-RESEARCH ARTICLE-

SOCIAL MOBILITY THROUGH TECHNOLOGICAL ASSETS: A REGIONAL MICROSIMULATION MODEL

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─Abstract─

Access to technology is a significant factor in facilitating upward social mobility by reducing disparities in access to information and fostering educational and employment opportunities. This study develops a microsimulation model for a region in Mexico to estimate the probabilities of households achieving social mobility through a two-year renewable microcredit scheme for acquiring a computer with internet access over a 14-year period. The data utilised include the National Income and Expenses Survey and a regional social mobility survey. The methodology incorporates principal component analysis to construct an Asset Index, ordered logistic regression for asset selection, a Markov Chain for transition probability estimation, and Monte Carlo simulation. The findings reveal that 13.75% of households could progress to a higher wealth quintile while sustaining their ability to repay the microcredit. The study advocates for targeting public programmes aimed at social mobility towards specific sectors rather than implementing universal initiatives. Additionally, it recommends enhancing credit conditions through public-private partnerships to mitigate inequality.

INTRODUCTION

Social mobility, defined as the changes in individuals' socioeconomic conditions, has been widely examined across various countries to understand and address inequality, particularly inequality of opportunity. Existing research has explored social mobility from multiple perspectives, including occupational mobility (Cortés & Escobar Latapí, 2005; Erikson & Goldthorpe, 2002; Goldthorpe, 2016) educational mobility (Torche, 2020), and income-based mobility (Chetty et al., 2014; Corak, 2013).

The objective of this study is to evaluate social mobility through the lens of asset accumulation, with a specific focus on technological assets. It examines how access to computers and the internet facilitates intergenerational social mobility, supported by a microcredit scheme as the financial mechanism for acquiring these resources. The theoretical underpinning of this approach is grounded in the work of Bukodi and Goldthorpe (2022), who contend that the most effective strategies for fostering social mobility combine individual effort with targeted public policies. Heckman and Landersø (2022) similarly argue that sector-specific programmes are more effective than universal interventions in addressing inequality. The World Economic Forum (2020) also highlights the importance of informed decision-making in guiding social mobility initiatives. Moreover, Conconi et al. (2007) assert that social mobility can be advanced through the development of metrics and mechanisms that promote equality of opportunity across all levels.

For some researchers (Anand & Segal, 2017; Chetty et al., 2014; Corak, 2013) income serves as a common metric for measuring social mobility in countries where such data is available, sufficient, and reliable. However, in regions where this type of information is unavailable, other studies (Behrman, 2015; Torche, 2020; Velez-Grajales, 2017) suggest that asset indices provide a widely used approximation of household wealth for estimating social mobility. Additionally, Cotler and Rodríguez-Oreggia (2010) highlight that asset accumulation can generate greater wealth and serve as an indicator of potential improvements in socioeconomic conditions. The critical question is which assets should be accumulated based on the specific characteristics of a given region; addressing this question constitutes the primary aim of this investigation. The analysis focuses on Nuevo León, a region in northern Mexico. The study identifies the assets relevant to positioning households in the upper wealth quintiles and estimates the probabilities of social mobility using a microsimulation model. These findings can inform public programmes aimed at reducing inequality by providing a reference for designing innovative approaches. Unlike traditional schemes that primarily target income, this research emphasises household capital formation as a pathway to foster social mobility.

This study is organised as follows: Section 2 provides a literature review, encompassing

the key elements of the research—social mobility, microcredits, and microsimulation models. Section 3 outlines the methodology and variables employed in the analysis. Section 4 presents the results, while Section 5 offers a discussion of the findings. Finally, the conclusions are summarised in Section 6.

LITERATURE REVIEW

Social Mobility

According to the Inter-American Development Bank (2020), social mobility refers to changes in an individual's socioeconomic status, either within their lifetime (intragenerational mobility) or relative to their parents' circumstances (intergenerational mobility). These changes can be measured in terms of education, employment, income, and other dimensions (Velez-Grajales, 2017). Social mobility is intrinsically linked to inequality of opportunities, aiming to assess the degree to which parental circumstances influence the outcomes of subsequent generations. This assessment facilitates conclusions about the impact of origin-related circumstances on an individual's trajectory (Solís, 2018). Velez-Grajales (2017) highlight the importance of understanding the influence of these origin characteristics to elucidate the relationship between inequality of opportunities and inequality of outcomes.

The absence of social mobility leads to highly stratified societies where individuals' futures are predominantly shaped by their conditions of origin rather than their efforts to improve their life circumstances. This dynamic perpetuates a negative cycle, further exacerbating inequality. Corak (2013) observes that countries with higher levels of inequality tend to exhibit lower levels of intergenerational social mobility. In countries where population income data is sufficient and reliable, such as the United States, Canada, or Switzerland, economic mobility is commonly measured using income as the primary variable (Anand & Segal, 2017; Chetty et al., 2014; Corak, 2013). However, in regions where such data is unavailable, asset indices have gained popularity as an approximation of household wealth and are frequently used to estimate social mobility (Behrman, 2015; Torche, 2020; Velez-Grajales, 2017). Sahn and Stifel (2003) argue that asset indices can serve as valid predictors of long-term poverty or wealth, often with greater precision than expenditure-based measurements. The model developed by (Filmer & Pritchett, 1998; Filmer & Pritchett, 2001), which constructs an index using principal component analysis, has been widely adopted for this purpose.

Quintile distributions are frequently employed in studies of economic inequality and social mobility. According to Best (2018), quintile data facilitates cross-country comparisons, as it is commonly available through national surveys such as the Census. Bank (2024) highlights that grouping information by quintiles enables users to quickly compare indicator values and contrast the position of one economy relative to others.

Several studies have utilised quintile distributions of asset indices to measure social mobility, including those by Campos-Vázquez et al. (2022) in Mexico, (Ruff et al., 2023) in Chile, and (Dodin et al., 2024) in Germany.

The accumulation of wealth through assets has been associated with improvements in academic performance and educational aspirations (Chowa et al., 2013; Fang et al., 2020; Shanks et al., 2010). Grawe (2008) suggests a causal relationship between wealth and the parent-child income association, which influences absolute social mobility. Additionally, Cotler and Rodríguez-Oreggia (2010) argue that asset accumulation can lead to increased wealth, serving as an indicator of potential improvements in socioeconomic conditions. Some studies have focused on specific assets, particularly those related to technology, recognising that access to technological resources can reduce inequalities by making information and knowledge equally available across all social strata (Nguyen, 2021). Among the technological assets assessed are computers and internet access (Singh & Muniyoor, 2022).

