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Covid-19 Pandemic and Total Factor Productivity in the Quarterly Model of Korea (2012-2021)

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Abstract

The paper examines the effects of Covid-19 Pandemic on total factor productivity (TFP) of the Republic of Korea using a quarterly model based on KIP database developed by Pyo, Chun and Rhee (2022). The Korean economy has met the Covid-19 Pandemic in the middle of rapid productivity convergence as observed in Rhee and Pyo (2022). The paper notes the annual model of total factor productivity cannot trace the impacts of Covid-19 due to the nature of low frequency and a long lag in annual data. Following Fernald (2014), the model incorporates both capacity utilization rate and work intensity to augment quarterly capital input and labor input respectively. The paper also finds the post-pandemic response in improving capacity utilization and work intensity is important in maintaining TFP at the level before the Pandemic.

Key Words: Total Factor Productivity (TFP), growth accounting, utilization

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1. Introduction

In recent years there has been increasing demand for high-frequency measures of technology shocks and change and to assess trends in potential output because of ICT-related technological advances and their fast spread within industries and across industries. There is also a new real-time need to measure the Solow residual at the time of real-sector or financial crisis. The COVID-19 Pandemic has caused a global recession and fiscal expansion on a global scale from the first quarter of 2020(Pyo (2021)). Relatively crude measures of total factor productivity(TFP) are easy to construct with annual data, for example, multifactor productivity estimated by the Bureau of Labor Statistics and EU KLEMS project. But the necessary data to estimate short-term high frequency technology measure are only available with a long lag. The use of the KLEMS-type industry-level measure of productivity for short-term productivity analysis and forecasting has been limited due to a long lag of 2-5 kl,years in official data-release and due to intensive and extensive data work to construct KLEMS-type estimates including quality index of labor inputs and decomposed capital stocks. As ICT-related innovation is making a fast progress in both manufacturing and service industries (Fukao et.al.(2019)), we believe the demand for short-term industrial database will be ever-increasing.

This paper constructs a new real-time quarterly growth-accounting database for the Republic of Korea following up Ahn, Han and Pyo (2019). We have adopted the approach taken by Fernald (2014) in constructing the quarterly database and estimating quarterly TFP. But it differs from Fernald (2014) in defining the sectors to be covered in actual growth accounting. Fernald (2014) constructs a quarterly database for the U. S. business sector while this paper constructs a quarterly database for both business sector and non-business (public) sector. The second difference lies in the way the variations in factor utilization (capital utilization and work intensity) are measured. Fernald (2014) estimates “purified” Solow residuals by estimating a Hall (1990)-style regression on industry-level data and applying the estimation methods by Basu, Fernald, and Kimball (2006). But we use observed capacity utilization index to measure capital utilization in Manufacturing and electricity consumption in Service following Jorgenson and Griliches (1997), Zaid and Bodger (2005) and Pyo and Song (2014). Basu, Fernald and Kimball (2006) also notes that electricity use might proxy for true capital services and it might be reasonable for some manufacturing industries but it ignores labor effort. Therefore, we have used the ratio of overtime working hours in total working hours as a separate proxy for effort per unit of labor. The third difference is that while Fernald (2014) includes consumer durables in the investment sector, we do not include consumer durables in the investment sector which consists of business equipment and structures and intellectual property investment. Since our measurement of value-added is based on Bank of Korea’s national accounts statistics, the measurement of investment is limited to capital formation in business and government sector and therefore, we have not included consumer durables as part of investment.

We have also estimated a quarterly regression model to supplement our findings from quarterly growth accounting model. The regression of labor productivity on

capital-labor ratio after imposing the constant-returns-to-scale (CRS) restriction estimates the share of factor inputs and the growth rate of neutral technical progress (TFP). By using a dummy variable to control the pandemic period from the first quarter of 2020 to the first quarter of 2022, we have identified the shift in labor productivity during the pandemic period.

This paper intends to report a preliminary KLEMS-type industry-level Quarterly Database for Korea (2012 First quarter-2022 First Quarter) which are consistent with its National Accounts Statistics. We have used quarterly interpolation and seasonal adjustments using various monthly or quarterly data on value-added, investment and hours worked to construct KLEMS-type quarterly database which is consistent with its annual counterparts. We also apply the database to conduct a quarterly growth accounting for the Korean economy and estimate quarterly total factor productivity by industries. Fernald (2014) estimated a quarterly growth-accounting database for the US business sector and produced the quarterly TFP series of which annualized growth rate is very close to the growth rate of the BLS (2009) Multifactor Productivity measure for the US private business sector. The correlation between annual changes in the two US series is reported to be 0.97.

Quarterly capital stock has been generated using segmented linear year-to-year interpolation. Quarterly depreciation has been linearly estimated interpolating the annual depreciation assuming that the annual depreciation is spread equally. Pyo and Song (2014) estimated the quarterly capital stock by distributing the annual gross fixed capital formation by assets and industries by interpolating quarterly weights of cumulated investment as quarterly weights of capital stocks. Quarterly depreciation is assumed to be the same as annual depreciation.

We find the quarterly database and the resulting estimates of TFP provide us with a very useful information throughout the COVID-19 pandemic period. Before the pandemic, the Korean economy is observed to have gone through a very rapid period of productivity convergence as observed in Pyo (2018) and Rhee and Pyo (2022). The major findings are that the COVID-19 after the first quarter of 2020 has made growth rates of both GDP and labor input turn negative. But the relative contribution of capital input and TFP make up almost 90 % of GDP growth. We also find the quarterly TFP estimates are exhibiting a pro-cyclical pattern which is closely related to the recovery cycle of the pandemic. For example, the quarterly estimates of TFP started to fall from the first quarter of 2020 when the Covid-19 was broken out and infected from China until the third quarter of the year. Then it started to increase until the third quarter of 2021 and then started to fall in the fourth quarter of 2021 when the so-called second wave of Pandemic due to Omicron and ultimately recovered by the end of the first quarter of 2022.

In what follows in section 2, we present a quarterly growth accounting model and construction of the quarterly database. Section 3 we present estimates of the quarterly TFP based on three alternative models: (1) Model 1 without using capital utilization index and work intensity index (2) Model 2 with using capital utilization index only (3) Model 3 with using both capital utilization and work intensity index.

Section 4 present the regression results of labor productivity on capital/labor ratio. The resulting estimates of TFP are compared with TFP estimates by the quarterly growth accounting models. The last section 5 concludes the paper.

2. A Quarterly Growth Accounting Model

There are two types of growth accounting in the literature of productivity analysis. One is the gross output growth accounting such as Jorgenson, Gollop and Fraumeni (1987) and EU KLEMS project (Timmer (2000)) and the other is the value-added growth accounting to estimate the Solow (1957) residual developed by Denison (1967) and Jorgenson and Griliches (1972) and used by most of other productivity studies for international comparison. In general, we need to either assume a strong separability of value-added from gross output or impose it as a restriction gross output production function (Pyo and Ha (2007)). For the present study, we will assume that there exists a strong separability of value-added from gross output production function.

Suppose we adopt the following aggregate production function from Fernald (2014):

$Y_t = F\,(\,Z_t\,K\,(K_{1,t-1},\,K_{2,t-1}\,\ldots\ldots..K_{j,t-1}),\,E_t\,L\,(H_{1t},\,H_{2t},\ldots\ldots H_{jt}),\,A_t)$ (1)

where *K*: j-type capital stock's capital service flow

Z: capital utilization rate

L: labor input (Aggregate Working Hours, Hj)

E: Effort per unit of labor /

$$\Delta \ln TFP_{it} = \Delta \ln V_{it} - \sum_{X=L,K} \bar{v}_{X,t}\,\Delta \ln X_{it}$$

and *A*: Technological change

We define TFP growth (the Solow residual) as:

(2)

where V is value-added and X are factor inputs.

Denoting Y as value-added and K as capital input and L as labor input and assuming perfect competition with zero markup of price over marginal cost, a differentiation of production function yields:

$$\Delta \ln Y = (\alpha \Delta \ln K - (1-\alpha) \Delta \ln L) + \Delta \ln U + \Delta \ln A \qquad (3)$$

where $\Delta \ln U = \alpha \Delta \ln Z - (1-\alpha) \Delta \ln E$.

We normalize the elasticity of F with respect to technology A to equal unity.

We can also define utilization-adjusted TFP growth as:

$$\Delta \ln TFP = \Delta \ln Y - \alpha \Delta \ln K - (1-\alpha) \Delta \ln L \qquad (4)$$

Given an estimate of the contribution of utilization, $\Delta \ln U$, utilization-adjusted TFP growth is:

$$\Delta \ln TFP\text{-}util = \Delta \ln TFP - \Delta \ln U \qquad (5)$$

where $\Delta \ln U = \alpha \Delta \ln Z + (1-\alpha) \Delta \ln E$

In the context of a specific model, the multiplicative technology term (A) in the production function using (1) is often defined as TFP. But accommodating capital utilization (z) and effort per unit of labor (E), we can decompose TFP growth into utilization change, $\Delta \ln U$ and utilization –adjusted TFP, $\Delta \ln ATFP$.

3. Data and Methodologies

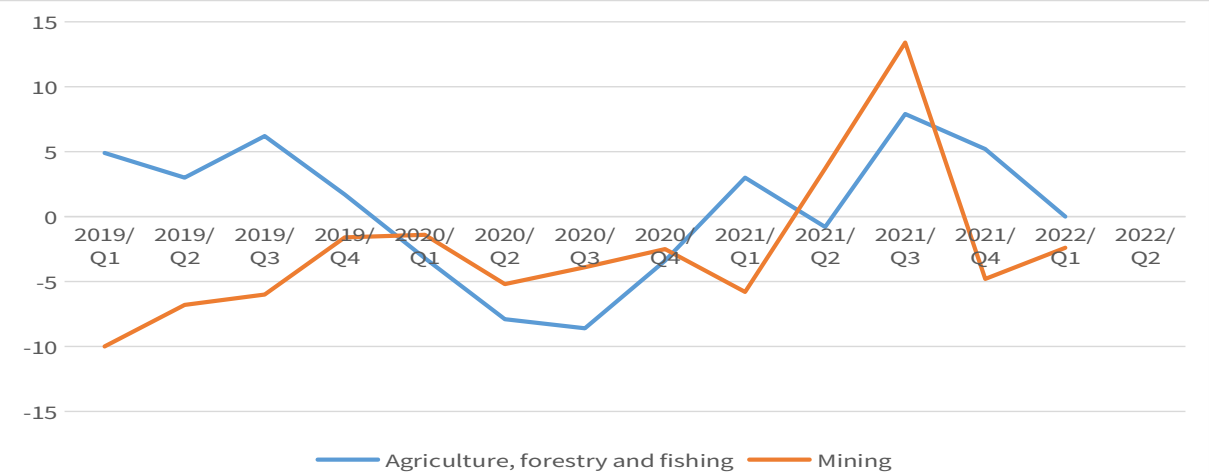
(1) GDP

As quarterly value-added data, we have used the Bank of Korea's quarterly data based on 2015 prices which are classified into 17 industries as listed in Appendix 1. There are two series in Bank of Korea's value-added data: seasonally-adjusted series and unadjusted series. We have used seasonally adjusted value-added data to accommodate seasonal variations in the data. There can be two alternative quarterly growth rates: the growth rate

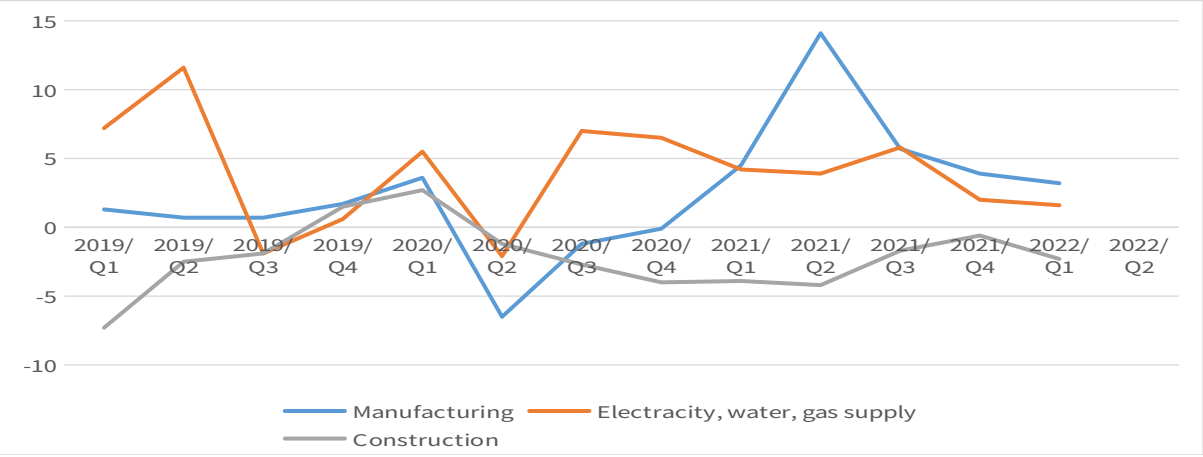
corresponding to the quarter in the previous year and the growth rate from the previous quarter. We have used the former because the summation of the corresponding quarterly growth rates is equal to yearly growth rate,

As shown in Figure 1- 4, quarterly real GDP data by sector shows a deep downturn starting from the first quarter of 2020 when Covid-19 Pandemic has erupted in Korea. In case of Manufacturing, the recovery started from the second quarter of 2020 but the contraction came a year later starting from the third quarter of 2021. We note a lot more volatility in the subsectors' quarterly GDP series. In particular, Accommodation /Food, Transportation/storage and Cultural/Other services sector had the largest volatility.

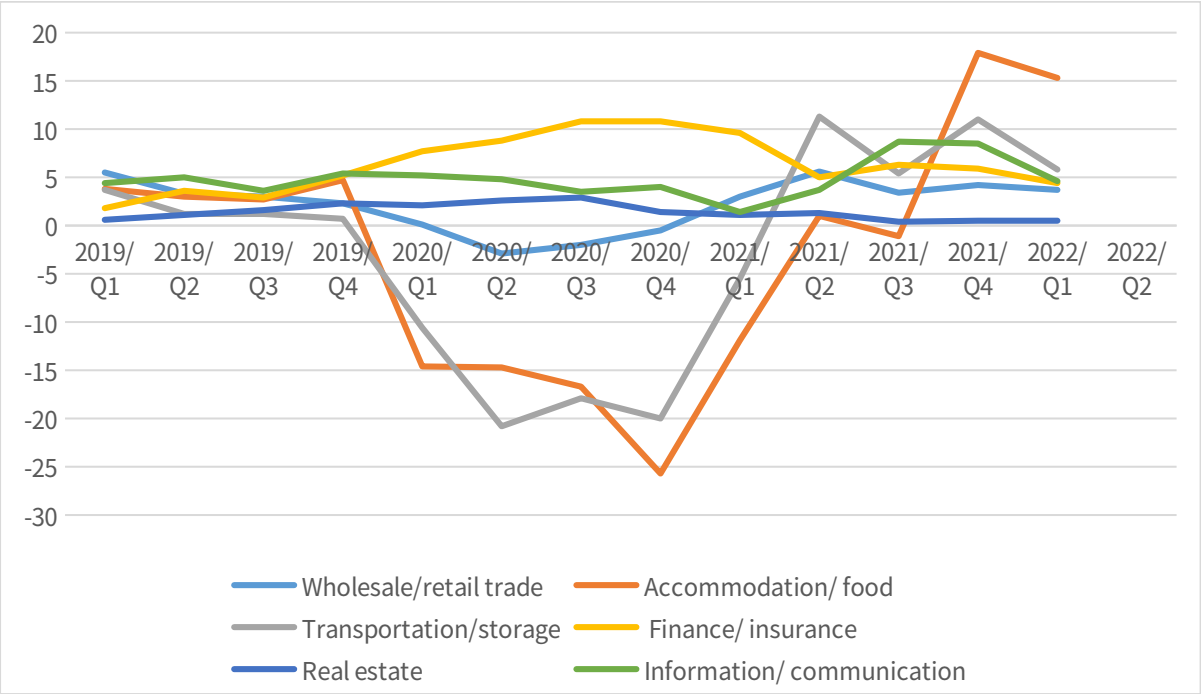
(Figure 1) Quarterly GDP Growth Rate (%, Primary Industry, 2019.1 ~ 2022.1)



