Payment System Innovation and Retailer Efficiency: Measuring the Impact of National Payment Gateway Implementation in Indonesia

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Abstract. The purpose of this study is to evaluate the effect of payment system innovation on retailer efficiency because of the implementation of the National Payment Gateway in Indonesia. We use a two-stage approach at the individual and national levels by adopting an efficient frontier approach using the Malmquist Productivity Index (MPI) based on data envelopment analysis (DEA) to measure the productivity of 5 Indonesian retailers during 2015–2020. Total assets, total expenses, and number of outlets are considered as inputs while net income, profit, and earnings per share (EPS) are considered as outputs. Result indicated that there was no significant improvement after GPN implementation in 2017. There was a lower improvement in MPI (1,0085971) during 2018–2020 as a period after GPN implementation as compared to MPI (1,0834615) during 2015–2017 as a period before GPN implementation. This study, however, is unable to prove that the implementation of GPN can improve retailer efficiency in Indonesia. The study's findings can help in our understanding of the efficient frontier, which can explain the relationship between payment system innovation and retailer efficiency. This will provide information for payment system policymakers to consider retail industry impact when setting up and/or initiating payment system innovations in the future.

Keywords: data envelopment analysis · efficiency · GPN · malmquist productivity · payment system

1 Introduction

The organized retail sector plays an important role in driving developed economies and provides developing countries with growth opportunities [1]. Today's retailers can no longer be accurately described as "merchant intermediaries" who buy from suppliers and sell to customers. Rather, they are best described as two-way platform orchestras or conductors where value is created and delivered to customers and acts as an ecosystem assigned by retailers and their business partners [2]. The link between retail sector organizations and payment systems was described in previous studies of the two- sided

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payment card market [3–7]. Payment cards have a long history in developed countries. Originally issued by merchants in the early 20th century, they replaced banknotes, coins and other paper-based musical instruments (mainly checks) as a means of payment to merchants [8]. From the point of view of retailers (in this case merchants), payment system innovations can effectively leverage these advances to simplify payment processes, provide customers with a seamless experience, speed payment completion, and reduce processing costs [9]. Based on this explanation, we build a logical approach to think that payment system innovation will increase retailer efficiency. Measuring efficiency levels has become an important issue for managers and investors. Consumers also benefit from efficient resource usage and allocation. This is because it can mean lower prices and more professional service [10]. This statement provides further logical thinking that the efficiency of business processes is also a customer expectation.

On June 21, 2021, Bank Indonesia issued Bank Indonesia Regulation No. 19/8/PBI/2017 concerning the National Payment Gateway (GPN), which is an initiation of a new era of ownership of Indonesia's domestic card payment network. This initiative specifically addresses the challenges of payment system conditions in Indonesia prior to the implementation of GPN. These are infrastructure that is still diverse, many payment system platforms are fragmented, many cards are issued and many transaction processing machines in the market but are not interconnected and cannot process each other, and transaction costs are relatively higher than neighboring countries [11].

We propose a question that has never been raised in empirical research on two-sided market model in Indonesia: *Does the implementation of GPN affect retailer performance?* We use a modified version of previous studies [1, 10, 12–15] on retailer efficiency using Malmquist Productivity Index (MPI) based on data envelopment analysis (DEA) to answer this research question.

The findings of this study contribute to knowledge of the efficient frontier that can explain the relationship between payment system innovation and retailer efficiency. This will provide input for payment system policy makers to consider the impact on the retail industry when setting up and/or initiating payment system innovations in the future.

2 Literature Review

The framework we use in developing the model in this research are as follows: First, we adapt the two-sided payment card market model [16–18] to find the relationship between payment system innovation and retailer efficiency, then Second, we will use DEA to measure the level of individual retailer efficiency from year to year (2015-2020). And finally, we will use MPI to find efficiency improvement over a period which is an extension tool of DEA.

