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Article

Keywords: Living labs, Smart-city, Stakeholder participation, Capability development, Civic-relational dimensions, Urban innovation

Posted Date: November 23rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11563617/v1

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Additional Declarations: No competing interests reported.

Beyond technology acceptance: participation, capabilities, and civic-relational dimensions of smart-city appropriation in a Moroccan living lab

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Abstract

Living labs increasingly connect technological experimentation with stakeholder participation in smart-city development. This study examines how participation-related involvement, capability-related outcomes, and civic-relational dimensions are associated with smart-city appropriation in a university-affiliated living lab in Rabat, Morocco. Survey data from 61 respondents were analysed using hierarchical regression. Participation and capability-related outcomes explained 84.7% of the variance in appropriation, while civic-relational dimensions added 3.6 percentage points ($\Delta R^2 = .036$, $p < .001$). The findings suggest that smart-city appropriation extends beyond technology acceptance to include relational and collective dimensions, although the cross-sectional design precludes causal inference.

Keywords: Living labs; Smart-city; Stakeholder participation; Capability development; Civic-relational dimensions; Urban innovation.

1. Introduction

Urban transformation is increasingly shaped by technological change, sustainability pressures, and growing demands for more inclusive governance. Although smart-city initiatives have often been technology-driven, research increasingly emphasizes the need to involve citizens and other stakeholders not merely as users of digital services but as contributors to urban innovation and decision-making. This shift reflects concerns that smart-city development may remain institutionally top-down when participation is limited to consultation or technology adoption (Bastos et al., 2022; Nguyen et al., 2022).

Living labs have emerged as one response to this challenge. They provide real-life environments in which citizens, public authorities, firms, and researchers can experiment with, evaluate, and refine innovations. Their distinctive feature lies not simply in testing technologies but in combining experimentation with user involvement, learning, and co-creation (Dell'Era

& Landoni, 2014; Voytenko et al., 2016; Menny et al., 2018). Their relevance to smart-city development therefore depends not only on technological experimentation but also on the forms of learning and interaction generated around that experimentation.

This distinction is important because participation, capability development, and empowerment are not equivalent. Participation concerns involvement in innovation processes, whereas capability development refers to the knowledge, confidence, and resources that may enable stakeholders to engage more meaningfully. Empowerment implies a further step involving actual influence over priorities, decisions, or institutional practices. Living labs may support learning and engagement, but participation alone does not demonstrate a redistribution of decision-making power (Nguyen et al., 2022; Kowaltowski et al., 2024). The present study therefore focuses on participation-related involvement, capability-related outcomes, civic-relational dimensions, and smart-city appropriation rather than treating these elements as a single empowerment construct.

The concept of appropriation extends the analysis beyond conventional technology acceptance. Whereas acceptance primarily concerns willingness to adopt or use a technology, appropriation refers more broadly to how actors interpret and integrate innovation within their social and institutional environment. Desdemoustier et al. (2019) show that smart-city appropriation varies across actors and cannot be understood as a uniform response to technological change. Accordingly, smart-city appropriation may depend not only on familiarity with technologies but also on the relational and collective conditions through which urban innovation acquires meaning for stakeholders.

Research on living labs has documented their contribution to experimentation, participation, and capability development, while recent quantitative work has begun to examine relationships between living-lab involvement and smart-city perceptions (Park et al., 2025). However, less attention has been given to whether civic-relational dimensions provide explanatory value beyond participation and capability-related perceptions themselves. This distinction matters because strong participation or technological familiarity does not necessarily imply that stakeholders interpret smart-city transformation as socially meaningful or connected to wider urban priorities.

The Moroccan context provides a relevant setting for examining these relationships. Evidence from Casablanca indicates that living-lab approaches can facilitate collaboration among citizens and institutional actors while adapting urban innovation to local conditions (Elbroumi et al., 2025). Examining these relationships in Rabat therefore extends empirical evidence on how technological, participatory, and civic-relational dimensions coexist within an emerging urban innovation ecosystem.

Accordingly, the study addresses three research questions:

RQ1. How is participation-related involvement associated with capability-related and civic-relational outcomes?

RQ2. How are participation-related involvement and capability-related outcomes associated with smart-city appropriation?

