Krakow Review of Economics and Management
Zeszyty Naukowe Uniwersytet Ekonomiczny w Krakowie
3 (1013)
2026

KREM, 2026, 3(1013): 81–96
ISSN 1898-6447
e-ISSN 2545-3238
https://doi.org/10.15678/krem.18812

Digital Competitiveness and Its Influence on Logistics Performance in Various Countries

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Suggested citation: Łukasik, P., Straka, M., Winkler, R., Turek, P., & Szakiel, J. (2026). Digital Competitiveness and Its Influence on Logistics Performance in Various Countries. *Krakow Review of Economics and Management / Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, 3(1013), 81–96. https://doi.org/10.15678/krem.18812

ABSTRACT

Objective: Examining the relationship between the country's ability to implement digital technologies and its logistics performance.

Research Design & Methods: To examine the relationship between a country's digital competitiveness and its logistics efficiency, Pearson's linear correlation analysis and simple linear regression analysis were used. The Digital Competitiveness obtained by a given country in the IMD World Digital Competitiveness Ranking was adopted as an independent variable, and the score obtained by a given country in the Logistics Performance Index: overall and other logistics performance sub-indices as a dependent variable. The analysis was conducted separately on two research samples from 2017 and 2022.

Findings: The digital competitiveness of a country has a positive impact on the overall efficiency of logistics, as well as on its component variables, such as: the efficiency of administrative services at borders, the quality of logistics infrastructure, the ease of planning competitively priced shipments, the quality of logistics services, the punctuality of parcel delivery, the ability to track and trace shipments.

Implications/Recommendations: An integrated policy for the implementation of Industry 4.0 should be developed, with a special focus on transportation and enterprise logistics. The policy should take into account changes in society, enterprises and government. Company managers should increase investment in the digitisation of logistics processes and take into account the values of digitisation and logistics performance indices in strategic decisions.

Contribution: This study is innovative due to the lack of current research on relationships between digital competitiveness and logistics performance.

Article type: original article.

Keywords: regression model, digitalisation, digital competitiveness, logistics, efficiency.

JEL Classification: M10, L91, L98.

1. Introduction

The digitalisation of businesses associated with the Fourth Industrial Revolution, or Industry 4.0, is taking place all over the world. However, its intensity and success vary between individual countries. The described state of digital transformation and its level of practical implementation in individual countries worldwide is represented by the so-called IMD World Digital Competitiveness Ranking index (IMD World Competitiveness Center, 2018, 2023).

Digitalisation and its practical effects affect both production and everyday life. The questions that arise from its definition are related to the concern about the implementation of digitalisation as part of Industry 4.0 and its impact on micro and macro logistics. It also relates to its quality in terms of securing resources, production itself, and product distribution. Supply chain management and the impact of digitalisation both on the entire supply chain and on its individual elements, are also significant. There may be, and certainly do occur, situations in which part of the chain has successfully implemented digitalisation measures, while another part is

still in the process of implementing digitalisation solutions. This creates bottlenecks in the system's flow.

Since logistics is understood as a flow management system, which is necessary to sell products on the market (Straka, 2019), the impact of its successful digitalisation on logistics can be considered fundamental. According to Kayikci (2018), the focus of digital transformation lies mainly on production. Therefore, terms such as "factory of the future" or "smart factory" are used synonymously with this concept. It follows then that logistics should gain a greater vision to fulfil the requirements of Industry 4.0 as sustainably as possible. This refers both to using appropriate technologies and to enhancing vertical and horizontal integration among the supply chain partners (Kayikci, 2018). Cichosz, Wallenburg, and Knemeyer (2020) state that the rapid advancement of digital technologies has fundamentally changed the competitive dynamics of the logistics service industry and forced logistics service providers to digitalise. However, many logistics service providers struggle to advance their digital transformation (Cichosz, Wallenburg & Knemeyer, 2020). Fusko, Rakyta, and Skokan (2020) state that behind the scenes of the world's leading industrial and manufacturing plants, a deep digital transformation is underway. This is due to new digital (disrupting) technologies, which allow for shortening delivery times, increasing resource utilisation, and maximising product quality (Fusko, Rakyta & Skokan, 2020). According to Gupta *et al*. (2022), logistics plays a very important role in any organisation. It becomes especially important in light of factors that impede the normal flow of goods through transportation systems, such as a pandemic. The use of information technology allows reacting quickly in such situations, so it promotes greater resilience of logistics systems to critical situations. However, in developing countries, digitalisation poses certain challenges (Gupta *et al*., 2022). Other researchers also express a similar view on the issue in their works (Bartosek & Jurová, 2019; Schneider *et al*., 2021; Wang & Sarkis, 2021).

