The diffusion of digital services in the Public Administration: patterns and drivers among Italian Municipalities

The advent of digital technologies has provoked the onset of what is commonly referred to as the "digital transformation", permeating various industries and society at large. Digital innovation arises from the synergy of both technical and organizational innovations, and the transformative process is influenced by factors operating at both organizational levels (such as culture and political elements) and institutional tiers (Hinings et al., 2018). As Stoneman and Battisti (2010) wrote "the analysis of diffusion [...] encompasses many of the large, important questions underlying the international development of economic well being, the growth of nations and the distribution of wealth" (p. 737), and the diffusion of Information and Communication Technologies (ICT) has been particularly uneven across sectors and geographies (Crespo et al., 2014).

Using a unique and comprehensive dataset about Italian Municipalities, this paper aims to analyze the geographic spread of digitalization within Italian Municipalities' public administrations and the effect that organizational factors, specifically the human capital of the public administrations' workforce and the characteristics of the mayor, have on digitalization's speed. Our paper provides a twofold contribution. It offers a novel analysis of the factors influencing the adoption and diffusion of digital technologies in the rather unexplored context of public administration. Furthermore, it leverages an original and extensive dataset and an innovative methodology, shedding new light on the effects of regional heterogeneity and geographical correlations on the patterns of digitalization adoption and diffusion. The analysis reveals that digital technologies initially permeate larger cities before gradually diffusing to smaller neighboring centers. The regression results also show that human capital characteristics have in general a limited effect on the adoption decision, but in the slower adopting regions the workforce age and the percentage of full-time employees in the municipality's public administration influence significantly the speed of adoption. When we introduce also the mayors' characteristics, we find that a change in mayoral leadership, marking the start of a new term, tends to accelerate digital adoption, except for the slower-adopting regions.

Since Griliches' seminal paper in 1957, geography has emerged as a pivotal component in the study of innovation diffusion. The adoption and diffusion of new technologies are facilitated by the geographical proximity between users and producers, improving communication (Gertler, 1995). Moreover, the diffusion process is strongly dependent on knowledge flows, which are hindered by geographical distances (Krugman, 1998). Recent evidence has assessed that, even though the Internet has enhanced knowledge flows among geographically distant locations (Forman and van Zeebroeck, 2019), geographical proximity still plays a crucial role in diffusion processes (von Graevenitz et al.,

2022). Two main mechanisms of geographical diffusion are hierarchical diffusion and neighborhood diffusion (Hägerstrand, 1967). According to the theory of hierarchical diffusion, innovation initially takes root in major urban centers, which then disseminate it to other large cities, often covering substantial distances. Conversely, the neighborhood process delves into the localized dimension of diffusion, observing that innovations spread more rapidly in close proximity. Recent evidence has shown that hierarchical and neighborhood models can partially overlap, and shift the roles they play over time (Bokányi et al., 2022).

Florida et al. (2001) outline that, alongside geographical factors, organizational factors (specifically organization's resources, innovativeness and systems) play a fundamental role in the diffusion process and adoption decision. The organization's recourses and capacities affect its ability to integrate external technologies into its processes (Cohen and Levinthal, 1990). The organization's innovativeness refers to the previous integration of new technologies and investments in R&D and intangible assets (Giotopoulos et al., 2017; DeStefano et al., 2019). The organization's systems encompass managerial practices and characteristics of the human capital (Cirillo et al., 2023; Cetrulo et al., 2019).

