# Competing providers as complements: Demand for prepaid mobile plans in Burkina Faso

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**Abstract**

In emerging economies, consumers often subscribe to multiple competing mobile service providers, i.e they multi-sim. This observation contrasts with the substitution patterns typically expected between competing firms and has important implications for price competition and consumer welfare. This paper quantifies the welfare gains from multi-simming using a 2020 survey of 1,899 subscribers in Burkina Faso. I estimate a discrete-continuous choice model of provider and service-usage decisions, flexible enough to identify the gains from multiple subscriptions and the complementarity or substitutability across services conditional on subscriptions. My results indicate that within a provider, internet and communication (voice and text) are substitutes. My counterfactual analysis shows that consumer surplus would have been 49.2% lower without multi-simming. Because consumers respond to price changes by choosing, service by service, which provider to use, multi-simming intensifies price competition and reduces firms' market power. I find that this price-related effect accounts for 8% of the welfare gains, while 92% comes from choice set expansion. I also find that the gains are larger for women, less educated users, and older users, as well as in lower-quality markets. This suggests that multi-simming helps mitigate digital divides.

**Keywords:** prepaid mobile plans, telecommunication, welfare, complementarity, discrete-continuous demand.

# 1 Introduction

*Pay-as-you-go* prepaid plans combine a contract-free, low-cost subscription with uniform service rates, making them attractive to cost-sensitive consumers and cheaper for firms to implement (Layton, 2014). This feature may explain why the *pay-as-you-go* plan is the most widely used plan worldwide, representing 72% of plans in 2020 (GSMA, 2020). It is particularly popular in emerging countries, especially in Africa, where it represents 94% of plans. In comparison, this proportion is lower in North America (21%) (GSMA, 2020). The literature has documented multi-simming, the act of subscribing to multiple competing providers, as a common behavior in emerging markets. The main reason highlighted is that multi-simming allows consumers to reduce spending and obtain better service quality by pairing each service with the cheapest provider or the one offering the best quality (Piason and Peter, 2025). Therefore, subscribing to an additional provider brings benefits that consumers cannot obtain otherwise. This observation suggests synergies in consumption across competing providers. Empirical assessment of the implications of such behavior for price competition and consumer welfare is also limited.

This paper contributes to the literature by evaluating the gains from multi-simming for both competition and consumer welfare. I propose a discrete–continuous choice model to formalize consumers' decisions regarding which providers to subscribe to and how much of each service to demand from those providers. This model is flexible enough to identify the gains from multi-simming as well as the complementarity or substitutability across services conditional on subscriptions. I estimate the model using a 2020 survey of 1890 mobile services users from Burkina Faso, a West African country. I use my estimates to run a counterfactual analysis to evaluate welfare gains from multi-simming.

Three providers operate in this country (Orange, Onatel, and Telecel), and the *pay-as-you-go* plan accounts for 99% of active plans. Providers offer recurring promotions, which take the form of extra data or minutes on standard plans or extra credit on top-ups (Digital Business Africa, 2023). Although providers do not officially charge higher rates for off-net calls or/and text, extra credit granted through promotions was, until 2025, only usable within the subscriber's own network (Burkina24, 2023; L'Économiste du Faso, 2025). Therefore, off-net calls were roughly four to eight times more expensive than on-net calls in 2020. This lim-

ited interoperability, together with providers' recurring price discounts, makes multi-simming cost-saving in Burkina Faso because it allows users to choose the cheapest provider for each consumption instance. Furthermore, providers offer financial services tied to their mobile plans- the mobile money service- commonly used for money transfers and for paying merchants and utility bills, including electricity and water (Orange Burkina Faso, 2026). Until 2025, cross-provider mobile money transfers were not possible. As a result, consumers had to subscribe to whichever provider offered the mobile money service their contacts used.

My analysis is subdivided into two parts. The first part provides a preliminary analysis and descriptive evidence on multi-simming. I document patterns of joint usage which are similar to those reported in similar contexts in the literature. Firstly, multi-simming is common; nearly 60% of the sample subscribed to at least two providers. In addition, I find that the probability of subscribing to a provider increases when consumers use any other competitor. This means that providers' subscriptions display complementarity in the spirit of Manzini et al. (2018)'s test.

Secondly, service usage habits suggest that consumers may use their providers as if they *complement each other*. Controlling for demographic characteristics (age, education, occupation, gender, and residence type), mobile money and internet users are more likely to subscribe to multiple providers. Mobile money and internet usage are associated with a 28.2- and 11.9-percentage-point higher probability of multi-simming. Also, multi-simmers tend to use a single provider for internet and mobile money among the providers they subscribe to. However, they use text and voice services with all their providers. This decision to use mobile money and internet services with a provider seems related to that provider's competitiveness in those services. My descriptive results are consistent with consumption synergy across providers, such that multiple providers offer advantages that a single provider cannot.

Although significant, these results may also be driven by unobserved characteristics that the first part of the analysis cannot control for (Gentzkow, 2007). My discrete-continuous choice model accounts for these unobserved components to quantify the utility gains from multi-simming. In this framework, consumers first choose the bundle of providers to subscribe to from those available in the market. Conditional on the chosen bundle, they decide their service usage level with each provider in the bundle. The discrete choice part of the model is a demand-bundling model similar to Gentzkow (2007). As in Iaria and Wang (2019a), Hawthorne

and Grzybowski (2025), and Thomassen et al. (2017), the model allows heterogeneous gains from multi-simming depending on the providers included in the bundle and consumers' characteristics. The continuous choice is described by a quadratic utility function, flexible enough to handle corner solutions and capture complementarity or substitutability between services from the same provider.

Identifying parameters related to complementarity/substitutability between two products relies on information about their joint consumption. However, joint consumption of two products can also arise from correlated tastes across products (Gentzkow, 2007). Consumers who value the first product may also value the second because of their observed and unobserved characteristics. Therefore, disentangling the contributions of complementarity and correlated tastes to joint consumption remains a real challenge in the literature. Gentzkow (2007) suggested, among other strategies, leveraging an exclusion restriction to separate them. This strategy relies on variables that affect the attractiveness of some alternatives and do not enter the utility of the other alternatives. In my framework, I rely on provider- and service-specific prices and quality indices. I assume that they affect the willingness to consume a service but do not enter the utility function of other services or other competitors. Sinkinson (2020); Thomassen et al. (2017), and Hawthorne and Grzybowski (2025) use the same strategy.

The quality index is market-specific and meant to capture variation in quality across markets. As in Weiergraeber (2022), I recover providers' quality from survey responses. People were asked to rate their satisfaction with their providers' services across several dimensions, including network coverage, network strength, dropped calls, audio quality, internet access, and speed. For both internet and communication services, I observe multiple service-quality dimensions that I then use in factor analysis to recover underlying quality. The index correlates positively with crowdsourced speed tests (Ookla[1]) and ranks the leading provider first, as nPerf[2] does.

The model is estimated for three available providers, offering two services, communication (voice and texts) and internet, in thirteen markets. Because the estimation is computationally

[1]The firm Ookla shares internet quality metrics obtained from crowdsourced measurements collected through its Speedtest platform. I was able to access metrics from all Speedtest results recorded in Burkina Faso in 2020.

[2]The company nPerf publishes annual country reports on mobile internet quality metrics, based on user test results conducted through its platform

involved, I rely on the simulated method of moments. In fact, estimation requires solving the consumer problem for each draw of unobserved characteristics, which involves finding all possible combinations of service-provider adoption and usage[3]. Estimation results show heterogeneous but largely positive gains from multi-simming. I find that the subscription cross-price elasticity between the two most popular providers is negative. This means that if one provider raises prices, the other's subscription becomes less valuable. Within the same provider, internet and communication services (texts and voice) are substitutes. This finding is consistent with the popularity of over-the-top messaging services, which are substitutes for providers' own voice and text services (Layton, 2014).

To evaluate the gain from multi-simming, I run a counterfactual exercise that drops multiple-provider bundles from consumers' choice set. I find the consumer welfare to be 49.2% lower than under multi-simming. I also find that prices would have been substantially higher. About 92% of the welfare gains from multi-simming come from the bundles it makes available, and the remaining 8% from its effect on prices. Finally, the welfare gains are larger for women, less-educated users, and older users, who are less likely to use mobile services (Institut National de la Statistique et de la Démographie (INSD) and ICF, 2023; Afrobarometer, 2022).

This paper's main contribution is to assess the gains from simultaneously using multiple competing prepaid providers. It is worth noting that most of the the literature assumes providers' plans are substitutes even in markets where multi-simming exists, such as Björkegren (2022); Hawthorne and Grzybowski (2025); Haucap et al. (2010); Hasbi and Dubus (2020); Hawthorne and Grzybowski (2021); Vélez-Velásquez (2019). Gentzkow (2007) highlighted that such restrictions on substitution patterns between products may produce biased demand estimates. My framework is flexible enough to identify substitutability and complementarity between services and between providers, conditional on the provider. Furthermore, the discrete-continuous model lets us decompose price elasticity into subscription price elasticity, service adoption elasticity conditional on the subscription, and service-intensive margin elasticity conditional on adoption and subscription. This decomposition helps identify which margins consumers react to more, which is crucial for evaluating the effect on market power. I find that when a

[3]Because I do not observe detailed mobile money consumption, its usage enters the model as an exogenous consumer characteristic.

service price increases, consumers shift consumption either to another service from the same provider or to services from competing providers, rather than reducing overall consumption. Between 60% and 90% of the demand response comes from consumers dropping or adopting the service.

More recent literature has focused on understanding factors explaining multiple subscriptions in emerging economies. Cost-saving and quality motives are typically reported as the main drivers of multi-simming. This is particularly important because these markets are also characterized by limited interoperability between networks, reflected in on-net/off-net price discrimination and recurring short-term price discounts (Ilembo and Walwa, 2022; Piason and Peter, 2025; Andersson and Göller, 2020; Layton, 2014). Ilembo and Walwa (2022) finds that Tanzanian users use multiple SIMs to benefit from lower prices and better service quality. Mvele et al. (2019) found similar patterns in Cameroon.

The literature has also documented that multi-simming may serve as insurance against poor service quality, limited network coverage, and short-term outages (Ilembo and Walwa, 2022; Layton, 2014). Service differentiation in such an environment often operates such that each provider is competitive in only a few services. Therefore, a single provider cannot meet consumers' needs across the range of services they use (Ilembo and Walwa, 2022; Mvele et al., 2019). Mobile money usage is also reported to play a role in multi-simming. Ilembo and Walwa (2022) documents that, in the Tanzanian market, providers with strong mobile money adoption are comparatively less popular for traditional telecom services. Piason and Peter (2025) further suggested that the high prevalence of multi-simmers may explain the high churn rates observed in Zimbabwe's telecommunications industry. However, none of these papers formally tested whether this joint consumption is driven by true complementarity between providers. Previous research also evaluates consumption synergies between mobile and fixed services (Grzybowski and Verboven, 2016; Grzybowski, 2014; Hawthorne and Grzybowski, 2025) or internet and voice services (Chen et al., 2019).

This work also builds on empirical research on bundling and complementarity, such as Gentzkow (2007); Iaria and Wang (2019a); Allen and Rehbeck (2020); Ershov et al. (2025); Sinkinson (2020); Manzini et al. (2018). Gentzkow (2007) documents the identification challenges for a structural demand model. I leverage the richness of my survey data to construct a provider-

and service-specific quality index. Sinkinson (2020) similarly uses network quality metrics as an exclusion restriction to separately identify consumers' preferences for handsets and for carriers.

My model is close to the discrete continuous choice model proposed by Thomassen et al. (2017). My model extends Thomassen et al. (2017) by allowing consumers, at the continuous stage, to split their consumption of a given service across several providers in their bundle, whereas in their model each category is purchased from a single store. While their framework could be extended to handle this feature, restricting each category to a single store is consistent with their descriptive evidence that consumers spend little in the second store they visit. In contrast, splitting is common in my setting, which makes relaxing this restriction necessary. Among multi-simmers, 97.69% use several providers for voice, 79.17% for text, and 26.98% for internet.

The rest of the paper is organized as follows: Section 2 presents the Burkinabe telecommunications industry and the dataset used in this study. Section 3 presents reduced-form evidence. The model is described in Section 4 and the estimation strategy in Section 5. The last two sections present estimation results and a counterfactual analysis.

# 2 Industry and data

## 2.1 Industry

Three providers are active in Burkina Faso's mobile market. The oldest provider, ONATEL S.A., henceforth Onatel, offers mobile services through its division *Moov* (previously *Telmob*). Onatel was formerly a national company established in 1996 and privatized in 2005. After market liberalization in 2000, two additional providers, *TELECEL FASO* (henceforth Telecel) and *CELTEL*, entered the market. *CELTEL* was later acquired by *Airtel*, which was later bought by *ORANGE BURKINA*, henceforth Orange, in 2016. The Burkinabe telecommunications regulator is the *Autorité de Régulation des Communications Électroniques et des Postes* (ARCEP).

Orange and Onatel are the most popular providers, accounting together for 80% of the country's subscriptions (Figure 1). Figure 1 also shows that upon entering the market in 2016, Orange quickly became the largest provider. All providers offer prepaid and postpaid mobile plans, but

only Orange and Onatel offer fixed-line services. The *pay-as-you-go* plan is the only prepaid option available in the country and accounts for 99% of the country's total mobile plans. Subscribing to a provider involves purchasing a SIM card, which grants access to voice, text, and internet services. Consumption requires having a positive balance, replenished by top-ups. However, a top-up is valid for a few days to several weeks, depending on the amount recharged. Each of the voice, internet, and text services is billed at service-specific constant marginal prices, paid directly after consumption. The total expenditure is then deducted from the consumer's balance.

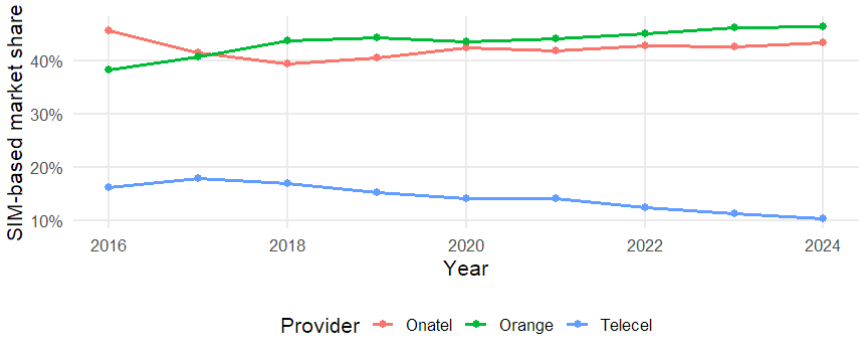
Service availability and quality vary substantially across operators and across the country. Service availability is mainly driven by differences in network coverage. In 2022, according to the regulator's figures, Onatel's and Orange's 2G coverage rates amounted to 84% and 82%, respectively, far ahead of Telecel's 68.2%. By comparison, 91.7% of localities were covered by at least one provider that year, revealing that in some areas, only a subset of providers is available.

nPerf's coverage maps (Figure 11 in Appendix D) suggest that these disparities may persist for more recent technologies as well[4]. These maps are built from crowdsourced measurements and reports, so coverage reflects where users have recorded a signal. These tests may be more concentrated in urban areas, and therefore possibly understate coverage in rural localities. However, they offer a more recent and geographically detailed picture of provider-level coverage than the regulator's 2022 aggregate figures. According to nPerf performance rankings for 2020–2025, Orange offers the best internet quality, followed by Onatel and Telecel[5]. However, in 2021, Telecel still had the worst coverage rates.

[4]The company nPerf publishes yearly country reports on internet quality metrics based on the results of user tests conducted through its platform. See nPerf's 2021 release.

[5]This ranking is consistent across all editions except in 2020, when Telecel was ranked second and Onatel third.

Figure 1: SIM-based market shares for prepaid plans, 2016–2024




*Notes:* This figure shows each provider's SIM-based market share, defined as its share of all active SIM cards in Burkina Faso, by quarter. Since many consumers hold SIMs from several providers, these shares count SIM cards, not individual subscribers. Data come from the regulator's quarterly industry reports, Q1-2016 to Q2-2024.

Panel A and Panel B of Table 1 report the official price and the average revenue per minute of the voice service. This difference between average revenue and the official price reflects frequent provider promotions[6]. Panel A shows that only Telecel officially charges higher rates for off-net calls. However, because of frequent discounts, the regulator-published real off-net price (average revenue per off-net minute) is at least four times the on-net real price. This differential between on-net and off-net operations may explain why nearly 90% of the provider's traffic occurs within its network, as shown in Figure 8 in Appendix A. In such an environment, multi-simming allows consumers to benefit from providers' promotional offers while avoiding costly off-net fees. (Ilembo and Walwa, 2022; Piason and Peter, 2025; Andersson and Göller, 2020).

Another important feature of Burkina Faso's mobile telecommunications industry is mobile money services. A mobile money account works essentially like a checking account, except that it is linked to the customer's mobile plan. This account can be used for transactions such as transfers, credit purchases, and, more recently, bill payments. After subscribing to a provider, a separate registration is required for the mobile money service.

The first mobile money offer was *Airtel Money*, launched in 2012 by *Airtel*, which became Orange. Later in 2013, Onatel introduced *Mobicash*. Telecel only launched its *Telecel money*

[6]Providers offer recurring promotions in the form of extra data or minutes on standard plans or extra credit on top-ups, which were until 2025 only usable for on-net consumption (Burkina24, 2023; L'Économiste du Faso, 2025).

Table 1: Prices and average revenue per unit (ARPU) in Q4-2020

*Panel A: Official tariffs*

| | Voice (FCFA/min) | | Text (FCFA/SMS) | |
|---|---|---|---|---|
| | On-net | Off-net | On-net | Off-net |
| Onatel | 90 | 90 | 10 | 20 |
| Telecel | 84 | 90 | 10 | 20 |
| Orange | 90 | 90 | 10 | 20 |

*Panel B: Average revenue per unit (voice and internet)*

| | Voice ARPU (FCFA/min) | | Internet ARPU (FCFA/GB) |
|---|---|---|---|
| | On-net | Off-net | - |
| Onatel | 8.96 | 76.09 | 808.65 |
| Telecel | 14.38 | 61.23 | 1207.21 |
| Orange | 7.84 | 71.47 | 1214.72 |

*Notes*: This table reports official tariffs and average revenue per unit (ARPU) for voice, text, and internet services from the regulator's reports. Average revenue per unit for text service is unavailable. Official internet prices are not reported, as providers offer multiple internet plans that vary by data volume (GB) and validity period. Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

mobile payment service in 2024[7]. As traditional financial institutions rely on branch networks, providers rely on their retail agent network for cash operations. The size of this network has been shown to differentiate providers, as a larger network lowers consumers' cost of accessing a retail agent (Grzybowski, Lindlacher, et al., 2023). In 2015, *Airtel Money*'s retail agent network counted 11,862 agents, more than nine times the size of Mobicash's retail network (Sanou, 2015). Since 2016, Orange has leveraged *Airtel Money* 's lead over Mobicash, together with its own experience operating similar services in other countries, to establish *Orange Money* as the market leader. This dominant position has, in turn, made *Orange Money* a major partner for merchants, banks, and other third parties seeking to integrate mobile money services. This integration has also made *Orange Money*, and therefore the Orange prepaid plan, increasingly attractive for consumers.

Until 2025, there was no cross-provider interoperability. This means that, before 2025, trans-

[7]Therefore, Telecel's mobile money service was unavailable during the period covered by the survey in 2020.

fers were only allowed within each provider's network. Therefore, consumers who wanted to access both Onatel's and Orange's mobile money networks had to subscribe to both providers.

## 2.2 Data

I use a survey commissioned in 2020 by the regulator, covering 1,890 mobile service subscribers aged 15 or older. This national survey aimed to understand consumers' consumption habits and measure satisfaction with providers' services. The survey collected detailed information on subscribers' active plans and service usage. I also observed demographic variables such as education, occupation, age, and gender.