In Mexico, asset index studies have been conducted to measure social mobility at the national level. For instance, DelaTorre-Díaz and Rodriguez-Aguilar (2021) developed an asset index and identified key assets for social mobility, including household appliances such as stoves, refrigerators, washing machines, microwaves, and computers. However, within any country, regional differences can be significant; thus, studies that are more focused on specific regions offer the advantage of tailoring public and social strategies to the realities of particular areas or groups. Research has shown that public programmes or policies targeting specific sectors, rather than universal ones, tend to be more effective. Government efforts can also be enhanced by partnering with the private sector to generate greater benefits (Heckman & Landersø, 2022; World Economic Forum, 2020). The recently published ESRU Social Mobility Survey of the State of Nuevo León (ESRU-EMOVI NL) provides an opportunity for a more in-depth analysis of social mobility within this state.

Social Mobility in Mexico

Restrictions on social mobility are linked to inequalities in income, education, and other areas, including gender, ethnicity, and race. In 2020, the World Economic Forum (WEF) published the Global Social Mobility Index (IGMS), which includes ten pillars: health, education access, quality education, lifelong learning, social protection, job opportunities, fair wages, working conditions, inclusive institutions, and technology access (World Economic Forum, 2020). The index evaluated 82 countries, with Denmark ranking first, followed by Norway and Finland, while Mexico ranked 58th. The WEF aims to highlight areas for improvement and provide policymakers with guidance. They note that inequality of opportunity and limited social mobility hinder productivity, exacerbate income inequality, and undermine social cohesion (World

Economic Forum, 2020). The OECD also underscores the negative effects of restricted social mobility, such as decreased productivity, lost talent, and opportunity monopolisation by the upper classes (OECD, 2018).

The IGMS highlights that Mexico's greatest areas of opportunity are in education access and quality, women's workplace participation, working conditions, and social protection, particularly for low wages (World Economic Forum, 2020). Social Mobility Surveys have been conducted in Mexico since 2006 to analyse intergenerational mobility patterns both nationally and regionally (Orozco-Corona et al., 2019). The 2017 survey results reveal persistent challenges in social mobility, with 57% of households in the upper quintile remaining there in the following generation, and 49% of households in the lowest quintile staying at the same level (Orozco-Corona et al., 2019). High persistence at the extremes of the distribution reflects the difficulty some households face in moving to higher levels.

The State of Nuevo León

Nuevo León is the third-largest economy in Mexico, contributing 8.1% to the national GDP in 2021. With a population of 5.8 million, it is the eighth most populous state (León, 2023). A preliminary look at economic inequality in the state can be seen in income distribution, where quintile 5 dominates, concentrating a significant portion of the average monthly household income. Households in quintile 5 earn ten times more than those in quintile 1 (see table 1). The results of the ESRU-EMOVI survey on social mobility in Nuevo León reveal considerable stability at the extremes of the distribution, surpassing even national trends. Figure 1 illustrates that 57% of households originating from quintile 1 in Nuevo León remained in the same quintile, in contrast to the 49% observed at the national level. Meanwhile, 38% of households from quintile 5 in Nuevo León remained at the same level, compared to 57% at the national level.

Table 1: Current Income by Quintile in the State of Nuevo León According to ENIGH 2022.

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Average Current Income	4,100.70	8,227.31	12,572.69	19,180.72	41,043.18
Dev. Standard	7,003.45	2,025.86	2,511.67	4,437.27	23,904.05
Minimum Current Income	-	5,467.09	9,619.51	14,601.84	23,001.00
Maximum Current Income	151,078.30	23,613.20	43,910.03	107,647.20	354,323.70

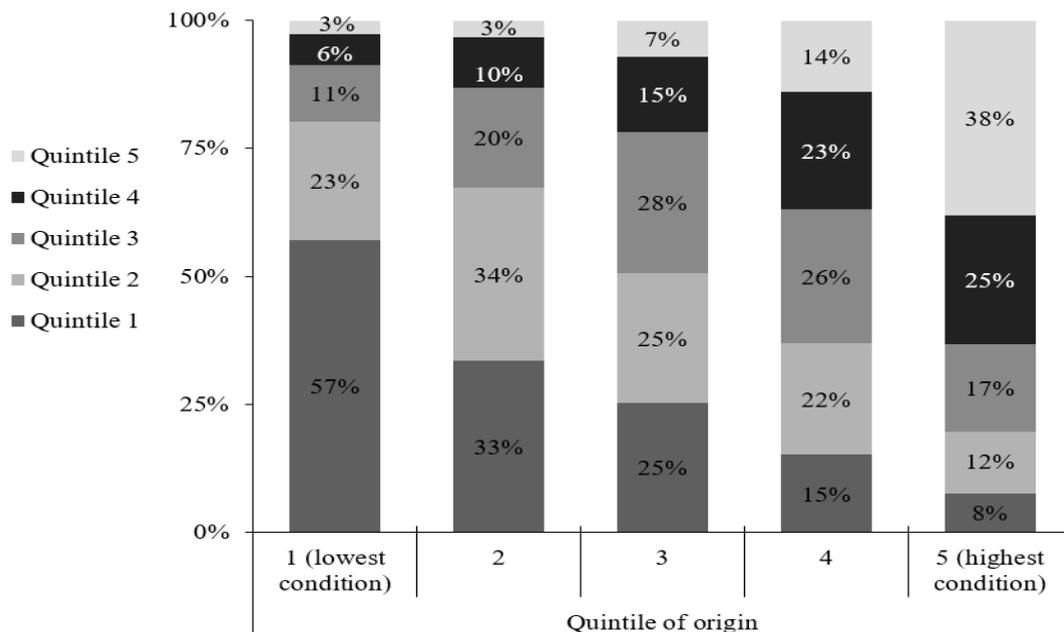Own Elaboration with Information from ENIGH 2022.

Figure 1: Social Mobility in the State of Nuevo León According to ESRU-EMOVI NL. Own Elaboration.

Social Mobility and Technological Assets

One of the key pillars in the construction of the IGMS is access to technology, due to its equalising effect on access to information, irrespective of individuals' socioeconomic background. Technological resources facilitate access to knowledge, which can be complemented by online learning and lifelong learning opportunities, thereby improving other pillars of social mobility (World Economic Forum, 2020). A tangible example of the benefits of technology access, particularly in relation to education and its impact on inequality of opportunities, emerged during the COVID-19 pandemic. The mobility restrictions forced educational institutions to transition to online teaching. Students with access to technological resources were able to fully engage with online classes, unlike children, primarily from lower socioeconomic backgrounds, who lacked the necessary tools to continue their education (Montacute, 2020).

The World Economic Forum (2020) emphasises that "New technology adoption drives business growth, new job creation, and the augmentation of existing jobs, provided it can fully leverage the talents of a motivated and agile workforce who are equipped with future-proof skills to take advantage of new opportunities through continuous retraining and upskilling. Similarly, access to technology can vastly expand the earning opportunities available to people by enhancing the market available to them to find roles, deploy their skills, or share their assets" (p. 16). In Mexico, data from the ENIGH 2022 reveals that 43.20% of households lack access to the internet, while 73.55% do

not own a computer. In Nuevo León, the figures are similar, with 41.11% of households reporting no internet access and 73.81% without a computer ((INEGI), 2023).

