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Can We Reveal the Growth Potentials with Input-Output Model at Sub-national Level?*

Sung-Goan Choi^{**}, Haemyoung Ji^{***} and Xiaoyun Zhao^{****}

Abstract: The regional growth potential, which frequently appears in economic analyses, is somewhat difficult to handle in practice. Estimation of growth potentials for development forecasting and strategic planning remains actual and meaningful, which is especially true for long-term predictions of structural shifts in the economy, both at national and regional level. The Regional Input-Output (RIO) model has been a powerful tool in applications of the industrial interdependence, impact analysis and policy strategies. Also the RIO model can be attempted to identify leading industries through linkage effects. The backward and forward linkages for the sectors in a single economy provide a mechanism for identifying key or leading sectors. In this study, we try to identify the leading industries by the RIO model along with non-survey techniques to explore growth potentials. The estimated multipliers which represent the backward linkage are compared with the survey based benchmarks through the rank correlation coefficients (Spearman's Rho and Kendall's Tau). From the empirical results, it appears that non-survey techniques may distort the information of regional industrial structure and be incapable for identifying leading industries. This suggests that more cautions might be needed while using LQs to identify the regional leading industries and reveal the growth potentials.

Key words: Growth potential, Input-Output model, Location quotients, Non-survey techniques, Leading industries

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I. Introduction

Perhaps, nowadays, there is not so popular in regional studies and such undeveloped category like 'growth potential'. It is obvious that there is no system-structural conceptions exist so far. However, definition and estimation of growth potentials for regional development forecasting and strategic planning goal remain substantial and meaningful. This is especially true for long-term predictions of structural shifts in the economy, both at national and regional level. In addition, it is helpful to narrow the regional development disparity and build up balanced economic growth framework with the information of regional growth potentials.

The regional growth potential could be diverse due to various factors. The most important one is related to term of 'resources'. Regions may be considered to offer potentially creative resources that may enhance the total factor productivity of all agents concerned, both private and public, as these resources will stimulate innovation in a broad sense (Nijkamp *et al.*, 2008). Consequently, resource diversity may be seen as an explanatory factor for differences in regional performance and growth potential (e.g. income growth per capita and labor force participation). These resources may be diverse in nature, caused by factors such as geographical accessibility, locational advantages, risk-seeking or opportunity-seeking behavior, knowledge intensity, and so forth. It is plausible that resource-rich regions will be prompted to be more creative and to be better performers than less privileged regions with a lower territorial capital-labor intensity. Furthermore, availability and use of productive regional resources are not an exogenously given phenomenon, but may be influenced by deliberate policy actions such as infrastructure policy (e.g. roads and railways), supra-structure policy (e.g. knowledge investments, education, R&D policy and industrial leadership) or institutional policy (e.g. participatory and responsive modes of public policy). The theoretical foundations for this line of thinking can be found in various recent paradigms such as the regional endogenous growth theory, the new economic geography approach, the innovation and entrepreneurship approach or the creative class literature (see, for example, Capello & Nijkamp, 2009).

The fundamental purpose of the Input-Output (IO) framework is to analyze the interdependence of industries in an economy. In its most basic form, an IO model consists of a system of linear equations, each one of which describes the distribution of an industry's product throughout the economy. The IO models can be useful in providing detailed information about an industry's effect both at the national level and regional level. By computing various kinds of multipliers, one can measure the impact of an industry on employment, household income, and the activity level of all industries, which is considerably meaningful for the economic development forecasting (see Burford and Katz, 1981). Researchers usually prefer to build the regional IO tables through adjusting the national ones with the non-survey techniques when the regional information is unavailable to analyze the impact effects and make growth strategic planning at the regional level. The examples can be found in Schaffer (1976), Schaffer and Chu (1969), Jensen (1978), Choi (2010), Zhao and Choi (2012)

etc. On the other hand, the IO model can be attempted to identify leading industries through linkage effects. The backward and forward linkages for the sectors in a single economy provide one mechanism for identifying ‘key’ or ‘leading’ sectors in the economy. Those sectors that are substantial connected and therefore, in some sense, most ‘important’, which, furthermore, could be considered as the sectors with high growth potential. However, due to the shortage of the regional information, the possibility of applying the non-survey techniques in the IO models to deduce ‘key’ sectors for the small regions is still a mystery.

In this study, we try to identify the ‘key’ sectors with growth potential by the IO model combined with non-survey techniques. The estimated multipliers which represent the backward linkage are compared with the survey based benchmarks through the rank correlation coefficients. The empirical study is given on two objective regions to verify the performance of non-survey IO model in revealing growth potentials, in the meantime, the feasibility of identifying ‘key’ sectors with non-survey techniques is demonstrated.

The paper is structured as follows. The second section reviews previous studies on examining the economic significance of sectors with strong inter-industry linkages in promoting regional competitiveness and enhancing the regional development, as well as the introduction of methods to identify ‘key’ sectors within the IO frameworks. The third section addresses the methodology we used here. The introduction of data and empirical test are followed in the fourth section. The final section contains our findings and conclusions.

