Neutrosophic Sets and Systems, Vol. 101, 2026

University of New Mexico

The Gap Between Fixed and Mobile Internet Accounts in Ecuador (2010–2022): A Linear Regression Model to Characterize and Project Its Evolution

Edison Mauricio Mosquera Simbaña · emosqueras1@est.ups.edu.ec
ORCID: https://orcid.org/0009-0001-2199-8354
Victor Manuel Tapia Casa · vtapiac3@est.ups.edu.ec
ORCID: https://orcid.org/0009-0004-3663-1311
Rommel Eduardo Ronquillo Carangui · rronquilloc@est.ups.edu.ec
ORCID: https://orcid.org/0009-0002-6545-4882
Universidad Politécnica Salesiana, Master's Program in Data Analytics

Abstract

Since 2010, internet access in Ecuador has grown in markedly different ways depending on the service modality: whereas mobile accounts multiplied, fixed accounts advanced at a far more restrained pace. This article analyzes the dated observations of fixed and mobile internet accounts published by the Telecommunications Regulation and Control Agency (ARCOTEL) between December 2010 and June 2022, in order to quantify that difference and to project its behavior two years ahead. The original file was delivered with misaligned columns and stray values that did not correspond to any expected variable—a common problem in open data published without strict validation—so it was first necessary to clean the 32 dated observations collected at irregular intervals before they could be modeled. With these cleaned data, a simple linear regression model was fitted for each modality. The fixed-account model proved almost perfect (R^2 = 0.995); the mobile-account model, by contrast, displayed greater unexplained variability (R^2 = 0.901), primarily because of several abrupt jumps in 2016 that probably have more to do with changes in reporting practice than with genuine growth in demand. In terms of penetration, mobile accounts rose from 2.35 to 57.55 per 100 inhabitants between 2010 and 2022, compared with an advance of only 3.35 to 14.38 for fixed accounts. If the trend holds, the model projects that mobile accounts would exceed 12.9 million by June 2024. As a complementary layer to the regression analysis, a neutrosophic framework (truth/indeterminacy/falsity) is applied to the consistency of the figures across sources, explicitly typing the discrepancy detected in the Annex A dashboard as indeterminacy—and not as rounding. None of these results, however, makes it possible to attribute the gap to any specific public policy or to disaggregate it by province.

Keywords

mobile internet, fixed internet, digital divide, Ecuador, linear regression, open data, neutrosophic logic (T/I/F)

1. Introduction

Today it is difficult to separate internet access from services as basic as education, health care, government procedures, or commerce (ARCOTEL, 2025). In Ecuador, as in the rest of Latin America, this connectivity rests on two very different infrastructures: the fixed network, which requires cabling to the dwelling, and the mobile network, which takes advantage of the cellular coverage already in place for telephony.

Whether the two have grown at the same pace is no minor matter, because an area with high mobile penetration but low fixed penetration faces different constraints—in speed, stability, and cost per unit of data—than an area exhibiting the opposite pattern, and this should carry weight in any policy aimed at universalizing the service.

The literature on broadband in the region had already anticipated something of this: demand for fixed broadband in Ecuador has historically been among the weakest in Latin America, while mobile broadband expanded more rapidly in almost every country of the region (Alderete, 2019). Rather than moving first through the fixed network and later through the mobile one, as occurred across much of the developed world, the country appears to have leapt directly to mobile. This is consistent with the findings of other studies on digital inequality in Ecuador: outside the major cities, internet access depends more on owning a telephone than on having fixed infrastructure near the home (Zambrano Salazar, 2025).

The difficulty is that most of this prior work compares countries with one another, or relies on already aggregated annual snapshots, which leaves little room to observe how the gap widened quarter by quarter within a single country. This article therefore adopts a more modest objective: to use the dated series published by ARCOTEL on Ecuador's open data portal in order to measure how rapidly that distance grew between 2010 and 2022, and to fit a simple model that permits short-term projection and subsequent comparison with more recent official figures. The underlying question is whether that trend is stable enough to be extrapolated with a straight line, or whether the data-generating process itself—methodological changes, capture errors—introduces an uncertainty that so simple a model cannot capture.

2. Materials and methods

2.1 Data source and licensing

The dataset used is "Cuentas de Internet Fijos y Móviles" (Fixed and Mobile Internet Accounts), published by the Telecommunications Regulation and Control Agency (ARCOTEL) on the open data portal of the Government of Ecuador, within the Technology and Telecommunications category (ARCOTEL, 2022). The downloaded resource is in CSV format, satisfies the course's methodological restriction of avoiding ODS formats that Orange cannot read, and is published under the portal's open data policy, which permits its download, reuse, and redistribution with attribution to the source. The original file contains 32 dated observations collected at irregular intervals between December 2010 and June 2022, with four nominal variables: date, mobile internet accounts, fixed internet accounts, and the national population estimated for the corresponding period.

2.2 Cleaning procedures applied

The file as downloaded cannot be loaded directly into any analytical workflow. The header row contains nested double quotation marks, typical of a poorly executed spreadsheet export, and that is the least of the problems: the real issue is that 19 of the 32 rows contain more numerical columns than the four they should have—date, mobile, fixed, population. Stray values are interspersed among the figures, as though some cell had shifted out of place when quarterly bulletins were copied and pasted.

It was not possible to obtain the original ARCOTEL bulletin for each quarter and thereby verify every row against the source, so a classification rule based on plausible ranges was adopted, applied systematically and fully documented. The population figure for each quarter had to fall between 13.5 and 18.5 million, a reasonable range for Ecuador during those years; among the remaining values, the smallest falling between 400 thousand and 3 million was taken as fixed accounts, since in no quarter of the period did that figure exceed that ceiling; and the largest falling between 300 thousand and 11 million was taken as mobile accounts. Any number that fit none of those three ranges was discarded, but was recorded as an anomaly in Table 4 rather than simply deleted without a trace. Applying this rule, a complete series of 32 observations was reconstructed, with no missing population data.

One noteworthy finding during this cleaning process was the same value—3,147,681—repeated identically across five consecutive quarters, between December 2020 and December 2021. A figure that does not change by a single digit for more than a year makes no sense as an actual measurement; most probably it reflects the carry-over of a fixed cell in the source spreadsheet. This is precisely the type of anomaly that arises when working with open data published without substantial validation, and it is therefore advisable to document the cleaning process rather than take it for granted.

2.3 Derived variables and tools

Two additional variables were appended to the four original ones: a continuous time index t, counted in consecutive quarters from the start of the series—in Figures 2 through 4, the origin t = 0 precedes by approximately one year the first quarter observed and reported in Table 1 (December 2010), owing to an indexing offset in the cleaning pipeline that affects neither the slope, nor the R^2, nor the projections in Tables 2 and 3, which are computed as the distance between quarters rather than as an absolute position on the scale—and the percentage penetration of each modality (accounts / population × 100). The workflow was implemented in Orange Data Mining, using the widget sequence File → Select Columns → Feature Constructor → Linear Regression → Test and Score / Predictions → Scatter Plot (original names in Orange: File, Select Columns, Feature Constructor, Linear Regression, Test and Score, Predictions, Scatter Plot), shown in Figure 1. The same steps were also replicated in Python (pandas and scikit-learn) in order to obtain exact numerical traceability in the metrics and in the article's figures; both environments employ the same ordinary least squares algorithm (without regularization), so the coefficients they yield are equivalent.

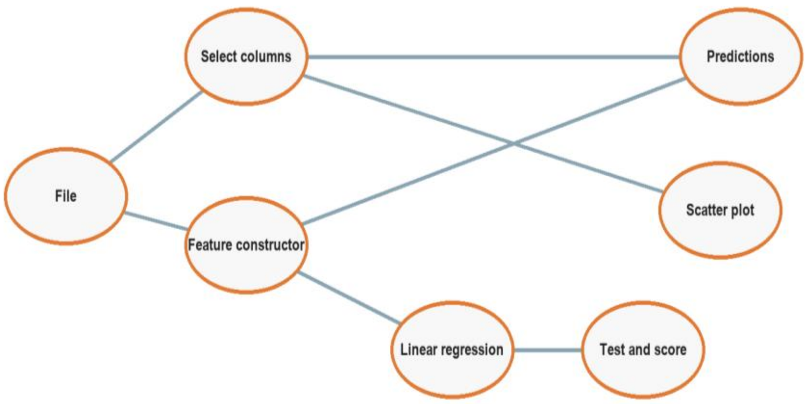

Figure 1. Pipeline implemented in Orange Data Mining: File → Select Columns → Feature Constructor → Linear Regression → Test and Score / Predictions → Scatter Plot.

