



From Registration to Activation: A Quantitative Analysis of Citizens' Uptake of a Downstream Co-production Service for Inclusive Mobility in Rome (Italy)

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Abstract

This paper examines the implementation and outcomes of the Taxi Voucher Program in Rome, introduced in the aftermath of the COVID-19 pandemic to provide safe urban mobility options for vulnerable groups, including women, the elderly, and persons with disabilities. The program is framed as an example of downstream process for the co-production of service delivery, involving digitally mediated participation in service delivery between municipal authorities, citizens and private transport providers. The study aims to assess the determinants of voucher activation timing and discuss the implications for inclusive mobility policy.

Keywords Co-production · Public service delivery · Inclusive mobility · Taxi voucher program · Accelerated failure time model

Introduction

In recent years, downstream co-production (Osborne & Stokosch, 2013) has become a central theme in public administration studies, being conceptualized as a mean through which a number of positive outcomes might be achieved: public service delivery can be improved (Brix et al., 2020), citizens can be empowered (Jo & Nabat-

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chi, 2018), innovation can be fostered (Strokosch, 2013) and accountability reinforced (Tuurnas et al., 2016).

Yet, scholars have pointed out that downstream co-production practices are exposed to potential risks concerning limited actual engagement of citizens and equity in access and in distribution of benefits/burdens (Osborne, 2018; Cepiku & Giordano, 2014). Indeed, there might be "... equity issues, with co-production being accessible only to specific social groups... there is a risk of less vocal citizens or those 'willing but unable' to participate" (Cepiku & Giordano, 2014, p. 323).

However, citizen participation in co-production is not only a matter of whether individuals engage, but also *when* and *to what extent* they are able to do so effectively. In digitalized service environments, participation typically unfolds in multiple stages, e.g., citizens must first register to access a platform and then activate or use the service for the first time. While the act of registration indicates a formal willingness or intention to engage in co-production, it does not necessarily translate into effective participation. The time elapsed between registration, and first use provides a useful proxy for assessing citizens' ability to operationalize their engagement. Longer activation delays can signal the presence of informational, cognitive, technological, organizational, motivational or contextual barriers and may therefore signal latent forms of exclusion that remain invisible when focusing only on registration figures. In this sense, temporal dynamics of engagement can reveal a "second layer" of inequality within digital co-production, capturing not only who is left out, but also who struggles to move from access to actual use. This is particularly valuable in the case of digital co-production services since digital technologies may both enable and constrain inclusion, depending on citizens' capacity to act through them (Lember et al., 2019).

Overall, these considerations call for expanding the case study literature on digital co-production to better understand who engages and under what conditions participation remains limited (Bovaird et al., 2016; Mulvale & Roberts, 2021). Extending this line of inquiry, the present work investigates the timing of engagement as an additional, yet overlooked, dimension of equity in downstream co-production services.

The analysis draws on a case study of the first edition of the *Buoni Viaggio Roma* online voucher program, launched between October and December 2021 by the Municipality of Rome (Italy). This program aimed at supporting the mobility needs of vulnerable groups while sustaining the taxi and chauffeured car hire (NCC) sector that were severely hit by the COVID-19 pandemic. Its beneficiaries included adult women, people over 65, persons with certified disabilities or reduced mobility, and other individuals in socio-economic hardship. All these people were granted access to a 50% discounts on taxi or NCC runs via a three-steps procedure including: (1) online registration on a dedicated web platform; (2) activation of a voucher for each trip, and (3) presentation of the voucher to the taxi of NCC driver at the end of the ride. As "citizens actively engage in the design and delivery of their personal services through a digital platform provided by the service organization" (Lember et al., 2019, p. 1668), the *Buoni Viaggio Roma* program is a case of downstream digitally mediated and market-supported co-produced service where "citizens have little choice but to participate in the service as provided 'top-down'....[and] both the contributions made and the benefits received by citizens are at an individual level" (Bovaird

et al., 2016, p.50). While the program involves elements of co-production, citizen participation occurs within a strongly top-down institutional framework, with limited opportunities to shape the design or implementation of the service. As such, it is more appropriately framed as a constrained form of co-production rather than a fully collaborative arrangement.

This paper conducts a quantitative analysis of the individual and contextual-level socio-economic variables that correlate with the delay between registration to the service and the first voucher activation. The basic idea is that this analysis is able to unveil factors that shape citizens' ability to translate intention into effective participation in this downstream co-production service, which provides further empirical evidence on to the selection of the users involved in co-production (Cepiku & Giordan, 2014) that appears still limited in the context of digitalization of public service provision. This study represents a genuine novelty within the literature on co-production, as the dual procedure of registration and use introduces an original dimension in the access process to co-produced services. At the same time, it provides a valuable case study for understanding how digitalization intersects with the inclusion (or exclusion) of vulnerable groups in the co-production of public services. As highlighted by Voorberg et al. (2015) and Lember et al. (2019), co-production increasingly depends on citizens' capacity to interact with digital interfaces and administrative platforms, making "digital readiness" a key determinant of participation and equity in public service delivery.

Findings suggest that both individual vulnerabilities (disability and older age) and local disparities shape citizens' ability to operationalize participation in digital co-produced services. They provide ground for a better design the co-production digital system delivery of mobility services.

The remainder of the paper is as follows: Section Two provides a literature review which aims at framing the theoretical premises and clarifying the specific contribution of this study; Section Three provides a detailed illustration of the case study; sections Four and Five describe the data used in the empirical analysis and the methodology. The results of the analyses are presented and in Section Six while findings obtained through robustness checks are in Section Seven. Finally, section Eight provides conclusive remarks.