II. Reviews on previous studies

New policy programs have been predicated on the view that there could be economic value in the identification and promotion of sectors that display strong forward and/or backward linkages in a region. The linkage concept is generalized to the observation that ongoing activities ‘induce’ agents to take up new activities. This effect expresses a linkage between the ongoing and the new activity. The backward linkage effects are related to derived demand, i.e. the provision of input for a given activity. The forward linkage effects are related to output utilization, i.e. the output from a given activity will induce attempts to use this output as inputs in some new activities (Hirschman, 1958).

In the framework of an IO model, production by a particular sector has two kinds of economic effects on other sectors in the economy. If sector j increases its output, this means there will be increased demands from sector j (as a purchaser) on the sectors whose goods are used as inputs to production in j . This is the direction of causation in the usual demand-side model, and the term *backward linkage* is used to indicate this kind of interconnection of a particular sector with those (‘upstream’) sectors from which it purchases inputs. On the other hand, increased output in sector j also means that additional amounts of product j are available to be used as inputs to other sectors for their own production – that is, there will be increased supplies from sector j (as a seller) for the sectors that use good j in their production. This is the

direction of causation in the supply-side model. The term *forward linkage* is used to indicate this kind of interconnection of a particular sector with those ('downstream') sectors to which it sells its output. If the backward linkage of sector *i* is larger than that of sector *j*, one might conclude that the growth potential of sector *i* is higher than sector *j*'s, more specifically, that is, a dollar's worth of expansion of sector *i* output would be more beneficial to the economy than would an equal expansion in sector *j*'s output, in terms of the productive activity throughout the economy that would be generated by it. Similarly, if the forward linkage of sector *r* is larger than that of sector *s*, it could be said that the sector *r*'s growth potential is higher than sector *s*'s, which indicates that the growth of sector *r* is more contributes to the economy. Comparisons of the strengths of backward/forward linkages for the sectors in a single economy provide one mechanism for identifying 'leading industry' in that economy (those sectors that are closely connected and therefore, in some sense, most 'important'), which, further, could be considered as the sectors with high growth potential.

The leading industry refers to a specialized industry or industrial cluster that has/have broad market prospects and strong technical progress ability, represents/represent direction or tendency of industrial structural evolution, can spur and promote the entire regional economic development in a certain period of a local economic development. To push forward development of regional leading industries is a necessary channel for realizing efficient allocation of regional resources, and is the engine to boosting rationalization and high-level of regional industrial structure. The question 'what sector is the most important?' is not a new one. Rasmussen (1956) first tried to answer this question and termed such an industry as 'key industry'. He described that the industry was enjoying high backward linkages while, simultaneously, other industries display a low amount of variance in their dependence upon the industry being measured. At almost the same time, Chenery and Watanabe (1958) noted that two ratios, the ratio of purchased inputs to the value of production and the ratio of intermediate to total demand for a given commodity, can be used to measure the nature of a sector's interdependence with the rest of an economy. Hirschman (1958) put forward these concepts as important considerations for developing economies when targeting industries for future investments, which emphasizes a more dynamic view of the key industry than we need.

However, some caution should be taken with this perspective. Sectors with the highest levels of inter-industry linkage in a region may not be the same as those that make the largest contributions to local employment and incomes (Midmore *et al.*, 2006). Hewings (1982) revealed that a problem with methods used to assess linkage intensities was that they were not always easily connected to the multifaceted goals of regional or national policy. Consequently, sectors of a regional economy that score highly in terms of local inter-industry linkages might score lower on their ability to create employment, or their ability to generate exports or substitute imports (Clements and Rossi, 1991).

It is well admitted that IO analysis is among the most data-ravenous regional economic models. The necessity of collecting enormous amount of data to undertake such analysis has resulted in the development of non-survey techniques which aim to

build in subnational input-output tables without having to undertake the traditional survey exercise. However, on theoretical and empirical grounds, a well-designed and executed survey IO model would be superior to non-survey one. Nevertheless, the enormous time and budgetary outlays required to complete survey regional applications often favor non-survey approaches of generating regional tables. So far, several alternative non-survey and semi-survey techniques for assembling regional input-output tables have been suggested in the literature. Most of them involve a method of adjusting or regionalizing the national coefficients, since regional coefficients are known vary considerably from national ones. A review of these techniques is provided in Miller and Blair (2009), Flegg and Tohmo (2010), Flegg and Webber (1997, 2000) Bonfiglio (2009), among others. Considering both the advantages and disadvantages of non-survey techniques, analysts have to admit that regional IO models become a powerful and analytical tool when the prime purpose of any regional IO application is essentially to assess the impact of local oriented policies or of national policies with regional differentiated impacts (Tzouvelekas and Mattas, 1995). The non-survey techniques are those methods that estimate the regional purchase coefficients through adjusting national technical coefficients, entirely based on the published information on the regional employment, income, or output, by the industry. Examples of such approaches are involved in Schaffer and Chu (1969), Round (1978), Morrison and Smith (1974) and Flegg (1995, 1997, 2010).