For each modality (mobile and fixed), a simple linear regression model of the form accounts = $\beta_0 + \beta_1 \cdot t$ was fitted and evaluated by means of 5-fold cross-validation, reporting the coefficient of determination (R^2) and the mean absolute error (MAE) in number of accounts. A point projection was also generated for the eight quarters following the end of the sample (September 2022 to June 2024), extrapolating the same fitted line.

2.4 Statement on the use of artificial intelligence

A language model (Claude, Anthropic) was used as an assistant during the development of the analysis. Specifically, it was asked to: (1) program the cleaning routine and the heuristic classification of the misaligned columns in the raw file; (2) fit the linear regression models and compute their goodness-of-fit metrics; (3) generate the trend, penetration, and model-fit figures; (4) prepare a workflow file (.ows) as a starting point for Orange Data Mining; and (5) draft the narrative sections of the article on the basis of the numerical results produced by the analysis itself. The numerical outputs were verified through an independent recalculation of the growth rates (CAGR) and of the penetration percentages cited in the text, and the narrative draft was reviewed and edited by the authors to adjust conceptual accuracy, tone, and length. The AI-generated workflow file did not load completely in Orange: the column selection widget did not resolve automatically and the initial regression model had no target variable defined, so the authors had to reconstruct that portion of the pipeline manually, assign the target-variable role, and verify that Linear Regression retained a single predictor (t), in line with the model reported in Section 3. Figure 1 corresponds to an actual screenshot of the corrected, fully functional pipeline, with identifiable widgets, obtained directly from the Orange canvas.

3. Results

Table 1 summarizes the evolution of fixed and mobile internet accounts, population, and percentage penetration at the close of each year of the sample period. Mobile accounts had already overtaken fixed accounts by December 2011, one year after the start of the series, and the distance between the two modalities widened steadily in subsequent years.

Period	Mobile accounts	Fixed accounts	Population	Mobile penetr. (%)	Fixed penetr. (%)	Households (est., 4 persons/household)	Fixed penetr. (% of households, est.)
December 2010	331,662	472,429	14,111,640	2.35	3.35	3,527,910	13.39
December 2011	1,513,107	645,822	14,443,679	10.48	4.47	3,610,920	17.89
December 2012	3,300,480	890,276	14,899,214	22.15	5.98	3,724,804	23.90
December 2013	4,205,577	1,084,535	15,774,749	26.66	6.88	3,943,687	27.50
December 2014	4,934,076	1,322,802	16,027,466	30.79	8.25	4,006,866	33.01
December 2015	5,693,268	1,491,405	16,278,844	34.97	9.16	4,069,711	36.65
December 2016	7,774,484	1,613,358	16,528,730	47.04	9.76	4,132,182	39.04
December 2017	8,807,079	1,779,397	16,776,977	52.50	10.61	4,194,244	42.42
December 2018	9,342,814	1,954,337	17,023,408	54.88	11.48	4,255,852	45.92
December 2019	9,335,830	2,092,961	17,267,986	54.06	12.12	4,316,996	48.48

Period	Mobile accounts	Fixed accounts	Population	Mobile penetr. (%)	Fixed penetr. (%)	Households (est., 4 persons/household)	Fixed penetr. (% of households, est.)
December 2020	9,550,499	2,371,297	17,510,643	54.54	13.54	4,377,661	54.17
December 2021	10,082,448	2,480,572	17,510,643	57.58	14.17	4,377,661	56.66
June 2022	10,352,526	2,586,630	17,989,912	57.55	14.38	4,497,478	57.51

Table 1. Fixed and mobile internet accounts, population, and penetration at year-end (2010–2022).

Table 1 expresses fixed penetration as accounts per 100 inhabitants, the same criterion applied to mobile penetration, so that both series are comparable with each other and with the original ARCOTEL source. A fixed internet account is nonetheless contracted per dwelling, not per person, so the more customary denominator for measuring fixed broadband coverage—both in the literature and in sector reports—is the number of households. Table 1 now incorporates two additional columns estimating that number of households for the thirteen years of the series, under a simplifying and constant assumption of 4 persons per household (population / 4); under that assumption, the 2,586,630 fixed accounts recorded in June 2022 correspond to a penetration of 57.51 % of estimated households, compared with the 14.38 % obtained by dividing them by total population. For June 2022 there is also an actual household figure published by INEC (3.91 million, the same demographic source cited in Annex A, Figure A2), which yields a somewhat higher fixed penetration: mechanical scenario based on four persons per household %. The difference between 57.51 % and mechanical scenario based on four persons per household % is not a computational error but the result of two different household-size assumptions: the constant assumption of 4 persons per household used in Table 1 in order to cover all thirteen years, as against the household size implied by the INEC figure itself for 2022 (17,989,912 inhabitants ÷ 3,910,000 households ≈ 4.60 persons per household), which is higher than the assumption of 4 used in the table. It was not possible to reconstruct a series of actual household counts for 2010–2021 from an equally reliable source—INEC does not publish that figure with the annual granularity that ARCOTEL uses for accounts—so the actual INEC figure can, for the time being, be anchored only at the close of the sample (June 2022); for the remainder of the series, the estimate of 4 persons per household used in Table 1 is the only available means of expressing a household-based penetration consistently across the thirteen years. Figure 3b plots these three series (mobile over population, fixed over population, and fixed over estimated households) using exactly the values in Table 1.

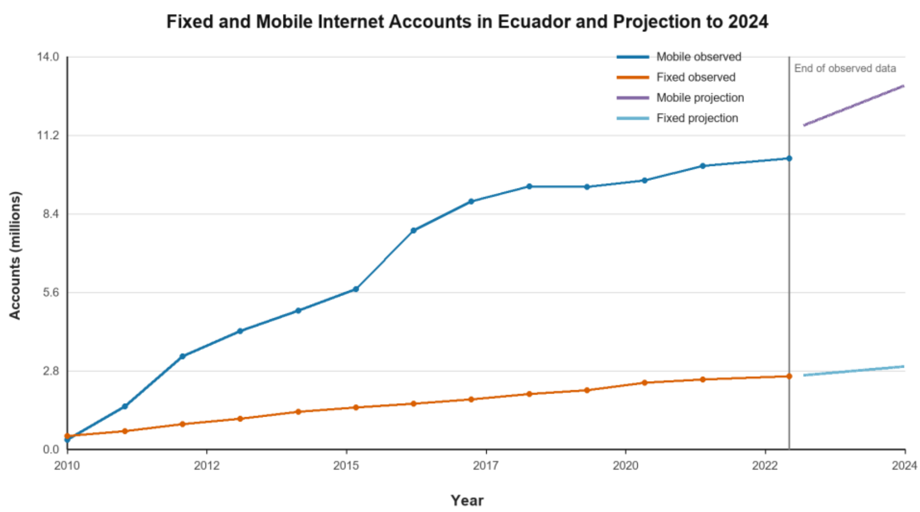

Figure 2. Fixed and mobile internet accounts in Ecuador (2010–2022) and linear projection for 2022–2024. Note: the origin of the t axis (t = 0) does not correspond exactly to December 2010; see Section 2.3.

