sector is one among the highly linked sectors in Indian economy. Sectors which are crucial to the economy, such as electricity, financial services, transport, and construction are reliant upon the communication sector. The sector has a large indirect employment generation potential, and the backward employment linkage of the sector is increasing over the years.

Keywords: Linkage Effect, Backward Linkage, Forward Linkage, Input-Output Analysis, Employment linkage.

Introduction

The importance of communication services, especially the telecommunication services is growing day-by-day as an integral part for the overall socio-economic development. Being a major part of the infrastructural base, the telecom industry has both direct and indirect implications on the economy. Over the recent decade. this sector has been a source of sizable investment, and competitive market, which has led to easy access to a cheaper and faster telecom services for the society at large. This increase in access and improvement in technological advancement has had a direct impact on the day-to-day activities in areas such as e-governance, telemedicine, online learning, remote work access, financial inclusion etc. Furthermore, there are indirect impacts through extensive linkages with multiple sectors and industries like financial services, machines, education, agriculture, etc. In other words, the development of the telecom sector which has both forward and backward linkages with other sectors can accelerate the demand for goods and services causing a boost in the larger economy context.

From a backward linkage standpoint, growth of telecom sector prerequisites inputs from industries like steel, machines, power, etc. In order to cater to this demand, these input suppliers shall need to generate investment and has implications for the employment and economic activity in these sectors. Through the forward linkages, the growth of output in the telecommunication sector can enhance the output demands made by sectors like business services, financial services, and transport services. The indirect effects of telecom in the form of reducing search and transaction cost have multiple impacts on productivity (Yang *et al*, 2013).Through these linkages, telecommunication sector has a multiplier effect on the economy. For example, this sectors expansion will encourage e-commerce industry as it relies on online transactions, which in turn will create demand for the outputs of the

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computer and software industries and further down the chain. Given the larger policy implication of the sector, it is necessary to look at the role of this sector in an economy empirically by analysing its linkage effects.

There are a few studies on the role of telecom sector in Indian economy. Dash (2006) analysed the relationship between telecom and economic growth and found that the telecom service was contributing to the overall economic growth through inter-industry linkages, but the magnitude of the impact of telecom services on economic growth was found to be lower than that of most of other sectors by using the input-output table for the year1993-94. This minor impact of the sector could be due to the time point of study which was 1993-94, a time when the telecom sector had just started growing. Thus, an analysis of the same linkage for the latest period may give a more prominent linkage effect. Narayana (2011) observed the demand function of telecom industry with a negative relation with price and a positive relation with income. Further, the study found that the introduction of mobile telephones had led to a rapid expansion of the private firms in this area and the telecom subscriber base had made a good influence on the country's economic growth in terms of its positive externalities.

However, none of these existing literatures have looked at the role of the telecom sector in Indian economy by examining its linkage effects; forward and backward linkages as suggested by Hirschman (1958). Backward linkage refers to the dependence of one sector on other sector for the input supplies, hence, growth in this sector will increase the demand for more inputs and it will boost those sectors which are providing inputs to this sector. On the other hand, the forward linkage refers to the boosting up of output demand in other sectors due to increase in the output of one sector. It is important to identify that through which sectors the growth of the economy origins and transmits for formulating the sectoral promotion or prioritisation policies. As a part to it, it is also important to identify how is telecom sector linked to other sectors directly or indirectly either through forward linkage or backward linkage. Identifying these linkage effects, especially those of indirect linkages, is very important, as it can help policymakers understand how the sectoral level development can be achieved through the telecom sector. In order to look at these linkage effects, the most useful modelling technique is the Input-Output analysis given by Leontief (1936).

The linkages we discussed above are output linkages. However, with an increase in output, there will be also the generation of employment. This employment generation will not only happen in the telecom sector but also in the other sectors through its indirect employment linkage effect. India being a labor surplus economy, evaluating the indirect employment linkages will help to understand the complete employment potential of the telecom sector. There are hardly any studies about the indirect employment linkages other than giving the (direct) employment shares of the sector. This paper is an attempt to fill this gap.

This paper unfolds as follows. Following the introduction, the second section presents a review of literature, the third section examines the growth of Indian communication sector and its associations with economic growth followed by the study methodology and data source in the fourth section. The section five elucidates the results of the analysis, and the final section concludes the study.

Review of literature

The communication sector contains services rendered by both public and private sectors telecom operators and postal services. Post office savings bank and postal insurance are excluded from this sector because those are classified under the banking and insurance sector. Further, the administrative and manufacturing works related to the telecom sector are included in the corresponding sectors (CSO, 2012). From the given definition of the communication sector, one can use the term communication and telecommunication sector interchangeably, because the role of postal services is very negligible as far as the Indian economy is considered. Hence, our literature review is mostly concentrated on the role of telecommunication sector in the economy.

Economic growth and telecom sector: Global context

Infrastructure plays a major role in the economic growth of the country. Telecommunication is a key element of the country's infrastructural base with a discernible impact on economic development. In this context, Roller and Waverman (2001) analysed the relation between telecommunication infrastructure and economic development for 21 OECD countries for 20 years, using telecommunication infrastructure investment and aggregate output as variables, and found a causal link between these two variables. The study revealed that investment in telecom leads to the creation of additional demand which, in turn, leads to economic growth and that the ability to communicate will increase the ability of firms to engage in new production activities. The study concluded by observing that investment in telecom creates an additional demand which, in turn, helps increase aggregate growth. However, it is not clear from the study the kind of relationship that exists between these variables. For example, investment in the telecom helps to reduce the transaction costs of the economy, thereby leading to an increase in the total output (Norton, 1992).

An analysis of the effect of telecommunication on externalities, information costs, and social benefit-cost with respect to economic development by Leff (1984) showed that telephone expansion has important positive effects on production and economic efficiency through positive externalities (expansion of the sector leads to a fall in the cost of service supply to earlier subscribers) and a reduction in information costs. It highlighted the positive impact of telecom investment in the sense that it leads to an increase in the customer's welfare through ready access to a larger network and those new participants would access service at a cheaper cost. In an economy, the time dimension also plays a crucial role in decision making. The telecommunication expansion helps reduce time lags in the business process, leading to a reduction in the cost of production. The major effect of telecommunication investment is an expanded communication (lowers the transaction costs) and increased equality in access to information (reduces uncertainty); these two aspects can intensify the market competition, thereby improving the performance of the economy.

