Physical activity recovery model in post Covid-19 period: Latvia case study

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Abstract. **Physical activity is one of the triggers to sustainable economic and social development of societies. The Political Declaration of the 2030 Agenda reflects on "the contribution sports make to the empowerment of women and of young people, individuals and communities, as well as to health, education and social inclusion objectives" [1]. COVID-19 restrictions forced the industry to find new ways to organize interregional and international events and find the ways out of the sudden crisis [2]. In this paper, authors focus on analysis of physical activity and sports recovery process after COVID-19 pandemic that has created profound challenges for youngsters and their family members. This research relies on empirical data collected from main orienteering sports events in Latvia and demonstrates original forecast model that compliments existing system dynamic simulation models affected by COVID-19 situation with respect to increased level of digitalization and extensive use of technologies. Research outcomes demonstrate that the cancellation of sports activities negatively affects such social aspects as people mobility, social cohesion, emotional satisfaction and excitement. As follows, it leads to lower physical and mental activity for individuals, especially children and youth. At the same time, the research outcomes of authors' developed system dynamics simulation model shows that a recovery process of analysed physical activity and sports events is reasonably fast and, in the most cases, in two years reached a level of pre-COVID-19 period with tendency to positive growth in future. Created original system dynamic simulation model embraces full data sets of ten years (2014-2023), extracted from orienteering sports events published data in Latvia, as well as outcomes of several practical testing and theoretical research activities in Latvia and Albania. For collection and systemization of empirical data, authors used the concept of "Citizen Science". The Citizen Science is an ever-growing field of public engagement with science, and recent years have seen an increasing number of studies examining its potential [3]. The conclusions, made by authors of this research, are useful for various sports and active lifestyle events' organizers, supporters, spectators and others, involved in the organization process of physical activity and sports events to attract more participants, spectators and tourists to their areas.**
Keywords: post COVID-19, socio-technical modelling, sports, system dynamic.

I. Introduction

COVID-19 has caused multiple, unforeseen, and cascading impacts that have severely affected societies worldwide. Addressing these impacts in the aftermath of such a complex crisis requires collaborative approaches where the whole-of-society works together to build and strengthen its resilience [4]. Consequently, it is important to forecast the impact of COVID-19 pandemic on the sports events management and tourism industries to determine effectiveness of government policies in supporting the post-recovery process of these industries. From a business perspective, a good understanding of the effects of the pandemic is likely to provide the actors of the tourism industry substantial insights on how to build and implement effective decision-making frameworks that can, in turn, ensure rapid responses to unanticipated events that threaten the financial sustainability of their businesses [5],[6],[7]. Although the COVID-19 pandemic forced the various event organizers to adopt their events to virtual and

hybrid formats, the concept of virtual or hybrid events is not applicable to outdoor physical activity and sports events where physical presence and active participation are mandatory elements [8].

The objective of this research is to determine an impact of COVID-19 pandemic and evaluate the recovery process of observed physical activity and sports events in Latvia. Authors are trying to find an answer to the specific research question: "What are the major trends of recovery process from COVID-19 pandemic impact for the societies, concerning specific physical activity and sports events in Latvia?"

II. MATERIALS AND METHODS

For mentioned above research purpose had been designed comprehensive logical structure to identify and analyse main factors of the physical activity recovery process on the post COVID-19 period in Latvia. An integrated set of methods and data management activities carried out by the authors of this research:

a) Theoretical literature studies on the contribution what physical training and sports make to the enhancing social inclusion objectives for individuals and communities.

b) Analysis of eight major orienteering sports events case studies with purpose to understand how physical activity and sports recovery process has been emerged before/during/after COVID-19 pandemic based on the available data sets collected by event organizers and published on: https://lof.lv/rezultati [10].

c) Authors collected available data sets by exploiting "Citizen Science" concept and published single data set for the period of the last 10 years (2014-2023) for seven major events and eight years for one event, all including three years period affected by COVID-19 pandemic.

d) For analysed events, authors calculated "trend-lines" and derived formulas for later use in STELLA system dynamic modelling tool as differential equations to simulate the recovery process from COVID-19 pandemic period and further development forecasting.