RQ3. Do civic-relational dimensions provide additional explanatory value for smart-city appropriation beyond participation and capability-related perceptions?

Four hypotheses are tested:

H1. Participation-related involvement is positively associated with capability-related outcomes.

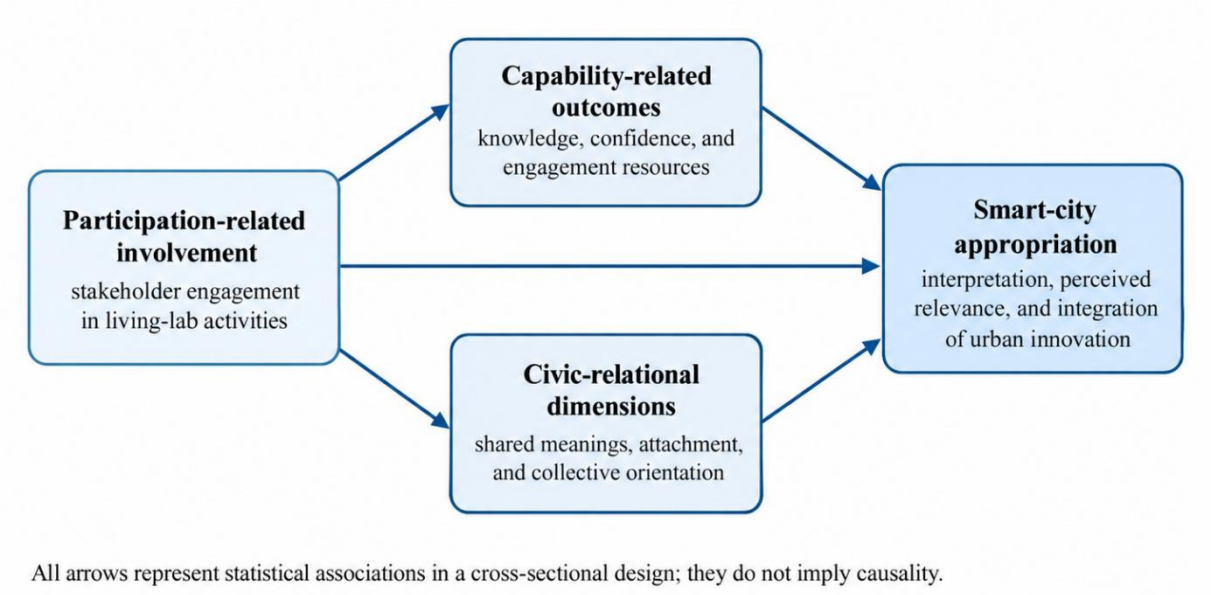
H2. Participation-related involvement is positively associated with civic-relational outcomes.

H3. Participation-related involvement and capability-related outcomes are positively associated with smart-city appropriation.

H4. Civic-relational dimensions provide additional explanatory value for smart-city appropriation beyond participation-related involvement and capability-related outcomes.

Figure 1 summarizes the analytical framework. Because the study uses cross-sectional data, all proposed relationships are interpreted as statistical associations rather than causal effects.

Figure 1. Conceptual framework linking living-lab involvement, capability and civic-relational dimensions to smart-city appropriation



Source: Authors.

The study contributes to the literature in three ways. First, it distinguishes participation-related involvement from capability and civic-relational outcomes rather than treating them as interchangeable manifestations of empowerment. Second, it tests whether civic-relational dimensions explain additional variance in smart-city appropriation beyond participation and capability-related perceptions. Third, it provides evidence from a Moroccan urban innovation context, extending empirical understanding of how technological and relational dimensions jointly relate to smart-city appropriation.

2. Materials and methods

2.1.Study setting, sampling, and ethics

The study was conducted in Rabat, Morocco, within the context of a university-affiliated living lab embedded in the innovation ecosystem of Mohammed VI Polytechnic University (UM6P). The living-lab setting combines technological experimentation with interactions among citizens and institutional stakeholders concerned with urban innovation and smart-city development.