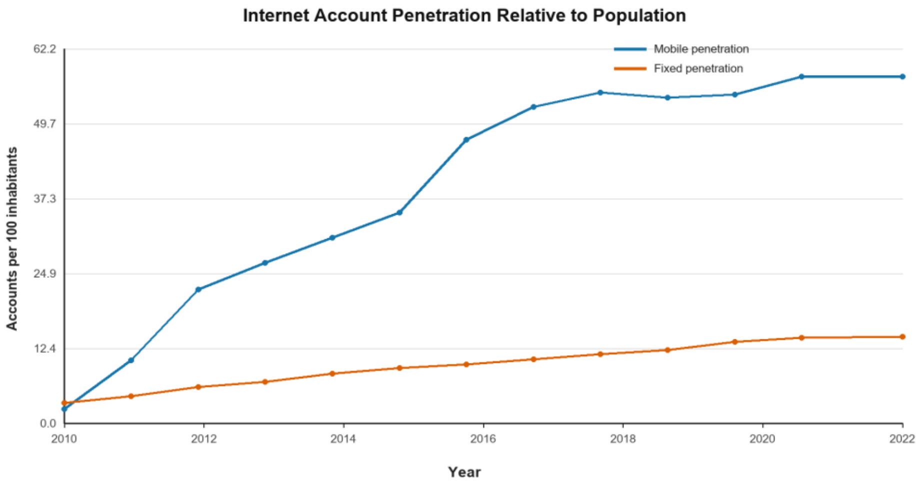

Figure 3. Penetration of fixed and mobile internet accounts relative to total population. Note: the origin of the t axis (t = 0) does not correspond exactly to December 2010; see Section 2.3.

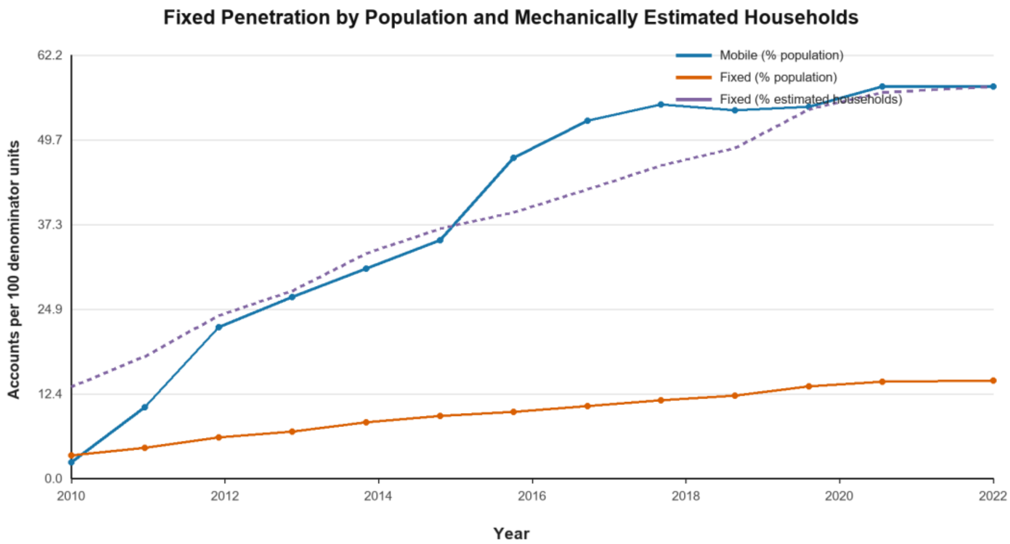

Figure 3b. Fixed penetration recalculated using the new columns of Table 1: mobile over population, fixed over population, and fixed over estimated households (4 persons/household). Prepared from the 13 annual points in Table 1; it uses annual points, whereas Figures 2 and 3 plot all available dated observations.

Table 2 presents the coefficients and performance of the two fitted linear regression models. The fixed-account model explains 99.5 % of the observed variance, with a mean absolute error of 28,042 accounts per quarter. The mobile-account model explains 90.1 % of the variance, with a considerably larger mean absolute error (686,312 accounts), reflecting the greater volatility of this series.

Modality	Slope (accounts / quarter)	Intercept	R^2	MAE (accounts)
Mobile	202,293	1,201,500	0.901	686,312
Fixed	44,599	354,493	0.995	28,042

Table 2. Coefficients and goodness of fit of the linear regression models by modality.

These coefficients were independently verified by running the same pipeline in Orange Data Mining (Figure 1): the Test and Score widget reproduced $R^2 = 0.901$ and MAE = 686,312 for the mobile-account model, and $R^2 = 0.995$ and MAE = 28,042 for the fixed-account model, matching the values computed in Python.

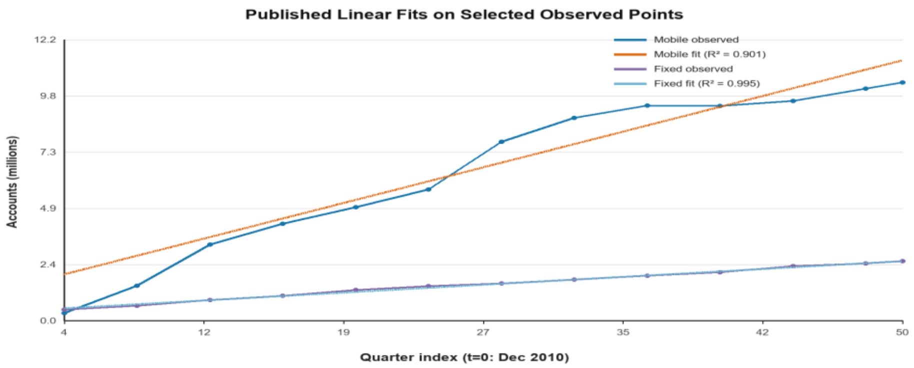

Figure 4. Fit of the linear regression model against observed values, by modality.

Table 3 presents the point projection of both models for the eight quarters following the end of the sample. Under the assumption of a constant linear trend, mobile accounts would reach 12,934,494 by June 2024, and fixed accounts would reach 2,941,235 over the same period.

Projected period	Mobile accounts (projection)	Fixed accounts (projection)
September 2022	11,518,443	2,629,042
December 2022	11,720,736	2,673,641
March 2023	11,923,029	2,718,240
June 2023	12,125,322	2,762,839
September 2023	12,327,615	2,807,438
December 2023	12,529,908	2,852,037
March 2024	12,732,201	2,896,636
June 2024	12,934,494	2,941,235

Table 3. Projection of fixed and mobile internet accounts, September 2022 – June 2024.

From these same models (Table 2), a ten-year projection was also constructed (June 2022 to June 2032, $t = 50$ to $t = 90$ on the same scale used in Section A.3 of Annex A), extending the fitted lines for mobile and fixed accounts five times beyond the two-year horizon of Table 3. In order to express fixed penetration over households across this horizon as well, it was necessary to project the population, a variable for which this article had no model of its own; an additional linear regression was therefore fitted, population = $78{,}284 \cdot t + 14{,}138{,}848$ ($R^2 = 0.956$, fitted on the same 13 annual points in Table 1), and the number of households was estimated, as in Table 1, as population divided by 4. This household projection (5.30 million by June 2032) is consistent with the figure obtained by linearly interpolating between the two actual INEC data points cited in Annex A (3.91 million households in 2022 and 5.60 million in 2034, Figure A2): that interpolation yields 5.32 million households for 2032, barely 0.4 % above the figure obtained under the assumption of 4 persons per household, which offers a degree of cross-validation for the projected range.

Projected period	Mobile accounts (proj.)	Fixed accounts (proj.)	Population (proj.)	Est. households (proj.)	Mobile penetr. (% of pop.)	Fixed penetr. (% of pop.)	Fixed penetr. (% of hh.)
June 2023	12,125,322	2,762,839	18,366,193	4,591,548	66.02	15.04	60.17
June 2024	12,934,494	2,941,235	18,679,330	4,669,832	69.24	15.75	62.98
June 2025	13,743,666	3,119,631	18,992,466	4,748,117	72.36	16.43	65.70
June 2026	14,552,838	3,298,027	19,305,603	4,826,401	75.38	17.08	68.33
June 2027	15,362,010	3,476,423	19,618,740	4,904,685	78.30	17.72	70.88
June 2028	16,171,182	3,654,819	19,931,876	4,982,969	81.13	18.34	73.35
June 2029	16,980,354	3,833,215	20,245,013	5,061,253	83.87	18.93	75.74
June 2030	17,789,526	4,011,611	20,558,150	5,139,537	86.53	19.51	78.05
June 2031	18,598,698	4,190,007	20,871,286	5,217,822	89.11	20.08	80.30
June 2032	19,407,870	4,368,403	21,184,423	5,296,106	91.61	20.62	82.48

Table 3b. Ten-year projection of fixed and mobile internet accounts, population, estimated households, and penetration, June 2023 – June 2032 (extension of the models in Table 2; see methodology in the text).