Background Literature

Rooted in Ostrom's work as "the process through which inputs used to produce a good or service are contributed by individuals who are not 'in' the same organization" (1996, p. 1073), the concept of co-production in public services has gained increasing attention in recent years, particularly as governments seek innovative ways to deliver services more efficiently and inclusively. Co-production involves the joint delivery of services by providers and users, and is seen as a means of enhancing responsiveness, trust, and social outcomes (Voorberg et al., 2015). Classical general definitions of co-production, as explained by Brandsen & Honing (2016, p. 428), refer to "production or provision of public services" and entail "collaboration between public agencies and citizens"; "an active input by individual citizens in shaping the service that

they personally receive”. Further elements which help identifying typology of co-production should include: “(1) the extent to which citizens design services delivered to them and (2) the proximity of co-production to the primary process” (Brandsen & Honing, 2016, p. 431). However, far from being straightforward, classification of co-production includes several dimensions, like the quantity and characteristics of actors involved as well as the timing and nature of the “production” activities (Nabatchi et al., 2017). As outlined by Brandsen and Honingh (2016), co-production requires citizens to act not just as beneficiaries, but as active agents. However, the success of such initiatives heavily depends on the capacity and willingness of individuals to engage, particularly when mediated by digital tools.

The importance of co-production is related to its capacity to create value for customers (*value-in-use*) (Osborne, 2018; Osborne et al., 2021). If “it is the citizen and/or service user who creates the performance and value of a public service” ... Public Service Organization (PSO), should integrate the service offering with citizens’ “needs, personal abilities and experiences, and their societal context” (Osborne, 2018, p. 229) in order to facilitate the value creation process. In this sense co-production is to be intended as “a collaborative process, not simply a synonym for user control, and so requires the active cooperation both of PSOs and public service officials and of service users” (Osborne et al., 2021, p. 649).

If citizen participation and value creation for them and society as a whole through the production and use/consumption of public services are a necessary condition for co-production to take place (Osborne et al., 2021), knowledge regarding the conditions under which citizen involvement is made possible represents a fundamental step of the co-production process (Voorberg et al., 2015). Such understanding in recent times must consider that the diffusion of e-governance technologies has created further channels to promote citizens-public agencies collaboration, giving rise to an even increasing literature on technology-enabled co-production (Clark et al., 2013, 2020). On one hand digital technology is expected to empower citizens. On the other hand, such technologies may prevent vulnerable/disadvantaged citizens to effectively access public services and being involved in their delivery (Lember et al., 2019).

Digital inclusion represents an asset to help vulnerable people bridge inequalities and entails “having proper support and the right digital skills to achieve personal and professional success” as well as “the availability of hardware and software, relevant content and services; and training for the digital literacy skills required for effective use of information and communication technologies” (Institute of Museum and Library Services et al., 2012: 1, cited in Pérez-Escolar & Canet, 2023, p.1060). Therefore, digital skills and competence become fundamental to encourage people to become a fully digitally included citizen. A recent systematic review on literature related to vulnerable people and digital inclusion evidenced that older adults are the most likely group to be excluded from the digital realm, followed by followed by people with disabilities, poor communities, low-income families, women and ethnic minorities (Pérez-Escolar & Canet, 2023, p.1064). Citizen empowerment is a matter of computer skills as well as usability and accessibility of digital technology tools: gender, geographical location and race, poverty and education, physical and cognitive limitations and age are described in the literature as the main sources of vulnerability which can exacerbate digital exclusion (Pérez-Escolar & Canet, 2023, pp.

1064–1065). Another paper has examined evidence on the ways in which ICTs enable or pose a barrier to co-production (Clifton et al., 2020), identifying the structural and cultural factors that act as barriers to, or enablers of, ICT enabled co-production in the cases of both governments and citizens. Financial and technical capacities, legal issues and organizational culture; citizens' technical skills, demographic factors (particularly age, gender and immigration status), social dynamics, as well as trust in government, emotional needs, type of technology and the perceived ease of use of the ICT are all factors which condition ICT-enabled co production (Clifton et al., 2020).

Single case studies on the use of digital technology for co-production of public services evidenced that user skills and institutional as well as context specific characteristics are key in explaining the use of digital tools in co-production activities. Young (2022) shows that the effectiveness of digital tools in service delivery depends not only on their technical design but also on citizen characteristics and neighborhood context. While Open 311 (a platform that provides open communication channels for issues that concern public space and public services¹) tends to accelerate problem resolution, its advantage narrows with more complex requests; Twitter, though less efficient overall, can strengthen equity by increasing visibility in both disadvantaged and politically influential areas. Clark et al. (2013) demonstrate that participation in Boston's 311 system (a free public service that connects citizens with the City of Boston for non-emergency help and information²) is uneven: while racial differences are generally modest, Hispanic and low-income communities engage less through web portals, whereas smartphone applications appear to lower barriers and mobilize disadvantaged and transient groups. These results suggest that the distributive impact of digital co-production depends on both citizen attributes and neighborhood context, with technology sometimes reinforcing inequalities and sometimes helping to bridge them. Xu and Tang (2020) find that minority and low-income households were more likely to use Tallahassee's 311 platform, (a 311 public service systems that provides access to non-emergency government services and information in the city of Tallahassee, in Florida)) after Hurricane Michael, and that their participation translated into faster power restoration, effectively narrowing pre-existing service disparities. The study shows that the distributive effects of digital co-production hinge on both citizen characteristics and community context, with e-governance platforms functioning as "digital capital" for historically disadvantaged groups. Shen et al. (2023) show that Jiaxing's Weijiayuan platform enabled a shift from short-term recovery to long-term transformative resilience, expanding from pandemic control to everyday services, dispute resolution, and participatory governance. Their analysis highlights that such outcomes depend on public entrepreneurship, widespread citizen uptake, incentive structures for co-production, and accountability mechanisms that strengthen both government responsiveness and user engagement within a top-down designed service.

In the field of urban mobility, research has focused on integrated transport systems, inclusive design, and the removal of access barriers for vulnerable populations. The Swiss Federal Railways (SBB) case represents an example of a public transport

¹ <https://www.open311.org/>.

² <https://www.boston.gov/departments/boston-311>.

provider that redesigned its service delivery model by integrating multiple user interaction channels, including self-service technologies, digital platforms, and customer feedback systems, allowing passengers to engage with the service at different stages of its provision. Gebauer et al. (2010) show that the Swiss Federal Railways shifted from merely facilitating value to actively co-creating it with passengers through engagement, self-service, customer experience, problem-solving, and co-design. Their case demonstrates that the success of public transport services hinges on managing co-creation comprehensively, with citizen participation becoming a strategic driver of efficiency, satisfaction, and sustainability.