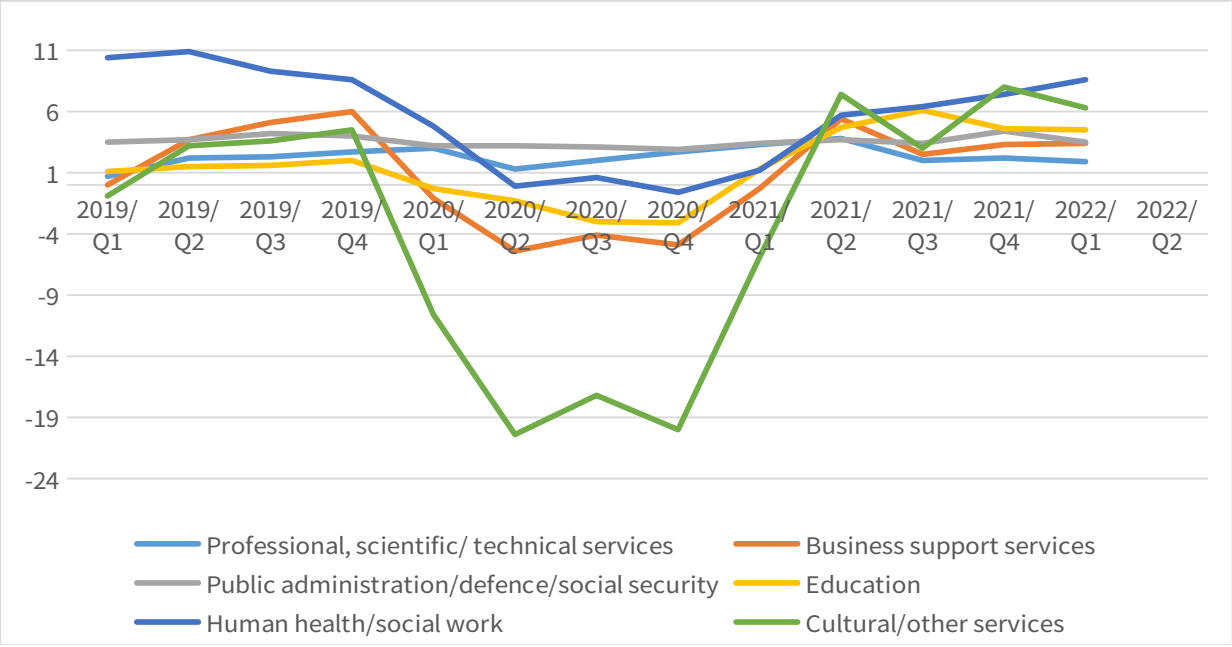
(Figure 2) Quarterly GDP Growth Rate (%, Secondary Industry, 2019.1 ~ 2022.1)



(Figure 3) Quarterly GDP Growth Rate (%, Service Industry, 2019.1 ~ 2022.1)



(Figure 4) Quarterly Trend of GDP Growth Rate (%, Service Industry, 2019.1 ~ 2022.1)



Sources: Bank of Korea

(2) Capital stock

Following Pyo and Song (2014) we have estimated the quarterly capital stock by distributing the annual gross fixed capital formation by assets and industries. We assumed the quarterly variations of the investments on the same asset are same across all the industries. By utilizing the quarterly share of investments on each asset as a weight, we have converted the annual gross fixed capital formation by assets and industries to quarterly investments. Then we have estimated the quarterly capital stock by applying the modified Perpetual inventory method as follows:

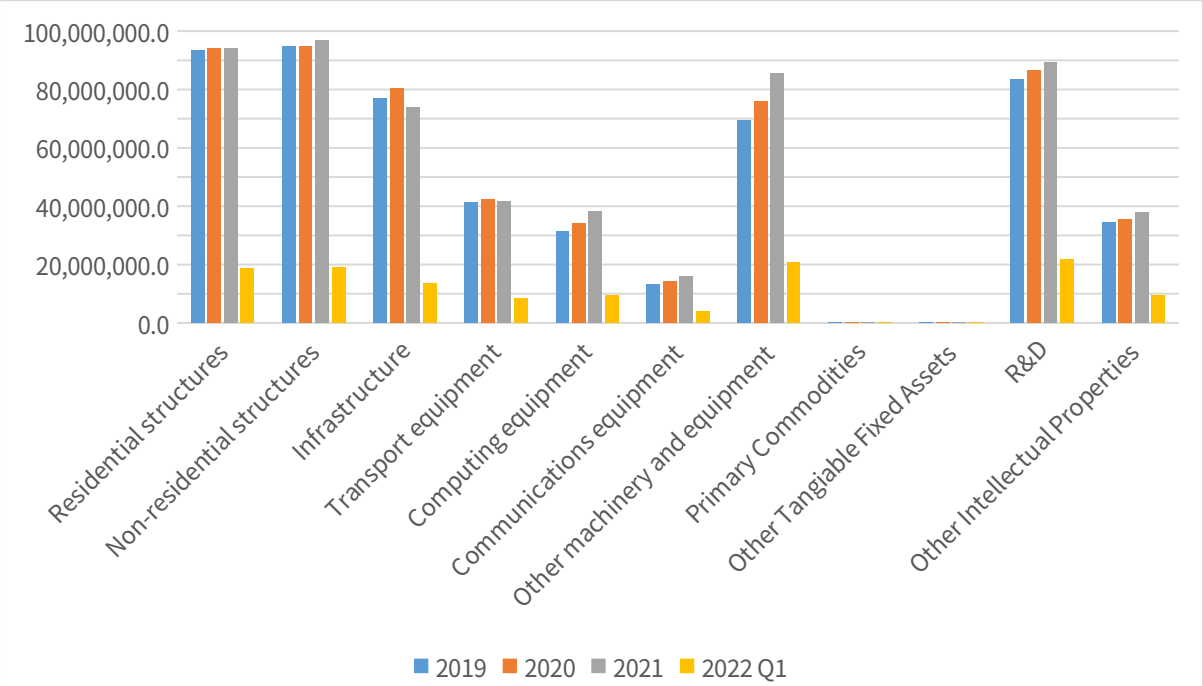
$$K_{t+k} = K_t + \frac{I_{t+k}}{I_{t+4}}(K_{t+4} - K_t)$$

$$= K_t + \frac{I_{t+k}}{I_{t+4}}(I_{t+4} - \delta K_t) \quad = (1 - \frac{I_{t+k}}{I_{t+4}}\delta)K_t + I_{t+k}$$

$$K_{t+4} = K_t(1-\delta) + I_{t+4} \qquad (6)$$

where K_t is capital stock in t quarter and I_t is capital formation in t quarter.

(Figure 5) Gross Fixed Capital Formation (2019.1 ~ 2022.1)



Source: Bank of Korea

(Table 1) Estimates of Capital Stock of 2021

$$Capital\,Stock_y = Capital\,Stock_{y-1} + Capital\,¿\,Formation\,¿_y - (Capital\,Stock_{y-1} \times rate\,of\,depreciation)$$

EUKLEMS	2020 Capital Stock	2021 Capital Fixed Formation	2020 capital stock x rate of depreciation	2021 Capital Stock
Residential structures	1756511634	94095900	57964883.9	1792642650
Non-residential structures	1331932643	96814000	39957979.3	1388788664
Infrastructure	1489824584	73985900	37245614.6	1526564870
Transport equipment	224902917.6	41730500	38008593.1	228624824.6
Computing equipment	163506405.5	38352978.89	15042589.3	186816795.1
Communications equipment	107597993	16090740.41	9899015.35	113789718
Other machinery and equipment	553252853.3	85483580.7	50899262.5	587837171.5
Primary Commodities	0	0	0	0
Other Tangible Fixed Assets	0	0	0	0
R&D	251731546.8	89413800	79295437.2	261849909.5
Other Intellectual Properties	105516624.9	37681300	33237736.9	109960188.1

(Table 2) Estimates of Depreciation Rates by Types of Assets

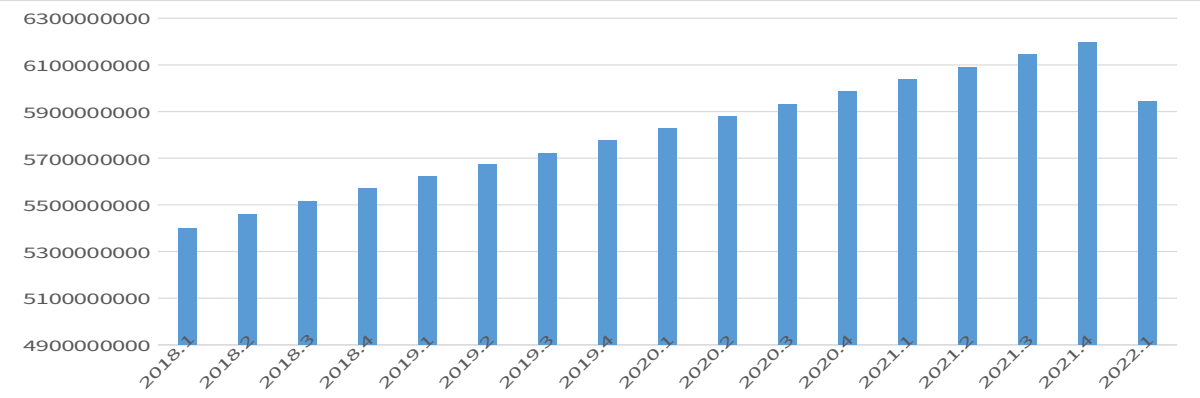
Types of Assets	Depreciation Rate
Residential structures	3.3
Non-residential structures	3
Infrastructure	2.5
Transport equipment	16.9
Computing equipment	9.2
Communications equipment	9.2
Other machinery and equipment	9.2
Primary Commodities	0
Other Tangible Fixed Assets	0
R&D	31.5
Other intellectual property	31.5

Sources: Pyo and Song (2014)

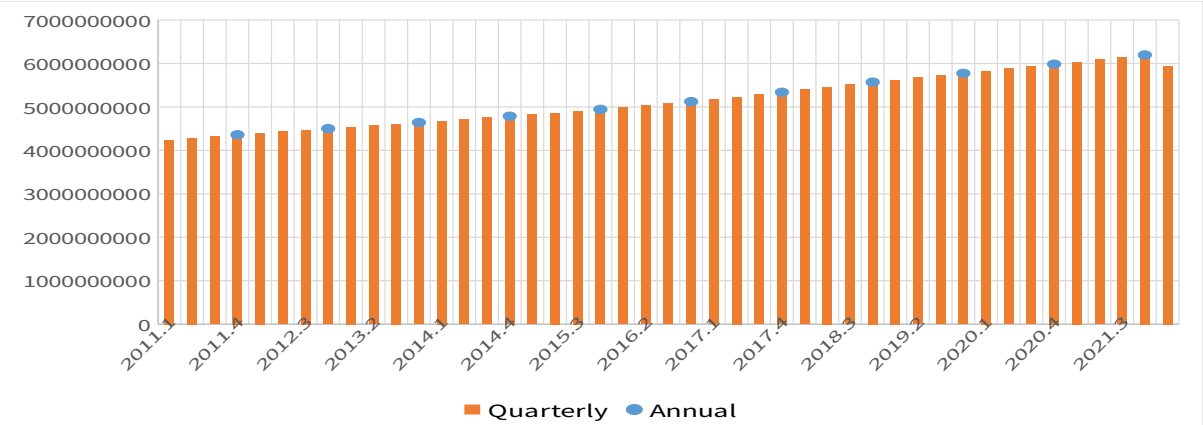
(Table 3) Estimates of Annual Capital Stock by Types of Assets (2019-2022.Q1)

	2019	2020	2021	2022 Q1
Residential structures	1719272114	1756511634	1792642650	1752259743
Non-residential structures	1275435715	1331932643	1388788664	1366185904
Infrastructure	1445425522	1489824584	1526564870	1501990148
Transport equipment	219652247.5	224902917.6	228624824.6	198378329.2
Computing equipment	142616686.4	163506405.5	186816795.1	178919867.4
Communications equipment	102785385.8	107597993	113789718	107218713.7
Other machinery and equipment	525823976	553252853.3	587837171.5	554462784.6
Primary Commodities	0	0	0	0
Other Tangible Fixed Assets	0	0	0	0
R&D	241354082.9	251731546.8	261849909.5	201197988
Other intellectual property	102412007.2	105516624.9	109960188.1	84777528.84

(Figure 6) Estimates of Quarterly Capital Stock (2018.1 ~ 2022.1)



(Figure 7) Estimates of Annual and Quarterly Capital Stock (2011.Q1 ~ 2022.Q1)

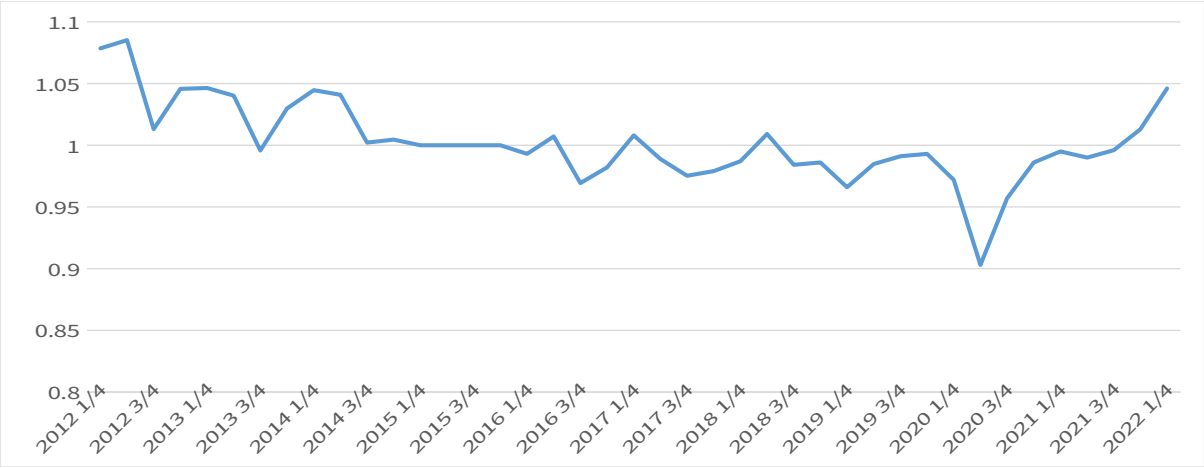


As noted by Fernald (2014), unobserved variations in factor utilization are important over the business cycle. Firms reduce the workweek of capital because it is not worth paying a shift premium to let them do overtime work or because the capital will depreciate as it is worked more intensively. While Fernald estimates utilization by the workweek of capital, *Z*t (e.g. varying the number of shifts) and by effort required of employees per hour of work *E*t through the regression method in Basu, Fernald and Kimball (2006), we estimated two utilization rates by employing proxy variables directly.

For capital utilization rate (*Zt),* we have adopted capacity utilization index by Statistics Korea for 21 Manufacturing industries with using 2015 as the base year. Following Pyo and Song (2014), we have used monthly electricity consumption statistics by Korea Energy Economics Institute(KEEI) as a proxy variable for non-manufacturing industries such as Agriculture and Forestry, Mining, and Service industries using 2015 as the base year. Figure shows the capacity utilization index generated by this method.

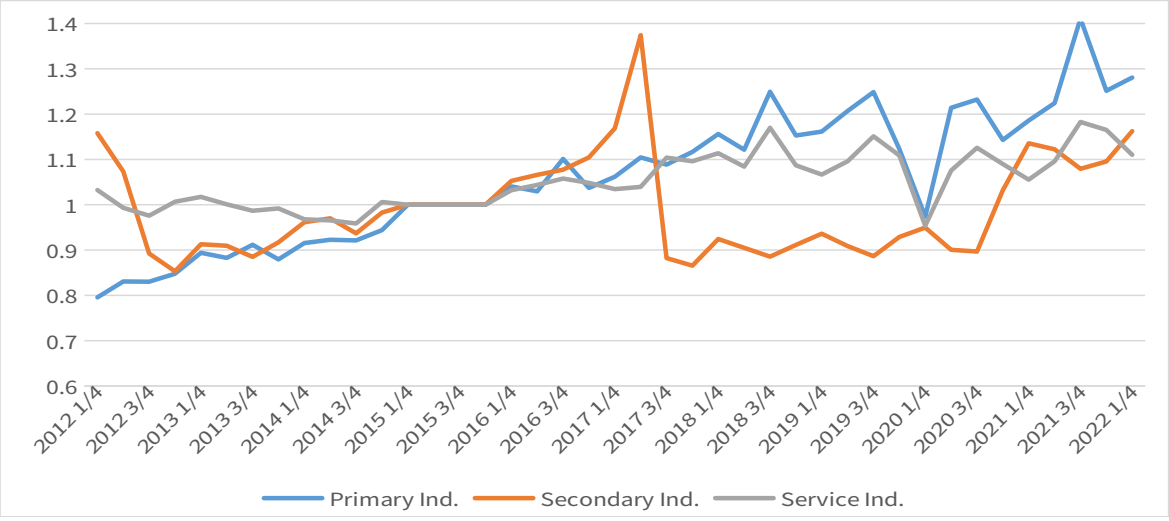
(Figure 8) Capital Utilization Rate for Manufacturing Industry (2012.Q1 ~ 2022.Q1)

<2015=1>



Sources: Statistics Korea

(Figure 9) Electricity Consumption by Industry (2012.Q1 ~ 2022.Q1) (2015=1)



Sources: Korea Energy Economics Institute (2022)

(3) Labor Input

The estimation of the total hours worked by industries has been conducted as follows:

In general, we have the following identity;

$$\sum_{i=1}^{4} qe_i / 4 = e \qquad (7)$$

where (qe) is quarterly number of workers and (*e*) is annual number of workers.

