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The impact of macro and micro shocks on the productivity improvements of the main public airports in Thailand

Nattawat Benjaparn
Faculty of Economics
Thammasat University
Thailand

Supawat Rungsuriyawiboon
Faculty of Economics
Thammasat University
Thailand

ABSTRACT

This paper studies the productivity measurement of the 6 main public airports in Thailand since Suvarnabhumi Airport (BKK) opened in 2007 to the year before the COVID-19 pandemic happened. This paper also discusses the effect of both the macro and micro shocks such as the global financial crisis between 2008 to 2009 and the big flooding in 2011 on the productivity growths of the airports. This paper is the first study that employs the Malmquist Total Factor Productivity Index (MPI) model to measure the productivity growths of Thailand's airports. The finding reveals that both shocks declined the performances of the airports. Within the study period, the airports promote productivity growth by emphasizing the adoption of new technologies than the operation of workers. The average productivity growth of the airports was 4.5 percent a year in this period implying that there existed productivity progress in this industry prior to the COVID-19 outbreak.

Keywords: Tourism, Productivity, Thailand

JEL Classification: L83, D24

1. Introduction

Thailand is one of the biggest tourism hubs in Asia. International tourists around the world have visited every year, more than 10 million since 2001. In 2019, the year before the COVID-19 pandemic spread, Thailand handled the highest number of international tourists all the time of 39.9 million. The capacity at the airports is important to support the growth of the tourism sector in Thailand. The annual reports of The Civil Aviation Authority of Thailand (CAAT) reported that the total number of air passenger movements of all airports in Thailand had handled increased by 10.31 percent a year between 2008 to 2019. In 2008, all airports handled 57 million people. On the other hand, the airports handled more than 160 million passengers in 2019. Currently, Thailand has 39 public airports entire the country. But the 6 main public airports had handled more than 80 percent of total passenger movements since 2008.

Measuring the efficiency and productivity changes at the airports will help the policymakers design future strategies to promote the sustainable development of the infrastructures and capacities at the airports in the long run. These will prevent the crowding situations at the airports and support the growth of tourism sector in Thailand.

This paper aims to measure the productivity growths of the 6 main public airports in Thailand and discusses the impacts of micro and macro shocks on the airports' performances. The study covers the periods from 2007 to 2019 where there existed both micro and macro shocks such as the global financial crisis between 2008 to 2009, the big flooding in Thailand at the end of 2011, the Phuket boat tragedy in 2018, and Thai baht appreciation in 2019.

To measure the productivity growths, this paper employs the Malmquist Total Factor Productivity Index (MPI) model proposed by Fare et al. (1994). The next section provides the literature reviews. The third and fourth sections discuss the methodology and data, respectively. Section 5 presents the results. The conclusion is the last section.

2. Literature Review

For measuring the full performances of the airports in the study period, we must measure both the technical efficiency and productivity growth. Charnes et al. (1978) proposed the basic model called the input-oriented CCR data envelopment analysis (DEA) model to estimate the technical efficiency level of the firm. The applications of the DEA model can be applied to many fields such as agricultural, medical, train, banking, airline, airport, and etc. A few research examined the technical efficiencies of Thailand's airports. Sopadang and Suwanwong (2016) measured the technical efficiency scores at the Chiang Mai International Airport (CNX) with the 19 airports in ASEAN in 2016. The authors employed both the CCR and BCC DEA models. An output variable included the number of passengers. For the input variables, they defined the terminal area (m^2), the number of runways, the number of gates, and the number of check-in desks.

Rapee and Peng (2014) employed the CCR DEA model with the analytic hierarchy process (AHP) model to calculate the technical efficiency scores of the 6 main public airports in Thailand in 2013. They defined 3 output variables such as the number of passengers, the number of aircraft movements, and the number of cargo movements (tons). The 3 input variables included the number of employees, the number of runways, and the terminal area (m^2).

Benjaparn and Rungsuriyawiboon (2021) also employed the input-oriented CCR DEA model to the technical efficiency scores at the 6 main public airports in Thailand between 2007 to 2019. They defined the 4 input variables such as the number of employees and runways, the apron area (m^2), and the terminal area (m^2). They defined the output variables as the same as Rapee and Peng (2014).

