How Digital Technologies are Applied to Fight Against the Covid-19 Pandemic: Evidence from Macao

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Abstract. Macao was shown to perform effectively in combating the Covid-19 pandemic despite being a heavily populated international resort city in China. By using documentary and comparative analysis, this paper aims to identify the key elements that are essential for dealing with the pandemic. It makes the case that big data and digital technologies were crucial in assisting the government in becoming more effective and adapting quickly to new policy-making models, which led to the success of the Macao government.

Keywords: digital technologies · big data · agile governance · documentary and comparative analysis · Macao

1 Introduction

The Covid-19 pandemic outbreak, which began in China and spread globally, presented governments with difficulties never before experienced. Due to such health concern, daily life, including work, school, travel, and community duty, is significantly impacted. Global governments were able to respond to the pandemic, and some of those efforts were successful. The government of Macao is one of the counterparts that performs better; its prompt and efficient preventive policies greatly aided in controlling the coronavirus, making Macao among the world's regions with the fewest pandemics.

From the perspective of agile governance, and specifically the way digital technologies and big data actually function in practice, this research tries to identify the essential aspects underpinning the effectiveness of managing and preventing the spread of coronavirus. The following sections of the study explore the pertinent literature review, show the methodology and data, analyze the key components of agile governance in the context of the COVID-19 pandemic reactions, and conclude with some policy implications.

2 Literature Review

2.1 Background

The root ideas of agile government derive from agile software development, which highlight the interaction between individuals and make users experience better. In 2001,

Table 1. Core Values of Agile [2]

1. Individuals and interactions over processes and tools
2. Working software over comprehensive documentation
3. Customer collaboration over contract negotiation
4. Responding to change over following a plan

17 software developers articulated four core values so as to fix the common problems of Water Fall Model, known as "the Agile Manifesto" [1]. It calls for outcomes over rules, responding to change over following a plan, encouraging wider participation over control and fostering self-organization over centralized government (see Table 1). Later on, 12 key principles for software developers to follow when building and deploying complex software projects were developed.

Briefly speaking, the articulation of the Agile Manifesto has brought remarkable changes to the governmental software engineering field, where a great many software methods, tools, techniques, and best practices have been introduced. The issue of how an agile approach is applied to governance in actual life has become a wide concern.

2.2 Agile Governance

As the Fourth Industrial Revolution has brought about huge advances in technology innovation, it requires the transformation of traditional governance structures and policy-making models. The government is under the pressure to proactively embrace change.

According to the World Economic Forum, agile governance is defined as adaptive, human-centred, inclusive and sustainable policy-making, which acknowledges that policy development is no longer limited to governments but rather is an increasingly multistakeholder effort. It implies being quick and adaptable to sudden change in a positive and efficient way. Agile governance is characterized by the four aspects: (a) there is a wide range of participants involved in policy making such as stakeholders, social organizations besides government, (b) it covers various fields and requires the continuous readiness to rapid change and learning for government, (c) the governing process is under change, hence requiring a dynamic and adapatable approach to deal with, (d) it focuses on the quick collection and update of data, ensuring the accuracy and efficiency [3].

3   Methodology and Data

This study adopted an exploratory review of the secondary literature sourced from local newspapers and official websites of the Macao Government and its departments as well as agencies by means of both documentary analysis and comparative analysis to have a clear picture of the pandemic situation in Macao and its adjacent areas in China, and examine the measures taken by the government.

Table 2. The Covid-19 situation in Macao (until June 20, 2020) [4]

New cases	Confirmed cases (Cumulative)	Deadly cases	Cured cases
0	45	0	45

Table 3. A comparison of the pandemic situation between Macao and adjacent areas (until August 8, 2020) [5]

Areas	Cumulative cases	Deadly cases	Cured cases
Macao	46	0	46
Hong Kong	3939	47	2620
Taiwan	477	7	443

In the beginning of the outbreak, there were only 45 confirmed cases, without any deaths or nosocomial infections, or community infections by June 20, 2020 in Macao (see Table 2).

Moreover, according to Table 3, Macao performed much better in response to the outbreak compared with its adjacent counterparts.