Table 12 in Appendix A compares the demographic distribution of the survey sample with that of the 2019 census for people aged 15 years or older. The sample overrepresents women, educated people, and people aged over 20. However, the SIM-based market shares observed in the sample are close to the national level. This difference may reflect that mobile phone owners differ from the rest of the population. My sample is also predominantly urban, with 70% of respondents living in urban areas. As a result, my sample likely understates geographic disparities in provider availability. All three providers are present in every market in the data, whereas some rural localities are covered by only a subset of them.

To address this selection problem in the estimation, I use the demographic distribution from the 2021 survey, the *Enquête Harmonisée sur les Conditions de Vie des Ménages* (henceforth EHCVM), in the structural model. The EHCVM was also used to compute the inside option market share, which corresponds to the population of mobile phone owners.

**Prices:** The services' price indices are constructed from the services' average revenue per unit. The price index for each service is the average of its on-net and off-net prices, weighted by their shares of total traffic. The internet price index is the average revenue per user at the time of the survey.

In structural estimation, I consider two services: internet and communication, the latter including text and voice services. The communication price is computed as the average of the text and voice price indices. Because I do not observe mobile money usage intensity, I treat mobile money usage as an exogenous consumer characteristic.

**Quality index:** As in Weiergraeber (2022), I recover each provider's quality from survey responses to questions about satisfaction with the provider's services. Consumers were asked to evaluate their providers' services across multiple dimensions[8]. For voice and text, the dimensions assessed included coverage, network strength, dropped calls, and audio quality. For internet services, four dimensions related to access and speed were evaluated. An additional question on overall satisfaction was asked for each service.

This information is then used to perform a factor analysis separately for communication and internet services[9]. For each service, one factor is extracted from the set of five dimensions initially evaluated. The resulting index can be interpreted as a proxy for service quality, with higher values indicating higher perceived quality for both services[10]. The index explains 74% and 94% of the total variance for communication service (voice and text) and internet services, respectively[11].

In Appendix D, I compare this index against two crowdsourced evaluations of provider internet quality in Burkina Faso. The index correlates positively with Ookla's market-level internet speeds and, like nPerf, ranks Orange as the best internet provider. The two rankings differ for Onatel and Telecel, consistent with the index also capturing network coverage, where Telecel is weakest. Figure 9 in Appendix D shows that the quality index varies substantially across both providers and markets, which helps identification. However, some markets, particularly in the northern regions[12], display unexpectedly high internet quality. This may reflect the predominantly urban composition of my sample, since mobile service quality is documented to be lower in rural areas.

Figure 2a shows the scatter plot of the quality index and providers' market shares[13]. Figure 2b shows the scatter plot of each service's user share versus the quality index. All variables are residualized by provider and market fixed effects. The internet quality index is positively related

[8] Each dimension is evaluated using Likert-scale satisfaction questions ranging from *Very satisfied* to *Not satisfied*.

[9] First, these questions are used to compute satisfaction rates for each market–operator–service–dimension combination. This step produces two datasets (one for internet services and one for communication services), each containing five variables and 39 observations (3 providers × 13 markets). Factor analysis is then performed on each dataset. See Appendix D for details.

[10] See Appendix D for details of computation and comparison with external sources of internet quality.

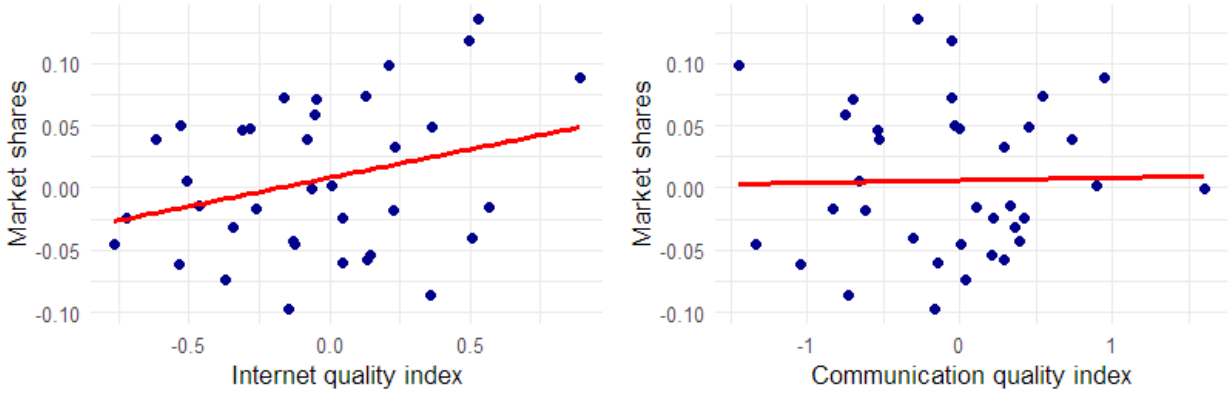
[11] Factor analysis restricted to multi-simmers yields similar results.

[12] Respondents from the northern regions live mainly in provincial capitals.

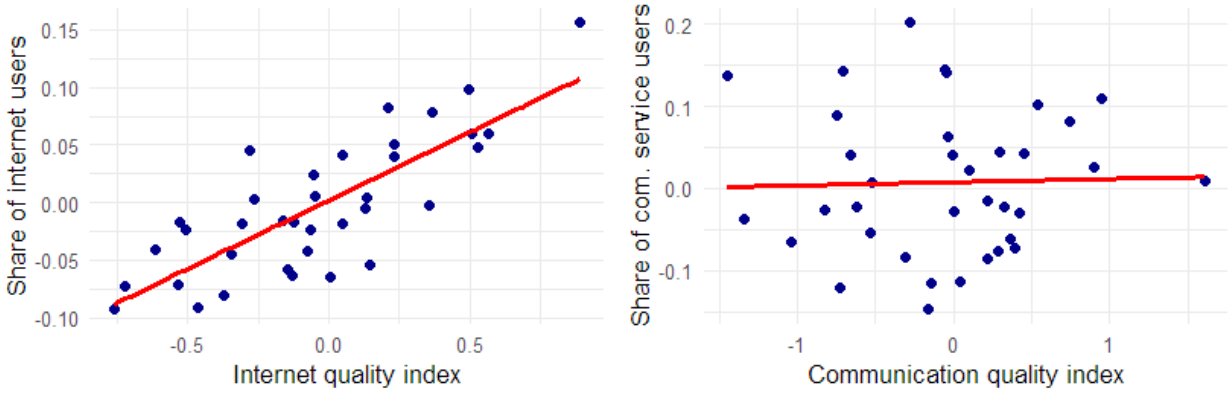
[13] Providers' market shares may sum to more than 1 because of multi-simming.

to both the share of internet users and providers' market shares. The communication index is a weaker predictor, but the relationship remains in the expected direction.

Figure 2: Market share, service usage and quality index




(a) Market share and quality index




(b) Share of users of each service and quality index

*Notes:* This figure plots each service's quality index against providers' market shares (Panel (a)) and against the share of service users (Panel (b)), defined as the proportion of all survey respondents in a given market who use the provider's service. Each dot represents a market–provider–service combination. All variables are residualized on provider and market fixed effects. The red line is the fitted OLS regression line.

# 3 Preliminary analysis

In this section, I provide descriptive evidence suggesting a positive synergy in providers' usage. I first show that providers' SIM card purchase incidences are positively correlated. This means that knowing that a consumer subscribes to one provider increases the probability of subscribing to another one. I then provide descriptive statistics suggesting that consumers use their subscriptions in tandem.

## 3.1 Evidence of multi-simming

In this section, I provide supporting evidence of multi-simming in the data. First, using multiple SIM cards is common. Panel A of Table 2 displays the distribution of the number of providers subscribed to, both among each provider's subscribers and for the overall sample. Overall, less than half of customers (42.76%) use a single provider. The majority of consumers in the sample (57.24%) subscribe to multiple providers. Nearly 40% of consumers use two providers, and 17.48% use all three. The distribution by provider shows that Telecel customers are more likely to be multi-simmers since only 10.46% of its subscribers use only this provider. This is consistent with Telecel having the lowest coverage and being the only provider not offering mobile money services during the sample period.

Panel B of Table 2 reports the distribution of the number of SIM cards from the same provider. Conditional on using a given provider, almost 90% of subscribers purchase a single SIM card from it. Therefore, people seem to prioritize provider diversity over the number of products when purchasing SIM cards.

To evaluate the significance of the numbers reported in Table 2, I implemented the correlation criterion test proposed by Manzini et al. (2018). The idea is to assess whether providers'subscriptions are complements. Manzini et al. (2018)'s test identifies the relationship between two goods by evaluating the statistical association between their purchase incidence. The main advantage of this test is that its implementation does not require information on prices or income.

Implementing the test for two goods $A$ and $B$ consists of computing the probability of purchasing $A$, $P_A$, and the probability of purchasing $A$ given that $B$ was purchased, $P_{A|B}$. The two

Table 2: Number of providers, SIM cards, and bundle shares

*Panel A: Number of providers held, conditional on subscribing to each provider (%)*

| #Providers | Onatel | Orange | Telecel | Any provider |
|---|---|---|---|---|
| 1 | 24.38 | 29.92 | 10.46 | 42.76 |
| 2 | 49.69 | 47.56 | 30.67 | 39.76 |
| 3 | 25.94 | 22.52 | 58.87 | 17.48 |

*Panel B: Number of SIM cards held from the same provider (%)*

| #Cards | Onatel | Orange | Telecel |
|---|---|---|---|
| 1 | 88.36 | 85.69 | 92.02 |
| 2 | 9.92 | 12.96 | 7.09 |
| 3+ | 1.64 | 1.36 | 0.89 |

*Panel C: Bundle market shares, unconditional (%)*

| | Onatel | Orange | Telecel | All providers |
|---|---|---|---|---|
| Onatel | 16.43 | | | - |
| Orange | 30.65 | 23.22 | | - |
| Telecel | 2.84 | 6.27 | 3.11 | - |
| All providers | - | - | - | 17.48 |

*Notes*: Panel A reports the number of distinct providers subscribed to for customers of each provider. The column "Any provider" represents the overall distribution. Panel B reports the number of SIM cards held from the same provider. Panel C displays bundle market shares: the share of consumers owning each bundle. Diagonal entries correspond to single-product bundles. Off-diagonal entries correspond to bundles combining the provider in the row with the one in the column.

goods $A$ and $B$ are then complements if $P_A < P_{A|B}$, substitutes if $P_A > P_{A|B}$ and independent if $P_A = P_{A|B}$. In the case where purchase incidence for several goods is observed, Manzini et al. (2018) suggests testing any pair of goods $A$ and $B$ using the marginal probabilities, unconditional on the other good being purchased.

Since my sample consists exclusively of users, all probabilities computed from the data are conditional on using any of the three providers. The following probabilities were computed for any pair of providers $A$ and $B$:

$$\begin{aligned} P_A &= P(\text{any provider})P(A|\text{any provider}); \\ P_B &= P(\text{any provider})P(B|\text{any provider}) \quad \text{and} \\ P_{A|B} &= \frac{P(A \text{ and } B)}{P(B)} = \frac{P(A \text{ and } B|\text{any provider})}{P(B|\text{any provider})}. \end{aligned} \tag{1}$$

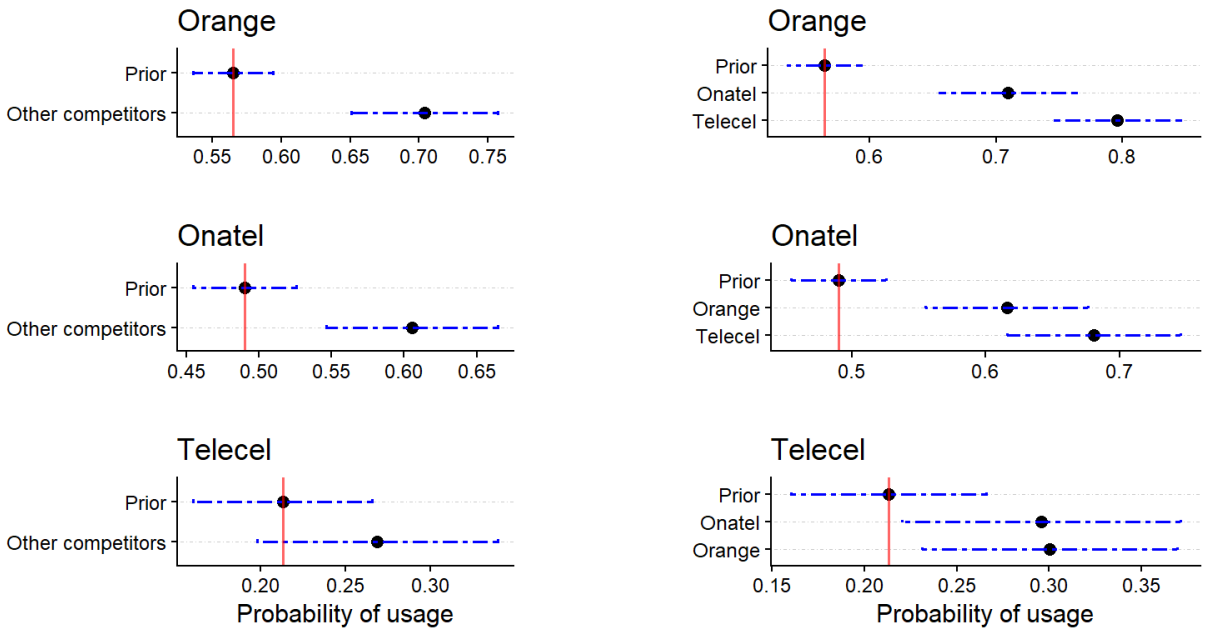
Figure 3 plots, for each provider, the probability of being chosen (*prior* row) and the choice probability given its competitors' usage. Both panels show point estimates and 95% confidence intervals. In Figure 3a, for each provider $A$, the other provider $B$ is *any of its competitors*. For all providers, the posterior probability exceeds the prior probability. This difference is significant at the 5% level except for Telecel, perhaps because it is the least represented in the sample. Knowing that at least one of its competitors is in use increases the probability that a given provider is also chosen. This result is consistent with a positive correlation in providers' SIM card purchase incidence. Figure 3b further implements the test for pairs of providers. This figure shows that the positive correlation remains for pairs of providers. Panel C of Table 2 shows that the most popular combinations are {Orange, Onatel} and {Orange, Onatel, Telecel}.

As highlighted in Manzini et al. (2018) and Iaria and Wang (2019b), this test may not be informative about *true* complementarity due to its limited micro-foundation. In fact, joint consumption does not necessarily come from complementarity. People who like one provider may also value another, reflecting correlated preferences rather than utility gains from joint consumption. Unfortunately, the correlation test cannot distinguish between the two mechanisms.

Ruling out complementarity at the discrete choice level requires that multi-simming not provide additional advantages that cannot be achieved by using a single provider. As a result, whenever a consumer subscribes to multiple providers, she should not use them in tandem[14]. This would be the case of consumers who have a strong taste for mobile services and value multi-simming purely to keep in touch with as many people as possible, with no regard for which specific SIM cards they hold. I will show that the patterns of service usage across providers are more consistent with utility gains from joint consumption, rather than pure correlation in tastes.

[14]Note that this also rules out any tariff-driven rationale for multi-simming, which would imply cost savings from reaching contacts on multiple networks. This would count as joint consumption driven by complementarity rather than a pure correlation in tastes, since a single provider cannot achieve the cost savings.

Figure 3: Comparing prior and posterior subscription probabilities (correlation test)




(a) (b)

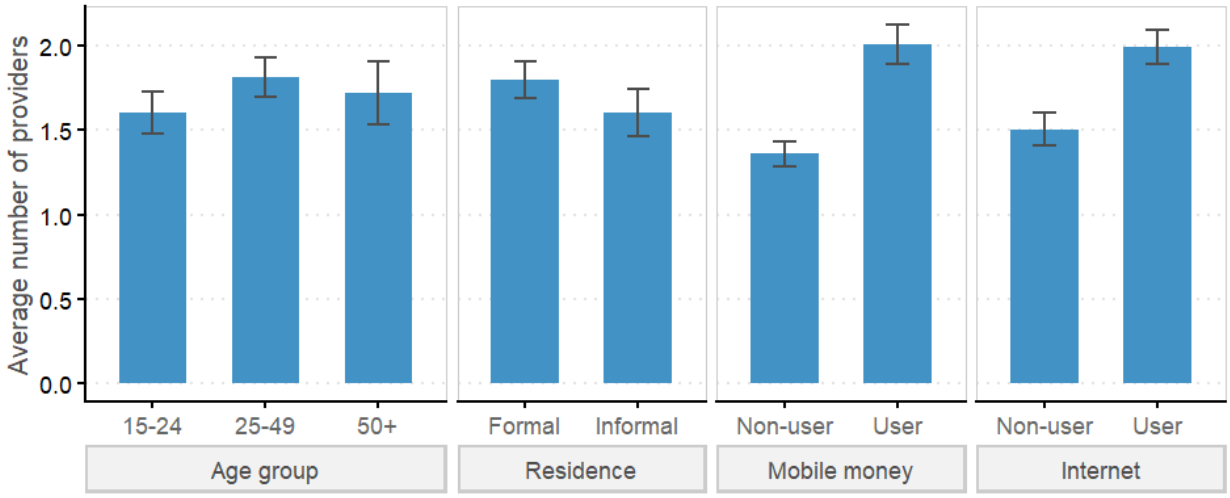
*Notes*: The prior row reports the unconditional choice probability of the corresponding provider. Confidence intervals are based on province-level clustered standard errors. In Figure (a), the *Other competitors* row reports the provider choice probability conditional on any of the other competitors being used. Disaggregated choice probabilities for each competitor are reported in (b).

## 3.2 Joint usage of services across providers

This section tests the benchmark set out in Section 3.1 directly against multi-simmers' usage habits, and shows that correlation in tastes is unlikely to be the sole driver of multi-simming.

If multi-simming were driven purely by correlated tastes, there would be no provider-specific motive for holding several SIM cards, and three testable implications would follow. Firstly, the type of services someone uses should not predict whether they multi-sim. Secondly, multi-simmers should not spread the services they consume across the providers they subscribe to. Finally, service usage with a given provider should not depend on how competitive its price or quality is relative to competitors. I confront each of these implications with the data. A linear probability model, presented in the next paragraph, shows that internet and mobile money usage significantly increase the probability of multi-simming. Descriptive statistics in the last two paragraphs show that multi-simmers are not indifferent between the providers they subscribe

Figure 4: Average number of providers subscribed to, by demographic group




*Notes*: Error bars show 95% confidence intervals computed with province clustered standard errors.

to: they spread the services they use across providers rather than using them interchangeably. These results are inconsistent with multi-simming solely originating from joint correlated taste across providers.

**Why do people multi-sim?** Many factors may explain multi-simming. Burkinabe industry sources highlight consumer demographics such as age, residential area, and internet and mobile money usage.

Figure 4 shows the average number of providers subscribed to by age group, type of residence, and internet and mobile money usage status. The average number of providers is higher in the 25-49 age group than in both the 15-24 and 50+ age groups. On average, people living in formal settlements subscribed to more providers than those living in informal settlements. However, the differences are not statistically significant. Age is expected to be positively correlated with multi-simming because of variation in available options across generations, given the entry of lower-cost, higher-quality offers from new entrants in 2000 and 2016. The last panels of Figure 4 display the average number of providers among users and non-users of internet and mobile money services. On average, internet users have nearly 2 providers, while non-users have 1.32. The same trend is observed for mobile money.

Table 3 provides estimates from a regression of the dummy indicating multi-simming on the number of minutes of voice, dummies for text, internet, and mobile money service usage, age, and a dummy for living in an informal settlement. The two sets of control variables are demographics (occupation, education, gender) and residence (province of residence, a dummy for living in an informal settlement). Column (1) displays the results without any controls. I control for residence in column (2), for demographics in column (3), and for both in column (4). In the last column, I restrict the sample to subscribers of the two providers, Orange and Onatel.