The literature on the adoption and diffusion of innovation is mainly focused on private organizations, leaving the context of public administration rather unexplored (Bugge and Bloch, 2016; Demircioglu and Audretsch, 2017; Neumann et al., 2022). However, public administrations are responsible for a multitude of fundamental services, from tax collection to the disbursement of subsidies and contributions, that could be improved by digitalization (Newman et al., 2022). Furthermore, innovations and improvements in public services can yield broad societal and industrial advantages. Organizational factors that have been recognized as pivotal in the diffusion and adoption of digital technologies, mainly in the context of private organizations, such as organizational size, organizational resources and human capital, are undeniably critical across all organizational contexts (Demircioglu and Audretsch, 2017). In fact, the Technology Organization Environment (TOE) and in general frameworks with comparable factors of interest have been applied to study public organizations as well, but especially focusing on Artificial Intelligence (for example: Neumann et al., 2022; Desouza et al., 2020). The empirical evidence on the diffusion and adoption of ICT technologies in the context of public organizations is overall rather scant.

Using a unique and very detailed dataset about Italian municipalities, the present paper aims to fill this gap addressing two research questions: i) What pattern of geographical diffusion does the digitalization of Italian municipalities follow? ii) How do organization factors, specifically the human capital and the mayor characteristics, influence the speed of digitalization in the municipalities' public administration?

To measure digitalization we employ a highly specific dataset provided by PagoPA. PagoPA is the platform designated for handling the payments of all public services. It was first mentioned in 2005 and became a central component of the digitalization of Italian Public Administration. Therefore, we consider the year the Municipality received the first payment through PagoPA as the year of adoption of digital technologies.

The dataset provided by PagoPA is then merged and harmonized with four other sources: (1) the Italian National Statistical Office Istat to capture the characteristics of the Municipalities' inhabitants; (2) the SIOPE database (*Sistema informativo sulle operazioni degli enti pubblici*), which outlines the operations and expenditures undertaken by the Municipalities; (3) the Conto Annuale, curated by the Italian Department of the State General Accounting Office (*Ragioneria Generale dello Stato*), that provides information about Municipalities' personnel and associated expenditures; (4) the registry of local and regional administrators from the Department for Internal and Territorial Affairs (*Dipartimento per gli Affari Interni e Territoriali*). The final dataset spans from 2012 to 2021, encompassing 6911 Italian Municipalities.

Given the research questions, we decided to employ a time-to-event analysis. The dataset is constructed as a time-to-event dataset with time-varying covariates and the event of interest is the digitalization of Italian municipalities. We delve into a relatively recent methodology known as Bayesian Spatial Survival Analysis (Zhou et al., 2018; Bivand and Gómez-Rubio, 2021), to account for the notable spatial correlation present in our data using spatial frailties. More specifically, we employed a Semiparametric Accelerated Failure Time model with Intrinsic Conditional Autoregressive (ICAR) specification for neighboring geographic-unit frailties.

The findings reveal an initial phase of digitalization diffusion characterized by a hierarchical pattern, wherein larger municipalities adopt the new digital technology faster and the diffusion moves to other big centers, often spanning considerable distances. Following this, the diffusion shifts towards a more localized dimension, extending to neighboring smaller city centers. Generally, the diffusion exhibits a faster pace in the North compared to the South. The results also show that factors related to human capital have limited influence on adoption decisions. Notably, the proportion of full-time PA personnel and workforce age prove to be influential on digitalization speed in slower-adopting regions. This highlights the insufficient level of training in Italian municipalities' public administration workforce, especially in the slower-adopting regions, making them rely on intrinsic characteristics of their personnel, such as age, to facilitate the digital transformation. Moreover, it shows the positive effect that more stable employment has on the diffusion and adoption of digital technologies. The inclusion of the mayors' information reveals that in general newly appointed mayors increase the speed of digitalization. However, even if newly appointed mayors make the decision early in their term, digital technologies require more time to be integrated into slower-adopting regions, likely due to the inadequate training of human capital in digital technologies. Additionally, only in the slower regions, mayors' higher educational attainments influence the speed of digitalization.

In summary, this study unveils significant insights into the diffusion of digital technologies in the understudied context of public organizations, drawing upon a unique and comprehensive dataset. The results confirm the crucial influence of geographical proximity and highlight the effects of inadequate training in digital technologies on digitalization's speed.

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