All in all, literature emphasizes that co-production requires both capability and opportunity, and that vulnerability is structural, linked to resources, networks, and institutional support (Brandsen & Honingh, 2016; Bovaird et al., 2016). In this perspective, vulnerability - referring to groups experiencing social and structural barriers that limit their full participation in health services and co-production activities (Grabovschi et al., 2013) - should be understood as a multidimensional condition that reflects not only individual characteristics but also unequal access to resources, capabilities, and institutional support. While co-production is often presented as a mechanism to empower citizens and enhance inclusion, its effects are not univocal. Depending on how services are designed and implemented, co-production may either reduce barriers to access or, conversely, reproduce and even amplify existing inequalities, particularly when participation requires specific skills or resources (Mulvale & Robert, 2021).

Sustainable co-production depends on tailored interfaces and low transaction costs, particularly in homelessness and disability services. Steen et al. (2018) caution that co-production is not inherently inclusive, as it may privilege organized and resourceful groups while excluding vulnerable populations. Their analysis shows that the distributive effects of co-creation depend on careful design and safeguards, without which participatory processes risk reinforcing inequalities rather than reducing them.

Mulvale and Robert (2021) highlight that the barriers and enablers of co-production vary across vulnerable groups: frail older adults require context-sensitive approaches such as situated interviews, refugees face language and bureaucratic obstacles, Black and Minority Ethnic (BAME) communities in the UK need safe spaces to address historical inequalities, and youth with mental health issues benefit from relational safety and sustained support. Taken together, the cases demonstrate that effective co-production depends on tailoring methods to the specific vulnerabilities and strengths of each community, rather than applying one-size-fits-all models.

Rome taxi voucher program is a case of individual co-production (Bovaird et al., 2016, p.50) “where citizens have little choice but to participate in the service as provided ‘top-down’...[and] the contributions made and the benefits received by citizens are at an individual level”. Moreover, following Brandsen and Honingh’s 2015 types of co-production, Rome taxi program can be considered as “complementary co-production in implementation” which “occurs when citizens are actively engaged in the implementation, but not the design, of a complementary task.” (Brandsen and Honingh, 2016, p. 433). However, in the analysis of the case study, together with the user’s characteristics, we have decided to adopt an holistic approach by combining

literature on the impact of technology on co-production (Lember et al., 2019) as well as studies on how to engage vulnerable citizens in the co-production of public services (Mulvale & Robert, 2021; Amann & Sleight, (2021)). Studying factors affecting the timeliness between voucher activation and use in the case of taxi voucher is crucial to understand the process of citizens engagement with public services in practice. It provides insights into the effectiveness and responsiveness of co-production processes, revealing whether users act as active partners or passive beneficiaries in policy implementation and evidencing possible obstacle/barriers and facilitators to effective co-production. It also helps policymakers to better frame a service deliberately targeted at vulnerable groups, which nevertheless requires a certain level of digital skills to be effectively accessed and used.

The Buoni Viaggio Roma Case Study

The Buoni Viaggio Roma Program was launched by the Municipality of Rome in 2021. It was Funded through resources transferred from the Ministry of Infrastructure and Sustainable Mobility to Roma Capitale. Funds came from the allocations of the National Law Decree 34/2020 (“*Decreto Rilancio*”) and were active from 6 October 2021 until the exhaustion of available funds and, in any case, no later than 31 December 2021.

The program targeted four main categories of beneficiaries: (i) adult women, (ii) individuals aged 65 or older, and (iii) adults with certified disabilities and (iv) other individuals in socio-economic hardship as identified by the municipality. Only during the Christmas period (8th–31st December 2021) the service was extended to young people aged 18–26. According to the enacting official resolution adopted by Roma Capitale (Roma Capitale, 2021), the measure was conceived as a dual-purpose intervention aimed, on the one hand, at supporting specific categories of vulnerable citizens in their mobility needs during the COVID-19 emergency, and, on the other hand, at sustaining the taxi and chauffeured car hire (NCC) sector, which had experienced a dramatic drop in demand. More broadly, the program was also intended to promote alternative forms of urban mobility and reduce pressure on public transport systems under social distancing constraints.

This dual objective helps explain the apparent tension between the program being considered successful in administrative terms—given the rapid implementation and number of registered users—and the relatively limited uptake among some of the intended target groups. In particular, while the measure was designed to be immediately accessible through a fully digital procedure, less emphasis appears to have been placed on mitigating potential access barriers for users with lower digital capabilities or higher levels of vulnerability. This design choice is likely to have contributed to the observed gap between formal eligibility and effective participation.

For all the target group, the benefit consisted of a 50% discount on the fare of each taxi or NCC ride licensed by Roma Capitale, up to a maximum reimbursement of €20 per trip and a total ceiling of €400 per beneficiary for the entire period, with a limit of two rides per day.

To receive this benefit, users had register on the official program platform (buonviaggiroma.romamobilita.it) using one of Italy's official digital identity systems, i.e., "SPID" (Public Digital Identity System), "CIE" (Electronic Identity Card), or "CNS" (National Service Card). During registration, applicants were required to provide personal information and, where applicable, supporting documentation to prove their eligibility, such as proof of residence or disability certificates. Once the registration was completed, the platform automatically verified whether the applicant met the programme's requirements. Only taxi and NCC operators accredited within the Buoni Viaggio Roma system were authorized to accept vouchers. These operators had to register on the same platform and ensure that they are equipped with a POS (point-of-sale terminal) for digital payments. To use a voucher for a ride, beneficiaries could access their personal area on the platform and activate the voucher before the end of the trip. The system then generated a unique "QR code" or "PNR code" associated with that specific journey to be shown to the driver. This mechanism ensured that the discount was securely linked to both the user and the accredited operator.

Table 1 examines the Rome Taxi Voucher program building on Amann and Sleigh's (2021) reflective framework and on Lember et al.'s (2019) conceptualization of how new technologies shape the different dimensions of co-production.