A purposive, heterogeneous, non-probability sampling strategy was used to capture diverse stakeholder perspectives. Respondents included university researchers, representatives of public authorities in Rabat, business managers, and, predominantly, citizens. Particular attention was given to diversifying the citizen component by age, gender, and educational attainment. The final analytical dataset comprised 61 respondents for whom complete responses were available across all multi-item measures included in the present model. The sample is therefore intended to provide heterogeneous analytical perspectives rather than statistical representativeness of the population of Rabat.

Three face-to-face interviews with the scientific and operational management of the living lab were conducted during 2025 to support questionnaire contextualization and interpretation of the study setting. These interviews provided contextual information only and were not analysed as an independent qualitative dataset.

Participation in the survey was voluntary. Before completing the questionnaire, respondents received an information and consent sheet explaining the purpose of the research and indicating that their responses would be used exclusively for scientific purposes. Responses were analysed anonymously, and identifying contact information was not included in the analytical dataset.

2.2.Instrument and measures

The questionnaire was developed in consultation with the living-lab management team and reviewed by facilitators and academic researchers for clarity, relevance, and contextual appropriateness. This review was intended to strengthen content validity rather than to establish full psychometric validation, consistent with recommendations for multi-item measurement development (Boateng et al., 2018).

For the analyses reported in this study, five multi-item dimensions were retained and operationalized as composite scores: participation-related involvement (AI; seven items), the capability-related dimension (SII; five items), two civic-relational dimensions (CI; six items and SC; three items), and smart-city appropriation-related perceptions (PCT; nine items). Responses were recorded on a five-point scale (1–5), and composite scores were calculated as the mean of the items associated with each dimension.

The items were selected to capture respondents' involvement in living-lab activities, capability-related perceptions, civic-relational orientations, and perceptions of smart-city appropriation; the complete item wording is available in the supplementary questionnaire.

Internal consistency was assessed using Cronbach's alpha before constructing the composite measures, with reliability estimates reported in the Results section. The resulting composite scores were treated as approximately continuous in the regression analyses, an approach generally considered appropriate for multi-category rating scales when analytical assumptions are adequately examined (Norman, 2010). The analytical dataset contained no missing observations for the variables retained in the reported models; therefore, no imputation was required.

2.3.Statistical analysis

The analysis proceeded in three stages. First, descriptive statistics, Cronbach's alpha coefficients, and Pearson correlations were calculated to characterize the composite measures

and examine their bivariate relationships. The correlation analysis was also used to identify substantial overlap among constructs before estimating the multivariable models.

Second, three separate standardized regression models examined whether participation-related involvement (AI) was associated with capability-related and civic-relational outcomes. The capability-related dimension (SII) was regressed on AI, while the two civic-relational dimensions (CI and SC) were analysed as separate dependent variables. These models provided the empirical tests of H1 and H2.

Third, hierarchical multiple regression was used to examine smart-city appropriation (PCT). Model 1 included participation-related involvement (AI) and the capability-related dimension (SII) as predictors, providing the test of H3. Model 2 added the two civic-relational dimensions (CI and SC). The incremental contribution of the civic-relational block was evaluated through the change in explained variance (ΔR^2) and the corresponding *F*-change test, providing the direct test of H4.

Given the analytical sample of 61 respondents, model specifications were kept parsimonious. Standardized regression coefficients (β), 95% confidence intervals, R^2, adjusted R^2, and ΔR^2 were reported. Heteroscedasticity-consistent confidence intervals were used for the hierarchical regression estimates, and variance inflation factors (VIFs) were examined to assess multicollinearity. Because substantial collinearity was detected in the extended model, interpretation emphasized changes in overall model explanatory power rather than comparisons among individual coefficients (O'Brien, 2007).

All statistical tests were two-sided, with $p < .05$ used as the conventional significance threshold. Analyses were conducted in R. Given the cross-sectional design, all regression coefficients were interpreted as statistical associations rather than causal effects.

3. Results

3.1. Descriptive statistics and measurement consistency

The analytical sample comprised 61 respondents. Composite scores were calculated as the mean of the items associated with each analytical dimension. Overall responses were moderately positive across the five-point scales. The participation-related score averaged 3.38 (SD = 0.75), while the capability-related dimension averaged 3.50 (SD = 0.81). The two civic-relational dimensions recorded means of 3.52 (SD = 0.85) and 3.61 (SD = 0.88), respectively. Smart-city appropriation-related perceptions averaged 3.57 (SD = 0.79).