Based on two-sided market theory, the utility of the platform is proportional to the number of network members on the other side of the market (indirect network effect). As a result, if a platform attracts issued payment card ($n1$) entities in the first group and installed electronic data capture machine ($n2$) at the merchant entities in the second, the utility of group 1 (u_1) and group 2 (u_2) entities may be stated as follows:

$$u_1 = \alpha_1 n_2 - p_1 \tag{1}$$

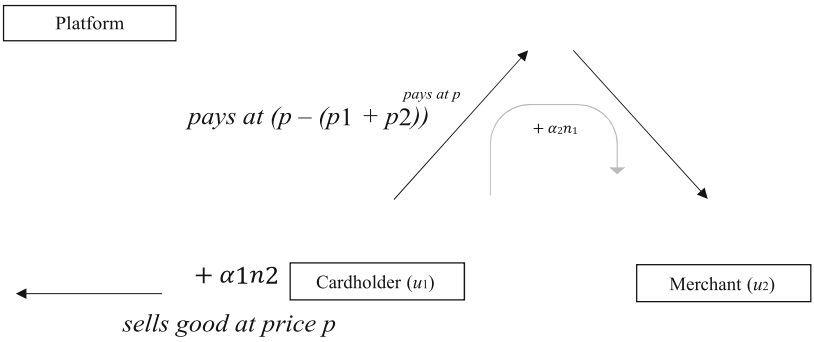

Fig. 1. Two-Sided Market Model of Card Payment (no surcharge rule)

$$u_2 = \alpha_2 n_1 - p_2 \tag{2}$$

Payment card customers are interested not only in the number of card transactions retailers accept, but also in the size of the merchant acceptance network. Merchants prefer to join the card network where cardholders use their cards. It is not just membership that matters to retailers, but card usage [17, 18]. For every initiative/innovation that increases the number of payment card users, it will increase the merchant utility. In addition to increasing the number of transactions, merchant utility can be obtained from the total efficiency obtained from simplifying processes and reducing processing costs [8]. Merchants in this case are retailers in the context of this study. Innovation in the retail context includes changes in products and/or processes, with the intent of reducing costs or increasing efficiency [19] (Fig. 1).

The DEA has proven to be a useful tool for assessing the efficiency of organizations characterized by multiple input and output structures [14]. DEA assigns an efficiency rating to each unit by comparing the efficiency rating of each unit with that of competitors. It identifies the best performing frontier. The DEA limit tracks the trajectory of all Pareto optimal points in the production set. Units that are at the limit are recognized as performance, and units that are not inefficient are recognized. DEA involves solving linear programming problems and adapting them to non-stochastic, nonparametric production frontiers based on actual input/output observations of the sample [10]. The benefits of using DEA to analyze efficiency are: (1) It is not necessary to give the mathematical form of the production function. (2) DEA can reveal complex patterns of data. (3) DEA can be used for all types of input/output measurements. (4) DEA can quantitatively analyze the causes of various inefficiencies. This advantage has made DEA a standardized non-parametric approach for analyzing the relative efficiency of DMUs [10].

The final part of this study will use an efficient frontier approach with a DEA-based Malmquist productivity index [14]. The Malmquist Productivity Index can be used to break down productivity changes into efficiency changes and technology changes. Changes in efficiency (transition to or out of production frontier) and technology changes (transition to production frontier) are two major drivers of productivity growth.

3 Methodology

We have selected the five largest public retailers in Indonesia to describe the DEA application in assessing multi-unit organizational performance. Then, we consider the selection of input-output variables found from previous research (see Table 1) and the availability of data from the 2015–2020 retailer annual reports. We then select input variables: Total Assets, Total Expenditure, and Number of Outlets, and output variables: Net Revenue, Profit, and earnings per share (EPS). The selection of number of outlets as one of the input variables is to become a proxy for payment system innovation that represents the availability of point-of- sales (POS) devices to accept payments using GPN cards (Fig. 2).

3.1 Data and Sample

We used a purposive sample technique to collect data in this study. We start with 89 primary consumer goods sector population listed on the Indonesia Stock Exchange, and we set a purposive sampling criterion: retailers who have been listed since December 2016 (1 year before the implementation of GPN) with the Supermarket sub-sector category and the annual report publication is available since 2015 (we found the remaining 5 companies as shown in Table 1).

We use data on the published financial statements of each company for 2015-2020 which is available on the KINERJA EMITEN database website. (https://emiten.kontan.co.id/).