Microcredits as a Financing Alternative

Microcredits are financing schemes that gained widespread attention following Muhammad Yunus' proposal at the Grameen Bank in Bangladesh, aiming to reduce poverty by creating an environment where individuals, particularly the less fortunate, could harness their creativity, primarily through entrepreneurship (Yunus, 2007). Between 1997 and 2013, the number of microcredit clients globally increased from 13 to 211 million (Results, 2023), leading to the growth of Microfinance Institutions (MFIs). However, the performance of MFIs has faced criticism, particularly in cases where microcredit dependency has negatively impacted debtors (Peprah & Koomson, 2014) or when the credits have not yielded conclusive improvements in the living conditions of the communities they serve (Banerjee et al., 2015).

Nevertheless, Kaka (2022) argues that microcredits do have a positive impact on business income, asset ownership, and children's education. Similarly, Dwivedi and Dwivedi (2022) assert that microcredits have significantly improved the socioeconomic status of women. López-Rodríguez (2021) identifies two key contributions of the financial system to social mobility: first, enabling investment in human capital through savings, financing, and asset accumulation, and second, fostering entrepreneurship and capital formation. Therefore, access to credit is shown to offer greater opportunities, particularly when resources are invested in education, health, or home equipment. In Mexico, the leading institution in microfinance is Compartamos Banco, which controls 26% of mixed group loans in the country and more than 68% of the group loan market for women (Gentera, 2022).

Microsimulation Models

Microsimulation models are commonly employed to estimate the effects of public policies on poverty, income, or inequality (Absalón & Urzúa, 2012). These models use large socioeconomic databases, primarily from income and expenditure surveys, to simulate the dynamics of variables such as transition probabilities (Gilbert & Troitzsch, 2005; Guerrero García, 2018; Spadaro, 2007). The use of large datasets allows for capturing population heterogeneity, projecting the structure of the target population through multiple iterations, and considering policy implementation and time progression. Spadaro (2007) distinguishes between static microsimulation models, which do not account for time, and dynamic models, which incorporate intertemporal decisions like marriage or fertility. The key advantages of these models are their ability to exploit information, identify the beneficiaries and detractors of a public policy, and evaluate the financial cost-benefit of interventions. All the earlier elements were

considered in the definition of the hypotheses for this study, as follows:

H1: *The increase in asset accumulation has a positive impact on the socioeconomic conditions of households.*
H2: *Technological assets are relevant for intergenerational social mobility.*
H3: *Households that have access to technological assets acquired through microcredit achieve upward social mobility by placing themselves in a higher quintile than their home of origin.*

This research aims to identify key assets that promote social mobility by integrating data from the National Survey of Household Income and Expenditure (ENIGH) and the ESRU-EMOVI NL. It also develops a microsimulation model to estimate the probability of households achieving upward social mobility through the acquisition of technological assets. Additionally, the study incorporates microcredits as the mechanism to provide these assets to less advantaged population segments.

METHODOLOGY

A quantitative research design was employed to assess the effectiveness of the proposed model on social mobility among households in Nuevo León. Statistical methods were applied to analyse the results and test the hypotheses.

Information Sources and Data Used

Two primary sources of data were used in this study. The first was the ESRU Survey of Social Mobility in Nuevo León (ESRU-EMOVI NL), conducted in 2021 among individuals aged 25 to 64, with a sample of 3,767 interviews (Centro de Estudios Espinosa Yglesias, 2022). The second source was the 2022 Household Income and Expenditure Survey (ENIGH), published by the National Institute of Statistics and Geography (INEGI), which included a sample of 105,525 households, representing over 128 million ((INEGI), 2023). Using the ENIGH 2022 data and drawing on the study by DelaTorre-Díaz and Rodriguez-Aguilar (2021), a set of variables was selected to describe asset accumulation in households, including physical assets like household goods. These variables are listed in Appendix A. This asset selection was used to construct an asset index, which was subsequently incorporated into a logistic regression model to identify the most relevant assets across five quintiles of asset accumulation. Data from the ESRU-EMOVI survey on identified relevant assets were used to estimate a difference-in-difference model and transition probabilities regarding changes in quintile positions.

The final component of the methodology is the microsimulation model, which requires additional variables:

a. Growth rate in monthly income and expenses per household: The change in average income and expenses by quintiles, based on the ENIGH data from 2016, 2018, 2020, and 2022, was used as a reference.

b. Inflation rate: The average annual inflation rate from 2012 to 2022, based on the National Consumer Price Index published by INEGI, was used to update the prices of technological assets with each credit renewal and to adjust for asset depreciation according to their estimated useful life.

c. Change in the annual interest rate for microcredit: The interest rate charged by Compartamos Banco, which offers individual loans with an annual interest rate of 62.70% (Banco Compartamos SA, 2024) for two-year loans with fixed monthly payments, was used as the initial rate. The variation in this rate over time was estimated using the average annual change in the 28-day Interbank Equilibrium Interest Rate (TIIE), published by Banco de México.

The microsimulation model incorporated a Monte Carlo Simulation to account for uncertainty in the projections. This simulation necessitates the a priori definition of the probability distribution for the variables. For this study, a triangular distribution was selected, meaning that for each variable, a minimum value, a base value, and a maximum value were defined. Table 2 summarises the values used for each variable.

Table 2: Description of Values Used in Variables of the Microsimulation Model.

Variable	Minimum Value	Base Value	Maximum Value
Revenue Growth Rate	Observed 2016-2022 according to ENIGH	Expected GDP for 2024 according to General Policy Criteria 2024, SHCP	Expected GDP for 2023 according to General Policy Criteria 2024
Expense Growth Rate	Observed 2016-2020 according to ENIGH	Average inflation 10 years, according to INEGI	Observed 2016-2022
Rate of Inflation	Banxico survey expectation for 2023	Average surveys on the Expectations of Private Sector Economics Specialists, 2023	Banxico survey expectation for 2022
Growth in Interest Rate	Average annual growth of the Banco Compartamos rate from 2012 to 2021	Average TIIE growth 2012-2018, according to Banxico	Average annual growth rate Banco Compartamos 2012-2018

Own elaboration with Information From: www.banxico.org.mx/www.inegi.gob.mx/ https://www.cefp.gob.mx/indicadores/gaceta/2022/iescefp0342022.pdf

Data Analysis Techniques Used

An Asset Index was developed from the initial data set extracted from the ENIGH survey using the Mixed Principal Components method. Unlike the traditional Principal Components model, this mixed method employs the Generalized Singular Value Decomposition (GSVD) to combine quantitative and categorical variables. Principal

Components are applied to the quantitative variables, while Multiple Correspondence Analysis is used for categorical ones, resulting in a linear combination of the observed variables (Zhen & Mengxian, 2020). The index generated reflects both asset ownership and the economic resources allocated to various activities in each household. To enhance interpretability, the index is adjusted to a range of [0,100], where higher values indicate greater asset ownership.

