

An Analysis of Regional Export Competitiveness using Export Structure Sophistication Index: With a focus on Gyeongnam

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1. Introduction

Korea, a small open economy, is characterized by its high dependency on the international environment and this also applies at the municipal level. In the past, Korea's economy grew by exporting goods of its main industries and in this process, certain strategically selected provinces paved the way in developing the region and Korea's economy by acting as an exporting foothold.

One such province, Gyeongnam, has consistently increased its export volume, ranking

third amongst the country's regions only behind Ulsan and Gyeong-gi in 2011 and has been a leading player in bringing wealth into the country. At that time, exports accounted for around 80 percent of Gyeongnam's GRDP, reflecting the high trade dependency of the region. However, the role of trade in Gyeongnam has diminished over time and now its export volume recently ranked 7th in the country in 2018. Furthermore, its export growth has fallen short of its total GRDP growth raising concerns about the role of trade in the region's growth.

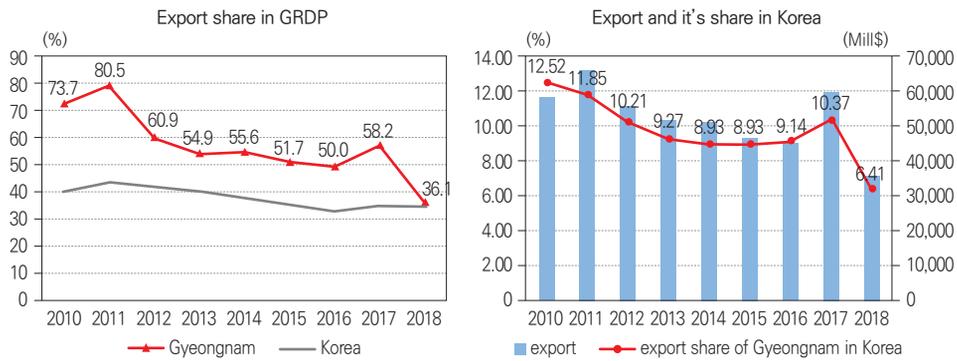
Table 1. Export Changes in Five Major Export Regions in Korea

Unit: million USD

	2001		2011		2018	
	Exports	Rank	Exports	Rank	Exports	Rank
Korea	150,437		555,187		604,860	
Gyeong-gi	29,946	1	87,557	2	143,338	1
Seoul	29,155	2	56,003	5	64,618	4
Ulsan	19,951	3	101,480	1	70,127	3
Gyeongnam	17,134	4	65,807	3	40,257	7
Gyeongbuk	14,462	5	52,129	6	40,891	5

Source: KITA database.

Figure 1. Export Change in Gyeongnam



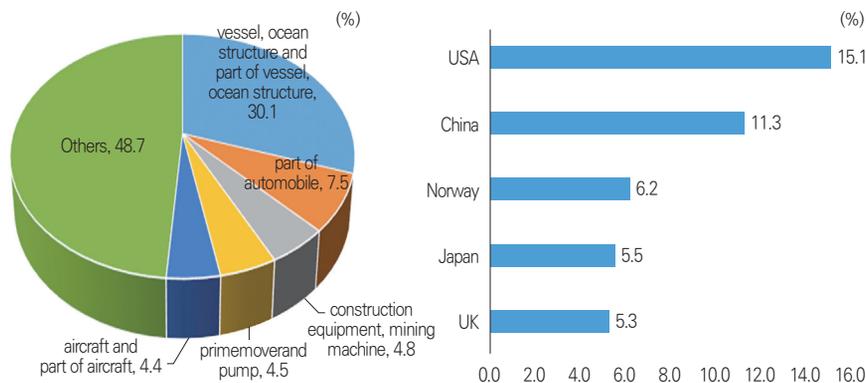
Source: KITA database.

The reasons for this decrease in exports can be explained by the increase in US protectionism, China's growth slowdown and structural reform and changes due to diversification of the global supply chain. Gyeongnam's exports, in particular, are highly biased to a few products and countries. For example, more than 30 percent of the region's exports are related to shipping whilst exports to the US and China each take up 15.1 percent and 11.3 percent of its exports, showcasing its serious dependency

on the two countries. These characteristics make Gyeongnam's exports more likely to be highly and directly vulnerable to international factors, such as changes in industry or the country's economy. As such, for Gyeongnam to gain competitiveness in the changing international trade environment, its export structure must encompass higher value-added and high-tech products.

