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Research Article

Futuristic Projection of Time-Varying NAIRU for Canadian Economy and Its Implication for Changes in Economic Growth

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Abstract: *The Non-Accelerating Inflation Rate of Unemployment stands for a rate of unemployment that will not put pressure on the economy and facilitates economic growth without any inflationary pressures. This concept originated from the Philips curve, in which if economic agents are employed at full capacity, the economy produces in the long run. If we remove the inflationary pressure, we can estimate the NAIRU, which is a better policy tool. This paper seeks to estimate the time series of NAIRU in the Canadian economy for the years between 2005 to 2022. The persistency of unemployment in the Canadian economy is analyzed via NAIRU and its fluctuations. Their contribution to economic growth is considered by breaking total unemployment to NAIRU and the Unemployment Gap, which is derived from the Philips curve. The results reflect that the equilibrium unemployment rate for the Canadian economy is around 2 percent, and according to the projection of future trends, the government and, specifically Central Bank should target this rate in order to prevent fluctuations and keep the economy in its steady state in the long run. Moreover, through the Granger causality test, it is approved that NAIRU is a granger cause of economic growth.*

Keywords: *NAIRU, Economic Growth, Granger Causality, persistency.*

I. INTRODUCTION

Non-accelerating Inflation Rate of Unemployment, abbreviated as NAIRU which, has been an important economic factor to be studied by numerous researchers in the macroeconomic field. The trend of NAIRU, as well as other variables influencing its movements, has been one one the important issues that economists focus on. When examining the labor market equilibrium in the context of the Philips curve, NAIRU is a crucial determinant of whether or not unemployed has been reduced to its long-term optimum level. In the labour market, the number of unemployed labour force is affected by various factors, say inflation, wage levels, labour supply and labour productivity (Mohebi, 2017). In their 2002 study, NAIRU in theory and practice, Laurence Ball and Gregory Mankiw emphasized that the primary reason driving NAIRU behavior is the effect of production. Komijani and Mohebi (2013) studied the effect of oscillating NAIRU on economic growth in a panel of oil-exporting countries. They proved, as expected that the intensity of NAIRU was a cause of the decrease in economic growth.

The direct path through which policymakers like the Central Bank of Canada can induce economic growth is by controlling the unemployment rate in the long run. They should target monetary policy to reach the optimum unemployment rates and then, by non-accelerating inflation rate, provide incentives for firms to employ more and, therefore, increase the economy's production and growth level. The Granger methodology applied in this study robustly confirms this policy advice and indicates that in the Canadian economy the growth is directly taking effect from unemployment levels. The rest of this paper is as follows: the first section discusses the data used in this study, the second section explains the estimation of NAIRU through the Kalman Filter and discusses the estimation results of NAIRU in the Canadian economy for the years 2995 to 2022, section three is devoted to the Granger causality analysis to determine the impact of NAIRU on economic growth in Canada, section four discuss the results of the estimations and the last part is conclusion.

II. LITERATURE REVIEW

NAIRU, standing for equilibrium unemployment of an economy, is an optimum reflection of how an economy's policies are inflationary or deflationary to control the unemployment rate to the extent that no more fluctuations cause economic growth to decline. Ball and Mankiw (2002) applied a regular method in the estimation of US NAIRU and took into consideration how other factors may have an impact on its long-run trend. Mohebi and Komijani (2017) considered the same method and analyzed the productivity shock effects on NAIRU for the three most important countries in the world. Mohebi (2017) considered factors influencing NAIRU by implementing a Panel-VAR approach. The importance of NAIRU in a developed country like Canada is high, and this study tries to provide an update on the NAIRU time series in the Canadian economy to provide policymakers with the current status of the economy in order to adapt their policies to control the unemployment rate in Canada. This paper suggests different methods regarding the estimation of time-varying NAIRU and

Philips curve slope for the Canadian economy between the years 2005 to 2022 with consideration of the Granger causality test to investigate the final impacts of the unemployment gap (i.e. the impact of NAIRU) on the economic growth rate of the Canadian economy. According to the results of NAIRU estimation by Kalman Filter and Granger causality analysis, the average of NAIRU for the Canadian economy is 2 percent, and NAIRU has an important influence on economic growth as it is Granger's cause of growth.