Fare et al. (1994) extended the concept of the DEA model to measure the productivity growths of the firms. The method is called the Malmquist Total Factor Productivity Index (MPI) model. To employ this model, full panel data is required.

DEA model can measure the technical efficiency scores in terms of the working systems of the firms at a specific time. However, this model cannot measure the change within the study period and the adoption rate of new technologies. Fare et al. (1994) extended the concept of the DEA model to measure the productivity growths of the firms. The method is called the Malmquist Total Factor Productivity Index (MPI) model. The MPI model can measure the total factor productivity changes (TFPC) of the firms in the study period. This model also decomposes productivity growth into technical efficiency change (TEC) and technical change (TC). To employ this model, full panel data is required.

Abbott and Wu (2002) employed both the DEA and MPI models to measure the full performances of the 12 Australian airports between 1989 to 2000. They defined the 2 output variables such as the number of passengers and the amount of cargo handled (tons). The input variables included the number of employees, the runway length (km), and the capital stock (dollar). Abbott (2015) also employed the MPI and Tobit regression models to measure productivity growths of 3 airports in New Zealand between 1991 to 2012.

Yang and Huang (2014) studied the technical efficiencies and productivity changes of 12 international airports in Asia between 1998 to 2006. The authors employed the stochastic frontier analysis (SFA) and MPI models. The SFA model is a parametric method employed to estimate the technical efficiency levels at the airports as the DEA model. This paper defined the output variable as the operating revenues. For the input variables, they included the number of employees, the runway length (km), and the operating costs.

There is no research study on the productivity changes at Thailand's airports. This paper is the first research that employs the input-oriented MPI model to measure the airports' productivity growths between 2007 to 2019. The next section discusses the detail of the methodology.

3. Methodology

The MPI model is a non-parametric method that applies the concept of the input distance function (D^i) to measure the productivity growths of airports. Productivity growths or total productivity changes ($TFPC^i$) can also be decomposed to measure the input-oriented technical efficiency changes (TEC^i) and the input-oriented technical changes (TC^i) at the airports in the study period. The TEC^i will measure whether the inner operating systems at the airports can promote productivity growth. The TC^i measures whether the airports took advantage of new technologies to promote productivity improvement within the study period. The following equation will explain how to calculate the airports' productivity growths:

$$m^i_{t,t+1}(y_t, y_{t+1}, x_t, x_{t+1}) = \left[m^i_t(y_t, y_{t+1}, x_t, x_{t+1}) \times m^i_{t+1}(y_t, y_{t+1}, x_t, x_{t+1})\right]^{\frac{1}{2}}$$

$$= \left[\frac{D^i_t(x_{t+1}, y_{t+1})}{D^i_t(x_t, y_t)} \cdot \frac{D^i_{t+1}(x_{t+1}, y_{t+1})}{D^i_{t+1}(x_t, y_t)}\right]^{\frac{1}{2}}$$

$$= \frac{D_{t+1}^{i}(x_{t+1,}y_{t+1})}{D_{t}^{i}(x_{t,}y_{t})}\left[\frac{D_{t}^{i}(x_{t+1,}y_{t+1})}{D_{t+1}^{i}(x_{t+1,}y_{t+1})}\cdot\frac{D_{t}^{i}(x_{t,}y_{t})}{D_{t+1}^{i}(x_{t,}y_{t})}\right]^{1/2}$$

Where $m_t^i(y_t, y_{t+1}, x_t, x_{t+1})$ is the input-oriented Malmquist's TFP index of the individual airports in period t.
$m_{t+1}^i(y_t, y_{t+1}, x_t, x_{t+1})$ is the input-oriented Malmquist's TFP index of the individual airports in period $t+1$.
$D_t^i(x_t, y_t)$ is the input distance function in period t using data of the individual airports in period t.
$D_{t+1}^i(x_t, y_t)$ is the input distance function in period $t+1$ using data of the individual airports in period t.
$D_t^i(x_{t+1,}y_{t+1})$ is the input distance function in period t using data of theindividual airports in period $t+1$.
$D_{t+1}^i(x_{t+1,}y_{t+1})$ is the input distance function in period $t+1$ using data of the individual airports in period $t+1$.
$\frac{D_{t+1}^{i}(x_{t+1,}y_{t+1})}{D_{t}^{i}(x_{t,}y_{t})}$ is the TEC^i measurement.
$\left[\frac{D_{t}^{i}(x_{t+1,}y_{t+1})}{D_{t+1}^{i}(x_{t+1,}y_{t+1})}\cdot\frac{D_{t}^{i}(x_{t,}y_{t})}{D_{t+1}^{i}(x_{t,}y_{t})}\right]^{1/2}$ is the TC^i measurement.