Let's assume that the variation of the quarterly number of workers (*qe*) is same as the variation of the quarterly number of employees (*q*). Then,

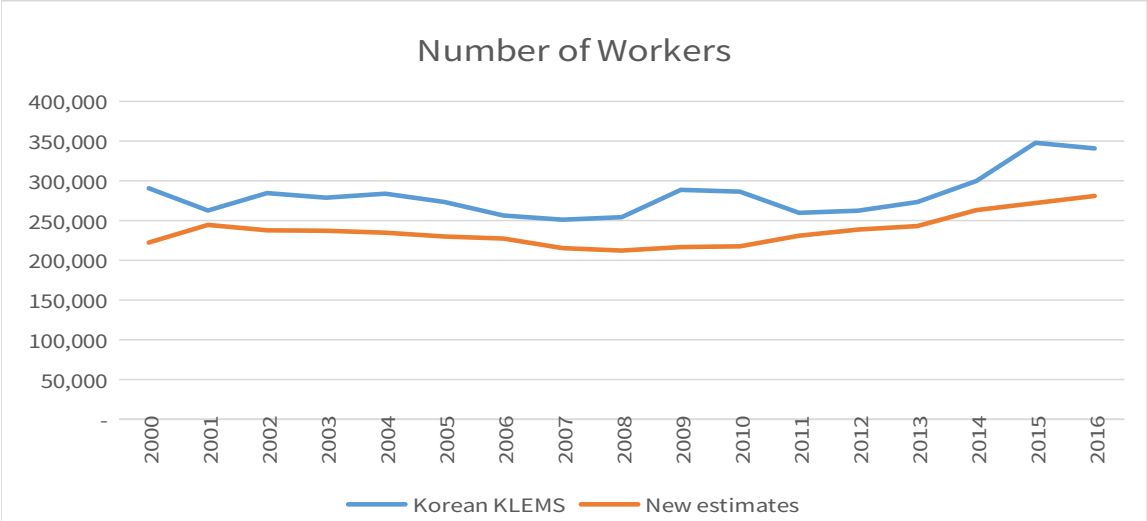
$$\frac{qe_i}{\sum_{i=1}^{4} qe_i} = \frac{q_i}{\sum_{i=1}^{4} q_i} \qquad (8)$$

Combining (1) and (2) together, we have

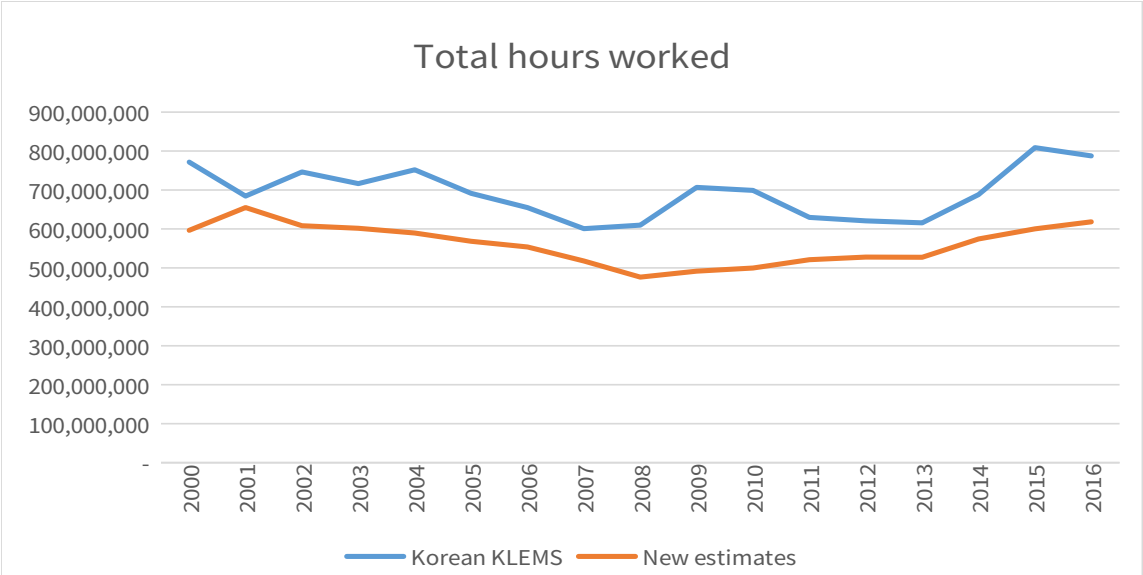
$$\widetilde{qe}_i = \frac{q_i}{\sum_{i=1}^{4} q_i} \times \sum_{i=1}^{4} qe_i = \frac{q_i}{\sum_{i=1}^{4} q_i} \times (4e) \qquad (9)$$

We have checked smoothness of total number of workers data in Figure 10 and total hours worked data in Figure 11.

(Figure 10) Manufacture of Food, Beverages, and Tobacco products



(Figure 11) Total hours worked



Notes: Korean KLEMS represents annual number of employees and total hours worked of the employees. The number of workers tend to be smaller than the number of employees in general. New estimates are systematically smaller than the Korean KLEMS data. But the trends are quite similar

Work Intensity (Effort per Unit of Labor)

Fernald(2014) notes that firms hoard labor in downturns, because they do not want to fire workers who have valuable skills that they will need in the future. He further notes that if labor is particularly valuable, firms will work existing employees both *longer* (oberved hours per worker rise) and *harder* (unobserved effort rises). Fernald(2014) created a quarterly labor- utilization series by using estimated industry coefficients from the regression of the growth rate of value-added ($\Delta \ln Yi$) on number of hours per unit of labor ($\Delta \ln (Hi/Ni)$) in i-th industry. In our paper, since we do not have quarterly intermediate-inputs data, we adopted the ratio of overtime working hours in total working hours as a proxy variable for work intensity.

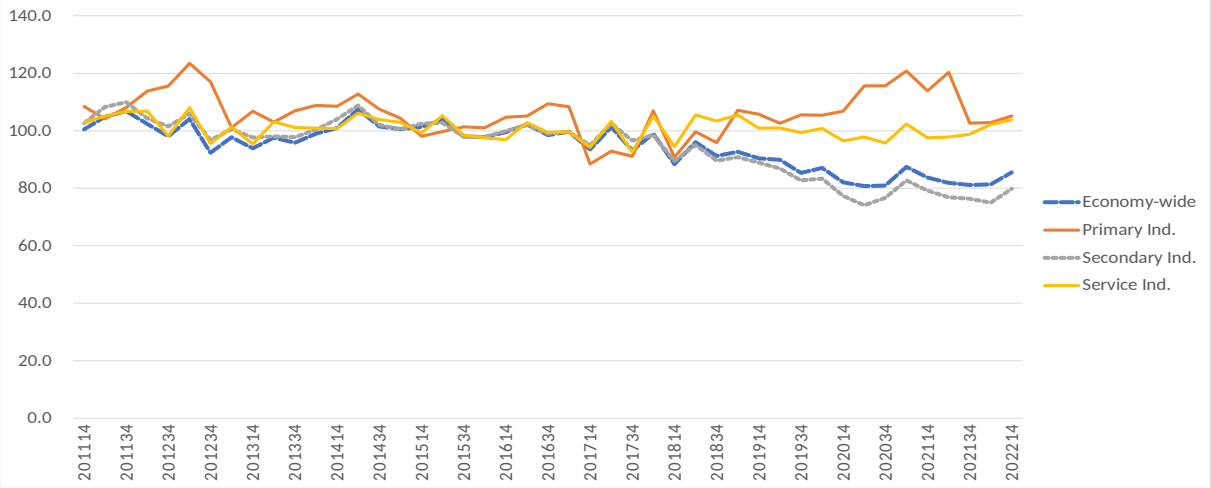
As shown in Figure 12, the work intensity has been increasing since the base year 2015 and its spread among different industries also became wider than before. It is interesting to note that the breakout of the Covid-19 pandemic has caused a wider spread of work intensity among industries, During Pandemic period, there was a labor law passed in Korean Assembly which limits total working hours per week as 52 hours.

This new legislation may have forced employers to seek more part-time workers to substitute over-time work demand and have caused work intensity to increase. In particular, in small and medium enterprises (SME), and self-employed shops and restaurants they had to cut or reduce part-time jobs causing work-intensity on the remaining full-time employees increase. Asshown in Figure 12 quarterly trend of work intensity index shows sharp increase in Primary and Service industry during

Pandemic.

(Figure 12) Quarterly Trend of Work Intensity Index (2011.1 ~ 2022.1)

<2015=100>



Source: Ministry of Employment and Labor, Labor Force Survey at Establishments

Note: Primary Industry includes just Mining industry due to the data limitation

(Table 4) Quarterly Trend of Work Intensity Index (2011.1 ~ 2022.1)

<2015=100>

Quarter	Economy-wide	Primary Ind.	Secondary Ind.	Service Ind.
201114	100.4	108.5	102.6	102.8
201124	104.8	104.1	108.3	105.1
201134	106.8	108.1	109.9	106.8
201144	102.4	113.8	104.3	106.9
201234	98.0	115.5	101.5	98.2
201234	104.1	123.5	105.9	108.1
201234	92.4	117.1	96.8	95.6
201244	97.8	101.1	100.5	101.3
201314	93.9	106.8	97.6	95.4
201324	97.6	103.1	98.0	103.1
201334	95.8	107.0	97.8	101.1
201344	99.0	108.8	100.4	100.9
201414	100.9	108.5	104.1	100.8
201424	107.5	112.8	108.8	106.2
201434	101.5	107.5	102.0	103.9
201444	100.6	104.4	100.5	102.9

201514	101.3	98.1	102.5	99.3
201524	103.8	99.7	102.8	105.3
201534	98.0	101.4	97.9	98.5
201544	97.8	101.0	97.9	97.5
201614	99.5	104.7	99.9	96.9
201624	102.2	105.1	102.0	102.9
201634	98.5	109.4	99.0	99.4
201644	99.7	108.4	99.6	99.7
201714	93.5	88.4	94.9	94.2
201724	101.3	92.9	102.6	103.3
201734	93.1	91.1	96.6	92.6
201744	99.0	106.9	98.6	105.2
201814	88.4	90.8	89.5	94.5
201824	96.0	99.7	95.1	105.5
201834	91.3	95.8	89.6	103.4
201844	92.7	107.1	90.8	105.5
201914	90.4	105.8	88.9	100.9
201924	89.9	102.6	86.9	101.0
201934	85.4	105.5	82.8	99.4
201944	87.1	105.4	83.4	100.8
202014	82.0	106.8	77.3	96.5
202024	80.7	115.6	74.0	97.8
202034	80.9	115.6	76.7	95.8
202044	87.4	120.8	82.7	102.3
202114	83.7	113.9	79.1	97.5
202124	81.9	120.4	76.9	97.9
202134	81.1	102.7	76.3	98.8
202144	81.3	102.8	75.0	102.2
202214	85.5	105.2	79.8	103.8

Source: Ministry of Employment and Labor, Labor Force Survey at Establishments

Note: Primary Industry includes just Mining industry due to the data limitation

(4) Estimates of Quarterly TFP

Estimates of quarterly TFP from Model 1 (unadjusted TFP), Model 2 (capital-adjusted) and Model 3 (capital-adjusted and labor-adjusted) are presented in Table

5-7, 8-10 and 11-13 respectively. It is noted that TFP growth rates at Economy-wide level are Model 1: 0.70(26.7 %), Model 2: 0.85 (32.4 %) and Model 3: 0.85 (32.4 %). The input-utilization adjustments have made the estimated TFP growth rates bigger in both absolute terms and relative contribution.

Model 1(Unadjusted TFP)

Model 1 estimates quarterly TFP without adjusting growth rates by input utilization rates. As shown in Table 5, 6 and 7, the economy-wide level of TFP growth rate is the largest during the Pandemic sub-period (2020 1/4-2022 1/4) because of negative growth rate (relative contribution) by labor input during the Pandemic period. It should be noted even during the Pandemic period, the growth rate of TFP in Secondary industry (2.19 %) and Service industry (1.51 %) explains almost all of GDP growth rate helped by positive growth rate of capital input (1.09 % and 0.89 % respectively).

Estimates of TFP by industry from Model 1(unadjusted TFP) shows a lot of recovery in Manufacturing (Figure 14). Within Service sector, Transportation & Storage, Accommodation & Food and Wholesale & Retail industry's TFP shows greater volatility (Figure 15) and most severely affected sectors from Pandemic as documented in Pyo (2021).

As shown in Figure 16, the TFP growth rate in Primary industry is found to be most volatile among three industries.

(Table 5) Quarterly Growth Accounting Result: Model 1 (Period: 2012 1/4-2022 1/4)

	GDP	Labor	Capital	TFP
Economy-wide	2.63 (100)	0.67 (25.5)	1.26 (47.8)	0.70 (26.7)
Primary Industry	0.39 (100)	0.01 (2.6)	0.16 (40.5)	0.22 (57.0)
Secondary Industry	2.42 (100)	0.50 (20.6)	1.66 (68.3)	0.27 (11.1)
Service Industry	2.85 (100)	0.81 (28.3)	1.04 (11.1)	1.00 (35.1)

Note: Relative contribution in parenthesis underneath growth rates

(Table 6) Quarterly Growth Accounting Result: Model 1 (Period: 2012 1/4-2019 1/4)

	GDP	Labor	Capital	TFP

Economy-wide	2.89 (100)	1.03 (35.6)	1.34 (46.5)	0.52 (17.8)
Primary Industry	0.66 (100)	-0.52 (-78.8)	-0.28 (-41.7)	1.47 (220.5)
Secondary Industry	2.59 (100)	0.99 (38.2)	1.85 (71.3)	-0.25 (-9.5)
Service Industry	3.17 (100)	1.19 (37.6)	1.08 (34.1)	0.89 (28.2)

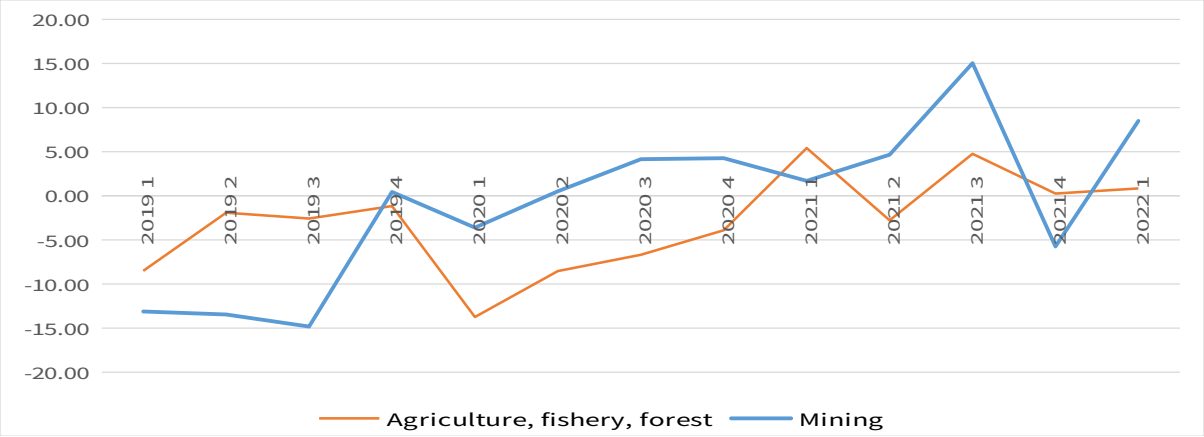
Note: Relative contribution in parenthesis underneath growth rates

(Table 7) Quarterly Growth Accounting Result: Model 1 (Period: 2020 1/4-2022 1/4)