Column (1) shows that, all else equal, heavy users of voice services, internet users, and mobile money users are more likely to multi-sim. However, text usage has no significant effects on the probability of multi-simming. These results seem to be partly driven by selection on demographics and the quality divide across markets. In fact, the marginal effects are reduced when controlling for residence (column (2)) or demographic variables (column (3)). Province and residence-type fixed effects also control for providers' service quality across markets.

After controlling for both demographics and residence (column (4)), the effects of internet and mobile money usage remain significant. Being a mobile money user increases the probability of using multiple SIMs by 28.2 percentage points, all else equal. Being an internet user increases this probability by 11.9 percentage points. I get similar results, when the sample is restricted to Orange and Onatel users (column 5) although both providers offer similar services (voice, text, internet, and mobile money).

These findings show that correlation in tastes across providers may not be completely ruled out, given that controlling for demographics changes the coefficients of the internet and mobile money usage dummies. These results also suggest that consumption synergies across providers cannot be ruled out, since the service one consumes can predict whether one multi-sims.

**Multi-simmers spread services across the providers they subscribe to:** Panel A of Table 4 displays the proportion of multi-simmers using the same providers for some combination of services used. Among multi-simmers, 73.59% use at least two services. The right-hand table in Panel A shows that, among those, only 30.12% use the same providers for all their services. While 75.65% of users of text and voice services use the same providers for both, only 29% use

Table 3: Linear probability model of multi-simming

| | *Dependent variable: Multi-simming indicator* | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Minutes of voice | 0.005** | 0.005** | 0.002 | 0.002 | 0.001 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) |
| Text usage | 0.047 | 0.026 | 0.060 | 0.040 | 0.054 |
| | (0.035) | (0.031) | (0.037) | (0.033) | (0.041) |
| Internet usage | 0.176*** | 0.152*** | 0.137*** | 0.119*** | 0.101*** |
| | (0.026) | (0.025) | (0.029) | (0.026) | (0.034) |
| Mobile money usage | 0.314*** | 0.322*** | 0.273*** | 0.282*** | 0.263*** |
| | (0.040) | (0.035) | (0.041) | (0.035) | (0.037) |
| Age:[25,50) | | | 0.061 | 0.073** | 0.042 |
| | | | (0.039) | (0.037) | (0.041) |
| Age:[50,85] | | | 0.073 | 0.081 | 0.044 |
| | | | (0.061) | (0.050) | (0.054) |
| Residence type: informal settlement | | −0.024 | −0.023 | −0.008 | −0.021 |
| | | (0.036) | (0.038) | (0.034) | (0.033) |
| **Controls** | | | | | |
| Other demographics | | | × | × | |
| Province fixed effects | | × | | × | × |
| Sample of providers | all | all | all | all | Telecel excluded |
| Observations | 1,794 | 1,794 | 1,794 | 1,794 | 1,277 |
| $R^2$ | 0.185 | 0.293 | 0.223 | 0.325 | 0.270 |

*Notes*: This table reports the estimated linear probability model, with the dependent variable taking the value 1 if the consumer uses multiple providers and 0 otherwise. The demographic variables include: gender (two categories), occupation (nine categories), and education (five categories). *p<0.1; **p<0.05; ***p<0.01. Province-level clustered standard errors are in brackets. The minutes of voice are estimated by dividing the monthly expenditure by the average voice price index across providers. Observations with extreme values for this variable (96 in total) are dropped during the estimation.

the same providers for communication (voice or text) as for internet.

The left-hand side table in Panel A of Table 4 also shows that multi-simmers are more likely to use multiple providers for text and voice. Among multi-simmers, almost all voice consumers (97.69%) and most text consumers (79.17%) use multiple providers for both services. However, only 26.98% of multi-simmers who consume internet rely on multiple providers. This means that the majority, 73.02%, of multi-simmers who consume internet rely on a single provider among those they subscribe to for internet service. This proportion is 62.2% for mobile money. Consistently, Panel B shows that multi-simmers are less likely to report indifference between their providers for internet than for voice or text.

These results show that consumers perceive differences in internet and mobile money services offered by different providers. The most common habit among multi-simmers is to use communication (voice and text services) with all providers they subscribe to, while choosing one provider for internet and mobile money services. The results are consistent with consumers spreading their demand across different providers. Ilembo and Walwa (2022) found similar results for Tanzanian consumers.

Table 4: Descriptive statistics about multi-simming

*Panel A: Service consumption among multisimmers*

| Share (%) using multiple providers for: | | Proportion (%) using the same set of providers for: | |
|---|---|---|---|
| Voice | 97.69 | All | 30.12 |
| Text | 79.17 | Voice & Text | 75.65 |
| Internet | 26.98 | (Voice or Text) & internet | 29 |
| Mobile money | 37.80 | | |

*Panel B: Indifference between all SIM cards for each service among multisimmers with :*

| | 2 providers | 3 providers |
|---|---|---|
| Voice | 75.20 | 64.45 |
| Text | 64.3 | 50.52 |
| Internet | 20.54 | 7.20 |

*Notes*: Statistics reported in this table are computed on multi-simmers only (consumers who subscribe to more than one provider). Panel A (left-hand side) reports, among multi-simmers who consume each service, the share relying on more than one provider for that service. Panel A (right-hand side) reports, for multi-simmers using the relevant service combinations, the share that rely on the same set of providers across those services. "All" refers to all services used by the consumer; "Voice & Text" compares the providers used for voice and for text; "(Voice or Text) & internet" compares the providers used for communication (voice or text) with those used for internet. Panel B reports the proportion of multi-simmers who report being indifferent between their providers for a given service, separately for multi-simmers subscribing to two and three providers. Indifference is based on a survey question allowing multiple preferred-provider responses per service.

**Internet and mobile money service usage with a provider appears to be related to its competitiveness:** Table 5 shows that, conditional on subscribing to multiple providers, consumers do not use providers equally for their internet and mobile money services. For all bundles including Orange, internet users favor Orange over Onatel, most markedly when Orange and Onatel are the only two providers held. Similarly, Onatel is more popular than Telecel for internet among consumers with a bundle involving both Telecel and Onatel. This ordering is consistent with Orange's higher-quality positioning relative to Onatel, and with Onatel's relative to Telecel. This result is inconsistent with usage being independent of relative price and quality, as would be expected under pure correlation in tastes.

If anything, the recurring promotions that characterize the Burkinabe market strengthen this interpretation: consumers face frequent, salient opportunities to reallocate their usage toward whichever provider currently offers the best deal. In such an environment, one would expect multi-simmers to report using all of their SIM cards for internet. Yet the ranking documented in Table 5 remains stable across all bundles. This stability suggests that consumers are

responding to a persistent quality positioning rather than to short-term price discounts. This further supports the idea that usage is related to providers' relative competitiveness.

Table 5 also reveals a similar pattern for mobile money. It is important to note that during the period covered by the survey, Telecel did not offer a mobile money service. Only Orange Money and Mobicash (Onatel) were available. Conditional on using Orange, users overwhelmingly rely on it for mobile money, consistent with Orange Money's leading position among the two available providers. Unlike internet, however, a substantial share of multi-simmers report using both Orange and Onatel for mobile money: 40.6% among two-SIM Orange-Onatel holders, rising to 53.8% among three-SIM holders. Mobile money is a network service, and Orange Money and Mobicash were not interoperable over this period. Consumers wishing to reach counterparties on both networks therefore had to hold an account with each, rather than choose one over the other.

Table 5: Combination of providers for internet and mobile money

| *Panel A: 2 SIM cards with Orange and Onatel* | | | | |
|---|---|---|---|---|
| | Internet | | Mobile money | |
| | % subscribers | % users | % subscribers | % users |
| No usage | 40.72 | – | 23.88 | – |
| Only Orange | 30.24 | 51.0 | 44.15 | 58.01 |
| Only Onatel | 15.12 | 25.5 | 0.10 | 0.23 |
| Both | 13.90 | 23.4 | 31.78 | 41.76 |
| *Panel B: 2 SIM cards with Orange and Telecel* | | | | |
| | % subscribers | % users | % subscribers | % users |
| No usage | 45.37 | – | 20.16 | – |
| Only Orange | 41.17 | 75.4 | 79.83 | 100 |
| Only Telecel | 5.88 | 10.8 | – | – |
| Both | 7.56 | 13.8 | – | – |
| *Panel C: 2 SIM cards with Onatel and Telecel* | | | | |
| | % subscribers | % users | % subscribers | % users |
| No usage | 48.14 | – | 88.89 | – |
| Only Onatel | 38.88 | 75.0 | 11.10 | 100 |
| Only Telecel | 3.70 | 7.1 | – | – |
| Both | 9.25 | 17.8 | – | – |
| *Panel D: 3 SIM cards* | | | | |
| | % subscribers | % users | % subscribers | % users |
| No usage | 25.30 | – | 9.33 | – |
| Only Orange | 24.09 | 32.2 | 41.56 | 45.8 |
| Only Onatel | 18.67 | 25.0 | 0.30 | 0.3 |
| Only Telecel | 4.21 | 5.6 | – | – |
| Orange + Onatel | 15.96 | 21.4 | 48.79 | 53.8 |
| Orange + Telecel | 3.31 | 4.4 | – | – |
| Onatel + Telecel | 1.80 | 2.4 | – | – |
| Onatel + Telecel + Orange | 6.62 | 8.9 | – | – |

*Notes*: Each panel reports the combinations of providers through which internet and mobile money services are used, computed for multi-simmers who subscribe to the corresponding set of providers. The “% subscribers” columns report shares among consumers who subscribe to exactly the panel’s set of providers. The "% users" columns renormalize this share among the subset who use the service, and therefore sum to 100 within each panel and service. "No usage" has no "% users" counterpart by construction.

# 4 Model

The previous analysis shows that consumers subscribe to multiple providers and that their usage may be consistent with synergy in consumption. However, these results are insufficient to conclude that consumers use providers as if they complement each other. In fact, this definition is tied to negative compensated cross-price elasticities between providers (Gentzkow, 2007; Dubé, 2019). A structural model is therefore important to compute cross-price elasticities. In addition, the reduced-form analysis leaves little room to account for unobserved characteristics of consumers and providers. These controls are important for identifying true complementarity between providers.

## 4.1 Model presentation

The environment consists of $J$ providers, each offering $L$ services (calls, text, internet) in $M$ markets. Without loss of generality, all providers supply the same service types, which may differ in quality. Mobile money consumption is not explicitly modeled because of data limitation[15]. In this environment, the consumer makes two sequential decisions. The first decision is the discrete choice of the bundle of providers to subscribe to. The consumer's second decision is to determine her demand for all services in her bundle.

The notation $\mathscr{B}$ denotes the set of bundles of two or more providers from the set of available providers $\mathscr{J} = \{1, 2, \ldots, J\}$. I further assume that subscribing to a provider gives access to all its services.

**Discrete choice of the bundle of providers:** This first step corresponds to choosing which providers to subscribe to. In the model, consumers choose a single bundle of providers among all available combinations $b \in \mathscr{B} \cup \mathscr{J} \cup \{0\}$, where bundle $b = 0$ is the outside option. In this environment, choosing the outside option is equivalent to choosing none of the providers[16]. I assume that conditional on choosing a bundle, consumers purchase a single SIM card from each provider included in their chosen bundle. This assumption is consistent with the figures

[15] In the empirical analysis, I consider mobile money usage with any provider as a consumer characteristic.

[16] In the empirical analysis, the set of consumers choosing the outside option is assumed to coincide with the set of individuals who do not own a mobile phone.

in Panel B of Table 2, showing that most consumers do not purchase multiple SIM cards from the same provider.

The utility gained by consumer $i$ in market $m$ for choosing bundle $b \in \mathscr{B} \cup \mathscr{J} \cup \{0\}$ is:

$$U_{ibm} = \begin{cases} \varepsilon_{i0m} & \text{if } b = 0, \\ \delta_b + \mu_{ibm} + \varepsilon_{ibm} & \text{if } b \in \mathscr{J}, \\ \sum_{j \in b}(\delta_j) + \mu_{ibm} + \Gamma_{ib} + \varepsilon_{ibm} & \text{otherwise.} \end{cases} \tag{2}$$

Plan fixed effects $(\delta_j)_j$ are common to all plan users and capture unobserved plan quality as well as costs such as those related to the SIM card purchase[17][18].

The synergy parameter $\Gamma_{ib}$ is meant to capture the utility gains consumer $i$ gets from multi-simming. As in Iaria and Wang (2019a), Hawthorne and Grzybowski (2025), and Thomassen et al. (2017), I assume this parameter is heterogeneous across consumers. In this framework, the multi-simming gains are bundle-specific and depend on consumers' observed and unobserved characteristics, $z_i^{\gamma}$ and $\varsigma_i$ respectively:

$$\Gamma_{ib} = \begin{cases} \Gamma_b + \gamma_1 z_i^{\gamma} + \gamma_2 \varsigma_i & \text{if } b \in \mathscr{B}, \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

where $\varsigma_i$ is an i.i.d standard normal shock.

Finally, $\mu_{ibm} = u_{ibm} + \sum_{j \in b}\left(\bar{\mu} z_i^{money} + \eta_{ij}\right)$ with $\boldsymbol{\eta} = (\eta_{ij})_j \sim \mathcal{N}(0, \Sigma)$ and $\Sigma$ is a symmetric matrix of dimension $J$ and $z_i^{money}$ equal to 1 if consumer $i$ reports being a mobile money service user and 0 otherwise. $\varepsilon_{ij}$ is assumed to have an extreme value distribution. $u_{ibm}$ is the utility gain from service usage, which follows from optimal service consumption.

**Choice of the optimal vector of consumption conditional on the chosen bundle:** Conditional on choosing provider $j$, consumer $i$ in market $m$ selects the optimal service levels that

[17]The SIM card price may also be viewed as the provider-specific access fee required to use that provider's services. This lump-sum cost may affect the discrete choice of the bundle but does not influence service usage intensity once the subscription is completed.

[18]An alternative formulation could be $\delta_j = \alpha_0 p_{0j} + b + \xi_j$ such that $\alpha_0$ is the SIM card price coefficient and $p_{0j}$ the SIM-card price. In the empirical analysis, the SIM card price does not vary across providers, which makes the parameter $\alpha_0$ unidentifiable.

maximize a quadratic utility function:

$$\boldsymbol{q}_{ijm} = \text{argmax}_{\boldsymbol{x}\in\mathbb{R}_+^L}(\boldsymbol{\omega}_{ijm} - \alpha_i \boldsymbol{p}_j)'\boldsymbol{x} - \frac{1}{2}(\boldsymbol{x})'\boldsymbol{\Lambda}\boldsymbol{x}. \tag{4}$$

where $\boldsymbol{p}_j \equiv (p_{jl})_{l=1...L}$ is the vector stacking prices of all services offered by provider $j$; $\boldsymbol{\omega}_{ijm} \equiv (\omega_{ijlm})_{l=1...L}$ is the vector stacking all preference shocks for services available from $j$ and $\boldsymbol{q}_{ijm} \equiv (q_{ijlm})_{l=1...L}$, the vector stacking all optimal consumption levels for the services offered by provider $j$.

The quadratic function is a widely used functional form in empirical studies of telecommunications because it flexibly captures the substitution patterns between services. As in Thomassen et al. (2017) and Chen et al. (2019), I explicitly add non-negativity constraints to allow for corner solutions.

$\boldsymbol{\Lambda} = (\Lambda_{ll'})_{l,l'=1...L}$ is an $L \times L$ symmetric matrix whose diagonal elements scale services' own-price effects. The off-diagonal element $\Lambda_{ll'}$ is related to the relationship between services $l$ and $l'$ of the same provider. The marginal utility of service $l$ is given by:

$$\omega_{ijlm} - \alpha_i p_{jl} - \sum_{l'} \Lambda_{ll'} x_{ijl'm} \, . \tag{5}$$

Therefore, negative values of $\Lambda_{ll'}$ positively affect the marginal utility of service $l$, all else equal, which implies a consumption synergy between the two services $l$ and $l'$. This matrix is assumed to be provider-invariant for tractability[19]. The price coefficient $\alpha_i$ is assumed to have a log-normal distribution with parameters $(\bar{\alpha}, \sigma_\alpha)$.

Each component of the vector of preference shocks $\boldsymbol{\omega}_{ijm} = (\omega_{ijlm})_{l=1...L}$ is defined as follows:

$$\omega_{ijlm} = \beta_{jl} + \beta_3^l(\boldsymbol{\beta}_1 \boldsymbol{z}_i^\omega + \beta_2 F_{jlm}) \, . \tag{6}$$

The provider-service fixed effects $(\beta_{jl})_{l=1...L}$ are common to all consumers and capture unobserved shocks such as service-specific firms' discount practices or quality, network effects, etc.

[19]The model can be extended to allow for provider-specific own- and cross-price effects. However, identifying each matrix requires observing detailed consumption within each provider.

The vector $z_i^{\omega}$ contains consumers' observed demographics that affect taste correlations across services. $F_{jlm}$ is the market-provider and service-specific quality measure extracted from survey responses. The parameter $(\beta_3^l)_{l=1,...L}$ is a service-specific scaling parameter.

Finally, the optimal demand for service $l$ for the product $j$ is given by:

$$q_{ijlm} = \max\{0, \frac{1}{\Lambda_{ll}}(\omega_{ijlm} - \alpha_i p_{jl} - \sum_{l' \neq l} \Lambda_{ll'} q_{ijl'm})\} \ . \tag{7}$$

The indirect utility of the continuous choice conditional on choosing provider $j$ is :

$$u_{ijm} = \max_{\boldsymbol{x} \in \mathbb{R}_+^L} (\boldsymbol{\omega}_{ijm} - \alpha_i \boldsymbol{p}_j)' \boldsymbol{x} - \frac{1}{2}(\boldsymbol{x})' \boldsymbol{\Lambda} \boldsymbol{x} \ .$$

The indirect utility of the continuous choice conditional on choosing $b$ is assumed to be additively separable in the providers included in bundle $b$:

$$u_{ibm} = \sum_{j \in b} u_{ijm} \ . \tag{8}$$

Unlike Thomassen et al. (2017), the model allows consumers to purchase the same service from multiple providers. This aligns with the reduced-form analysis, which shows that most consumers use communication services from all the providers they subscribe to.

**Consumption synergies in the model:** This model distinguishes two types of consumption synergies, each related to the two steps of consumer choice. The discrete choice synergy parameter $\Gamma_{ib}$ captures the utility gains from multi-simming. Consumer $i$ gains from multi-simming if $\Gamma_{ib} > 0$, and losses if $\Gamma_{ib} < 0$. If $\Gamma_{ib} = 0$, then consumer $i$ experiences neither an additional gain nor an additional loss from multi-simming. In such a case, her choice of whether or not to multi-sim is fully driven by correlation in tastes for providers. Correlation in tastes for providers is captured by the off-diagonal entries of the covariance matrix $\Sigma$ of provider-specific shocks $(\eta_j)_j$. In this model, both the synergy parameter $\Gamma_{ib}$ and the covariances across providers' shocks in $\Sigma$ drive the multi-simming behavior.

The second type of synergy considered here is continuous-choice synergy, which operates conditional on the bundle choice. It captures utility gains from jointly using multiple services

from the same provider. As noted above, the off-diagonal entries of matrix $\Lambda$ capture synergies across services from the same provider. These parameters help identify whether or not services from the same provider are substitutes or complements. If $\Lambda$ is a diagonal matrix, services from the same provider are independent. In that case, consumption of multiple services from the same provider is fully explained by correlated tastes for services driven by consumers' observed and unobserved characteristics, respectively, $z_i^{\omega}$ and $\alpha_i$.

The model assumes that, conditional on choosing bundle $b \in \mathscr{B}$, the bundle's overall gain is additively separable across the gains from each of its component providers (equation 8). One implication of this assumption is that conditional on multi-simming, consumers do not adjust their service usage across providers. The separability assumption is consistent with tariff-mediated network effects for text and voice services. Consumers use each provider they subscribe to to contact that provider's other subscribers. However, this restriction may not hold for internet usage. In fact, the previous section shows that conditional on holding multiple providers, internet usage across providers is consistent with substitution and sub-additivity with respect to internet consumption. Another implication is that, at the individual level, gains from multi-simming are restricted to gains from providers' joint subscription $\Gamma_{ib}$ and are independent of service usage intensity. I use this restriction because of data limitations. Unfortunately, the survey does not record service usage disaggregated by provider, which is necessary to identify level-specific synergies across providers (Gentzkow, 2007; Chen et al., 2019).