If the value of $m_{t,t+1}^i(y_t, y_{t+1}, x_t, x_{t+1})$ or $TFPC^i$ is higher than 1, it indicates an airport has productivity progress between the 1st and 2nd periods. Otherwise, it indicates productivity regress.

If the value of TEC^i is higher than 1, it indicates that the airport can promote productivity growth through the improvement of the operational system. Otherwise, it indicates that the working system at the airport in terms of labor obstructs productivity growth between the 1st and 2nd periods.

If the value of TC^i is higher than 1, it indicates that the airport adopts new technologies smoothly to promote higher productivity growth between the 1st and 2nd periods.

Otherwise, it indicates that the airport lacks to take the advantage of technologies to promote productivity growth.

4. Data

This paper employs the input-oriented MPI model to measure productivity growths of the 6 main public airports in Thailand between 2007 to 2019. These airports are operated under the Airports of Thailand Public Company Limited (AOT), the big airport company in the world. They include Suvarnabhumi Airport (BKK), Don Mueang International Airport (DMK), Phuket International Airport (HKT), Chiang Mai International Airport (CNX), Hat-Yai International Airport (HDY), and Mae Fah Luang-Chiang Rai International Airport (CEI). Figure 1 shows the locations of the 6 main public airports have located. The figure is obtained from AOT's corporate presentation in 2020. DMK is located in the central city of Thailand, Bangkok. BKK is located in Samut Prakan province. CNX is located in Chiang Mai province. HKT is located in Phuket province. HDY and CEI are located in Songkhla and Chiang Rai provinces, respectively. DMK, BKK, CNX, and HKT are the airport hubs in Thailand. The total number of passenger movements have more than 10 million per year for these airports.

This paper defines the same input and output variables as Benjaparn and Rungsuriyawiboon (2021). The input variables include the number of employees and runways, the apron area (m^2), and the terminal area (m^2) at the individual airports. The output variables include the total number of passengers, the total number of aircraft movements, and the air cargo shifted in tonnes. All data are collected from the AOT's annual reports between 2007 to 2019, SET56-1 FORMs between 2008-2019, and airport presentations between 2007 to 2019.

Figure 1. Locations of the 6 main public airports in Thailand under AOT.

Source: AOT's Corporate Presentation, 2020, p.3

Table 1 shows the descriptive statistics of all variables employed in this paper. The number of employees ranges between 3,257 and 105 people. BKK had the highest number of employees in 2019 and CEI had the lowest number of employees in 2007. Only BKK and DMK have 2 runways.

BKK also has the largest of both terminal and apron areas of 563,000 and 1,033,000 in meter squares, respectively. In 2019, the number of passenger movements that passed through this airport was higher than 64 million. Total aircraft movements also had the highest of 378,886 times. The amount of cargo shifted was higher than 1.5 million tons.

CEI had the lowest amount of cargo shifted in 2009 of 2,287 tons. The number of both passenger and aircraft movements had the lowest of 648,783 people and 5,546 times, respectively. The size of the apron area had the lowest of 28,800 in meter squares. However, HDY had the lowest size of the terminal area between 2007 to 2014 of 14-thousand-meter squares. After HDY expanded the terminal area to 19,375 m^2in 2015, CEI has been the lowest size of terminal area of 17,000 m^2.

This paper runs the DEAP program to analyze the data and obtain the results.

Table 1. Descriptive Statistics of all variables used in this paper.