Globally, it can be stated that the interest in digitalisation, or digital services is growing in all areas of logistics. However, from the point of view of the sustainability of effective implementation of practical digitalisation, the degree of reaching the desired functional state must be regularly monitored and analysed. A similar opinion is shared by Herold *et al*. (2021), who state that organisation theory researchers do not pay enough attention to the issue of digitalisation in logistics, despite the increasing use of information technology in this area. Hence, more and more authors are using an institutional approach in their work, recognising digitalisation as a social construct (Herold *et al*., 2021). Lenort *et al*. state that the perceived potentials of digitalisation in logistics can be expected to affect financial, environmental, and social indicators, which still need to be scientifically evaluated (Lenort *et al*., 2022). According to Parhi *et al*. (2022), sustainable Logistics 4.0, still in the nascent stage, is attracting the favourable attention of practitioners as it

provides an opportunity to improve sustainability aspects of the business through digital intervention. Technology infrastructure, digital solutions, top management's commitment, as well as governmental norms, were found to be the top contributing factors influencing the implementation of sustainable Logistics 4.0 (Parhi *et al*., 2022). Cichosz states that Industry 4.0 technologies contribute to increasing the value of logistics services for customers, but do not replace them (Cichosz, 2018). Very interesting research findings are presented by Loske and Klumpp (2020), who state that logistics is of central importance in the development of digitalisation of the economy. This is due to the connection between the flow of information and material throughout supply chains. The results of the model indicate that a change in the level of digitalisation entails a loss of the efficiency level in the first stage, which can be compensated for and even surpassed later (Loske & Klumpp, 2020).

Currently, there is no doubt that the Fourth Industrial Revolution, Industry 4.0, and the digitalisation associated with it, also in the field of logistics, are being successfully implemented in practice. But what has been neglected so far is the identification of factors that influence the success of the transformation. Xu *et al*. also address this issue in their work, stating that it is necessary to measure the impact of digitalisation of logistics on the efficiency of natural resource deployment and depletion (Xu *et al*., 2023). Haidi *et al*. state that the mediating role of customer collaboration between digitalisation of logistics and company performance based on corporate information processing theory must be explored, and the moderating role of government support must be examined (Haidi *et al*., 2023). Buss, Oberbeck, and Tullius found in their research that ongoing changes should not be interpreted as technology-driven upheaval, but rather as industry-specific developments of systemic rationalisation (Buss, Oberbeck & Tullius, 2022). In order for the next industrial revolution, or Industry 5.0, to develop successfully, several analyses and evaluations of the previous revolution must be carried out. Some authors are currently working on the subject in their research work (De Andres Gonzalez *et al*., 2021; Luo & Wang, 2023; Yang & Lin, 2024).

Taking into account the results of the above-mentioned research, it was considered appropriate to conduct a study aimed at examining the relationship between the country's ability to implement digital technologies and its logistics performance. This relates to both general terms and individual aspects of logistics, such as the quality of services, punctuality, or the ability to track deliveries.

2. Literature Background

Logistics Performance Index (LPI) is used in studies to assess the area of the economy related to transportation and logistics in various countries (cf. Lo Storto & Evangelista, 2023; Miškić *et al*., 2023; Oğuz, 2023; Jonasikova & Konecny, 2024; Ju *et al*., 2024).

Several important factors affect LPI. One is the quality of public management, as shown in a study conducted by Uyar, Fernandes and Kuzey (2021) on a large sample of 677 records, consisting of 144 countries and 5 study years. Another factor related to a country's policies and legal system is the level of corruption, which negatively affects the LPI (Saldanha & DeAngelo, 2022). A study conducted by Friske, Yun and Ozpolat (2025) on a sample of 287 observations from 2010, 2012, 2014, 2016 and 2018, from 92 countries showed a positive impact of the UK legal system, based on precedents, and the level of economic freedom.