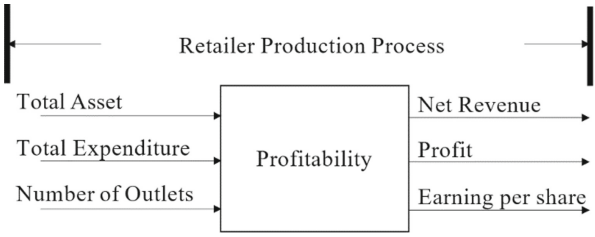

Fig. 2. Retailer Production Process

Table 1. List of Selected Retailer for this study

No	Stock code	Company name
1	AMRT	Sumber Alfaria Trijaya Tbk
2	HERO	Hero Supermarket Tbk
3	MIDI	Midi Utama Indonesia Tbk
4	MPPA	Matahari Putra Prima Tbk
5	RANC	Supra Boga Lestari Tbk.

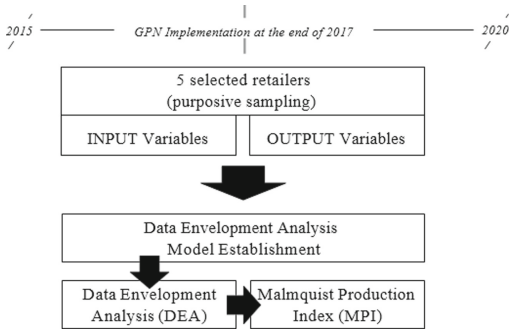

Fig. 3. Research Framework

Table 2. Descriptive Statistics of Input and Output Variables

Variable	Min	Max	Mean	SD
Total Asset	720,739	2,5970,743	7,778,973	7,418,444
Total Expenditure	1,448,748	60,414,446	15,770,954	18,513,060
Number of Outlets	27	17,538	3,437.8	5,949.765
Net Revenue	1,915,699	75,826,880	19,895,845	22,970,835
Profit	-1,257,255	1,138,888	-4,103	580,385.6
EPS	-299	70.45	-16.55	98.83

3.2 Research Framework

We developed the hypothesis that implementing GPN will lower merchant costs and increase sales, and hence increasing retailer efficiency. We use the DEA method to measure efficiency along years, while MPI is used to measure efficiency changes before and after GPN implementation. Figure 3 is the research framework we developed to answer the research questions in this study.

From Table 1 and Table 2 we can see that from the 5 selected retailers in this study, the data variance on each variable is very diverse. It was noted that RANC had the smallest Total Assets and Number of Outlets, HERO and MPPA were the most frequently found experiencing losses, and AMRT and MIDI dominated the highest numbers for Number of Outlets and Net Revenue. Furthermore, it was found that the 3 retailers with the highest EPS were MIDI, RANC, and AMRT (Fig. 3).

4 Analysis and Results

Before we carry out further analysis, we have prepared Table 2 to present descriptive statistics on all input and output variables used in this study.

Table 3. Summary of Efficiency Score of Selected Retailer in Indonesia Year 2015–2020

DMU	CCR	BCC	Efficiency Scale	RTS	DMU	CCR	BCC	Efficiency Scale	RTS
AMRT2015	**1,0000**	**1,0000**	**1,0000**	**Constant**	MPPA2015	0,8804	1,0000	0,8804	Decreasing
AMRT2016	0,9643	0,9857	0,9784	Decreasing	MPPA2016	0,8760	0,9903	0,8846	Decreasing
AMRT2017	0,9550	0,9856	0,9690	Decreasing	MPPA2017	0,8173	1,0000	0,8173	Decreasing
AMRT2018	0,9851	0,9969	0,9881	Decreasing	MPPA2018	0,8543	1,0000	0,8543	Decreasing
AMRT2019	1,0000	1,0000	1,0000	Constant	MPPA2019	0,8937	0,9831	0,9091	Decreasing
AMRT2020	0,9764	1,0000	0,9764	Decreasing	MPPA2020	0,8938	0,9092	0,9831	Decreasing
HERO2015	0,9331	0,9836	0,9487	Decreasing	**RANC2015**	**1,0000**	**1,0000**	**1,0000**	**Constant**
HERO2016	0,9832	1,0000	0,9832	Decreasing	**RANC2016**	**1,0000**	**1,0000**	**1,0000**	**Constant**
HERO2017	0,9746	0,9883	0,9862	Decreasing	RANC2017	0,9928	0,9948	0,9980	Decreasing
HERO2018	**1,0000**	**1,0000**	**1,0000**	**Constant**	**RANC2018**	**1,0000**	**1,0000**	**1,0000**	**Constant**
HERO2019	**1,0000**	**1,0000**	**1,0000**	**Constant**	**RANC2019**	**1,0000**	**1,0000**	**1,0000**	**Constant**
HERO2020	0,9795	0,9815	0,9980	***Increasing***	**RANC2020**	**1,0000**	**1,0000**	**1,0000**	**Constant**
MIDI2015	0,9690	0,9921	0,9767	Decreasing					
MIDI2016	0,9802	1,0000	0,9802	Decreasing					
MIDI2017	0,9615	0,9736	0,9875	Decreasing					
MIDI2018	0,9673	0,9898	0,9773	Decreasing					
MIDI2019	0,9694	1,0000	0,9694	Decreasing					
MIDI2020	0,9660	1,0000	0,9660	Decreasing					