Households in Nuevo Leon were divided into five quintiles based on the Asset Index. An ordered logistic regression was then used to identify the assets most associated with a household's quintile. The quintile was treated as the categorical dependent variable, while the assets forming the index served as independent variables. The logistic regression model determined the conditional probability of an event occurring based on the explanatory variables.

$$Pr(Y = 1 | x_1, x_2, \ldots, x_p) \tag{1}$$

However, in the multinomial version, the dependent variable can take three or more values. The model is defined by the following equations:

$$p_1(X_1, X_2, \ldots, X_p) = p_1 = E(Y_1) = \frac{\exp(Z_1)}{1 + \exp(Z_1) + \exp(Z_2) + \cdots + \exp(Z_p)} \tag{2}$$

$$p_2(X_1, X_2, \ldots, X_p) = p_2 = E(Y_2) = \frac{\exp(Z_2)}{1 + \exp(Z_1) + \exp(Z_2) + \cdots + \exp(Z_p)} \tag{3}$$

$$p_n = E(Y_p) = 1 - p_1 - p_2 - \cdots - p_{n-1} \tag{4}$$

Where:

$$Z_1 = \alpha_1 + B_1 X_1 + B_2 X_2 + \cdots + B_p X_p \tag{5}$$
$$Z_2 = \alpha_2 + B_1 X_1 + B_2 X_2 + \cdots + B_p X_p \tag{6}$$
$$Z_p = \alpha_p + B_p X_1 + B_p X_2 + \cdots + B_p X_p \tag{7}$$

This analysis was further expanded by determining the marginal effects, which estimate the change in the probability of a household belonging to a specific quintile when the ownership of each asset analysed changes. The marginal effects results provided valuable insights into selecting a set of assets that are indicative of higher quintile membership. Given the focus of this study, these assets were identified as technological resources, specifically computers and internet access.

Using a Differences-in-Differences (DiD) model, and drawing on data from the ESRU-EMOVI NL survey, the impact of technological assets on social mobility was assessed. This model was employed to validate the role of these assets as facilitators of social mobility. The DiD model is commonly used in evaluating the impacts of social

programmes or public policies, involving two groups—one receiving an intervention or treatment—followed by a comparison of results between the two groups post-treatment (Bertrand et al., 2004). In this study, the "intervention" refers to the possession of technological assets in the current household, where these assets were absent in the household of origin. A binary variable was created to represent asset ownership, assigning a value of 1 if the assets were owned, and 0 if no or some assets were present in the current household. The difference was then estimated through a regression model with the following specification:

$$Y = \mu + \alpha D + \beta X + \varepsilon \qquad (8)$$

In this model, Y represents the difference between the asset index of the current household and the asset index of the home of origin (dependent variable). μ denotes the fixed effects, while α and β are the coefficients for the independent variables D and X. The binary variable D represents the intervention, indicating ownership of technological assets, and X is a set of control variables. Additionally, the ESRU-EMOVI NL survey enabled the estimation of transition probabilities using the Markov Chain model. This model analysed changes in quintile among households in Nuevo León when technological assets were absent in the home of origin but present in the current household. Only households showing upward social mobility, that is, a shift to a higher quintile, were selected for this analysis. The probabilistic Markov Chain method relies on a sequence of random variables Xn, where the distribution at any given stage depends solely on the current state, not on prior stages. The transition probability is the likelihood of moving from state i to state j in n stages (Spedicato et al., 2016), and is represented by the following equation:

$$p_{ij}^{(n)} = Pr(X_n = s_j | X_0 = s_i) \qquad (9)$$

A microsimulation model was developed to assess the changes in household quintile positions based on their net income, factoring in the monthly payments for a microcredit aimed at acquiring and renewing technological assets. The projection covered a 14-year period, aligning with the generational transition time. Transition probabilities were applied to the model results to estimate the number of households in each quintile and the proportion achieving upward social mobility. The model was based on data from 255 households in Nuevo Leon, as recorded in the ENIGH 2022 survey. These households had no technological assets selected for this analysis, limited access to the financial system (no financial instruments or credits), were in quintiles 1, 2, or 3 in terms of income, and had a difference between income and monthly expenses sufficient to cover the proposed microcredit. These 255 observations represent a total of 88,931 households, according to the expansion factor. Given the rapid obsolescence of technological assets, it was assumed that the computer would be renewed every two years, coinciding with the credit term's end. Additionally, a Monte Carlo Simulation

was incorporated to introduce uncertainty into the model. In the 5,000 iterations, variations in household income and expense growth rates, inflation, and interest rate growth were included.

RESULTS

The Asset Index for the state of Nuevo Leon was created, revealing a skewed distribution that indicates a concentration of assets in a small proportion of households (see figure 2). The index was constructed on a scale from 0 to 100, where a higher value indicates greater asset ownership. The average index value for households in Nuevo Leon is 19.71, with only 42.7% of households in the sample exceeding this average (Table 3). While the bias is present in both rural and urban areas, the data reveals that urban households have a higher average asset index, with some reaching 100% of the assets analysed. In contrast, rural households have a maximum value of 73.57, and their average index is lower than the state's overall average, at 15.89.

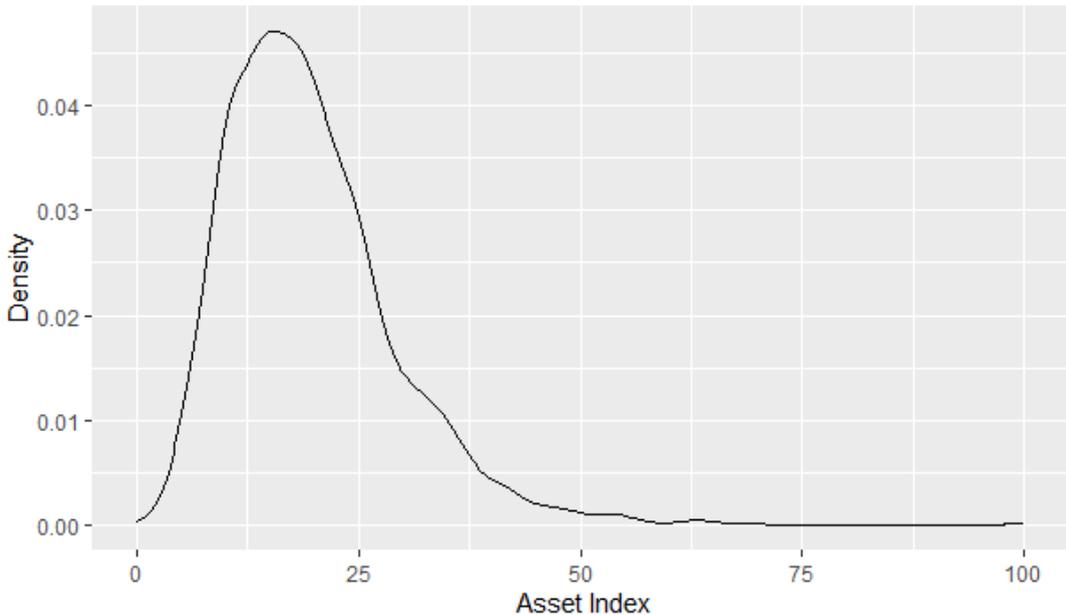**Figure 2:** Distribution of the Asset Index for the State of Nuevo León. (Own Elaboration).