This paper aims to diagnose and analyze Gyeongnam's export structure and through

Figure 2. Characteristics of Gyeongnam's Export Composition



Source: KITA database.

this try to find lessons to help increase the region's trade competitiveness. In sum, the paper aims to learn how Gyeongnam can change its export structure to move up the value chain by utilizing preexisting resources such as labor and technology to their fullest.

2. Gyeongnam's Export Structure and Sophistication level

(1) Prody Index

To diagnose the level of sophistication of a region's export composition, the Prody index as introduced by Hausmann et al (2006) can be applied. This index, developed to measure the level of technology and factor intensities of exports, uses the revealed comparative advantage of an export commodity and the income level of the exporting country.

The Prody index can be defined as the weighted average of the GDP per capita of countries (Y_j) exporting each commodity. The weights are assigned by the revealed comparative advantage (RCA) possessed by each country regarding the commodity. The RCA that a country has of a certain commodity l is calculated as the share of a country's exports out of the total exports of commodity l .

$$prody_l = \sum_j \frac{(x_{jl}/X_j)}{\sum_j (x_{jl}/X_j)} Y_j$$

The higher the per capita GDP and the

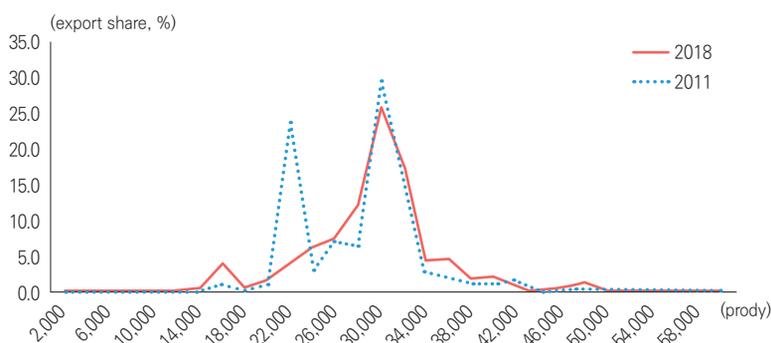
higher the RCA of a country, the higher the Prody level. This is based on the assumption that if countries with higher incomes levels have more comparative advantage over the commodity, it must imply that that a certain commodity requires higher-skilled labor and productivity. On the contrary, if lower-income countries have a comparative advantage over the commodity, it implies the commodity is more likely to be low-skill labor intensive. Therefore, a commodity which requires more advanced and sophisticated technology is assigned a higher level of Prody index, implying more competitiveness.

As such, this paper will calculate the level of sophistication of Gyeongnam's export products, Prody, and based on this, analyze the export composition of Gyeongnam.

(2) Gyeongnam's Export Sophistication

Comparing the export sophistication of Gyeongnam with its income level, the results show that Gyeongnam's export composition is less sophisticated compared to the level of its economy. When considering Gyeongnam's income level, the expected technology level is higher than what is actually exported. Gyeongnam's GDP per capita based on PPP is 34,906 USD, and a large 88 percent of its exports have sophistication levels that are lower than what is expected at that income level. Only a mere 12 percent of exports have sophistication levels that surpass its expected

Figure 3. Changes in Gyeongnam's Export Sophistication level



Source: KITA database.

Note: Calculated using Gyeongnam 2011 and 2018 export data.

sophistication level.

However, one thing to note is that the export sophistication level has generally been on the rise since 2011. In 2011, exports with sophistication levels below 30,000 USD took up 73 percent of Gyeongnam's share, whereas by 2018 the share had fallen to 64 percent. The

share of exports of the 34,000 to 40,000 USD range in 2018, in particular, had increased to nearly twice of that of 2011.