However, allowing heterogeneous price sensitivity and discrete synergies yields richer substitution patterns within and across providers. The price sensitivity parameter $\alpha_i$ is assumed to be log-normally distributed. The discrete choice synergy parameter is also flexibly estimated via observed and unobserved consumer characteristics.

## 4.2 Choice outcomes

The set of parameters to be estimated is: $\boldsymbol{\theta} = (\boldsymbol{\theta^d}, \boldsymbol{\theta^c})$ such that $\boldsymbol{\theta^d} \equiv (\boldsymbol{\delta}, \boldsymbol{\Gamma}, \Sigma)$ affect the discrete choice and $\boldsymbol{\theta^c} \equiv (\bar{\alpha}, \sigma_\alpha, \beta_{jl}, \beta_1, \beta_2, \beta_3, \Lambda)$ affect the continuous choice. $\boldsymbol{\delta} \equiv (\delta_j)_{j \in \mathscr{J}}$ is the vector of plan fixed effects and $\boldsymbol{\Gamma} \equiv ((\Gamma_b)_b, \gamma_1, \gamma_2)$ are the discrete choice synergy parameters. The vector of unobservables $\boldsymbol{\pi_i} = ((\eta_{ij})_j, \alpha_i, \varsigma_i)$ is assumed independent of demographics with a CDF $G(\cdot)$. The vector of the consumer's observed characteristics is $\boldsymbol{z_i} = (\boldsymbol{z_i^{\omega}}, z_i^{money})$.

The probability for consumer $i$ in market $m$ to choose bundle $b$ is then:

$$P_{bm}(\boldsymbol{\theta}, \boldsymbol{z_i}) = \int \frac{\exp(\delta_b + \mu_{ibm} + \Gamma_{ib})}{1 + \sum_{b' \in \mathscr{B} \cup \mathscr{J}} \exp(\delta_{b'} + \mu_{ib'm} + \Gamma_{ib'})} dG(\boldsymbol{\pi}|\theta) \ . \tag{9}$$

The probability of provider $j$ being chosen by consumer $i$ in market $m$ is therefore:

$$P_{jm}(\boldsymbol{\theta}, \boldsymbol{z_i}) = \sum_{b \in \mathscr{B} \cup \mathscr{J} : j \in b} P_{bm}(\theta, z_i) \ . \tag{10}$$

The market share of bundle $b$ and product $j$ are respectively:

$$s_{bm}(\boldsymbol{\theta}) = E\left(P_{bm}(\boldsymbol{\theta}, \boldsymbol{z_i})\right) \text{ and} \tag{11}$$

$$s_{jm}(\boldsymbol{\theta}) = \sum_{b \in \mathscr{B} \cup \mathscr{J} : j \in b} s_{bm}(\boldsymbol{\theta}) \ . \tag{12}$$

The expected demand for service $l$ of product $j$ and the total demand for service $l$ by consumer $i$ are given by:

$$q_{jlm}(\boldsymbol{\theta}, \boldsymbol{z_i}) = \int \sum_{b \in \mathscr{B} \cup \mathscr{J} : j \in b} q^b_{ijlm} \frac{\exp(\delta_b + \mu_{ibm} + \Gamma_{ib})}{1 + \sum_{b' \in \mathscr{B} \cup \mathscr{J}} \exp(\delta_{b'} + \mu_{ib'm} + \Gamma_{ib'})} dG(\boldsymbol{\pi}|\theta), \tag{13}$$

$$q^T_{lm}(\boldsymbol{\theta}, \boldsymbol{z_i}) = \sum_{j \in \mathscr{J}} q_{jlm}(\boldsymbol{\theta}, \boldsymbol{z_i}) \ . \tag{14}$$

The probability of $i$ consuming service $l$ of product $j$ is:

$$P_{jlm}(\boldsymbol{\theta}, \boldsymbol{z_i}) = \int \sum_{b \in \mathscr{B} \cup \mathscr{J} : j \in b} \mathbb{I}_{q^b_{ijlm} > 0} \frac{\exp(\delta_b + \mu_{ibm} + \Gamma_{ib})}{1 + \sum_{b' \in \mathscr{B} \cup \mathscr{J}} \exp(\delta_{b'} + \mu_{ib'm} + \Gamma_{ib'})} dG(\boldsymbol{\pi}|\theta) \ . \tag{15}$$

# 5 Estimation

The empirical application uses a sample of 1890 users, with $J = 3$ providers offering $L = 2$ services (a composite communication service and an internet service) across $M = 13$ markets.

## 5.1 Estimation strategy

The model is estimated using the method of simulated moments because the estimation is computationally costly. This follows from the requirement to solve the consumer problem for each draw of the preference shocks. Unlike maximum likelihood, the simulated method of moments is consistent with a fixed number of draws [20]. The idea is to find the vector $\theta$ that best matches the predicted moments to their empirical counterparts. Three sets of moments were used.

**Market shares** The first set of moments matches the predicted (Equation (12)) and observed market shares for each provider.

$$g_1(\theta) = (s_{jm}(\boldsymbol{\theta}) - s^0_{jm}), \quad \forall\ m = 1 \cdots M, j = 1 \cdots J\ . \tag{16}$$

The integrals in the market share expression were evaluated using draws from the empirical demographic distribution. The survey interviewed only providers' subscribers, i.e a selected group[21]. As in Berry et al. (2004), I evaluated the choice probabilities using demographic distributions from a representative survey of the population. In my case, the EHCVM 2021 survey provides demographic distributions from a representative sample of the population [22]. This survey also defines the outside-option market share, i.e the share of individuals aged 15 and above who do not own a mobile phone.

**Choice moments** The second set of moments matches probabilities of non-zero service usage and consumers' subscription choices. It is expected that:

$$\begin{aligned} &E(Y_{bjm}(\boldsymbol{\theta}, \boldsymbol{z_i}) - Y^*_{ibjm} | \boldsymbol{X}^p_{ibm}) = 0, \\ &E(Y_{bjlm}(\boldsymbol{\theta}, \boldsymbol{z_i}) - Y^*_{ibjlm} | \boldsymbol{X}^{pc}_{ibjlm}) = 0\ . \end{aligned} \tag{17}$$

[20] See Train (2009) chapter 10 for further discussion.

[21] Table 12 in Appendix A compares the demographic distribution from the sample to the 2019 census and mobile phone owners from EHCVM.

[22] Each variable is assumed to follow a multinomial distribution with parameters estimated from the EHCVM.

where $Y^*_{ibjm}$ is a dummy for the usage of product $j$ in bundle $b$, $Y^*_{ibjlm}$ is a dummy for the usage of service $l$ of product $j$ in bundle $b$ and $\boldsymbol{X}^{p}_{ibm}$ and $\boldsymbol{X}^{pc}_{ibjlm}$ are vectors of exogenous consumers and service characteristics. $Y_{bjlm}$ and $Y_{bjm}$ are such that:

$$
\begin{aligned}
Y_{bjlm}(\boldsymbol{\theta}, \boldsymbol{z_i}) &= \int \mathbb{I}_{q^b_{ijlm}>0} \frac{\exp(\delta_b + \mu_{ibm} + \Gamma_{ib})}{1 + \sum_{b' \in \mathscr{B} \cup \mathscr{J}} \exp(\delta_{b'} + \mu_{ib'm} + \Gamma_{ib'})} dG(\pi|\theta), \\
Y_{bjm}(\boldsymbol{\theta}, \boldsymbol{z_i}) &= \int \mathbb{I}_{j \in b} \frac{\exp(\delta_b + \mu_{ibm} + \Gamma_{ib})}{1 + \sum_{b' \in \mathscr{B} \cup \mathscr{J}} \exp(\delta_{b'} + \mu_{ib'm} + \Gamma_{ib'})} dG(\pi|\theta) \ .
\end{aligned}
$$

The moment conditions used for estimation are then:

$$
g_{i2}(\boldsymbol{\theta}) = \begin{pmatrix} \sum_b \boldsymbol{X^p_{ibm}} (Y_{bjm}(\boldsymbol{\theta}, \boldsymbol{z_i}) - Y^*_{ibjm}) \\ \sum_b \boldsymbol{X^{pc}_{ibjlm}} (Y_{bjlm}(\boldsymbol{\theta}, \boldsymbol{z_i}) - Y^*_{ibjlm}) \end{pmatrix} . \tag{18}
$$

The empirical counterpart of the moment conditions is: $g_2(\boldsymbol{\theta}) = N^{-1} \sum g_{i2}(\boldsymbol{\theta})$ where $N$ is the sample size.

**Total expenditure on each service :** The third moment matches observed and predicted expense for each service:

$$
g_{i3}(\theta) = \boldsymbol{X}^D_{im} \left( D^T_{lm}(\boldsymbol{\theta}, \boldsymbol{z_i}) - D^{T*}_{ilm} \right) \Rightarrow g_3(\theta) = N^{-1} \sum g_{i3}(\theta) \ . \tag{19}
$$

where $N$ is the sample size, and $D^T_{lm}(\boldsymbol{\theta}, \boldsymbol{z}_i) = \sum_j p_{jl} q_{jlm}(\boldsymbol{\theta}, \boldsymbol{z}_i)$ and $D^{T*}_{ilm}$ are the predicted and observed total expenditure on service $l$, and $\boldsymbol{X}^D_{im}$ is a vector of exogenous consumer and service characteristics.

**GMM objective** The estimation consists of solving the following problem:

$$
\begin{aligned}
\hat{\boldsymbol{\theta}} &= \text{argmin}_{\boldsymbol{\theta}} \left[ g(\boldsymbol{\theta})' W^{-1} g(\boldsymbol{\theta}) \right] \\
g(\boldsymbol{\theta}) &= \begin{pmatrix} g_1(\boldsymbol{\theta}) & g_2(\boldsymbol{\theta}) & g_3(\boldsymbol{\theta}) \end{pmatrix}^T
\end{aligned} \tag{20}
$$

with $W^{-1}$ a weighting matrix[23].

[23] I use the standard two steps GMM estimation. The integrals were approximated using the quasi-Monte Carlo approach with R=5 draws per observation. Following Thomassen et al. (2017), I corrected for simulation noise by multiplying the variance estimates by the factor $1 + \frac{1}{R}$. See Train (2009) and the references therein for more details.

I end up with 184 moment conditions to estimate 40 parameters.

## 5.2 Identification

Provider fixed effects $\delta$ are market invariant and can be identified from market shares (Berry et al., 1995; Iaria and Wang, 2019a).

The demographic variables in $z_i^{\omega}$ used for the service preference shocks include age, sex, education, and residence type. Those variables were also included $\boldsymbol{X}_{ibjlm}^{pc}$ in addition to the quality index. $\boldsymbol{X}_{ibm}^{p}$ includes demographics, the bundle average quality index, as well as the number of providers in the bundle and a dummy for mobile money usage. $\boldsymbol{X}_{ilm}^{D}$ consists of demographics. These variables are important for identifying the coefficients on the continuous preference shocks, $\beta_1, \beta_2, \beta_{jl}$, as well as the parameter $\bar{\mu}$ (Conlon and Gortmaker, 2025; Thomassen et al., 2017).

It is worth noting that there are two parameters governing price effects described by $\alpha_i$ and $\boldsymbol{\Lambda}$. The first parameter, $\alpha_i$, affects both discrete and continuous choices. The second parameter $\boldsymbol{\Lambda}$ drives within-provider price effects conditional on the discrete choice. The diagonal entries of $\boldsymbol{\Lambda}$ scale services' own price effects. The identification of these price effects relies on variation in prices across providers and in expenses across consumers. As in Thomassen et al. (2017) and in Chen et al. (2019), I use product and service fixed effects to deal with price endogeneity. As in Thomassen et al. (2017), I include the bundles' average prices in $X_{ibm}^{p}$ and prices in $X_{ibjlm}^{pc}$ to identify the price parameters. I further interact consumer demographics in $\boldsymbol{X}_{ilm}^{D}$ with expenses in service $l$.

In my particular context with $L = 2$ services, the off-diagonal parameter of $\Lambda$ is related to the cross-price derivative of the compensated demand whose sign[24] indicates Hicksian complementarity or substitutability:

$$\frac{\partial x_{ij1m}}{\partial p_{j2}} = -\frac{\Lambda_{12}}{\Lambda_{11}} \frac{\partial x_{ij2m}}{\partial p_{j2}}.$$

A positive sign indicates substitutability; a negative sign indicates complementarity; and zero indicates independence between the two services. The main challenge is to identify this

[24]The parameter $\Lambda_{11}$ which captures the own-price effect is negative.

parameter separately from the correlation in preferences for the two services, since both may generate joint consumption. Conditional on the chosen bundle, taste correlation across providers comes from consumers' observed and unobserved characteristics. This issue also exists at the discrete dimension because both $\mathbf{\Gamma}$ and $\mathbf{\Sigma}$ drive multi-simming. Observing, for example, that *Orange* and *Telecel* are regularly used together may signal a non-zero synergy parameter across the two providers, captured in $\mathbf{\Gamma}$. It may also be a sign of a significant correlation in the taste for the two providers, captured by the off-diagonal entries of $\mathbf{\Sigma}$. Without additional information, the two parameters cannot be separately identified.

Gentzkow (2007) suggests exploiting exclusion conditions to separately identify synergies and correlated tastes. The idea is to rely on variation in variables that affect, for example, the attractiveness of one alternative without directly affecting the utility gain from the other alternatives[25]. Those variables are expected to affect the likelihood of the corresponding goods being matched with other goods only through their effects on the likelihood of choosing them. This strategy is also exploited by Hawthorne and Grzybowski (2025), Chen et al. (2019) and Sinkinson (2020).

The present paper relies on provider-service-specific prices and market-provider-service-specific quality indices to identify the off-diagonal parameters of $\mathbf{\Lambda}$. These variables are assumed to affect the attractiveness of the related service but do not enter the utility gained from using other services of the same provider or from other providers. The excluded variables are also helpful to identify discrete choice synergy parameters $\Gamma$ since they do not enter the utility of competing providers. Mobile-money usage is also limited to the utility of providers offering the service. Indeed, only Orange and Onatel provide mobile money services. Thus, mobile money usage is indicative of owning a SIM card from one of the two providers[26].

Demographic variables, mobile money usage, and average prices and quality indices are therefore included in $\boldsymbol{X}^{p}_{ibm}$. In addition, both a provider's own prices and quality indices, as well as the prices and quality indices of competing firms, are included in $\boldsymbol{X}^{pc}_{ibjlm}$. The demographics included in $\boldsymbol{z}^{\gamma}_{i}$ are age and residence type, as suggested by industry sources.

[25] See Allen and Rehbeck (2020) for recent identification results and further discussion.

[26] This intuition is further confirmed by Agbo and Zabsonré (2022), who established a positive relationship between network size and mobile money adoption among Orange customers in Burkina Faso. The study further shows that this indirect effect is substantially higher than the effect of the provider's size on mobile money users.

It is important to know that the resulting complementarity or substitutability of providers and services should be interpreted conditional on the set of alternative options available in the market. Empirical tests of complementarity for two goods become challenging when those goods are also related to other products[27] (Gentzkow, 2007; Manzini et al., 2018). This is due to the fact that observed cross-price elasticity between two goods is confounded by the indirect link between each good and other related products, including unobserved options within the outside option [28]. Gentzkow (2007) proposes to use exclusion conditions to control for observed related goods. Gentzkow (2007) highlighted that the observed synergies between goods should be interpreted as conditional on the related goods in the outside option since those included in the outside option cannot be controlled for.

# 6 Results

## 6.1 Estimation and model fit

Estimation results for the continuous and discrete components of the model are reported in Tables 6 and 7. The quality index entering service preferences is significant with the expected positive sign: higher quality of internet and communication services is associated with higher marginal values of usage. The coefficient on the mobile money dummy also has the expected positive sign: people value using mobile money.

Several demographic variables entering service preferences are statistically significant. Adults aged 25 to 49 and seniors aged 50 and over, on average, have a higher marginal value for communication and internet services than people aged 15 to 24. The results also indicate that higher education levels are generally associated with higher marginal valuation of mobile service usage, and men place a higher value on mobile service usage than women do. These findings are consistent with the demographic component of the digital divide in the use of telecommunications services documented in Africa and Burkina Faso (Afrobarometer, 2022; GSMA Intelligence, 2020; Institut National de la Statistique et de la Démographie (INSD) and ICF, 2023).

[27] See Gentzkow (2007) and the references therein for more discussion.

[28] Samuelson's example cited by Gentzkow (2007) illustrated this issue: " ...suppose that the cross-partial of utility is negative for coffee and tea, positive for tea and cream, and positive but smaller for coffee and cream. Then coffee and cream will be substitutes by the standard Hicksian definition."

The coefficient $\alpha_i$ captures sensitivity to service prices. Both the mean and the standard deviation of this parameter's distribution are significant, indicating substantial heterogeneity across consumers.

The scaling parameters for service own- and cross-price effects in $\Lambda$ are also significant. The positive cross-price effect $\Lambda_{12}$ between internet and communication indicates substitutability between the two services. This result is consistent with the popularity of over-the-top messaging services such as WhatsApp and Messenger.

Table 6: Estimation results for SIM card-choice parameters

| Parameter | Estimate | Std. Error |
|---|---|---|
| **Mobile money usage $\bar{\mu}$** | 0.235*** | (0.087) |
| **Covariance of taste for providers** | | |
| Orange $\Sigma_{11}$ | 42.837** | (17.968) |
| Telecel $\Sigma_{22}$ | 23.439* | (12.177) |
| Onatel $\Sigma_{33}$ | 46.511** | (19.935) |
| Orange-Telecel $\Sigma_{12}$ | 26.575** | (12.013) |
| Orange-Onatel$\Sigma_{13}$ | 26.911*** | (10.177) |
| Onatel-Telecel $\Sigma_{23}$ | 21.016** | (9.183) |
| **Provider-level synergy** | | |
| *Intercept* $\Gamma_b$ | | |
| Orange Telecel $\Gamma_1$ | 3.693*** | (1.281) |
| Orange-Onatel $\Gamma_2$ | 5.881*** | (1.612) |
| Onatel-Telecel $\Gamma_3$ | 3.893*** | (1.375) |
| Orange-Onatel-Telecel $\Gamma_4$ | 0.091 | (1.667) |
| *Random component* $\gamma_2$ | 5.674*** | (1.596) |
| *Demographics* $\gamma_1$ | | |
| Residence type: Informal settlement | 2.468** | (1.049) |
| Age: 25-49 | 2.093** | (0.944) |
| Age: 50+ | 5.972*** | (1.338) |
| **Provider fixed effects:** | | |
| Orange $\delta_1$ | -5.219*** | (1.198) |
| Telecel $\delta_2$ | -7.493*** | (1.507) |
| Onatel $\delta_3$ | -4.244*** | (1.021) |

*Notes*: Standard errors are reported in parentheses. Following Thomassen et al. (2017), they are computed using the formulas in Wooldridge (2002:p. 423). Because integrals are evaluated with only $R = 5$ simulation draws per observation, the variance is multiplied by $1 + 1/R = 1.2$ to account for simulation noise (McFadden, 1989). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 7: Estimation results for service-usage parameters

| Parameter | Estimate | Std. Error |
|---|---|---|
| **Quality index**: $\beta_2$ | 4.131*** | (1.248) |
| **Provider-service fixed effects:** | | |
| *Communication:* | | |
| Scaling parameter $\beta_3^1$ | 2.183*** | (0.577) |
| Orange $\beta_{11}$ | 3.054 | (4.059) |
| Telecel $\beta_{21}$ | 0.762 | (3.732) |
| Onatel $\beta_{31}$ | 4.309 | (3.262) |
| *Internet:* | | |
| Scaling parameter $\beta_3^2$ | 1.498*** | (0.041) |
| Orange $\beta_{12}$ | 3.761 | (4.140) |
| Telecel $\beta_{22}$ | 3.975 | (20.882) |
| Onatel $\beta_{32}$ | 3.024*** | (0.150) |
| **Demographics:** $\beta_1$ | | |
| *Residence type*: Informal settlement | 0.159 | (1.571) |
| *Age*:15-24 | | |
| $25-49$ | 2.646* | (1.558) |
| 50+ | 4.226** | (1.679) |
| *Gender:* Male | 5.869** | (2.420) |
| *Education* :No formal education | | |
| Primary level | 1.885 | (2.345) |
| Post-primary level | 5.871* | (3.552) |
| Secondary level | 6.940*** | (1.901) |
| Higher level | 2.305 | (2.935) |
| **Price effect** | | |
| *Overall price effect* | | |
| Mean $\log(\alpha_i) = \bar{\alpha}$ | 1.429*** | (0.348) |
| Sd $\log(\alpha_i) = \sigma_\alpha$ | 2.518*** | (0.099) |
| *Services own and cross price effects*: $\Lambda$ | | |
| Communication $\Lambda_{11}$ | 62.911*** | (3.371) |
| Internet $\Lambda_{22}$ | 78.299*** | (11.122) |
| Internet-communication $\Lambda_{12}$ | 40.819*** | (7.554) |

*Notes*: Standard errors are reported in parentheses. Following Thomassen et al. (2017), they are computed using the formulas in Wooldridge (2002:p. 423). Because integrals are evaluated with only $R = 5$ simulation draws per observation, the variance is multiplied by $1 + 1/R = 1.2$ to account for simulation noise (McFadden, 1989). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 6 reports the covariance matrix $\Sigma$ driving correlations in preferences across providers

and the provider-level synergy parameters $\Gamma$, both of which influence the frequency of multi-simming. The off-diagonal elements of the covariance matrix $\Sigma$ are precisely estimated and positive. Synergy-related parameters $\Gamma$ are also generally significant and positive. This indicates that both correlation in tastes and consumption synergies contribute to multi-simming. Figure 5 reports the estimated distributions of the individual synergy parameters $\Gamma_{ib}$, which capture the utility gains from multi-simming. Table 8 reports the sample average and standard deviation of individual-level synergy by bundle and demographic variables.

