



# The effects of Covid-19 related response policies on the performances of technology-driven financial services companies

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## ABSTRACT

This study examines the causal connections between COVID-19-related restrictions, economic support measures, and the performance of fintech enterprises with combined Granger causality and Fractional Frequency Flexible Fourier-form Toda-Yamamoto (FFFYTY) causality tests. We find the evidence of unidirectional permanent causality running from Covid-19 related government response stringency and economic supports to the performance of the technology-driven financial services (TDFSC) in most of the countries in the sample, where traditional tests fail. Our findings indicate that these companies seem to be the primary beneficiaries of Covid-19-related policies (restrictions and economic support) implemented by governments to mitigate the negative impacts of the pandemic.

## 1. Introduction

The aim of our study is to analyze the causal interconnections between COVID-19-related restrictions, economic support measures, and the performance of fintech companies primarily engaged in TDFSC. We hypothesize that the COVID-19 pandemic and the implemented policies have cultivated a conducive milieu for fintech companies, engendering a noteworthy, enduring influence on their performance. Within this study, we endeavor to address three pivotal research inquiries: (1). Does a unidirectional causality persistently exist from government response policies related to COVID-19, encompassing stringency and economic support, to the performance of TDFSC companies operating in developed nations? (2). Do these unidirectional causal connections exhibit permanence or transience? (3). What implications do our findings carry for the assessment of the consequences of government restrictions and support policies?

The COVID-19 pandemic, in conjunction with the governmental policies enacted to alleviate its deleterious impacts, bears noteworthy repercussions for global, national, and sector-specific economies. These measures have precipitated substantial consequences, inducing adverse shocks in both supply and demand (Abay et al., 2020). At the same time, it is challenging to ascertain that the Covid-19 pandemic has uniformly and equally affected every economy and sector with the same degree of intensity. Furthermore, the various types of adverse demand and supply shocks can unexpectedly prompt individuals and companies to adopt specific

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technological advancements (Fu and Mishra, 2022). These shocks can also lead to long-term changes in communities and economies (Vukovic et al., 2021), with either temporary or enduring consequences. In contrast to the negative impacts of the Covid-19 pandemic and restrictive regulations, Fintech have emerged and accelerated the adoption of innovative financial services (Financial Stability Board, 2022).

Regardless of the already strong trend of the impact of financial innovations on inclusion and the adoption of new technologies, such as e-banking and crowdfunding (Peer-to-peer - Jiang et al., 2021; crowdfsource - Sul, 2020; crypto market – Maiti et al., 2023), social distancing measures during the Covid-19 pandemic have further encouraged the adoption of new financial technologies. In the contemporary context, there is a clear shift towards digital financial services, electronic payments, and online commerce. As a result, we anticipate that the lasting impacts of Covid-19 regulations and the performance of fintech companies are likely to be permanent. However, the recovery in face-to-face businesses, as Covid-19 restrictions are relaxed, suggests that the pandemic's effects may be temporary (Financial Stability Board, 2022).

In providing answers to these questions, our study makes two significant contributions to the existing literature. First, as far as our knowledge extends, this is the first attempt to employ a non-linear methodology that takes into account non-linearity and multiple structural breaks in the data to investigate the effects of Covid-19-related stringency and economic support policies on the performance of TDFSC. Second, we present supplementary data that can enhance our understanding of the potential impacts of such policies on specific sectors' performance. This is achieved by offering evidence of the causal relationship between these policies and the fintech industry while also examining whether these causal connections are permanent or temporary.

The primary findings of our study indicate that there is evidence of unidirectional and permanent causal relationships between the stringency of government responses to Covid-19 and the economic support provided, and the performance of TDFSC in a sample of twelve countries. Furthermore, we believe that the strictness of restriction policies and the determination of policymakers in individual countries play a pivotal role in producing such results. Since the responses to the Covid-19 pandemic vary significantly from one country to another, the results exhibit differences across nations.

The rest of the study is organized as follows: Section 2 explains the data and methods in the study. Section 3 presents and discusses the empirical results of the study and section 4 concludes.