Internal consistency was satisfactory across the item blocks retained in the analysis. Cronbach's alpha ranged from .835 for the participation-related dimension to .927 for smart-city appropriation-related perceptions. These coefficients indicate satisfactory internal consistency of the composite measures. Given the high correlations subsequently observed among several dimensions, their empirical distinctiveness is interpreted cautiously.

The bivariate associations with smart-city appropriation were consistently positive. Participation was strongly correlated with appropriation-related perceptions ($r = .894$, $p < .001$), as was the capability-related dimension ($r = .910$, $p < .001$). The two civic-relational dimensions were similarly associated with appropriation, with $r = .926$ and $r = .885$, respectively ($p < .001$ in both cases). The magnitude of these correlations also indicates substantial overlap among the

constructs, requiring caution when interpreting their unique effects in multivariable models (Table 1).

Table 1. Descriptive statistics, reliability, and associations with smart-city appropriation

Analytical dimension	Item block	Items	Mean	SD	Cronbach's α	*r* with appropriation
Participation-related involvement	AI	7	3.38	0.75	.835	.894***
Capability-related dimension	SII	5	3.50	0.81	.875	.910***
Civic-relational dimension 1	CI	6	3.52	0.85	.906	.926***
Civic-relational dimension 2	SC	3	3.61	0.88	.924	.885***
Smart-city appropriation	PCT	9	3.57	0.79	.927	—

Note: Scores range from 1 to 5. All reported correlations are significant at $p < .001$.

3.2.Participation, capability development, and civic-relational outcomes

Participation-related involvement was strongly associated with the capability-related dimension. In a standardized regression, participation explained approximately 85.5% of the variance in the capability-related score ($R^2 = .855$), with a standardized coefficient of $\beta = .925$, 95% CI [.840, 1.010], $p < .001$.

Participation was also strongly associated with both civic-relational dimensions. The association was particularly pronounced for the first civic-relational dimension ($\beta = .973$, $R^2 = .947$, $p < .001$), while the second dimension was also strongly related to participation ($\beta = .880$, $R^2 = .774$, $p < .001$).

Together, these results support H1 and H2, indicating that participation-related involvement is strongly and positively associated with both capability-related and civic-relational outcomes within the studied living-lab context.

3.3.Capability, civic-relational dimensions, and smart-city appropriation

A hierarchical regression was used to examine whether civic-relational dimensions provide additional explanatory value beyond participation and capability-related perceptions.

In the baseline model, participation-related involvement and the capability-related dimension jointly explained 84.7% of the variance in smart-city appropriation ($R^2 = .847$; adjusted $R^2 = .842$). Both predictors contributed significantly. The standardized association was $\beta = .361$ for participation, 95% CI [.105, .618], $p = .007$, and $\beta = .576$ for the capability-related dimension, 95% CI [.302, .849], $p < .001$.

The two civic-relational dimensions were subsequently added to the model. The extended specification explained 88.3% of the variance in smart-city appropriation (adjusted $R^2 = .875$). The civic-relational block therefore contributed an additional 3.6 percentage points of explained variance ($\Delta R^2 = .036$). This improvement was statistically significant, $\Delta F(2, 56) = 8.68$, $p < .001$.

Within the extended model, the first civic-relational dimension retained a significant positive association with appropriation ($\beta = .708$, 95% CI [.187, 1.229], $p = .009$). The second civic-relational dimension did not show a statistically significant unique association ($\beta = .136$, 95%

CI [−.123, .394], p = .299). Participation and capability-related scores also ceased to show statistically significant unique coefficients after the civic-relational variables were introduced.

This change in individual coefficients should not be interpreted as evidence that participation or capability development become irrelevant. The predictors are strongly intercorrelated, and multicollinearity is substantial in the extended model. Variance inflation factors reached approximately 20.8 for the participation score and 27.5 for the first civic-relational dimension. Individual coefficients in the full model should therefore be interpreted cautiously.

The more robust result is the block-level finding: adding civic-relational dimensions significantly improves the explanation of smart-city appropriation beyond participation and capability-related perceptions. This provides evidence consistent with the central proposition of H4, although the data do not support attributing that incremental contribution equally to both civic-relational dimensions (Table 2).