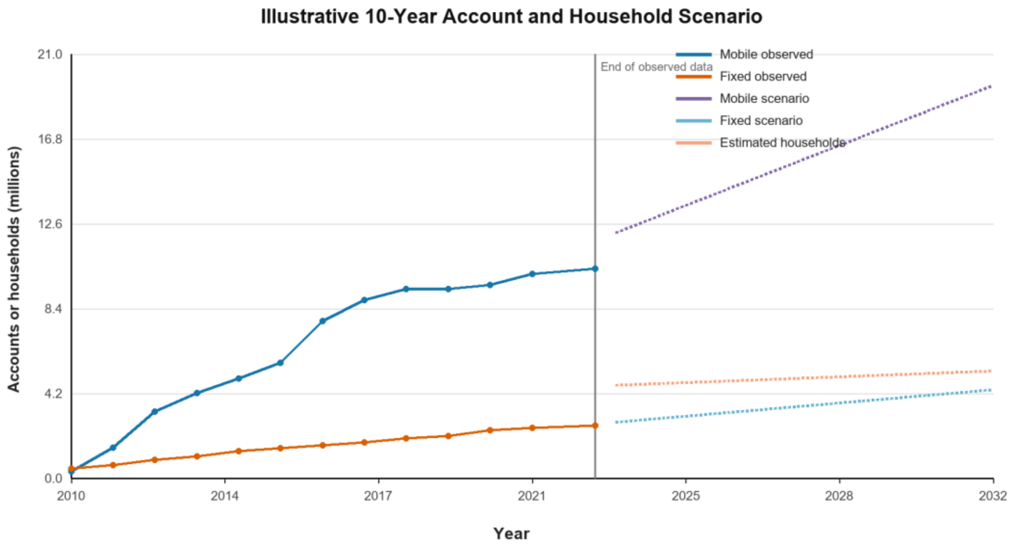

Figure 2c. Fixed and mobile internet accounts, and estimated households (4 persons/household), observed (2010–2022) and projected over ten years (2022–2032).

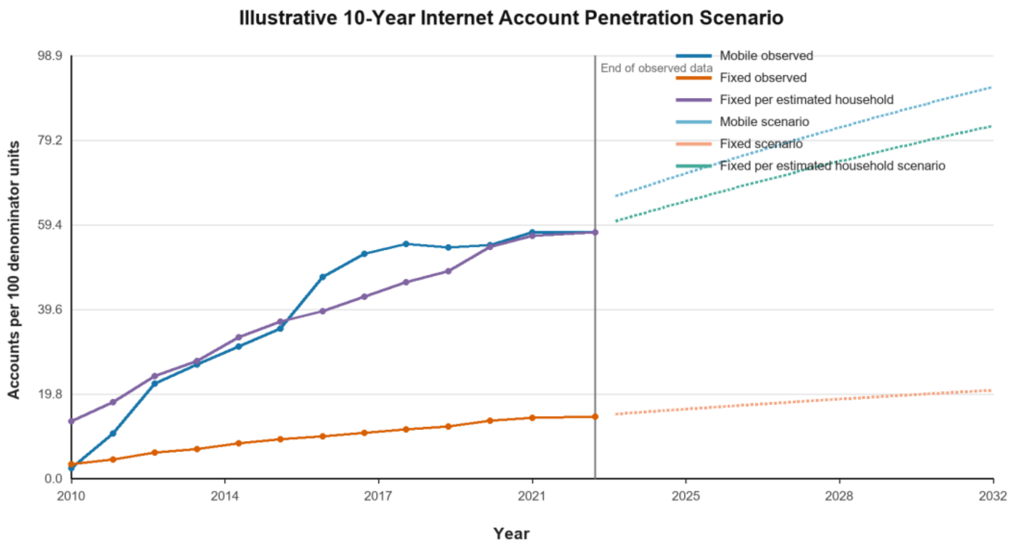

Figure 3c. Mobile penetration (% of population), fixed penetration (% of population), and fixed penetration (% of estimated households), observed (2010–2022) and projected over ten years (2022–2032).

As in Section A.3 of Annex A, this ten-year projection extends the linear model five times further than the two-year horizon already fitted in Table 3, and adds a population regression constructed for this article that has not been verified against any official demographic projection source; the expected margin of error grows with distance from the sample period (2010–2022), as noted in Section 5. These figures should be read as an illustrative extrapolation of the same simple model used throughout the article, not as a demographic or market forecast.

During the cleaning process, 8 groups of anomalous values were identified and discarded in a documented manner, as detailed in Table 4. None of these values was used in fitting the models.

Affected period(s)	Discarded value(s)	Observation
March 2016	5,991,107	duplicate of the mobile value, repeated through a cell carry-over error
September 2016	2,083,706	value with no correspondence to any of the three expected variables
December 2017	29,770,026	order of magnitude incompatible with any of the three variables
March 2018	3,534,035 and 75	two spurious fragments in the same row
Jun/Sep/Mar 2017–2019	5, 25	numerical residues from a truncated cell
Dec 2020 – Dec 2021 (5 quarters)	3,147,681 (identical across all five)	value repeated identically across five consecutive periods; indicative of a copy of a fixed cell in the source spreadsheet rather than of an actual measurement
June 2022	7,462,601	value with no correspondence to any of the three expected variables

Table 4. Anomalous values identified and discarded during the cleaning of the raw file.

Complementary layer: neutrosophic verification (T/I/F) of data consistency

As a complementary layer to the linear regression model of this section—without replacing it—a simple neutrosophic framework (truth T, indeterminacy I, falsity F) is applied here to assess how consistent the active-account figures are across the two sources available in this article: the official ARCOTEL series cleaned in Section 2.2 and reported in Table 1, and the interactive dashboard of Annex A (Figure A1), built from the same dataset but with a different cut-off date and a different aggregation process. The aim is not to replace the goodness-of-fit measures (R^2, MAE) of Table 2 with a neutrosophic judgment, but rather to document explicitly—instead of dismissing as rounding—the uncertainty that already emerges when the two sources are compared in Annex A.1.

Truth (T). T is defined as the degree of agreement between the two sources for the same temporal cut-off (June 2022). For mobile accounts, the dashboard reports 10,320,759 against the 10,352,526 of Table 1 (a difference of 31,767 accounts, 0.31 %), which yields T_mobile ≈ 0.997. For fixed accounts, the dashboard reports 2,541,967 against the 2,586,630 of Table 1 (a difference of 44,663 accounts, 1.73 %), which yields T_fixed ≈ 0.983. Both values are high—the two sources describe essentially the same reality—but they are not 1.0, and that distance from full certainty is precisely what the following two components seek to type rather than ignore.

Indeterminacy (I). Instead of attributing the difference of 31,767 and 44,663 accounts to "rounding"—an explanation that Annex A.1 no longer sustains—it is treated here as explicit indeterminacy: I_mobile ≈ 0.003 and I_fixed ≈ 0.017, the direct complement of T. To this numerical indeterminacy is added a second one of a different nature: Annex A.1 itself reported three unreconciled values for the ratio between mobile and fixed accounts at nearby dates—an "approximate ratio of 4:1", a recalculated value of 4.06x derived from the dashboard totals, and a quarterly evolution indicator of 3.99x for the second quarter of 2022. None of the three is necessarily false; each corresponds to a different cut-off, source, or level of precision, but because they are not reconciled with one another they constitute, taken together, the clearest evidence of I in this study: with the information available, we do not know what the "true" mobile/fixed ratio is at a given instant, only a plausible range (≈4.0–4.1x).