## 2. Data and preliminary analysis

Our study uses three indices to test the existence of unidirectional causality running Covid-19 related government response stringency to performances of the TDFSC. First one is the Indxx Global Fintech Thematic Index (IFINX), with the aim to track the performance of companies listed in developed markets. Such companies provide technology-driven financial services, in six categories: Personal Finance Software, Automated wealth Management and Trading, Enterprise Solutions, Crowdfunding, Mobile Payments, Blockchain and Alternative Currencies, and P2P and Marketplace Lending (Fig. 1). We extract data about this index from <https://www.indxx.com/indxx-global-fintech-thematic-index-tr>. The second is the COVID-19 Stringency Index provided by The Oxford Coronavirus Government Response Tracker (Hale et al., 2021). We include from this index 23 developed countries with composite measure of nine of the response metrics (Table A1). All indices take the value between 0 and 100 (Hale et al., 2021). We focus on developed countries since the index exclusively monitors the performance of technology-driven financial services enterprises. Our sample consists of daily observations. The third is the economic support index. We use this index to analyze the effects of COVID-19-related economic supports on the performance of the TDFSC. This index measures the income, the debt, and the contract relief provided to individuals and companies during the pandemic. We extracted all the data for these three indices from the Thomson Reuters Refinitiv database.

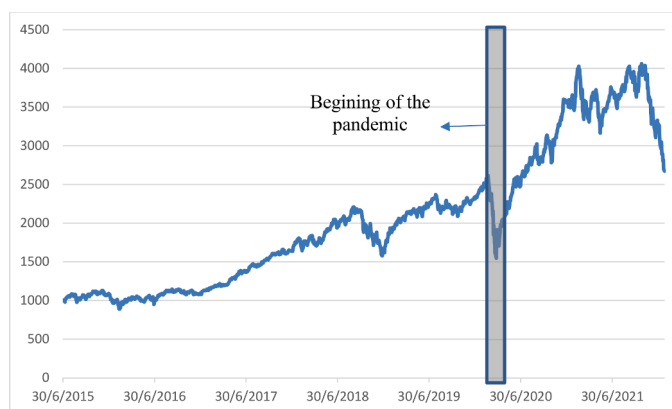


Fig. 1. The plot of IFINX.

Source: Author's calculations based on Indxx Global Fintech Thematic Index <https://www.indxx.com/indxx-global-fintech-thematic-index-tr>. Data are collected from the Thomson Reuters Refinitiv database.

### 3. Empirical strategy

Our study's empirical strategy consists of two stages. In the initial stage, we implement both linearity and unit root tests of Fourier ADF (FADF). FADF is a precondition for implementing the causality test, that we implement in the second stage of our study. The reason why we prefer to use this test is that it allows us to test the maximum degree of integration of variables by considering unspecified structural breaks and possible non-linearities in the data. Unfortunately, traditional unit root tests, such as ADF, PP and KPSS, do not consider these important points. Furthermore, it should be noted that existing tests designed to detect structural breaks have limitations. These tests often focus on a predetermined number of breaks and rely on preselected break data, neglecting the potential presence of non-linear patterns within the data. We can express the degree of integration of variables in Eq. (1):

$$\Delta y_t = d(t) + c_0 + \rho y_{t-1} + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^l c_i \Delta y_{t-i} + u_t \quad (1)$$

where  $\gamma_1$  and  $\gamma_2$  are the coefficients for the Fourier approximation. These coefficients measure the height and the width of the frequency component. Next,  $k$  is the frequency for the estimation of Fourier series,  $n$  is the number of frequencies,  $t$  denotes trend term,  $T$  represents the number of observations,  $l$  is the lag length determined by using AIC, and  $\pi = 3.1416$ . Based on this equation, we first use the  $F$ -test (Bozoklu et al., 2020) to evaluate the significance of the coefficient of trigonometric terms to see if there is an unattended nonlinearity in the data, and then we use the normal unit root test to assess the coefficient of the lagged dependent variable  $\rho$ . This test relies on fractional frequency to identify whether Covid-19-type shocks are producing temporary or permanent data breakdowns. Breaks are permanent when the optimum frequency ( $k$ ) is fractional. When we fail to provide evidence of non-linearity in the data, we carry out traditional unit root tests of ADF, PP, KPSS.