To quantify the impact of COVID-19 on a city through the number of people affected by the pandemic, and to reflect the responsibility of the city to the pandemic control, we defined the index k for quantification, which is defined as follows,

$$k = K + D - C \tag{1}$$

where K denotes the weight of cumulative cases, D denotes the weight of deadly cases, and C denotes the weight of cured cases. To be more concrete, we will go through the detail of each variable as follows.

$$k = w_1 \cdot k + w_2 \cdot d^2 - w_3 \cdot c \tag{2}$$

According to the formula above, $w_1 \cdot k$ denotes K, where k denotes the amount of cumulative cases, $w_2 \cdot d^2$ denotes D, where d denotes the amount of deadly cases, and $w_3 \cdot c$ denotes C, where c denotes the amount of cured cases. As can be seen from the formula, the larger the value, the more serious the pandemic.

For the sake of comparison, here we set the weight coefficients (i.e., w_1, w_2, w_3) of ownership equal to 1 and calculate the coefficient k between different regions. After the calculation, k for Macao, Hong Kong and Taiwan are 0, 3528, 83, separately.

In order to make the coefficient quantified and compared among more regions with large population differences, we try to introduce the technique of logarithmic scaling, whose formula is deformed as follows.

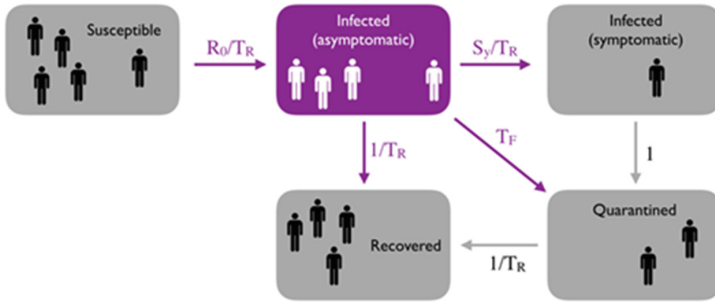$$k = w_1 \cdot \log(k + 10) + w_2 \cdot \log((d + 10))^2 - w_3 \cdot \log(c + 10) \tag{3}$$

Fig. 1. The lifecycle of the pandemic population [6]

In the actual situation, different temporal and spatial conditions may have different actual impacts on the pandemic. In order to take the time conditions into account, we deformed the formula as follows.

$$k = w_1 \cdot \log\left(\sum_{i=0}^{t} k_i \cdot 1.0001^i + 10\right)$$
$$+ w_2 \cdot \log\left(\sum_{i=0}^{t} d_i \cdot 1.0001^i + 10\right)^2 - w_3 \cdot \log\left(\sum_{i=0}^{t} c_i \cdot 1.0001^i + 10\right) \tag{4}$$

where t represents the number of days from the current time. We believe that the longer the time distance, the greater the impact on the current pandemic.

As shown in Fig. 1, the population infected by the pandemic will have a life cycle change as shown in Fig. 1. We can also incorporate the population conditions of infection, close contact and recovery into the indicator consideration to obtain a more complete measurement result of the severity of the pandemic.

4   Findings and Discussion

AS illustrated above, when the ourbreak occurred, the Macao government were quick to adopt the effective measures for controlling the spread such as travel bans, lockdown and 14-day quarantines, which greatly helped in containing the pandemic spread. It is by no means an easy job to cope with for Macao, since it has the world's highest population density at 23,172/km^2 [7]. Due to the good performance, the Macao government was widely praised around the world that could be found in the report named "Las Vegas needs a COVID-19 containment lesson from Macao" by the Global Times [8]. Therefore, the Macao government is taken as a classic example of agile governance.

Through both a documentary and comparative analysis, the paper identified the three hidden factors that contribute to the success, specifically from the perspective of agile governance. Those factors are described below.

4.1   Intergovernmental Relations

First, agile governance requires swift response to sudden change in circumstances. The Macao government set up the Novel Coronavirus Response and Coordination Center on

January 21, 2020 to facilitate the cooperation between different departments. Under the direct leadership of chief executive, the center took the responsibility of formulating the schemes and responding to the changing situation of coronavirus, which is conducive to time cost reduction and efficiency improvement.

Second, the Macao government took initiatives to work closely with the neighbour city Zhuhai in terms of shared information and responsive measures for border crossing. The two sides established a joint prevention and control mechanism on coping with the coronavirus at the earliest time. The smooth intergovermental relations ensured the policies implementation in all aspects without too much difficulty.

4.2 Big Data Application

A major component of agile governance is the shift in ICT and digital infrastructure decreasing the need for physical travel and speeding up transactions and ultimately decision making [9]. The Macao government displayed its agile leadership in the deployment of big data and the advancement of technology. For instance, the government introduced the system of automatic fingerprint passing through customs in 2005, and hereafter the face recognition system in 2016, both of which relied upon artificial intelligence as well as facial mapping systems and algorithms.