In terms of decision-making power, the program opened access to a subsidy targeted at vulnerable groups, but the design largely reflected governmental priorities, limiting citizens' role in shaping eligibility or allocation. At the stage of involvement, online registration lowered entry costs for those digitally literate, yet it discouraged many potential beneficiaries—particularly older adults and some people with disabilities—highlighting the tension between motivation and structural barriers. Modes of interaction reveal a similar ambivalence: the digital procedure allowed faster information exchange and automatic validation, but at the same time it reduced opportunities for relational trust-building and personal assistance that many vulnerable groups rely on. Finally, tools and methods suggest that the municipality mobilized resources from citizens themselves, requiring them to navigate online systems and manage digital vouchers, which in some cases shifted administrative burdens onto users.

The 2021 edition of the program was deemed a success with over 17,000 registered users and close to 20,000 vouchers issued in just two months, correspondent to an amount of 185.000 euro, according to Roma Capitale's own reporting³. Also on the basis of these figures, the service was further funded in 2022 and 2023.

Nevertheless, this program's target groups take-up rates were particularly low. According to official released data on 2021 edition of the program⁴, women represented the largest share of registered users, with 15,312 beneficiaries, corresponding to an estimated take-up rate of 1.19% of the adult female resident population in Rome. Older men (aged 60 and above) accounted for 1,671 active users, representing only 0.48% of the corresponding male resident population. Individuals with certified disabilities numbered 154 active users. Finally, young men aged 18–26 (included because of socio-economic hardship or during Christmas period) were a marginal segment of the user base, with just 29 active users while. Such a limited uptake may

³ <https://www.comune.roma.it/web/it/informazione-di-servizio.page?contentId=IDS860973>.

⁴ <https://www.comune.roma.it/web/it/informazione-di-servizio.page?contentId=IDS860973>.

Table 1 Rome Taxi Voucher Reflective framework. Adapted from Amann and Sleigh (2021) and Lember et al. (2019)

Dimension of co-production (Amann & Sleigh, 2021)	Impact of technology on co-production (Lember et al., 2019).	Challenges
Decision making power	Sharing decision making Empowers citizens through a more open process and improved knowledge Diminishes the need for shared decision making, by allowing governments to manipulate and citizens to self organise more effectively	Resource-related challenges Limited resources Ethics overheads Lack of guidance
Stages of involvement	Motivation Increases motivation by lower threshold, better evidence and more entertainment Decreases motivation by crowding out intrinsic motives and threatening privacy	Initiation challenges Gaining Access Identifying members Gaining trust
Mode of interaction	Establishing direct interaction: Allows swifter and broader exchange of information Digital interaction diminishes physical interaction	Collaboration challenges (1) Logistics Communication
Tools and methods	Bringing resources to the service: Allows the mobilization of resources from citizens on a far wider scale Enables hidden privatization	Collaboration challenges (2) Managing group & power dynamics Concerns for well-being

point to informational barriers, procedural burdens or mismatches between the program’s operational features and citizens’ needs which are worth of attention in the light of the increasing role of digital technologies in co-production and co-creation (Lember et al., 2019).

Data

Our analysis relies on administrative (secondary) data on the program and its user that were provided by Roma Capitale, i.e., the authority that administers the territory of the Municipality of Rome. The data concern the first edition of the program (from October to December 2021) and record a variety of information on the program’s users: date of registration, date of the first voucher activation, total number of activated vouchers, gender, age class. The total number of observations in the sample is 7,855. Of these: 7,167 are women (91.2%) and 221 are men aged over 60 (2.8%); 73 are persons with disabilities (0.9%); and 4 are men aged 18–26 (0.5%). Number of observations in our sample differ from official released data because users registered

on the platform who did not make any trips were excluded from the transferred file. This means to limit our analysis only to citizens who were effectively engaged in the co-production process.

To enrich this information, data were merged with socio-economic indicators gathered through the *Mappa Roma Project* (Lelo et al., 2021) and measured at the ZIP Code (CAP -Codice di Avviamento Postale)-level, i.e., at the level of territory identified by one five-digit postal code. The inclusion of these contextual variables aim at capturing local contextual socio-economic conditions, including average income, the Gini index of income inequality, the total resident population, and the share of foreign residents.

Table 2 reports descriptive statistics for all variables used in the analysis, while Table 3 shows their corresponding values aggregated at the ZIP (CAP) code level.

On average, residents registered 5.37 vouchers and 10.5 days passed from registration to activation but this number turns out to be highly variable (s.d.=approximately 15 days) (Table 2). Detailed statistics in Table 3 suggest that the number of vouchers and the number of users vary considerably across ZIP (CAP) areas. Moreover, this variability is not always correlated with population density. Compared to the resident population, some ZIP (CAP) areas exhibit a high number of users (CAPs 184, 192, 193, 195, 196) and a high total number of registered and activated vouchers

Table 2 Description and summary statistics of variables used in the study

Labels	Obs	Mean	Std. Dev.	Min	Max	Description
Individual-level variables						
sex	7,854	0.91	0.28	0	1	0=male, 1=female
disability	7,854	0.01	0.10	0	1	0=no, 1=yes
age_group	7,854	4.71	1.64	1	9	1=10–19 (yrs); 2=20–29; 3=30–39; 4=40–49; 5=50–59; 6=60–69; 7=70–79; 80=8–89; 9=90–99
total voucher	7,854	5.37	8.17	1	99	Vouchers (n) per individual
Time to voucher activation	7,854	10.62	15.04	0	84	Days (n) from voucher registration to first activation
Cap-level variables (n Cap=73)						
population	7853*	40,094.36	19,281.73	8,022	116,617	Residents (n) per Cap area
gini index	7853*	0.49	0.07	0.38	0.66	Gini index within each CAP area, ranging from 0 (perfect equality) to 1 (maximum inequality)
average income	7853*	862.39	340.14	205.42	1,752.78	Average income (€) per Cap area
foreign population	7853*	0.14	0.05	0.07	0.35	Foreign residents on total residents(%) per Cap area

Cap is missing for one voucher user

Source: Individual-level variables were derived from administrative (secondary) data provided by *Roma Capitale*

Cap-level variables were derived by data from *Mappa Roma Project* (www.mapparoma.it, Lelo et al., 2021)

Table 3 Detailed statistics by Rome ZIP Code (CAP)