Second, we utilize the lag-augmented VAR (LAVAR) model with a Fourier function to assess non-linear causality with FFFFTY. Our preferred test allows us to model the permanent or transitory effects of Covid-19-related government response stringency measures on TDFSC performance. We present the test equations as follow:

$$\text{IFINX}_t = \beta_0 + \beta_1 \sin\left(\frac{2\pi kt}{T}\right) + \beta_2 \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{l+d_{\max}} \theta_i \text{IFINX}_{t-i} + \sum_{i=1}^{l+d_{\max}} \delta_i \text{C19\_STR}_{t-i} + \varepsilon_t \quad (2)$$

To test that C19\_STR does not cause IFINX based on Eq. (2), we test the null hypothesis of  $\delta_l = 0, \forall l = 1, \dots, l$  by using Wald statistic which has a  $\chi^2$  distribution. Critical values are obtained by bootstrap simulations. Also in this test, inclusion of trigonometric terms allows us to determine whether the established causalities between variables are temporary or permanent.

### 4. Main results

In order to determine the causal effects of Covid-19 related restrictions and economic supports on the performances of the TDFSC, we start determining if the variables used in the study are linear or nonlinear by implementing the Harvey et al. (2008) linearity test. As the test results given in Table A2 in Appendix shows, most of the variables, 30 out of 47, in sample countries are non-linear allowing us to use non-linear unit root tests to determine the degree of integration of the variables (see the second and fourth columns).

The results of both linear (ADF) and non-linear (Fourier ADF) unit root tests are presented in Table A3. To determine the integration of the variables we use the results given in fourth sixth and seventh columns of Table A3. According to results in Table A3, maximum degree of integration of variables is one. Also results show that IFINX is non-linear along with stringency index of FIN, ITA, and USA. Finally, the economic support index is non-linear for the USA.

After determining the maximum degree of integration of variables, we implement FFFF-TY Causality Tests.<sup>1</sup> The findings displayed in Table 1 indicate the presence of the permanent unidirectional causality (see bootstrap p-values of the test statistics given in third column of Table 1), running from both Covid-19 related government response stringency and economic supports to performances of the TDFSC (without any exception in the sample countries). Due to the adoption of both policies, such response policies might have "unintended" implications in some sectors of economies, such as the TDFSC. Lockdown procedures initially slowed performance during the COVID-19 epidemic, although demand for the sector's services has since increased. How these companies manage sudden demand increases depends on how they employ existing technologies.

Our findings validate the prior results that the COVID-19 pandemic is resulting in a decrease in demand and supply, as well as a shift in their patterns (Manolova et al., 2020). This has an adverse effect on the market (Baig and Chen, 2022), but has also opportunities for innovative and fintech companies within an innovation landscape (Margherita et al., 2023; Ebersberger and Kuckertz, 2021). Companies can limit the effects of the COVID-19 pandemic by strategically using digital technology (Luo et al., 2023). Nevertheless, the distinctiveness of our analysis lies in the utilization of a non-linear causality model (FFFFTY) which allows us to identify either permanent or transitory impacts of government response stringency measures related to Covid-19 on the fintech companies' performances.

<sup>1</sup> We also carry out traditional VAR-Granger causality tests for each country and results are given in Table A4 in Appendix. When we compare the results of traditional Granger causality tests with FFFF-TY causality tests, it is clearly seen that while the former fails to provide significant causal relations between variables, the latter finds many significant causal relations implying the advantage of using right method in the applied study.

**Table 1**

The results of Fractional Frequency Flexible Fourier Toda-Yamamoto (FFFF-TY) causality tests.