Table 3: Descriptive Statistics of the Asset Index.

	Mean	Median	SD	Min	Max
Total	19.70	18.12	9.95	0	100
Rural	15.89	14.44	8.18	0	73.57
Urban	22.68	21.20	10.10	2.65	100

(Own Elaboration).

Identification of Relevant Assets

An ordered logistic regression model was employed, with the dependent variable being the quintile to which each household belongs based on the asset index value. The explanatory variables included all the assets used to construct the index. An initial approximation was made to identify the assets that have the greatest impact on the probability of a household belonging to a particular quintile. The signs of the coefficients were analysed to determine which assets have a higher or lower probability of belonging to the respective quintiles. Table 4 presents the complete regression results.

Table 4: Results of Ordered Logistic Regression.

Variable	Coefficient	SD	95% Confidence Interval		P>|z|
Landline	6.141	0.342	5.471	6.811	0.000
Cell Phone	-1.037	0.292	-1.610	-0.464	0.000
Pay TV	4.594	0.259	4.086	5.103	0.000
Internet Connection	5.606	0.326	4.967	6.245	0.000
Credit Card	4.608	0.276	4.068	5.149	0.000
Incomplete Primary Education of Family Head	2.742	0.448	1.863	3.620	0.000
Complete Primary Education of Family Head	-1.420	0.423	-2.249	-0.592	0.001
Incomplete Secondary Education of Family Head	11.943	0.787	10.400	13.486	0.000
Complete Secondary Education of Family Head	-1.027	0.402	-1.814	-0.239	0.011
Incomplete High School Education of Family Head	3.716	0.509	2.719	4.713	0.000
Complete High School Education of Family Head	6.471	0.564	5.365	7.577	0.000
Incomplete Undergraduate Education of Family Head	6.753	0.668	5.444	8.061	0.000
Complete Undergraduate Education of Family Head	8.212	0.618	7.001	9.422	0.000
Graduate Education of Family Head	21.878	1.344	19.244	24.513	0.000
Number of Members Who Receive Income	1.413	0.096	1.224	1.602	0.000
Educative Credit	-45.995	3.022	-51.917	-40.072	0.000
Major Medical Expenses Insurance	20.223	1.123	18.022	22.424	0.000
Life Insurance	19.052	1.054	16.987	21.118	0.000
Voluntary Savings for Retirement	5.118	0.436	4.263	5.973	0.000
Educational Scholarship	40.956	1.749	37.529	44.383	0.000
Insabi /Free Health System	-3.351	0.327	-3.992	-2.709	0.000
Medical Affiliation	1.278	0.172	0.940	1.616	0.000
Vehicles	2.671	0.183	2.313	3.030	0.000
Radio	2.195	0.224	1.756	2.634	0.000
Analog TV	-4.680	0.313	-5.293	-4.067	0.000
Digital TV	3.435	0.308	2.831	4.039	0.000
DVD	5.798	0.403	5.009	6.587	0.000
VCR	18.453	1.075	16.347	20.560	0.000
Roaster	5.476	0.323	4.843	6.109	0.000
Microwave	4.085	0.245	3.606	4.565	0.000
Fridge	-3.225	0.522	-4.248	-2.203	0.000
Stove	-1.299	0.428	-2.138	-0.461	0.002

Variable	Coefficient	SD	95% Confidence Interval		P>|z|
Washing Machine	-0.246	0.212	-0.663	0.170	0.246
Sewing Machine	1940	0.213	1.523	2.358	0.000
Vacuum Cleaner	7.731	0.555	6.642	8.819	0.000
Computer	5.311	0.321	4.682	5.940	0.000
Printer	5.001	0.363	4.290	5.712	0.000
Video Game	3.727	0.289	3.161	4.294	0.000
Domestic Service	33.347	1.515	30.378	36.316	0.000
Piped Water Outside the Home	-9.333	0.650	-10.607	-8.060	0.000
Piped Water from Public Tap	62.019	2.733	56.663	67.375	0.000
Rainwater Collectors	13.726	0.949	11.866	15.585	0.000
Piped Water Carried from Another Home	11.257	0.833	9.623	12.891	0.000
Pipe Water	5.779	0.643	4.518	7.040	0.000
Well, Water, River, Lake, Stream	0.047	0.324	-0.589	0.683	0.885
Toilet	29.864	1.633	26.662	33.065	0.000
Private Electricity Plant	-5.312	1.256	-7.774	-2.849	0.000
Electricity by Solar Panel	-4.498	0.681	-5.832	-3.164	0.000
Other Electricity Source	-1.681	1.155	-3.944	0.583	0.146
Electrical Unavailability	4.565	0.850	2.898	6.232	0.000
Housing Tenure	1.001	0.394	0.229	1.774	0.011
Infonativ Financing. Fovissste	3.245	0.435	2.393	4.097	0.000
Bank Credit. Sofol. Savings Bank	5.100	0.584	3.955	6.245	0.000
Mortgage Loan from Another Institution	17.631	1.144	15.389	19.873	0.000
Financing Housing Family Loan	13.647	0.982	11.722	15.572	0.000
Own Financing Resources Living Place	-2.248	0.398	-3.028	-1.468	0.000
Solar Heater	-20.295	1.248	-22.741	-17.848	0.000
Gas Heater	-4.204	0.248	-4.689	-3.718	0.000
Expenditure on Vehicle Acquisition	0.000	0.000	0.000	0.001	0.000
Housing Spending	0.002	0.000	0.002	0.002	0.000
Scholarship Amounts	-0.000	0.000	-0.000	0.000	0.411
Expenditure on Household Goods	0.065	0.005	0.057	0.074	0.000
Health Spending	0.011	0.003	0.005	0.016	0.000
Communication Spending	0.062	0.004	0.055	0.070	0.000
Education Spending	0.001	0.000	0.001	0.002	0.000
Capital Perception	0.002	0.000	0.002	0.002	0.000
Savings Deposits	0.000	0.000	0.000	0.000	0.000

(Own Elaboration).