e) From complete data set, authors identified and adjusted three specific cases in Year 2020 when events had been postponed from regular spring activity period to the summer period with less or no-existent restrictions imposed by COVID-19.

f) From complete data set, authors adjusted two special cases in Year 2021 when events had been organised in special "COVID-19" mode with respect to all specific restrictions imposed by COVID-19 procedures in Latvia.

g) For model verification and validation purposes a cumulative trend-line had been calculated statistically from 72 events in total (6 events excluded because of COVID-19 restrictions) during the last 10 years period from year 2014 until year 2023.

h) Finally, based on collected data sets and statistically calculated polynomial trend-lines of individual events by use of specific differential equations authors created the original system dynamic simulation model in STELLA modelling environment. The purpose of model is to forecast the velocity of recovery process for physical activity and sports events in Latvia after restrictions imposed by COVID-19 pandemic.

In this research to determine the most appropriate modelling differential equations and calculated values used for converters, instead of traditional linear trend-line statistical function had been used polynomial trend-line statistical function which provides more reliable results in case of datasets where some data is missing, equal to zero or fluctuating over the time. Polynomial trend line describes a regression through equation $y=\Sigma i(ai \cdot xi)$, with degree of polynomial is given as 2. All statistically calculated formulas of trend-lines further in this article displayed above graphs in the figures of the next chapters.

III. RESULTS AND DISCUSSION

Reliable data sets from eight major Latvian orienteering sports events had been analysed during this research by exploiting "Citizen Science" concept using data collected and calculated electronically by Latvian orienteering sports clubs within period from year 2014 until year 2023.

All available data from events authors collected in the single data set (Table 1) for the period of the last 10 years for seven major events and eight years for one event (it starts in year 2016), all data sets include full three years period from 2020 until year 2022, affected by COVID-19 pandemic.

TABLE 1 TOTAL NUMBER OF PARTICIPANTS (ALL EVENTS)

EVENT TITLE	YEAR 2014	YEAR 2015	YEAR 2016	YEAR 2017	YEAR 2018	YEAR 2019	YEAR 2020	YEAR 2021	YEAR 2022	YEAR 2023
Mazā Balva	347	441	348	347	273	512	398	489	495	549
Ozona (Rīgas) čempionāts	452	384	445	432	372	522	0	486	461	540
Aronas kauss	337	360	343	442	291	399	555	500	561	482
Ziemeļu divdienas	520	508	501	518	434	439	515	407	548	650
Kurzemes pavasaris	669	630	808	738	708	728	0	296	838	900
LČ garajā distancē	441	529	495	539	528	583	665	517	525	489
Latvijas Skolu kauss	N/A	N/A	642	268	668	666	0	331	562	501
Rīgas kausi	910	785	746	633	805	868	0	0	0	599
IN TOTAL	**3676**	**3637**	**4328**	**3917**	**4079**	**4717**	**2133**	**3026**	**3990**	**4710**
AVERAGE PER EVENT	**525**	**520**	**541**	**490**	**510**	**674**	**533**	**432**	**570**	**589**
Special notes:							(3 events original data change)	(2 events in limited "covid" mode)		

The total number of participants in all eight events in year 2019 grows up until 4717 people and after have significant decrease in the first year of Covid-19 pandemic until 2133 participants. Data shows also quick adaptation of organizers to the specific situation and number of participants steadily grow up during the next three years and in year 2023 almost are levelling the situation before Covid-19 pandemic (Fig.1).
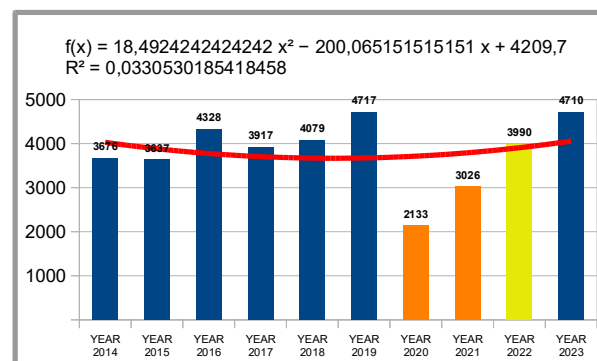

Fig. 1. Total number of participants in all events

Cumulative data set and pre-calculated polynomial trend-line formula attributes in this research authors' use further for the verification and validation stages of the activity forecast model.