III. DATE OF THE STUDY

As we have an unobservable variable known as NAIRU in Philips identification, we should use the State-Space method to estimate the state variable. In Philips's identification of the inflation and unemployment relationship, inflation expectation is considered as indigenous variable which should be estimated before using it in the State-Space model. In most studies, the expected inflation is simply considered as the average of the inflation rate. However, in this paper, the ARIMA model is used to estimate the expected inflation as it considers the effects of the shock and fluctuations with two lags in autoregressive and one lag in moving average processes. The data on the unemployment rate and inflation are gathered from World Bank statistics and have been tested for stationary and proven to be stable.

IV. TIME-VARYING NAIRU ESTIMATIONS WITH KALMAN FILTER FOR THE CANADIAN ECONOMY

The most useful tool to estimate the unobservable variable of this study is the Kalman-Filter in most studies. But in the current study, it is merged with the State-Space approach and estimation done by Stata software with the minimum level of errors.

A) Kalman Filter Specification

The time-varying NAIRU is estimated via the Kalman filter. The Kalman filter was first created to help in aviation. One of the main benefits of the Kalman filter is the fact that it may be used in real-time; that is, every value that is seen of a time period can be used to forecast the value of the following observation. This makes the method very useful and significant in the financial industry. The filter is solely based on past data, but it responds quickly to shifting circumstances. These practical characteristics attest to the Kalman filter's value and suitability, given the dynamic nature of hedge-fund portfolios and its critical role in identifying crises and significant shifts in the market. The Kalman filter is appropriate to consider, in fact. The Kalman filter (Kalman, 1994) is a Bayesian updating scheme that maximizes the likelihood of correctly estimating unknown parameter values (Koch, 2006). The filter addresses the general problem of attempting to estimate the state [$x \in \Re n$] of a discrete, time-controlled process governed by the linear stochastic difference equation:

$$xt = Fxt\text{-}1 + But\text{-}1 + wt\text{-}1 \qquad (1)$$

[$x \in \Re n$]:

$$zt = Hxt + vt \qquad (2)$$

Process white noise and assessment white noises are represented, respectively, by the random variables □ and □. It is assumed that these have normal probability distributions and are separate from one another (0 correlation):

$$(\cdot)\sim(0, \boldsymbol{Q})$$

$$(\cdot)\sim(0, \boldsymbol{R})$$

Although they are considered to be constant here, in practice, the process noise covariance (□) and measurement noise covariance (□) matrices (here variance matrices since □ = 0) may change with each time step (Koch, 2006). These numbers were from maximum likelihood calculations. Considering no driving functions or process noise, the state at the previous time, step □ − 1, is linked to the current state at step □ by the 2 × 1 (in this example) state transition matrix □. The optional control input □ ∈ ℜ□ is related to the state □ through the 2 × 2 control matrix □. The state and the measurement K are related by the 2 × 1 matrix □ in the measure. While □ and □ may vary with each successive step in execution, they are both taken to be constant in this case. The estimation process involves a series of past dependent recurrences, which, in fact, projects the state with one time step forward and predicts as in equation (3). In order to obtain the results for the whole estimating period Kalman Filter involves an update process for both the main variable and its error covariance;

$$\hat{\boldsymbol{x}}t|t-1 = \boldsymbol{F}t\hat{\boldsymbol{x}}t-1|t-1 + \boldsymbol{B}t\boldsymbol{u}t \qquad (3)$$

$$\boldsymbol{K}t = \boldsymbol{P}t|t-1\boldsymbol{H}t\mathrm{T}\,(\boldsymbol{H}t\boldsymbol{P}t|t-1\boldsymbol{H}t\mathrm{T} + \,)\text{-}1 \qquad (5)$$

where $\hat{\boldsymbol{x}}$ is the estimated state, $\boldsymbol{F}$ is the state transition matrix (i.e., transition between states), $\boldsymbol{u}$ represents the control variables, $\boldsymbol{B}$ is the control matrix (i.e., mapping control to state variables), $\boldsymbol{P}$ is the state variance matrix (i.e., error of estimation, $\boldsymbol{H}$ is the measurement matrix (i.e., mapping measurements onto the state) and $\boldsymbol{K}$ is the Kalman gain.