A study by Cronin *et al* (1993) shows that finance and insurance, personal and miscellaneous services, business services, trade, and transport are the most telecom intensive sectors while analysing the contribution of telecom infrastructure in US economy. Further, the study found that investment telecom infrastructure has a significant effect on the nation's productivity and the economy is able to save its resources if it invests more on the telecom infrastructure. Sridhar and Sridhar (2007) empirically

investigated the relationship between telephone penetration and economic growth for developing countries using 3SLS. They found that the traditional economic factors explain the demand for mainlines and mobile phones and observed a positive impact of mobile and landline phones on national output.

Economic growth and telecom sector: Indian context

In India, the telecom sector received a major impetus after the introduction of new telecom policy in 1999, after which the sector started attracting private investment, and the contribution to the total output started increasing. In the Indian scenario, there exist a few studies that deal with the relationship between telecom and economic growth. Dash (2006) analysed the relationship between telecom and economic growth, using national income approach and input-output model. Through the first method, he found a positive contribution made by the communication sector to GDP. In the second model, using the input-output table-1993-94, it is found that the telecom service was contributing to the overall economic growth through inter-industry linkages. Further, the extent of the impact of telecom services on economic growth was found to be lower than that of most of the other sectors. Considering that the growth of the telecom sector is mainly driven by an increase in the number of subscribers, it becomes important to look at it from the demand side as well. Narayana (2011) observed that the larger expansion of the output in the sector has occurred during the period 2001-02 to 2007-08. The telecom subscriber base has had a good influence on the country's economic growth in view of the positive externalities associated with it.

Sectoral growth and Linkage Effect

The key sectors that contribute to economic growth can be identified by looking at the linkage effects of each sector. Erumban and Das (2016) in their study using India- KLEMS data for the period 1986-2011 tried to identify the sources of economic growth with a special focus on the role of ICT sector in Indian economy. They looked at the direct effect of ICT investment on aggregate economy and manufacturing growth as well as its indirect effect on the total factor productivity growth (TFPG) in ICT using and producing sectors. They found that though the sector's role in overall economic growth was considerable, its contribution to the manufacturing growth was low. However, the study provides evidence of increased growth contribution in ICT using sectors, which is predominantly the service sector. Further, the study gives evidence of the role of ICT producing sectors, including telecom sector in improving the TFPG. Mukherjee (2016), studied the linkage between IT sector and other sectors by using the input-output analysis. The study was undertaken from the background argument that the IT sector would increase the productivity of the economy through its linkage. However, the analysis reveals that both forward and backward linkages of the IT sector and the rest of the economy have been static and diminishing correspondingly over time. Further, Kite (2014) found that the IT sector had an indirect effect on creating employment with significant linkage effects.

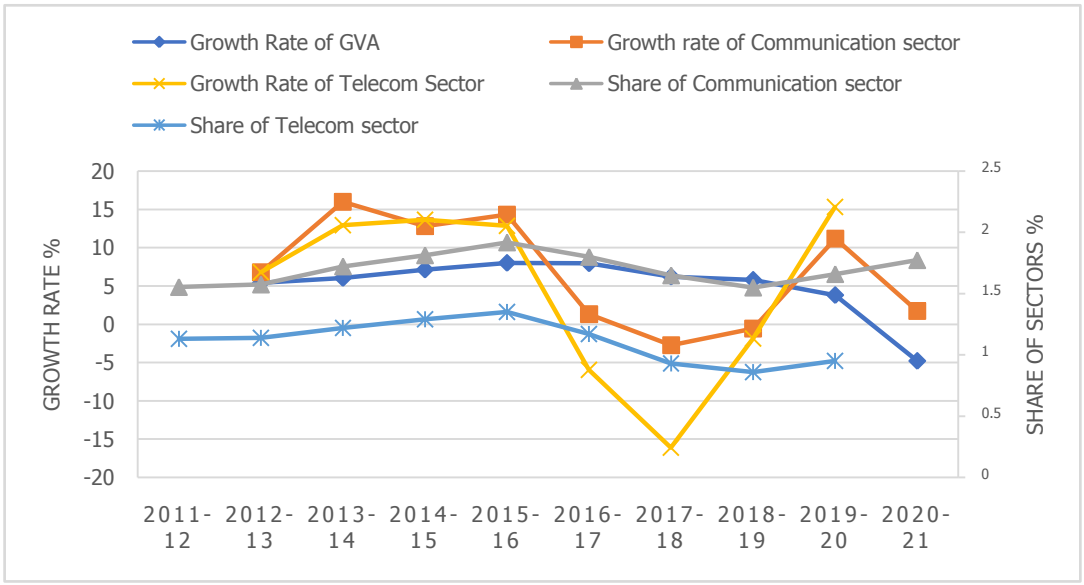
Though the literature examines the role of telecommunication/communication sector in economic growth, it is important to highlight through which sectors the growth transmits. In other words, the sectors in the economy that avail the benefits from the communication sector either directly or indirectly through different linkage effects need to be identified. This aspect has not received much

attention in the current literature. Secondly, given the potential direct and indirect linkages of this sector with many other important sectors of the economy, a well-performing telecom sector is necessary for ascertaining the overall balanced economic growth through its employment creating capacity. This further helps the creation of employment in the economy as a whole. Hence, the analysis of employment linkages in the communication sector will help us to find the role of this sector in providing employment both directly and indirectly. As a labour surplus economy like India, jobless growth is a great matter of concern. So, finding out the employment potential of a sector is very important. There are only limited studies on this aspect (Bhattacharya & Rajeev, 2014; Sarma & Ram, 1989). Hence the present study is an addition to the existing knowledge base.

Growth of Communication and telecommunication sector in India

In order to assess the growth of communication sector in Indian economy, we look at the growth rate of the sector in comparison to the economy as well as the share of sector in total GVA over the years. This will give an overall idea of the role of the communication sector in India's economy. The contribution of the communication sector to GVA at basic price (2011-12 constant prices) is shown in Figure 1. We have considered three variables: annual growth of GVA, the share of the communication sector in total GVA and annual growth of communication sector. According to the National Account Statistics of India, communication sector includes post and courier services, telecommunication, and other broadcasting services. The Telecom sector being a major dynamic sub-sector of the communication sector, it can be inferred that any fluctuation in the GVA of the communication sector can be largely due to the changes in the telecom sector.