The next step is to calculate CCR, BCC, and Scale Efficiency, which can be interpreted as either locally or globally efficient, since scale efficiency is the efficiency ratio between CCR and BCC. DMUs with an efficiency value of "1" are classified as frontier, with the CCR model's efficiency and the BCC model's efficiency both being "1" (Globally efficient). When only one of the efficiencies of the CCR model or the BCC model is "1" the model is said to be Locally efficient.

To calculate CCR, BCC, and Efficiency Scale, we use the "deaR" package application in RStudio Version 1.4.1717. The last column "RTS" is the interpretation of return to scale, with the explanation that "Increasing" RTS means that when our inputs are increased by m, our output increases by more than *m*, "Constant" RTS means that if we increase our inputs by *m*, our output will also increase by *m*, and "Decreasing" RTS is when our inputs are increased by *m*, our output increases by less than *m*.

Based on Table 3, retailers that are Globally efficient in 2015: AMRT and RANC, in 2016: RANC, in 2017: none, in 2018: HERO and RANC, in 2019: AMRT, HERO, and RANC, and in 2020: RANC. In general, RANC can be considered the most efficient during the 2015–2020 period.

The CCR and BCC models were then subjected to a sensitivity analysis (see Table 4) which compares the percentage difference between the efficiency target value and the original value to the original value. To be efficient, the retailer must reduce the input in question while maintaining the same level of output.

Table 4. Summary of Efficiency Score of Selected Retailer in Indonesia Year 2015–2020

CCR Model

DMU	Total Asset	Total Expenditure	Number of Outlets
AMRT	-2,36%	-2,36%	-48,77%
HERO	-12,78%	-2,05%	-31,43%
MIDI	-8,86%	-3,40%	-84,21%
MPPA	-33,47%	-10,62%	-10,62%
RANC	0,00%	0,00%	0,00%

BCC Model

DMU	Total Asset	Total Expenditure	Number of Outlets
AMRT	0,00%	0,00%	0,00%
HERO	-14,25%	-1,86%	-34,83%
MIDI	0,00%	0,00%	0,00%
MPPA	-30,80%	-9,08%	-9,08%
RANC	0,00%	0,00%	0,00%

Table 5. Geometric mean of MPI based on DMUs

DMU	Malmquist Index	Efficiency Change	Technical Change
AMRT	0,994001	1	0,994001
HERO	1,025502	1,001505	1,023961
MIDI	0,989762	0,996577	0,993162
MPPA	0,981150	0,981906	0,999230
RANC	1,192871	1	1,192871

And according to results of the sensitivity analysis, MPPA must reduce Total Assets by 33.47 percent, Total Expenditure by 10.62 percent, and Numbers of Outlets by 10.62 percent to be efficient (CCR model), MPPA must reduce Total Assets by 30.80 percent, Total Expenditure by 9.08 percent, and Numbers of Outlets by 9.08 percent, and HERO must reduce Total Assets by 14.25 percent, Total Expenditure by 1.86 percent, and (BCC model). This finding explains why HERO and MPPA are closing some stores and buyback some of their stocks between 2021 and 2022 [20–23].

The following step is to calculate and analyze the changes in retailers' productivity for the years 2015–2020 using Malmquist productivity index (MPI). Productivity change of retailers during the period 2015–2020 can be evaluated by MPI as shown in Table 5 and Table 6. The values indicated in Table 5 is geometric mean of MPI based on DMUs and Table 8 gives MPI summary of annual means for the five periods, 2015–2016, 2016–2017, 2017–2018, 2018–2019, and 2019–2020.