ZIP (CAP)	Municipium	tot voucher user	tot voucher	tot pop	tot foreign pop	foreign pop(%)	tot income	average income	gini index	Time to voucher activation (days)
118	VII	23	134	28,877	2,293	7.94	24,230.68	467.17	0.42	4.65
119	X	8	19	12,284	1,096	8.92	16,387.77	487.06	0.55	19.13
121	X	17	90	43,061	5,078	11.79	22,036.42	594.74	0.42	5.71
122	X	26	162	38,405	4,038	10.51	24,664.81	631.96	0.41	13.38
123	X	22	117	49,291	9,651	19.58	26,561.35	771.87	0.52	7.77
124	X	19	145	48,435	5,141	10.61	32,361.46	971.72	0.5	20.32
125	X	30	171	55,590	6,229	11.21	25,312.55	887.96	0.43	7.23
126	X	9	49	30,911	4,166	13.48	20,451.18	387.04	0.39	12.00
127	IX	12	48	15,262	1,275	8.35	32,935.66	334.59	0.43	12.17
128	IX	40	109	43,415	4,594	10.58	29,930.23	838.14	0.46	11.23
131	IV	7	29	22,898	2,385	10.42	21,981.42	315.59	0.38	5.86
132	VI	23	103	110,947	20,133	18.15	19,043.29	1231.74	0.38	10.83
133	VI	44	201	116,617	20,127	17.26	18,970.11	1315.10	0.4	10.48
134	IX	19	65	29,893	3,382	11.31	25,441.49	490.74	0.41	5.89
135	XIV-XV	169	789	80,241	11,521	14.36	33,489.07	1752.78	0.55	10.34
136	I-XIV	253	1237	43,981	4,470	10.16	42,562.02	1281.12	0.51	12.42
137	III-IV	126	559	45,583	3,508	7.70	33,915.82	1065.19	0.45	10.66
138	III	29	195	28,860	3,610	12.51	22,343.30	417.71	0.41	12.86
139	III	184	985	88,406	6,370	7.21	26,800.22	1580.41	0.43	9.79
141	III	244	1364	49,750	5,715	11.49	32,054.20	1109.84	0.46	8.49
142	VIII	141	682	44,929	4,042	9.00	36,767.45	1134.97	0.43	10.54
143	IX	75	300	41,487	3,149	7.59	31,705.22	885.34	0.44	9.39
144	IX	133	507	51,824	3,448	6.65	42,298.25	1502.35	0.47	10.45
145	VIII	110	605	19,889	2,515	12.65	29,197.25	393.11	0.43	9.79
146	II-X-XI	182	1015	60,663	9,923	16.36	22,726.76	906.93	0.41	11.37

Table 3 (continued)

ZIP (CAP)	Municipium	tot voucher user	tot voucher	tot pop	tot foreign pop	foreign pop(%)	tot income	average income	gini index	Time to voucher activation (days)
147	VIII	87	288	23,376	2,735	11.70	34,793.50	548.28	0.47	8.80
148	XI	62	303	62,145	8,478	13.64	22,018.33	854.49	0.42	9.27
149	XI	112	557	37,982	3,650	9.61	28,806.64	749.84	0.43	11.96
151	XII	177	891	33,556	3,158	9.41	36,289.03	835.63	0.49	10.37
152	XII	279	1682	48,392	5,780	11.94	33,792.03	1098.17	0.49	9.74
153	I	265	1546	31,991	5,955	18.61	39,381.49	770.93	0.57	10.32
154	VIII	168	1014	31,616	3,776	11.94	27,426.04	583.52	0.45	11.20
155	IV-V	85	691	62,033	6,201	10.00	23,041.58	936.73	0.39	10.62
156	IV	50	251	43,913	5,207	11.86	22,725.74	622.96	0.43	12.26
157	IV	62	388	18,792	2,569	13.67	24,249.50	315.61	0.41	11.35
158	IV	21	206	14,157	1,086	7.67	21,799.78	205.42	0.41	14.62
159	IV	108	572	39,468	3,473	8.80	23,370.91	640.60	0.41	10.40
161	II	96	532	14,379	1,737	12.08	48,187.05	467.56	0.53	9.91
162	II	173	850	25,468	2,452	9.63	39,712.48	692.90	0.49	10.50
163	XII	38	160	20,330	2,399	11.80	26,020.78	346.18	0.44	12.97
164	XII	27	140	14,435	1,722	11.93	28,006.63	271.38	0.47	4.96
165	XIII	204	1157	39,105	6,285	16.07	35,817.84	888.86	0.52	9.78
166	XII-XIII	122	678	98,421	13,539	13.76	21,874.68	1331.95	0.42	12.52
167	XIII	112	435	39,760	5,477	13.78	27,462.67	741.79	0.45	15.23
168	XIV	116	680	63,310	8,067	12.74	22,880.89	938.73	0.42	12.69
169	VI-VII	27	137	33,640	4,649	13.82	20,906.77	457.40	0.38	10.04
171	V	60	348	36,100	5,401	14.96	20,509.33	481.21	0.39	10.02
172	V	75	363	53,052	8,957	16.88	20,268.38	689.92	0.39	9.92
173	VII	51	344	50,248	4,082	8.12	24,958.46	828.25	0.39	10.84
174	VII	77	303	31,359	2,950	9.41	27,731.72	622.55	0.43	13.49

Table 3 (continued)