Figure 1: The Share and Growth Rate of Communication Sector in Indian Economy (Value in %) (2011-12 to 2020-21) (at 2011-12 Constant Prices)



Source: Compiled from National Accounts Statistics-MOSPI/ EPWRF; various years

As an important part of the service sector, the communication sector has grown drastically over the years. The growth of the telecommunication sector depends on many things; the growth of the firms in the industry, various policies in this sector, and the number of subscribers (Mani, 2008). The privatization of the telecommunication sector led to tremendous growth in the industry. The numbers of the firms have increased and the number of customers (teledensity) also started increasing. The growth rate of the industry is reduced after a certain period of time, it can be due to that the number of telecom subscribers cannot be increased once a certain number of subscribers has been created for the industry unless the population increases.

Figure 1 explains the growth share of the communication sector as a whole. Separate data for the telecom sector was not available up to 2011. According to the latest statistics of the department of telecom, the annual growth rate of telecom started increasing (15.32%) recently after falling into a negative rate, especially following the entry of Reliance Jio Infocom. The entry of Reliance Jio has made drastic changes in the sector; especially the introduction of predatory pricing which led to the price war between firms to sustain their market share and many firms were left to losses and debt burden. Further, the increase in the competition forced some of the firms to go for the merger (Vodafone and Idea), and some other firms were already gone out of the market (Reliance communication Ltd, Videocon). Once the Jio ended giving the free data and calls, the price changes happened largely in the sector. It made the sector to positively contribute to the GVA. Further, we can see that the share of telecom to the GVA is as same as the communication sector, which implies the postal sector has only a negligible role in the communication sector.

The above discussion shows the growth and relative contribution of communication/telecom sector to the economy. As a major infrastructural sub-sector, the communication sector has direct as well as indirect impact on the economy. The direct impact is through providing inputs to other sectors directly and indirect impact is through helping one sector indirectly by providing inputs to the related sectors. These effects are called linkage effects, which has an important role in inducing economic growth. These effects are analysed in the next section by using Input-Output analysis.

Input-Output Approach -Methodology

The input-output analysis framework is used to analyse the role of telecom industries in Indian economy and its backward and forward linkages. Input-Output analysis is considered as the best method to analyse the linkage effects. The Input-Output tables and their applications were introduced by Wassily Leontief (1936). An Input-Output (I-O) Table, which is also known as Transactions Table or Inter-Industry Table, shows the flows of goods and services from one sector of the economy to various other sectors of the economy over a particular period of time, generally a year.

There are three assumptions for I-O multiplier analysis. Those are:

1. *Principle of homogeneity: There is no substitution between the outputs of different sectors.*
2. *Principle of proportionality: The quantity of each input used by any sector is a constant proportion of the level of output of that sector.*
3. *Principle of consistency: It is assumed that the classification of data of the input–output tables is in accordance with that of the National Accounts Statistics in order to allow for comparison of*

aggregate results such as Gross Value Added of the economy, and total final demand, and other things.

Under the I-O approach, the economy has a number of homogeneous sectors, represented by a row and a column. The entry in the cell of the i^{th} row and j^{th} column is the quantity of output of sector 'i' consumed as input by sector 'j', and which is denoted by $\mathbf{X_{ij}}$ (Pradhan, Saluja& Singh, 2006).

$$X_i = \Sigma_j X_{ij} + F_i,\ i=1,2,\ldots,n \qquad \ldots\ldots\ldots\ldots\ldots (1)$$

Accordingly, the mathematical representation of the model consists of 'n' sectors in the economy and thus, the following equation holds well in this model:

Where, $\mathbf{X_i}$= Output of sector 'i'

$\mathbf{\Sigma_j X_{ij}}$ = Total intermediate demand for the output of sector 'i'

F_i= Final demand for sector 'i" s output.

Thus, a sector's output is the summation of total intermediate demand and the final demand for producing that output.

According to assumption 2

$$X_{ij} = a_{ij}X_j \qquad \ldots\ldots\ldots\ldots\ldots (2)$$

$$\textbf{Thus, } a_{ij} = \frac{X_{ij}}{X_j} \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

Where, a_{ij}'s are known as the structural or technical coefficient, also called the input-output ratio. Thus, a_{ij} gives the direct input requirement of the i^{th} sector for producing one unit of output of the j^{th} sector.

With regard to the assumption of fixed proportionality in the demand driven Leontief model (1941) aij is fixed with any change in the final demand. This assumption is very much ideal, where there are surplus resources to supply inputs. In an economy with scarce resources this assumption may not hold good. It may happen that the amount of output to be distributed by the suppliers in turn depends on the quantity of their own production. in order to solve this problem Ghosh in 1958 introduced a new allocation model in the I-O system, where he argues that the supply of one's sector output to others depends on its own allocation of output.

From this the allocation coefficient is:-

$$b_{ij} = x_{ij}/x_i \qquad \ldots\ldots\ldots\ldots\ldots (4)$$

where b_{ij} is allocation coefficient, x_{ij} is i^{th} commodity going to j^{th} sector as inputs and X_i is i^{th} sectors output. Here the i^{th} commodity going to j^{th} sector in turn depends on i^{th} sectors output only. But both a_{ij} and b_{ij} does not include the indirect effects involving in the production process (Pradhan, Saluja & Singh, 2006).

Now, with the help of this relation (2), we can write equation (1) as follows:

$$X_i = \Sigma_j a_{ij}X_j + F_i,\ i=1, 2\ldots n \qquad \ldots\ldots\ldots\ldots\ldots (5)$$

In matrix notation, equation (3) can be written as:

$$(I - A)X = F \qquad \text{..... (6)}$$

Where, I = Identity matrix

A = (n,n) I-O coefficient matrix

X = Vector of outputs

F = Vector comprising of total final demand.

From (4), we can also write the following equation:

$\mathbf{X = (I - A)^{-1} F = R * F}$, where, $\mathbf{R = [r_{ij}]}$, known as Leontief inverse matrix.

$$r_{ij} = (I-A)^{-1} \qquad \text{..... (7)}$$

As compared to a_{ij}, r_{ij} represents the amount of output of sector 'i' required directly as well as indirectly for one unit of final demand of sector 'j'.