Figure 5 shows substantial heterogeneity in multi-simming gains across consumers. The last row of Table 8 reports the probability of drawing a negative synergy value $\Gamma_{ib}$, reflecting losses from multi-simming. We conclude that a positive draw is more likely, suggesting consumers are more likely to gain from multi-simming. Figure 5 also shows that the best combination of providers is Orange and Onatel since this bundle provides higher gains from multi-simming. However, adding Telecel to this combination substantially reduces the benefits of multi-simming. Notably, this latter combination offers the lowest potential gains. This may reflect higher multi-simming costs for three providers than for two. Since most smartphones support only two SIM cards, using a third one typically requires a second handset, which adds a fixed cost[29]. Finally, all pairs involving Telecel show similar gains because their intercepts are close.

Figure 5: Distribution of the gains from multi-simming by bundle

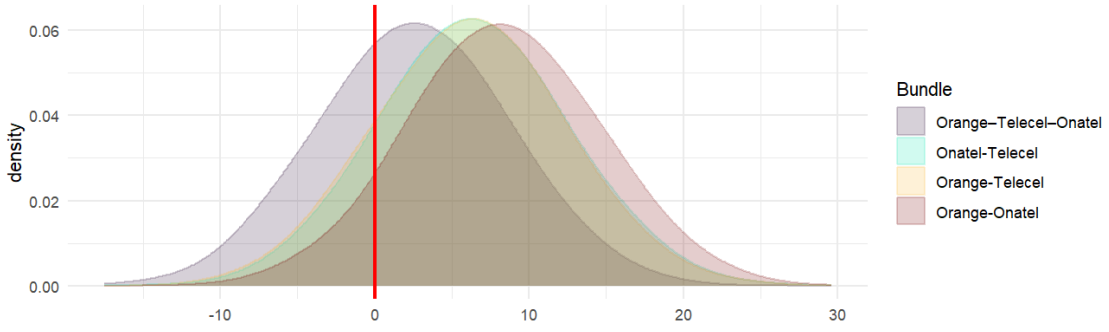



Table 8 displays the sample average and standard deviation of individual-level synergy by

[29]Over 2019–2020, Transsion brands (Tecno, Infinix, itel) and Samsung accounted for 74–79% of mobile web page views from identified devices in Burkina Faso (StatCounter). This reflects the popularity of these brands whose entry-level models are dual-SIM.

bundle and demographic variables. Age positively affects the gain from multi-simming. Adults aged 25 to 49 and seniors aged 50 and over, on average, gain more from subscribing to multiple providers than people aged 15 to 24. Consumers living in informal settlements gain more from multi-simming[30].

Table 8: Estimated Gamma parameters

| | | Orange-Telecel | Orange-Onatel | Onatel-Telecel | All the three |
|---|---|---|---|---|---|
| *By type of residence* | | | | | |
| Formal settlement | Average | 5.622 | 7.583 | 5.883 | 1.920 |
| | S.D. | 5.913 | 5.907 | 5.818 | 5.942 |
| Unformal settlement | Average | 7.845 | 10.609 | 7.809 | 4.461 |
| | S.D. | 5.770 | 5.780 | 6.078 | 5.725 |
| *By age group* | | | | | |
| [15,25) | Average | 4.316 | 6.483 | 4.476 | 0.664 |
| | S.D. | 5.741 | 5.777 | 5.731 | 5.757 |
| [25,50) | Average | 6.435 | 8.609 | 6.621 | 2.832 |
| | S.D. | 5.743 | 5.844 | 5.716 | 5.793 |
| [50,85] | Average | 10.305 | 12.390 | 10.573 | 6.641 |
| | S.D. | 5.811 | 5.777 | 5.816 | 5.797 |
| *Overall* | | | | | |
| | Average | 6.185 | 8.350 | 6.371 | 2.564 |
| | S.D. | 5.954 | 6.019 | 5.943 | 5.989 |
| | $\Pr(\Gamma_{ib} < 0)$ | 0.149 | 0.083 | 0.142 | 0.334 |

*Notes:* This Table reports the sample average and standard deviation of the individual-level synergy parameter $\Gamma_{ib}$ by residence type, age group, and overall.

**Model fit:** To assess the model fit, three sets of statistics are computed and reported in Table 9. The first set of indicators, computed at the market level, includes the mobile penetration rate and the proportion of multi-simmers. The mobile penetration rate is defined as the share of the population subscribing to mobile services. Panel A reports the average and median values of both statistics computed across the $M = 13$ markets. In Panel B, the same exercise is repeated using providers' market shares. The last set of indicators corresponds to providers'

[30]One may wonder whether the estimated synergies across providers arise from unobserved related goods included in the outside option, such as fixed-line services or broadband, for which we are unable to control. For example, Orange and Onatel may be used together only because they both complement fixed-line services. Fixed-line services and broadband penetration rates were lower than 1% in 2020 [31]. These small penetration rates may make them unlikely to drive observed synergies.

market shares among service users. Overall, the model can reproduce the patterns observed in the data.

It is important to note that neither the share of multi-simmers (Panel A) nor the service-specific provider market shares (Panel C) were targeted moments in the estimation. However, the model's predictions are close to the observed values for both indicators.

Table 9: Model Fit

*Panel A: Market participation and multi-simming*

| | Average | | Median | |
|---|---|---|---|---|
| | Obs. | Pred. | Obs. | Pred. |
| Mobile penetration rate: $\sum_{b\in\mathcal{J}\cup\mathcal{B}} s_{bm}(\theta)$ | 0.699 | 0.613 | 0.723 | 0.614 |
| Share of multi-simmers: $\sum_{b\in\mathcal{B}} s_{bm}(\theta)$ | 0.573 | 0.533 | 0.611 | 0.531 |

*Panel B: Provider market shares (unconditional)*

| | Average | | Median | |
|---|---|---|---|---|
| | Obs. | Pred. | Obs. | Pred. |
| Orange | 0.547 | 0.533 | 0.573 | 0.527 |
| Telecel | 0.221 | 0.105 | 0.245 | 0.091 |
| Onatel | 0.471 | 0.523 | 0.477 | 0.528 |

*Panel C: Service extensive margins (unconditional)*

| | Obs. | Pred. |
|---|---|---|
| Communication | | |
| Orange | 0.438 | 0.445 |
| Telecel | 0.180 | 0.101 |
| Onatel | 0.382 | 0.454 |
| Internet | | |
| Orange | 0.546 | 0.644 |
| Telecel | 0.069 | 0.017 |
| Onatel | 0.385 | 0.339 |

*Notes*: Averages and medians are computed across the 13 markets. Service extensive margins in Panel C report the distribution of internet/communication users (non-zero demand for that service) across providers. Median and average are not reported since the distribution is aggregated at the sample level.

## 6.2 Price elasticities

Using the estimates, I compute consumers' reactions to changes in service prices. I compute three types of elasticities and report their average across markets in Table 10.

Panel (a) presents the subscription price elasticity, averaged across markets. This elasticity captures how changes in service prices affect each provider's subscription probability. Panel (b) reports each service's unconditional extensive-margin elasticity, averaged across markets. These elasticities capture both bundle switching at the discrete-choice margin and service-adoption switching within and across providers, conditional on that discrete choice. Panel (c) shows the total demand elasticities, which further incorporate changes in usage intensity. As expected, the own-price elasticities are negative and have larger absolute values than the cross-price elasticities. Panels (b) and (c) support the conclusion that consumers are more sensitive to internet price changes than to communication price changes. They also confirm that internet and communication from the same provider are substitutes. However, this substitution is asymmetric, with internet being a better substitute for communication than the reverse.

Overall, the subscription elasticities, in Panel (a), indicate that subscription probabilities are not highly sensitive to service prices. This may reflect the nature of prepaid plans: holding a SIM card involves no usage commitment. Therefore, consumers can respond to price changes by adjusting their usage rather than dropping their subscription. Although these elasticities are small in magnitude, their sign may help explain substitution between firms. The positive cross-price elasticities between Telecel and each of Orange and Onatel suggest that Telecel acts as a substitute for the two largest providers. For both pairs of providers, a price increase by one provider brings subscribers to the other, and therefore increases the latter's service usage, at both the adoption and usage-intensity margins (Panels (b) and (c)). Orange and Onatel have negative cross-price elasticities at the subscription, service adoption, and usage-intensity margins, suggesting that consumers use them together. This implies that an increase in Onatel's (resp. Orange's) service prices negatively affects Orange's (resp. Onatel's) market share and service usage, consistent with gains from using both providers.

The model also allows me to decompose consumers' response to prices along each step of the choice process: which provider(s) to subscribe to, which services to use, and how much

of each service to consume once subscribed. In Table 14 in Appendix B, I decompose each provider-service pair's own-price elasticity (the diagonal entries in Panel (c) of Table 10) into a subscription-choice elasticity, an extensive-margin elasticity capturing service adoption conditional on subscription, and an intensive-margin elasticity capturing usage intensity conditional on both subscription and service adoption. The figures in Table 14 show that consumers respond mainly on the adoption margin. In response to higher service prices, they stop using that provider's service rather than reducing their total usage. This finding is consistent with the fact that consumers have several alternatives to providers' services. First, multi-simming lets consumers shift usage across providers at negligible cost, since they already have multiple SIM cards. Second, even if they subscribe to a single provider, consumers can substitute between communication and internet services within that provider.

Table 10: Price effects

(a) Subscription price elasticity

| | Orange | | Telecel | | Onatel | |
|---|---|---|---|---|---|---|
| Demand for *SIM card* | Com. price | Int. price | Com. price | Int. price | Com. price | Int. price |
| Orange | -0.0399 | -0.0192 | 0.0134 | 0.0000 | -0.0113 | -0.0014 |
| Telecel | 0.0480 | 0.0274 | -0.2378 | -0.0011 | 0.0652 | 0.0078 |
| Onatel | -0.0097 | -0.0042 | 0.0146 | 0.0000 | -0.0476 | -0.0053 |

(b) Service extensive-margin unconditional elasticities

| | Orange | | Telecel | | Onatel | |
|---|---|---|---|---|---|---|
| Demand for *service* | Com. price | Int. price | Com. price | Int. price | Com. price | Int. price |
| *Orange* | | | | | | |
| Communication | -0.7120 | 0.1647 | 0.0130 | 0.0000 | -0.0104 | -0.0016 |
| Internet | 0.4074 | -0.8391 | 0.0131 | 0.0000 | -0.0109 | -0.0015 |
| *Telecel* | | | | | | |
| Communication | 0.0444 | 0.0274 | -0.6826 | 0.0057 | 0.0619 | 0.0101 |
| Internet | 0.0114 | 0.0209 | 0.3339 | -1.3120 | 0.0208 | 0.0353 |
| *Onatel* | | | | | | |
| Communication | -0.0077 | -0.0044 | 0.0151 | 0.0000 | -0.5111 | 0.0874 |
| Internet | -0.0110 | -0.0062 | 0.0148 | 0.0001 | 1.6973 | -1.7464 |

(c) Service unconditional elasticities

| | Orange | | Telecel | | Onatel | |
|---|---|---|---|---|---|---|
| Demand for *service* | Com. price | Int. price | Com. price | Int. price | Com. price | Int. price |
| *Orange* | | | | | | |
| Communication | -0.8205 | 0.3323 | 0.0125 | 0.0000 | -0.0107 | -0.0016 |
| Internet | 0.5582 | -1.1287 | 0.0127 | 0.0000 | -0.0104 | -0.0018 |
| *Telecel* | | | | | | |
| Communication | 0.0434 | 0.0270 | -0.7410 | 0.0472 | 0.0621 | 0.0100 |
| Internet | 0.0113 | 0.0207 | 0.7269 | -1.4673 | 0.0196 | 0.0435 |
| *Onatel* | | | | | | |
| Communication | -0.0075 | -0.0044 | 0.0152 | 0.0000 | -0.5866 | 0.0998 |
| Internet | -0.0103 | -0.0059 | 0.0151 | 0.0001 | 2.2689 | -2.5803 |

*Notes:* Columns report elasticities with respect to the communication (Com.) and internet (Int.) service prices of each provider. Rows report the provider-service pair for which demand is measured, grouped by provider and service type. All elasticities in Panels (b) and (c) are *unconditional*, computed with respect to the full market population rather than conditional on SIM card ownership or service adoption. Panel (b) captures the probability of using a service (extensive margin); Panel (c) captures usage intensity (intensive margin).

# 7 Counterfactual analysis

## 7.1 Provider's problem

I assume a Nash-Bertrand game where providers take the SIM-card price as given and set service prices to maximize their total profit at the national level. Provider $j$ 's total profit is given by:

$$\begin{aligned} \pi_j(\boldsymbol{p},\hat{\theta}) &= \sum_l (p_{jl} - c_{jl})\, Q_{jl}(\boldsymbol{p}) \;+\; (p_{j0} - c_{j0})\, N_j(\boldsymbol{p}) \\ Q_{jl}(\boldsymbol{p}) = \sum_{m=1}^{M} \sum_{i=1}^{N_m} q_{jlm}(\hat{\theta}, \boldsymbol{z}_i); &\quad N_j(\boldsymbol{p}) = \sum_{m=1}^{M} \sum_{i=1}^{N_m} P_{jm}(\hat{\theta}, \boldsymbol{z}_i) \end{aligned} \tag{21}$$

$Q_{jl}(\boldsymbol{p})$ and $N_j(\boldsymbol{p})$ denote respectively the national sales of service $l$ and SIM cards from provider $j$ as functions of on the prices vector $\boldsymbol{p}$; $(c_{j0})_{j\in\mathscr{J}}$ denotes SIM card marginal costs and $(p_{j0})_{j\in\mathscr{J}}$ denotes SIM card prices.

The derivative of the profit function with respect to provider $j$'s service $l$ price gives the following first-order conditions:

$$\frac{\partial \Pi_j}{\partial p_{jl}} = Q_{jl}(\boldsymbol{p}) + \sum_{l'=1,2} (p_{jl'} - c_{jl'}) \frac{\partial Q_{jl'}(\boldsymbol{p})}{\partial p_{jl}} + (p_{j0} - c_{j0}) \frac{\partial N_j(\boldsymbol{p})}{\partial p_{jl}} = 0 \tag{22}$$

Finally, stacking these equations for all provider-service pairs gives the following system:

$$\boldsymbol{Q} \;+\; \big(\boldsymbol{\Omega} \circ \Delta \boldsymbol{Q}\big)'(\boldsymbol{p} - \boldsymbol{c}) \;+\; \big(\boldsymbol{S} \circ \Delta \boldsymbol{N}\big)'(\boldsymbol{p}_0 - \boldsymbol{c}_0) \;=\; \boldsymbol{0} \tag{23}$$

where $\boldsymbol{Q}$, $\boldsymbol{p}$ and $\boldsymbol{c}$ are $JL$-vectors of service quantities, prices and marginal costs; $\boldsymbol{p}_0$ and $\boldsymbol{c}_0$ are $J$-vectors of SIM card prices and costs; $\Delta\boldsymbol{Q}$ is the $JL \times JL$ demand Jacobian matrix $\partial Q_r / \partial p_s$; $\Delta\boldsymbol{N}$ is the $J \times JL$ subscription jacobian matrix with elements $\partial N_k / \partial p_s$; $\boldsymbol{\Omega}$ is the $JL \times JL$ ownership matrix ($\Omega_{rs} = 1$ if services $r$ and $s$ belong to the same provider); and $\boldsymbol{S}$ is the $J \times JL$ matrix with $S_{ks} = 1$ if service $s$ is offered by provider $k$. SIM card prices $\boldsymbol{p}_0$ are taken as given[32].

[32] See Appendix B for details on marginal costs recovery.

## 7.2 Shutting down multi-simming

To evaluate the welfare gain of multi-simming, I compare the welfare I obtain from my estimates with the welfare computed from a counterfactual environment where I shut down multi-simming. This exercise restricts the choice set to single-provider bundles in $\mathscr{J}$. Using equation (22), I recompute the new equilibrium prices, assuming the change in choice set does not affect firms' conduct.

Telecel's recovered internet marginal cost is negative, possibly because it is estimated on a small cell (1.6% of consumers, with usage about 5 to 19 times lower than Orange's and Onatel's). I therefore exclude this service from price optimization and hold its price at the observed level. Since shutting down multi-simming makes consumers concentrate all their consumption with a single provider, it increases providers' market power and puts upward pressure on prices. By not allowing Telecel's internet price to adjust, the counterfactual may therefore underestimate the welfare loss from the shutdown.

**Price effects** Panel B of Table 11 shows that without multi-simming, prices rise substantially, especially for communication. Communication prices increase by 229% to 360%, against 79% to 180% for internet. By locking each consumer into a single provider, shutting down multi-simming gives each provider more market power. Onatel's and Telecel's total profits rise, while Orange's falls by 12.5%.

Table 20 in Appendix C decomposes the change in total profit into profit from service consumption and profit from SIM-card sales. Since consumers no longer purchase multiple SIM cards in the counterfactual, SIM-card profit falls by 57% to 88% for all providers. Changes in service profit, especially internet, therefore drive the overall changes in profits. Despite the drop in total usage, conditional internet usage increases for all providers[33]. Two forces may explain this pattern. First, consumers who previously split their internet use across several providers must now concentrate it on a single provider. Second, the subscribers who remain may be heavier internet users.

Together, these results show that multi-simming disciplines prices, as providers compete for service usage by consumers they share with their rivals. Multi-simming also raises SIM-card

[33] see Panel B of Table 19 for change in usage.

sales, but for Onatel and Telecel this gain does not offset the lower service margins it imposes. Without multi-simming, Onatel's total profit would be 128% higher. Telecel's profit would also increase by 72.9%. Orange is the only provider that benefits from multi-simming as it generates more usage of its internet service and therefore a higher profit.