Table 2. Hierarchical regression predicting smart-city appropriation

Predictor / model	Standardized β	95% CI	*p*
Model 1			
Participation-related involvement	.361	[.105, .618]	.007
Capability-related dimension	.576	[.302, .849]	<.001
R^2 / Adjusted R^2	**.847 / .842**		
Model 2			
Participation-related involvement	−.257	[−.624, .109]	.165
Capability-related dimension	.371	[−.101, .842]	.121
Civic-relational dimension 1	.708	[.187, 1.229]	.009
Civic-relational dimension 2	.136	[−.123, .394]	.299
R^2 / Adjusted R^2	**.883 / .875**		
ΔR^2	**.036**	ΔF = 8.68	<.001

Note: Standardized coefficients are reported with heteroscedasticity-consistent 95% confidence intervals. Because of substantial multicollinearity in Model 2, emphasis should be placed on the incremental explanatory contribution of the civic-relational block rather than on comparisons among individual coefficients.

4. Discussion

4.1. From participation and capabilities to smart-city appropriation

The findings provide a differentiated account of how living-lab engagement relates to smart-city appropriation. Participation-related involvement and capability development were both strongly associated with appropriation-related perceptions, jointly explaining 84.7% of their variance in the baseline model. This result reinforces the view that living labs can operate as environments in which engagement with innovation is accompanied by learning and greater familiarity with emerging urban technologies. Similar research has emphasized the capacity of living labs to combine experimentation, citizen involvement, and capability development rather than functioning solely as technology-testing environments (Gascó, 2017; Park et al., 2025).

The main contribution of the study, however, lies in showing that technological capability and participation do not fully account for smart-city appropriation. Adding the civic-relational dimensions increased explained variance by 3.6 percentage points (ΔR^2 = .036, $p < .001$). Although modest relative to the already high explanatory power of the baseline model, this incremental contribution is theoretically meaningful because it indicates that citizens' orientation toward smart-city development is connected not only to their involvement and technological capabilities but also to relational and collective dimensions.

This finding supports a broader conception of appropriation. Smart-city appropriation does not simply refer to citizens' willingness or ability to use technological services; it also concerns how urban innovation is interpreted and integrated within collective representations of the city. Desdemoustier et al. (2019) similarly show that smart-city appropriation varies across actors and cannot be reduced to a homogeneous process of technological adoption. The present findings extend this perspective by suggesting that civic-relational factors provide additional explanatory information even after participation and capability-related dimensions are considered.

This distinction also contributes to debates surrounding citizen empowerment in living labs. Participation can create opportunities for learning and interaction, but empowerment requires more than exposure to innovation. It involves conditions under which citizens can develop the capacity to interpret information, deliberate with other actors, articulate priorities, and potentially influence decisions. Research on living labs has similarly emphasized that capability building and participation can support empowerment, while meaningful influence ultimately depends on the organization of participatory processes and underlying power relationships (Nguyen et al., 2022; Ruijer et al., 2024; Kowaltowski et al., 2024).

The results should nevertheless not be interpreted as showing that one civic-relational dimension is intrinsically more important than participation or technological capability. The predictors are highly intercorrelated, and substantial multicollinearity was detected in the extended model. The reduction in the individual statistical significance of participation and capability after introducing the civic-relational block is therefore more plausibly interpreted as evidence of considerable shared variance among these dimensions than as evidence that technological capability becomes unimportant. Living-lab participation, capability development, and civic-relational engagement may represent closely interconnected aspects of the same broader participatory experience.

This interpretation has practical implications for living-lab design. Evaluation should not rely exclusively on participation counts, technological uptake, or short-term learning outcomes. Living labs may generate greater value when technological experimentation is combined with opportunities for interaction, collective interpretation of urban challenges, and meaningful stakeholder involvement. For public authorities, universities, and innovation actors, this implies designing participation processes that connect technological learning with deliberation and opportunities for citizens to articulate needs and urban priorities. Such an orientation is consistent with evidence that living labs can contribute to more inclusive forms of public innovation when users participate as contributors rather than merely as recipients of predetermined solutions (Gascó, 2017; Veeckman & Temmerman, 2021).