B) Time-varying NAIRU estimation for the Canadian economy and its projection

The persistence of the unemployment rate should be considered in explaining its long-run behavior. The simple answer to why, in some periods unemployment rate remains high, based on information provided by Table (1) and Figure (1), is the existence of persistence. This persistence is studied for the Canadian economy by Ossama Mikhail, Curtis J. Eberwein and Jagdish Handa. The results indicate that the fluctuations in aggregate and sectoral Canadian unemployment are characterized by persistence. In fact, in the years between 2005 to 2008, policies regarding the reduction of inflation caused the Canadian economy to experience the extra cost of persistent unemployment.

Table 1: Time-varying NAIRU for the Canadian economy

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
NAIRU		1.872088	1.658062	1.965016	1.924417	1.781328	1.866464	2.136536	2.249641
Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
NAIRU	2.441608	2.510322	2.41824	1.575497	1.467208	1.915939	1.975399	2.387612	2.0451436

The Unit root test is done to see if NAIRU is stationary or not. The Unit Root test indicates that NAIRU is stationary in level. This stationary NAIRU implies that there is a constant mean, variance and autocorrelation structure over time, which causes the NAIRU to remain high for long periods. On the other hand, any fluctuation in a trend of NAIRU will be accompanied by persistency that causes NAIRU to fluctuate by long time intervals. Estimated records vividly support this notion as between the years 2005 to 2010, NAIRU hardly fluctuates around 1.8 percent, which approves the hypothesis of persistency as well as unit root test results regarding no periodical fluctuations in NAIRU. But starting from 2011, there is an upward leap which characterizes the long-term interval fluctuations of NAIRU. Persistency in NAIRU results in its constant value of around 2.3 percent in the medium term of five years. This process can be constantly monitored for Canadian NAIRU during the period under investigation. The estimation results of the Kalman Filter reflect that in the Canadian economy, the equilibrium long-run unemployment rate at which there is no inflationary pressure fluctuation is around two percent. Despite reaching of actual unemployment rates to the rate of 1.46 as in the year 2018 is somehow difficult, performing at rates near this rate, around 2 percent, will provide enough incentives for decision makers like firms to employ more and increase the production level, which will directly influence the economic growth in the Canadian economy. Therefore, the Central Bank of Canada should arrange its target function to reach this rate by which inflation is also under control.

To analyze how the aggregate unemployment rate takes effect from NAIRU and unemployment gap which it is consists of both NAIRU as equilibrium unemployment and total unemployment are depicted together. As later will be proven by Granger test results, NAIRU's rise and fall are not in the same direction as total unemployment. However, its fluctuations, as later will be shown in Granger causality results, will directly affect aggregate unemployment rates. This kind of effect of variance of NAIRU will be resulted in changing total unemployment in later periods; thus, it can be certainly asserted that there is a casual relationship between them.

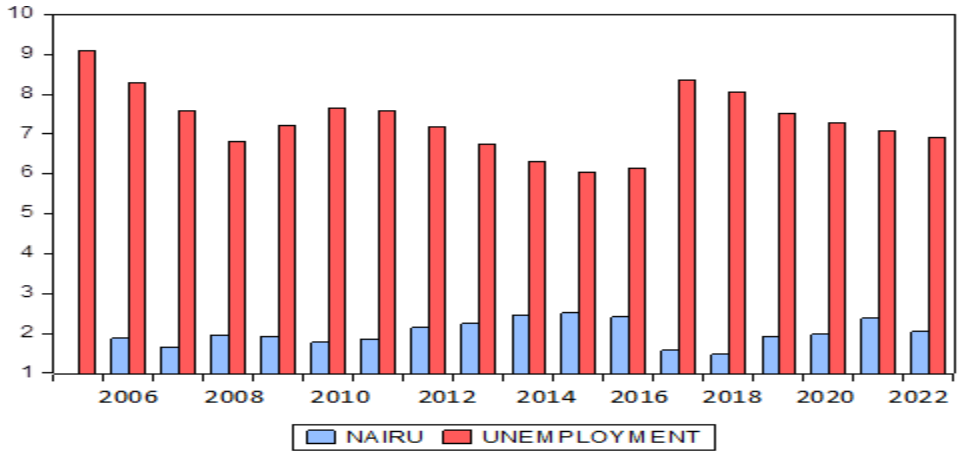

Fig. 1 NAIRU and Unemployment for the Canadian Economy

As is reflected in Figure (1), there is a gap between current unemployment levels and NAIRU. While in some periods, the difference is reduced, but there is a meaningful correlation. This reflects that the policies should be oriented to reduce the

unemployment rates in order to reach the optimum long-run rates. Monetary policy is the main tool to do this by which the policymaker can control inflation and unemployment.