Similarly with allocation coefficient we get similar like equation 7.

Where $X = (I - B)^{-1} F = B^* F$….. where X is the vector of output F is the final demand and

$(I - B)^{-1} = B = rij$ ..... (8)

is the Leontief inverse matrix based on allocation coefficient matrix B .

Thus, if the I-O coefficient matrix 'A' and B and the final demand vector 'F' can be calculated, then the equilibrium value of output of any sector can be determined.

Linkage Effect

In this study, we have used the demand driven standard Leontief model (1941) for measuring the backward linkage coefficient and the supply driven Gosh model (1958)has used for analysing forward linkage coefficient. Rasmussen (1956) came up with Leontief inverse matrices to include both the forward and backward effects while analysing the linkages. In this form, the sum of the column elements $\sum_i rij$(A Matrix) gives the total increase in the output of different sectors required for one unit increase in the final demand of sector 'j'. The sum of raw elements $\sum_j rij$(B Matrix) gives the increase in the output of sector 'i' needed to cope with a unit increase in the final demand of all the sectors. To make the comparison across sectors, the normalization procedure is done by comparing the average stimulus created by sector 'j' with the overall average.

$$U_j = \frac{\sum_i rij/n}{\sum i \sum j\, rij/n2} = \frac{\sum_i rij}{\sum i \sum j\, rij/n} \quad \textit{Backward Linkage} \qquad \text{.....(9)}$$

Where U_j is the backward linkage coefficient for sector 'j', r_{ij} are the elements of $(I-A)^{-1}$matrix and 'n' is the number of sectors. Here, the numerator represents the average stimulus that a unit increase in demand for sector 'j' imparts to the other sectors of the economy. The denominator represents the average stimulus for the economy when final demand in all sectors increases by one unit. If $U_j>1$ says that average direct and indirect input requirement for a unit increase in demand for j^{th} sector is greater than the average for the whole economy.

$$Z_i = \frac{\sum_j rij/n}{\sum i \sum j\, rij/n2} = \frac{\sum_j rij}{\sum i \sum j\, rij/n} \quad \textit{Forward Linkage} \qquad \text{.....(10)}$$

Where Z_i is the Forward Linkage coefficient for the sector 'i', r_{ij} are the elements of $(I-B)^{-1}$ matrix and n is the number of sectors. When the value of Z_i is more than one, it implies that the sector 'i' has a higher forward linkage than the average of the economy. Z_i denotes the increase in the total output of sector 'i', needed to cope with a unit increase in the final demand of each of the sector in the economy (Pradhan, Saluja& Singh, 2006).

Employment Linkage

In the Leontief Input-Output model (1936), i, j^{th} element of the Leontief inverse $(I-A)^{-1}$ can be interpreted as the total effect (both direct and indirect) on the gross output of the i^{th} sector when the j^{th} sector final demand changes by one unit. Now with each output change, there will be an associated change in employment. Also following the dual-sector Lewis model, we have assumed that a change in output is linked to a fixed proportional change in employment, that is, the proportion of labour consumed per unit of output remains the same irrespective of the scale of production (Pradhan, Saluja & Singh, 2006). This constant return to scale assumption is considered standard in respect of an Input-Output framework. Though this assumption appears somewhat restrictive, it is to be noted that the entire literature on input-output analysis is developed and based on this assumption. Following this assumption, we get the fixed employment coefficients for each sector, noted as follows:

$\mathbf{Ei} = \frac{\boldsymbol{Li}}{\mathbf{Xi}}$**---------** (1), (i = 1, 2, …, n), where L_i is the employment in sector 'i', X_i is the gross output and E_i is the fixed employment coefficient. In other words, $E_i$is the labour required per unit of gross output, Xi. We can, therefore, write:

$\mathbf{L_i = \hat{E}_i * X_i}$--------- (2), where $\hat{E}_i$is a diagonalized matrix formed from the vector 'E', whose elements are defined by equation (1). The diagonalized matrix of $\hat{E}_i$ clearly shows the labour required for each sector with respect to per unit of gross output.

Now, from our conventional I-O model, we have, $X = (I-A)^{-1} F$ --------- (3)

Substituting the relation of X from (3) in (2), we have got the following labour equation:

$L = \hat{E} (I-A)^{-1}F = KF$ --------- (4) , where $\hat{E}$ is the diagonalized matrix formed with elements of E_i,$(I-A)^{-1}$ is the Leontief Inverse matrix, 'F' is the vector comprising final demand, 'L' is the employment requirement, $K = [k_{ij}]$, the i, j^{th} element of K , which measures employment created directly and indirectly in the i^{th} sector when the j^{th} final demand changes by one unit. Again, $\sum_i k_{ij}$ gives the employment multiplier, thus measuring the total direct and indirect employment created throughout the economy, when the j^{th} sector final demand increases by one unit (Pradhan, Saluja & Singh, 2006; Bulmer-Thomas, 1982).

Further we calculated appropriate indices to capture employment forward and backward linkages (Bulmer-Thomas, 1982). This, in turn, helps to identify a key employment generating sector. These indices as we consider are as follows:

Employment Backward Linkage: $Yj' = \frac{[(1/n)\, kj]}{[(1/n^2)\, \sum jkj]}$ (j = 1, 2, …, n),

Employment Forward Linkage: $Zj' = \frac{[(1/n)\, ki]}{[(1/n^2)\, \sum iki]}$ (i = 1, 2, …, n).

Data Sources

To analyse the linkage effects, we have used Input-Output tables for the years 1998-99, 2003-04 and 2007 – 08 from the Central Statistical Organization (CSO), India.(data for the year 2013-14 is obtained from Singh and Saluja (2018), and for the year 2015-16, the data are obtained from Chadha *et al* (2020)). Since the I-O table does not provide information on the absolute employment numbers of respective sectors, we have used a large sample unit level data of the 55th (1999-2000), 61st (2004-05) 64th (2007-08) and 68th (2011-12) rounds of National Sample Survey (NSSO) on the employment-unemployment situation in India. For the year 2015-16, the employment data has been obtained from the Labour Bureau 2015-16. These rounds have been chosen to match the data with the corresponding I-O tables. We have used the usual principal as well as the subsidiary status (UPSS) of the sample observations as their employment status. From the definition, "the usual activity status relates to the activity status of a person during the reference period of 365 days preceding the date of the survey. The activity status on which a person spent relatively longer time (i.e. major time criterion) during the 365 days preceding the date of the survey is considered as the usual principal activity status of the person". In addition, a person whose usual principal status was determined on the basis of the major time criterion could have pursued some economic activity for a shorter time throughout the reference year of 365 days preceding the date of the survey or for a minor period, which is not less than 30 days, during the reference year (NSSO (2010)).