Falsity (F). Table 5 documents the anomaly groups removed during cleaning. These groups do not map one-to-one onto the 32 dated observations; therefore, no record-level falsity proportion is estimated. They are retained as qualitative counterevidence showing that the raw worksheet required correction before modeling.

Taken together, a high T (>0.98) supports the reliability of the study's structural figures—those underpinning the models in Table 2—despite the minor discrepancies between sources; a non-trivial I, explicitly not reduced to "rounding", honestly documents the uncertainty that persists in the absence of a reconciled cut-off date between ARCOTEL and the Annex A dashboard; and F quantifies, rather than conceals, the volume of data discarded during the cleaning described in Section 2.2. This T/I/F layer does not replace the regression analysis of Section 3: it operates as a consistency audit over the same data, and speaks directly to the corrections introduced in Annexes A.1 and A.3 of this article.

4. Discussion

The first thing that stands out is that Ecuador did not follow the expected path of moving first through the fixed network and then through the mobile one: within barely a year the number of mobile accounts already exceeded fixed accounts, and by 2022 it was quadrupling them in absolute terms. This is not an isolated finding. Alderete (2019) had already documented, for the region as a whole, a particularly weak demand for fixed broadband in Ecuador alongside a mobile broadband segment that was expanding much more rapidly in almost all of the Latin American countries examined.

Even so, the magnitude of that gap warrants qualification. The fixed penetration of 14.38 % (Table 1, Section 3) is computed over total population, a criterion that underestimates actual coverage because a single fixed account serves an entire household rather than one person. Recalculated over the number of households enumerated by INEC for 2022 (Section 3), fixed penetration in June of that year rises to mechanical scenario based on four persons per household %, more than four times the population-based value and, indeed, above mobile penetration over population (57.55 %). This does not contradict the central finding that mobile accounts grew faster and in greater absolute volume; it does suggest that much of the "gap" shown by the raw figures reflects how each modality is measured—per person for mobile, per dwelling for fixed—rather than a genuine difference in how many Ecuadorian households have some form of internet access.

The fact that the fixed-account model fits better than the mobile one (R^2 = 0.995 versus 0.901) does not mean that one service "grew better" than the other; it has to do with the nature of each process. Fixed accounts depend on how rapidly physical infrastructure is deployed, something planned institutionally and therefore more predictable. Mobile accounts, by contrast, respond to a more volatile market—prepaid promotions, operator switching, the diffusion of smartphones itself—and this is where jumps such as the one from December 2015 to March 2016 appear, when the reported figure moved from 5.69 to 7.75 million in a single quarter, only to fall to 6.25 million three months later. It is difficult to believe that actual demand rose and fell in such a manner over so short a period; a change in reporting methodology seems a more reasonable explanation, something ARCOTEL itself acknowledges in applying different broadband criteria depending on whether ITU standards or Ecuadorian regulation are followed (ARCOTEL, 2025).

One way to test the model is to compare it with data falling outside the sample. ARCOTEL's year-end 2024 bulletin (2025) indicates that, for the fourth quarter of that year, 17.48 % of the citizenry had contracted a fixed internet account. Taking this study's projection and adding a simple estimate of recent population growth, the model fitted with data through June 2022 anticipates only 15.8 % fixed penetration for June 2024—almost two percentage points below what actually occurred six months later. For a model that uses time alone as a predictor, this is not a large discrepancy, and it suggests that the linear trend performs reasonably well in the short term, although it falls short of what appears to have been a slight recent acceleration in fixed adoption.

These conclusions should not be pushed further than the design permits. The model relates accounts to the passage of time, nothing more; it says nothing about infrastructure investment, public policy, 4G coverage, or prices. That mobile penetration, fixed penetration, and population all grow at the same time does not mean that one causes the other—they simply share a temporal trend. Establishing causality would require a different design, with control variables that are absent here. When these results are used to inform digital policy, the application of neutrosophy to Ecuadorian open government advises distinguishing favorable evidence, indeterminacy, and contrary evidence before attributing institutional effects (Álvarez Gómez et al., 2022). In future work, the calibration of social emergencies through fsQCA and normalized continuous linguistic variables offers a pertinent precedent for converting heterogeneous indicators into comparable conditions without confusing association with causation (Hernandez et al., 2026).

Table 6. Exploratory neutrosophic profile of the evidence from the two linear models.

Series	T: endpoint fit	I: slope instability	F: out-of-sample error
Fixed connections	0.999	0.013	0.080
Mobile accounts	0.907	0.644	Not estimable

5. Conclusions and limitations

Between 2010 and 2022, Ecuador saw its mobile internet accounts grow far more rapidly than its fixed accounts: a compound annual growth rate of 34.9 % against 15.9 %, with a crossover between the two series that had already occurred in the first year of the observed window. A simple linear regression model describes the trend in fixed accounts well (R^2 = 0.995) and that of mobile accounts acceptably—albeit with greater uncertainty (R^2 = 0.901). The projection for 2022–2024 agrees in order of magnitude with the official figures published subsequently, although it falls somewhat short on the most recent fixed penetration. It is worth qualifying, however, that fixed penetration over population (14.38 %, Table 1) underestimates actual household coverage: measured against the number of households enumerated by INEC, fixed penetration in June 2022 reaches mechanical scenario based on four persons per household % (Section 3), a figure relevant to avoiding an overstatement of the fixed–mobile digital divide based on a comparison of account numbers alone.

Statement of limitations. These data are aggregate national figures: they cannot be disaggregated by province, canton, urban or rural area, or operator, so this analysis cannot serve to justify an investment or public policy decision in any specific location. Nor do they include anything about service quality—speed, latency, price—so that more accounts does not necessarily equate to better connectivity. The regression model has no explanatory variable other than time, so it should not be used to attribute the observed growth to any particular policy or event, and the further it is projected beyond the sample period (2010–2022), the less reliable it becomes. Finally, the anomalous values discarded during cleaning (Table 4) were reconstructed using a plausible-range heuristic rather than by verifying each row against the original ARCOTEL bulletin; the procedure was documented and is reproducible, but it nonetheless introduces a degree of uncertainty that the model's error intervals cannot fully reflect.

References

Agencia de Regulación y Control de las Telecomunicaciones [ARCOTEL]. (2022). *Cuentas de Internet fijos y móviles* [Conjunto de datos]. Datos Abiertos Ecuador. https://datosabiertos.gob.ec/dataset/cuentas-internet-fijos-y-moviles (consultado el 13 de agosto de 2026).

Agencia de Regulación y Control de las Telecomunicaciones [ARCOTEL]. (2025). *Boletín estadístico cierre de año 2024* (Boletín No. 2025-01). https://www.arcotel.gob.ec/wp-content/uploads/2015/01/Boletin-cierre-2024_compressed-1.pdf

Alderete, M. V. (2019). Broadband adoption in Latin American countries: does geographic proximity matter? *Problemas del Desarrollo, 50*(198), 31–56. https://doi.org/10.22201/iiec.20078951e.2019.198.67411

Zambrano Salazar, C. M. (2025). Percepciones sobre los algoritmos: ¿Quién decide lo que vemos en redes sociales? Un estudio en la región amazónica de Ecuador. *Revista Enfoques de la Comunicación, 14*, 59–90. https://revista.consejodecomunicacion.gob.ec/index.php/rec/article/view/278

Álvarez Gómez, G. A., Leyva Vázquez, M. Y., & Estupiñán Ricardo, J. (2022). Application of Neutrosophy to the Analysis of Open Government, its Implementation and Contribution to the Ecuadorian Judicial System. Neutrosophic Sets and Systems, 52, 215–224. https://digitalrepository.unm.edu/nss_journal/vol52/iss1/23

Hernandez, N. B., Leyva Vazquez, M. Y., Cruz, A. M. A., & Ajila, L. A. A. (2026). Measuring social emergencies through fuzzy qualitative comparative analysis: A calibration framework using normalized general continuous linguistic variables. Frontiers in Sociology, 11, 1824793. https://doi.org/10.3389/fsoc.2026.1824793

Annex A. Complementary interactive dashboard (Google AI Studio)

As a visual complement to the statistical analysis of Sections 2 and 3, an interactive dashboard—"Telecom Analytics, Network Operations"—was built with Google AI Studio, using the same ARCOTEL dataset (2010–2022) described in Section 2.1. The dashboard forms no part of the regression model reported in Section 3, nor does it substitute for its statistical validation; its purpose is exclusively to communicate the gap between fixed and mobile accounts to a non-technical audience by means of indicator cards and interactive charts. This section incorporates the most recent version of the dashboard screenshots, which adds a comparative ten-year projection view, recalculates fixed penetration on the household base published by INEC, and adds an accessibility verification module (WCAG) for the dashboard itself.

