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FRÉDÉRIC AUGUSTE ARNAUD ROZEIRA DE SAMPAIO MARIZ

**Financial inclusion and electronic payments;
Explaining electronic payments in Brazil with Principal Components
Analysis and SARIMAX Models**

**A inclusão financeira e o setor de pagamentos eletrônicos :
Um estudo dos meios de pagamentos eletrônicos no Brasil
Através da análise de componentes principais e modelos SARIMAX**

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Prof. Dr. Marco Antônio Zago

Reitor da Universidade de São Paulo (USP)

Prof. Dr. Adalberto Américo Fischman

Diretor da Faculdade de Economia, Administração e Contabilidade

Prof. Dr. Roberto Sbragia

Chefe do Departamento de Administração

Prof. Dr. Moacir de Miranda Oliveira Júnior

Coordenador do Programa de Pós-Graduação em Administração

FRÉDÉRIC AUGUSTE ARNAUD ROZEIRA DE SAMPAIO MARIZ

Financial inclusion and electronic payments in Brazil
Inclusão financeira e meios de pagamentos eletrônicos no Brasil

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“Les causes primordiales ne nous sont point connues; mais elles sont assujetties à des lois simples et constantes, que l'on peut découvrir par l'observation, et dont l'étude est l'objet de la philosophie naturelle.”

Joseph Fourier, Théorie analytique de la chaleur, Discours préliminaire, Paris: Firmin Didot, 1822

“We began by trying to gain an understanding of family behavior and a vocabulary of materials and techniques, correlated through a logical approach to economics, and adapted to an industrialized system of mass production. We agreed that the house must make no insistent demands for itself, but rather aid as a background for life in work. This house acts as reorientator and shock absorber.”

Charles Eames (1907-1978)

Auf eine von der Zeit verleschte Grabschrift

Vor wurd' / durch diese Schrift / die hier die Zeit zerstört /
Daß alles auf der Welt vergänglich sey / gelehrt;
Und nun / man sie nicht lesen kan.
So zeigt sie es nor klärer an:
Kein größer Zeugnüß kan man haben /
Die Grabschrift selbst liegt hier begraben.

Christian Wernicke (1661-1725)

ABSTRACT

Mariz, Frederic de, **Financial inclusion and electronic payments in Brazil**. 2017. 180 p. Thesis (Ph.D. in Finance) – Faculdade de Economia e Administração, Universidade de São Paulo, São Paulo, 2017.

Financial inclusion is a public policy objective that fosters development through access to financial services for all. Financial inclusion can be defined as access, usage and quality of financial services. Inclusion of individuals and small enterprises has made considerable progress but it has also reached excesses in some situations. Regulatory changes and technological innovation have helped the expansion of financial services. Our contribution to the literature is threefold. First, we expand the large body of research that focuses on financial inclusion based on access to credit, through our analysis of payments. We provide an unique analysis of the quality dimension of payments, which we define as a catalyst between the access and usage dimensions. Second, we provide a detailed analysis of the Brazilian payment market, which transacts close to \$400bn per year, in the scarce literature on developing countries. Third, we isolate the determinants of electronic payments through statistical methods, including a principal component analysis and auto regressive models (SARIMA, SARIMAX), which have not yet been used by researchers. We find that four macro characteristics have a strong explanatory power: bank credit card lending, active population, retail sales and cash-in-circulation. Surprisingly, we find that cash-in-circulation presents a *positive* relationship with electronic payments, suggesting a possible distrust of citizens towards the banking system, high levels of informality, and shedding a new light on the precautionary principle described by Keynes. Our analysis is based on monthly deflated card payment data for Brazil from January 2007 to March 2017.

Keywords: Electronic payments. Financial inclusion. Credit card. Financial innovation. FinTech. Principal components. SARIMAX.

RESUMO

Mariz, Frédéric de, **A inclusão financeira e o setor de pagamentos eletrônicos no Brasil**. 2017. 180 f. Tese (Doutorado em Finança) – Faculdade de Economia e Administração, Universidade de São Paulo, São Paulo, 2017.