The original I-O tables are based on factor cost while the latest one by Singh and Saluja (2018) and Chadha *et al* (2020) are based on basic price. The factor costs are defined as the cost excluding trade and transport margins (TTM) and net indirect taxes. Singh & Saluja (2018) and Chadha *et al* (2020) have generated the latest I-O table from Supply Use Tables (SUT) of 2012-13 and 2015-16 respectively. SUT is given in purchasing price with 66 sectors and has converted the table into 130 sectors and to basic price by subtracting TTM and taxes (product tax). The sector adjustment from SUT to I-O has done by assuming that the factor cost is not much different from the basic price.

Originally, I-O table contains 130*130 sectors. We have reduced these sectors into 12*12 sectors (Appendix 1) through merging using NIC codes and related sectors. The 12*12 sectors have been chosen by giving importance to the service sectors by assuming that these chosen sectors have more linkage with the communication sector. All the I-O tables have been deflated into the 2004-05 base year prices by using implicit price deflators from price indices for several years for the 12 sectors.

To calculate the employment share of each sector, we have taken the data from the above said NSSO rounds and the Labour Bureau survey (2015-16) for both principal and subsidiary status. While we have combined the data for 12 sectors from the NSSO rounds, the share has been calculated only for 11 sectors for the year 2015-16. This is because, the data drawn from the Labour Bureau corresponding to the latest I-O table did not provide the disaggregated data for manufacturing sector. The work force participation rates of each rounds of the survey are taken for the calculation of the total number of employees. By using the population of the corresponding years, we have calculated the total employees of each sector. To extract the employment data by sector wise, we have followed the NIC concordance tables.

Estimation and Results

Structural Coefficients

The structural or, technical coefficient of the communication sector explains the level of output from the communication sector directly used by various sectors for producing one unit of their outputs. In another way we can say that the structural coefficients give the direct input requirement of each sector for producing one unit of output. For example, one unit of output produced in the banking sector needs 0.5 unit of input from the communication sector. Thus, the structural coefficients would reflect which sectors are highly dependent on the communication sector output production.

Table 1: Structural or Technical Coefficient (a_{ij}) of Communication Sector to other Sectors (1998-99, 2003-04, 2007-08, 2013-14 and 2015-16) at 2004-05 base year prices

	Direct linkage (a_{ij})				
Sectors	**1998-99**	**2003-04**	**2007-08**	**2013-14**	**2015-16**
Agriculture	0.0002	0.0004	0.0003	0.0004	0.0004
Mining and Quarrying	0.0008	0.0014	0.0015	**0.0251**	0.0002
Manufacturing Other than Machines	0.0023	0.0044	0.0037	0.0016	0.0008
Machines	**0.0078**	**0.0280**	**0.0248**	0.0005	0.0005
Construction	0.0045	0.0015	0.0010	0.0076	0.0148
Electricity	**0.0086**	**0.0077**	**0.0070**	**0.0540**	0.0408
Transport Services	**0.0134***	**0.0203**	**0.0121**	**0.0230**	**0.0649**
Communication	0.0067	**0.0352**	**0.0077**	0.0023	**0.1724**
Trade	0.0031	0.0051	0.0038	0.0032	0.0067
Hotel and Restaurant	0.0024	0.0031	0.0030	0.0001	0.0009
Financial Services	**0.0105**	**0.0170**	**0.0157**	**0.0121**	**0.0158**
Other Community Social and Personal Services	0.0022	0.0049	0.0066	**0.0230**	0.0088

Source: Calculated by the author using input-output table; various years

* 1.34 unit of communication inputs required directly to satisfy 100 units of output demand in transport sector.

Table 1 shows that in the year 1998-99, the transport sector used the highest share (0.013 units) of communication sector's output as its inputs while producing one unit of output, followed by financial service, electricity, and machines. However, over the years, the orders of sectors have changed. In 2003-04, the communication sector itself used 0.035 units of its inputs for one unit of output followed by machines, transport, and financial services. In 2007-08, the machines sector used the largest share (0.024 units) of communication output for one unit of its production, followed by finance, transport, and communication. Further, in the year 2013-14, the major share of the communication sector's output was going to the electricity sector (0.0540) as their input, followed by mining, transport, and personal services. In 2015-16, the communication sector itself used 0.1724 units of its inputs for one unit of output followed by transport services and financial services. This shows that electricity, transportation, finance, machines are the major sectors which are directly using communication sectors output as their inputs. So, these sectors will have a direct impact from the

growth of the communication sector by providing better flow of inputs. Agriculture sector uses the least amount of communication sector output directly in their production process.

Leontief Inverse Coefficients

The Leontief inverse coefficients (r_{ij}) represent the amount of output of the sector 'i' required as input directly as well as indirectly for one unit of final demand of the sector 'j'. The difference between r_{ij} and a_{ij} gives the indirect input requirement from each sector. The communication sector impacts the economy not only by giving direct inputs but also it supports through its indirect effects, such as helping the banking sector by providing better communication facilities like mobile banking services. It helps other sectors to manage their transactions much easier.