ZIP (CAP)	Municipium	tot voucher user	tot voucher	tot pop	tot foreign pop	foreign pop(%)	tot income	average income	gini index	Time to voucher activation (days)
175	VII	87	442	44,793	5,871	13.11	22,282.60	682.00	0.38	9.51
176	V	194	796	49,261	11,714	23.78	21,893.87	696.31	0.43	11.41
177	V	140	665	56,487	10,311	18.25	21,876.89	805.09	0.4	11.92
178	VII-VIII	36	159	26,891	2,984	11.10	29,433.47	509.35	0.47	10.14
179	VII	212	1072	43,172	5,744	13.30	31,955.98	915.86	0.46	12.74
181	VII	120	684	28,873	3,503	12.13	28,928.78	581.90	0.44	12.71
182	VII	136	662	20,981	2,424	11.55	31,529.10	461.62	0.46	9.95
183	VII	176	1019	26,667	3,072	11.52	33,487.28	622.93	0.47	8.86
184	I	154	883	15,234	2,790	18.31	46,497.15	441.35	0.55	10.27
185	I-II	257	1495	35,539	9,221	25.95	29,254.61	646.44	0.52	10.07
186	I	149	857	22,564	7,994	35.43	59,070.28	669.68	0.66	10.87
187	I	92	838	10,150	1,994	19.65	66,941.36	417.11	0.63	8.95
188	XV	23	105	35,037	6,551	18.70	21,078.71	448.55	0.43	9.61
189	XV	67	307	39,950	9,550	23.90	32,102.31	770.58	0.54	6.97
191	XV	86	486	22,853	3,319	14.52	51,522.72	760.48	0.58	11.77
192	I	126	1000	13,818	1,474	10.67	41,130.87	391.81	0.55	8.66
193	I	83	480	8,022	1,244	15.51	56,082.76	277.27	0.61	9.95
195	I	225	1079	24,829	2,203	8.87	46,885.56	811.92	0.55	8.82
196	II	147	652	16,103	1,581	9.82	45,350.92	497.09	0.55	12.67
197	II	125	839	22,602	4,415	19.53	72,038.53	988.44	0.62	11.92
198	II	261	1419	30,461	3,937	12.92	59,459.17	1218.85	0.58	10.44
199	II	358	2029	46,555	5,432	11.67	43,719.12	1360.06	0.52	10.81

(CAPs 184, 187, 192, 193, 195, 196). These ZIP codes (CAP) are located in central neighborhoods and report an average income significantly below the citywide mean. Conversely, lower numbers of users relative to the resident population are observed in ZIP code (CAP) areas located in peripheral neighborhoods, where the average income is either significantly below (131, 134, 138) or above (132, 133) the citywide mean. Similarly, the number of vouchers relative to population is lower in peripheral ZIP (CAP) areas with average income below (119, 126, 131) or above (132) the citywide mean.

Figure 1 provides a spatial map of voucher distribution across the city. By presenting data at the municipium level, it offers a clearer and a more informative overview of spatial patterns in voucher distribution⁵. Figure 2 displays the distribution of time-to-activation. It turns out to be highly skewed: most individuals activate within the first 20 days, while only a small minority delay activation beyond one month.

⁵ Municipia (I–XV) are the administrative level immediately below the city level. Unfortunately, map

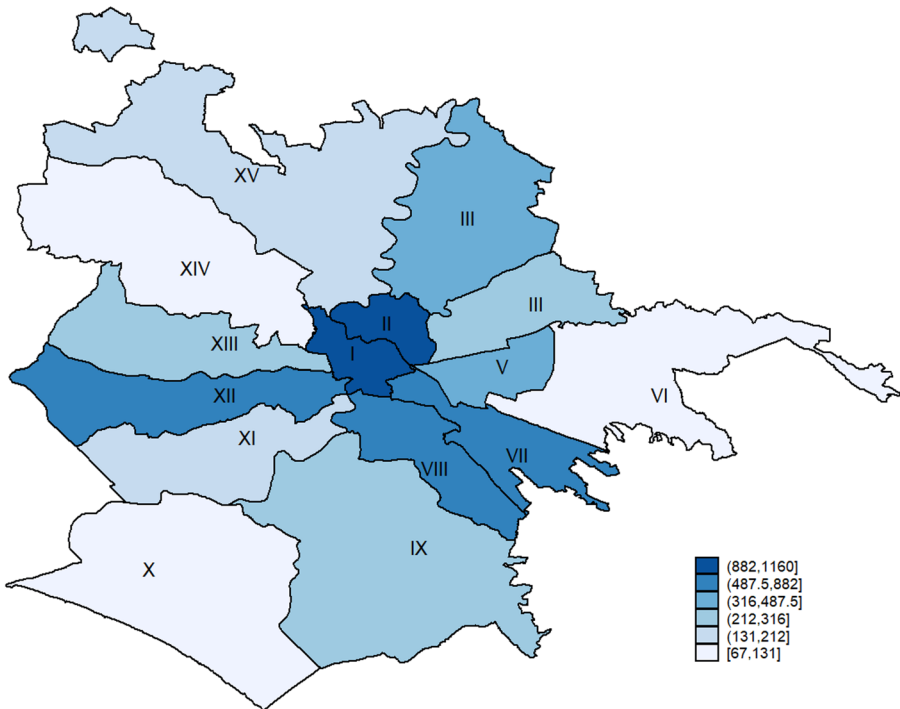


Fig. 1 Distribution of vouchers by Municipium Boundaries of Roma Capitale. Source: own elaboration on data from Istat and Roma Capitale Note: This map excludes vouchers activated by residents in ZIP codes (CAP) spanning more than one municipium ($n=6,760$ vouchers; 16% of the total) (for details on these ZIP codes (CAP), see Table 3)

presented in Fig. 1 does not report the all number of vouchers activated. This is because, as it is shown in Table 3, some ZIP codes (CAP) are included in more the one municipality.

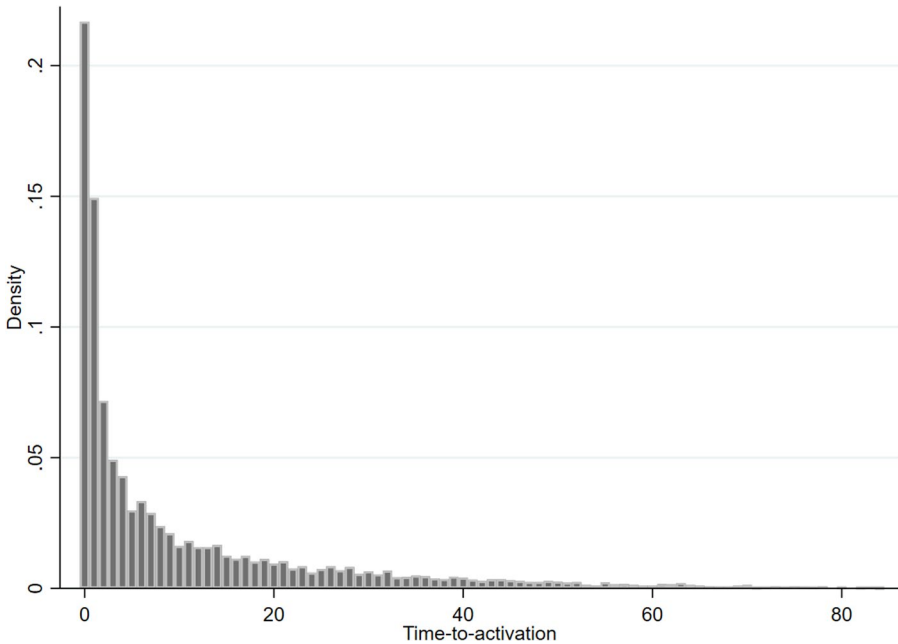


Fig. 2 Time from registration to first activation (days). Distribution of values. Source: own elaboration on data from Roma Capitale