A Inclusão financeira é um objetivo de política pública que procura desenvolvimento através do acesso de todos aos serviços financeiros. Esse conceito pode ser definido com as suas três dimensões de acesso, uso e qualidade dos serviços. A inclusão de indivíduos e empresas conheceu uma melhora significativa, e em alguns casos, apresentou excessos. Adaptações regulatórias e inovação tecnológica serviram de pano de fundo para a inclusão. Apresentamos as três contribuições da nossa pesquisa. Primeiro, existe ampla literatura sobre inclusão financeira com foco em crédito, e apresentamos um estudo original sobre pagamentos e sua dimensão de qualidade, definida como o catalisador entre acesso e uso. Segundo: nossa pesquisa apresenta uma análise única do setor de pagamentos no Brasil, um setor com faturamento de mais de R\$1.2 trilhões de reais anuais, no âmbito da escassa literatura sobre economias em desenvolvimento. A terceira contribuição apresenta os determinantes dos meios de pagamentos eletrônicos, usando modelos estatísticos originais, como componentes principais e modelos auto regressivos (SARIMA, SARIMAX), que não tinham sido usados na literatura de inclusão financeira. Identificamos quatro características com significância para explicar meios eletrônicos: crédito bancário, população ativa, vendas do varejo e dinheiro em posse das famílias. De maneira surpreendente, dinheiro em posse das famílias apresentou correlação *positiva* com meios eletrônicos, sinalizando uma desconfiança dos consumidores com o setor bancário ou um maior grau de informalidade da economia brasileira, e trazendo uma interpretação original ao princípio de precaução descrito por Keynes. Nossa pesquisa se baseou em dados agregados e deflacionados de pagamentos para o Brasil entre Janeiro de 2007 e Março de 2017.

Palavras-chave: Meios de pagamento. Desenvolvimento social. Cartão de crédito. Inovações tecnológicas.

LIST OF ABBREVIATIONS

ABECS	Brazilian Card Association
AFI	Association for Financial Inclusion
ARMA	Auto Regressive Moving Average (Model)
ATM	Automated Teller Machine
BACEN	Banco Central do Brasil, Brazilian Central Bank
B2B	Business to Business
B2C	Business to Customer
B2G	Business to Government
BCB	Banco Central do Brasil, Brazilian Central Bank
BTCA	Better Than Cash Alliance
C2B	Customer to Business
C2C	Customer to Customer
C2G	Customer to Government
CGAP	Consultative Group to Assist the Poor
CSFI	Center for the Study of Financial Innovation
EFA	Exploratory Factor Analysis
FINTECH	Financial Technology
G20	Group of 20 most industrialized countries
G2B	Government to Business
G2C	Government to Customer
G2G	Government to Government
GDP	Gross Domestic Product
IBGE	Brazilian Statistics Institute
IGPM	Inflation index
IPCA	Inflation index
IMF	International Monetary Fund
MDR	Merchant Discount Rate
MSME	Micro-, Small-, Medium-Sized Enterprises
MSMR	Micro-, Small- and Medium-Sized Retailers

NBFI	Non-Bank Financial Institutions
OLS	Ordinary Least Squares
PAFI	Aspects for Financial Inclusion
PCA	Principal components analysis
POS	Point of Sale, sometimes used to refer to terminals
SARIMA	Seasonal Auto Regressive Integrated Moving Average (Model)
SME	Small- and Medium-Sized Enterprises
UFA	Universal Financial Access
UN	United Nations
US	United States
VIF	Variance Inflation Factor
WBG	World Bank Group

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1 INTRODUCTION

Financial inclusion has become a consensual policy objective. There is a large literature offering support for a link between financial inclusion and development, while excessive or inappropriate inclusion can also bring risks. In our research, we analyze financial inclusion from the angle of electronic payments. Those include payments with credit, debit, prepaid cards, and other electronic means such as online and mobile payments. The growing use of electronic payments is evidence of higher financial inclusion. This, in turn, can be beneficial to households and companies by opening the door to a wider range of financial services, including – but not limited to – credit.

Access to and usage of financial services have improved thanks to deeper branch networks, and the rise of correspondents. Over the past two decades, technology and regulations have boosted inclusion. Brazil has been at the forefront of financial innovation and inclusion, ever since the introduction of banking correspondents in the 1970's, a regulation copied by several other countries. The theme of financial inclusion remains relevant in Brazil, where it is estimated that 50 millions citizens lack access to financial services. Data on the penetration of financial services, such as bank accounts, credit, insurance or payments all point to a meaningful improvement over the past 20 years, but still ample room to improve. While the literature on credit and insurance is already ample, detailed knowledge on the use of electronic payments is still in its infancy.