Direction of causality	W-statistics	Bootstrap prob. value	p	s
IFINX $\neq$ > AUS_C19_STR	29.32	0.030**	10	0.1
IFINX $\neq$ > AUT_C19_STR	0.535	0.424	1	0.1
IFINX $\neq$ > BEL_C19_STR	62.39	0.002*	11	0.1
IFINX $\neq$ > CAN_C19_STR	91.49	< 0.001*	9	0.1
IFINX $\neq$ > CHE_C19_STR	5.828	0.035**	1	0.1
IFINX $\neq$ > DEU_C19_STR	51.64	0.002*	10	0.1
IFINX $\neq$ > DNK_C19_STR	7.194	0.016**	1	0.1
IFINX $\neq$ > ESP_C19_STR	22.85	0.098***	12	0.1
IFINX $\neq$ > FIN_C19_STR	20.98	0.080***	10	0.1
IFINX $\neq$ > FRA_C19_STR	39.58	0.004*	8	0.1
IFINX $\neq$ > GBR_C19_STR	52.76	0.001*	8	0.1
IFINX $\neq$ > HKG_C19_STR	0.246	0.573	1	0.6
IFINX $\neq$ > IRL_C19_STR	18.34	0.157	13	0.1
IFINX $\neq$ > ISR_C19_STR	19.45	0.087***	10	0.1
IFINX $\neq$ > ITA_C19_STR	13.53	0.148	9	0.1
IFINX $\neq$ > JPN_C19_STR	5.660	0.094***	3	0.1
IFINX $\neq$ > LUX_C19_STR	0.837	0.304	1	0.1
IFINX $\neq$ > NLD_C19_STR	6.581	0.029**	1	0.1
IFINX $\neq$ > NZL_C19_STR	25.90	0.015**	8	0.1
IFINX $\neq$ > SGP_C19_STR	1.867	0.374	2	0.6
IFINX $\neq$ > SWE_C19_STR	48.71	0.001*	12	0.1
IFINX $\neq$ > TWN_C19_STR	1.014	0.570	2	1.0
IFINX $\neq$ > USA_C19_STR	8.766	< 0.001*	13	0.1
IFINX $\neq$ > AUS_C19_ES	0.660	0.082***	1	0.8
IFINX $\neq$ > AUT_C19_ES	38.19	0.001*	2	0.1
IFINX $\neq$ > BEL_C19_ES	< 0.001	0.945	1	0.1
IFINX $\neq$ > CAN_C19_ES	0.358	0.441	1	0.1
IFINX $\neq$ > CHE_C19_ES	1.678	0.136	1	0.1
IFINX $\neq$ > DEU_C19_ES	0.176	0.582	1	0.1
IFINX $\neq$ > DNK_C19_ES	27.99	0.017**	6	0.9
IFINX $\neq$ > ESP_C19_ES	22.91	0.005*	3	0.1
IFINX $\neq$ > FIN_C19_ES	0.053	0.743	1	0.1
IFINX $\neq$ > FRA_C19_ES	3.208	0.055***	1	0.1
IFINX $\neq$ > GBR_C19_ES	12.50	0.019**	2	0.1
IFINX $\neq$ > HKG_C19_ES	3.897	0.047**	1	0.1
IFINX $\neq$ > IRL_C19_ES	22.90	0.016**	3	0.1
IFINX $\neq$ > ISR_C19_ES	1.742	0.124	1	0.1
IFINX $\neq$ > ITA_C19_ES	25.79	0.006***	3	0.1
IFINX $\neq$ > JPN_C19_ES	0.340	0.453	1	0.1
IFINX $\neq$ > LUX_C19_ES	8.162	0.037	2	0.1
IFINX $\neq$ > NLD_C19_ES	26.89	0.010**	3	0.1
IFINX $\neq$ > NZL_C19_ES	13.84	0.016**	2	0.1
IFINX $\neq$ > SGP_C19_ES	6.306	0.097***	3	0.1
IFINX $\neq$ > SWE_C19_ES	34.72	< 0.001*	4	0.1
IFINX $\neq$ > TWN_C19_ES	64.58	< 0.001*	4	0.1
IFINX $\neq$ > USA_C19_ES	0.004	0.803	1	0.1

\*, \*\*, \*\*\* significant at 1 %, 5 % and 10 % respectively.