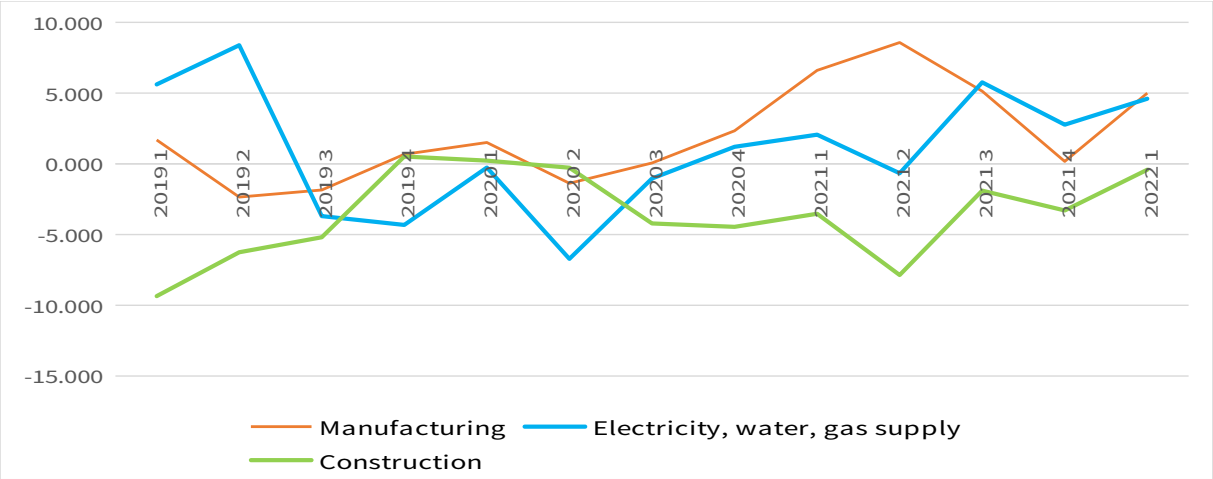
	GDP	Labor	Capital	TFP
Economy-wide	1.94 (100)	-0.62 (-31.8)	0.94 (49.9)	1.59 (81.9)
Primary Industry	-0.89 (100)	0.64 (-72.0)	1.11 (-124.7)	-2.65 (296.7)
Secondary Industry	2.34 (100)	-0.94 (-40.0)	1.09 (46.6)	2.19 (93.5)
Service Industry	1.81 (100)	-0.58 (-31.9)	0.89 (48.9)	1.51 (83.0)

Note: Relative contribution in parenthesis underneath growth rates

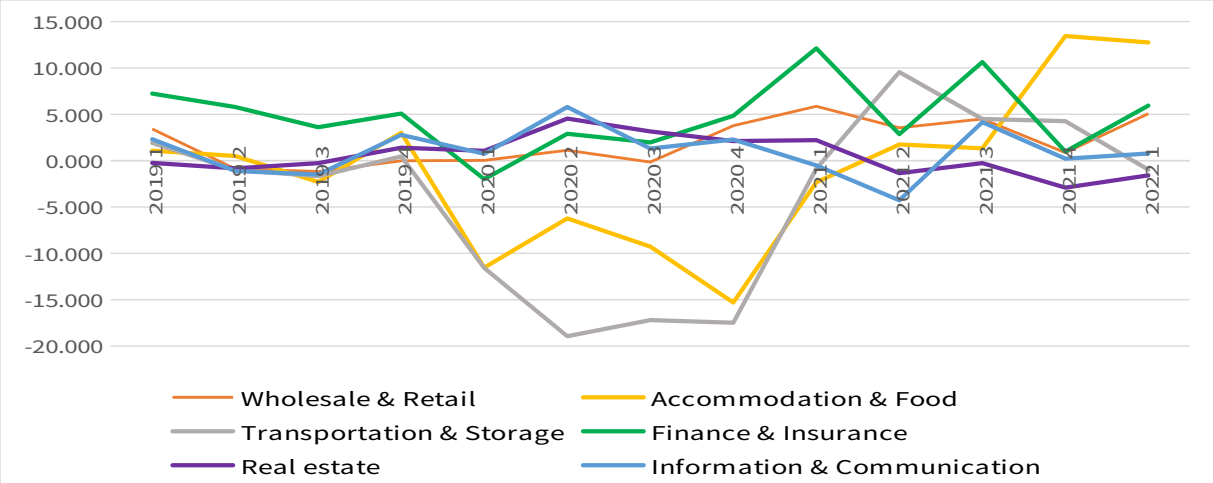
(Figure 13) Estimates of Total Factor Productivity (TFP) (Primary Industry, 2019.Q1 ~ 2022.Q1)



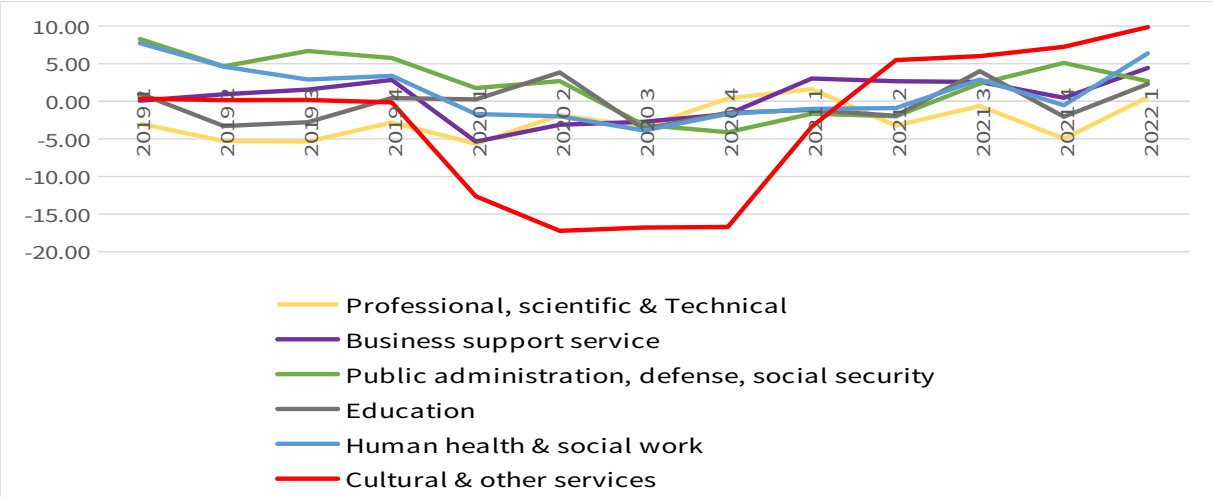
(Figure 14) Estimates of Total Factor Productivity (TFP) (Secondary Industry, 2019.Q1 ~ 2022.Q1)



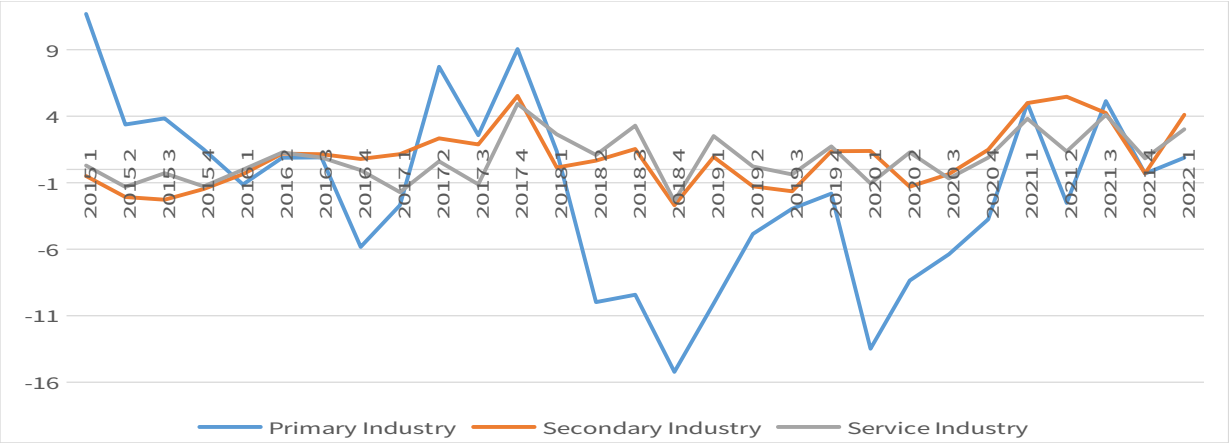
(Figure 15) Estimates of Total Factor Productivity (TFP) (Service Industry, 2019.Q1 ~ 2022.Q1)



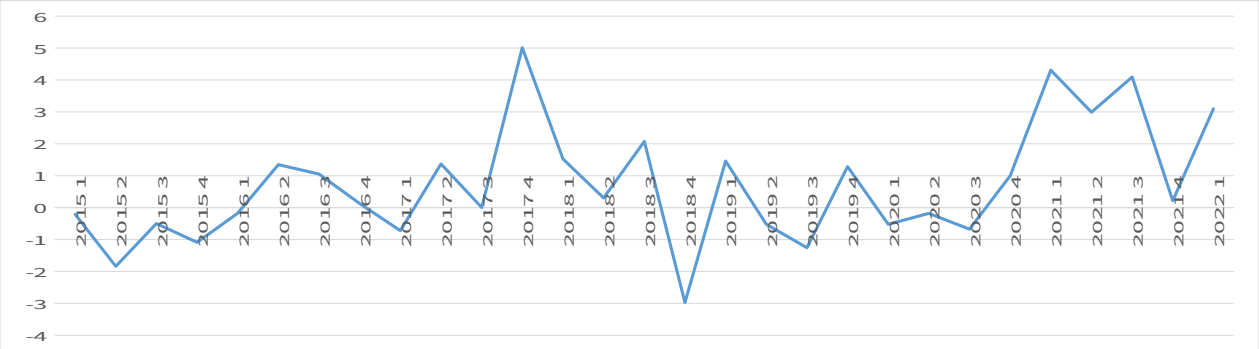
(Figure 15 cont.) Estimates of Total Factor Productivity (TFP) (Service Industry, 2019.Q1 ~ 2022.Q1)



(Figure 16) Estimates of Total Factor Productivity (TFP) by Industry (2015.Q1 ~ 2022.Q1)



(Figure 17) Estimates of Total Factor Productivity (TFP) for Economy-Wide (2015.Q1 ~ 2022.Q1)



Model 2 (Capital-adjusted TFP)

Model 2 adjusts capital input using capacity utilization ratio index from Statistics Korea for Manufacturing sector and the utilization index using Electric Power Usage in all other Non- Manufacturing industries by using Energy Statistics by Korea Energy Economics Institute following Pyo and Song (2014).

Quarterly estimates of TFP growth rates for the entire period in Table 8 shows the fastest growth in Service industry (0.94 %) with a significant relative contribution (33.1 %). On the other hand, during the Pandemic period, capital–adjusted TFP growth rate in Table 10 is the largest in Manufacturing (2.22 %) with dominant relative contribution to GDP (94.8 %). It implies during the Pandemic-period Secondary industry including Manufacturing has managed to record 2.34 % GDP growth rate and a 1.06 % growth rate of capital input after being adjusted by capacity utilization rate.

The pattern of estimated TFP growth rates from Model 2 are quite similar to those from Model 2. It is noted in Figure 25 that Cultural/Other Service industry shows the largest volatility during the Pandemic period followed by Transportation & Storage, Accommodation & Food and Wholesale & Retail industry.

(Table 8) Quarterly Growth Accounting Result: Model 2 (Period: 2012 1/4-2022 1/4)

	GDP	Labor	Capital	TFP
Economy-wide	2.63 (100)	0.67 (25.5)	1.11 (42.1)	0.85 (32.4)
Primary Industry	0.39 (100)	0.01 (2.6)	-0.18 (-46.1)	0.56 (143.5)
Secondary Industry	2.42 (100)	0.50 (20.6)	1.33 (54.8)	0.59 (24.5)
Service Industry	2.85 (100)	0.81 (28.3)	1.10 (38.6)	0.94 (33.1)

Note: Relative contribution in ( ) underneath growth rates

(Table 9) Quarterly Growth Accounting Result: Model 2 (Period: 2012 1/4-2019 1/4)

	GDP	Labor	Capital	TFP
Economy-wide	2.89 (100)	1.03 (35.6)	1.08 (37.3)	0.78 (27.1)
Primary Industry	0.66 (100)	-0.52 (-78.8)	-0.79 (-118.4)	1.97 (297.2)
Secondary Industry	2.59 (100)	0.99 (38.2)	1.41 (54.5)	0.19 (7.3)
Service Industry	3.17 (100)	1.19 (37.6)	1.12 (35.5)	0.85 (26.9)

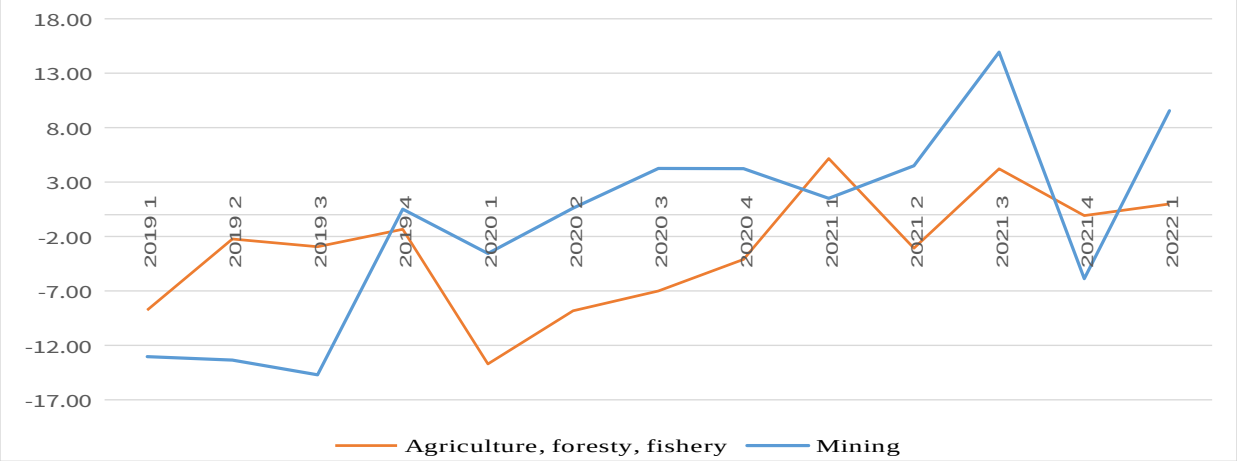
Note: Relative contribution in ( ) underneath growth rate

(Table 10) Quarterly Growth Accounting Result: Model 2 (Period: 2020 1/4-2022 1/4)

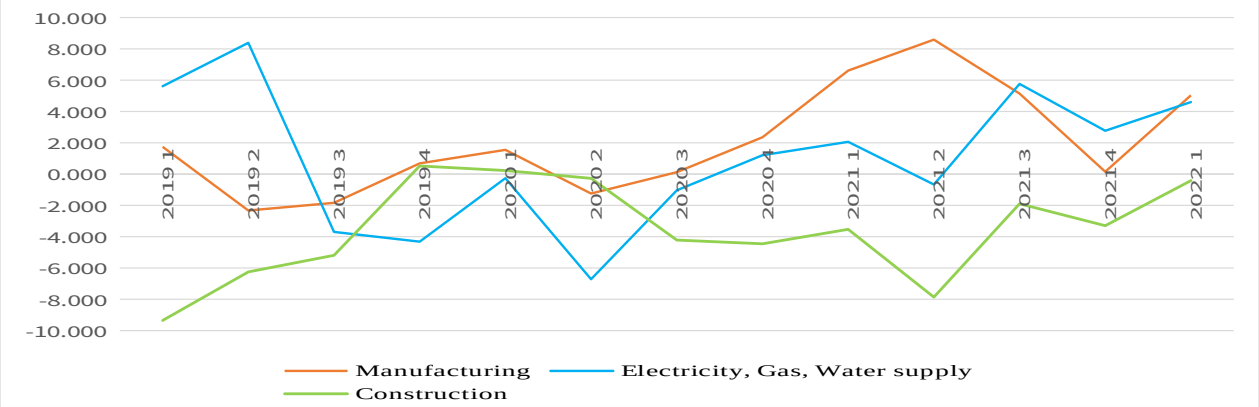
	GDP	**Labor**	**Capital**	**TFP**
Economy-wide	1.94 (100)	-0.62 (-31.8)	1.09 (55.9)	1.47 (75.9)
Primary Industry	-0.89 (100)	0.64 (-72.0)	1.23 (-138.1)	-2.76 (310.1)
Secondary Industry	2.34 (100)	-0.94 (-40.0)	1.06 (45.2)	2.22 (94.8)
Service Industry	1.81 (100)	-0.58 (-31.9)	0.97 (53.4)	1.42 (78.5)