Macroeconomic factors also affect the value of the LPI. A study by Ababou and Benomar (2024) found that Foreign Direct Investment (FDI) and trade (the sum of exports and imports) in relation to Gross Domestic Product (GDP) had a significant positive impact. Other studies have found GDP *per capita* and FDI to be statistically significant macroeconomic factors (Larson, 2020; Friske, Yun & Ozpolat, 2025).

Research using the Global Competitiveness Index (GCI) plays an important role in the study of a country's logistics performance factors. Such research was conducted by Kabak, Ekici, and Ülengin (2020) on panel data from 2010, 2012, 2014, 2016 from over 100 countries. Using structural modelling, they extracted the seven most important components of the GCI index affecting LPI: quality of business management, degree of development of financial markets, infrastructure, efficiency of the market for goods and services, education and training, technological readiness, and innovation. A similar study was conducted for the years between 2007 and 2017 by Kálmán and Tóth (2021) on a group of 160 countries. The factors with the strongest direct impact on LPI were the implementation of information and communications technology (ICT) and innovation (Kálmán & Tóth, 2021). Interesting research on the impact of GCI on LPI was also conducted by Chen and Hasan (2023). They proved the significant impact not only of the aforementioned GCI on LPI, but also the impact of shipping connectivity and quality of ports and infrastructure.

A very important factor determining the size of the LPI is the level of digitalisation of the country. Research in this area was conducted by Moldabekova *et al*. (2021). They conducted correlation and regression analyses between the Digital Economy and Society Index (DESI) and the LPI. The data covered the period from 2014 to 2018 and included 28 countries in the European Union. All correlations (except for digital public services) between the components of both indices proved statistically significant. Similarly, regression analysis confirmed a significantly statistical effect of the DESI and its components (except digital public services) on the LPI (Moldabekova *et al*., 2021).

Also, Mance, Vilke and Debelić (2023) conducted a study on data from 11 countries for the period from 2011 to 2019 and confirmed the positive impact of infrastructure from the ICT area on LPI and access to ICT on LPI.

One of the more interesting studies on LPI factors was conducted by Larson (2020). He proved the direct negative impact of corruption and the negative impact of corruption through the indirect negative impact of gender inequality on LPI. Cultural differences are an equally interesting factor, but are rarely seen in this research area. A study by Kesavan and Deif (2021) found a negative impact of power distance and uncertainty avoidance, and a positive impact of individualism and long-term orientation. Research on the impact of LPI on other variables is equally important, as it highlights the importance of logistics performance for a country and its economy.

As for macroeconomic variables, first of all, there is a positive relationship between LPI and GDP *per capita* (Saini & Hrušecká, 2021; Karabulut & Civelek, 2023). A positive effect of LPI on export value added (Zaninović & Bugarčić, 2023) and on exports (Turna, 2024) has also been proven. Another important effect of logistics performance in the economy is a higher density of new businesses (new business density) and a higher number of patent applications (Friske, Yun & Ozpolat, 2025).

In addition, a country's higher level of LPI contributes to its competitiveness as measured by the GCI (Kalansuriya *et al*., 2024).

3. Methodology

To examine the relationship between a country's digital competitiveness and its logistics efficiency, Pearson's linear correlation analysis and simple linear regression analysis were used. The Digital Competitiveness (*DC*) score obtained by a given country in the IMD World Digital Competitiveness Ranking was adopted as an independent variable, and the score obtained by a given country in the Logistics Performance Index: Overall (*LPI*) and other logistics performance sub-indices as a dependent variable. The analysis was conducted separately on two research samples from 2017 and 2022. As part of the study, the following hypotheses were formulated:

1. There is a positive correlation between the *DC* score and the *LPI*.
2. There is a positive correlation between the *DC* score and the Customs score (*CS*).
3. There is a positive correlation between the *DC* score and the Infrastructure score (*IS*).
4. There is a positive correlation between the *DC* score and the International Shipments score (*Ish*).
5. There is a positive correlation between the *DC* score and the Logistics Competence and Quality score (*LC&Q*).
6. There is a positive correlation between the *DC* score and the Timeliness score (*TS*).