When looking at the individual commodity level, the average sophistication level (Prody index) of the top ten export commodities when ranked by volume in 2018 was 27,263

Table 2. Export Share and Sophistication of Gyeongnam's Top Ten Exports (2018)

SITC	Commodity	Export share (percent)	Prody Index (\$)	Related industry
79322	Tankers of all kinds	12.6	31,952	Building of ships and boats
79327	Other vessels for the transport of goods	6.9	28,627	Building of ships and boats
79355	Floating, submersible drilling, production platforms	6.1	28,532	Building of ships and boats
78439	Other parts and accessories	3.8	22,813	Manufacture of motor vehicles
72322	Mechanical shovels, excavators and shovel loaders	3.3	29,114	Manufacture of Machinery
79329	Other vessels	3.0	14,919	Building of ships and boats
79295	Other parts of airplanes or helicopters	2.8	27,127	Manufacture of other transport equipment
6251	Tires, pneumatic, new, of a kind used on motor cars	2.1	25,089	Manufacture of chemicals and chemical products
7812	Motor vehicles for the transport of persons	1.9	29,738	Manufacture of motor vehicles
73131	Horizontal lathes, numerically controlled	1.5	35,721	Manufacture of Machinery

Source: Calculated based on KITA and UN Comtrade data.

Note: Classification and classification names are based on SITC Rev4.

Each classification is matched to its relevant industry based on UN Comtrade SITC-HS code reference table and Bank of Korea (2016)

Table 3. Gyeongnam's Top Ten Classifications Ranked by Sophistication (2018)

SITC	Commodity	Export share (percent)	Prody Index (\$)	Related industry
77256	Connectors for optical fibers, optical fiber bundles or cables	0.001	83,289	Manufacture of electronic components and electrical machinery
88532	Other wrist-watches	0.000	70,985	Manufacture of Precision instruments
68261	Copper foil	0.073	70,479	Manufacture of non-ferrous metals
67686	Sheet piling of iron or steel	0.028	69,324	Manufacture of steel products
67682	U,I,H,L,T Sections	0.010	67,707	Manufacture of steel products
64178	Gummed or adhesive paper and paperboard	0.000	67,310	Manufacture of wood and products of wood
67443	Plated or coated with aluminium	0.002	66,157	Manufacture of steel products
72851	Parts for the machines of heading 728.41	0.001	64,872	Manufacture of Machinery
65793	Tire cord fabric of high tenacity yarn	0.003	63,723	Manufacture of textile and wearing apparel
34310	Natural gas, liquefied	0.000	62,670	Manufacture of chemicals and chemical products

Source: Calculated based on KITA and UN Comtrade data.

Note: Classification and classification names are based on SITC Rev4.

Each classification is matched to its relevant industry based on UN Comtrade SITC-HS code reference table and Bank of Korea (2016).

Table 4. Export Share and Sophistication Level of Each Industry in Gyeongnam (2018)

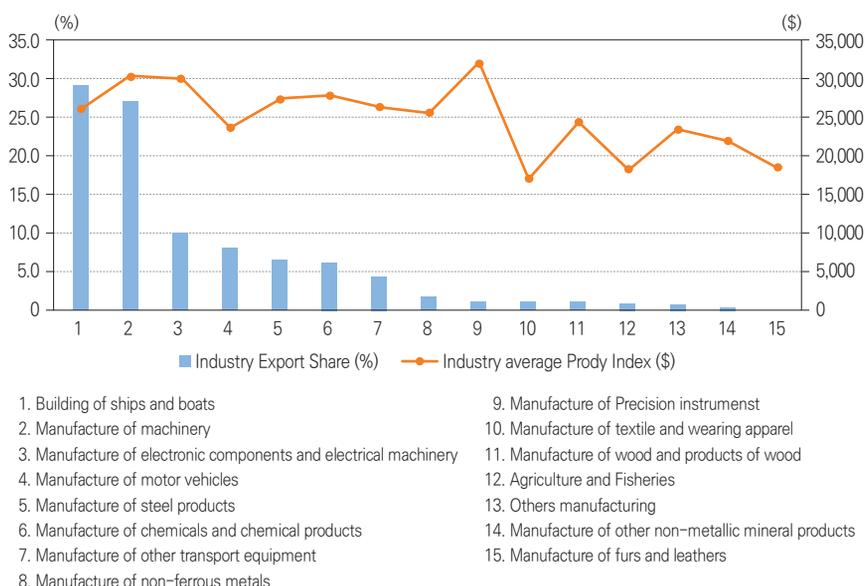
Industry	Industry-average Export Share (percent)	Industry-average Prody Index (\$)
Building of ships and boats	29.3	25,944
Manufacture of machinery	27.1	30,440
Manufacture of electronic components and electrical machinery	10.0	29,944
Manufacture of motor vehicles	7.9	23,640
Manufacture of steel products	6.5	27,402
Manufacture of chemicals and chemical products	6.1	27,809
Manufacture of other transport equipment	4.3	26,278
Manufacture of non-ferrous metals	1.7	25,315
Manufacture of Precision instruments	1.1	32,030
Manufacture of textile and wearing apparel	1.0	17,003
Manufacture of wood and products of wood	0.9	24,393
Agriculture and Fisheries	0.9	18,203
Other manufacturing	0.6	23,476
Manufacture of other non-metallic mineral products	0.3	21,894
Manufacture of furs and leathers	0.0	18,592