Note: Relative contribution in ( ) underneath growth rates

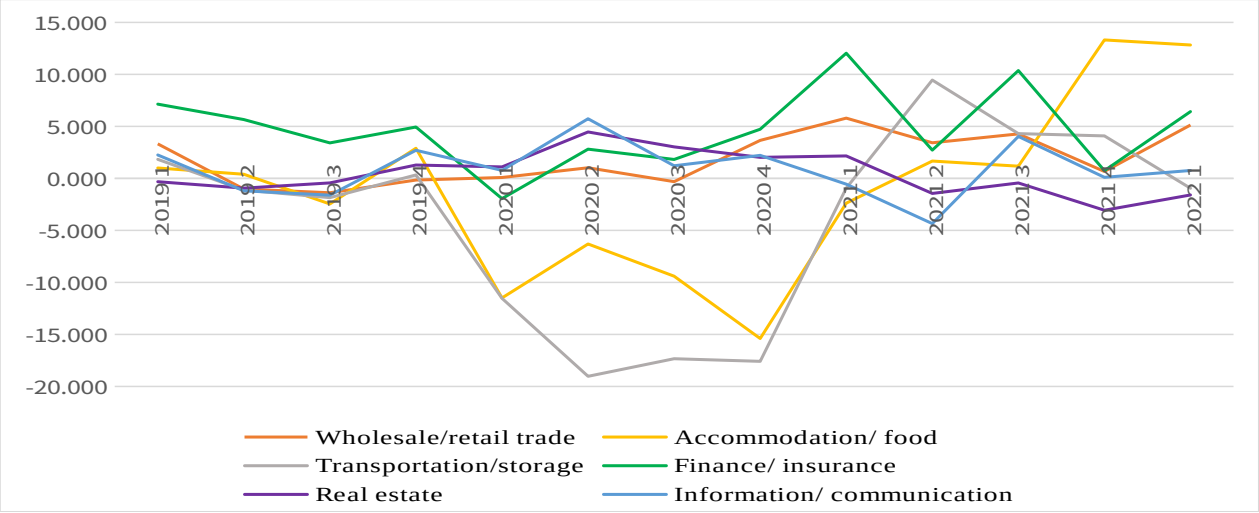
(Figure 18) Estimates of TFP (Model 2, Primary Industry, 2019.Q1 ~ 2022.Q1)



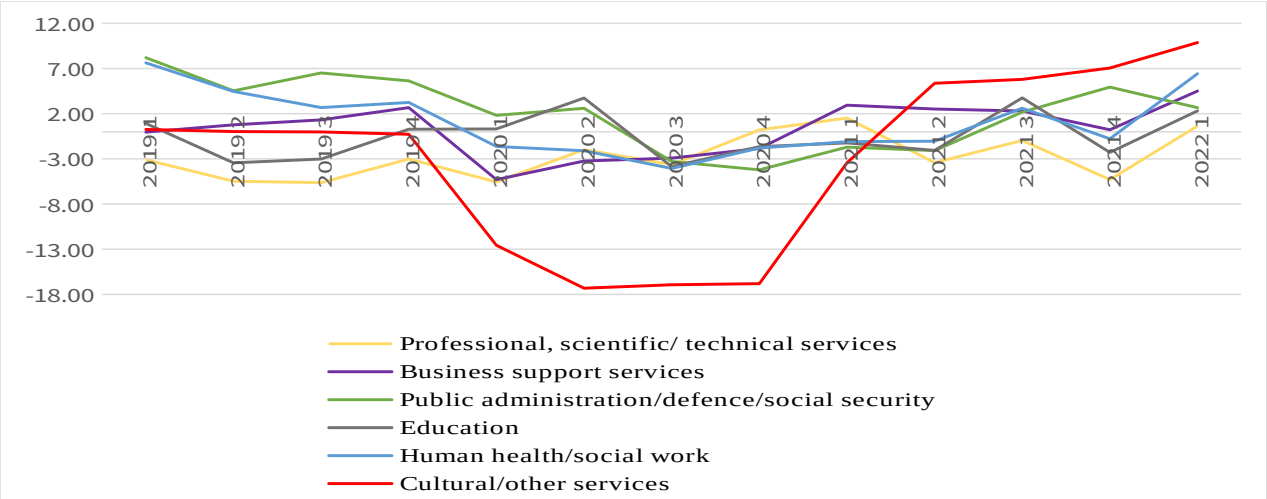
(Figure 19) Estimates of TFP (Model 2, Secondary Industry, 2019.Q1 ~ 2022.Q1)



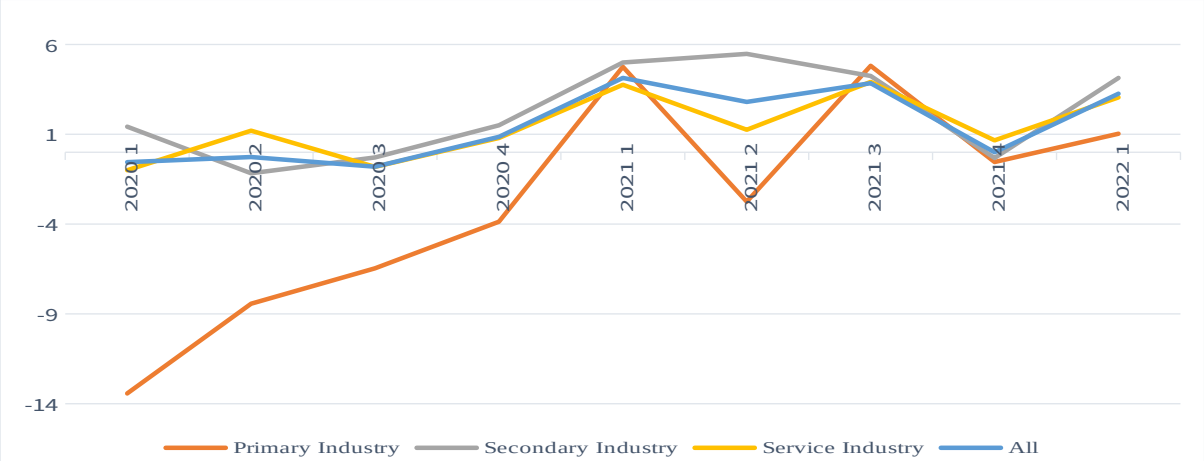
(Figure 20) Estimates of TFP (Model 2, Service Industry, 2019.Q1 ~ 2022.Q1)



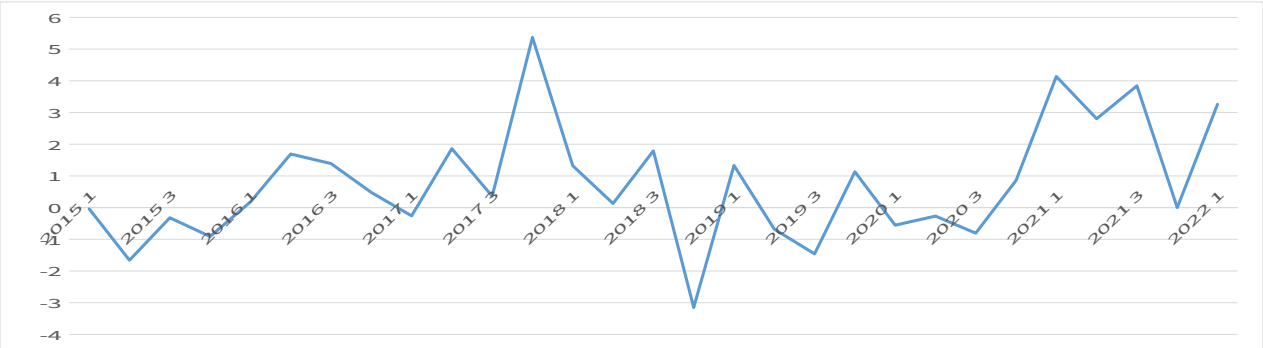
(Figure 20 cont.) Estimates of TFP (Model 2, Service Industry, 2019.Q1 ~ 2022.Q1)



(Figure 21) Estimates of TFP by Industry (model 2, 2020.Q1 ~ 2022.Q1)



(Figure 22) Estimates of TFP for Economy-Wide (model 2, 2015.Q1 ~ 2022.Q1)



Model 3 (Both Capital- and Labor- adjusted TFP)

The last model of quarterly growth accounting adjusts TFP by both capacity utilization index and labor-intensity index. For the entire period of estimation (2012 1/4 – 2022 1/4), the growth rate of TFP is the largest in Service sector (0.94 %) with relative contribution (33.0 %) as shown in Table 11. During the Pandemic period (2020 1/4 – 2022 1/4) reported in Table 13, Secondary industry's TFP growth rate is 2.38 % contributing to almost 100 % of the sector's GDP growth rate (2.34 %) even though labor growth rate was negative (- 1. 09 %) and capital growth rate was weak (1.06 %).

It should be noted that as shown in Figure 12 during the Pandemic period the work intensity index of the Secondary sector did not increase but rather got reduced implying that there was not massive lay-offs. Therefore, the labor input during the Pandemic period was not adjusted much by work-intensity index maintaining the similar growth rate of TFP from Model 2 (2,22 %)

(Table 11) Quarterly Growth Accounting Result: Model 3 (Period: 2012 1/4-2022 1/4)

	GDP	Labor	Capital	TFP
Economy-wide	2.63 (100)	0.67 (25.5)	1.11 (42.1)	0.85 (32.4)
Primary Industry	0.39 (100)	-0.13 (-34.1)	-0.18 (-46.1)	0.70 (180.2)
Secondary Industry	2.42 (100)	0.51 (21.0)	1.33 (54.8)	0.59 (24.2)
Service Industry	2.85 (100)	0.81 (28.4)	1.10 (38.6)	0.94 (33.0)

Note: Relative contribution in ( ) underneath growth rates

(Table 12) Quarterly Growth Accounting Result: Model 3 (Period: 2012 1/4-2019 4/4)

	GDP	Labor	Capital	TFP
Economy-wide	2.89 (100)	1.02 (35.4)	1.08 (37.3)	0.79 (27.3)
Primary Industry	0.66 (100)	-0.64 (-96.5)	-0.79 (-118.4)	2.09 (314.9)
Secondary Industry	2.59 (100)	1.05 (40.6)	1.41 (54.5)	0.13 (4.9)
Service Industry	3.17 (100)	1.18 (37.2)	1.12 (35.5)	0.86 (27.3)

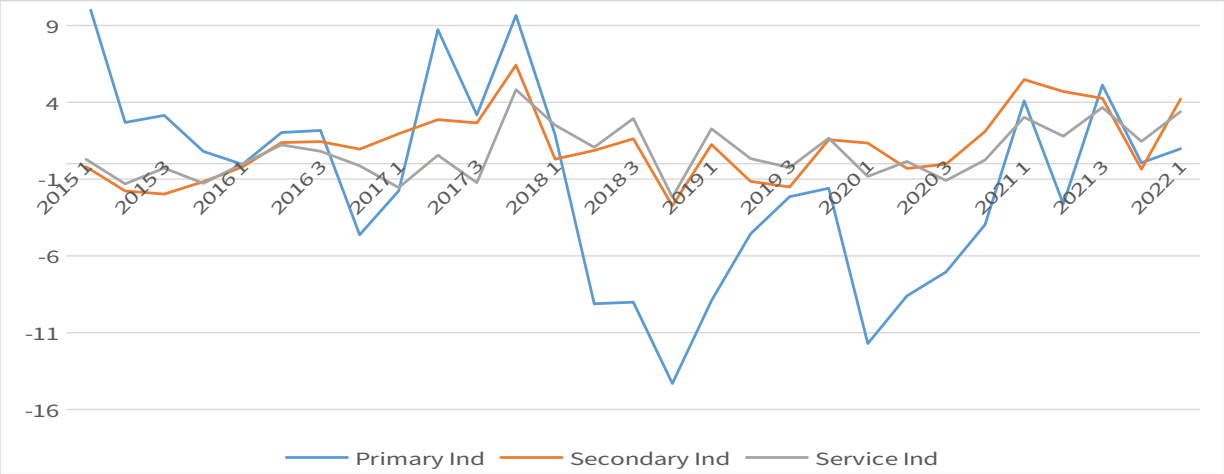
Note: Relative contribution in ( ) underneath growth rates

(Table 13) Quarterly Growth Accounting Result: Model 3 (Period: 2020 1/4-2022 1/4)

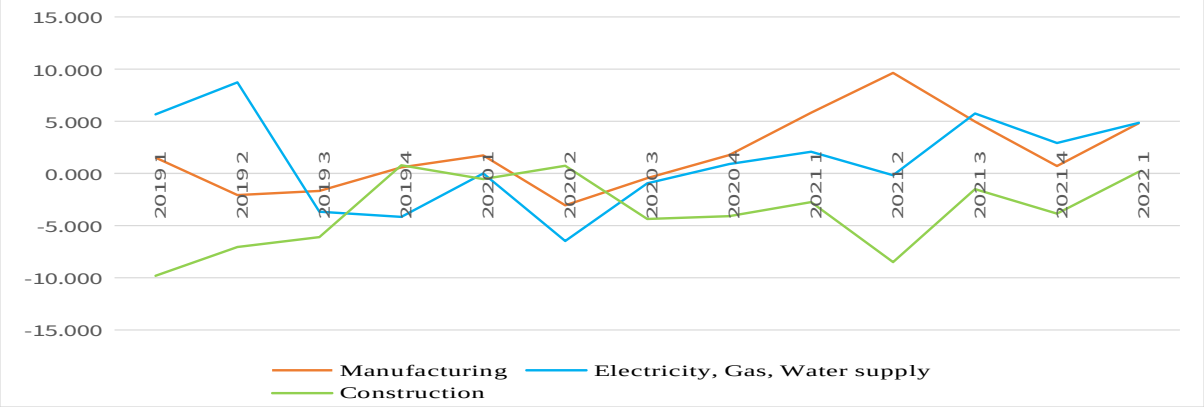
	GDP	Labor	Capital	TFP
Economy-wide	1.94	-0.60	1.09	1.45
	(100)	(-30.6)	(55.9)	(74.7)
Primary Industry	-0.89	0.51	1.23	-2.63
	(100)	(-57.2)	(-138.1)	(295.3)
Secondary Industry	2.34	-1.09	1.06	2.38
	(100)	(-46.6)	(45.2)	(101.4)
Service Industry	1.81	-0.46	0.97	1.31
	(100)	(-25.6)	(53.4)	(72.2)

Note: Relative contribution in ( ) underneath growth rate

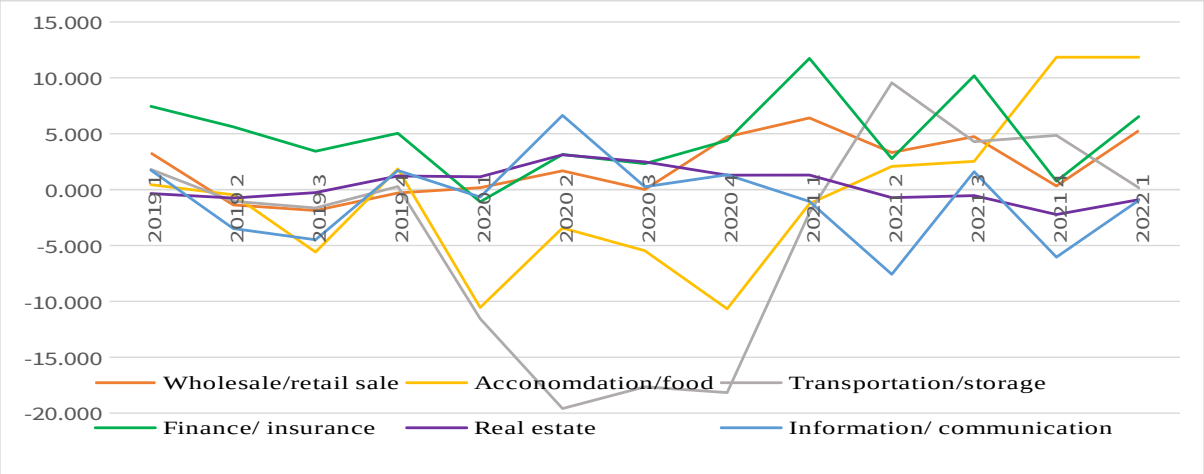
(Figure 23) Estimates of TFP (Model 3, Primary Industry, 2015.Q1 ~ 2022.Q1)