V. GRANGER CAUSALITY BETWEEN UNEMPLOYMENT GAP AND ECONOMIC GROWTH

To implement effective market policies and programs is by looking at the behavior of NAIRU. Policies regarding controlling fluctuations of NAIRU by stable insurance and monetary regulations could only be performed by monitoring the behavior of NAIRU (Mehdi Mohebi, 2017). The gap between unemployment and NAIRU is depicted below. The gap or dynamic part of unemployment shown in Figure (2) brings much variation to its trend. It should be controlled by institutional policies such as insurance and hiring of firms to reduce the effects of persistent unemployment caused by monetary policies. Based on Table(2), the test reflects that NAIRU is more prone to explain the behavior of total unemployment than the Unemployment Gap does, and its fluctuations will cause aggregate unemployment to increase more in the long run. Policies regarding the labor market, like contract periods and social care coverage by the government, should be regulated to an extent to lesser friction and uncontrolled unemployment to minimize NAIRU and its fluctuations; besides, money market policies in controlling inflation should consider persistence in total unemployment and NAIRU in the Canadian economy to not cause the economy to bear the unemployment cost due to deflation. According to the results below, unemployment not being the Granger cause of NAIRU is rejected, which means that the rate of NAIRU will be affected by the current levels of unemployment and, therefore, the fluctuations of unemployment due to weak monetary and fiscal policies will change the NAIRU and long-run potential path of unemployment rate;

Table 2: Pairwise Granger Causality Tests

Null Hypothesis	Obs	F-Statistic	Prob.
Unemployment does not Granger Cause NAIRU	15	2.12807	0.1698
NAIRU does not Granger Cause Unemployment		2.09609	0.1737
Unemployment does not Granger Cause Unemployment Gap	14	1.96651	0.2077
Unemployment Gap does not Granger Cause Unemployment		1.58602	0.2765

As Table 2 shows, the hypothesis that unemployment is not Granger's cause of the unemployment gap is rejected, which means that controlling current levels of unemployment will significantly influence the gap and if Canada wants to reduce the gap and perform at long-run levels, they should perform policies incentivizing job creation and reducing unemployment.

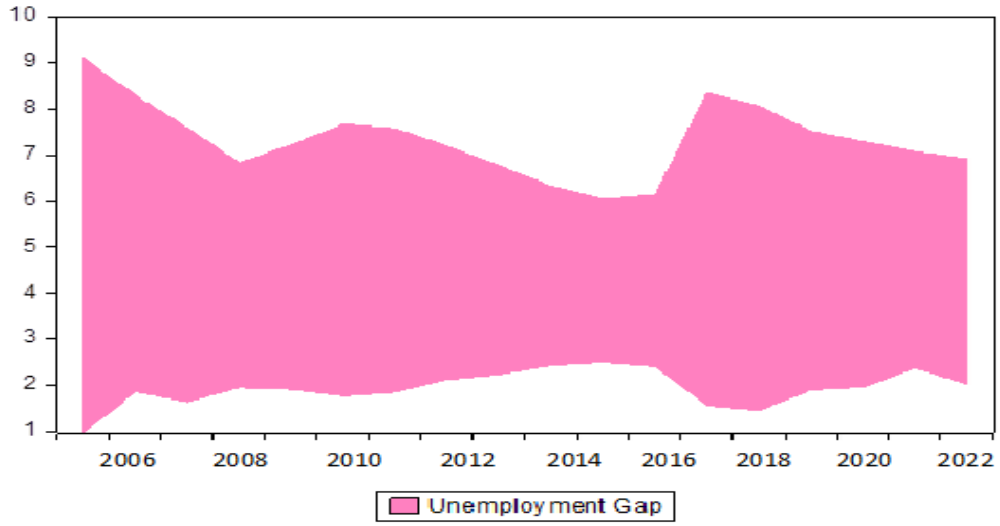

Fig. 2 Unemployment Gap for the Canadian Economy

According to the Unemployment Gap figure above, the gap decreased between the years 2006 to 2016, which reflects the economy's heading to long-run full employment and maximum usage of the labour force. Therefore, the policies facilitated economic growth with regard to low inflation levels. From 2016 to 2018 the gap worsened that is because of unstable policies by Central Bank or government.