A key assumption underlying ordinal logistic regression is the proportionality, also known as the proportional odds assumption, which posits that no explanatory variable should have a disproportionate effect on a particular level of the response variable. In other words, the slope should remain consistent regardless of the partition pair being considered (McNulty, 2021). The proportional odds assumption test was conducted on the regression results, revealing that five variables exhibited issues in maintaining proportionality, as outlined in Table 5.

Table 5: *P*-Values of the Test for Proportional Odds Assumptions on Selected Variables.

Variable	x^2	DF	P>|z|
Landline	14.88	3	0.0019 **
Pay TV	11.16	3	0.0109 *
Number of Members Who Receive Income	14.98	3	0.0018 **
Medical Affiliation	8.37	3	0.0390 *
Analog TV	8.65	3	0.0344 *
Savings Deposits	19.81	3	0.0002 ***

(Own Elaboration).

Following the identification of proportionality issues, the variables listed in Table 5 were removed from the model. Additionally, the Variance Inflation Factor (VIF) test was conducted to assess multicollinearity among the independent variables. This test revealed collinearity problems between two variables: housing tenure and the financing scheme used for housing acquisition, which included categories such as Infonavit Financing, Fovissste, bank credit, Sofol, savings banks, mortgage loans from other institutions, and family loans. These variables were also removed from the model. The full results of the VIF test are available in Appendix B.

After recalculating the ordered logistic regression, although it provided valuable insights into identifying assets relevant to social mobility in Nuevo Leon, the results were more clearly interpreted through the estimation of marginal effects. These effects represent the change in the probability of a household belonging to a particular quintile in response to changes in asset ownership, reflecting shifts in the explanatory variables. Table 6 presents the results of the marginal effects for each quintile. In the extreme case of quintile 1, almost all variables exhibit either a negative or zero-value coefficient, which may indicate the challenges a household faces in remaining at the lowest level when acquiring more assets. This table only includes assets common to both the ENIGH and ESRU-EMOVI NL surveys, as the retrospective generational data provided by the latter is essential for estimating transition probabilities between quintiles.

An interesting finding from the estimation of marginal effects is the clear distinction between assets that increase the likelihood of belonging to the fourth quintile and those that raise the probabilities of belonging to quintiles 2 and 3. This differentiation is evident in the sign of the coefficients. For example, owning a refrigerator, benefiting from the free health system, or having a stove and mobile phone are assets relevant to belonging to quintile 3 but also reduce the chances of reaching quintile 4. Given that a simultaneous increase in all relevant assets is not feasible due to their diversity, a selection was made of assets that could be acquired through microcredit, with priority given to technological assets. Moreover, assets that increase the probability of a household belonging to quintile 4 were prioritised, as the greatest social mobility tends

to occur at medium levels rather than at the extremes (OECD, 2018). The results of the marginal effects indicate that more assets are associated with a higher probability of belonging to quintile 4. Consequently, computer ownership, linked to internet access, was identified as the asset with the most significant impact on the likelihood of a household reaching the fourth quintile.

Table 6: Results of Marginal Effects by Quintile.

Variable	Q5	Q4	Q3	Q2	Q1
Internet Connection	0.018 ***	0.647 ***	-0.447 ***	-0.211 ***	-0.006 ***
Computer	0.017 ***	0.442 ***	-0.408 ***	-0.05 ***	-0.001 ***
Vacuum Cleaner	0.026 **	0.416 ***	-0.406 ***	-0.035 ***	0 ***
Credit Card	0.014 ***	0.412 ***	-0.378 ***	-0.047 ***	-0.001 ***
Toaster	0.017 ***	0.397 ***	-0.374 ***	-0.039 ***	0 ***
Digital TV	0.005 ***	0.395 ***	-0.231 ***	-0.164 ***	-0.005 ***
DVD	0.02 ***	0.385 ***	-0.371 ***	-0.033 ***	0 ***
Toilet	-0.986 ***	0.381 ***	0.565 ***	0.038 ***	0 ***
Gas Heater	0.01 ***	0.379 ***	-0.338 ***	-0.05 ***	-0.001 ***
Pipe Water	0.025 **	0.357 ***	-0.355 ***	-0.026 ***	0 ***
Piped Water Carried from Another Home	0.174 **	0.35 ***	-0.492 ***	-0.03 ***	0 ***
Microwave	0.007 ***	0.348 ***	-0.292 ***	-0.06 ***	-0.001 ***
Electrical Unavailability	0.017 NS	0.338 ***	-0.327 **	-0.027 ***	0 ***
Video Game	0.011 ***	0.309 ***	-0.289 ***	-0.029 ***	0 ***
Vehicles	0.004 ***	0.219 ***	-0.185 ***	-0.036 ***	0 ***
Radio	0.004 ***	0.172 ***	-0.156 ***	-0.019 ***	0 ***
Other Electricity Source	0.448 ***	0.097 NS	-0.513 ***	-0.031 ***	0 ***
Expenditure on Vehicle Acquisition	0 ***	0.048 ***	-0.042 ***	-0.006 ***	0 ***
Washing Machine	0 NS	0.014 NS	-0.012 NS	-0.002 NS	0 NS
VCR	0.596 ***	0.014 NS	-0.569 ***	-0.04 ***	-0.001 ***
Well Water, River, Lake, Stream	-0.001 *	-0.07 *	0.061 *	0.01 NS	0 NS
Stove	-0.001 NS	-0.076 NS	0.068 NS	0.009 *	0 NS
Rainwater Collectors	-0.001 NS	-0.08 NS	0.067 NS	0.013 NS	0 NS
Cell Phone	-0.002 **	-0.122 **	0.111 **	0.014 **	0 **
Solar Heater	0.772 ***	-0.176 *	-0.558 ***	-0.037 ***	0 ***
Electricity by Solar Panel	-0.003 **	-0.21 **	0.155 ***	0.056 NS	0.001 NS
Fridge	-0.008 **	-0.256 ***	0.24 ***	0.024 ***	0 ***
Piped Water Outside the Home	-0.005 ***	-0.411 ***	-0.022 NS	0.419 ***	0.019 ***
Private Electricity Plant	-0.004 ***	-0.415 ***	-0.544 ***	-0.035 *	0.999 ***
Piped Water from Public Tap	0.994 ***	-0.44 ***	-0.521 ***	-0.031 ***	0 ***

*** $p<0.001$, **$p>0.05$, *$p<0.1$, NS=Not Significant. (Own Elaboration).

Differences in Differences

Once the key assets for the analysis were identified, a Differences-in-Differences model was employed to statistically confirm the impact of technological assets on household social mobility. The "Assets" variable was defined as 0 when the household lacked both

a computer and internet in the home of origin, and 1 when both assets were present in the current household. Control variables were incorporated to isolate the effect of technological assets on changes in household socioeconomic conditions. These variables included the gender of the interviewee, the rural or urban status of the household, and the years of education of the father, mother, or interviewee. The dependent variable was the change in the household wealth index, as estimated from the ESRU-EMOVI NL (see Table 7).