A.1 General overview and consistency with the observed data

The dashboard's "Overview" view (Figure A1) reports, in this updated version, a total of 10,320,759 mobile accounts and 2,541,967 fixed accounts, with a gap of 7,778,792 accounts and an aggregate growth rate of +8.5 % year over year—figures consistent with the closing values of the series observed in Figure 2 and Table 1 of this article (≈ 10.3 and ≈ 2.5 million mobile and fixed accounts, respectively, as of June 2022; the difference relative to the exact figures in Table 1 (10,352,526 and 2,586,630) is 31,767 mobile accounts (0.31 %) and 44,663 fixed accounts (1.73 %); this difference could not be reconciled with the exact cut-off date of the dashboard's visualization tool, and is declared here as a limitation of the study—not as rounding—and as evidence of indeterminacy (I) in the neutrosophic sense developed in the subsection "Complementary layer: neutrosophic verification (T/I/F)", at the end of Section 3). The dashboard further summarizes the relationship between modalities as an approximate ratio of 4:1 (see the reconciliation of this figure with the other mobile/fixed ratios cited in this article in the subsection "Complementary layer: neutrosophic verification (T/I/F)", at the end of Section 3), consistent with the finding discussed in Section 4. This view also incorporates a "Live Telemetry" module (active nodes, trunk saturation, latency, and network throughput) that simulates real-time operational indicators for purely illustrative purposes; these values derive neither from the ARCOTEL dataset described in Section 2 nor from any actual network measurement, and are therefore not interpreted as part of this study's results.

The "Gap Analysis (Fixed vs. Mobile Connectivity)" view (Figure A2) was updated to compute the penetration of each modality on a different demographic base: mobile penetration remains over total population (57.5 %, practically identical to the penetration computed in this study: 57.55 %, Section 3.1), whereas fixed penetration is now computed over the total number of households enumerated by INEC (3.91 million households in 2022, projected to 5.60 million in 2034), rather than over individual population as in Section 3.1. Under that criterion, the dashboard reports a fixed penetration of 65.0 % of households—a figure that Section 3 of this article already reproduces using the exact ARCOTEL figure: 2,586,630 fixed accounts ÷ 3.91 million INEC households = mechanical scenario based on four persons per household % as of June 2022 (the small difference relative to the dashboard's 65.0 % arises because the dashboard uses its own count of fixed accounts, 2,541,967, rather than the exact value in Table 1)—far above the 14.38 % obtained by dividing fixed accounts by total population (Table 1). This difference reflects no discrepancy in the data, but rather the use of a different denominator: households, in which several people share a single account, as against individual population. This household criterion is in fact the more customary one in the literature and in sector reports for measuring fixed broadband coverage, which is why Section 3 incorporates it as an additional reading—not as a replacement—of the population-based figure, which is retained for consistency with mobile penetration, with the original ARCOTEL source, and because no historical household series is available for the remainder of the period (2010–2021).

Under the household criterion, fixed penetration (65.0 %) even exceeds mobile penetration (57.5 % of population)—a relationship inverse to that obtained by comparing absolute accounts (10.32 million mobile against 2.54 million fixed) or population-based penetrations (57.55 % against 14.38 %). This does not contradict the findings of Sections 3 and 4 regarding the predominance of mobile accounts in volume, but it illustrates how the choice of denominator can invert the reading of which modality has the greater relative penetration. In terms of volume, the dashboard reports a gap of 7.78 million lines (10.32 million mobile accounts against 2.54 million fixed), a ratio of 4.06x (10.32 million ÷ 2.54 million, using the dashboard's own totals; an earlier version of this section erroneously cited 4.8x, a value not reproducible from these same totals—see the reconciliation of the various figures for this ratio in the subsection "Complementary layer: neutrosophic verification (T/I/F)", at the end of Section 3), a figure consistent with the 4.00x obtained from the exact data in Table 1 (10,352,526 ÷ 2,586,630), and a quarterly evolution indicator for that same ratio placing it at 3.99x toward the second quarter of 2022, declining from values close to 4.2x in early 2020—a trend of gradual closing of the relative gap, even as the absolute account gap continues to widen, in line with Section 4—with a year-over-year growth rate of +8.7 % for this cut-off.

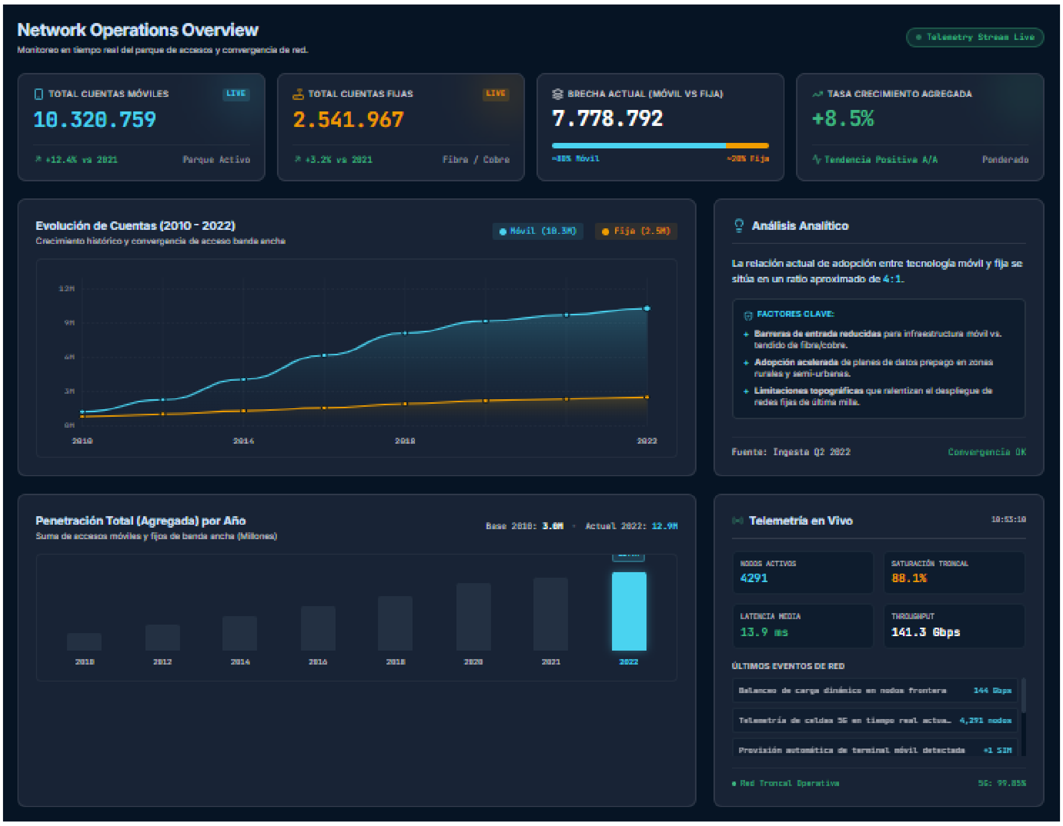

Figure A1. "Network Operations Overview" view of the Telecom Analytics dashboard (updated version): total accounts, mobile–fixed gap, aggregate growth rate, and evolution 2010–2022.