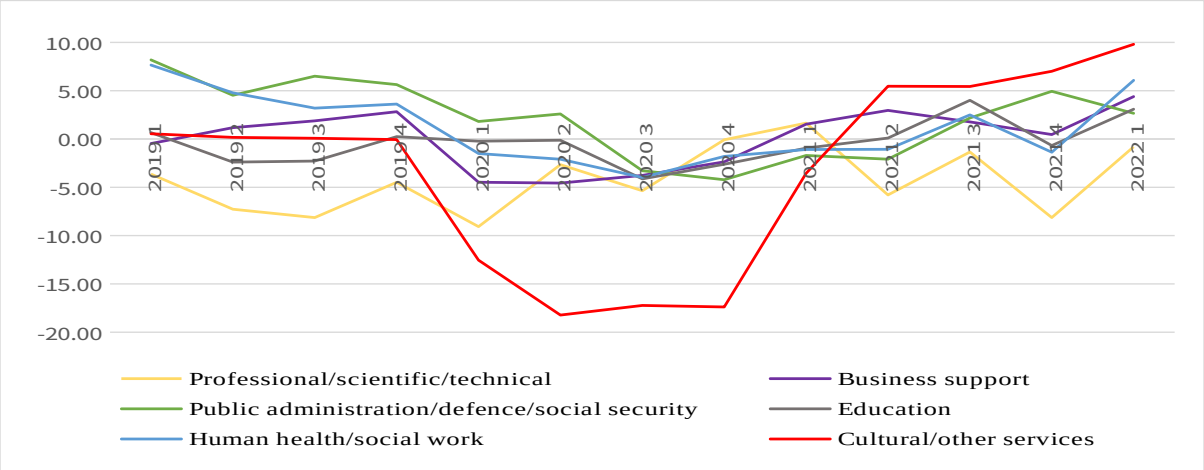
(Figure 24) Estimates of TFP (Model 3, Secondary Industry, 2019.Q1 ~ 2022.Q1)



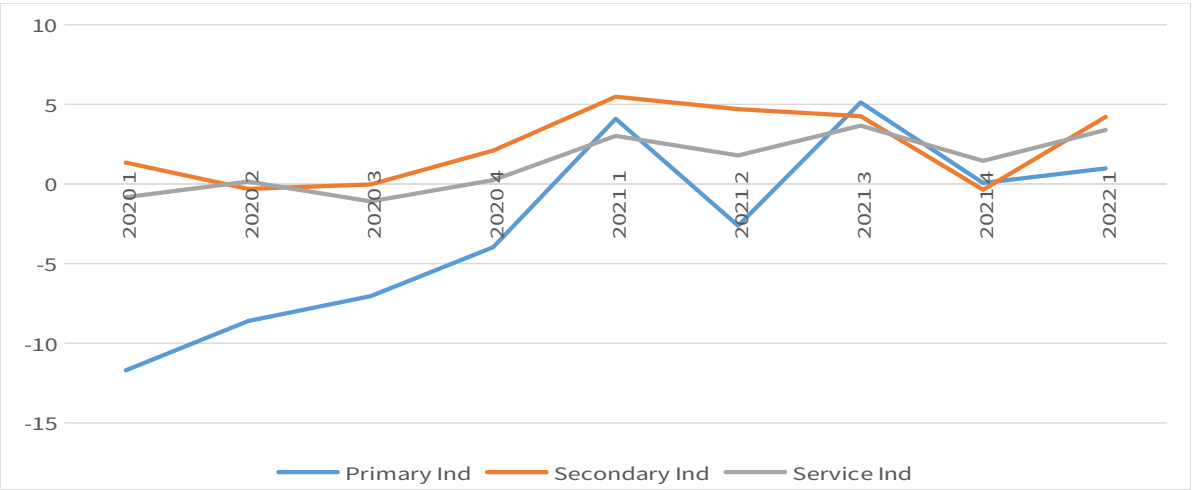
(Figure 25) Estimates of TFP (Model 3, Service Industry, 2019.Q1 ~ 2022.Q1)



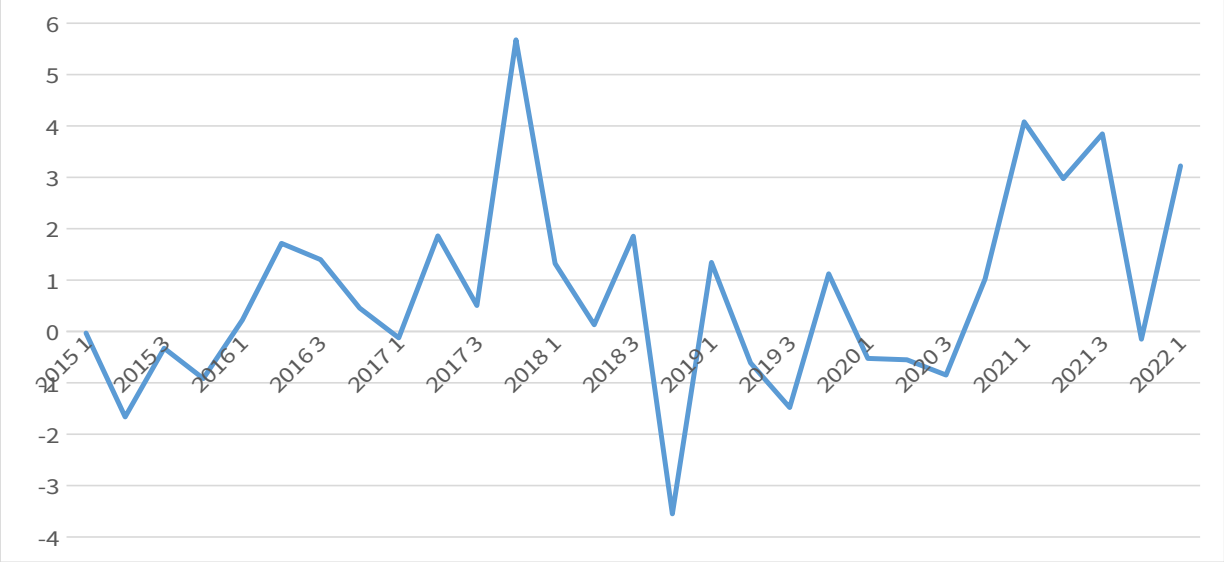
(Figure 25 cont.) Estimates of TFP (Model 3, Service Industry, 2019.Q1 ~ 2022.Q1)



(Figure 26) Estimates of TFP by Industry (model 3, 2020.Q1 ~ 2022.Q1)

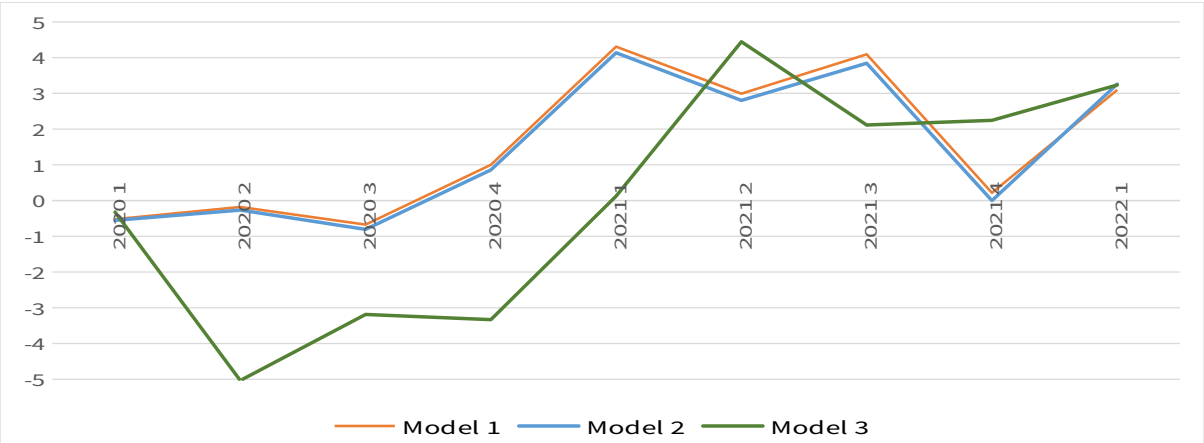


(Figure 27) Estimates of TFP for Economy-Wide (model 3, 2015.Q1 ~ 2022.Q1)



(Figure 28) TFP Comparison: Model 1, Model 2 and Model 3

(Economy-wide, 2020.Q1 ~ 2022.Q1)



In summary, the estimated quarterly TFP series at Economy-wide level are shown in Figure 28. The unadjusted series from Model 1 and the capital utilization-adjusted series from Model 2 are quite similar. They moved downturn at the first quarer of 2020 when the Covid-19 Pandemic broke out. It went down again after the recovery duringthe period from second quarter of 2020 to the third quarter of 2021. But it declined sharply in the fourth quarter of 2021 during the resurgence of Omicron to be followed by a sharp recovery during the first quarter of 2022. Therefore, we can verify that TFP movements are very pro-cyclical with the Pandemic cycle.

4. Regression of Labor productivity on Capital Intensity

In order to supplement the quarterly estimation of TFP by growth accounting models, we have adopted the following regression model where the constant returns to scale is imposed:

Model: $lnY/L = \alpha + \beta lnK/L + \varepsilon$

where Y = value-added, L = labor input and ε is a stochastic disturbance term

The regression result shows that estimated share of capital input is the greatest in Service industry (0.80) followed by Primary industry (0.52) and Manufacturing (0.48). The regression with Time index estimates the growth rate of a neutral technical progress or TFP. The estimates are Primary (0.1 %), Manufacturing (0.1 %) and Service (0.2 %). The regression result with Time Dummy Variable for the Covid-19 period (First quarter of 2020 – First Quarter of 2022) shows negative signs in Primary and Service industry while the signs of Manufacturing coefficient are positive implying that labor productivity in Manufacturing improved during the pandemic period.

(Table 14) Regression of labor productivity on capital intensity by Industry (2011.1 – 2022.1)

Model 1: Estimation without Time Index Variable or Time Dummy Variable

	Economy-wide		**Manufacturing**		**Service**		**Primary Ind.**	
	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)
ln(K/L)	0.57***	0.59***	0.47***	0.48***	0.80***	0.82***	0.52***	0.53***
se	-0.044	-0.025	-0.04	-0.032	-0.046	-0.036	-0.089	-0.049
_cons	-2.35***	-2.37***	-2.23***	-2.24***	-2.54***	-2.55***	-2.49***	-2.55***
se	-0.015	-0.009	-0.033	-0.027	-0.009	-0.007	-0.104	-0.057
Adj. R^2	0.79	0.93	0.76	0.84	0.87	0.92	0.44	0.73
Obs.	45	45	45	45	45	45	45	45
DW	2.47	1.69	1.86	1.24	1.25	0.46	1.97	0.56

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

Note : se=standard error, s.a.=seasonal adjustment

Model 2: Estimation of labor productivity including time trend

- **Model:** $lnY/L = \alpha + \beta lnK/L + time + \varepsilon$

(Table 15) Regression of capital intensity on labor productivity by Industry (2011.1 – 2022.1)

	Economy-wide		Manufacturing		Service		Primary Ind.	
	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)
ln(K/L)	0.340***	0.469***	0.426**	0.719***	0.528***	0.602***	0.517***	0.523***
se	-0.098	-0.059	-0.182	-0.155	-0.073	-0.06	-0.09	-0.049
time	0.002**	0.001**	0.001	-0.003	0.002***	0.001***	0.001	0.001
se	-0.001	0.000	-0.002	-0.002	0.000	0.000	-0.002	-0.001
_cons	-3.575***	-2.993***	-2.248***	-2.133***	-3.758***	-3.501***	-3.695**	-3.444***
se	-0.466	-0.279	-0.09	-0.075	-0.28	-0.23	-1.591	-0.868
Adj. R^2	0.82	0.93	0.76	0.84	0.91	0.94	0.43	0.73
Obs.	45	45	45	45	45	45	45	45
DW	2.33	1.65	1.78	1.52	1.63	0.96	1.99	.56

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

Note : se=standard error, s.a.=seasonal adjustment

Model 3: Estimation of Labor Productivity including Dummy Variable

- Model: $lnY/L = \alpha + \beta lnK/L + dum + \varepsilon$

(Table 16) Regression of capital intensity on labor productivity by Industry (2011.1 – 2022.1)

	Economy-wide		Manufacturing		Service		Primary Ind.	
	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)	Model_1	Model_2 (s.a.)
ln(K/L)	0.617***	0.653***	0.411***	0.423***	0.954***	1.016***	0.538***	0.541***
se	-0.073	-0.04	-0.061	-0.049	-0.082	-0.059	-0.088	-0.046
dum	-0.012	-0.017*	0.031	0.028	-0.029**	-0.037***	-0.085	-0.079**
se	-0.015	-0.008	-0.022	-0.018	-0.013	-0.009	-0.057	-0.03
_cons	-2.363***	-2.383***	-2.178***	-2.198***	-2.565***	-2.580***	-2.462***	-2.516***
se	-0.022	-0.012	-0.048	-0.039	-0.013	-0.01	-0.105	-0.054

Adj. R^2	0.79	0.93	0.77	0.84	0.88	0.94	0.45	0.76
Obs.	45	45	45	45	45	45	45	45
DW	2.57	1.93	1.96	1.39	1.52	0.59	2.04	0.63

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

Note 1) se=standard error, s.a.=seasonal adjustment

2) dum=0 (2011.1 ~ 2019.4), 1(2020.1~2022.1)

5. Concluding Remarks

Estimation of the work intensity index was tougher than expected. because there is no consistent quarterly dataset from a single data source in Korea. However, estimation should be done anyway for the quarterly data generation. A key idea is finding a proxy variable that explains the quarterly variation. Because we don't have detailed information about labor market, such as education level, age, or sex, KLEMS approach cannot be fully applied to our quarterly dataset. Instead, we can apply a simple growth accounting to generate the quarterly TFP.

There are three major findings in the present paper. The first finding is that when we adjusted both capital input and labor input by Model 3, estimated profile of TFP was quite different from those of Model 1 and Model 2 and was much more volatile than those of Model 1 and Model 2. We conjecture the proxy variable (the ratio of overtime working hours / total working hours) we have chosen is very sensitive at the time of Pandemic and over business cycle, The second finding is that the regression of labor productivity on capital intensity produced estimates of the coefficient of capital income share and the growth rate of TFP. The estimation with a Time Dummy Variable for Pandemic period produced negative coefficients reflecting a significant downward pressure on GDP during the pandemic-inflicted period (First Quarter 2020 – First Quarter 2022). The third finding is that the COVID-19 after the first quarter of 2020 has made growth rates of both GDP and labor input turn negative. But the relative contribution of capital input and TFP make up almost 90 % of GDP growth. We also find the quarterly TFP estimates are exhibiting a pro-cyclical pattern which is closely related to the recovery cycle of the pandemic. This finding is in contrast with the finding by Basu, Fernald and Kimball (2006) who supports technology improvements are contractionary: when technology improves, inputs and investment generally fall in the short run, and output itself may also fall.