Unfortunately, the empirical results show that the various non-survey methods always overestimated regional inter-industry flows significantly, underestimated the exports, and thus overestimated the regional income multipliers. In an effort to address this problem, Flegg *et al.* (1995) proposed a new employment-based location quotient, the Flegg's location quotient (FLQ) formula, which took regional size explicitly into account. They posited an inverse relationship between regional size and the propensity to import from other regions. This FLQ formula was subsequently refined by Flegg and Webber (1997). A further refinement, Augmented Flegg's location quotient (AFLQ), was proposed by Flegg and Webber (2000) which aimed to capture the effect of regional specialization on the magnitude of regional input coefficients. Flegg and Tohmo (2010) examined both input coefficients and type I sectoral output multipliers with 20 survey-based data sets from 1995 which were published by Statistics Finland. The results showed that the FLQ outperformed the conventional LQs. Furthermore, the best single value for estimating multipliers is $\delta = 0.15$ with the minimum mean proportional difference as the criterion. On the other hand, it suggested that a $\delta > 0.15$ might be required if the criteria based on the absolute values for both multipliers and coefficients are used. Choi (2010) estimated the regional multiplier with the non-survey based LQs using 2003 Korean data and compared them to the survey-based multipliers. The findings implied that the FLQ and AFLQ perform better than the conventional LQs. The results showed that the best non-survey LQ is FLQ with a $\delta = 0.6$ for Dae-Gyeong region (Daegu and Gyeongbuk).

Tzouvelekas and Mattas (1995) offered a practical way to measure the regional growth potential with the non-survey techniques. The regional IO tables are generated

from national tables with two widely used non-survey techniques---the Generation of Regional Input-Output Tables (GRIT) and Supply-Demand Pool Analysis (SDP). Then, the multipliers and input-output elasticity are considered as impact indicators to compare. The multipliers are generally accepted to provide the most comprehensive information concerning the economic impact of any change in the level of economic activity in any particular country, nation, or region measure the response of the economy to an exogenous change in the final demand. The input-output elasticity, which incorporates information on the size of the economic sectors whose impacts are analyzed, is to reveal percentage change in the total output, income, or employment of the economy due to percentage changes in the final demand of any sector. The conclusion shows that both techniques provide estimates for the alternative IO indices which are not substantially different and evince almost identical results concerning the identification of the regional key sectors. Besides, it also suggested that a realistic development plan in the future requires a detailed, quantitative analysis not only of the sectoral dynamics (input-output multipliers) but also of the relative capacity of each sector to generate impacts according to its size (input-output elasticity).

Midmore *et al.* (2006) evaluated several alternative methods of assessing inter-industry linkages using IO tables to identify the industries with the potential. In particular, it used financial information from Welsh IO tables for 1995 to derive a measure giving specific insights into regional industry interdependency, and the presence of relatively self-contained groups of activity. This was the first time that this more complex measure had been applied to a regional transactions table in the UK, with the method shown to be of direct relevance to a smaller open economy. The results revealed differences in the rankings of 'key' sectors compared with more conventional approaches. Conclusions discussed the importance of assessing industry interdependencies for the regional strategic planning process, and the problems associated with using IO frameworks for such assessment.

III. Methodology

1. Regional IO modeling: Non-survey techniques

Since the regional information, such as GRDP, income, value-added data are not available at hand, the regional IO tables have to be deduced from national IO tables with Location Quotients (LQs) which is one of non-survey techniques widely used in the process of constructing IO tables recently. All the non-survey techniques are aimed at estimating the regional input coefficients assuming that the regional and the national technologies are identical except for the product mix approach (Miller and Blair, 2009). The regional input coefficient is estimated accordingly: $\hat{r}_{ij} = q_{ij}a_{ij}$, where \hat{r}_{ij} is the estimated regional input coefficient, a_{ij} is the national technical coefficient and q_{ij} represents the degree of modification of the national coefficient which must be less than or equal to unity. If $q_{ij} > 1$, we set: $\hat{r}_{ij} = a_{ij}$. In other words:

$$\hat{r}_{ij} = \begin{cases} q_{ij}a_{ij} & \text{if } q_{ij} \leq 1 \\ a_{ij} & \text{if } q_{ij} > 1 \end{cases}$$

The non-survey techniques can be considered as different ways of estimating q_{ij} , which included the Simple Location Quotient (SLQ), the Cross-Industry Location Quotient (CIQ), the Semi-logarithmic Location Quotient (RLQ), nine versions of the FLQ and nine versions of the AFLQ. The choice of these methods depends on the fact that some of them appear frequently in the literature whereas the others (i.e. the FLQ and, in particular, the AFLQ) are relatively recent and therefore they have not been discussed extensively.

The SLQ is defined as

$$SLQ_i = \frac{E_i^R/E^R}{E_i^N/E^N} = \frac{E_i^R/E_i^N}{E^R/E^N}$$

where i represents a given sector, E is employment, R and N indicate the region and the nation, respectively. As a result of the limitation of the data at a local level, the employment data are often replaced with the output, value added data, and so on. The constraint $SLQ_i = 1$ is imposed when $SLQ_i > 1$. Round (1978) mentioned that the size of the regional input coefficients can be expressed as a function that depends on: (a) the relative size of the regional selling sector compared with that of the nation; (b) the relative size of the regional purchasing sector; (c) the relative size of the region; (d) the additional unspecified factors. From the formula, it is easy to note that the SLQ incorporates the first and the third property. Actually, contrary to expectations, as the relative size of the region decreases, the SLQ increases and the adjustment of national coefficients for regional imports diminishes (Bonfiglio and Chelli, 2008).