Source: Calculated based on KITA and UN Comtrade data.

Note: Classification and classification names are based on SITC Rev4.

Each classifications is matched to its relevant industry based on UN Comtrade SITC-HS code reference table and Bank of Korea (2016).

Figure 4. Export Share and Sophistication Level of Each Industry in Gyeongnam



USD and accounted for 44 percent of total exports (Table 2). Amongst those ten, numerically controlled horizontal lathes (SITC 73131) had the highest level of sophistication but took up just 1.5 percent of total exports. When looking at the commodities with the highest sophistication index, most of them had sophistication levels of at least 60,000 USD, but their share out of total exports was only 0.1 percent (Table 3).

When classifying exports based on industries, shipping, which takes up that largest amount of Gyeongnam's total exports, has a sophistication level of only 25,944 USD (Table 4). Considering the fact that the sophistication level of Gyeongnam's whole export basket is 28,423 USD, shipping, one of the province's main industries, has a comparatively low sophistication level.

Industries that show sophistication levels higher than Gyeongnam's average are manufactures of machinery, electronic components and electrical machinery and precision instruments. Of these three, export volumes of machinery and electronic components and machinery exports are the second and third-highest of its total exports. While these two take up a relatively large part of Gyeongnam's exports, however, the export volume of precision instruments, which requires the highest level of sophistication, takes up only 1.1 percent.

The following results show that Gyeongnam's exports are composed mostly of products with low levels of sophistication. In other words, Gyeongnam tends to export commodities of low value added and low technology.

3. Potential for Export Transition

(1) Method of Analysis

For a region to attain global competitiveness using its current resources, it needs to use production capabilities that are inherent in currently-exported goods to develop new products with higher levels of value added and technology, resulting in a concentration of the region’s capabilities in products with a higher level of sophistication.

In this section, we explore the probability of export transition to the commodities that have higher proximity to Gyeongnam’s current export commodities and at the same time have higher sophistication level than current ones. Having high export proximity means that certain commodities have a greater chance of appearing in the same export basket simultaneously, which in turn implies similar factors of productions such as inputs, technology, and knowledge. As such, if a commodity has a higher proximity to commodities that are already being exported, it means preexisting resources are mainly being utilized, so it will be more efficient to shift to such commodities, compared to commodities of low proximity. Meanwhile, for the newly-expanded range of export commodities to be competitive in the global market, it is critical to have high levels of technology and productivity. As such, this paper aims to calculate the probability of moving towards higher technology and value

added export commodities by using preexisting resources; in other words, commodities with higher sophistication level that also has high proximity to current commodities.

First, export commodities with high proximity are found by using the concept of product space introduced by Hidalgo et al (2007). Proximity is an index that indicates the revealed similarities of products in the export market, for example, whether products are sold in the same market or require the same infrastructure. A higher index implies it is easier to transition between two exports using previously-accumulated capabilities and resources.

The product space of two products, p and p' , are calculated using the RCA of each product (Equation 1). $P(RCA_p > 1 | RCA_{p'} > 1)$ is the probability that an exporting country’s comparative advantage over product p' will be higher than 1 if its comparative advantage of p is higher than 1 as well. RCA_p is the relative comparative advantage over product p and is calculated using the methodology introduced by Balassa (1965) (Equation 2).

$$\phi_{p,p'} = \min\{P(RCA_p > 1 | RCA_{p'} > 1), P(RCA_{p'} > 1 | RCA_p > 1)\} \quad \text{(Equation 1)}$$

$$RCA_{cp} = \left(\frac{X_{cp}}{\sum_p X_{cp}}\right) / \left(\frac{\sum_c X_{cp}}{\sum_p \sum_c X_{cp}}\right) \quad \text{(Equation 2)}$$