Table 11: Market response to the single-operator counterfactual: demand, prices, and welfare

*Panel A: Market shares and penetration (baseline vs. counterfactual)*

| | Orange | Telecel | Onatel | Mobile penetration rate |
|---|---|---|---|---|
| Baseline | 0.744 | 0.158 | 0.695 | 0.853 |
| Counterfactual | 0.318 | 0.020 | 0.277 | 0.614 |
| Change | −0.426 | −0.138 | −0.418 | −0.239 |

*Panel B: Firm response, prices and profits*

| | Δ Communication price (%) | Δ Internet price (%) | Δ Total profits (FCFA) | Δ Total profits (%) |
|---|---|---|---|---|
| Orange | 228.817 | 78.942 | −22,711,039.586 | −12.464 |
| Telecel | 334.593 | 0.000[a] | 150,799,302.587 | 72.996 |
| Onatel | 359.676 | 180.063 | 22,115,010.576 | 128.037 |

*Panel C: Substitution patterns among multi-SIM users (%)*

| Base bundle | Orange | Telecel | Onatel | Outside option |
|---|---|---|---|---|
| Orange–Telecel | 50.877 | 1.754 | — | 47.368 |
| Orange–Onatel | 23.186 | — | 42.478 | 34.336 |
| Telecel–Onatel | — | — | 33.333 | 66.667 |
| Orange–Telecel–Onatel | 62.857 | 0.635 | 36.508 | — |

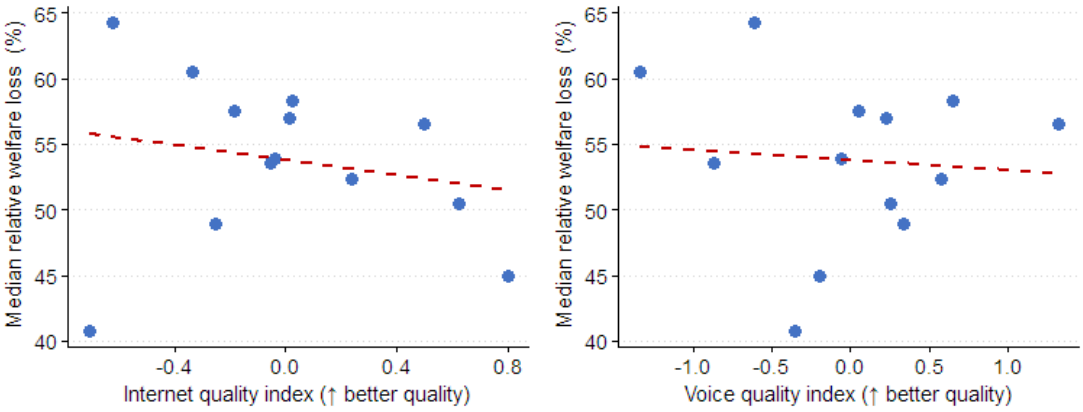
*Panel D: Consumer surplus variation (FCFA)*

| | Mean | Median | Total |
|---|---|---|---|
| $\Delta CS$ | −54,086.565 | −22,643.031 | −99,627,452.055 |
| $\Delta CS^{-\mathcal{B}}$ | −50,229.925 | −18,284.000 | −92,523,521.000 |

*Notes:* The counterfactual restricts each consumer to at most one SIM card and allows firms to re-optimize service prices in response. No sampling weights are applied. See Appendix C for the weighted estimates. Panel A reports average market shares and mobile penetration across the 13 markets. Panel B reports the % change in each firm's communication (voice and text services) and internet prices and in its total profits (service profits across both services plus SIM-card profits, summed across markets), relative to the observed level. Telecel's internet marginal cost is estimated on a thin cell (1.6% of consumers, with usage about 5–19 times lower than Orange's and Onatel's) and negative. This service was excluded from price optimization by holding its price at the observed level. Panel C reports the share (%) of multi-SIM holders in each baseline bundle who move to each single-operator option or exit the market under the restriction; "—" denotes a destination chosen by no multi-simmer in the sample. Panel D reports mean, median, and aggregate compensating variation (Small and Rosen, 1981), in FCFA, per individual for mean and median, and summed across the sample for the total. Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

**Mobile penetration** Panel A of Table 11 shows a substantial drop in mobile penetration in the counterfactual, from 85.3% to 61.4%, i.e. 23.9 percentage points. Panel A of Table 16 in Appendix C shows that, if providers kept their prices at observed levels, penetration would fall by

Figure 6: Relative welfare loss and service quality, by market




*Notes:* Each figure plots the corresponding service market quality level against the median relative welfare loss in the market. Each point is one of the 13 markets. The market quality level is defined as the average quality index of the corresponding service across providers. The vertical axis is the average absolute welfare loss from shutting down multi-simming.

14 percentage points. Moreover, Telecel nearly disappears in the counterfactual, with a market share of about 2%.

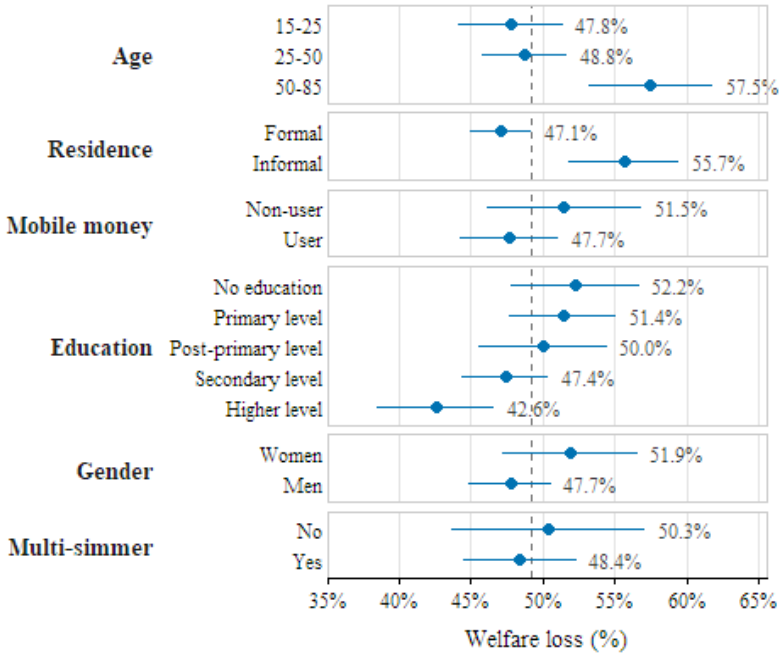
Together, these results show that multi-simming keeps 23.9% of the sample from leaving mobile services. More than half of this effect (14%) comes directly from access to multi-operator bundles. The remainder (9.9 %) reflects the price increases that follow the shutdown.

**Welfare gains from multi-simming** Panel D of Table 11 shows, in its first row, the consumer welfare[34] loss from shutting down multi-simming. The median consumer welfare loss of banning multi-simming is 22,643.031 FCFA per month (mean: 54,086.565 FCFA/month). In relative terms, the shutdown halves consumer welfare, which drops by 49.24%. I also evaluate the welfare loss directly stemming from the loss of alternatives, reported in the second row, $\Delta CS^{-\mathscr{B}}$[35]. In comparison, $\Delta CS^{-\mathscr{B}}$ represents 92.86% of the total welfare gain from multi-simming. This means most of the welfare benefit from multi-simming comes from the consumers' choice set expansion. The remaining 8% of the gains from multi-simming come from downward pressure on prices.

[34] See Appendix C for details about consumer surplus calculation.

[35] This welfare loss is computed as the change in consumer surplus from removing multi-operator bundles from the choice set, holding prices fixed at their observed levels.

Figure 7: Relative welfare loss by demographic group




*Notes:* Welfare loss from shutting down multi-simming, as a percentage of baseline consumer surplus. The dashed line represents the sample average of 49.5%. Both point estimates and 95% confidence intervals (bars) are represented with standard errors clustered by market.

**Who gains the most from multi-simming?** Figure 6 plots the average absolute welfare loss without multi-simming against the average quality index across operators for the 13 markets. This figure indicates that lower-quality service markets experience, on average, greater gains from multi-simming. This result is consistent with multi-simming serving as insurance against providers' lower quality (Piason and Peter, 2025).

Figure 7 displays the average relative welfare loss, as a percentage of baseline consumer surplus, by demographic group. Comparing this figure with Table 21 in Appendix C shows an interesting contrast. Women, less educated people, and older consumers (50-85), who have the lowest mobile service usage[36], experience larger relative losses. Shutting down multi-simming would therefore weigh proportionally more on groups that are already less connected. Taken together, these results indicate that multi-simming may mitigate existing geographic and demographic digital divides in Burkina Faso.

[36]See (Institut National de la Statistique et de la Démographie (INSD) and ICF, 2023; Afrobarometer, 2022) for more details on the digital divide in Burkina Faso and Africa

# 8 Conclusion

In this paper, I quantify the welfare gains from multiple subscriptions among mobile services consumers in Burkina Faso. As in many African economies, I find that multi-simming is common among consumers. Furthermore, consumers spread their consumption across the providers they subscribe to in such a way that providers complement each other.

My estimation results show that internet and communication services from the same provider are substitutes. This suggests that internet adoption may reduce communications revenue, as over-the-top messaging services substitute for providers' own communication services. I also find that the two largest providers act as complements, meaning consumers gain from using them together. Finally, service own-price elasticity suggests that consumers react to price changes by switching their consumption mainly to other services of their providers. The cannibalization effect across providers is therefore relatively low compared to within-provider services.

The counterfactual analysis indicates that multi-simming reduces digital divides by disciplining prices and allowing consumers to choose the best provider for each service. Therefore, any policy that makes multi-simming costlier, such as taxing SIM cards or limiting the number of SIM cards, would have substantial welfare effects.

Finally, these synergies across providers raise the question of whether market consolidation would benefit consumers. A merged firm would internalize them, which puts downward pressure on prices. However, because consumers respond to price changes mainly at the extensive margin, a merger would weaken the price-disciplining effect of multi-simming and increase the merged entity's market power. Evaluating the full welfare effects of such a merger is an avenue for future research.

More broadly, my results show that shutting down multi-simming reduces the welfare of mobile money users. Telecommunications regulation therefore also affects mobile money adoption and financial inclusion. In particular, the mobile money interoperability introduced in 2025 removes the need to hold several SIM cards to access different mobile money networks, and thus reduces consumers' incentives to multi-sim. Quantifying how interoperability affects mobile service usage and consumer welfare is a natural next step.

# References


Afrobarometer (2022). *Digital divide: Who in Africa is connected and who is not*. Afrobarometer Dispatch AD582. Consulté le 21 juin 2026. Afrobarometer.

Agbo, Maxime and Agnès Zabsonré (2022). *Mobile Phone Communication and Mobile Money Adoption in Burkina Faso: A Direct and Indirect Network Effects Analysis*. Rochester, NY.

Allen, Roy and John Rehbeck (2020). "Hicksian complementarity and perturbed utility models". *Economic Theory Bulletin* 8(2), pp. 245–261.

Andersson, Kjetil and Daniel Göller (2020). "Mobile Telephony in Emerging Markets: The Importance of Dual-SIM Phones". *Review of Network Economics* 19(3), pp. 189–219.

Autorité de Régulation des Communications Électroniques et des Postes (2021). *Rapport de l'enquête relative à l'expérience client des abonnés sur les services offerts par les opérateurs de communications électroniques au Burkina Faso*. Rapport d'enquête. Ouagadougou, Burkina Faso: Autorité de Régulation des Communications Électroniques et des Postes (ARCEP).

Berry, Steven, James Levinsohn, and Ariel Pakes (1995). "Automobile Prices in Market Equilibrium". *Econometrica* 63(4), pp. 841–890.

Berry, Steven, James Levinsohn, and Ariel Pakes (2004). "Differentiated Products Demand Systems from a Combination of Micro and Macro Data: The New Car Market". *Journal of Political Economy* 112(1), pp. 68–105.

Björkegren, Daniel (2022). "Competition in network industries: Evidence from the Rwandan mobile phone network". *The RAND Journal of Economics* 53(1), pp. 200–225.

Burkina24 (2023). *Téléphonie mobile au Burkina Faso: les bonus accordés par les opérateurs seront ouverts à tous les réseaux (ARCEP)*.

Chen, Liang, Yao Luo, and Ping Xiao (2019). "Estimating the Demand for Service Bundles under Three-Part Tariffs". en. *The Journal of Industrial Economics* 67(3-4), pp. 448–483.

Conlon, Christopher and Jeff Gortmaker (2025). "Incorporating Micro Data into Differentiated Products Demand Estimation with PyBLP". *Journal of Econometrics*, p. 105926.

Digital Business Africa (2023). *Burkina Faso: Moov Africa, Orange et Telecel offrent 10% du volume data de plus sur les forfaits classiques de connexion Internet mobile*.

Dubé, Jean-Pierre (2019). "Chapter 1 - Microeconometric models of consumer demand". *Handbook of the Economics of Marketing, Volume 1*. Ed. by Jean-Pierre Dubé and Peter E. Rossi. Vol. 1. Handbook of the Economics of Marketing. North-Holland, pp. 1–68.

Ershov, Daniel et al. (2025). "Estimating Complementarity With Large Choice Sets: An Application to Mergers". *The RAND Journal of Economics* 56(4), pp. 689–707.

Gentzkow, Matthew (2007). "Valuing New Goods in a Model with Complementarity: Online Newspapers". *American Economic Review* 97(3), pp. 713–744.

Grzybowski, Lukasz (2014). "Fixed-to-mobile substitution in the European Union". *Telecommunications Policy* 38(7), pp. 601–612.

Grzybowski, Lukasz, Valentin Lindlacher, and Onkokame Mothobi (2023). "Interoperability Between Mobile Money Agents and Choice of Network Operators: The Case of Tanzania". *Review of Network Economics* 22(1), pp. 27–52.

Grzybowski, Lukasz and Frank Verboven (2016). "Substitution between fixed-line and mobile access: the role of complementarities". *Journal of Regulatory Economics* 49(2), pp. 113–151.

GSMA (2020). *Access to Mobile Services and Proof of Identity: Global Policy Trends, Dependencies and Risks*. Tech. rep. GSMA, Mobile for Development.

GSMA Intelligence (2020). *The Mobile Economy Sub-Saharan Africa 2020*. London: GSM Association (GSMA).

Hasbi, Maude and Antoine Dubus (2020). "Determinants of mobile broadband use in developing economies: Evidence from Sub-Saharan Africa". *Telecommunications Policy* 44(5), p. 101944.

Haucap, Justus, Ulrich Heimeshoff, and Mehmet Karaçuka (2010). *Competition in the Turkish mobile telecommunications market: Price elasticities and network substitution*. Working Paper 12. DICE Discussion Paper.

Hawthorne, Ryan and Lukasz Grzybowski (2021). "Distribution of the benefits of regulation vs. competition: The case of mobile telephony in South Africa". *International Journal of Industrial Organization* 74, p. 102673.

Hawthorne, Ryan and Lukasz Grzybowski (2025). "Narrowing the "Digital Divide": The Role of Fixed and Mobile Infrastructure". *Journal of Economics & Management Strategy* 34(4). _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/jems.12622, pp. 799–829.

Iaria, Alessandro and Ao Wang (2019a). *Identification and Estimation of Demand for Bundles*. en. SSRN Scholarly Paper. Rochester, NY.

Iaria, Alessandro and Ao Wang (2019b). *Inferring Complementarity from Correlations rather than Structural Estimation*. en. SSRN Scholarly Paper. Rochester, NY.

Ilembo, Bahati and Jackson Walwa (2022). "Analysis of Multi-SIM Behaviour in Tanzania ' s Telecom Market Using Binary Logit Model". *Tanzania Journal of Development Studies* 20(1).

Institut National de la Statistique et de la Démographie (2022). *5e Recensement Général de la Population et de l'Habitation du Burkina Faso : Résultats définitifs – Volume 4 : Projections démographiques 2020–2035*. INSD.

Institut National de la Statistique et de la Démographie (2024). *Monographies régionales*. INSD.

Institut National de la Statistique et de la Démographie (INSD) and ICF (2023). *Enquête Démographique et de Santé du Burkina Faso 2021*. Rapport final FR378. Ouagadougou, Burkina Faso et Rockville, Maryland, USA: INSD et ICF.

L'Économiste du Faso (2025). *Communications électroniques: l'ARCEP impose 1 mois de validité pour 1Go et baisse le prix des SMS*.

Layton, Roslyn (2014). "The Prepaid Mobile Market in Africa". *The African Mobile Story*. Num Pages: 27. River Publishers.

Manzini, Paola, Marco Mariotti, and Levent Ülkü (2018). "Stochastic Complementarity". en. *The Economic Journal* n/a(n/a).

McFadden, Daniel (1989). "A Method of Simulated Moments for Estimation of Discrete Response Models Without Numerical Integration". *Econometrica* 57(5), pp. 995–1026.

Mvele, Sigismond Hervey, Larissa Ango Mengue, and Guy Christol Ekome Ekane (2019). "Multiple subscriptions to mobile networks and consumer satisfaction". *Journal of Retailing and Consumer Services* 47, pp. 375–381.

Ofcom (2011). *Wholesale Mobile Voice Call Termination: Statement*. London: Office of Communications (Ofcom).

Orange Burkina Faso (2026). *Orange Money – Paiement de facture*.

Piason, Viriri and Chimwanda Peter (2025). "Causes of Customer Switching Behaviour in the Zimbabwean Mobile Telecommunication Industry". *International Journal of Research and Review* 12(2), pp. 143–155.

Rencher, Alvin C and William F Christensen (2012). *Methods of Multivariate Analysis*. 3rd. Wiley: Hoboken, New Jersey.

Sanou, Soumanan (2015). "Étude des déterminants socio-économiques de l'adoption et de l'usage du mobile money au Burkina Faso". Directeur de mémoire : David Bounie. Mémoire de Mastère Spécialisé en Régulation du Numérique. Télécom ParisTech.

Sinkinson, Michael (2020). *Pricing and Entry Incentives with Exclusive Contracts: Evidence from Smartphones*. Rochester, NY.

Thomassen, Øyvind et al. (2017). "Multi-category Competition and Market Power: A Model of Supermarket Pricing". en. *American Economic Review* 107(8), pp. 2308–2351.

Train, Kenneth E. (2009). *Discrete Choice Methods with Simulation*. 2nd ed. Cambridge University Press.

Vélez-Velásquez, Juan Sebastián (2019). "Merger effects with product complementarity: Evidence from Colombia's telecommunications". *Information Economics and Policy* 49, p. 100831.

Weiergraeber, Stefan (2022). "Network Effects and Switching Costs in the U.s. Wireless Industry". *International Economic Review* 63(2), pp. 601–630.

Winter, J. C.F. de and D. Dodou (2012). "Factor recovery by principal axis factoring and maximum likelihood factor analysis as a function of factor pattern and sample size". *Journal of Applied Statistics* 39(4), pp. 695–710.

Wooldridge, Jeffrey M. (2002). *Econometric Analysis of Cross Section and Panel Data*. MIT Press: Cambridge, MA.

# Appendices

## A On data

### A.1 Sample calibration

Table 12 compares demographic statistics computed from the sample and the 2019 census. Females, people aged over 20, and educated inhabitants are overrepresented. I calculate calibrated weights to correct for sample selection so my sample represents mobile services users.

**Step 1. Finding the sampling weights from the official survey design.** The dataset does not include sampling weights. I reconstructed them using the official sample design. The survey was conducted before 2025 and therefore uses the former Burkinabe administrative division, which divided the country into 13 regions, 45 provinces, and 350 municipalities[37].

According to the survey report (Autorité de Régulation des Communications Électroniques et des Postes, 2021), the sample uses a semi-probabilistic, 4-stage design. However, it does not detail the sampling procedure at each stage. The report highlighted that the sample allocation across provinces was proportional to province size and population, using the official 2020 demographic projections. The communes covered by the survey in both capital cities were also selected based on lower-level administrative divisions within each city, such as municipalities, sectors, or villages. To ensure data confidentiality, ARCEP did not disclose lower-level units such as villages and sectors.