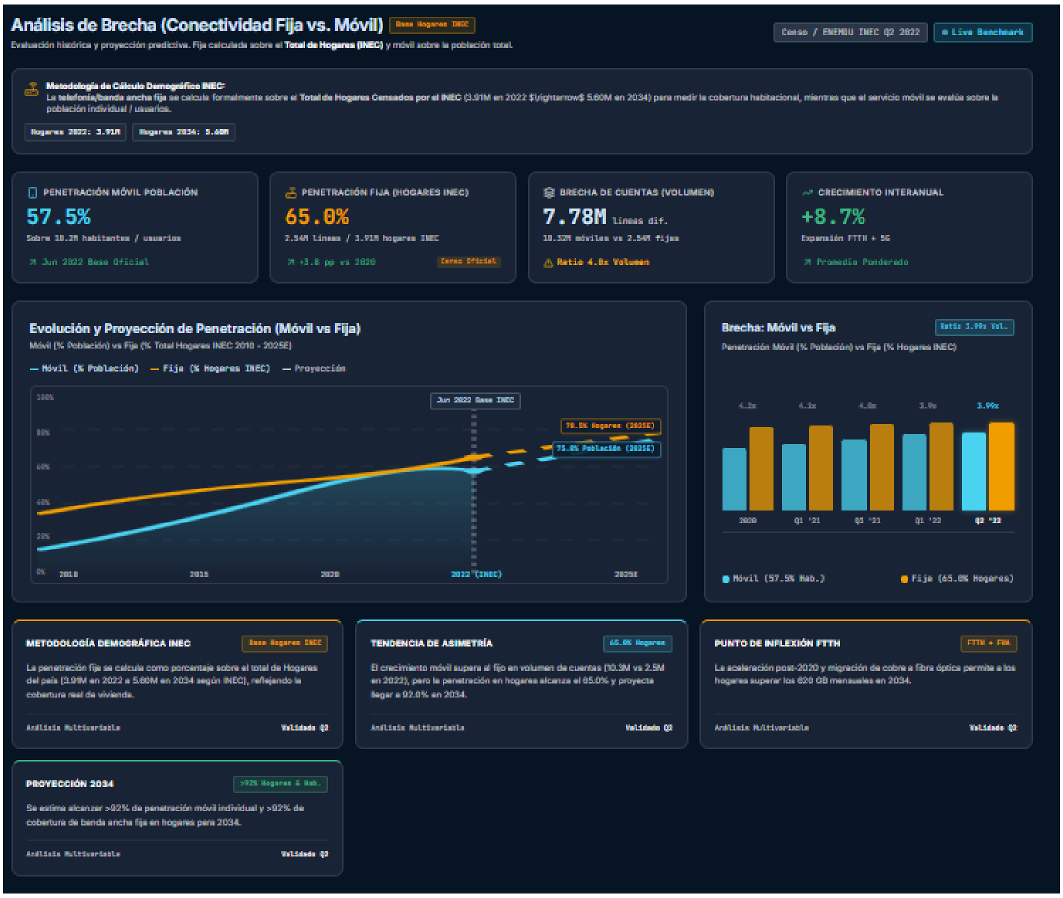

Figure A2. "Gap Analysis (Fixed vs. Mobile Connectivity)" view of the dashboard (updated version): mobile penetration over population and fixed penetration recalculated over the total number of INEC households, with a short-term projection (2010–2025E).

A.2 Exploratory projections to 2034: scope and methodological caveat

The dashboard also includes a ten-year projection module (Figure A3) that estimates, for 2034, a penetration of 92 % in both the mobile modality (20.41 million subscriptions, against 57.5 % in 2024) and the fixed modality (5.15 million households, against 63.9 % in 2024, on the same INEC household base), with a gap ratio declining from 4.16x to 3.96x over the horizon, and an estimated cumulative investment of USD 3.45 billion (USD 2.09 billion in mobile and USD 1.36 billion in fixed) for the period 2024–2034. The figure of 5.15 million fixed households in 2034 is coherent with the 5.60 million total households projected by INEC and cited in Figure A2 (92 % of 5.60 M ≈ 5.15 M). The module also adds a projection of the underlying technological change: in the mobile modality, the 4G share would fall from 76 % (2024) to less than 5 % (2034), with 5G reaching 88 % and a preliminary 6G share of 10 %; in the fixed modality, fiber to the home (FTTH) would rise from 58 % to a target of 80 % of connections (complemented by 20 % fixed wireless access, FWA, over 5G/6G), completely displacing copper (xDSL).

Unlike the eight-quarter projection (September 2022 to June 2024), which is indeed derived from the ordinary least squares model fitted in Section 3.3, this 2034 module extrapolates ten years beyond the end of the sample used in this article (June 2022) and adds investment and technology-migration assumptions with no methodology or source cited; it was generated as an illustrative view of the dashboard prototype, not from the statistical fit of this article. In line with the limitations already stated in Section 5—the reliability of a linear projection decays the further it moves from the sample period (2010–2022), and this article's model incorporates no cost, investment, or network technology variables—these 2034 figures should not be read as a fitted result of this study. They are included here solely for transparency regarding the full scope of the visualization tool, not as an extension of the statistical analysis.

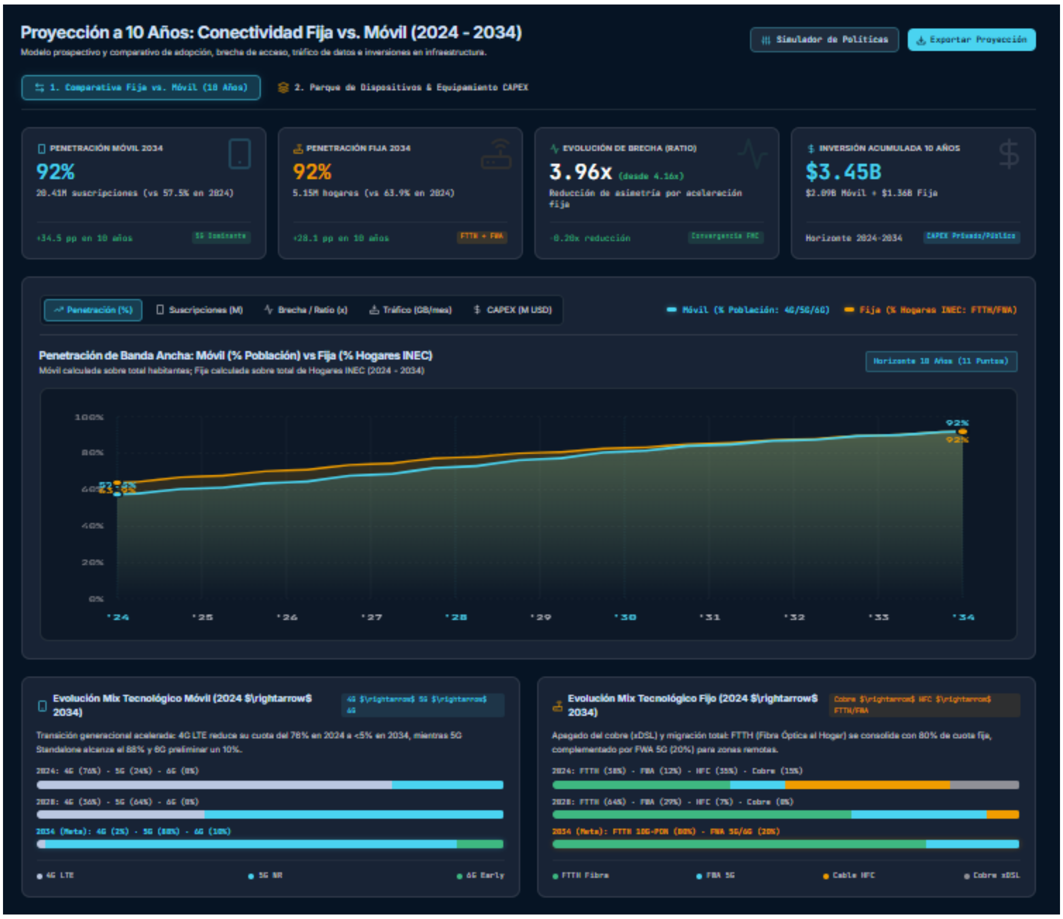

Figure A3. "10-Year Projection: Fixed vs. Mobile Connectivity (2024–2034)" module of the dashboard (updated version): convergence of mobile and fixed penetration, evolution of the gap ratio, estimated cumulative investment, and projected technology migration. Note: the projection, investment, and technology migration are illustrative and not derived from the model in Section 3; see the caveat in the text.