The CIQ takes the form as following:

$$CIQ_{ij} = \frac{E_i^R/E_i^N}{E_j^R/E_j^N} = \frac{SLQ_i}{SLQ_j}$$

The CIQ compares the proportion of employment (or national output) of selling industry i in the region to that of purchasing industry j . From the formula, it can be easily noted that the CIQ neglects the relative size of the region. As we discussed above, the size of the regional input coefficients can be expressed as a function that depends on three properties: the relative size of the supplying sector, the purchasing sector, and the relative size of the region. Round (1978) pointed out that SLQ incorporates the first and the third of these variables, whereas CIQ embodies the first two, but not the third, which can be demonstrated easily with the formulas above. In order to capture all three desirable properties simultaneously, he postulated the following semi-logarithmic adjustment formula:

$$RLQ_{ij} = \frac{SLQ_i}{[\log_2(1 + SLQ_j)]} = \frac{E_i^R/E^R}{E_i^N/E^N} / [\log_2 \left(1 + \frac{E_j^R}{E_j^N} * \frac{E^N}{E^R} \right)]$$

It should be noted that the factor $\frac{E^N}{E^R}$ does not cancel out in the above expression – as same as it is in the CIQ, which indicates the relative importance of the region. Also, via the inclusion of both SLQ_i and SLQ_j , it incorporates the relative size of both sectors. As same as the others, the RLQ should not be more than a unit.

The FLQ method is established by Flegg (1995) which combined the merits of the RLQ and CIQ, while avoided their short-comings. The FLQ takes the following form:

$$FLQ_{ij} = \begin{cases} CIQ_{ij} * \lambda & \text{for } i \neq j \\ SLQ_i * \lambda & \text{for } i = j \end{cases}$$

where $\lambda = [\log_2(1 + E^R/E^N)]^\delta$, $0 \leq \delta < 1$, $0 \leq \lambda \leq 1$. The application of the SLQ along the main diagonal is to eliminate the problem of overestimation of the intra-sectoral coefficients. The FLQ is proposed to incorporate the advantages of the CIQ and the SLQ and avoided the relevant shortcomings. The relative size of the selling and purchasing sectors is taken into account through the inclusion of CIQ, whereas the relative size of the region appears in terms of λ . The inclusion of the exponent δ introduces an element of flexibility by altering the convexity of the function λ . A higher value of δ would lower the value of λ and thus greater adjustments of regional imports are made. However, the choice of value of δ is considered to be an empirical matter. The principal advantage of the FLQ may well be that it footers a way of tackling the problem – inherent in other LQ-based approaches – of underestimating regional imports and hence overstating regional multipliers (Flegg and Webber, 2000). On the basis of the studies concerning Peterborough's economy in 1968 (Morrison and Smith, 1974) and Scotland in 1989, Flegg and Webber (1997) found that an approximate value of δ with 0.3 allows the derivation of the closer multipliers to those obtained by the surveys than multipliers obtained by the conventional cross-industry location quotients. However, the authors reminded us that more empirical studies are needed to confirm the value of δ .

The AFLQ formula is a variant of the FLQ, which was conceived to incorporate a measure of regional specialization (Flegg and Webber, 2000). It takes the following form:

$$AFLQ_{ij} = \begin{cases} FLQ_{ij} * [\log_2(1 + SLQ_j)] & \text{for } SLQ_j > 1 \\ FLQ_{ij} & \text{for } SLQ_j \leq 1 \end{cases}$$

where $[\log_2(1 + SLQ_j)]$ has been included to allow for the effects of regional

specialization. If $SLQ_j > 1$ and $FLQ_{ij} > 1$, the national coefficients are scaled upwards. Therefore, the constraint $FLQ_{ij} \leq 1$ is imposed to avoid the upwards scaling.

Zhao and Choi (2012) studied the 2005 industrial construction of Daegu and Gyeongbuk and testified which LQ is the best one to build regional IO table for Daegu and Gyeongbuk with 2005 national IO tables and regional employment data. The conclusion shows that the best LQ is FLQ with $\delta = 0.5$ for Daegu city and FLQ with $\delta = 0.6$ for Gyeongbuk province, respectively. For the convenience of calculation, only FLQ with $\delta = 0.5$ is quoted for Daegu city and $\delta = 0.6$ for Gyeongbuk province in this study.

2. Linkage measurement

A measure of the strength of the backward linkage of sector j is given by the sum of the elements in the j th column of the direct input coefficients matrix \mathbf{A} , namely¹

$$BL(d) = \sum_{i=1}^n a_{ij}$$

Since the coefficients in \mathbf{A} are measures of direct effects only, this is called the *direct backward linkage*. To capture both direct and indirect linkages in an economy, column sums of the Leontief inverse matrix, $\mathbf{L} = [l_{ij}]$, were proposed as a *total backward linkage* measurement, namely,²

$$BL(t) = \sum_{i=1}^n l_{ij}$$

An early measure of direct forward linkage was also proposed, based on \mathbf{A} and \mathbf{L} , as the row sum of $\mathbf{A}\mathbf{i}$, along with an associated total forward linkage measure, the row sum of $\mathbf{L}\mathbf{i}$. Both of these have been viewed with skepticism, because they are generated by a peculiar stimulus --- a simultaneous increase of one unit in the gross outputs of every sector in the case of $\mathbf{A}\mathbf{i}$ and an increase of one unit in the final demands of every sector in the case of $\mathbf{L}\mathbf{i}$.