Moreover, the Granger causality test is implemented to determine how turbulence in the unemployment gap will cause the economic growth rate to change. According to the results taken from the estimation, the hypothesis that the Unemployment Gap does not Granger Cause Economic Growth is rejected at the 3 percent level, meaning that the unemployment gap has a direct impact on economic growth, but the reverse relationship from economic growth to unemployment is not accepted reflecting the one-directional causality between economic growth and Unemployment Gap.

Table 3: Pairwise Granger Causality Tests

Null Hypothesis	Obs	F-Statistic	Prob.
NAIRU does not Granger Cause Economic Growth	15	2.72235	0.1138
Economic growth does not Granger Cause NAIRU		0.274	0.7659
Unemployment Gap does not Granger Cause Economic Growth	15	4.73462	0.0357
Economic growth does not Granger Cause Unemployment Gap		0.00801	0.992
NAIRU Fluctuations does not Granger Cause Unemployment	12	2.70635	0.2198
Unemployment does not Granger Cause NAIRU Fluctuations		48.7585	0.0046

As the above table clearly reflects, the unstable monetary policies causing movements in the unemployment and NAIRU will definitely cause movements in economic growth, which in the long run is not good for the Canadian economy and will bring unstable conditions in which firms will be demotivated to produce more and increase economy's production level. In order to examine the truthfulness of the conclusion driven by the Granger Causality test, both NAIRU and economic growth have been projected for the years 2021 to 2023. Based on the results in Figures (3) and (4), NAIRU for those years will be a rate between 2 and 2.2, and at the same time, the economic growth is about 2.1 on average for three years. The most intriguing issue regarding the fan charts is their representation of strong evidence (90 percent confidence) of the direction of NAIRU and Growth in coming years. Regulating stabilizing policies in the Canadian economy by both monetary authorities and the government will strengthen the economy to a degree that will achieve constant economic growth. At the same time, unemployment is preserved in the target rate more plausible. In this sense, the inflation rate should be controlled by contracting the money supply and damping the extra demand in the economy.