Table 5 shows that RANC has the highest performance increase with an MPI of 1.192871, while MPPA has the highest performance decrease with an MPI of 0.988115. The term "technical efficiency" change refers to changes in technical management,

experience, and investment planning. Technical efficiency is further subdivided into scale efficiency change and pure technical efficiency change. As shown in Table 6, two out of every five retailers improved in terms of technical efficiency between 2015 and 2020. RANC improved the most (1,192871), followed by HERO (1,023961). MIDI slumped to a trough of (0,993162), followed by AMRT (0,994001) and MPPA (0,999230). Changes in the difference between the CRS and VRS are determined by the scale efficiency change component. Essentially, it is a ratio of the efficiency of the CCR and BCC models. In terms of scale efficiency, three out of five retailers improved between 2015 and 2020. AMRT, HERO, and RANC showed nearly identical improvements in scale efficiency change (1 and 1,001505), but MPPA showed the greatest deterioration (0,981906), followed by MIDI (0,996577).

The average Malmquist Index for the 2015–2017 period is 1.0834615, while the average Malmquist Index for the 2018–2020 period is 1.0085971, indicating that the performance increase for the 2015–2017 period is greater than the performance increase for the 2018–2020 period (see Table 8). Since MPI was greater than "1", the improvement was still found under the MPI criterion. This finding suggests that our hypothesis, that implementing GPN will lower merchant costs and increase sales, thereby increasing retailer efficiency, was not fully supported by this study.

5 Conclusion and Future Research Direction

Our study is an attempt to find out DEA score for selected Indonesian retailers using CRS and VRS during period 2015–2020. Efficiency over a period time can be find out with the help of MPI. The outcome revealed the actual reality of performance of Indonesian retailers. This study also includes possible improvement for inefficient retailers and provide a recommendation to improve efficiency. In the most important part of this study, MPI was considered to find the efficiency of retailers over a period during 2015–2020. Result indicated that there was no significant improvement after GPN implementation in 2017. There was a lower improvement in MPI (1,0085971) during 2018–2020 as a period after GPN implementation as compared to MPI (1,0834615) during 2015–2017 as a period before GPN implementation. Even this indicated that performance of retailers was decreasing slowly and hence they needed to plan in such a way that their efficiency would increase year after year. However, this study is unable to prove that the implementation of GPN can improve retailer efficiency in Indonesia.

These are some of the research paper's limitations. Some retailers are not considered due to a lack of data between 2015 and 2020. The inefficiency score will assist top management in determining the system bottleneck and developing an action plan to improve efficiency. As a result, management can try to reduce inputs or increase output to improve efficiency. Further research can be conducted by considering different inputs and outputs, which can provide even more meaning insights. The study's findings can help in our understanding of the efficient frontier, which can explain the relationship between payment system innovation and retailer efficiency. This will provide information for payment system policymakers to consider retail industry impact when setting up and/or initiating payment system innovations in the future.