A.3 Own estimate: demand for mobile lines and equipment cost over ten years (June 2032)

The previous version of this dashboard module displayed, across two different screens, mutually incompatible equipment figures (19.5 million units and USD 1,868.5 million on one, against 15.2 million units and USD 5,050 million on the other), which led to neither being used as a basis for estimating how many additional mobile lines will be required over the coming decade or what their cost would be. The updated version of the dashboard (Figure A3) replaces that table with a single cumulative investment of USD 3.45 billion (USD 2.09 billion in mobile and USD 1.36 billion in fixed) for 2024–2034, but it still does not document the calculation methodology, the unit cost assumptions, or the sources; nor did the authors have access to the dashboard's complementary "Device Fleet & Equipment CAPEX" tab, which might contain that breakdown. For this reason the original criterion is maintained: instead of using the dashboard figure, an own estimate was computed by extending the regression model already fitted in Section 3.3, with a documented and traceable methodology, rather than relying on the dashboard's illustrative figures.

Methodology. The mobile-account model from Table 2 was taken (accounts = 202,293·t + 1,201,500; t in quarters since December 2010, R^2 = 0.901) and extended 40 quarters beyond the close of the observed sample (t = 50, June 2022), through to t = 90, equivalent to June 2032—exactly ten years after the last real data point available. The required increase in lines was computed as the difference between the value projected by the model for June 2032 and the actual value observed in June 2022 (10,352,526 accounts, Table 1), rather than against the value the model itself predicts for 2022, so as to anchor the estimate to a measured data point and not to another already projected one. To translate that figure into a cost, the average import price of cellular equipment in Ecuador reported for 2024 was used, computed from the total import value (USD 420 million) over 3.2 million imported units: USD 420,000,000 ÷ 3,200,000 = USD 131.25 per unit (this figure corrects a range of USD 120–125 cited in an earlier version of this analysis, which was arithmetically incompatible with those same import data), and one new terminal device was assumed per additional mobile line, without including the replacement of existing devices.

Mobile lines projected for June 2032: 19,407,870 accounts (model from Section 3.3 extended to t = 90). Additional lines required over the decade (Jun. 2022 → Jun. 2032): 9,055,344 new accounts. Estimated associated equipment cost: USD 1,188.5 million (9,055,344 additional lines × USD 131.25 per terminal; this corrects the figure of USD 1,109 million computed with the erroneous range of USD 120–125, see the methodology in this same section).

Limitations of this estimate. This figure combines two sources of uncertainty that compound rather than cancel each other out. First, it extends the linear model 40 quarters beyond the sample period (2010–2022), five times further than the eight-quarter projection already reported in Section 3.3 and explicitly beyond what Section 5 recommends: the reliability of a simple linear projection decays the further it moves from the observed period, and at a ten-year horizon the expected margin of error is substantially larger than the quarterly MAE of the original fit (686,312 accounts). Second, the cost derives neither from ARCOTEL nor from the regression model—which includes no price or investment variable—but rather from an external data point (the average import price of cell phones, not of subsidized equipment or network infrastructure) combined with the simplifying assumption of one new device per new line, without replacement of the installed base or costs of network deployment, spectrum, or maintenance. This estimate should be read as an illustrative planning exercise with a transparent and traceable methodology, not as a result of the statistical model fitted in this article. For reference, the cumulative investment of USD 3.45 billion reported by the updated version of the dashboard for 2024–2034 (Figure A3, Section A.2) is approximately 2.9 times larger than this corrected estimate (USD 3.45 billion ÷ USD 1,188.5 million; the previous comparison spoke of "almost an order of magnitude", a reading that did not hold even with the original figure of USD 1,109 million, whose quotient already yielded ≈3.1x rather than ≈10x), a difference to be expected if—as its name suggests—it includes investment in the network and not only in terminal equipment; without documented dashboard methodology, however, it is not possible to decompose or verify that figure.

A.4 Accessibility verification (WCAG) of the dashboard

As an additional quality control on the dashboard itself—not on the ARCOTEL data analyzed in this article—the tool incorporates an accessibility verification module (Figure A4) that evaluates the chromatic contrast of its visual components against the interface background color (#051424) under the WCAG 2.1 level AA standard (minimum contrast ratio of 4.5:1), and simulates reading the dashboard under two conditions of color vision deficiency: grayscale (achromatopsia) and deuteranopia (difficulty distinguishing red and green). The five color tokens evaluated—mobile-cyan (#22D3EE), fixed-amber (#F59E0B), on-surface (#D4E4FA), on-surface-variant (#C6C6CD), and projection-emerald (#10B981)—all meet the standard, with contrast ratios between 6.52:1 and 12.1:1. This verification is documented solely as evidence that Figures A1–A3 are legible under common color-blindness conditions and satisfy a recognized criterion of visual accessibility; it neither contributes to nor modifies any analytical result of this study.

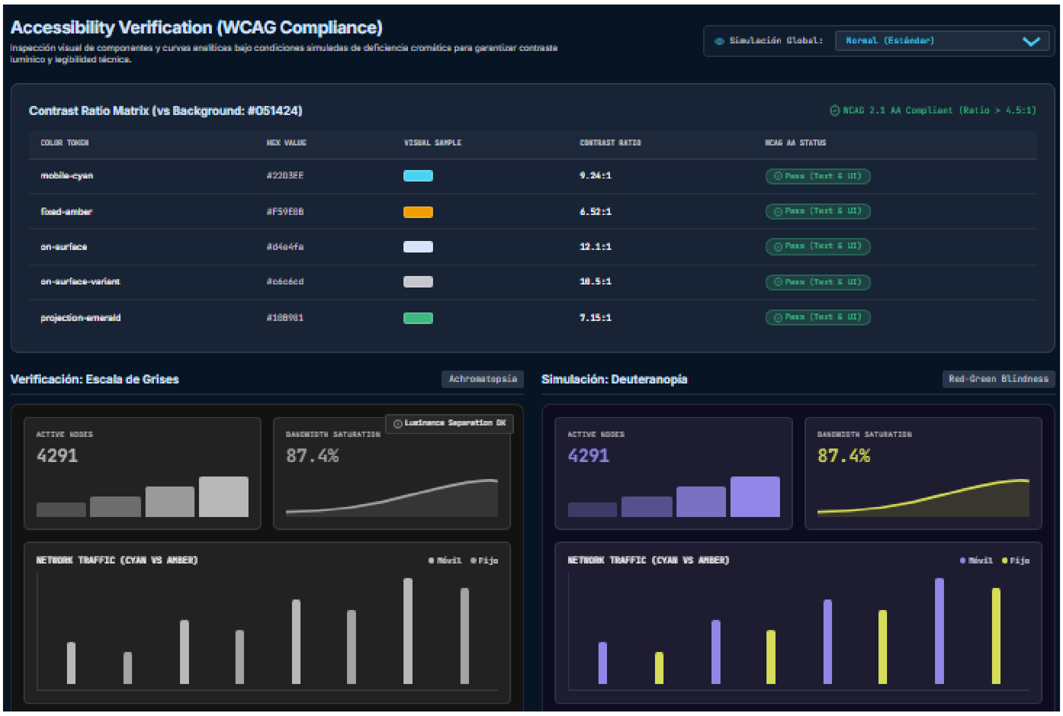

Figure A4. Accessibility verification module (WCAG 2.1 AA) of the dashboard: contrast ratio matrix by color token and simulation of color vision deficiencies (grayscale and deuteranopia).

Dashboard link

https://telecom-roquillo-tapia-mosquera-1.ai.studio