7. There is a positive correlation between the *DC* score and the Tracking and Tracing score (*T&T*).

The variables were described based on digital competitiveness reports of respective countries for 2018 and 2023, prepared by the IMD World Competitiveness Center, as well as reports on logistics performed by the World Bank. These were the most up-to-date reports that contained both indices. It was not possible to include data for 2018, 2019, 2020, and 2021, because the values of the Logistics Performance Index for these years were not available.

The survey, which is the foundation for calculating the above-mentioned indices was conducted in 2017 and 2022, respectively (Arvis *et al*., 2018, 2023; IMD World Competitiveness Center, 2018, 2023). The digital competitiveness index ranges from 0 to 100 points (IMD World Competitiveness Center, 2018; 2023). The ranking evaluates the degree to which countries adopt and use digital technologies, as it leads to changes in society, enterprises, and government administration. The ranking consists of three main factors (IMD World Competitiveness Center, 2018, 2023):

– knowledge – application knowledge, which is important in the development and implementation of new technologies,

– technology – factors influencing the development of digital technologies,

– future readiness – the level of the country's openness to digital transformation.

Data to calculate the index came from national, international, and regional statistics, as well as surveys conducted by an international panel of experts (IMD World Competitiveness Center, 2023).

The *LPI* consists of six sub-indices relating to: customs procedures, quality of infrastructure for the implementation of transport processes, price competitiveness of shipping, competence in the provision of logistics services and the quality of these services, ability to supervise shipments, punctuality of deliveries (Arvis *et al*., 2018, 2023).

To verify the hypotheses, correlation and regression analysis were performed between the independent variable *DC* score and the dependent variables corresponding to *LPI* score and its sub-indices: Customs score, Infrastructure score, International Shipments score, Logistics Competence and Quality score, Timeliness score, Tracking and Tracing score.

4. Results

The research results were presented for 2017 ($n = 63$) and 2022 ($n = 63$). Table 1 shows the correlations between the score for digital competitiveness and the logistics performance index and its components.

The obtained correlation results (see Table 1) are statistically significant at the significance level of $p < 0.05$. They confirm the hypotheses regarding the relationships between the country's digital competitiveness and Logistics Performance

score and its components. Then, regression analysis was performed for individual dependent variables.

Table 1. Pearson's Linear Correlation Coefficient

Variables	Correlations between *DC* and Other Variables and *p*-value	
	2017	2022
LPI	0.83 (*p*-value = 0.00)	0.47 (*p*-value = 0.00)
CS	0.86 (*p*-value = 0.00)	0.53 (*p*-value = 0.00)
IS	0.84 (*p*-value = 0.00)	0.59 (*p*-value = 0.00)
Ish	0.60 (*p*-value = 0.00)	0.39 (*p*-value = 0.00)
LC&Q	0.83 (*p*-value = 0.00)	0.53 (*p*-value = 0.00)
TS	0.76 (*p*-value = 0.00)	0.42 (*p*-value = 0.00)
T&T	0.81 (*p*-value = 0.00)	0.50 (*p*-value = 0.00)

Source: own study based on Arvis *et al*. (2018, 2023), IMD World Competitiveness Center (2018, 2023).

The results of the simple linear regression analysis describing the relationship between the independent variable *DC* score and *LPI* score and its sub-indices are presented in Table 2 and Table 3. The analysis was carried out in 2017 and 2022.

Table 2. Results of Regression Analysis between *DC* Score, *LPI* Score, and Its Component Variables for the Year 2017

Statistics	*LPI*	*CS*	*IS*	*Ish*	*LC&Q*	*TS*	*T&T*
b	0.02	0.03	0.03	0.01	0.02	0.02	0.02
T	11.57	12.94	12.13	5.92	11.82	9.26	10.71
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R^2 (%)	69	73	71	36	70	58	65
St. er. of est.	0.26	0.28	0.32	0.31	0.29	0.27	0.30
F	133.80	167.44	147.04	35.01	139.81	85.67	114.75

Source: own study based on Arvis *et al*. (2018, 2023), IMD World Competitiveness Center (2018, 2023).