This pattern suggests that the program was predominantly accessed immediately or shortly after registration, yet a non-negligible tail of late adopters remains.

Empirical Strategy

The *Buoni Viaggio Roma* time-to-activation is modeled through an Accelerated Failure Time (AFT) specification which provides a direct parametric framework for the analysis of duration data. The choice of the AFT model is motivated by the fact that all individuals in the sample eventually activated at least one voucher, leaving no censored observations. In such cases, a proportional hazards specification, like the Cox proportional hazards model (Cox, 1972), would not be appropriate, while the AFT model offers a more natural interpretation. A proportional hazard model assumes that the effect of a covariate is to multiply the hazard to a constant factor. By contrast, an AFT model assumes that the effect of a covariate is to accelerate or decelerate the course of an event by a constant factor.

In order to investigate the delay of activation, the model is specified by Eq. (1):

$$\begin{aligned}
 T_i = & \beta_0 + \beta_1 sex_i + \beta_3 disability_i \\
 & + \beta_2 age_i + \beta_3 average_income_i \\
 & + \beta_4 gini + \beta_4 \%foreigners_i + \varepsilon_i
 \end{aligned}
 \tag{1}$$

T_i is defined as the number of days between the registration date and the first voucher use, therefore it represents the time-to-activation. All the individual-level and CAP-level covariates described in previous section are included on the right side of the equation: a dummy equal to 1 for women (*sex*); a dummy equal to 1 if the individual reports disability (*disability*); age-group dummies (*age*); average total income (*average_income*); the Gini index of gross income (*gini*) and the percentage of foreign residents over the total population according to CAP. ϵ_i is the error term. The basic specification uses a log-normal distribution with robust standard errors.⁶

In the AFT model the β coefficients are interpreted as time ratios (TR), using the following formula:

$$TR_i = \exp(\beta_i) \quad (2)$$

A time ratio greater than 1 indicates that the variable increases the time to voucher activation (delays activation); conversely, a time ratio lower than 1 indicates that the variable reduces the time to voucher activation (accelerates activation).

Results

Table 4 reports the Eq. (1) estimates. Column (1) shows the β coefficients while column (2) displays the time ratios calculated for the statistically significant coefficients, according to formula (2).

The use of the AFT model enables the quantification of the extent to which individual characteristics (gender, age, disability) and territorial characteristics (income, inequalities, demographic structure) accelerate or delay the activation of the voucher.

Results show that gender is not a relevant determinant of activation time: the coefficient associated with the female dummy is small and statistically insignificant, indicating no systematic difference between men and women in the speed of voucher activation. By contrast, disability status is associated with longer delays. The estimated coefficient is positive and statistically significant at the 10% level, with a time ratio of approximately 1.17. This implies that individuals reporting a disability take on average about 17% longer to activate their first voucher compared to those without a disability. Age patterns are generally weak, but some differences emerge at the upper tail of the age distribution. While most age-group dummies are statistically insignificant, the coefficient for the 80–89 group is both positive and significant. The estimated time ratio is around 1.31, meaning that individuals in this age bracket activate their first voucher roughly 31% later than the reference group (20–29 years). This finding suggests that advanced age may generate additional frictions in accessing and using the digital platform, although the effect is not monotonic across all age groups.

⁶Figure 1 shows a distribution concentrated at short durations with a long right tail. Such skewness supports the use of parametric duration models, and in particular the log-normal specification adopted in the baseline model.

Table 4 AFT estimates of delay between users' registration and first voucher activation (days). Coefficients and robust standard errors (in parentheses)

	Coefficient	Time ratios
Sex	0.0448 (0.035)	
Disability	0.1574* (0.089)	1.170
Age_20–29 years	0.0937 (0.107)	
Age_30–39 years	0.1314 (0.101)	
Age_40–49 years	0.1171 (0.107)	
Age_50–59 years	0.1236 (0.107)	
Age_60–69 years	0.1219 (0.106)	
Age_70–79 years	0.1566 (0.110)	
Age_80–89 years	0.2715** (0.112)	1.312
Age_over 90 years	0.1306 (0.170)	
Average_income	–0.0000 (0.000)	
Gini index	0.3464*** (0.142)	1.414
%foreigners	0.0000 (0.000)	
Observations	6,150	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Turning to contextual variables, the average income of the CAP does not appear to influence activation time: the coefficient is close to zero and far from conventional significance levels. By contrast, income inequality, as measured by the Gini index of gross income, exerts a clear effect. The estimated coefficient is positive and statistically significant at the 1% level, corresponding to a time ratio of 1.41. This means that, holding other factors constant, residents of areas with higher income inequality experience activation times about 41% longer than those in areas with lower levels of income inequality. This result highlights the role of local inequality as a structural barrier to timely take-up of the policy. Finally, the share of foreign residents within the CAP has no detectable impact on activation time.

Taken together, the results emphasize the salience of two dimensions. First, individual characteristics such as disability status, and to a lesser extent advanced age, slow down the activation of vouchers, reflecting potential barriers to accessibility. Second, the socio-economic context plays a crucial role: higher inequality is robustly associated with longer delays, pointing to the importance of territorial disparities in shaping the effectiveness of mobility subsidies. Conversely, average income levels and the presence of foreign residents do not systematically condition the speed of activation.