Descriptive Statistics					
Input/Output	**Variables**	**Maximum**	**Minimum**	**Average**	**Std. Dev.**
Input	No. of employees	3,259	105	774.59	933.18
Input	No. of runways	2	1	1.33	0.47
Input	Apron Area (m^2)	1,033,000	28,800	359,842.83	421,071.25
Input	Terminal Area (m^2)	563,000	14,656	158,410.45	207,761.04
Output	No. of passengers	64,711,010	648,783	15,008,488.94	2,093,598.13
Output	Aircraft movement	378,886	5,546	98,548.17	111,622.81
Output	Cargo Volumes (tons)	1,500,139	2,287	229,988.73	475,124.33

5. Result

Thailand faced both macro and micro shocks during this study period. In this paper, the global financial crisis between 2008 to 2009 is considered as a macro shock whereas the big flooding in Thailand at the end of 2011, the boat collapsed in

Phuket in 2018, and the appreciation of Thai baht in 2019 are represented as micro shocks. During the big flooding, many provinces in Thailand and DMK were flooded. This section also analyzes the effects of the shocks in each period for the individual airports. Table 2 shows the annual average of the MPI model for the overall airports.

The 6 main public airports had the geometric mean of total factor productivity change (TFPC) growth increased by 4.5 percent a year between 2007 to 2019. The technical efficiency change (TEC) had progressed by 1.8 percent per year. The technical Change (TC) had progressed by 2.6 percent per year. This means that adopting and taking advantage of new technologies were the main factors to drive productivity improvements of the airports.

During the global financial crisis period, both the total air passenger and traffic movements had declined by more than 10 percent in the airport hubs. The TEC had declined by 4.2 percent and the TC had declined by 11.5 percent. This finding implies that this macro shock obstructed both the operating systems and the adoption of new technologies at the airports through the decline of air passenger and traffic movements.

During the big flooding period, DMK was the only airport that was flooded. The TEC of the overall airports had declined by 10.9 percent. But the TC had progressed by 7.6 percent. There made the TFPC had regressed by 4.2 percent. This means that the big flooding at the end of 2011 obstructed the working flow at the airports while supporting the airports to take advantage of technologies to promote productivity growth instead.

In 2018, Thailand had a problem with China about more than 40 Chinese tourists died in Phuket. This made the decline of Chinese and international tourists visiting Phuket and Songkhla provinces in 2019 (Bangkok Post, 2018; Bangkok Post, 2019). The AOT's annual reports reported that both

HKT and HDY had decreased in total passenger movements by 400 thousand and 1.6 million people between 2018 to 2019, respectively. At the same period, Thai baht had appreciated. This also supported the fewer international tourists traveling to tourist cities. Hence, the TEC of the overall airports had regressed by 1.5 percent. The TC had regressed by 1 percent. The TFPC had regressed by 2.4 percent.

Table 2. The annual means of Malmquist Indices of the overall airports.

Annual Means of Malmquist Indices of 6 Airports			
Periods	**TEC**	**TC**	**TFPC**
2007-2008	1.023	0.972	0.995
2008-2009	0.958	0.885	0.847
2009-2010	0.931	1.260	1.172
2010-2011	1.133	1.086	1.231
2011-2012	0.891	1.076	0.958
2012-2013	1.164	0.974	1.133
2013-2014	1.049	1.037	1.088
2014-2015	1.034	1.036	1.072
2015-2016	1.073	0.947	1.016
2016-2017	1.014	1.051	1.067
2017-2018	0.996	1.040	1.037
2018-2019	0.985	0.990	0.976
Geometric Mean	1.018	1.026	1.045

Table 3 shows the individual Malmquist indices of the 6 airports in different periods. The periods include the global financial crisis, the big flooding in Thailand, and the Thai baht appreciation between 2007 to 2019.

Table 3. The Individual Malmquist Indices of 6 airports between 2007 to 2019, Global Financial Crisis, Big flooding in Thailand, and Declining of Chinese Tourists Periods.

Airport Names (Code Names)	Between 2007 to 2019			Global Financial Crisis Period			Big Flooding Period			Thai baht Appreciation		
	TEC	TC	TFPC	TEC	TC	TFPC	TEC	TC	TFPC	TEC	TC	TFPC
Suvarnabhumi Airport (BKK)	1.000	1.014	1.014	1.000	0.857	0.857	1.000	1.071	1.071	1.000	0.955	0.955
Don Mueang International Airport (DMK)	1.071	1.029	1.102	0.639	0.890	0.569	0.449	1.048	0.471	1.000	0.973	0.973
Phuket International Airport (HKT)	1.000	1.026	1.026	1.000	0.887	0.887	1.000	1.089	1.089	1.000	0.966	0.966
Chiang Mai International Airport (CNX)	1.000	1.019	1.019	1.175	0.903	1.061	1.021	1.088	1.111	1.000	0.986	0.986
Hat-Yai International Airport (HDY)	1.016	0.996	1.012	1.116	0.879	0.981	1.008	1.075	1.084	0.920	1.019	0.937
Mae Fah Luang-Chiang Rai International Airport (CEI)	1.024	1.072	1.097	0.920	0.895	0.823	1.082	1.086	1.175	0.996	1.044	1.040
Geometric Mean	1.018	1.026	1.045	0.958	0.885	0.848	0.891	1.076	0.959	0.985	0.990	0.975