Trend-line calculation formulas and mathematical values for use as STELLA convertors and differential equations authors' calculated separately for each event. Fig. 2 reveals that "Mazā Balva" event did not have significant loss in number of participants, mostly because of activity in summer time with less Covid-19 pandemic restrictions.
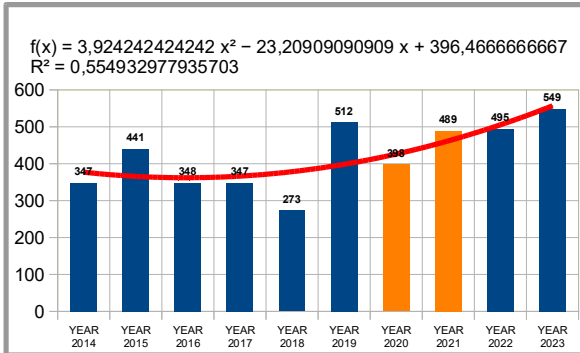
$f(x) = 3,924242424242\ x^2 − 23,20909090909\ x + 396,4666666667$
$R^2 = 0,554932977935703$

Fig. 2. Number of participants in "Mazā balva" event.

Covid-19 restrictions critically influenced "Ozona (Rīgas) čempionāts" event (Fig. 3) in year 2020 and organizer decided to cancel this event completely. Change of activity time from spring to summer in 2021 had positive effect with almost no impact from Covid-19 restrictions.
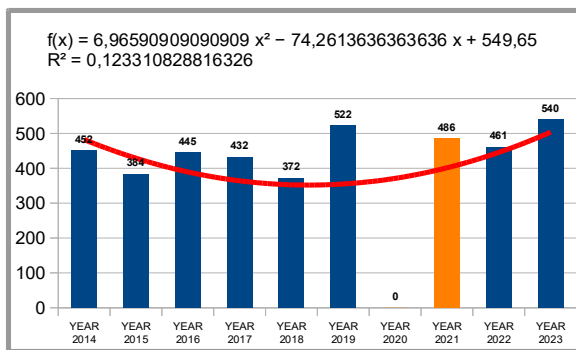
$f(x) = 6,96590909090909\ x^2 − 74,2613636363636\ x + 549,65$
$R^2 = 0,123310828816326$

Fig. 3. Number of participants in "Ozona (Rīgas) čempionāts" event.

$f(x) = 0,613636363636\ x^2 + 17,15303030303\ x + 309,0333333333$
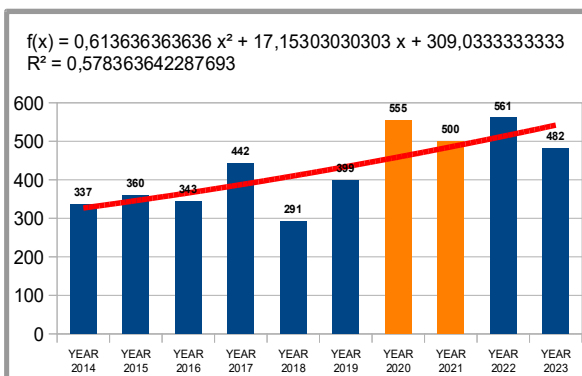$R^2 = 0,578363642287693$

Fig. 4. Number of participants in "Aronas kauss" event.

"Aronas kauss" event (Fig. 4) did not suffer significantly from Covid-19 restrictions because postponed this event and organized it later in autumn when the most of restrictions imposed by Covid-19 had been cancelled.

Organized as traditional late springtime event "Ziemeļu divdienas" (Fig. 5) some problems experienced in year 2021, with decrease in number of participants approximately 20% but successfully recovered during the next year and continue growing.
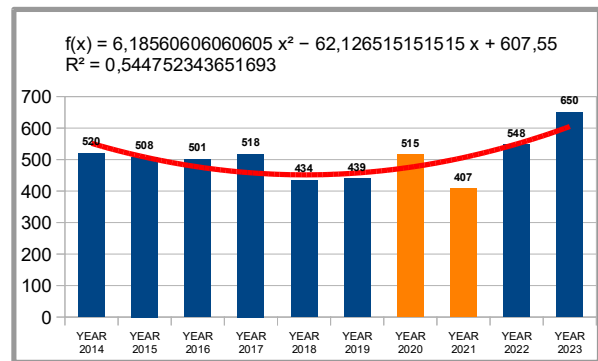
$f(x) = 6,18560606060605\ x^2 − 62,126515151515\ x + 607,55$
$R^2 = 0,544752343651693$

Fig. 5. Number of participants in "Ziemeļu divdienas" event.