This dissatisfaction led to the suggestion that elements from the Ghosh model would be more appropriate as forward linkage measures. The row sums of $\mathbf{B}\mathbf{i}$ were suggested as better measures of *direct forward linkage*. In terms of transactions (\mathbf{Z}), this is simply the value of total intermediate sales by sector i ($\sum_{j=1}^n z_{ij}$) as a proportion of the value of i 's total output. In addition, row sums of the Ghosh inverse, $\mathbf{G} = [g_{ij}]$, were suggested as a better measure of *total forward linkages*. Symmetrically, the forward linkages are measured as:³

¹ The definition was first proposed by Chenery and Watanabe (1958).

² The definition was first proposed by Rasmussen (1957).

³ The definition was also first proposed by Chenery and Watanabe (1958).

$$FL(d) = \sum_{j=1}^n b_{ij}$$

$$FL(t) = \sum_{j=1}^n g_{ij}$$

where $\mathbf{B} = [b_{ij}]$ is the Ghosh matrix. (Miller and Blair, 2009)

IV. Empirical analysis

1. The data

The data we employed here is the national input coefficient tables issued by the Bank of Korea (BOK) 2005 based on survey as well as employment data of 2005 issued by the Korean National Statistical Office (KNSO). A brief description of two regions is listed as following.

Table 1. The characteristics of Daegu City and Gyeongbuk Province in 2005 (out of nation)

Region	Population (%)	Output (%)	Employment (%)
Daegu	5.22	2.9	4.72
Gyeongbuk	5.52	8.4	5.44

*Source: Bank of Korea (2008) and National Statistical Office of Korea (2006)

Table 1 and 2 reveal some marked differences in the characteristics of two regions, most notably in terms of their relative size. Regional size can be measured in several different ways and it's expressed with employment data since we have to use the employment as a proxy for regional output data, which are not normally available.

Table 2. The relative size of the industries in Daegu City and Gyeongbuk Province base on employment data

Codes	Sections	Nation	Percentage (%)	Daegu	Percentage (%)	Gyeongbuk	Percentage (%)
1	Agriculture, forestry and fishing	32,294	0.2132	306	0.0428	3,098	0.3762
2	Mining and quarrying	19,372	0.1279	131	0.0183	1,393	0.1692
3	Food, beverages and tobacco products	300,663	1.9849	9,522	1.3323	23,266	2.8253
4	Textile and apparel	378,108	2.4962	37,891	5.3016	23,541	2.8587
5	Wood and paper products	109,157	0.7206	4,739	0.6631	6,687	0.8120

6	Printing and reproduction of recorded media	137,877	0.9102	4,567	0.6390	3,085	0.3746
7	Petroleum and coal products	103,26	0.0682	8	0.0011	202	0.0245
8	Chemicals, drugs and medicines	387,908	2.5609	10,876	1.5218	29,130	3.5373
9	Non-metallic mineral products	107,162	0.7075	2,209	0.3091	13,512	1.6408
10	Basic metal products	126,871	0.8376	4,174	0.5840	26,517	3.2200
11	Fabricated metal products except machinery and furniture	325,472	2.1487	27,248	3.8125	20,301	2.4652
12	General machinery and equipment	362,961	2.3962	17,991	2.5173	15,155	1.8403
13	Electronic and electrical equipment	617,864	4.0790	12,308	1.7221	74,488	9.0453
14	Precision instruments	71,683	0.4732	3,887	0.5439	3,960	0.4809
15	Transportation equipment	372,425	2.4587	16,011	2.2402	19,260	2.3388
16	Furniture and other manufactured products	142,416	0.9402	4,053	0.5671	5,909	0.7175
17	Electricity, gas, steam and water supply	66,370	0.4382	2,419	0.3385	6,245	0.7583
18	Construction	779,864	5.1485	30,666	4.2907	41,123	4.9937
19	Wholesale and retail trade	2,440,701	16.1129	131,073	18.3395	105,070	12.7590
20	Accommodation and food services	1,696,133	11.1975	81,161	11.3559	97,122	11.7938
21	Transportation	881,104	5.8168	40,463	5.6615	37,368	4.5377
22	Communications and broadcasting	138,577	0.9149	5,786	0.8096	5,802	0.7046
23	Finance and insurance	591,969	3.9080	29,293	4.0986	25,954	3.1517
24	Real estate and business services	1,470,397	9.7072	56,735	7.9383	37,237	4.5218
25	Public administration and defense	539,085	3.5589	23,333	3.2647	36,177	4.3931
26	Education, health and social work	1,841,109	12.1546	96,743	13.5361	100,651	12.2223
27	Other services	1,199,603	7.9195	61,110	8.5504	61,247	7.4374
Total		15,147,471	100	714,703	100	823,500	100