Given the available information in my dataset, I assume a two-step sampling process that involves stratification by the 45 provinces. I allocate the sample across provinces based on the number of municipalities and the province's total population. The primary sampling unit is the municipality within which a sample of users is drawn by simple random sampling. From the detailed administrative division, I compute the number of municipalities in each province. The

[37] In July 2025, Burkina Faso officially adopted a new administrative division.

population in municipality $c$ from region $r$ is defined as :

$$Pop_{cm} = Pop_m \times \text{weight of c's population in region } r$$

where $Pop_{im}$ and $Pop_m$ are the population sizes of the municipality and the region. I use the 2020 demographic projections to obtain the distribution of the Burkinabe population across regions (Institut National de la Statistique et de la Démographie, 2022). The weight of municipalities in their regions is derived from regional monographs (Institut National de la Statistique et de la Démographie, 2024). All these statistics are based on the 2019 census and published on the country's national statistics agency's website, *Institut National de la Statistique et de la Démographie*. The sampling weight is defined as:

$$\begin{aligned} W_{icp} &= \frac{1}{\pi_{icp}} \\ \pi_{icp} &= \frac{\#\text{covered municipalities of province } p}{\#\text{municipalities of province } p} \times \frac{\text{sample size in municipality c}}{\text{Population in municipality} c} \end{aligned} \tag{24}$$

**Step 2. Calibrated weights based on EHCVM** The idea is to compute calibrated weights such that the sample can exactly reproduce the marginal distributions of selected variables computed on the population of mobile services users. In this analysis, I use the number of mobile services users in each region. For each region, the number of mobile services users is computed from the population size (Institut National de la Statistique et de la Démographie, 2022) and the mobile penetration rate. The mobile penetration rate is approximated by the share of mobile phone owners computed from EHCVM 2021. Given the limited information about my survey design, estimates using these weights are only reported in the Appendix.

Table 12: Comparison of Survey data and official statistics

| | **Survey** | **official statistics**[1] | EHCVM (Mobile phone owners) |
|---|---|---|---|
| | | *Gender* | |
| Male | 35.76 | 53.4 | 50.47 |
| Female | 64.24 | 46.6 | 49.52 |
| | | *Age distribution* | |
| 15-24 | 27.39 | 35 | 27.41 |
| 25-49 | 64.04 | 47.65 | 55.5 |
| 50+ | 8.55 | 17.34 | 17.08 |
| **Average** | 34.25 | 32.90 | 35.39 |
| | | *Education* | |
| None (never attended) | 27.28 | 75.5 | 60.58 |
| Primary (including part) | 18.01 | 13.9 | 14.52 |
| Post-primary | 13.38 | 6.4 | 15.80 |
| Secondary | 29.59 | 2.3 | 5.94 |
| Tertiary (or Higher education) | 11.74 | 1.9 | 3.15 |
| | | *SIM-based market shares (%)* | |
| Onatel | 38.58 | 42.24 | |
| Orange | 44.42 | 44.60 | |
| Telecel | 17 | 14.58 | |

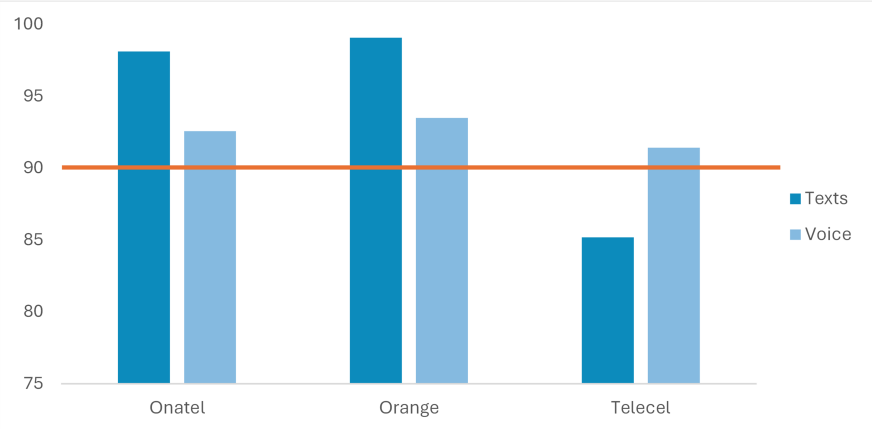
[1] Source for demographic statistics: *Institut National de la Statistique et de la Démographie*, population aged 15 and over, Burkina Faso (census 2019). Sources for market shares: *Autorité de Régulation des Communications Électroniques et des Postes*.

Table 13: Services prices and expenditure

| *Panel A: Spending (FCFA)* | | | |
|---|---|---|---|
| Voice & Text | | Internet | |
| Share of text service users (%) | 47.49 | Share of users (%) | 49.4 |
| Share of voice service users (%) | 99.89 | Average monthly spending | 7179.42 |
| Average monthly spending | 43835.85 | SD of monthly expenditure | 13484.26 |
| SD of monthly expenditure | 725922.61 | | |

Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor). In 2021, GDP per capita was 496 602 FCFA (World Bank: GDP per capita (current local currency) - Burkina Faso).

Figure 8: Share of on-net traffic in the total in 2020




*Notes:* This figure shows the share of on-net traffic in total traffic originated by each provider for the voice and text services.

# B Additional details on the model and estimation

## B.1 Price elasticity

The model decomposes consumers' reaction to price changes into three dimensions: subscription changes, extensive margins (service adoption) conditional on subscription, and intensive margins:

$$\underbrace{\bar{Q}_{jl}(p)}_{\text{Average demand for l}} = \underbrace{P_j(p)}_{\substack{\text{Subscribing} \\ \text{to } j}} \underbrace{P_{l|j}(p)}_{\substack{\text{Adopting service } l \\ \text{|Subscribing to } j}} \underbrace{Q_{l|l>0,j}(p)}_{\substack{\text{Average demand conditional} \\ \text{on adopting service } l \\ \text{and Subscribing to } j}} \tag{25}$$

Taking the log of this equation and differentiating with respect to the log of the price of service $l$ :

$$\underbrace{\frac{\partial \ln Q_{jl}}{\partial \ln p_l}}_{\xi^{\text{total}}} = \underbrace{\frac{\partial \ln P_j}{\partial \ln p_l}}_{\xi^{\text{subscription}}} + \underbrace{\frac{\partial \ln P_{l|j}}{\partial \ln p_l}}_{\xi^{\text{extensive|subscription}}} + \underbrace{\frac{\partial \ln Q_{l|l>0,j}}{\partial \ln p_l}}_{\xi^{\text{intensive|subscription, extensive}}},$$

Similarly, the unconditional elasticity of extensive margins depends on the subscription elasticity and service adoption conditional elasticity. Therefore, the elasticities related to the

three dimensions satisfy the following identities:

$$\xi_{jl}^{\text{total}} = \xi_{jl}^{\text{subscription}} + \xi_{jl}^{\text{extensive|subscription}} + \xi_{jl}^{\text{intensive|subscription,extensive}}, \tag{26}$$

$$\xi_{jl}^{\text{extensive unconditional}} = \xi_{jl}^{\text{subscription}} + \xi_{jl}^{\text{extensive|subscription}}. \tag{27}$$

I use these formulas to decompose total elasticities (Table 14).

Table 14: Decomposition of own-price elasticities: subscription, extensive, and intensive margins

| | Orange | | Telecel | | Onatel | |
|---|---|---|---|---|---|---|
| | Com. | Int. | Com. | Int. | Com. | Int. |
| *Panel A* | | | | | | |
| Total | -0.8205 | -1.1287 | -0.7410 | -1.4673 | -0.5866 | -2.5803 |
| Subscription | -0.0399 | -0.0192 | -0.2378 | -0.0011 | -0.0476 | -0.0053 |
| Extensive margin (unconditional) | -0.7120 | -0.8391 | -0.6826 | -1.3120 | -0.5111 | -1.7464 |
| *Panel B: Decomposition* | | | | | | |
| Subscription | -0.0399 | -0.0192 | -0.2378 | -0.0011 | -0.0476 | -0.0053 |
| Extensive margin (conditional) | -0.6720 | -0.8200 | -0.4448 | -1.3110 | -0.4635 | -1.7410 |
| Intensive margin (conditional) | -0.1085 | -0.2895 | -0.0584 | -0.1553 | -0.0755 | -0.8340 |
| Total | -0.8205 | -1.1287 | -0.7410 | -1.4673 | -0.5866 | -2.5803 |

*Notes:* Own-price elasticities decomposed by margin, for the Communication (Com.) and Internet (Int.) services of each provider. *Subscription* reports the subscription elasticity (Panel (a) of Table 10) with respect to that same provider's own price for that service (e.g., the Communication column uses the elasticity with respect to the provider's own communication price). *Extensive margin (unconditional)* is the own-price elasticity of the unconditional probability of consuming the service (Panel (b)). *Total* is the own-price elasticity of unconditional expected demand (Panel (c)). Panel B decomposes Total into three additive components: Subscription, Extensive margin (conditional) = Extensive (unconditional) − Subscription, and Intensive margin (conditional) = Total − Extensive (unconditional). The three sum exactly back to Total for every firm-service pair.

## B.2 Supply side

The SIM card marginal costs $(c_{j0})_{j\in\mathcal{J}}$ are fixed at their wholesale price level, while SIM card prices $(p_{j0})_{j\in\mathcal{J}}$ are fixed at their level observed at the time of the survey[38]. According to the market intelligence company IndexBox[39], wholesale prepaid SIM card prices range from 0.08

[38] In the model, the demand sensitivity with respect to SIM card prices is not explicitly modeled. This component is captured by the provider fixed effects $\delta = (\delta_j)_j$. In Burkina Faso, SIM card prices are market-invariant and identical across providers. Gentzkow (2007) also encounters a similar challenge: See Gentzkow (2007) for further discussion.

[39] see IndexBox's report

USD to 0.15 USD. The marginal cost is set to the lower bound of this range[40].

Marginal costs for services $(c_{jl})_{l=1,2}$ are also fixed according to industry standards. The marginal cost of providers' voice service is defined as the average of the off-net and on-net marginal costs of voice service, weighted by the share of each type of service in the corresponding firm's total traffic. The marginal cost of off-net calls is the termination rate, which is provider-invariant and regulated in Burkina Faso. In the telecommunications industry, the marginal cost of on-net calls is generally assumed to depend on network congestion and remains very low in the absence of congestion (Ofcom, 2011). Since I do not observe industry costs for internet services, I recover them by inverting the first-order condition of firms' profit-maximization problem.

Using the previously computed marginal costs, I first recompute the new equilibrium prices assuming the ban does not change firms' conduct. The idea is to find the price vector that satisfies firms' FOCs. In this framework, solving the FOC is computationally intensive because consumption has no closed-form expression. Therefore, each step requires evaluating optimal consumption from the consumer problem (Equation 4) for all draws of unobservables. Genetic algorithms are used to solve for the vector of prices that brings the first-order conditions the closest to zero.

[40] Both Orange and Onatel are affiliated with major multinational mobile groups operating across Africa. This affiliation may allow them to negotiate SIM card procurement contracts covering aggregate demand across all countries in which they operate, which could result in lower per-unit costs. robustness check in progress

Table 15: SIM card price, SIM card marginal cost, and internet marginal cost recovery (Nash-Bertrand scenario)

*Panel A: SIM card price and marginal costs from external sources (FCFA)*

| | Orange | Onatel | Telecel |
|---|---|---|---|
| Price | 500 | 500 | 500 |
| Cost | 50 | 50 | 50 |

*Panel B: Communication marginal costs from external sources*

| | Orange | Onatel | Telecel |
|---|---|---|---|
| Off-net marginal costs: Termination rate (FCFA/min) | 12.5 | 12.5 | 12.5 |
| On-net marginal costs: FCFA/min | 0 | 0 | 0 |
| On-net (off-net) share: % of total traffic | 94.49 (6.51) | 92.55 (7.45) | 91.41 (8.59) |
| Marginal cost: FCFA/min | 0.81 | 0.93 | 1.07 |

*Panel C: Internet marginal costs recovered from firms' profit maximization*

| | Orange | Onatel | Telecel[a] |
|---|---|---|---|
| Marginal cost (FCFA/G) | 169.31 | 566.04 | 159 134.67 |
| Lerner index | 0.860 | 0.300 | -130.820 |

Panel A reports SIM card price and marginal cost set to industry values: See IndexBox report for SIM card marginal costs. Panel B reports the components of communication service marginal costs. Communication marginal costs are defined as the average of on-net and off-net voice marginal costs weighted by their respective share within the providers' total traffic. The third row of the panel reports the on-net share, with the numbers in brackets representing the off-net shares. Panel C reports internet marginal costs recovered by inverting firms' first-order pricing conditions (FOC), under the assumption that the estimated demand and observed prices are consistent with a Nash-Bertrand equilibrium. [a] Telecel's internet marginal cost is estimated from a thin cell (1.6% of consumers, with usage about 5–19 times lower than Orange's and Onatel's) and should be interpreted with caution. Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

# C Counterfactual analysis

The variation in consumer $i$'s surplus is given by:

$$\Delta CS_i = E\left(\frac{\log\left(1+\sum_{b\in\mathscr{J}\cup\mathscr{B}} U^1_{ibm}(\pi_i)\right)-\log\left(1+\sum_{b\in\mathscr{J}\cup\mathscr{B}} U^0_{ibm}(\pi_i)\right)}{\alpha_i}\right) \tag{28}$$

where the integration is over the vector of unobservable $\boldsymbol{\pi_i} = (\alpha_i, (\eta_{ij})_j, \varsigma_{ib})$, $U^1_{ibm}$ and $U^0_{ibm}$ are the counterfactual and pre-counterfactual utility gained from choosing the bundle $b$.

To account for the role of $\boldsymbol{\pi_i} = (\alpha_i, (\eta_{ij})_j, \varsigma_{ib})$ in the bundle choices, the expectation is com-

puted using the distribution of unobservables conditional on the chosen bundle (Gentzkow, 2007). If consumer $i$ 's pre-counterfactual optimal bundle is $b$ , then her surplus is given by:

$$\Delta CS_i = \sum_{r=1}^{R} w_{ir} \frac{\log\left(1+\sum_{b\in\mathscr{J}\cup\mathscr{B}} U^1_{ibm}(\pi^r_i)\right) - \log\left(1+\sum_{b\in\mathscr{J}\cup\mathscr{B}} U^0_{ibm}(\pi^r_i)\right)}{\alpha_i} \tag{29}$$

$$w_{ir} = \frac{f(\pi^r_i) \times P_{bm}(\pi^r_i)}{\bar{P}_{bm}}, \quad \bar{P}_{bm} = R^{-1}\sum_r P_{bm}(\pi^r_i), \tag{30}$$

$$P_{bm}(\pi^r_i) = \frac{\exp(\delta_b + \mu_{ibm} + \Gamma_{ib})}{1+\sum_{b'\in\mathscr{B}\cup\mathscr{J}} \exp(\delta_{b'} + \mu_{ib'm} + \Gamma_{ib'})} \tag{31}$$

The total change in consumer surplus is then: $\Delta CS = \sum_i \Delta CS_i$.

In this Appendix, I report welfare figures extrapolated to the total population using calibrated weights.

Table 16: Consumers' response to the single-operator counterfactual without price adjustment, unweighted figures

*Panel A: Market shares and penetration (baseline vs. counterfactual)*

| | Orange | Telecel | Onatel | Mobile penetration rate |
|---|---|---|---|---|
| Baseline | 0.744 | 0.158 | 0.695 | 0.853 |
| Counterfactual | 0.343 | 0.035 | 0.334 | 0.710 |
| Change | −0.401 | −0.123 | −0.361 | −0.142 |

*Panel B: Substitution patterns among multi-SIM users (%)*

| Base bundle | Orange | Telecel | Onatel | Outside option |
|---|---|---|---|---|
| Orange–Telecel | 64.912 | 4.386 | — | 30.702 |
| Orange–Onatel | 24.071 | 1.062 | 58.938 | 15.929 |
| Telecel–Onatel | — | — | 58.333 | 41.667 |
| Orange–Telecel–Onatel | 50.159 | 0.635 | 49.206 | — |

*Panel C: Consumer surplus variation (FCFA)*

| | Mean | Median | Total |
|---|---|---|---|
| $\Delta CS^{-\mathscr{B}}$ | −50,229.925 | −18,283.599 | −92,523,521.206 |

*Notes:* This counterfactual restricts each consumer to at most one SIM card but holds all equilibrium prices fixed at their observed level (no firm re-optimization). No calibrated sampling weights are applied.
Panel B reports the share (%) of multi-SIM holders in each baseline bundle who move to each single-operator option or exit the market; "—" denotes a destination chosen by no multi-simmer in the sample.
Panel C reports mean, median, and aggregate compensating variation (Small and Rosen, 1981), in FCFA.
Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

Table 17: Consumers' response to the single-provider counterfactual without price adjustment, weighted figures

*Panel A: Market shares and penetration (baseline vs. counterfactual)*

| | Orange | Telecel | Onatel | Mobile penetration rate |
|---|---|---|---|---|
| Baseline | 0.749 | 0.166 | 0.699 | 0.871 |
| Counterfactual | 0.344 | 0.037 | 0.335 | 0.733 |
| Change | −0.404 | −0.129 | −0.364 | −0.137 |

*Panel C: Substitution patterns among multi-SIM users (%)*

| Base bundle | Orange | Telecel | Onatel | Outside option |
|---|---|---|---|---|
| Orange–Telecel | 70.897 | 3.202 | — | 25.901 |
| Orange–Onatel | 19.951 | 0.401 | 65.530 | 14.119 |
| Telecel–Onatel | — | — | 60.813 | 39.187 |
| Orange–Telecel–Onatel | 46.935 | 0.258 | 52.807 | — |

*Panel D: Consumer surplus variation (FCFA)*

| | Mean | Median | Total |
|---|---|---|---|
| $\Delta CS^{-\mathscr{B}}$ | −50,654.296 | −19,823.843 | −405,088,333,136.545 |

*Notes:* Same counterfactual as above (prices held fixed, no re-optimization), with calibrated sampling weights applied throughout. Panel B reports the weighted share (%) of multi-SIM holders in each baseline bundle who move to each single-operator option or exit the market; "—" denotes a destination chosen by no multi-simmer (by weight) in the sample.
Panel C reports weighted mean, median, and aggregate compensating variation, in FCFA.
Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

Table 18: Heterogeneous welfare effects of the no multi-SIM counterfactual without price adjustment

| | Unweighted | | Weighted | |
|---|---|---|---|---|
| | Mean $\Delta CS^{-\mathscr{B}}$ | Median $\Delta CS^{-\mathscr{B}}$ | Mean $\Delta CS^{-\mathscr{B}}$ | Median $\Delta CS^{-\mathscr{B}}$ |
| *All individuals* | −50,229.925 | −18,283.599 | −50,654.296 | −19,823.843 |
| *By multi-SIM status* | | | | |
| Single-SIM | −14,122.727 | −6,918.241 | −14,710.136 | −7,248.205 |
| Multi-SIM | −77,951.382 | −45,392.757 | −72,278.876 | −40,280.792 |
| *By age group* | | | | |
| 15-25 | −60,951.021 | −21,873.846 | −65,522.909 | −25,160.399 |
| 25-50 | −44,340.051 | −16,298.459 | −42,560.747 | −16,470.262 |
| 50-85 | −60,018.652 | −25,930.386 | −65,613.733 | −36,617.337 |
| *By gender* | | | | |
| Female | −42,439.262 | −15,305.514 | −44,248.017 | −18,124.126 |
| Male | −54,662.772 | −21,480.840 | −54,174.113 | −22,098.902 |
| *By residence type* | | | | |
| Formal | −49,775.759 | −18,578.580 | −49,929.603 | −20,389.046 |
| Informal | −51,567.136 | −17,713.333 | −53,471.908 | −18,194.761 |
| *By education* | | | | |
| No formal education | −44,053.185 | −14,438.511 | −47,023.454 | −17,287.764 |
| Primary | −55,217.505 | −20,785.445 | −53,191.257 | −20,104.086 |
| Post-primary | −52,679.046 | −24,461.294 | −49,792.473 | −23,763.523 |
| Secondary | −51,602.059 | −19,915.591 | −51,000.700 | −21,394.531 |
| Higher | −51,000.373 | −17,788.822 | −53,941.416 | −19,050.910 |
| *By mobile money usage* | | | | |
| Non-user | −37,869.700 | −10,411.272 | −38,950.048 | −11,693.903 |
| User | −58,700.014 | −29,486.208 | −57,437.799 | −28,876.065 |