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Appendix 1

1. Data Sources

(1) Labor inputs

Statistics	Availability	# of workers		Hours worked	
		Industry	Frequency	Industry	Frequency
Economically Active Population Survey	2000-2021	1-digit	Quarterly		
The Establishment Status	2000-2021	2-digit	Yearly		
Establishment Labor Force Survey	1999 1/4 - 2010 4/4	2-digit	Quarterly		
	2011 1/4 - 2021 1/4			2-digit	Quarterly

(2) Capital stock

Extension of the estimates by Pyo and Song (2014)

(3) Value-added

Bank of Korea, National Accounts

(4) Labor share

Compensation of Employees – Bank of Korea, National Account

2. Industry Classifications

10 industries		32 industries	
1	Mining and quarrying	1	Mining and quarrying
2	Manufacturing	2	Food, Beverages, and Tobacco products
		3	Textiles, Clothing, and Leather products
		4	Wood, Paper, Pringting and Reproduction of Recorded Media
		5	Coke and Refined Petroleum Products
		6	Chemicals and chemical products
		7	Pharmaceuticals, Medicinal Chemicals
		8	Rubber and Plastic products
		9	Other Non-metallic Mineral Products
		10	Basic Metal Products
		11	Fabricated Metal Products
		12	Electronic components, Computer, Medical Precision and Optical Instruments
		13	Electrical equipment
		14	Other Machinery and Equipment
		15	Motor Vehicles, Trailers and Semitrailers
		16	Other Trnasport Equipment

		17	Other manufacturing
3	Electricity, Gas, Steam and water supply	18	Electricity, gas, steam and air conditioning supply
		19	Water supply, Sewerage, waste management, remediation activities
4	Construction	20	Construction
5	Wholesale and retail trade, Accommodation, food service activities	21	Wholesale and retail trade
		22	Accommodation and food service activities
6	Transfortation, Information and communications	23	Transportation
		24	Publishing, Motion picture, video and television programme production, broadcasting
		25	Telecommunications
		26	Information service activities
7	Financial and insurance activities	27	Financial and insurance activities
8	Real estate, Professional/Scientific activities, and business support services	28	Real estate activities and renting and leasing
		29	Professional, scientific and technical acitivites
		30	Business support services
9	Human health and social work activities	31	Human health and social work activities
10	Arts, sports and recreation related services	32	Arts, sports and recreation related services

3. Data and Methodologies

Methodologies(I)

The estimation of the Total hours worked by industries

Statistics	**Availability**	**# of workers**		**Hours worked**	
		Industry	Frequency	Industry	Frequency
Economically Active Population Survey (EAPS)	2000-2021	1-digit	Quarterly		
The Establishment Status (ES)	2000-2021	2-digit	Yearly		
Establishment Labor Force Survey (ELFS)	1999 1/4 - 2010 4/4	2-digit	Quarterly		
	2011 1/4 - 2021 2/4			2-digit	Quarterly

Appendix 2

Estimates of Quarterly TFP by Industry: Model 1

	Agriculture, fishery, and forest				Mining			
	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP
2019 1	4.99	11.94	1.57	-8.51	-10.91	0.99	1.22	-13.12
2019 2	2.40	2.82	1.50	-1.92	-7.65	4.65	1.16	-13.46
2019 3	6.04	7.17	1.45	-2.58	-5.56	8.16	1.10	-14.83
2019 4	2.35	2.11	1.40	-1.17	-0.24	-1.73	1.06	0.44
2020 1	-3.20	9.19	1.35	-13.74	-1.40	1.23	0.98	-3.61
2020 2	-7.90	-0.71	1.35	-8.54	-5.20	-6.69	0.97	0.51
2020 3	-8.60	-3.27	1.36	-6.69	-3.90	-9.03	0.98	4.15
2020 4	-3.40	-0.85	1.36	-3.91	-2.50	-7.74	0.98	4.26
2021 1	3.00	-3.74	1.33	5.41	-5.80	-8.84	1.35	1.69
2021 2	-0.80	0.65	1.33	-2.78	3.70	-2.31	1.35	4.66
2021 3	7.90	1.82	1.32	4.76	13.40	-2.98	1.34	15.04
2021 4	5.20	3.64	1.31	0.25	-4.80	-0.38	1.33	-5.75
2022 1	0.00	-0.30	-0.54	0.84	-2.40	-4.34	-6.56	8.49

	Manufacturing				Electricity, Water, Gas Supply				Construction			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	1.58	-1.71	1.60	1.69	7.60	0.77	1.21	5.61	-7.12	0.82	1.41	-9.35
2019 2	0.82	1.63	1.54	-2.35	11.68	2.15	1.15	8.39	-2.23	2.67	1.35	-6.25
2019 3	0.65	1.02	1.48	-1.85	-2.34	0.26	1.09	-3.70	-1.99	1.90	1.30	-5.19
2019 4	1.43	-0.68	1.44	0.68	0.53	3.80	1.04	-4.32	1.27	-0.50	1.25	0.52
2020 1	3.60	0.72	1.37	1.51	5.50	4.72	1.05	-0.26	2.70	1.26	1.21	0.23
2020 2	-6.50	-6.49	1.37	-1.38	-2.10	3.58	1.04	-6.72	-1.20	-2.14	1.21	-0.27
2020 3	-1.20	-2.64	1.38	0.06	7.00	6.99	1.05	-1.04	-2.70	0.30	1.22	-4.22
2020 4	-0.10	-3.81	1.38	2.33	6.50	4.24	1.05	1.20	-4.00	-0.76	1.22	-4.45
2021 1	4.50	-3.48	1.37	6.61	4.20	1.24	0.90	2.06	-3.90	-1.61	1.25	-3.53
2021 2	14.10	4.16	1.37	8.58	3.90	3.67	0.89	-0.67	-4.20	2.42	1.24	-7.86
2021 3	5.70	-0.79	1.36	5.14	5.80	-0.84	0.88	5.76	-1.70	-1.04	1.23	-1.90
2021 4	3.90	2.38	1.35	0.17	2.00	-1.64	0.87	2.77	-0.60	1.48	1.22	-3.30
2022 1	3.20	-0.98	-0.82	5.00	1.60	-3.13	0.13	4.60	-2.30	-1.06	-0.82	-0.42

	Wholesale & Retail				Accommodation & Food				Transportation & Storage			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	5.54	0.65	1.47	3.42	3.59	1.36	1.15	1.08	2.91	-0.27	1.27	1.91
2019 2	3.23	2.72	1.41	-0.89	2.86	1.27	1.09	0.50	1.40	1.20	1.20	-1.01
2019 3	3.05	2.87	1.35	-1.17	2.36	3.63	1.04	-2.30	1.43	1.96	1.15	-1.68
2019 4	2.23	0.94	1.31	-0.02	5.49	1.49	0.99	3.01	1.05	-0.50	1.10	0.45
2020 1	0.10	-1.17	1.24	0.03	-14.60	-4.05	0.99	-11.54	-10.60	-0.08	1.06	-11.58
2020 2	-2.90	-5.26	1.24	1.11	-14.70	-9.46	0.99	-6.23	-20.80	-2.92	1.06	-18.95
2020 3	-2.00	-3.09	1.25	-0.15	-16.70	-8.42	1.00	-9.28	-17.90	-1.77	1.07	-17.20
2020 4	-0.50	-5.51	1.25	3.77	-25.70	-11.39	1.00	-15.31	-20.00	-3.58	1.07	-17.49
2021 1	3.00	-4.09	1.23	5.86	-11.90	-10.39	0.83	-2.34	-5.50	-5.69	1.07	-0.88
2021 2	5.60	0.83	1.23	3.54	1.00	-1.57	0.82	1.75	11.30	0.68	1.07	9.56
2021 3	3.40	-2.31	1.22	4.50	-1.10	-3.24	0.81	1.33	5.40	-0.15	1.06	4.50

2021 4	4.20	2.13	1.20	0.86	17.90	3.65	0.80	13.45	11.00	5.70	1.04	4.26
2022 1	3.70	-0.73	-0.63	5.06	15.30	3.20	-0.65	12.75	5.80	7.06	-0.28	-0.98
	Finance/Insurance				Real estate				Information/communication			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	1.89	-6.76	1.41	7.23	0.69	-0.24	1.17	-0.24	4.83	1.60	0.91	2.32
2019 2	3.47	-3.66	1.35	5.78	1.28	1.00	1.11	-0.83	5.29	5.55	0.85	-1.11
2019 3	2.96	-1.94	1.29	3.61	1.63	0.84	1.06	-0.27	3.49	4.19	0.80	-1.49
2019 4	5.25	-1.07	1.25	5.08	2.05	-0.35	1.01	1.39	4.81	1.28	0.75	2.78
2020 1	7.70	8.51	1.19	-2.00	2.10	0.09	0.95	1.06	5.20	3.75	0.71	0.74
2020 2	8.80	4.71	1.19	2.90	2.60	-2.89	0.95	4.54	4.80	-1.70	0.71	5.79
2020 3	10.80	7.63	1.20	1.97	2.90	-1.21	0.96	3.15	3.50	1.48	0.72	1.30
2020 4	10.80	4.76	1.20	4.84	1.40	-1.67	0.96	2.11	4.00	1.00	0.72	2.28
2021 1	9.60	-3.99	1.47	12.12	1.10	-2.06	0.95	2.21	1.40	1.23	0.69	-0.52
2021 2	5.00	0.68	1.47	2.86	1.30	1.71	0.94	-1.35	3.70	7.30	0.68	-4.28
2021 3	6.30	-5.79	1.46	10.63	0.40	-0.26	0.93	-0.27	8.70	3.88	0.67	4.15
2021 4	5.90	3.47	1.45	0.98	0.50	2.49	0.92	-2.91	8.50	7.63	0.66	0.21
2022 1	4.40	2.77	-4.32	5.95	0.50	2.03	0.06	-1.59	4.60	3.73	0.10	0.77

	Professional, scientific & Technical				Business support service				Public administration, defense, social security			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	0.69	1.64	2.02	-2.97	-0.05	-1.88	1.75	0.08	3.43	-6.15	1.30	8.28
2019 2	2.27	5.60	1.95	-5.29	3.93	1.31	1.69	0.93	3.69	-2.20	1.24	4.65
2019 3	2.32	5.78	1.90	-5.35	5.23	2.04	1.63	1.56	4.26	-3.61	1.18	6.68
2019 4	2.58	3.55	1.85	-2.82	5.72	1.29	1.59	2.84	4.05	-2.84	1.14	5.75
2020 1	3.00	6.84	1.80	-5.64	-1.10	2.75	1.51	-5.36	3.20	0.32	1.11	1.76
2020 2	1.30	1.35	1.80	-1.84	-5.40	-3.79	1.51	-3.12	3.20	-0.59	1.11	2.68
2020 3	2.00	3.62	1.80	-3.42	-4.10	-2.89	1.52	-2.73	3.10	5.12	1.12	-3.14
2020 4	2.70	0.53	1.80	0.37	-4.90	-4.70	1.52	-1.72	2.90	5.90	1.12	-4.11
2021 1	3.30	-0.24	1.92	1.62	-0.30	-4.86	1.54	3.02	3.40	4.03	1.01	-1.65
2021 2	3.80	5.12	1.92	-3.24	5.40	1.20	1.54	2.66	3.70	4.68	1.01	-1.99
2021 3	2.00	0.72	1.90	-0.62	2.50	-1.60	1.53	2.57	3.40	0.04	1.00	2.36
2021 4	2.20	5.28	1.89	-4.98	3.30	1.32	1.51	0.47	4.40	-1.69	0.99	5.10

2022 1	1.90	2.15	-0.80	0.55	3.40	-0.38	-0.65	4.43	3.50	0.80	0.03	2.66

	Education				Human health & social work				Cultural & other services			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	1.15	-1.54	1.65	1.03	10.26	0.98	1.55	7.73	-0.33	-2.09	1.41	0.35
2019 2	1.74	3.43	1.59	-3.29	10.63	4.54	1.49	4.60	3.66	2.16	1.35	0.15
2019 3	1.69	2.94	1.53	-2.78	9.43	5.10	1.44	2.89	3.66	2.20	1.30	0.17
2019 4	1.73	-0.20	1.49	0.44	8.93	4.15	1.39	3.39	3.41	2.30	1.25	-0.15
2020 1	-0.30	-1.94	1.39	0.25	4.80	5.11	1.39	-1.70	-10.60	0.84	1.19	-12.63
2020 2	-1.30	-6.53	1.39	3.84	-0.10	0.51	1.39	-2.00	-20.40	-4.36	1.19	-17.23
2020 3	-3.00	-0.72	1.40	-3.68	0.60	3.09	1.39	-3.89	-17.20	-1.61	1.20	-16.78
2020 4	-3.10	-2.98	1.40	-1.52	-0.60	-0.31	1.39	-1.68	-20.00	-4.49	1.20	-16.70
2021 1	1.30	1.05	1.41	-1.16	1.20	0.69	1.52	-1.01	-5.90	-3.69	1.16	-3.37
2021 2	4.70	5.23	1.40	-1.93	5.70	5.09	1.51	-0.90	7.40	0.77	1.16	5.48
2021 3	6.10	0.70	1.39	4.00	6.40	2.01	1.50	2.88	3.00	-4.15	1.15	6.00
2021 4	4.60	5.28	1.38	-2.06	7.40	6.44	1.49	-0.53	8.00	-0.38	1.14	7.24
2022 1	4.50	2.34	-0.13	2.30	8.60	2.76	-0.53	6.37	6.30	-3.42	-0.13	9.85

Estimates of Quarterly TFP by Industry: Model 2

	Agriculture, fishery, and forest				Mining			
	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP
2019 1	4.99	11.94	1.57	-8.51	-10.91	0.99	1.22	-13.12
2019 2	2.40	2.82	1.50	-1.92	-7.65	4.65	1.16	-13.46
2019 3	6.04	7.17	1.45	-2.58	-5.56	8.16	1.10	-14.83
2019 4	2.35	2.11	1.40	-1.17	-0.24	-1.73	1.06	0.44
2020 1	-3.20	9.19	1.35	-13.74	-1.40	1.23	0.98	-3.61
2020 2	-7.90	-0.71	1.35	-8.54	-5.20	-6.69	0.97	0.51
2020 3	-8.60	-3.27	1.36	-6.69	-3.90	-9.03	0.98	4.15
2020 4	-3.40	-0.85	1.36	-3.91	-2.50	-7.74	0.98	4.26
2021 1	3.00	-3.74	1.33	5.41	-5.80	-8.84	1.35	1.69
2021 2	-0.80	0.65	1.33	-2.78	3.70	-2.31	1.35	4.66
2021 3	7.90	1.82	1.32	4.76	13.40	-2.98	1.34	15.04
2021 4	5.20	3.64	1.31	0.25	-4.80	-0.38	1.33	-5.75
2022 1	0.00	-0.30	-0.54	0.84	-2.40	-4.34	-6.56	8.49

	Manufacturing				Electricity, Water, Gas Supply				Construction			
	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP
2019 1	1.58	-1.71	1.60	1.69	7.60	0.77	1.21	5.61	-7.12	0.82	1.41	-9.35
2019 2	0.82	1.63	1.54	-2.35	11.68	2.15	1.15	8.39	-2.23	2.67	1.35	-6.25
2019 3	0.65	1.02	1.48	-1.85	-2.34	0.26	1.09	-3.70	-1.99	1.90	1.30	-5.19
2019 4	1.43	-0.68	1.44	0.68	0.53	3.80	1.04	-4.32	1.27	-0.50	1.25	0.52
2020 1	3.60	0.72	1.37	1.51	5.50	4.72	1.05	-0.26	2.70	1.26	1.21	0.23
2020 2	-6.50	-6.49	1.37	-1.38	-2.10	3.58	1.04	-6.72	-1.20	-2.14	1.21	-0.27
2020 3	-1.20	-2.64	1.38	0.06	7.00	6.99	1.05	-1.04	-2.70	0.30	1.22	-4.22
2020 4	-0.10	-3.81	1.38	2.33	6.50	4.24	1.05	1.20	-4.00	-0.76	1.22	-4.45
2021 1	4.50	-3.48	1.37	6.61	4.20	1.24	0.90	2.06	-3.90	-1.61	1.25	-3.53
2021 2	14.10	4.16	1.37	8.58	3.90	3.67	0.89	-0.67	-4.20	2.42	1.24	-7.86
2021 3	5.70	-0.79	1.36	5.14	5.80	-0.84	0.88	5.76	-1.70	-1.04	1.23	-1.90
2021 4	3.90	2.38	1.35	0.17	2.00	-1.64	0.87	2.77	-0.60	1.48	1.22	-3.30
2022 1	3.20	-0.98	-0.82	5.00	1.60	-3.13	0.13	4.60	-2.30	-1.06	-0.82	-0.42

	Wholesale & Retail				Accommodation & Food				Transportation & Storage			
	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP
2019 1	5.54	0.65	1.47	3.42	3.59	1.36	1.15	1.08	2.91	-0.27	1.27	1.91
2019 2	3.23	2.72	1.41	-0.89	2.86	1.27	1.09	0.50	1.40	1.20	1.20	-1.01
2019 3	3.05	2.87	1.35	-1.17	2.36	3.63	1.04	-2.30	1.43	1.96	1.15	-1.68
2019 4	2.23	0.94	1.31	-0.02	5.49	1.49	0.99	3.01	1.05	-0.50	1.10	0.45
2020 1	0.10	-1.17	1.24	0.03	-14.60	-4.05	0.99	-11.54	-10.60	-0.08	1.06	-11.58
2020 2	-2.90	-5.26	1.24	1.11	-14.70	-9.46	0.99	-6.23	-20.80	-2.92	1.06	-18.95
2020 3	-2.00	-3.09	1.25	-0.15	-16.70	-8.42	1.00	-9.28	-17.90	-1.77	1.07	-17.20
2020 4	-0.50	-5.51	1.25	3.77	-25.70	-11.39	1.00	-15.31	-20.00	-3.58	1.07	-17.49
2021 1	3.00	-4.09	1.23	5.86	-11.90	-10.39	0.83	-2.34	-5.50	-5.69	1.07	-0.88
2021 2	5.60	0.83	1.23	3.54	1.00	-1.57	0.82	1.75	11.30	0.68	1.07	9.56
2021 3	3.40	-2.31	1.22	4.50	-1.10	-3.24	0.81	1.33	5.40	-0.15	1.06	4.50
2021 4	4.20	2.13	1.20	0.86	17.90	3.65	0.80	13.45	11.00	5.70	1.04	4.26
2022 1	3.70	-0.73	-0.63	5.06	15.30	3.20	-0.65	12.75	5.80	7.06	-0.28	-0.98