As a season opening event in the first days of April, significant impact had "Kurzemes pavasaris" orienteering event (Fig. 6) in year 2020 when it was cancelled completely as well as in year 2021 when it had been organized in a very limited "protective distancing" mode. However, in years 2022 and 2023 this event recovered in full extent with figures even higher than in pre-Covid-19 period.
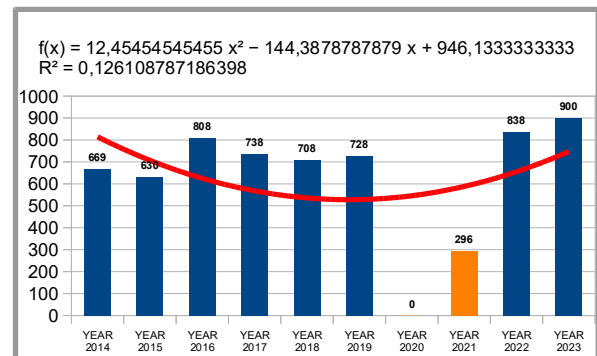
$f(x) = 12,45454545455\ x^2 − 144,3878787879\ x + 946,1333333333$
$R^2 = 0,126108787186398$

Fig. 6. Number of participants in "Kurzemes pavasaris" event.

Different trends display events "LČ garajā distancē" (Fig. 7) organized in late autumn period, with almost no impact during pandemic but with slower velocity of recovery in years 2022 and 2023 when the most of pandemic restrictions was non-existent.

Orienteering event "Latvijas Skolu kauss" (Fig. 8) shows trend similar to "Kurzemes pavasaris" event. Both events planned their activities in April with significant reductions in year 2020 and 2021. In year, 2020 organizers cancelled this event, but in year 2021 they got just half from number of participants than before Covid-19 limitations.

The heaviest impact from Covid-19 restrictions met event "Rīgas kausi" (Fig. 9). Because of competition area

locations close to the capital Riga it was forbidden to organize in spring bigger scale events for three years period from 2020 till 2022.
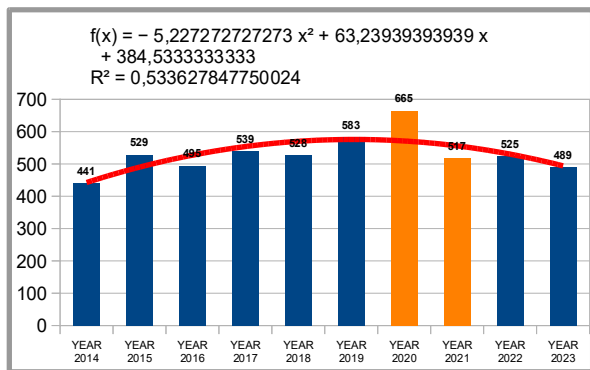
$$f(x) = -5.227272727273\ x^2 + 63.23939393939\ x + 384.5333333333$$
$$R^2 = 0.5336278477550024$$

Fig. 7. Number of participants in "LČ garajā distancē" event.

$$f(x) = 14.90476190476\ x^2 - 148.3571428571\ x + 742.2857142857$$
$$R^2 = 0.115735736895508$$
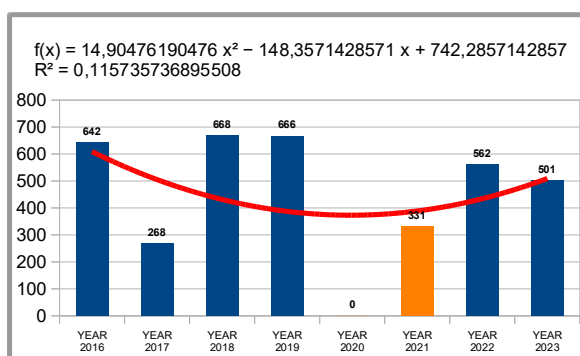
Fig. 8. Number of participants in "Latvijas skolu kauss" event.