*Notes:* Counterfactual restricting each consumer to at most one SIM card, with prices held fixed at observed levels (no firm price response). Reports mean and median compensating variation for the full sample and by demographic subgroup, unweighted and weighted by calibrated sampling weights. Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

Table 19: Consumers' response to the single-operator counterfactual: demand and welfare (weighted)

*Panel A: Market shares and penetration (baseline vs. counterfactual)*

| | Orange | Telecel | Onatel | Mobile penetration rate |
|---|---|---|---|---|
| Baseline | 0.749 | 0.166 | 0.699 | 0.871 |
| Counterfactual | 0.321 | 0.021 | 0.278 | 0.636 |
| Change | −0.427 | −0.144 | −0.421 | −0.234 |

*Panel B: Conditional usage and extensive margin*

| | Δ Uncond. quantity (%) | Δ Cond. quantity (%) | Ext. margin, cond.: CF [obs.] | Δ Ext. margin, cond. (pp) |
|---|---|---|---|---|
| Orange – Communication | −64.996 | −32.397 | 0.566 [0.763] | −19.664 |
| Orange – Internet | −53.155 | 3.360 | 0.804 [0.805] | −0.068 |
| Telecel – Communication | −90.738 | −35.323 | 0.628 [0.864] | −23.673 |
| Telecel – Internet[a] | −66.465 | 296.050 | 0.451 [0.159] | 29.194 |
| Onatel – Communication | −68.407 | −34.321 | 0.599 [0.811] | −21.211 |
| Onatel – Internet | −61.023 | 15.129 | 0.498 [0.357] | 14.169 |

*Panel C: Substitution patterns among multi-SIM users (%)*

| Base bundle | Orange | Telecel | Onatel | Outside option |
|---|---|---|---|---|
| Orange–Telecel | 57.059 | 0.812 | — | 42.129 |
| Orange–Onatel | 20.222 | — | 46.817 | 32.961 |
| Telecel–Onatel | — | — | 38.854 | 61.146 |
| Orange–Telecel–Onatel | 62.123 | 0.258 | 37.619 | — |

*Panel D: Consumer surplus variation (FCFA)*

| | Mean | Median | Total |
|---|---|---|---|
| $\Delta CS$ | −54,691.479 | −24,918.887 | −437,374,165,503.701 |
| $\Delta CS^{-\mathscr{B}}$ | −50,654.29558 | −19,823.84319 | −405,088,333,136.545 |

*Notes:* The counterfactual restricts each consumer to at most one SIM card and allows firms to re-optimize service prices in response. Calibrated sampling weights are applied throughout this table. Panel A reports weighted-average market shares and mobile penetration across the 13 markets. Panel B reports, for each firm-service pair, the weighted % change relative to baseline in unconditional and conditional quantity, the weighted conditional extensive-margin probability in the counterfactual with the observed baseline value in brackets, and its change in percentage points (pp). Telecel's internet price is held fixed at the observed level (see Table 20). Panel C reports the weighted share (%) of multi-SIM holders in each baseline bundle who move to each single-operator option or exit the market; "—" denotes a destination chosen by no multi-simmer (by weight) in the sample. Panel D reports weighted mean, median, and aggregate compensating variation (Small and Rosen, 1981), in FCFA. Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

Table 20: Firm response to the single-operator counterfactual: prices and profit

| *Panel A: Price and profit variation by service* | | | | |
|---|---|---|---|---|
| | Δ Price (FCFA) | Δ Price (%) | Δ Profit | Δ Profit (%) |
| Orange – Communication | 25.794 | 228.817 | 792,071.444 | 25.399 |
| Orange – Internet | 958.922 | 78.942 | −23,150,910.866 | −12.972 |
| Telecel – Communication | 35.557 | 334.593 | −426,960.852 | −42.373 |
| Telecel – Internet[a] | 0.000 | 0.000 | 151,341,078.914 | 72.857 |
| Onatel – Communication | 39.341 | 359.676 | 1,729,380.302 | 49.240 |
| Onatel – Internet | 1,456.083 | 180.063 | 20,732,303.267 | 157.256 |
| *Panel B: SIM-card and total profit variation by firm* | | | | |
| | Δ SIM profit | Δ SIM profit (%) | Δ Total profit | Δ Total profit (%) |
| Orange | −352,200.165 | −57.140 | −22,711,039.586 | −12.464 |
| Telecel | −114,815.475 | −87.556 | 150,799,302.587 | 72.996 |
| Onatel | −346,672.993 | −60.146 | 22,115,010.576 | 128.037 |

*Notes:* The counterfactual restricts each consumer to at most one SIM card and allows firms to re-optimize service prices in response. No calibrated sampling weights are applied. Panel A reports variations by firm–service pair; Panel B reports variations in SIM-card profit and in total profit (service profit across both services plus SIM-card profit), summed across markets. Price and profit variations in levels are in FCFA. All variations are relative to the observed (pre-counterfactual) level.
[a] Telecel's internet price is held fixed at the observed level rather than re-optimized. Its profit still changes through quantities. Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

Table 21: Heterogeneous welfare effects of the no multi-SIM counterfactual

| | Unweighted | | Weighted | |
|---|---|---|---|---|
| | Mean $\Delta CS$ | Median $\Delta CS$ | Mean $\Delta CS$ | Median $\Delta CS$ |
| *All individuals* | −54,086.565 | −22,643.031 | −54,691.479 | −24,918.887 |
| *By multi-SIM status* | | | | |
| Single-SIM | −17,087.489 | −9,912.431 | −17,925.348 | −11,025.017 |
| Multi-SIM | −82,492.764 | −51,241.529 | −76,810.571 | −47,041.835 |
| *By age group* | | | | |
| 15-25 | −63,424.302 | −24,608.600 | −68,286.731 | −28,225.892 |
| 25-50 | −49,006.841 | −21,634.509 | −47,324.452 | −21,958.353 |
| 50-85 | −62,237.546 | −29,956.932 | −68,103.852 | −37,857.210 |
| *By gender* | | | | |
| Female | −46,091.798 | −19,179.116 | −48,174.559 | −21,880.208 |
| Male | −58,635.546 | −25,783.917 | −58,272.087 | −26,357.198 |
| *By residence type* | | | | |
| Formal | −53,687.948 | −23,291.894 | −54,020.325 | −25,225.992 |
| Informal | −55,260.220 | −21,601.947 | −57,300.936 | −22,410.580 |
| *By education* | | | | |
| No formal education | −47,040.330 | −18,638.250 | −50,233.079 | −21,135.288 |
| Primary | −59,428.960 | −26,297.746 | −57,376.265 | −25,256.143 |
| Post-primary | −56,157.247 | −27,785.997 | −53,415.656 | −28,276.485 |
| Secondary | −55,944.199 | −25,007.500 | −55,508.517 | −26,401.824 |
| Higher | −55,593.234 | −22,871.598 | −58,599.613 | −24,659.523 |
| *By mobile money usage* | | | | |
| Non-user | −41,160.380 | −14,521.081 | −42,588.162 | −15,896.326 |
| User | −62,944.490 | −34,048.056 | −61,706.274 | −33,470.723 |

*Notes:* The counterfactual restricts each consumer to at most one SIM card and allows firms to re-optimize service prices in response. Reports mean and median compensating variation, for the full sample and by demographic subgroup, unweighted and weighted by calibrated sampling weights. Monetary values are expressed in FCFA (XOF, *franc de la Communauté financière africaine*). In 2020, one international dollar was equivalent to 199.52 FCFA francs at purchasing power parity (World Bank, PPP conversion factor).

# D Quality index formulation

I rely on customers' evaluations of services to infer service quality. In fact, quality may help explain both usage and satisfaction with providers' services. Weiergraeber (2022) takes a similar approach by using survey-based consumer ratings of their mobile provider's performance as a proxy for provider quality.

I leverage the richness of the survey to build a market-provider and service-specific quality index. Each consumer in the survey was asked about satisfaction with the services offered by the providers they subscribed to across multiple dimensions. The dimensions evaluated differ across services, as the determinants of service quality are service-specific. The voice-related dimensions evaluated are network strength, dropped-call frequency, and audio quality. For internet service, access and speed were evaluated. Additional questions about general satisfaction with services-one for voice service and two for internet- were included. Finally, providers' coverage was also evaluated. Customers' satisfaction was evaluated using a five-point scale ranging from *Very satisfied* to *Not satisfied*. I end up with five dimensions for each service to compute a market-provider-service-specific index.

**Calculating the index:** For each service, the quality indices are computed following two steps. In the first step, I compute, for each market and each dimension, the proportion of each provider's users who report being satisfied. The idea is to adjust satisfaction levels based on the service's popularity, since non-usage of a provider's service is sometimes related to dissatisfaction or poor service quality. This is particularly true in the Burkina Faso context because providers' price discounts occur frequently within a month. The correlation between service popularity and quality is valid among multi-simmers, who have lower switching costs for changing their service usage across providers. The analysis performed with the sample restricted to multi-simmers gives similar results. The resulting dataset has five variables corresponding to the five dimensions and 39 observations (13 markets × 3 providers).

In the second step, the dataset from the previous step is then used to perform a factor analysis[41].

[41] The factor analysis is performed on market-level data rather than individual-level data to ensure robustness to sampling errors. See Rencher and Christensen (2012),p470 for further discussion.

Table 22 summarizes the analysis performed on the market-level dataset. Panel A of the table reports the results of some preliminary tests meant to assess the sample adequacy for factor analysis. The KMO (Kaiser-Meyer-Olkin) statistic evaluates the extent to which the variables share common variance. Values above 0.8 indicate that the dataset contains sufficient shared variance for the extracted factors to provide a meaningful summary of the information (Rencher and Christensen, 2012). Bartlett's test of sphericity evaluates how close the variables' correlation matrix is to the identity matrix. The closer it is to the identity matrix, the less meaningful the summary provided by the extracted factors. The null hypothesis of this test is that the correlation matrix is equal to the identity matrix.
Both the KMO statistic and Bartlett's test indicate that factor analysis on my dataset may yield satisfactory results.

Panels B and C of Table 22 display the results of the factor analysis[42]. From the set of 5 variables initially used, one factor was extracted, representing 74% and 94% of the total variance for voice-text and internet service, respectively.

Variable loadings (Panel C of Table 22) correspond to the correlation coefficients with the extracted factors and indicate how each factor should be interpreted. Communality represents the share of the variance of the variables explained by the factor, indicating how well the factor captures their information.

For internet service, all the variables are positively and strongly correlated with the factor. Therefore, the extracted factor may reflect internet service quality, with higher values indicating higher performance by the corresponding provider for this service. The same result is observed for voice service, even though the voice service quality index explains only 33.5% of the dropped-calls dimension variance.

**Comparison with external sources: Ookla's open dataset** The firm Ookla shares internet quality metrics obtained from crowdsourced measurements from its Speedtest platform. The dataset provides quarterly data on both mobile and fixed-line internet quality of small geographic units

[42] Factors are extracted using the principal component approach because this approach has been shown to be more robust to weak factors and small sample size (see Winter and Dodou (2012) and references therein). The *Varimax* rotation method is used for the loadings calculation.

Table 22: Factor analysis results for internet and voice/text quality indices

*Panel A: Preliminary tests*

| | Internet | Voice/Text |
|---|---|---|
| KMO statistic (global) | 0.901 | 0.831 |
| Bartlett's test of sphericity | 119.56*** | 183.17*** |

*Panel B: Factor characteristics*

| | Internet | Voice/Text |
|---|---|---|
| Variance explained | 93.9 % | 73.5 % |
| TLI | 0.997 | 0.917 |
| $R^2$ (scores) | 0.996 | 0.961 |
| Observations | 39 | 39 |

*Panel C: Factor loadings*

| | **Internet** | | | **Voice/Text** | |
|---|---|---|---|---|---|
| Variable | Loading | Communality | Variable | Loading | Communality |
| Network coverage | 0.874 | 0.763 | Network coverage | 0.873 | 0.762 |
| Overall quality | 0.995 | 0.990 | Overall quality | 0.963 | 0.928 |
| Access | 0.994 | 0.989 | Network strength | 0.902 | 0.814 |
| Speed | 0.984 | 0.969 | Dropped calls | 0.579 | 0.335 |
| Overall satisfaction | 0.991 | 0.982 | Audio quality | 0.915 | 0.837 |

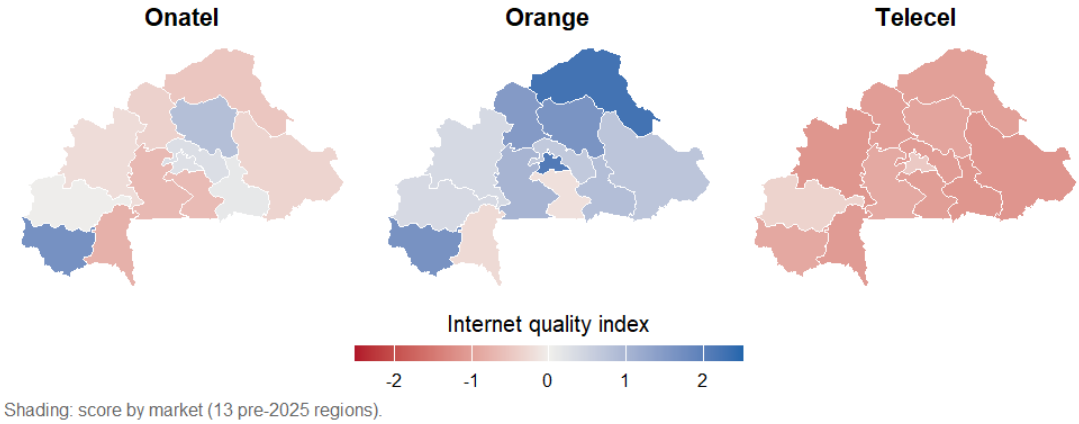
*** $p < 0.001$. A KMO statistic above 0.8 indicates excellent sampling adequacy. Internet index estimated by maximum likelihood; voice/text index by principal axis factoring. Observations = 13 markets × 3 operators.

called tiles[43].

I restricted the dataset to mobile internet quality measurements across all the quarters of 2020 on the 2327 tiles covering Burkina Faso. This information is aggregated to obtain average metrics by market. Unfortunately, Ookla does not provide information disaggregated by provider. I compare the average index across providers in each market to the metrics provided by Ookla. Figure 10 shows a scatter plot of the average quality index and download and upload speeds, as well as the average latency for all the $M = 13$ markets. The quality index is significantly correlated with the download and upload speeds.

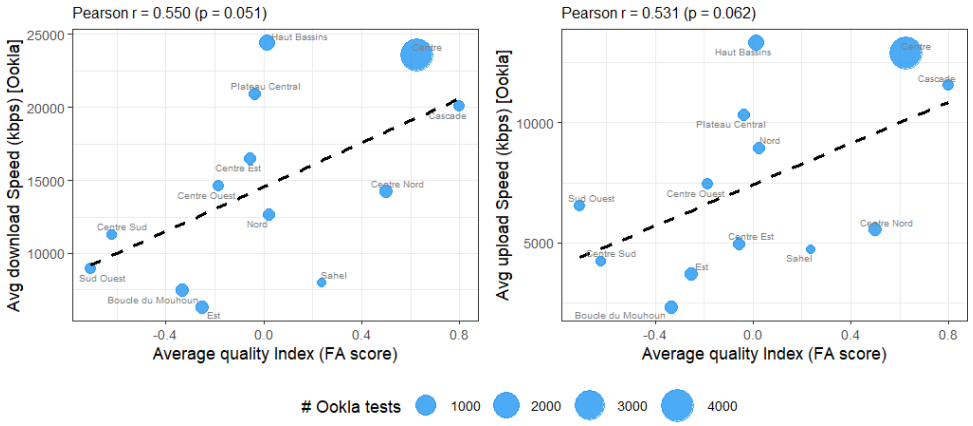
[43]Tiles can be viewed as units that correspond to a certain level of zooming $z$ on the Earth. Therefore, a level $z = 0$ corresponds to the whole planet; a tile of $z = 1$ is obtained from dividing the Earth into four parts that together cover the globe. Ookla uses tiles of level $z = 16$ that are approximately equal to 610.8 meters by 610.8 meters at the equator.

Figure 9: Internet quality index by region and operator




Each panel shows one operator. Regions are shaded by internet quality index, computed from respondents in each region, using the 13 regions in place at the time of the survey. The sample is predominantly urban (70% of respondents live in urban communes), particularly in the northern regions, where respondents live mainly in provincial capitals. Regional scores therefore reflect quality in surveyed areas rather than across the whole region.

Figure 10: Quality index vs Ookla internet quality metrics




**Comparison with nPerf performance reports:** The company nPerf publishes annual country reports on mobile internet quality metrics, based on user test results conducted through its platform. The reports provide detailed information on providers' performance along multiple metrics. I compare providers' rankings from the Internet Quality Index with the rankings published by nPerf. Since nPerf did not release a report specifically for 2020, I rely on statistics from

the 2021 edition. I believe that the 2021 report provides a reasonably accurate picture of the industry in 2020, as improvements in network performance require long-run investment.

Table 23 displays the providers' internet quality ranking from nPerf along with the rankings according to the quality index. Both nPerf and the quality index agree that Orange provides the best internet service. However, they diverge on the ranking of the other two providers. Unlike nPerf, the quality index ranks Onatel's internet service above Telecel's. This ranking is essentially stable across the 13 observed markets.

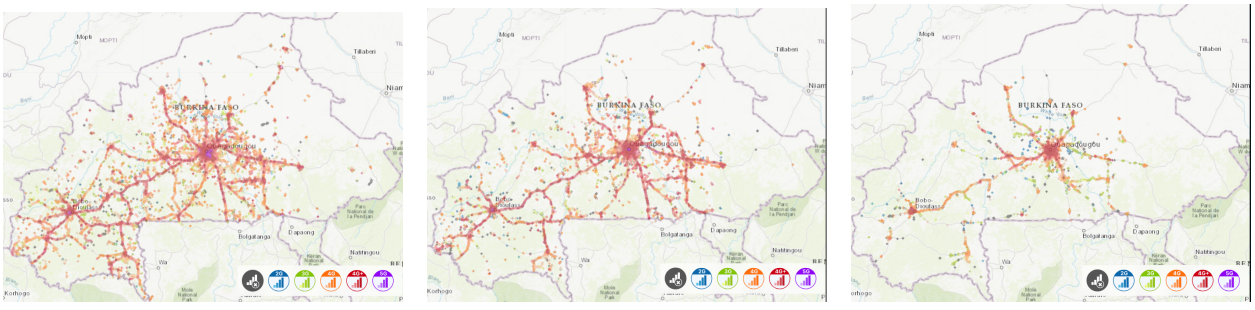
This divergence in the rankings of the two providers is consistent with my quality index accounting for coverage and being adjusted for the service's popularity. Even though Telecel's internet service is better than Onatel's, it has the worst coverage in Burkina Faso (see Figure 11).

Table 23: Internet quality ranking: FA index vs. nPerf 2021

| Provider | nPerf (2021) | FA Internet Index | | | | |
|---|---|---|---|---|---|---|
| | Rank | Rank | Average score | #1st | #2nd | # markets |
| Orange | 1 | 1 | +0.970 | 12 | 1 | 13 |
| Onatel | 3 | 2 | −0.032 | 1 | 12 | 13 |
| Telecel | 2 | 3 | −0.937 | 0 | 0 | 13 |

*Notes:* nPerf ranks from the 2021 Burkina Faso mobile annual report (24,914 tests). FA score = average factor analysis internet quality index across 13 regions. #1st and #2nd count the number of regions (out of 13) in which each operator ranks first or second.

Figure 11: Mobile network coverage by provider - Burkina Faso (2026)



(a) Orange BF (b) Onatel (Telmob) (c) Telecel

Notes: Darker areas indicate stronger signal.
Source: nPerf.