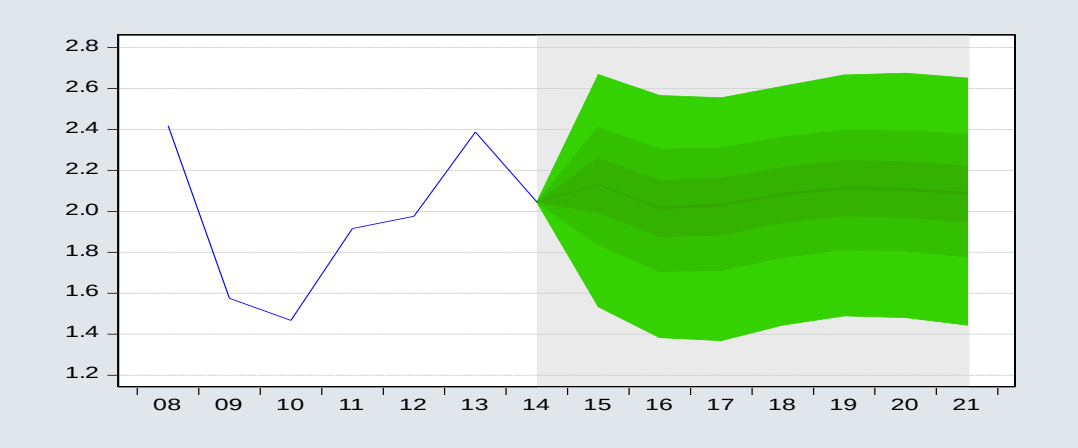

Fig. 3 The projection of NAIRU for the years 2021 to 2023

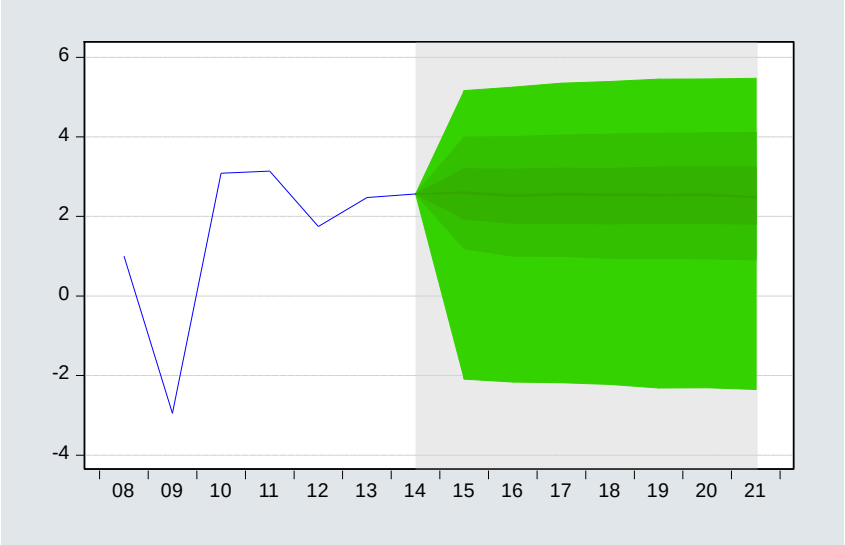

Fig. 4 The projection of economic growth for the years 2021 to 2023

The projection of NAIRU through fan charts reflects that for the coming years, the NAIRU level will also be around 2 percent, which is a hint for policymakers to adapt their target unemployment rates by performing sound policies. The range of fluctuations of NAIRU is between 2 to 2.2 percent, and it is the level we expect to be good levels of unemployment for the Canadian economy in the coming years.

VI. RESULTS AND DISCUSSION

As unemployment and inflation have co-movements according to the specification done by Philips, the control of unemployment by policies targeting the inflation levels will help the economy to reach its long-run optimum level and also will prevent inefficiency in the economy. In the current study, an update to the current estimation of equilibrium unemployment for the Canadian economy is presented. Using the estimated time series, the relationship between unemployment and economic growth through Granger causality is tested. If the economic convention that more employment will increase production and economic growth is considered, policies targeting the control of inflation will increase unemployment. However, the NAIRU which shows us the rate at which inflation is also under control, will better reflect the influence of reducing unemployment on economic growth. In this paper, the average estimated NAIRU for the Canadian economy is around 2 percent, which is the level of unemployment at which we have controlled inflation and induced production by holding the long-run unemployment rate at low levels. The Granger causality is applied to data of NAIRU and economic growth that meaningfully supports the hypothesis of growth taking influence from the long-run unemployment rate. In fact, if policymakers like the Central Bank of Canada target economic growth with low levels of unemployment and control inflation, they will keep the unemployment rate at a 2 percent level and perform monetary policies to hold the rate around the 2 percent average NAIRU rate.

VII. CONCLUSION

NAIRU and the Unemployment Gap are two constituents of Aggregate Unemployment and, in analyzing the relationship between economic growth and unemployment should be considered separately. Numerous studies have focused on estimating NAIRU solely without taking into consideration how its fluctuations during economic periods will cause major economic indices to change. In our study, a progressed version of the method used in previous studies has been applied to estimate time-varying NAIRU for the Canadian economy. Furthermore, total unemployment has been broken into two parts in order to study its behavior and its effects on economic growth. Results reflect that NAIRU and its fluctuation have the most influence on total unemployment rates in the long run and explain the persistency in Canadian unemployment. Based on causality tests, both the Unemployment Gap (or turbulent part of unemployment) and NAIRU trigger economic growth. This result is further proven to be strong by the projection of both NAIRU and economic growth for the years 2023 to 2024, which highlights the role of policies to be implemented by the government of Canada in the coming years. Policies to stabilize unemployment will facilitate the economy's reaching the target growth rates. The average estimated NAIRU for the Canadian economy is 2 percent. As approved by Granger causality, policymakers should target unemployment levels at the NAIRU level in order to incentivize economic growth with no inflationary pressures.

Interest Conflicts
The author(s) declare(s) that there is no conflict of interest concerning the publishing of this paper.

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