Table 2: Leontief Inverse Coefficients of Communication to other Sectors (1998-99, 2003-04, 2007-08, 2013-14 and 205-16) 2004-05 base year

	Direct and Indirect Linkage $(I-A)^{-1}$				
Sectors	**1998-99**	**2003-04**	**2007-08**	**2013-14**	**2015-16**
Agriculture	0.0015	0.0037	0.0030	0.0045	0.0070
Mining and Quarrying	0.0020	0.0057	0.0061	0.**0388**	0.0140
Manufacturing Other than Machines	0.0068	0.0139	0.0125	0.0182	0.0137
Machines	**0.0137**	**0.0464**	**0.0419**	0.0180	0.0142
Construction	0.0080	0.0099	0.0089	0.0223	**0.0388**
Electricity	**0.0179**	**0.0232**	**0.0150**	**0.0711**	**0.0669**
Transport Services	**0.0190***	**0.0303**	**0.0183**	**0.0371**	**0.0926**
Trade	0.0049	0.0089	0.0071	0.0116	0.0245
Hotel and Restaurant	0.0053	0.0098	0.0092	0.0071	0.0133
Financial Services	**0.0118**	**0.0212**	**0.0182**	0.0205	0.0266
Other Community Social and Personal Services	0.0044	0.0077	0.0090	0.0316	0.0200

Source: Calculated by the authors using input-output table; various years

* 1.19 unit of communication inputs required directly and indirectly to satisfy 100 units of output demand in transport sector.

While analysing the direct and indirect requirement of communication sector input to the production of the final output, we observe that the order of sectors is different from that of the structural coefficient. This implies that many sectors use communication sector output indirectly as well. In table 2 the values of the coefficients have increased from the structural coefficient for every sector. In the year 1998-99, the transport sector used the highest share (0.019 units) followed by electricity, machines and financial services. The coefficients have increased over the years as well, implying increased importance of communication sector over the years. In 2003-04, machines sector stood first in the usage of communication as input directly and indirectly followed by transport, electricity, and finance. Almost the same trend is observed in the year 2007-08. In the year 2013-14, the electricity sector stood first followed by mining and transport. Further, we can see that in the year 2013-14, the trade sector also showed great dependence on the communication sector than preceding years. In the case of direct input requirement from the communication sector, the role of trade was very negligible.

In the year 2015-16, the transport sector used the highest share (0.0669 units) followed by electricity and construction. The construction sector was not benefited much in the beginning years.

The coefficients of the above-discussed tables are derived from the input-output tables. The input-output table gives the output and inputs of the sectors in value terms. So here the major limitation is that a sector which has low price products will be underrated in the coefficients even though the sector plays a major role. In order to cover this limitation, we have deflated the price into 2004-05 prices based on implicit price deflators of each sector.

So far, we have investigated which of the sectors are using communication sector's output as inputs directly and indirectly in their production process, as well as the order of the sectors regarding inputs usage from the communication sector. The linkage effect of communication sector will lead to chain linkages to other industries through the direct and indirect usages. So here we identified the sectors which will have direct and indirect effects from the communication sector's growth. The next step of our analysis is to find out the impact of the communication sector's growth to the economy as a whole by looking at the output and employment linkages.

Output Linkages

At the beginning of the paper we have discussed the output linkages and the two types of output linkages; forward linkage and backward linkage. In this part of the analysis, we are looking at the forward and backward linkages of the communication sector, and also, we are comparing the linkage effect of communication sector with that of other sectors. Through the linkage effect, growth in a sector will increase the demand for more inputs and it will supply more outputs to other sectors. So, in this way, the sectors which are linked to this sector by supplying inputs and receiving outputs will be benefited from the growth. Hence, sectors with high backward and forward linkages are called the critical sectors of the economy. Table 3 discusses these linkages.

Table 3: Output Forward Linkage (1998-99, 2003-04, 2007-08, 2013-14 and 2015-16) at 2004-05 base year prices

	Sectors	1998-99	2003-04	2007-08	2013-14	2015-16
1	Agriculture	0.8	0.8	0.8	0.87	0.90
2	Mining and quarrying	2.32	2.67	2.97	3.10	2.42
3	Manufacturing other than machinery	1.02	0.99	0.93	0.90	0.98
4	Machinery	0.84	0.87	0.94	0.80	0.72
5	Construction	0.58	0.56	0.54	0.54	0.52
6	Electricity Gas, Water Supply	1.43	1.35	1.17	1.18	1.10
7	Transport and Storage	0.93	0.85	0.83	0.68	1.03
8	Communication	0.96	1.05	0.90	0.96	1.22
9	Trade	0.9	0.89	0.87	0.85	1.05
10	Hotels and Restaurants	0.64	0.6	0.76	0.82	0.77
11	Financing Related Services	0.89	0.87	0.8	0.81	0.87
12	Other Community Social, Personal Services	0.7	0.51	0.49	0.49	0.43

Source: Calculated by the authors using input-output table; MoSPI, various years

It highlights that mining and quarrying, and electricity are the sectors which have forward linkages more than the benchmark point (the coefficient equals one) of one in all the years. Forward linkage for the communication sector is very close to the benchmark point in 1998-99, 2007-08 and 2013-14, however, in the year 2003-04 and 2015-16, this sector crossed the benchmark point. Thus, the communication sector has better forward linkage compared to other sectors, which implies the sector have crucial output supplying linkage with the economy. In the previous section of the analysis, we have discussed how this output is transmitting through the sectors. A more focus on the communication sector would lead to better output flow from this sector and it would help the economy as a whole to grow through its forward linkage effect. Hence, an investment in this sector will lead to multiplier impacts on all dependent sectors. Manufacturing other than machinery sector crossed the benchmark point in the beginning and all other years it is coming very close to the benchmark point. Hence, we can say that the mining and quarrying, electricity, manufacturing other than machinery and the communication sectors are the high linked sectors regarding output supplies.

Table 4: Output Backward Linkage (1998-99, 2003-04, 2007-08, 2013-14 and 2015-16) 2004-05 base year price

	Sectors	1998-99	2003-04	2007-08	2013-14	2015-16
1	Agriculture	0.78	0.85	0.87	0.74	0.73
2	Mining and quarrying	0.69	0.75	0.82	0.97	0.79
3	Manufacturing other than machinery	1.26	1.25	1.32	1.22	1.19
4	Machinery	1.31	1.41	1.47	1.32	1.07
5	Construction	1.05	1.10	1.27	1.19	1.08
6	Electricity Gas, Water Supply	1.51	1.45	1.08	1.18	1.29
7	Transport and Storage	1.27	1.18	1.07	1.01	1.01
8	Communication	0.73	0.81	0.79	1.08	1.36
9	Trade	0.73	0.69	0.74	0.80	1.01
10	Hotels and Restaurants	1.12	1.12	1.21	0.92	1.01
11	Financing Related Services	0.68	0.71	0.68	0.73	0.67
12	Other Community Social, Personal Services	0.88	0.68	0.7	0.84	0.80