Amongst the export commodities that are deemed to have a high proximity to Gyeongnam’s main export commodities, the paper

aims to find which one of these has a higher sophistication level than current export commodities. The probability of export transition to a higher sophistication level, which ranges from 0 to 1, is the probability that a commodity's proximity to current commodities is above average and at the same time has a higher level of sophistication (i.e., higher level of Prody index). The higher the transition probability, the higher the possibility of diversifying into more sophisticated commodities.

$$\text{Transition Probability}_p = P(\text{prody}_{p'} > \text{prody}_p | Q_{p,p'} > \bar{Q}_p)$$

prody_p : the sophistication level of product p ,

$Q_{p,p'}$: the proximity of p and p' ,

\bar{Q}_p : the average proximity of p and other commodities

(2) Results

The average proximity of all of Gyeongnam's exports goods is 0.16. Among industries, machinery and motor vehicle manufacturing exhibit higher proximity compared to other industries whilst the proximity of agriculture and furs and leathers manufacturing is relatively low.

The probability of transition towards more sophisticated commodities is on average 0.64. The textile industry has the highest probability, 0.85, while it is lowest for the precision instruments industry. The precision instruments

and machinery manufacturing industry has a high proximity level with other industries but it seems it is difficult to transition into an even higher level of sophistication. On the other hand, the shipping industry, which takes up the largest portion of Gyeongnam's exports, has a transition probability of 0.66, which is slightly above the average of 0.64 (Table 5).

The transition probability of Gyeongnam's top ten exports averages around 0.6. Most of Gyeongnam's top ten exports comprise transportation manufacturing industries such as shipping and automobiles, but they exhibit a wide range of transition probability. Tankers of all kinds, a commodity in the shipping industry, takes up the largest share of Gyeongnam's exports but has a low proximity level of 0.11 to other commodities and the probability it will transition into the commodities of higher sophistication level is 0.29, which is also below average. On the other hand, the products of the Other Vessels category have a Prody level of 14,919 USD, which is very low, but a very high transition probability of 0.96. This implies that Other Vessels can be strategically utilized in the sophistication of export composition in Gyeongnam (Table 6).

To be more specific, we plotted the commodities that can substitute for those with the highest and lowest transition probability out of Gyeongnam's top ten exports, respectively. SITC 79329 (Other vessels), a commodity in the shipping industry, had the highest transition probability amongst Gyeongnam's top

Table 5. Industry-average Proximity and the Probability of a Transition to more Sophisticated Commodities

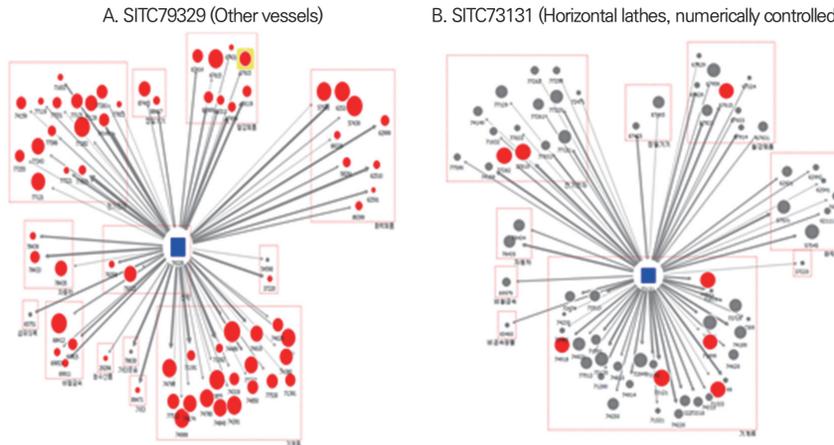
Industry	Industry-average Prody Index (\$)	Industry-average Proximity	Probability of transition to higher Prody
Manufacture of precision instruments	32,042	0.17	0.40
Manufacture of machinery	30,478	0.19	0.45
Manufacture of electronic components and electrical machinery	29,908	0.17	0.48
Manufacture of chemicals and chemical products	27,811	0.16	0.55
Manufacture of steel products	27,392	0.18	0.57
Building of ships and boats	26,508	0.15	0.66
Manufacture of other transport equipment	26,325	0.17	0.64
Manufacture of non-ferrous metals	25,308	0.16	0.65
Manufacture of wood and products of wood	24,379	0.17	0.64
Manufacture of motor vehicles	23,817	0.18	0.65
Other manufacturing	23,564	0.16	0.68
Manufacture of other non-metallic mineral products	21,651	0.16	0.72
Agriculture and Fisheries	18,204	0.14	0.78
Manufacture of furs and leathers	17,941	0.15	0.85
Manufacture of textile and wearing apparel	17,137	0.16	0.85
Average	24,831	0.16	0.64