The key research question we try to address is: what are the drivers of the usage of electronic payments in Brazil?

Throughout our research, we touch on a number of related topics, with ramifications outside of the finance field, into economy and public policy. We do not pretend to exhaust those secondary objectives. Those themes are developed throughout our study and may be developed in future work.

- we analyze the close connection between electronic payments and financial inclusion, following research by Ramirez, Vásquez and Pereda et al. (2015),

Bagnall et al. (2014), von Kalckreuth, Schmidt and Stix (2009). In particular, this is the first work to develop the quality dimension of payments, alongside access and usage;

- we gauge whether financial inclusion has reached a limit in Brazil and might be receding, following the literature by the Demirgüç-Kunt et al. (2015), CGAP (2015). Recently included citizens are at risk of being excluded from financial services;
- we assess the risks and opportunities brought by innovation and FinTech to electronic payments in the Brazilian context, following de Mariz (2016) and Bader (2007).

Following the existing literature, in particular Bagnall et al. (2015), Fish and Whymark (2015), von Kalckreuth, Schmidt, and Stix (2014), Kumar (2005), we make the hypothesis that the proximity of banking services, the size of transaction and all-in costs are the main drivers of electronic payments in Brazil.

We used several approaches to analyze the various aspects of the thematic, with methodologies including:

- an in-depth bibliographical revision, which we detail in our revision of the literature. We highlight in particular the connection between electronic payments, financial inclusion, and credit;
- a descriptive analysis detailing the trends in both financial inclusion and usage of electronic payments in Brazil. We also provide a unique analysis of the strengths and weakness of the payment industry in Brazil;
- a series of detailed statistical tests to determine the drivers of the use of electronic payments in Brazil, adjusted for inflation, including principal components analysis and auto-regressive models ARMA.

As a result, our study combines exploratory, descriptive and quantitative methodologies. On the quantitative side, we build a simple regression with a number of independent variables. The dependent variable is the usage of electronic payments, as

measured by monthly data from the Brazilian Card Association (ABECS). Our research is based on monthly aggregated payment data at the macro level from January 2007 to March 2017, representing 123 data points, adjusted for the IPCA inflation index. Quarterly and annual data during this time period was instrumental for descriptive analysis and complemented our statistical tests.

In order to ease the understanding of the research problem, we propose a table summarizing the question to be answered, the revision of the literature, the methodology, data sets and expected results.

Table 1 - Summary of research

Research Problem	Review of Literature	Methodology	Data sets	Results
<p>Background: The rise in electronic payments goes hand in hand with higher financial inclusion and brings various development-related benefits to a country, contrary to cash usage.</p>	<p>Currents of literature include:</p> <ol style="list-style-type: none"> 1) Strong literature on financial inclusion, but only an incipient emphasis on payments; 2) A well-structured literature from Central Banks, with a focus on the demand for money; 3) More recent studies on transaction characteristics and consumer preference to explain payment types. 	<p>Regression, Principal Components Analysis, SARIMA, SARIMAX models.</p>	<p>Brazilian Central Bank, IBGE, PNAD, FGV, World Bank Findex, IMF, IFC, Observatorio da criminalidade, ABECS.</p>	<p>Country characteristics as well as transaction characteristics are found to have a strong explanatory power for electronic payments in Brazil.</p>
<p>Problem: What are the drivers of electronic payments in Brazil?</p>				<p>We highlight credit card lending, employment, supermarket sales, cash-in-hand, transaction size and all-in cost as key variables.</p>
<p>Related problems: What is the intersection of payments and financial inclusion? Are electronic payments losing ground versus cash after a period of strong growth? What is the quality dimension of electronic payments? What are the strengths and weaknesses of electronic payments in Brazil?</p>				<p>We also find that the best predictor of electronic payments is their past pattern, via SARIMA models.</p>

Source: Author.