## 5. Conclusion

This study addresses the question of whether the Covid-19-related restrictions and economic supports are the main drivers of the TDFSC's enhanced performance. According to the study's findings, Covid-related restrictions and economic supports have a permanent unidirectional causal effect on the performance of these companies. However, the majority of these permanent unidirectional causal effects stem from Covid-19-related restriction policies when compared to economic support policies. Policymakers and international organizations should promote financial innovation, allocate resources for technology adoption, and enhance legal environments to boost fintech development. If policymakers and international organizations seek ways to enhance financial inclusion, they must promote financial innovation by enhancing the performance and capacity of fintech companies. To achieve this, they should allocate more resources to efforts aimed at increasing the use of technology. Simultaneously, they should encourage commercial and financial companies to upgrade and update their systems to better prepare for and identify unforeseen risks, such as global pandemics like COVID-19.

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### CRediT authorship contribution statement

**Mustafa Özer:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing, Project administration. **Darko B. Vukovic:** Conceptualization, Data curation, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing, Project administration. **Michael Frömmel:** Conceptualization, Investigation, Supervision, Validation, Writing – original draft, Project administration. **Serap Kamişli:** Data curation, Formal analysis, Investigation, Visualization, Writing – original draft.

### Declaration of Competing Interest

The authors declare no conflict of interest.

### Data availability

Data will be made available on request.

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### Supplementary materials

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### References

- Abay, K.A., Tafere, K., Woldemichael, A., 2020. Winners and Losers from COVID-19: Global Evidence from Google Search. (Policy Research Working Paper No: 9268). <https://doi.org/10.1596/1813-9450-9268>.
- Baig, A.S., Chen, M., 2022. Did the COVID-19 pandemic (really) positively impact the IPO Market? An Analysis of information uncertainty. *Finance Res. Lett.* 46, 102372.
- Bozoklu, S., Yilanci, V., Gorus, M.S., 2020. Persistence in per capita energy consumption: a fractional integration approach with a Fourier function. *Energy Econ.* 91, 104926.
- Ebersberger, B., Kuckertz, A., 2021. Hop to it! The impact of organization type on innovation response time to the COVID-19 crisis. *J. Bus. Res.* 124, 126–135.
- Financial Stability Board. (2022). FinTech and market structure in the COVID-19 pandemic implications for financial stability. Retrieved from: <https://www.fsb.org/wp-content/uploads/P210322.pdf>.
- Fu, J., Mishra, M., 2022. Fintech in the time of COVID–19: technological adoption during crises. *J. Financ. Intermed.* 50, 100945.
- Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Samuel, W., Cameron-Blake, E., Hallas, L., Majum-dar, S., Tatlow, H., 2021. A global panel database of pandemic policies (Oxford COVID-19 Government Response Track-er). *Nat. Hum. Behav.* 5 (4), 529–538.
- Jiang, J., Liao, L., Wang, Z., Zhang, X., 2021. Government affiliation and peer-to-peer lending platforms in China. *J. Empir. Finance* 62, 87–106.
- Luo, Y., Cui, H., Zhong, H., Wei, C., 2023. Business environment and enterprise digital transformation. *Finance Res. Lett.* 57, 104250.
- Maiti, M., Vukovic, D., Frömmel, m., 2023. Quantifying the asymmetric information flow between Bitcoin prices and electricity consumption. *Finance Res. Lett.* 57 (2023), 104163.
- Margherita, A., Nasiri, M., Papadopoulos, T., 2023. The application of digital technologies in company responses to COVID-19: an integrative framework. *Technol. Anal. Strat. Manage.* 35 (8), 979–992.
- Manolova, T.S., Brush, C.G., Edelman, L.F., Elam, A., 2020. Pivoting to stay the course: how women entrepreneurs take advantage of opportunities created by the COVID-19 pandemic. *Int. Small Bus. J.* 38 (6), 481–491.
- Sul, E. (2020). Effects of Fintech and crowdsourced forecasting on firms: evidence from Estimize. *Available at SSRN 3573152*.
- Vukovic, D., Lapshina, K., Maiti, M., 2021. Wavelet coherence analysis of returns, volatility and interdependence of the US and the EU money markets: pre & post crisis. *N. Am. J. Economics and Finance* 58, 101457, 2021.