2. Empirical results

Our focus on output multipliers is motivated by their importance in regional analysis, along with the fact that many earlier studies have attempted to derive satisfactory estimates of such multipliers. The multipliers which are calculated with LQs have been ranked by the size (see <table 7> and <table 8> in appendix). By attempting to find the leading industries with non-survey methods, the ranks generated by LQs are compared with benchmark which is issued by the BOK. At first sight, the ranks are inconsistent with each other severely. If we pick up five industries with the biggest multipliers as the leading industries in Daegu city, section 23 (Finance and insurance), 27 (Other services), 22 (Communications and broadcasting), 5 (Wood and paper products) and 4 (Textile and apparel) are represented by survey data. Meanwhile, the non-survey method produced very different outcomes. The SLQ shows that the section 15, 12, 4, 11 and 5 are primary industries and the CIQ confirms section 10, 13, 15, 16 and 8 meanwhile the RLQ marks section 10, 15, 13, 16 and 12. It is more skeptical that section 7, 2, 16, 1 and 4 are voted by the FLQ which is known as the best non-survey method to generate the regional IO table (See <table 3>). It turns out

that the relative smallest industry (section 7, Petroleum and coal products) is accompanied with the largest multiplier. In order to capture the difference of rankings more deeply, rank correlation coefficients are employed to expose this chaos. <Table 5> shows the correlation on the Spearman's rho and Kendall's tau. The values of correlation coefficient indicate that the ranking orders are totally irrelevant with each other, except the coefficient between CIQ and RLQ, which is represented by the value of 0.943 on Kendall's tau and 0.991 on Spearman's rho. As a matter of fact, it is not surprising that CIQ and RLQ produce the similar output since their formulas show clearly that RLQ is an extensive version of CIQ. The discussion so far has focused on statistics of Daegu city, so we might need take a look at the results on the Gyeongbuk province and see whether it generate comparable results. <Table 4> provides the five industries with the biggest multipliers by each of LQs. <Table 6> describes the rank correlation coefficients of Gyeongbuk province. Despite the fact that Gyeongbuk province is bigger than Daegu city geographically, it gives only slightly better results. The significant values indicate that there are certain connections between survey method and non-survey methods, say, 0.436 of Kendall's tau and 0.590 of Spearman's rho between benchmark and SLQ as well as equivalent amount between benchmark and others. However, they are not as plausible as we expect.

Under this circumstance, it appears that non-survey methods may not be a suitable proxy to determine the leading industries at the sub-national level, furthermore, the results from the rank correlation indicates that LQs might have distorted the regional industrial structures from the begin. A larger amount of previous studies explored the performance and capability of LQs in constructing regional input-output tables as well as estimation of the regional inter-/intra-industrial impact effects in the last decades. Examples can be seen in Bonfiglio (2009), Dietzenbacher and Miller (2009), Flegg and Webber (1997, 2000), Lahr (1993), Miller and Blair (2009) and so on. However, few of them have focused on the ability of LQs on reflecting the industrial structure. Indeed, the non-survey methods offer a cost-effective way of building the foundations of a hybrid model, argued by Flegg, and LQ-generated coefficients can be used as the initial values in the application of the RAS iterative procedure. From this study, however, the non-survey methods obviously fail to construct regional IO tables since they may distort the industrial structure severely, especially for Daegu city. In addition, this problem is not the first time appears here. Examples can be found in other reference as well, such as Flegg and Webber (1997, 2000), Flegg and Tohmo (2010) *etc.* One of the explanations might be the failure of LQs to capture the regional specialization. Besides, the accuracy of the survey data also requires special scrutiny since this is second time for the BOK, unlike national survey IO tables, issued the regional survey data and first time issued the survey data for 16 regions (The BOK issued 2003 regional survey data for 6 regions and 2005 data for 16 regions).

Table 3. The industries with the biggest five multipliers of Daegu City

Rank	Benchmark	SLQ	CIQ	RLQ	FLQ
1	23	15	10	10	7
2	27	12	13	15	2
3	22	4	15	13	16
4	5	11	16	16	1
5	4	5	8	12	4

Table 4. The industries with the biggest five multipliers of Gyeongbuk Province

Rank	Benchmark	SLQ	CIQ	RLQ	FLQ
1	10	10	15	15	10
2	11	13	12	10	7
3	3	15	10	12	11
4	12	11	11	11	12
5	15	8	16	16	15

Table 5. The Rank correlation of Daegu

Spearman's rho						Kendall's tau_b					
Correlation coefficient	BK	SLQ	CIQ	RLQ	FLQ	Correlation coefficient	BK	SLQ	CIQ	RLQ	FLQ
BK	1.000					BK	1.000				
SLQ	.315	1.000				SLQ	.219	1.000			
CIQ	.073	.407*	1.000			CIQ	.043	.299*	1.000		
RLQ	.114	.476*	.991**	1.000		RLQ	.077	.356**	.943**	1.000	
FLQ	.240	-.139	.559**	.572**	1.000	FLQ	.162	-.071	.390**	.413**	1.000

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

*** FLQ is estimated with $\delta=0.5$.

Table 6. The Rank correlation of Gyeongbuk

Spearman's rho						Kendall's tau_b					
Correlation coefficient	BK	SLQ	CIQ	RLQ	FLQ	Correlation coefficient	BK	SLQ	CIQ	RLQ	FLQ
BK	1.000					BK	1.000				
SLQ	.590**	1.000				SLQ	.436**	1.000			
CIQ	.623**	.761**	1.000			CIQ	.453**	.573**	1.000		