Following this introduction, four sections compose this paper. In a second section, we make a detailed revision of the literature on financial inclusion, its benefits and risks to development. In a third section, we explain the importance of electronic payments, and list the many advantages of a cashless economy, and the connection between financial inclusion, electronic payments and credit. We also develop the quality dimension of payments, alongside access and usage. In a third section, we analyze the macro trends of the usage of electronic payments in Brazil. We show that after a period of accelerated growth, Brazil seems to have reached a limit to electronic payments. We also provide a unique analysis of strengths and weaknesses of the payment industry in Brazil. In a fourth section, we develop statistical tests to answer the question of the adoption of electronic payments. In particular, we build a regression analysis, followed by an analysis of principal components, SARIMA and SARIMAX models. Finally, we conclude our research, summarizing the main messages supported by our quantitative and descriptive analyses and making recommendations to policy makers to foster enhanced financial inclusion through payments.

We list three main reasons that insert our research effort into the existing literature, while highlighting its originality:

- a) From a monetary standpoint, our thesis complements the growing literature on the demand for money on one hand, and the choice of payment means on the other hand.
- b) From an economic policy standpoint, our research provides a unique contribution to the literature of finance and development economics, as it bridges the gap between payment means and financial inclusion. It focuses on means of payments as a vehicle for inclusion, while the current body of knowledge on financial inclusion focuses on access to microcredit.
- c) Moreover, our research brings a new perspective on Brazil, one of the largest markets globally for electronic payments, complementing the literature focusing on developed economies and the small and patchy literature on select developing countries.

As far as we know, this is the first research venture that uses statistical analysis to isolate the determinants of electronic payments usage in Brazil. Furthermore, we believe no academic research on payments in other countries has used the potential from PCA, SARIMA and SARIMAX models to explain and predict electronic payments.

Our findings suggest that macroeconomic characteristics have a strong explanatory power for electronic payments. Based on statistical tests, we isolated four variables with a strong fit with card payment data: bank credit card lending, the size of the active population, cash in circulation and retail sales. We highlight results that contrasted with our expectation: we found that cash-in-hand is *positively* correlated with electronic payments, which could suggest a preference for cash by Brazilian consumers. We also find that the best predictor of future electronic payments is their past trend, and found that auto regressive models (SARIMA) presented a good fit.

2 REVISION OF THE LITERATURE ON FINANCIAL INCLUSION

2.1 The three dimensions of financial inclusion: access, usage, quality

There is a diversity of definitions of financial inclusion. Allen et al. (2012) define it simply as the use of formal accounts. We find that the definition of the Consultative Group to Assist the Poor (CGAP), a group housed at the World Bank, best describes this phenomenon. CGAP defines financial inclusion as the process whereby “households and businesses have access [to] and can effectively use appropriate financial services. Such services must be provided responsibly and sustainably, in a well regulated environment” (CGAP, 2015). The Center for Financial Inclusion (CFI) provides a complementary dimension to that ample definition, by stating that financial inclusion allows everyone to have “access to a full suite of quality financial services at affordable prices, with convenience, dignity, and consumer protection, delivered by a range of providers in a stable, competitive market to financially capable clients” (KELLY and RHYNE, 2015). Kelly and Rhyne explain that financial inclusion is much more than banking the unbanked and define five dimensions to advance financial inclusion: develop financial capabilities, attend customer needs, technology-enabled businesses, credit reporting, and customer protection.

The definitions illustrate that being financially included is different from - and much more complex than - being banked: having a bank account at a formal bank institution. Being banked is a state where individuals have a relationship with a formal financial institution, including banks, cooperatives and credit unions. Authors note that financial inclusion consists in having access to a wide range of financial services, not just credit (MAS, 2009). Moreover, bank branches are just one channel through which customers can take advantage of those services.

Roa (2015) defines three critical dimensions of financial inclusion as access, usage and quality related to formal financial services. Understandably, **access** to financial services has been the first focus of policy makers, especially for underserved rural and poor segments of the population. Regulations around banking correspondents, simplified financial services, mandatory free basic financial offering, investments into

branch opening and mobile banking have helped increase meaningfully the convenience for citizens to be banked. Depth is an important factor for the financial services that people can have access to, including savings, insurance, credit, and electronic payments.

Usage, or outreach, is the willingness of people to take advantage of accessible financial services. Allen et al. (2012), highlights that “those who have access, but choose not to use services pose less of a problem for policymakers”. Research shows that among survey participants without an account in the 2014 Findex survey, only 4% said they do not need one (DEMIRGÜÇ-KUNT et al., 2015).