Source: Calculated by the authors using input-output table; various years

Table 4 shows that there are six sectors; manufacturing other than machinery, machinery, construction, electricity-gas-water supply, transport-storage, hotels-restaurants with backward linkage more than the benchmark point, one. The backward linkage will work through by demanding the inputs from other sectors, thus, an investment in these sectors will help those sectors which supply input to these sectors. Among the high backward linked sectors, electricity and transport services are the major sectors which mainly depend on the input from the communication sector. Hence, a high backward linkage in these sectors will induce growth in the communication sector, as well as other sectors through its multiplier effect. The backward linkage for the communication sector is less than one except in the year 2013-14 and 2015-16. The backward linkage of a sector increases according to the spread of the input demand by the sector. As far as the communication sector is concerned, the input demand of

the sector has changed over the years because of the technological advancement. In the initial stage the sector was controlled by the department of telecom and the growth of the sector was very slow. Over the years, the private companies entered into the industry and the number of firms started increasing, so the input demand by the sector is also increased. This trend in input demand can be traced out from the increasing backward linkage of the communication sector as shown in the table.

The major factors which lead to an increase in linkages of the communication sector with the economy are the innovations and technological developments. Over the years the technology has developed from Analog calls to high-quality video calls with faster data transfer and the innovation of smart phones and internet usages attracted many sectors to use the outcome of the communication sector. The emergence of new services like e-commerce, internet banking, e-governance, direct cash transfers, and computer linked services in agriculture, healthcare, education, and scholarships, etc. are clearly stating the linkage of communication sector with the rest of the economy.

After understanding the relevance of the communication sector in output linkages, in the next section we analyse the role of communication sector in creating the employment by using input-output table and employment data.

Employment Shares

Generally, the role of a sector in the employment creation is analysed by looking at the share of that sector in the total employment. The problem with this perspective is that the indirect role of creating employment by some sectors is completely mistaken. Hence, with the help of the input-output table and NSSO data, we are trying to analyse the role of the communication sector in creating employment. Table 5 shows the direct employment share of 12 sectors, which is extracted from the NSSO rounds corresponding to the input-output tables.

Table 5: Employment share in % (1998-99, 2003-04, 2007-08, 2011-12 and 2015-16)

	Sectors	1998-99	2003-04	2007-08	2011-12	2015-16
1	Agriculture	62.28	63.14	60.71	48.9	46.9
2	Mining and quarrying	0.56	0.54	0.49	0.54	0.4
3	Manufacturing other than machinery	9.99	10.08	9.96	12.11	10.3
4	Machinery	0.56	0.42	0.5	0.5	
5	Construction	4.31	5.67	7.1	10.6	11.6
6	Electricity gas, water supply	0.28	0.23	0.22	0.27	0.6
7	Transport and storage	3.2	3.06	3.43	3.93	4.6
8	Communication	0.31	0.35	0.37	0.35	0.8
9	Trade	8.65	8.16	8.07	9.32	10.3
10	Hotels and restaurants	1.1	1.11	1.25	1.64	1.6
11	Financing related services	1.04	1.21	1.48	1.11	1.2
12	Other community social, personal services	7.72	6.03	6.42	10.73	11.7

Source: Compiled from various rounds of NSSO survey on Employment-unemployment & Labour Bureau's Employment- Unemployment Survey

We can see that the agriculture sector is having the major share in total employment followed by the manufacturing sector, other community social-personal services, and construction sector. The share of the communication sector falls below one percent, which implies that the direct contribution to the employment by the communication is negligible.

Backward and Forward Employment Linkages

Those sectors which are having more than unitary employment backward linkage are capable of creating above average (more than one unit) employment in other sectors when final demand increases by a unit. In contrast, the sectors having more than unitary employment forward linkage are capable of creating above-average employment within that sector when final demand for all the sectors increases by one unit. The employment share represents the creation of only direct employment within the sectors, while a linkage analysis covers the creation of employment not only within the sectors but also in other sectors. Table 6 explains the forward employment linkages of 12 sectors of the economy.

Table 6: Employment forward linkage (1998-99, 2003-04, 2007-08, 2011-12 and 2015-16)

	Sectors	1998-99	2003-04	2007-08	2011-12	2015-16
1	Agriculture	10.5	5.71	5.98	4.49	4.45
2	Mining and quarrying	2.1	1.47	1.37	0.83	0.39
3	Manufacturing other than machinery	1.08	0.54	0.43	0.33	0.31
4	Machinery	0.38	0.11	0.14	0.14	
5	Construction	0.72	0.61	0.51	2.66	0.57
6	Electricity gas, water supply	0.59	0.14	0.17	0.01	0.28
7	Transport and storage	1.31	0.43	0.47	0.48	0.92
8	Communication	0.68	0.45	0.46	0.2	0.74
9	Trade	1.96	1.31	1.13	1.25	1.83
10	Hotels and restaurants	1.04	0.53	0.58	0.99	0.97
11	Financing related services	0.32	0.2	0.23	0.09	0.10
12	Other community social, personal services	1.47	0.49	0.52	0.53	0.44

Source: Authors' calculation based on various rounds of NSSO survey on Employment-unemployment and IO tables compiled by MoSPI.

In the case of the forward employment linkage, agriculture and trade have been consistently performing well. While the communication sector linkages are slowly falling down over the years. The higher forward employment linkage implies a unit increase in the final demand of all other sectors creating a more than average employment in agriculture and trade. Other sectors are comparatively less benefitted from the forward linkage, which means a unit increase in the final demand of other sectors are not making any employment benefit to these sectors. Here communication sector is also not creating much employment in its own sector because of increase in the final demand by other sectors. Basically, this is because communication sector is a highly technology-oriented sector and an increase in demand from other sectors will make this sector to improve its technology and provide quality services.