$$f(x) = 4.87499999999999\ x^2 - 137.625\ x + 1103.85$$
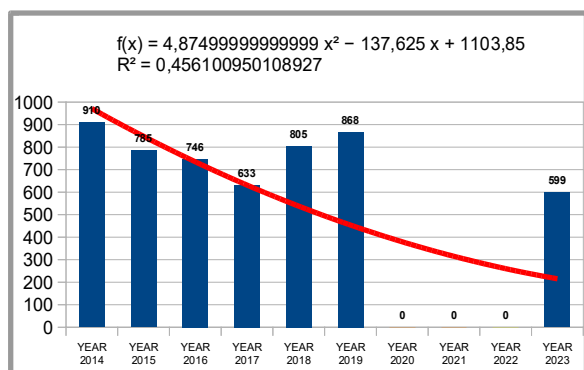$$R^2 = 0.456100950108927$$

Fig. 9. Number of participants in "Rīgas kausi" event.

All statistical trend-line functions and calculation formulas authors used in the next modelling step to create the final cumulative system dynamic simulation model in STELLA modelling environment (Fig. 10).

Latvian physical activity events recovery model outcome (as a cumulative recovery forecast line) after Covid-19 limitations period shows a positive development trend and, as expected, during the next two years it will exceed the level of pre- Covid period by total number of participants in Latvia organized physical activity events.
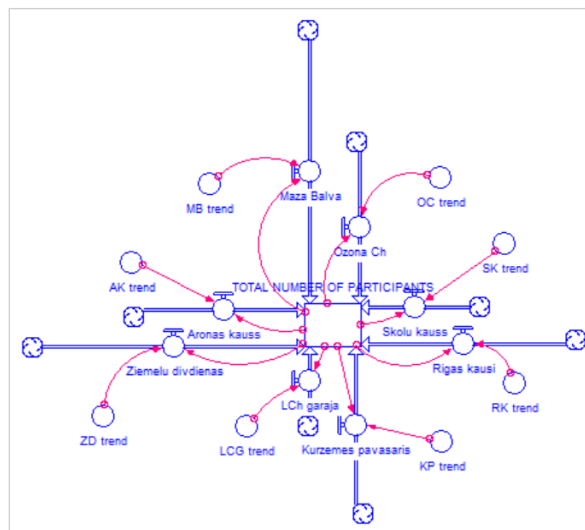
Fig. 10. Cumulative forecast simulation model in STELLA.

IV. CONCLUSIONS

Limitations and prohibitions imposed during the COVID-19 pandemic had negative impact to the most of outdoor sports and physical activities as in lower quality of events as well as in decreased number of participants and athlete performance aspects [11],[12].

The system dynamic simulation model in STELLA shows that physical activity and sports events in Latvia have started showing the significant positive trends of recovery after three years of the COVID-19 pandemic and have stable growing tendency in total number of attracted participants of organized events (Fig. 11).
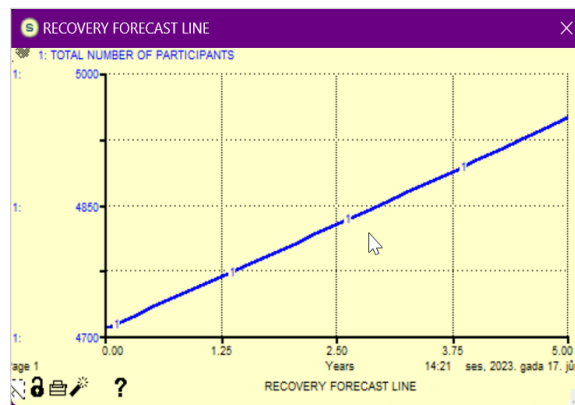
Fig. 11. Cumulative forecast trend-line (predicted total number of participants from 2023 until 2028) in STELLA.

The result of created STELLA model proves the validity of authors' originally created system dynamic simulation model, the cumulative statistical trend-line from analysed events has similar tendency as STELLA produced forecast line concerning predicted number of participants in physical activity and sports events for the next five years.

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