In this sense, the study moves beyond a technology-acceptance interpretation of living labs. Its results suggest that smart-city appropriation is better understood as the outcome of interconnected technological and civic-relational processes. The contribution of living labs may consequently lie not only in making technologies easier to understand or use, but also in embedding technological experimentation within social processes through which participants interpret the meaning and relevance of urban transformation.

4.2.Limitations and future research

The findings should be interpreted in light of several limitations. First, the study relies on cross-sectional and self-reported data, preventing causal conclusions about whether participation

generates capability development or more favorable appropriation-related perceptions. Reverse relationships are equally plausible, since individuals already interested in smart-city development may be more likely to engage with living-lab activities.

Second, predictors and outcomes were measured within the same questionnaire. Common-method variance may therefore contribute to the particularly strong correlations observed among participation, capability, civic-relational dimensions, and appropriation (Podsakoff et al., 2003). Future studies should combine survey measures with behavioral indicators, observations, longitudinal measurements, or data collected at different points in time.

Third, the high correlations among the explanatory constructs produced substantial multicollinearity in the extended regression model. The block-level increase in explained variance is consequently more reliable for interpretation than comparisons among individual regression coefficients. Future research should refine the measurement structure and examine discriminant validity more explicitly before attempting to isolate the unique contribution of closely related participatory and civic constructs.

Fourth, the non-probability, purposively diversified sample provides heterogeneous stakeholder perspectives but does not support statistical generalization to the population of Rabat or Morocco. The findings should therefore be understood as analytical evidence from the studied urban innovation context rather than population estimates. Larger multi-site studies could examine whether the relationships identified here persist across living labs with different governance arrangements and participant populations.

Finally, the study examines appropriation-related perceptions rather than actual redistribution of decision-making power. Capability development and favorable smart-city perceptions should therefore not be equated with empowerment. Future longitudinal research could investigate whether participation and capabilities subsequently translate into greater involvement in agenda setting, co-design, resource allocation, or other forms of institutional influence. This distinction is particularly important because living labs may create conditions favorable to empowerment without necessarily altering existing power relations (Nguyen et al., 2022).

Conclusion

This study examined how participation-related involvement, capability development, and civic-relational dimensions are associated with smart-city appropriation in the Moroccan context. Rather than treating participation, technological capability, and empowerment as equivalent, the study distinguishes the technological and civic-relational dimensions through which stakeholders relate to smart-city transformation.

The findings show that participation-related involvement and capability development are strongly associated with smart-city appropriation. More importantly, the addition of civic-relational dimensions provides significant explanatory value beyond participation and technological capability alone. This result suggests that smart-city appropriation cannot be reduced to technological familiarity or participation intensity. It is also connected to the relational and collective dimensions through which urban innovation acquires meaning for stakeholders.

The main contribution of the study therefore lies in moving beyond a technology-acceptance perspective toward a broader understanding of appropriation. Living labs may create value not only by exposing participants to technologies or strengthening their capabilities, but also by providing spaces in which technological experimentation can interact with collective interpretation, stakeholder engagement, and civic relationships. For urban authorities, universities, and innovation actors, this implies that living-lab performance should not be assessed solely through participation levels or technological outcomes, but also through the quality of the interactions and relational conditions surrounding experimentation.

These findings should nevertheless be interpreted cautiously. The cross-sectional and self-reported design does not establish causal relationships, the non-probability sample limits statistical generalization, and the strong correlations among the explanatory dimensions indicate substantial shared variance. The evidence therefore supports associations between participation, capabilities, civic-relational dimensions, and appropriation, rather than demonstrating citizen empowerment or a redistribution of decision-making authority.

Future research should use longitudinal and comparative designs, stronger construct validation, and behavioral measures to examine whether the relationships identified here persist across different living-lab settings. A particularly important next step is to determine whether participation and smart-city appropriation eventually translate into effective influence over problem definition, co-design, and urban decision-making. This would allow future research to distinguish more clearly between participating in innovation, appropriating urban transformation, and actually shaping it.

Declarations

Funding

This research received no external funding.

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Supplementary Files

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- SupplementaryFile1SurveyQuestionnaire.docx
- SupplementaryFile2AnonymizedAnalyticalDataset.xlsx