For 2017, interpretation of the estimated value of the β_1 parameter allows the conclusion that an increase in the index value for the IMD World Digital Competitiveness Ranking by 1 point increases the *LPI* score value and its component variables in the range of 0.01 to 0.03 points. The value of the *t*-statistic and the corresponding level of significance confirm that the parameter β_1 differs significantly from zero for all dependent variables. Based on the obtained regression

analysis model, it can be concluded that the independent variable explains 69% of the *LPI* score variance. Depending on the dependent variable, the R^2 value ranges from 36% to 73%. So, it is only one case in which the R^2 value is below 50%. It could be caused by specific of *Ish*, which depends more on macroeconomic factors in each country than digital competitiveness. The average difference between the actual values of all dependent variables and the values predicted by the model was in the range of 0.26 to 0.32. The high value of the *F*-statistic for the models of the relationship between *DC* score and *LPI* score (and its component variables), and the corresponding probability level *p* ($p < 0.001$) confirm the statistical significance of the constructed linear models (cf. Mustafy, Rahman & Siddqui, 2024).

Table 3. Results of Regression Analysis between *DC* Score and *LPI* Score and Its Component Variables for the Year 2022

Statistics	*LPI*	*CS*	*IS*	*Ish*	*LC&Q*	*TS*	*T&T*
b	0.02	0,02	0.02	0.01	0.02	0.02	0.02
T	11.42	12.93	10.88	6.98	9.96	7.38	9.84
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R^2 (%)	68	73	66	44	62	47	61
St. er. of est.	0.24	0.25	0.31	0.29	0.29	0.30	0.30
F	130.35	167.28	118.41	48.72	99.125	54.54	96.93

Source: own study based on Arvis *et al*. (2018, 2023), IMD World Competitiveness Center (2018, 2023).

For 2022, interpretation of the estimated value of the β_1 parameter allows the conclusion that an increase in the index value for the IMD World Digital Competitiveness Ranking by 1 point increases the *LPI* score value and its component variables in the range from 0.01 to 0.02 points. The value of the *t*-statistic and the corresponding level of significance confirm that the parameter β_1 differs significantly from zero for all dependent variables. Based on the obtained regression analysis model, it can be concluded that the independent variable explains 68% of the *LPI* score variance. Depending on the dependent variable, the R^2 value ranges from 44% to 73%. The variance of *Ish* was also explained by digital competitiveness at a level lower than 50%, which confirms earlier explanations. However, the variance in the punctuality of deliveries was explained by digital competitiveness also at a level lower than 50%, which could be caused by supply chain disruptions being an effect of the COVID-19 pandemic. The average difference between the actual values of all dependent variables and the values predicted by the model was in the range from 0.24 to 0.31. The high value of the *F*-statistic for the models of the relationship between *DC* score and *LPI* score and its component variables, and the

corresponding probability level p ($p < 0.001$) confirm the statistical significance of the constructed linear models (cf. Mustafy, Rahman & Siddqui, 2024).

5. Conclusion

The conducted research allowed achieving the assumed goal, which was to investigate the relationship between a country's digital competitiveness and logistics performance, both in general and individual aspects of logistics, which are sub--indices of the Logistics Performance Index.

The study confirmed the hypotheses, so it can be stated that:

1. The country's digital competitiveness has a positive impact on logistics performance in general, which is consistent with previous research on various digital technologies in logistics.

2. The country's digital competitiveness has a positive impact on the efficiency of administrative services at borders, which is consistent with the concept of sustainable Logistics 4.0 (Parhi *et al*., 2022).

3. The country's digital competitiveness has a positive impact on the quality of logistics infrastructure, which also confirms the conclusions from research on the concept of sustainable Logistics 4.0 (Parhi *et al*., 2022).

4. The country's digital competitiveness has a positive impact on the ease of planning competitively priced shipments.

5. The country's digital competitiveness has a positive impact on the quality of logistics services that are digitalised (Cichosz, Wallenburg & Knemeyer, 2020).

6. The country's digital competitiveness has a positive impact on the punctuality of parcel delivery, which is consistent with research that indicates an improvement in the timeliness of processes thanks to digitalisation (Fusko, Rakyta & Skokan, 2020).

7. The country's digital competitiveness has a positive impact on the ability to track and trace shipments because logistics itself is a flow management system (Straka, 2019). This means that the implementation of digitalisation in logistics is fundamental.