According to the "Macao SAR Electronic Governance General Plan 2015–2019", Macao has made several achievements in several areas like e-government development, information security, and public e-services. Moreover, "Building a smart city" is one of the components of the "Macao SAR Five-Year Development Plan (2016–2020)" formulated by the government. On August 4, 2017, Macao SAR and Alibaba Group signed the "Framework Agreement on Strategic Cooperation in Building a Smart City". The project covers the development of cloud computing technology, smart tourism, transportation, medical treatment and government affairs, and talent training through big data applications [10]. That greatly helped the Macao government deal with the outbreak to a great extent.

According to Fig. 2, in order to better apply big data techniques under the condition of COVID-19, we describe some application of scenarios of specific data combined
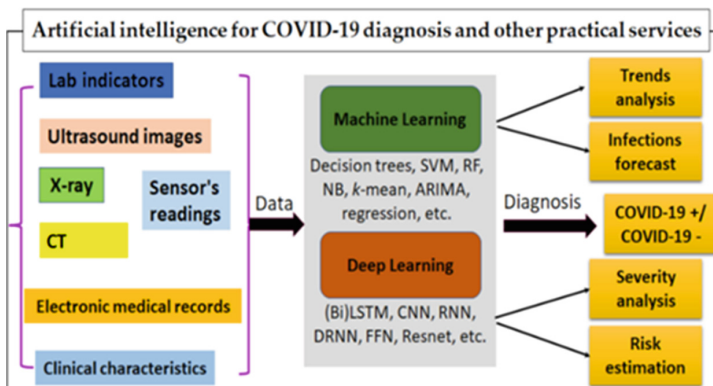

Fig. 2. Aritificial intelligence application for fighting against Covid-19 [11]

with specific technologies. In order to diagnose COVID-19 more quickly, we introduce computer vision technology to quickly help medical staff locate users' lesions and detect infections based on CT and X-ray detection results. Based on a large number of users' previous cases and existing diagnosis and treatment methods, supplemented by traditional machine learning methods based on statistics, we can diagnose and detect the disease faster and more effectively. In addition, large-scale operator data and relevant user behavior data are able to predict the spread of the pandemic situation as well as the disease. As such, we believe that combining a large number of multi-modal user data with data-driven and artificial intelligence technology as the core can well help modern society to fight against the spread and divergence of the COVID-19 pandemic.

One of the major factors for the success of fighting the pandemic was the early detection of the existence of the diseases. A health QR code was developed and used by the government to track people suspected or confirmed to have been infected with the coronavirus. Thanks to data analytics and observation methodology, a basic epidemiological survey was made possible within 6 h and a detailed one within 24 h when a case was diagnosed, which helped to bring the coronavirus situation under control in a short time.

4.3 Sufficient Supply and Economic Aids

During the course of the Covid-19 pandemic, the Macao government took a series of economic measures to mitigate the negative effects on the economy and guarantee the people's livelihood. First, the government provided sufficient medical supply especially masks to residents for self-protection. Second, a variety of tax-exempt policies were implemented for small and medium-sized enterprises. Third, the Macao government issued an electronic consumer card with a value of MOP 3,000 to every Macao citizen, serving several purposes such as assisting residents, boosting consumption, helping businesses, and stimulating the economy. In addition, a tailor-made training program was launched mainly targeting at the unemployed. Those who complete the program will receive a subsidy of MOP 6,656 [12]. Overall, all of the above measures combined to boost the economy and maintain the social stability (see Table 4).

Table 4. A list of economic aids measures taken by the Macao government in 2020 [self-made]

Items	Contents
Wealth Partaking Scheme	MOP 10,000 for permanent residents MOP 6,000 for impermanent residents
Medical supply	Residents are required to buy masks at health center or registered pharmacy stores by using medical vouchers
Tax exemption	Individuals and businesses enjoy exemption from some tax on property, tour and licence etc.
Electronic consumer card	MOP3,000 per person
Traing program	A subsidy of MOP6,656 granted if finished.

5   Conclusion

This paper argues that agile governance accounts for the good performance of the Macao government in fighting the Covid-19 pandemic and outlines the three key factors contributing to the success. Especially with the help of big data and new digital technology, the government adopted an agile approach to quickly adapt itself to the issues arising from the environment and enhance its capability to manage the service delivery. That will provide implications for policymakers and practitioners to consider a new way of governing.

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