Robustness Checks

The results are robust to a set of alternative specifications whose findings are not reported in order to save space but are available upon request to authors. First, we re-run our estimates by calculating errors in a cluster-robust form at the CAP level. This choice accounts for the fact that individuals living in the same area may share unobserved characteristics—such as quality of local services, digital literacy, or access to information—that generate within-CAP correlation in activation times. Clustering therefore ensures that statistical inference does not rely on the potentially unrealistic assumption of independence across individuals within the same territory. The baseline findings are generally confirmed, in magnitude and significance.

Second, we test the sensitivity of the baseline findings to different assumptions about the underlying distribution of activation times. While the baseline model relies on a log-normal specification, we re-estimate the AFT model using alternative distributions, namely Weibull and log-logistic. These families differ in the shape they impose on the hazard and survival functions, allowing us to check whether results hinge on the log-normal assumption. The results are generally not sensitive to distributional assumptions. With the log-logistic specification we confirm the baseline results for all the key variables of interest - disability status, advanced age, and the Gini index. By contrast, with the Weibull distribution the coefficient for disability status loses statistical significance, suggesting that this effect may be less robust.⁷

Discussion and Conclusion

The results indicate that barriers to activation emerge primarily along two dimensions. First, individual vulnerabilities matter: while gender differences are negligible, individuals reporting a disability activate their first voucher about 17% later than others, suggesting that specific accessibility constraints can hinder the immediate use of digital services. Moreover, the elderly, particularly those aged 80–89, exhibit activation times that are roughly 31% longer. This evidence points to persistent age-related frictions in navigating digital platforms, even when the service is designed to be broadly inclusive. Second, contextual inequalities play a significant role. Average income levels of the CAP are not associated with activation times, but local income inequality—as captured by the Gini index—is strongly and robustly correlated with slower take-up. Residents in more unequal areas experience activation delays of approximately 41% relative to those in areas with lower income inequality. This result underscores that not only individual vulnerabilities, but also structural features of the local socio-economic environment, shape the effectiveness of co-produced digital services. By contrast, the share of foreign residents does not exert a statistically significant effect, suggesting that the timing of activation is not systematically related to local migrant concentration.

⁷ Results are available upon request.

These findings are consistent with the view of vulnerability as a structural and multidimensional condition, which may limit the ability of certain groups to effectively engage in digitally mediated co-production processes.

Results also highlight a set of structural shortfalls in the co-production design of the program. In particular, the reliance on fully digital access procedures appears to shift part of the administrative burden onto users, requiring digital skills and resources that are unevenly distributed across the population. As a result, co-production in this context risks becoming selectively accessible, favoring individuals who are already better equipped to navigate digital systems, while disadvantaging those with higher levels of vulnerability. Overall, the case illustrates that co-production is not inherently inclusive: its distributive effects depend critically on design choices, particularly in digitally mediated service environments.

From a policy perspective, these findings suggest that improving equity in co-produced digital services requires moving beyond access provision toward supported participation. This may include the introduction of assisted access points, hybrid service delivery models combining digital and face-to-face interaction, and targeted outreach strategies in high-inequality areas. More broadly, integrating users' capabilities into service design—rather than assuming homogeneous digital readiness—appears crucial to prevent the reproduction of existing inequalities.

Moreover, taking a broader perspective, improving equity in co-produced digital services also requires assessing and addressing the level of digital skills endowment in the target population of policy initiatives. Aggregate data show a significant gap in Italy's digital skills relative to EU comparators. According to the Eurostat ICT survey, in 2021 only 45.75% of Italian individuals aged 16–74 had basic or above-basic overall digital skills, compared to the EU average of 55.6%. Moreover, for 18.4% of individuals, digital skills could not be assessed, since they had not used internet in the three months prior to data collection, while the EU average for this group is 11% (Eurostat, 2021)⁸. These figures remind us that equity in contemporary societies strongly depends also on digital skill endowment and the use of digital tools, and must primarily be addressed through education policy. Moreover, in countries like Italy that underperform in these areas, greater efforts should also be devoted to assessing digital skill levels and actively involving target groups in the co-design of public services that ultimately aim to reduce inequalities in access.

Hower, these policy recommendations stem from an analysis whose findings cannot be generalized, as they are based on a specific local context and dataset characterized by restricted temporal coverage and stem from the use of robust conditional correlation which may constrain the interpretation of causality. Therefore, our study offers an empirically grounded blueprint for future research offering valuable insights for enhancing equity and accessibility but should be regarded as exploratory and subject to further validation through broader and longitudinal datasets.

Some further reflections can be drawn from our empirical exercise. First, the dataset does not include information on individuals who activated the procedure but never used the taxi voucher, effectively opting out of co-production. Analyzing these cases would have allowed for a more nuanced and complete picture, particularly

⁸ Accessed 16/12/2025.

regarding patterns of non-compliance. Second, our sample is heavily skewed toward women compared to other vulnerability groups. This imbalance is largely due to the fact that women are the only group eligible for the measure even at younger ages—a feature that proved decisive in accessing the taxi vouchers. Familiarity with technology and digital skills appear to be crucial for the effective use of the vouchers. Other categories of beneficiaries, such as elderly men or persons with disabilities, are either discouraged from using the service or—more likely—require mediation to access it, as frequently highlighted in the literature on vulnerable people and co-production (Amann & Sleight, 2021; Mulvale, & Robert, 2021). For these latter groups, the ineffectiveness of the measure is evident. Future initiatives should therefore ensure the involvement of these vulnerable populations not only in the actual delivery but also in the co-design of such measures, to better understand and overcome the barriers posed by digitalization. Future research could explore comparative analyses across cities or programs.

Authors' Contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Elina De Simone and Federica Lanterna. The first draft of the manuscript was written by Elina De Simone, Giuseppe Lucio Gaeta and Mauro Pinto and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data Availability The data that support the findings of this study are available from Roma Servizi per la Mobilità. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors with the permission of Roma Servizi per la Mobilità.

Declarations

Compliance with ethical standards and informed consent Not applicable.

Artificial Intelligence (AI) The authors declare use of Generative AI tool (ChatGPT) for Language improvement.

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