Pearson's linear correlation coefficients suggest a strong positive correlation between digital competitiveness and the parameters examined. The regression analysis performed for the analysed data showed that there is a positive relationship between digital competitiveness and the growth of other variables. The best fit of the model was obtained when comparing the *DC* score and the *CS*, which was confirmed by the values of Pearson's linear correlation coefficients (a strong positive correlation at $r = 0.86$). Based on the above, it can be concluded that this variable can be taken into account as a potential predictor when modelling the studied connections. This is because these variables are strong, and the analysis suggests that there is a strong relationship between digital competitiveness and the country's

logistic efficiency. This knowledge could be useful in developing economic development strategies and activities aimed at improving the competitiveness of a country in the international arena.

Please note that the described relationships turned out to be statistically significant in both analysed periods, i.e. 2017 and 2022. This was true despite significant events such as the COVID-19 pandemic, which took place between the analysed periods and had a significant impact on logistics, also in 2022. This indicates the permanence of the examined relationships. However, due to the multidimensional nature of these phenomena (some of the R^2 values are below 50%), further research on the impact of digitalisation on logistics performance is required.

6. Recommendations

Among researchers of LPI determinants, Friske, Yun and Ozolpat (2025) point out that economic policy makers can use LPI as a benchmark. Businesses, too, should take this indicator into account when making decisions about supply chain structure. This is especially important for companies that supply their products to many countries around the world. Small companies, on the other hand, according to these authors, should cooperate with companies supplying goods to countries with high LPI (Friske, Yun & Ozolpat, 2025).

In contrast, Lo Storto and Evangelista (2023) emphasise that in addition to the LPI, measures relating to sustainable development should be incorporated into a country's transportation policy. According to Azwardi, Fuadah and Syathiri (2024), transportation policies should use environmentally friendly development strategies based on assumptions such as environmentally friendly technologies used in the expansion of transportation infrastructure and investment in renewable energy sources. These authors also point to the need to invest in the digitalisation of logistics through the development of specialised digital platforms, the implementation of information and communication technologies, the Internet of Things and blockchain technologies.

On the other hand, Chen and Hasan (2023) advocate increasing the competitiveness of the port sector through greater participation of private enterprises and better management of port infrastructure. Kesavan and Deif (2021), on the other hand, highlight the role of human relations and communication in culturally diverse environments when implementing international logistics processes. This is important for both policymakers and logistics managers (Kesavan & Deif, 2021).

Taking into account the recommendations of other authors and the results of the research contained in this article, the following recommendations can be proposed:

1. An integrated policy for the implementation of Industry 4.0 should be developed with a special focus on the area of transportation and enterprise logistics,

which should take into account changes in society, enterprises and government administration.

2. Investment by transportation enterprises in digital technologies should be increased.

3. Initiatives involving cooperation between the public and private sectors for the digitalisation of public transportation and the digitalisation of logistics processes in enterprises should be established.

4. The LPI and IMD Digital Competitive Indices should be used in the development of digitisation and transportation policies at the national and international levels.

5. Strategic decisions in enterprises should be made based on data from logistics and digitisation indices and research in this area.

Given the dynamic nature of the phenomena examined in this article, further research is needed on the digitisation of international logistics processes. In recent years, the stability of global supply chains has become increasingly critical, underscoring the importance of thoroughly investigating the role of emerging information technologies, including AI, in enabling rapid decision-making within the logistics sector.

Acknowledgement and Financial Disclosure

The article presents the results of the Project no. 049/ZZZ/2025/POT financed from the subsidy granted to the Krakow University of Economics.

Authors' Contribution

The authors' individual contribution is as follows: Paweł Łukasik: conceptualisation (lead), formal analysis (lead), methodology (lead), writing – original draft preparation (lead), writing – review & editing (lead). Martin Straka: conceptualisation (equal), methodology (equal), supervision (lead), writing – original draft preparation (equal). Renata Winkler: conceptualisation (equal), funding acquisition (lead), methodology (support), project administration (lead), writing – original draft preparation (equal), writing – review & editing (equal). Paweł Turek: conceptualisation (support), formal analysis (equal), methodology (equal), writing – original draft preparation (equal). Jerzy Szakiel: conceptualisation (support), formal analysis (equal) methodology (equal), writing – original draft preparation (equal).

Conflict of Interest

The authors declare no conflict of interest.

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