For the overall period, DMK, HDY, and CEI had TEC progress. For the TC, only HDY had TC regress. DMK had the highest TFP growth. The reason was in 2015 and 2018, DMK became the biggest low-cost carrier in the world. This made DMK had very high growth in the study period. CEI was the second-highest productivity growth airport. The airport had the total number of passengers increased more than 3 times between 2013 to 2019.

During the global financial crisis, every airport had declined in technical changes by at least 10 percent. Only DMK and CEI had TEC decline. By DMK had the TEC regress by 36.1 percent. CEI had TC regress by 8 percent. DMK was the central airport in Thailand. But after BKK opened in 2007, DMK had closed for a short period. This made the total passenger movements at DMK was lower than 10 million between 2007 to 2012. But after DMK followed the policy to handle only low-cost carrier in 2010, the total passenger movements were higher than 10 million after 2012 and reached 40 million in 2018. The result shows that the macro shock declined the TFP of all airports except CNX.

In 2011, Thailand had faced the big flooding in many provinces. DMK also was flooded. The result shows that only

DMK had TFPC regress by 52.9 percent. The TEC had regressed of 55.1 percent while the TC had progressed of 4.8 percent. This means that the flooding obstructed the working flow at DMK. And DMK tried to use new technologies to promote productivity instead.

Between 2018 to 2019, the period that more than 40 Chinese tourists died, and Thai baht had appreciated, all airport hubs had regressed in TC, but the nonairport hubs had declined in TEC. Only CEI had the TFPC incline by 4 percent.

Figure 2 to 4 show the comparing the TEC, TC, and TFPC of the individual airports in different periods.

Figure 2. Comparing the TEC of the individual airports in different periods.

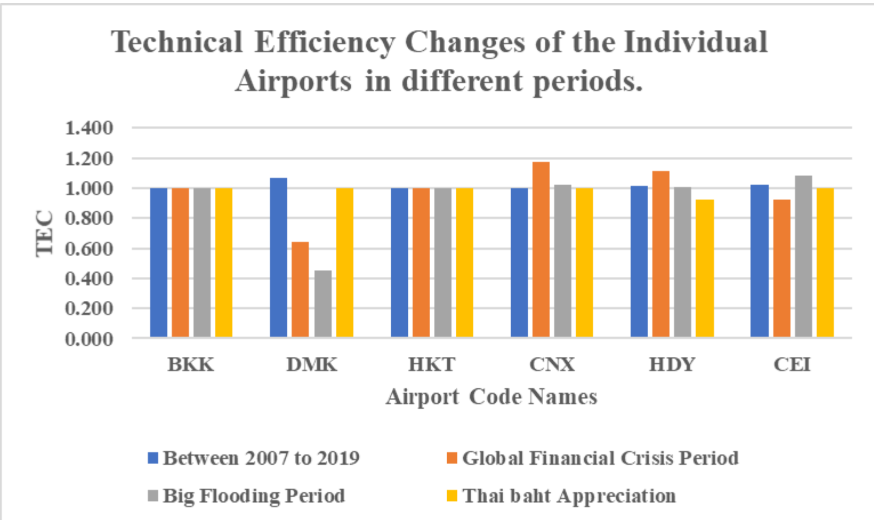


Figure 3. Comparing the TC of the individual airports in different periods.