Table 7: Results of the Differences in Differences Models.

Variable	Model 1	Model 2
Constant	0.7015*	0.7225*
Assets	.3693*	0.3302*
Interviewed Gender		-0.1142*
Rural or Urban Condition		0.1725*
Years of Education of Father		-0.0256*
Years of Education of Mother		-0.0042
Years of Education Interviewed		0.0111
Prob > F	0.000	0.000
R2 Coefficient	0.1123	0.1435

*Indicates $p<0.05$. (Own Elaboration).

In both models, the "Assets" variable is statistically significant. In Model 2, the control variables for the respondent's education and the mother's education are not statistically significant at the 0.05 level. The coefficient values for the "Assets" variable indicate that households with technological assets experience a change in the wealth index 0.3693 standard deviations higher than those without these assets in Model 1, and 0.3302 standard deviations higher in Model 2.

Transition Probabilities Between Quintiles

The data collected in the ESRU-EMOVI NL was utilised to determine the probabilities of transitioning between quintiles as a result of changes in the possession of technological assets in households in Nuevo Leon. The Markov Chain model was applied, generating the frequency matrices displayed in Table 8.

Table 8: Frequency Matrices Obtained with Markov Chain.

		Quintile of the Later Generation				
		1	2	3	4	5
Quintile of Origin	1	6.88	63.03	47.34	51.98	22.05
	2	2.06	8.19	67.66	98.68	66.11
	3	0.18	2.29	14.48	97.67	82.17
	4	2.89	4.56	12.39	16.12	95.99
	5	-	0.90	5.38	12.02	16.07

(Own elaboration).

Subsequently, the probability percentages of a household in an initial quintile transitioning to other quintiles were calculated. The results are presented in Table 9. From these results, it can be interpreted that a household originating from quintile 3 would have a 0.09% probability of moving to quintile 1 upon acquiring technological assets, a 1.17% probability of moving to quintile 2, a 7.36% probability of remaining in the same quintile, a 49.63% probability of advancing to quintile 4, and a 41.75% probability of advancing to quintile 5.

Table 9: Transition Probabilities between Quintiles.

		Quintile of the Later Generation				
		1	2	3	4	5
Quintile of Origin	1	3.60%	32.95%	24.75%	27.17%	11.53%
	2	0.85%	3.38%	27.88%	40.66%	27.24%
	3	0.09%	1.17%	7.36%	49.63%	41.75%
	4	2.19%	3.46%	9.39%	12.22%	72.75%
	5	0.00%	2.63%	15.65%	34.97%	46.75%

(Own Elaboration).

Microsimulation Model

The information generated in previous steps facilitated the development of the final microsimulation model. A total of 255 households were included, representing 88,931 households in Nuevo Leon when adjusted for the expansion factor. These households were classified into quintiles based on their monthly net income, and net expenses were estimated using the methodology employed by the National Council for the Evaluation of Social Development Policy (CONEVAL) for poverty estimation (Consejo Nacional de Evaluación de la Política de Desarrollo Social, 2009). The model proposes a microcredit for households to acquire a computer with internet access. Initial values were based on current average prices from three retail companies selling computers and three internet service providers. The credit was set for a two-year period, after which the equipment would be renewed and updated according to inflation. Table 10 presents the variations in technological asset prices, using the base inflation rate.

Table 10: Value of Technological Assets at the Time of Credit Renewal.

		Computer Renewal			
	INITIAL	2 Years	4 Years	6 Years	8 Years
Internet Access	6,352.00	$6,928.58	$7,557.50	$8,243.50	$8,991.77
Computer	9,165.67	$9,997.65	$10,905.15	$11,895.02	$12,974.75
Average Cost	15,517.67	$16,926.23	$18,462.64	$20,138.52	$21,966.52
		Computer Renewal			
		10 Years	12 Years	14 Years	
Internet Access		$9,807.97	$10,698.25	$11,669.35	
Computer		$14,152.48	$15,437.12	$16,838.37	
Average cost		$23,960.45	$26,135.38	$28,507.72	

(Own Elaboration).

The income and expenses of each household were projected using an annual growth rate for both variables. In each annual projection, it was determined whether the household could maintain its ability to repay the microcredit by subtracting expenses, including the credit repayment, from income. This projection was carried out over a 14-year period, with income and expense growth rates, inflation, and interest rate changes estimated randomly within a triangular distribution. These projections were conducted across 5,000 iterations using Monte Carlo Simulation. The average values applied in the simulations are presented in Table 11.

Table 11: Average Values Used in the 5 Thousand Iterations of the Monte Carlo Simulation.

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Net Income	2.99%	2.39%	1.80%	1.02%	-0.52%
Net Expense	24.20%	15.81%	6.97%	6.59%	6.01%
Inflation	4.73%	4.73%	4.73%	4.73%	4.73%
Change in Interest Rate	0.62%	0.62%	0.62%	0.62%	0.62%

(Own Elaboration).

The average value from the Monte Carlo Simulation revealed the final distribution of households across quintiles, based on their expansion factor as shown in Table 12.

Table 12. Monte Carlo Simulation Results.

			Final Location Quintile				
		Number of Households	1	2	3	4	5
Quintile at the End of the Simulation	1	3,710.43	133	1,223	918	1,008	428
	2	4,021.75	3. 4	136	1,121	1,635	1,095
	3	5,255.13	5	61	387	2,608	2,194
	4	7,736.06	169	267	726	945	5,628
	5	11,974.43	0	315	1,874	4,188	5,598

(Own elaboration).

The shaded boxes represent households that would experience upward social mobility, moving to a higher quintile than their original position. According to these results, 12,230 households would advance to a better level, which accounts for 13.75% of the 88,931 households initially included in the model. Of these, 73.32% could be positioned in quintiles 4 and 5.

DISCUSSION

This research combines various models and methodologies to assess the impact of selected assets on social mobility in Nuevo Leon. The key component was the development of a microsimulation model, designed to evaluate changes in household

income and expenses when a microcredit for acquiring technological assets was factored into their expense dynamics. The inclusion of microcredits aimed to make technological assets accessible to households. Following the creation of an asset index using the mixed principal components methodology and an ordered logistic regression to identify assets most relevant to each quintile, two technological assets—computer ownership and internet access—were selected for analysis. The first hypothesis was confirmed, demonstrating that the possession of more assets increases the likelihood of households moving to higher quintiles in the wealth distribution. A Differences in Differences model further validated that the ownership of technological assets significantly impacts social mobility across generations, confirming the second hypothesis.