Note: The transition probability has been calculated mainly for commodities that show higher than average proximity and also have sophistication levels higher than the commodity in question. The results are the average of individual commodities in the industry.

Table 6. Proximity and the Probability of Transition of Gyeongnam’s Top Ten Export Commodities

Commodity	Related Industry	Prody Index (\$)	Proximity	Transition Prob.
Tankers of all kinds	Building of ships and boats	31,952	0.1	0.29
Other vessels for the transport of goods	Building of ships and boats	28,627	0.1	0.67
Floating, submersible drilling, production platforms	Building of ships and boats	28,532	0.1	0.58
Other parts and accessories	Manufacture of motor vehicles	22,813	0.2	0.88
Mechanical shovels, excavators and shovel loaders	Manufacture of machinery	29,114	0.1	0.61
Other vessels	Building of ships and boats	14,919	0.2	0.96
Other parts of airplanes or helicopters	Manufacture of other transport equipment	27,127	0.2	0.56
Tires, pneumatic, new, of a kind used on motor cars	Manufacture of chemicals and chemical products	25,089	0.2	0.65
Motor vehicles for the transport of persons	Manufacture of motor vehicles	29,738	0.2	0.35
Horizontal lathes, numerically controlled	Manufacture of machinery	35,721	0.2	0.12
Average		27,363	0.2	0.6

Figure 5. Distribution of Commodities in terms of Proximity and Sophistication



Note: 1) The thickness of the line shows how proximate each commodity is to the commodity in question (blue square). The size of the circle is correlated with the level of sophistication.
 2) A red spot indicates that a commodity's proximity is higher than the average, with sophistication levels higher than the commodity in question. A red box indicates that the individual commodities are in the same industry.

ten exports. This commodity shows a high proximity to several industries such as electronics, machinery, chemical products and steel manufacturing and several of these have high sophistication levels. On the other hand, SITC 73131 (Horizontal lathes, numerically controlled), has a low transition probability of 0.12. There are several commodities that have high proximity to SITC73131, but only a few commodities included in the machinery and electronics manufacturing have a higher sophistication level than that of SITC73131.

4. Conclusion and Policy Implications

The sophistication level of Gyeongnam's exports has increased compared to the past, but it still falls short of its economic level. This implies that with its current export composi-

tion, there are limits to gaining comparative advantage in the global market for Gyeongnam. Considering the fact that commodities with low sophistication levels are more likely to be exported by developing countries using low-skilled labor, it seems rather difficult for the region to attain comparative advantage for such commodities. Considering Gyeongnam's income level, rather than focusing on low technology and low-skilled labor intensive products, gaining comparative advantage over exports that require higher levels of technology is the strategy it needs to follow. In other words, a strategy to develop higher technological skills and become more competitive in high-tech products should be followed, rather than trying to gain price competitiveness for low tech products over developing countries.

To achieve this, a structural shift towards

more sophisticated export commodities is required. In short, a strategy using preexisting production capabilities and resources to develop exports that can create higher value is needed.

The probability of Gyeongnam diversifying into a high value added export structure is 0.64, with a big difference among industries and commodities. Commodities included in shipping, a major regional exporting industry, are seen to have high proximity to various industries such as electronics, machinery and chemical products and several of these indus-

tries have high sophistication levels making the transition of Gyeongnam's export composition into a high value added one all the more easier. Considering Gyeongnam (alongside a few other regions) has been designated as a special development region in 2018 due to the downfall of the shipping industry, a strategy focused on the transition of the shipping industry to a high value added sector can help cushion the region from the shipping industry's slowdown and help develop the region's economic growth.

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