References

1. N. M. Agrawal, "Benchmarking efficiency of Indian retailers using parametric and non-parametric approach," *Int. J. Logist. Syst. Manag.*, vol. 35, no. 3, pp. 372–386, 2020, doi: https://doi.org/10.1504/IJLSM.2020.105918.
2. A. Sorescu, R. T. Frambach, J. Singh, A. Rangaswamy, and C. Bridges, "Innovations in retail business models," *J. Retail.*, vol. 87, no. SUPPL. 1, pp. S3–S16, 2011, doi: https://doi.org/10.1016/j.jretai.2011.04.005.
3. É. Keszy-Harmath, G. Kóczán, S. Kováts, B. Martinovic, and K. Takács, "The role of the interchange fee in card payment systems," *Magy. Nemzeti Bank Occas. Pap.*, vol. 96, 2012.
4. M. Song and H. Ullrich, "Assessing the Impact of Payment Card Fee Regulation," pp. 1–54, 2016.
5. D. N. Bank, "Card acceptance and surcharging : the role of costs and competition 1 Preliminary version Please do not quote without the author ' s permission," no. April, 2011.
6. M. Bourreau and M. Verdier, "Interchange Fees and Innovation in Payment Systems," *Rev. Ind. Organ.*, vol. 54, no. 1, pp. 129–158, 2019, doi: https://doi.org/10.1007/s11151-018-9648-6.
7. M. Zhang, Z. Zhang, and L. Hu, "An Empirical Test of the Cross-group Network Externality of Two-sided Market," 2012, doi: https://doi.org/10.2991/iccia.2012.253.
8. J. C. Maixé-Altés, "Retail trade and payment innovations in the digital era: a cross-industry and multi-country approach," *Bus. Hist.*, vol. 62, no. 4, pp. 588–612, 2020, doi: https://doi.org/10.1080/00076791.2018.1471062.
9. Vangelisti and M. Iride, "How small and medium-sized retail enterprises can make the best use of payment innovations," *J. Payments Strateg. Syst.*, vol. 15, no. 1, pp. 109–117, 2021.
10. M. M. Mostafa, "Does efficiency matter?: Examining the efficiency-profitability link in the US specialty retailers and food consumer stores," *Int. J. Product. Perform. Manag.*, vol. 59, no. 3, pp. 255–273, Mar. 2010, doi: https://doi.org/10.1108/17410401011023582.
11. Bank Indonesia, "Materi Sosialisasi Gerbang Pembayaran Nasional," *Dep. Elektron. dan Gerbang Pembayaran Nas.*, 2018.
12. C. Pestana Barros and C. A. Alves, "Hypermarket retail store efficiency in Portugal," *Int. J. Retail Distrib. Manag.*, vol. 31, no. 11, pp. 549–560, Nov. 2003, doi: https://doi.org/10.1108/09590550310503285.
13. K. Ko, M. Chang, E. S. Bae, and D. Kim, "Efficiency analysis of retail chain stores in Korea," *Sustain.*, vol. 9, no. 9, p. 1629, Sep. 2017, doi: https://doi.org/10.3390/su9091629.
14. J. de J. Moreno, "Productivity growth of European retailers: A benchmarking approach," *J. Econ. Stud.*, vol. 37, no. 3, pp. 288–313, Aug. 2010, doi: https://doi.org/10.1108/01443581011061285.
15. A. Šegota, "Evaluating shops efficiency using data envelopment analysis: Categorical approach," *Zb. Rad. Ekon. Fak. au Rijeci*, vol. 26, no. 2, pp. 325–343, 2008.
16. M. Armstrong, "Competition in Two-sided Markets," *RAND J. Econ.*, vol. 37, no. 3, pp. 668–691, 2006.
17. J. Górka, "Two-Sided Markets and Interchange Fees," in *Interchange Fee Economics*, Springer International Publishing, 2018, pp. 1–43.
18. M. Rysman, "The Economics of Two-Sided Markets," *J. Econ. Perspect.*, vol. 23, no. 3, pp. 125–143, 2009, [Online]. Available: https://www.aeaweb.org/articles?id=10.1257/jep.23.3.125.
19. S. Ganesan, M. George, S. Jap, R. W. Palmatier, and B. Weitz, "Supply Chain Management and Retailer Performance: Emerging Trends, Issues, and Implications for Research and Practice," *J. Retail.*, vol. 85, no. 1, pp. 84–94, 2009, doi: https://doi.org/10.1016/j.jretai.2008.12.001.
20. S. Sidik, "Satu Lagi dari Multipolar, Mau Buyback Maksimal Harga Rp 720," Jun. 10, 2021. https://www.cnbcindonesia.com/market/20210610085302-17-251936/satu-lagi-dari-multipolar-mau-buyback-maksimal-harga-rp-720 (accessed Mar. 11, 2022).

21. P. Situmorang, "Matahari (MPPA) Memasuki Tren Pemulihan, Bagaimana Prospek Sahamnya?," Jan. 19, 2022. https://investor.id/market-and-corporate/278952/matahari-mppa-memasuki-tren-pemulihan-agaimana-prospek-sahamnya (accessed Mar. 11, 2022).
22. CNN Indonesia, "Alasan Hero Tutup Semua Gerai Giant per Juli 2021," May 25, 2021. https://www.cnnindonesia.com/ekonomi/20210525140558-92-646722/alasan-hero-tutup-semua-gerai-giant-per-juli-2021 (accessed Mar. 11, 2022).
23. R. Wulandari, "Keputusan HERO Menutup Semua Gerai Giant Dinilai Tepat | Republika Online," Jun. 04, 2021. https://www.republika.co.id/berita/qu5grn384/keputusan-hero-menutup-semua-gerai-giant-dinilai-tepat (accessed Mar. 11, 2022)