Table 7: Employment backward linkage (1998-99, 2003-04, 2007-08, 2011-12 and 2015-16)

	Sectors	1998-99	2003-04	2007-08	2011-12	2015-16
1	Agriculture	3.7	4.03	4.15	2.74	2.60
2	Mining and quarrying	0.32	0.45	0.39	0.53	0.28
3	Manufacturing other than machinery	1.17	1.07	1.02	0.95	0.76
4	Machinery	0.71	0.65	0.65	0.75	
5	Construction	0.75	1.04	1.06	1.61	1.01
6	Electricity gas, water supply	0.66	0.46	0.38	0.65	0.72
7	Transport and storage	0.95	0.7	0.74	0.76	0.78
8	Communication	0.3	0.32	0.37	0.71	0.82
9	Trade	0.66	0.76	0.72	0.95	1.22
10	Hotels and restaurants	1.76	1.76	1.7	1.3	1.92
11	Financing related services	0.19	0.21	0.24	0.27	0.18
12	Other community social, personal services	0.83	0.56	0.6	0.78	0.71

Source: Authors' calculation based on various rounds of NSSO survey on Employment-unemployment and IO tables compiled by MoSPI.

Table 7 shows how the sector behaves in case of backward employment linkage when final demands of each sector increase by one unit. If the number is more than unity, which implies an increase in the final demand of these sectors will help the economy more than that of a unit increase in the final demand of the whole economy. More than unitary employment backward linkage shows the ability of these sectors to increase the employment of other sectors by providing its output as well as taking inputs. In the case of backward linkages, sectors like agriculture, manufacturing, construction, and hotels and restaurants perform well. Further, we can see an increasing trend in the case of the communication sector as well. This implies the sector will be able to create above average employment creation in other sectors. Here we can see that the communication sector is also playing an imperative role in employment creation in the economy.

Table 8: Linakges of Communication sector (1998-99, 2003-04, 2007-08, 2011-12 and 2015-16)

Linkages	1998-99	2003-04	2007-08	2013-14	2015-16
Output Forward Linkage	0.96	1.05	0.90	0.96	1.22
Output Backward Linkage	0.73	0.81	0.79	1.08	1.36
Employment forward linkage	0.68	0.45	0.46	0.20	0.74
Employment backward linkage	0.3	0.32	0.37	0.71	0.82

Source: Authors' calculation based on various rounds of NSSO survey on Employment-unemployment and IO tables compiled by MoSPI.

Table 8 shows that the output forward linkage of communication sector has crossed the benchmark point (one) in the year 2003-04 and 2015-16, and in other years the linkage coefficient is near to the benchmark point. This shows the importance of communication sector in supplying its outputs to other sectors as a key linkage sector. As far as backward output linkage is concerned the coefficient is increasing over the years and crossed the benchmark point in the latest two data points. This implies that the input supplying sectors of communication is getting benefitted over the years due

to the technological changes and developments occurring in this sector. With regard to the employment linkage, the backward linkage of communication sector has increased over the years by demanding more inputs from the machinery and manufacturing sector to adjust with the technological change in the communication sector. The forward employment linkage of this sector has remined low because this sector is a capital-intensive sector which demands high and medium skilled labour. The study by Bhattacharya *et al* (2020) pointed out that communication with the other major service sector creating direct and indirect medium-high and high-skilled employment in the economy.

With the increasing demand for internet services, the government of India has decided to expand broadband services to 2.5 lakh panchayaths by 2019 using universal service obligation fund. This will be implemented through Bharat Net program, and the estimated employment creation from this policy is 12.5 lakhs by developing the digital skills. Further, the implementation of the digital India program through smart cities is also expected to expand employment opportunities. The skill development plan of the department of telecom aims to improve the employment capacity of the sector to 87 lakhs by 2022, which require an additional creation of 47 lakh jobs. Most of the jobs which are going to be created are either skilled or semi-skilled. These include jobs like customer care executives in call centres and relationship offices, sales executives, technicians in the various stages of service delivery, tower technicians, broadband technicians, operators, and telecom executives with others sectoral exposures like banking, health transport, education, etc (DoT, 2016). These new areas of job opportunities are happening mainly because of the linkage effect of the sector with the rest of the economy.

The results of this paper are more or less matching with the studies of Bhattacharya & Rajeev (2014), and Sarma & Ram (1989).They found that agriculture and manufacturing sector are the key employment generating sectors possessing high employment forward as well as backward linkages. The result of Leontief inverse in our study is also in line with the findings of Cronin *et al* (1993). It found that finance and insurance, personal and miscellaneous services, business services, trade, and transport are the most telecom intensive sectors while analysing the contribution of telecom infrastructure in the US economy.

Conclusion

Communication sector, which mainly comprises of the telecom sector, contributes to the economic growth in a significant way, and its importance is increasing over time. There is a shift in the structural composition of the Indian economy. This is in terms of the share to the national product. This shift is likely to cause substantial changes in the production and demand linkages among various sectors and in turn, could have a significant effect for the growth and development process in the Indian economy. Communication sector is one of the high linked sectors with a better forward linkage compared to other sectors, which indicates that the output of this sector goes to a large number of sectors as input, hence, an increase in the output of this sector will induce an increase in the output of these entire sectors that use it as an input. *Sectors which are crucial to the economy, such as electricity, financial services, transport, and construction are reliant upon the communication sector.* So it is important to promote communication sector through better investment polies and technologies viz ; licensing and spectrum to

supply better services to the crucial sectors in the economy. In the case of employment linkages, even though the sector is not getting employment benefit from an increase in the demand of other sectors, the sector is helping other sectors to improve their employment creating potential through the backward linkage. So, an investment in communication sector will help other sectors through its indirect employment linkages. The communication and telecommunication sector has a crucial role in Indian economy especially post 2000. The neglect of the communication sector can obstruct the growth of some other key sectors of the economy. Therefore, the communication sector (including telecom sector) should be given high priority in policy making in order to boost overall sectoral growth in the economy and to boost the economic growth in the country.

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Appendix 1: Mapping of the sector

Sl. No	Sector Name	Code of sector in I-O Table
1	Agriculture	1-26
2	Mining and Quarrying	27-37
3	Manufacturing Other Than Machinery	38-82,95-105
4	Machinery	83-94
5	Construction	106
6	Electricity Gas and Water Supply	107-108
7	Transport and Storage	109-114
8	Communication	115
9	Trade	116
10	Hotel and Restaurant	117
11	Financing Insurance, Real Estate and Business Services	118-120,123,125-127
12	Other Community Social and Personal Services	121-122,124,128-130

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