	Finance/Insurance				Real estate				Information/communication			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	1.89	-6.76	1.41	7.23	0.69	-0.24	1.17	-0.24	4.83	1.60	0.91	2.32
2019 2	3.47	-3.66	1.35	5.78	1.28	1.00	1.11	-0.83	5.29	5.55	0.85	-1.11
2019 3	2.96	-1.94	1.29	3.61	1.63	0.84	1.06	-0.27	3.49	4.19	0.80	-1.49
2019 4	5.25	-1.07	1.25	5.08	2.05	-0.35	1.01	1.39	4.81	1.28	0.75	2.78
2020 1	7.70	8.51	1.19	-2.00	2.10	0.09	0.95	1.06	5.20	3.75	0.71	0.74
2020 2	8.80	4.71	1.19	2.90	2.60	-2.89	0.95	4.54	4.80	-1.70	0.71	5.79
2020 3	10.80	7.63	1.20	1.97	2.90	-1.21	0.96	3.15	3.50	1.48	0.72	1.30
2020 4	10.80	4.76	1.20	4.84	1.40	-1.67	0.96	2.11	4.00	1.00	0.72	2.28
2021 1	9.60	-3.99	1.47	12.12	1.10	-2.06	0.95	2.21	1.40	1.23	0.69	-0.52
2021 2	5.00	0.68	1.47	2.86	1.30	1.71	0.94	-1.35	3.70	7.30	0.68	-4.28
2021 3	6.30	-5.79	1.46	10.63	0.40	-0.26	0.93	-0.27	8.70	3.88	0.67	4.15
2021 4	5.90	3.47	1.45	0.98	0.50	2.49	0.92	-2.91	8.50	7.63	0.66	0.21
2022 1	4.40	2.77	-4.32	5.95	0.50	2.03	0.06	-1.59	4.60	3.73	0.10	0.77

	Professional, scientific & Technical				Business support service				Public administration, defense, social security			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	0.69	1.64	2.02	-2.97	-0.05	-1.88	1.75	0.08	3.43	-6.15	1.30	8.28
2019 2	2.27	5.60	1.95	-5.29	3.93	1.31	1.69	0.93	3.69	-2.20	1.24	4.65
2019 3	2.32	5.78	1.90	-5.35	5.23	2.04	1.63	1.56	4.26	-3.61	1.18	6.68
2019 4	2.58	3.55	1.85	-2.82	5.72	1.29	1.59	2.84	4.05	-2.84	1.14	5.75
2020 1	3.00	6.84	1.80	-5.64	-1.10	2.75	1.51	-5.36	3.20	0.32	1.11	1.76
2020 2	1.30	1.35	1.80	-1.84	-5.40	-3.79	1.51	-3.12	3.20	-0.59	1.11	2.68
2020 3	2.00	3.62	1.80	-3.42	-4.10	-2.89	1.52	-2.73	3.10	5.12	1.12	-3.14
2020 4	2.70	0.53	1.80	0.37	-4.90	-4.70	1.52	-1.72	2.90	5.90	1.12	-4.11
2021 1	3.30	-0.24	1.92	1.62	-0.30	-4.86	1.54	3.02	3.40	4.03	1.01	-1.65
2021 2	3.80	5.12	1.92	-3.24	5.40	1.20	1.54	2.66	3.70	4.68	1.01	-1.99
2021 3	2.00	0.72	1.90	-0.62	2.50	-1.60	1.53	2.57	3.40	0.04	1.00	2.36
2021 4	2.20	5.28	1.89	-4.98	3.30	1.32	1.51	0.47	4.40	-1.69	0.99	5.10
2022 1	1.90	2.15	-0.80	0.55	3.40	-0.38	-0.65	4.43	3.50	0.80	0.03	2.66

	Education				Human health & social work				Cultural & other services			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	1.15	-1.54	1.65	1.03	10.26	0.98	1.55	7.73	-0.33	-2.09	1.41	0.35
2019 2	1.74	3.43	1.59	-3.29	10.63	4.54	1.49	4.60	3.66	2.16	1.35	0.15
2019 3	1.69	2.94	1.53	-2.78	9.43	5.10	1.44	2.89	3.66	2.20	1.30	0.17
2019 4	1.73	-0.20	1.49	0.44	8.93	4.15	1.39	3.39	3.41	2.30	1.25	-0.15
2020 1	-0.30	-1.94	1.39	0.25	4.80	5.11	1.39	-1.70	-10.60	0.84	1.19	-12.63
2020 2	-1.30	-6.53	1.39	3.84	-0.10	0.51	1.39	-2.00	-20.40	-4.36	1.19	-17.23
2020 3	-3.00	-0.72	1.40	-3.68	0.60	3.09	1.39	-3.89	-17.20	-1.61	1.20	-16.78
2020 4	-3.10	-2.98	1.40	-1.52	-0.60	-0.31	1.39	-1.68	-20.00	-4.49	1.20	-16.70
2021 1	1.30	1.05	1.41	-1.16	1.20	0.69	1.52	-1.01	-5.90	-3.69	1.16	-3.37
2021 2	4.70	5.23	1.40	-1.93	5.70	5.09	1.51	-0.90	7.40	0.77	1.16	5.48
2021 3	6.10	0.70	1.39	4.00	6.40	2.01	1.50	2.88	3.00	-4.15	1.15	6.00
2021 4	4.60	5.28	1.38	-2.06	7.40	6.44	1.49	-0.53	8.00	-0.38	1.14	7.24
2022 1	4.50	2.34	-0.13	2.30	8.60	2.76	-0.53	6.37	6.30	-3.42	-0.13	9.85

Estimates of Quarterly TFP by Industry: Model 3

	Agriculture, fishery, and forest				Mining			
	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP
2019 1	4.99	11.94	1.57	-8.51	-10.91	0.99	1.22	-13.12
2019 2	2.40	2.82	1.50	-1.92	-7.65	4.65	1.16	-13.46
2019 3	6.04	7.17	1.45	-2.58	-5.56	8.16	1.10	-14.83
2019 4	2.35	2.11	1.40	-1.17	-0.24	-1.73	1.06	0.44
2020 1	-3.20	9.19	1.35	-13.74	-1.40	1.23	0.98	-3.61
2020 2	-7.90	-0.71	1.35	-8.54	-5.20	-6.69	0.97	0.51
2020 3	-8.60	-3.27	1.36	-6.69	-3.90	-9.03	0.98	4.15
2020 4	-3.40	-0.85	1.36	-3.91	-2.50	-7.74	0.98	4.26
2021 1	3.00	-3.74	1.33	5.41	-5.80	-8.84	1.35	1.69
2021 2	-0.80	0.65	1.33	-2.78	3.70	-2.31	1.35	4.66
2021 3	7.90	1.82	1.32	4.76	13.40	-2.98	1.34	15.04
2021 4	5.20	3.64	1.31	0.25	-4.80	-0.38	1.33	-5.75
2022 1	0.00	-0.30	-0.54	0.84	-2.40	-4.34	-6.56	8.49

	Manufacturing				Electricity, Water, Gas Supply				Construction			
	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP
2019 1	1.58	-1.71	1.60	1.69	7.60	0.77	1.21	5.61	-7.12	0.82	1.41	-9.35
2019 2	0.82	1.63	1.54	-2.35	11.68	2.15	1.15	8.39	-2.23	2.67	1.35	-6.25
2019 3	0.65	1.02	1.48	-1.85	-2.34	0.26	1.09	-3.70	-1.99	1.90	1.30	-5.19
2019 4	1.43	-0.68	1.44	0.68	0.53	3.80	1.04	-4.32	1.27	-0.50	1.25	0.52
2020 1	3.60	0.72	1.37	1.51	5.50	4.72	1.05	-0.26	2.70	1.26	1.21	0.23
2020 2	-6.50	-6.49	1.37	-1.38	-2.10	3.58	1.04	-6.72	-1.20	-2.14	1.21	-0.27
2020 3	-1.20	-2.64	1.38	0.06	7.00	6.99	1.05	-1.04	-2.70	0.30	1.22	-4.22
2020 4	-0.10	-3.81	1.38	2.33	6.50	4.24	1.05	1.20	-4.00	-0.76	1.22	-4.45
2021 1	4.50	-3.48	1.37	6.61	4.20	1.24	0.90	2.06	-3.90	-1.61	1.25	-3.53
2021 2	14.10	4.16	1.37	8.58	3.90	3.67	0.89	-0.67	-4.20	2.42	1.24	-7.86
2021 3	5.70	-0.79	1.36	5.14	5.80	-0.84	0.88	5.76	-1.70	-1.04	1.23	-1.90
2021 4	3.90	2.38	1.35	0.17	2.00	-1.64	0.87	2.77	-0.60	1.48	1.22	-3.30
2022 1	3.20	-0.98	-0.82	5.00	1.60	-3.13	0.13	4.60	-2.30	-1.06	-0.82	-0.42

	Wholesale & Retail				Accommodation & Food				Transportation & Storage			
	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP
2019 1	5.54	0.65	1.47	3.42	3.59	1.36	1.15	1.08	2.91	-0.27	1.27	1.91
2019 2	3.23	2.72	1.41	-0.89	2.86	1.27	1.09	0.50	1.40	1.20	1.20	-1.01
2019 3	3.05	2.87	1.35	-1.17	2.36	3.63	1.04	-2.30	1.43	1.96	1.15	-1.68
2019 4	2.23	0.94	1.31	-0.02	5.49	1.49	0.99	3.01	1.05	-0.50	1.10	0.45
2020 1	0.10	-1.17	1.24	0.03	-14.60	-4.05	0.99	-11.54	-10.60	-0.08	1.06	-11.58
2020 2	-2.90	-5.26	1.24	1.11	-14.70	-9.46	0.99	-6.23	-20.80	-2.92	1.06	-18.95
2020 3	-2.00	-3.09	1.25	-0.15	-16.70	-8.42	1.00	-9.28	-17.90	-1.77	1.07	-17.20
2020 4	-0.50	-5.51	1.25	3.77	-25.70	-11.39	1.00	-15.31	-20.00	-3.58	1.07	-17.49
2021 1	3.00	-4.09	1.23	5.86	-11.90	-10.39	0.83	-2.34	-5.50	-5.69	1.07	-0.88
2021 2	5.60	0.83	1.23	3.54	1.00	-1.57	0.82	1.75	11.30	0.68	1.07	9.56
2021 3	3.40	-2.31	1.22	4.50	-1.10	-3.24	0.81	1.33	5.40	-0.15	1.06	4.50
2021 4	4.20	2.13	1.20	0.86	17.90	3.65	0.80	13.45	11.00	5.70	1.04	4.26
2022 1	3.70	-0.73	-0.63	5.06	15.30	3.20	-0.65	12.75	5.80	7.06	-0.28	-0.98

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	Finance/Insurance	Real estate	Information/communication

	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP	Value-added	Labor	Capital	TFP
2019 1	1.89	-6.76	1.41	7.23	0.69	-0.24	1.17	-0.24	4.83	1.60	0.91	2.32
2019 2	3.47	-3.66	1.35	5.78	1.28	1.00	1.11	-0.83	5.29	5.55	0.85	-1.11
2019 3	2.96	-1.94	1.29	3.61	1.63	0.84	1.06	-0.27	3.49	4.19	0.80	-1.49
2019 4	5.25	-1.07	1.25	5.08	2.05	-0.35	1.01	1.39	4.81	1.28	0.75	2.78
2020 1	7.70	8.51	1.19	-2.00	2.10	0.09	0.95	1.06	5.20	3.75	0.71	0.74
2020 2	8.80	4.71	1.19	2.90	2.60	-2.89	0.95	4.54	4.80	-1.70	0.71	5.79
2020 3	10.80	7.63	1.20	1.97	2.90	-1.21	0.96	3.15	3.50	1.48	0.72	1.30
2020 4	10.80	4.76	1.20	4.84	1.40	-1.67	0.96	2.11	4.00	1.00	0.72	2.28
2021 1	9.60	-3.99	1.47	12.12	1.10	-2.06	0.95	2.21	1.40	1.23	0.69	-0.52
2021 2	5.00	0.68	1.47	2.86	1.30	1.71	0.94	-1.35	3.70	7.30	0.68	-4.28
2021 3	6.30	-5.79	1.46	10.63	0.40	-0.26	0.93	-0.27	8.70	3.88	0.67	4.15
2021 4	5.90	3.47	1.45	0.98	0.50	2.49	0.92	-2.91	8.50	7.63	0.66	0.21
2022 1	4.40	2.77	-4.32	5.95	0.50	2.03	0.06	-1.59	4.60	3.73	0.10	0.77

	Professional, scientific & Technical				Business support service				Public administration, defense, social security			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	0.69	1.64	2.02	-2.97	-0.05	-1.88	1.75	0.08	3.43	-6.15	1.30	8.28
2019 2	2.27	5.60	1.95	-5.29	3.93	1.31	1.69	0.93	3.69	-2.20	1.24	4.65
2019 3	2.32	5.78	1.90	-5.35	5.23	2.04	1.63	1.56	4.26	-3.61	1.18	6.68
2019 4	2.58	3.55	1.85	-2.82	5.72	1.29	1.59	2.84	4.05	-2.84	1.14	5.75
2020 1	3.00	6.84	1.80	-5.64	-1.10	2.75	1.51	-5.36	3.20	0.32	1.11	1.76
2020 2	1.30	1.35	1.80	-1.84	-5.40	-3.79	1.51	-3.12	3.20	-0.59	1.11	2.68
2020 3	2.00	3.62	1.80	-3.42	-4.10	-2.89	1.52	-2.73	3.10	5.12	1.12	-3.14
2020 4	2.70	0.53	1.80	0.37	-4.90	-4.70	1.52	-1.72	2.90	5.90	1.12	-4.11
2021 1	3.30	-0.24	1.92	1.62	-0.30	-4.86	1.54	3.02	3.40	4.03	1.01	-1.65
2021 2	3.80	5.12	1.92	-3.24	5.40	1.20	1.54	2.66	3.70	4.68	1.01	-1.99
2021 3	2.00	0.72	1.90	-0.62	2.50	-1.60	1.53	2.57	3.40	0.04	1.00	2.36
2021 4	2.20	5.28	1.89	-4.98	3.30	1.32	1.51	0.47	4.40	-1.69	0.99	5.10
2022 1	1.90	2.15	-0.80	0.55	3.40	-0.38	-0.65	4.43	3.50	0.80	0.03	2.66

	Education				Human health & social work				Cultural & other services			
	Value-added	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**	**Value-added**	**Labor**	**Capital**	**TFP**
2019 1	1.15	-1.54	1.65	1.03	10.26	0.98	1.55	7.73	-0.33	-2.09	1.41	0.35
2019 2	1.74	3.43	1.59	-3.29	10.63	4.54	1.49	4.60	3.66	2.16	1.35	0.15
2019 3	1.69	2.94	1.53	-2.78	9.43	5.10	1.44	2.89	3.66	2.20	1.30	0.17
2019 4	1.73	-0.20	1.49	0.44	8.93	4.15	1.39	3.39	3.41	2.30	1.25	-0.15
2020 1	-0.30	-1.94	1.39	0.25	4.80	5.11	1.39	-1.70	-10.60	0.84	1.19	-12.63
2020 2	-1.30	-6.53	1.39	3.84	-0.10	0.51	1.39	-2.00	-20.40	-4.36	1.19	-17.23
2020 3	-3.00	-0.72	1.40	-3.68	0.60	3.09	1.39	-3.89	-17.20	-1.61	1.20	-16.78
2020 4	-3.10	-2.98	1.40	-1.52	-0.60	-0.31	1.39	-1.68	-20.00	-4.49	1.20	-16.70
2021 1	1.30	1.05	1.41	-1.16	1.20	0.69	1.52	-1.01	-5.90	-3.69	1.16	-3.37
2021 2	4.70	5.23	1.40	-1.93	5.70	5.09	1.51	-0.90	7.40	0.77	1.16	5.48
2021 3	6.10	0.70	1.39	4.00	6.40	2.01	1.50	2.88	3.00	-4.15	1.15	6.00
2021 4	4.60	5.28	1.38	-2.06	7.40	6.44	1.49	-0.53	8.00	-0.38	1.14	7.24
2022 1	4.50	2.34	-0.13	2.30	8.60	2.76	-0.53	6.37	6.30	-3.42	-0.13	9.85