RLQ	.602**	.813**	.984**	1.000	RLQ	.430**	.664**	.909**	1.000		
FLQ	.484*	.505**	.808**	.819**	1.000	FLQ	.390**	.407**	.607**	.630**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

*** FLQ is estimated with $\delta=0.6$.

V. Summary and conclusions

There is a wildly growing belief that regional economic development has to be considered as a strictly integrated process involving not only one particular sector but a whole range of economic activities. Several sectors, closely interconnected, can be expanded to provide as impulse to the regional economic engine. A various studies suggest that identification and promotion of leading industries that display strong forward and/or backward linkages in a region could contribute to the analysis of regional economic development. Furthermore, it helps with the regional new strategic policy programs. The IO models have been proved to be useful in providing detailed information about an industry's effect both at the national level and regional level. By computing various kinds of multipliers, one can measure the impact of an industry on employment, household income, and the activity level of all industries, which is considerably meaningful for the economic development forecasting. Researchers usually prefer to build the regional IO tables through adjusting the national ones with the non-survey techniques when the regional information is unavailable to analyze the impact effects and make growth strategic planning at the regional level. The examples can be found in Schaffer (1976), Schaffer and Chu (1969), Jensen (1978), Choi (2010), Zhao and Choi (2012) *etc.* On the other hand, the IO model can be attempted to identify leading industries through linkage effects. The backward and forward linkages for the sectors in a single economy provide a mechanism for identifying 'key' sectors or 'leading' industries in the economy. Those sectors that are most connected and therefore, in some sense, most 'important', which, further, could be considered as the sectors with high growth potential. However, due to the shortage of the regional information, is it possible to apply the non-survey techniques in the IO models to deduce the 'key' sectors for the small regions? In this article, we try to identify the leading industries by the IO model along with non-survey techniques to explore their growth potential. The estimated multipliers which represent the backward linkage are compared with the survey based benchmarks through the rank correlation coefficients. The empirical study is given on two objective regions to verify the performance of non-survey IO model in revealing regional growth potentials. In the meantime, the feasibility of identifying key sectors with non-survey techniques is demonstrated.

Based on the empirical test, it appears, unfortunately, that non-survey techniques may distort the information of regional industrial structure and be incapable for identifying leading industries. Given by the empirical results, the low rank correlation coefficients between benchmarks and estimated backward linkages indicate that all of the non-survey techniques may not be a suitable proxy to identify the 'key' sectors,

since the industrial structure couldn't be reflected correctly. However, despite of the fact that few demonstrations have been provided to illustrate whether the non-survey techniques can reflect industrial structure properly, it has been well admitted that the non-survey techniques have been a powerful tool to analyze the regional impact effects since they offer a low cost and time-saving options to construct regional IO tables or build the initial foundations for the hybrid IO models. Above all, it's highly suggested that more cautions may need while using LQs to identify the regional leading industries and reveal the growth potentials.

In order to explore the growth potential, it is also expected to be valuable for a more comprehensive analysis that examines the perspectives provided on 'key' sectors at the sub-national level by IO model combined with non-survey methods in the future research. In revealing growth potential with 'key' sectors, structural inter-linkages are one issue among many. In particular, it should be recognized that measures of linkage are abstracted completely from the levels of activity in the sectors identified. It is suggested that a multi-sectoral qualitative analysis of growth sectors may need to provide various information about industries together with an analysis of the characteristics of the objective region. Such methods are expected to reveal perspectives on regional and industrial core competencies, risk and linkage possibilities, which should be useful on policy-making. In the meantime, more indicators may be helpful of identifying 'key' sectors rather than only backward linkage.

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Table 7. The multipliers and ranking of Daegu City