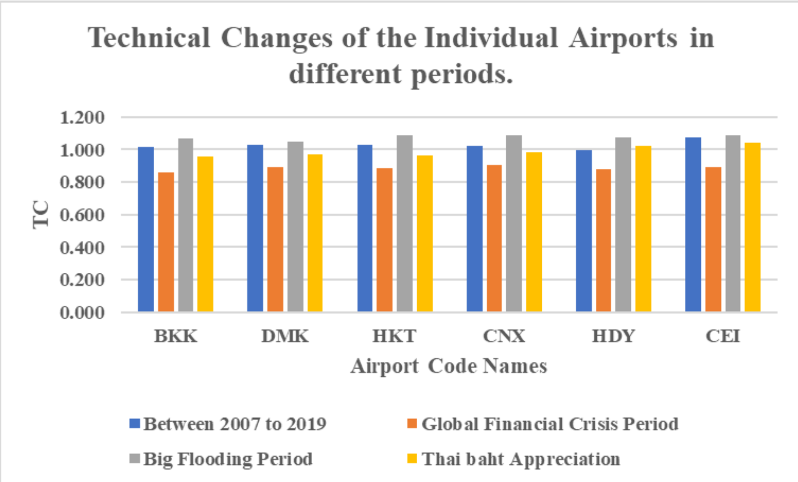
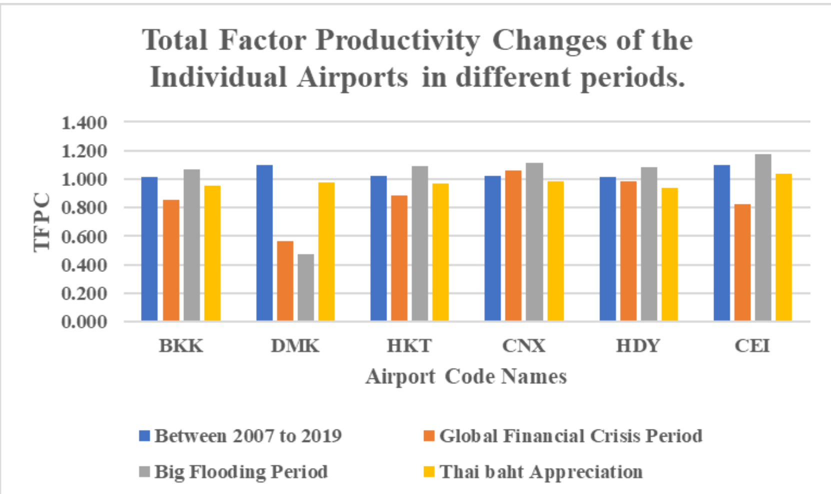


Figure 4. Comparing the TFPC of the individual airports in different periods.



According to Benjaparn and Rungsuriyawiboon (2021), the authors employed the input-oriented CCR DEA model to measure the technical efficiency scores of the airports between 2007 to 2019. During the global financial crisis from 2008 to 2009, the airports had technical efficiency scores declined more than 9 percent. In the big flooding period from 2011 to 2012, DMK was the only airport that faced the technical efficiency level decreased by more than 35 percent while the other airports showed technical efficiency improvement. Lastly, during the Thai baht appreciation from 2018 to 2019, the average technical efficiency scores of all airports also declined by 0.5 percent. Only HKT and HDY were affected by this event.

6. Conclusion

This paper studies the productivity changes of the main public airports in Thailand between 2007 to 2019. This paper employs the input-oriented Malmquist Total Factor Productivity Index (MPI) model to measure airports' productivity growths. The results obtained from this paper are consistent with the findings of Benjaparn and Rungsuriyawiboon (2021). The results indicate that the global financial crisis reduced productivity of the airports through the decrease of international tourists. Every airport failed to adopt new technologies to promote growth. The big flooding in Thailand had only a negative impact on DMK by obstructing the working processes and adopting new technologies. However, the technological adoption rate had still be progressed to offset the inefficiency in the airport's operating system. Lastly, the tragedy at Phuket in 2018 and Thai bath appreciation in 2019 prevented the airport hubs from taking advantage of new technologies, and the nonairport hubs performed poorly in the operating system.

This paper is the first paper that employs the MPI model with the airports in Thailand. But we have some gaps that are not fulfilled. This paper discusses the shocks to the airports that happened during the period between 2007 to 2019. The study period does not cover the year 2020, the beginning period of the COVID-19 pandemic. And the paper covers only the 6 main public airports in Thailand. Future research can find data of the other airports to analyze and compare them with the airports under AOT. Moreover, future research can analyze the full performances of the airports between the pre- and post-COVID-19 pandemic periods.

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