The average results of this study indicate that 13.75% of households starting in quintiles 1, 2, and 3 in Nuevo León could improve their socioeconomic status, advancing to a higher quintile following the acquisition of technological assets through microcredit. This confirms Hypothesis 3: households with access to technological assets through microcredit achieve upward social mobility by advancing to a higher quintile than their household of origin. Previous studies linking access to technology with improvements in living conditions highlight the benefits of easier access to information, particularly in education and employment. The COVID-19 pandemic underscored the importance of having a computer with internet access, as it enables children and young people to engage in innovative educational schemes, reducing the disadvantages posed by distance from educational centres or the absence of them in certain communities.

Few studies with objectives similar to those of the present research were found. However, some studies present results in line with this study's findings. For example, Weng et al. (2024) demonstrated that internet usage significantly promotes social mobility between low-income rural groups and middle-income groups in China. Additionally, Plassot et al. (2019) examined the effect of wealth accumulation on social mobility in various regions of Mexico. In the northern region (which includes Nuevo León), they found a 32% probability of upward social mobility, with a 6% probability of moving from quintile 1 to quintile 6. However, their study does not provide details on the effect of individual assets included in the wealth measurement.

CONCLUSION

Upward social mobility is widely recognised as crucial in reducing inequality, as it facilitates the bridging of gaps between different socioeconomic levels and enables individuals to achieve better living standards. While most studies on social mobility in Mexico are national in scope, the ESRU-EMOVI NL 2022 provides data specific to Nuevo León, allowing for a more nuanced analysis of factors affecting socioeconomic change in this distinct region. This focused approach may yield more effective policy

outcomes. For instance, national microsimulation models identified several assets—such as stoves, refrigerators, washing machines, microwaves, and computers—as key to social mobility. However, in Nuevo León, only computer ownership emerged as a significant asset for enhancing mobility. The use of asset indices to measure social mobility is common, particularly in contexts where household income data is unavailable or unreliable. However, there is room for further research into the relevance of specific assets in driving social mobility, and this study contributes by identifying key assets that promote upward mobility, adapting existing methodologies for regional analysis. While the model indicated that 13.75% of households might experience upward mobility, this result is based on certain assumptions and initial values, which could be refined in future research. These include the use of historical income and expense data, the inflation rate, and interest rates, all of which could influence the model's outcomes. A reduction in interest rates, for example, could increase accessibility to microcredits, thereby allowing more households to acquire technological assets. Future studies could explore public-private partnerships to reduce interest rates and improve the affordability of microcredits, or investigate collaboration with technology manufacturers to lower costs. Longitudinal studies in regions where asset acquisition programmes have been implemented would also help validate the findings. Ultimately, the proposed microsimulation model could serve as a foundation for public policies aimed at reducing inequality and promoting social mobility. We suggest focusing on targeted sectoral policies, in partnership with the private sector, to achieve greater benefits. Inequality, as highlighted by recent research, is not inevitable, but a political choice that requires proactive policy action.

AUTHORS CONTRIBUTION

Conceptualization, LD; Methodology, LD; Validation, HR; Formal Analysis, LD and HR; Investigation, LD; Data Curation, LD; Writing – Original Draft Preparation, LD; Writing – Review & Editing, HR; Visualization, HR; Supervision, LD; Project Administration, HR.

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APPENDIX A

Table A1: Set of variables selected to describe the accumulation of assets in households in different areas.

Variables			
Analog television	Home ownership	Monthly amount allocated to a savings account	Toilet
Cell phone	Insurance for major medical expenses	Monthly amount for housing payment	Solar heater
Computer	Internet connection	Monthly amount for vehicle acquisition	Stove
Credit card	Life insurance	Monthly amount received from financial perceptions	Type of home financing
Digital television	Machine sewing	Monthly amount received from scholarships	Vacuum cleaner
Domestic service	Medical membership in another institution	Number of household members receiving income	VCR
DVD	Membership in the free health services system	Pay television	Vehicle
Educational level of the head of the family	Microwave	Printer	Video games
Educational credit	Monthly amount allocated to communication	Radio	Voluntary retirement savings account
Educational scholarship	Monthly amount allocated to education	Refrigerator	Washing machine
Electricity availability	Monthly amount allocated to health	Telephone	Water availability
Gas heater	Monthly amount allocated to household goods	Toaster	

Own elaboration.

APPENDIX B

Table B1: Variance Inflation Factor Test results.

Variable	GVIF	Df	GVIF^(1/(2*Df))
Landline	1.5964	1	1.2635
Cell phone	1.2001	1	1.0955
Pay TV	1.2584	1	1.1218
Internet connection	2.0243	1	1.4228
Credit card	1.312	1	1.1454
Household head education	2.6614	9	1.0559
Number of members who receive income	1.1661	1	1.0799
Educative credit	1.0979	1	1.0478
Major medical expenses Insurance	1.1742	1	1.0836
Life insurance	1.1042	1	1.0508

Table B1: Variance Inflation Factor Test results. (Continued)

Variable	GVIF	Df	GVIF^(1/(2*Df))
Voluntary savings for retirement	1.0639	1	1.0315
Educational scholarship	1.1689	1	1.0812
Insabi/free health system	1.2006	1	1.0957
Medican affiliation	1.2773	1	1.1302
Vehicles	1.3181	1	1.1481
Radio	1.0576	1	1.0284
Analog TV	1.5194	1	1.2327
Digital TV	1.7371	1	1.318
DVD	1.1147	1	1.0558
VCR	1.0733	1	1.036
Toaster	1.2666	1	1.1254
Microwave	1.3475	1	1.1608
Fridge	1.4069	1	1.1861
Stove	1.38	1	1.1747
Washing machine	1.3887	1	1.1784
Sewing machine	1.0882	1	1.0432
Vacuum cleaner	1.3066	1	1.1431
Computer	1.9233	1	1.3868
Printer	1.6102	1	1.2689
Video game	1.3056	1	1.1426
Domestic service	1.2216	1	1.1053
Water availability	1.663	6	1.0433
Toilet	1.0564	1	1.0278
Electricity availability	1.1428	4	1.0168
Housing tenure	6.1678	1	2.4835
Financing scheme used for housing acquisition	9.5734	5	1.2534
Solar heater	1.073	1	1.0359
Gas heater	1.3627	1	1.1674
Expenditure on vehicle acquisition	1.0688	1	1.0338
Housing spending	1.233	1	1.1104
Scholarship amounts	1.0597	1	1.0294
Expenditure on household goods	1.1161	1	1.0565
Health spending	1.1728	1	1.083
Communication spending	1.3046	1	1.1422
Education spending	1.094	1	1.046
Capital perception	1.0404	1	1.02
Savings deposits	1.1211	1	1.0588

Own elaboration.