Codes	Sectors	Benchmark	Rank	M_SLQ	Rank	M_CIQ	Rank	M_RLQ	Rank	M_FLQ5	Rank
1	Agriculture, forestry and fishing	1.205959	19	1.184065	26	1.764112	18	1.703726	18	1.357320	4
2	Mining and quarrying	1.287227	7	1.215625	25	1.692745	20	1.672649	20	1.441415	2
3	Food, beverages and tobacco products	1.231959	16	1.728464	16	1.851531	16	1.778264	17	1.176530	20
4	Textile and apparel	1.291328	5	2.443078	3	1.892850	13	1.980266	11	1.304117	5
5	Wood and paper products	1.318034	4	2.353779	5	2.336994	7	2.278142	6	1.224289	13
6	Printing and reproduction of recorded media	1.287471	6	1.837339	13	2.197530	9	2.122916	9	1.252240	8
7	Petroleum and coal products	1.150909	27	1.022263	27	2.214128	8	2.175143	8	1.943801	1
8	Chemicals, drugs and medicines	1.190289	21	1.787259	15	2.465943	5	2.243726	7	1.205708	14
9	Non-metallic mineral products	1.250560	12	1.511680	23	2.083493	10	1.972267	12	1.277315	7
10	Basic metal products	1.163804	23	2.124505	7	3.105518	1	2.738311	1	1.200928	15
11	Fabricated metal products except machinery and furniture	1.244405	13	2.442125	4	1.881837	14	1.944317	13	1.185841	19
12	General machinery and equipment	1.281484	8	2.566591	2	2.392040	6	2.339907	5	1.232517	12
13	Electronic and electrical equipment	1.231834	17	1.549671	22	2.890316	2	2.528776	3	1.280300	6
14	Precision instruments	1.243964	14	2.334595	6	2.047560	11	2.023845	10	1.189998	17
15	Transportation equipment	1.264035	10	2.597485	1	2.738541	3	2.615276	2	1.235151	10
16	Furniture and other manufactured products	1.239892	15	1.871511	11	2.505348	4	2.392201	4	1.383579	3
17	Electricity, gas, steam and water supply	1.151237	26	1.655352	18	1.522675	26	1.486513	26	1.102377	27
18	Construction	1.214560	18	1.866640	12	1.938042	12	1.875973	14	1.195989	16
19	Wholesale and retail trade	1.276710	9	1.719990	17	1.568066	24	1.575912	23	1.162952	21
20	Accommodation and food services	1.190356	20	1.982173	8	1.707612	19	1.691167	19	1.136752	26
21	Transportation	1.162436	24	1.906678	10	1.676432	21	1.660693	21	1.141557	25
22	Communications and broadcasting	1.331486	3	1.792755	14	1.854496	15	1.817007	16	1.188760	18
23	Finance and insurance	1.424420	1	1.630294	20	1.574296	23	1.572089	24	1.141951	24
24	Real estate and business services	1.161757	25	1.483833	24	1.556306	25	1.532773	25	1.156274	22
25	Public administration and defense	1.253510	11	1.636368	19	1.628258	22	1.610017	22	1.232673	11
26	Education, health and social work	1.174343	22	1.587017	21	1.473388	27	1.466539	27	1.149448	23
27	Other services	1.332443	2	1.980861	9	1.829083	17	1.820677	15	1.246388	9

*M_SLQ means multiplier based on SLQ.

Table 8. The multipliers and ranking of Gyeongbuk province

Codes	Sectors	Benchmark	Rank	M_SLQ	Rank	M_CIQ	Rank	M_RLQ	Rank	M_FLQ6	Rank
1	Agriculture, forestry and fishing	1.23591073	20	1.955191	17	1.631906	22	1.743331	21	1.125638	26
2	Mining and quarrying	1.28344963	15	1.866539	18	1.585677	25	1.620656	23	1.157299	23
3	Food, beverages and tobacco products	1.51242591	3	2.497077	9	2.18046	12	2.256533	12	1.210285	16
4	Textile and apparel	1.34132719	9	2.701693	8	2.441723	8	2.470175	10	1.227836	14
5	Wood and paper products	1.28860358	14	2.76642	7	2.502048	6	2.533343	8	1.231138	13
6	Printing and reproduction of recorded media	1.27719352	16	1.583483	24	2.318938	11	2.257567	11	1.350843	7
7	Petroleum and coal products	1.08675645	27	1.477798	26	2.158784	13	2.168304	13	1.603479	2
8	Chemicals, drugs and medicines	1.21268666	22	2.868383	5	2.428184	9	2.482271	9	1.240462	12
9	Non-metallic mineral products	1.27240586	17	2.464075	11	1.790943	19	1.959686	16	1.205722	18
10	Basic metal products	1.7251674	1	3.488091	1	2.772804	3	2.967712	2	2.0094	1
11	Fabricated metal products except machinery and furniture	1.59889477	2	3.0257	4	2.628797	4	2.713019	4	1.595915	3
12	General machinery and equipment	1.458773	4	2.48615	10	2.779396	2	2.770083	3	1.521001	4
13	Electronic and electrical equipment	1.24720839	19	3.043455	3	2.405193	10	2.561592	6	1.345051	8
14	Precision instruments	1.32750553	10	2.839473	6	2.494346	7	2.544218	7	1.323239	9
15	Transportation equipment	1.44568759	5	3.143619	2	2.988781	1	3.014434	1	1.394125	5
16	Furniture and other manufactured products	1.36880693	6	2.383048	12	2.622273	5	2.629722	5	1.393978	6
17	Electricity, gas, steam and water supply	1.20556325	23	2.1573	15	1.750592	20	1.870759	19	1.144565	25
18	Construction	1.36015906	7	2.333619	13	2.102816	14	2.143963	14	1.314447	10
19	Wholesale and retail trade	1.26930669	18	1.608866	23	1.671966	21	1.643759	22	1.16477	22
20	Accommodation and food services	1.32448411	11	2.285956	14	2.061786	15	2.096703	15	1.189394	19
21	Transportation	1.14355713	26	1.82172	19	1.924616	17	1.880847	18	1.154568	24
22	Communications and broadcasting	1.31545464	12	1.73795	21	1.865955	18	1.830825	20	1.181403	20
23	Finance and insurance	1.3110198	13	1.50196	25	1.578734	26	1.545622	27	1.114112	27
24	Real estate and business services	1.17845935	24	1.350823	27	1.622729	23	1.60726	25	1.208833	17
25	Public administration and defense	1.21770333	21	1.746642	20	1.574307	27	1.59873	26	1.211381	15
26	Education, health and social work	1.17479681	25	1.722073	22	1.599654	24	1.608703	24	1.166421	21
27	Other services	1.34798565	8	2.045023	16	1.931749	16	1.933743	17	1.248848	11