Finally, the academic literature emphasizes **quality**, explaining that people need to develop a list of financial capabilities to be able to fully take advantage of services that are offered to them. The financial capability of the customer has become an increasingly central aspect of the thinking about financial inclusion, and authors note the incipient focus of Brazilian authorities on this theme (SAVOIA; SAITO; SANTANA, 2007). Authors define financial capabilities for customers who “have knowledge, skills, and behaviors that enable them to make sound financial decisions” (KELLY and RHYNE, 2015). Authors show that for users of mobile money in poor communities in Kenya, “financial education did not necessarily precede uptake of financial services” (MONEY..., [s.d]). In fact, the authors explain that “experience, rather than education, is at the core of improvements in financial capability, and that experience includes actual usage of financial products, even before they are fully understood”.

Over the past several decades, innovation and regulation have allowed financial services to be distributed outside of the traditional brick-and-mortar bank branches. Different types of providers have developed, including non-government organizations, cooperatives, community-based development institutions, commercial and state banks, insurance and credit-card companies, telecommunications and wire services, post offices, and other businesses that provide point-of-sale (POS) access. Those businesses that are not regulated like banks are often referred to as Non-Bank Financial Institutions (NBFIs). Technology, with the advent of the Internet and mobile solutions, has played a critical role in the recent growth of those channels.

Financial inclusion considers all economic agents, either individuals or

corporates, with a special attention for the more vulnerable and excluded segments, such as the poorer segments of the population in emerging markets. That said, the reverse concept of financial exclusion also happens, and is a growing concern, in developed economies, such as the US (BURHOUSE and OSAKI, 2014). World Bank (2013) notes that 20% of the US adult population is underbanked, which the authors define as having a bank account but using financial service from another alternative non-FDIC insured financial provider.

Within corporates, the research on financial inclusion focuses especially on small- and medium-sized enterprises (SMEs). The literature on asymmetries of information shows that SMEs are at a disadvantage when it comes to accessing financial services (STIGLITZ and WEISS, 1981). Akerlof (1970), in his seminal paper, related quality and uncertainty, noting that information asymmetry can be detrimental to the market as a whole. Using the words of Stiglitz, the credit market is imperfect in a sense that there may not be a price that clears the supply and demand for credit, if banks simply refuse to lend for lack of information (STIGLITZ and WEISS, 1992). Research even suggests that credit market conditions amplify and propagate the effects of real monetary shocks, under a phenomenon described as the financial accelerator (BERNANKE; GERTLER; GILCHRIST, 1994, BERNANKE and GERTLER, 1995). Bernanke, Lown and Friedman (1991) explain that borrowers who face relatively high agency costs in credit markets will bear the brunt of economic downturns. Agency costs stem from the situation where a principal (the lender) cannot costlessly acquire information on the agent (the borrower). SMEs have a particularly difficult time accessing sources of funding, either via bank credit or the capital markets. Gambacorta and Marques-Ibanez (2011) also note that “bank characteristics can have a large impact on the provision of credit”, strengthening the hypothesis of a bank lending channel. Credit is different from other goods, due to the central role of information, and sunk costs from information gathering act as barriers to entry for borrowers (GREENWALD and STIGLITZ, 2003). Meanwhile SMEs are the larger provider of employment in most economies and therefore play a key role in development. At the intersection of individuals and SMEs, the segment of micro-entrepreneurs has received a high level of attention.

In the case of Brazil, Castelar Pinheiro and Moura (2001) discuss the influence of

high inflation on the segmentation of the credit market, between retail, middle-market and corporate clients. The authors note that the existence of asymmetries of information mean that some customers are “informationally captured”, stressing the importance of credit registries or credit bureaus, and differentiating between black or negative information, used for enforcement, and white or positive information, used for credit scoring.

However, the most recent research brings a more complex analysis on relationship lending and goes against the existing paradigm. Some authors suggest that the specialization of bank on the SME segment may not lead to superior efficiency (BECK and DE JONGHE, 2013). The paper is the first to empirically gauge the relationship between bank lending specialization and bank performance and stability in an international sample. The authors find that sectorial specialization increases volatility and systemic risk exposures, while not leading to higher returns. The paper suggests that banks that are specialized in niche segments such as SMEs are not at an advantage compared to banks with more traditional intermediation models. Berger, Goulding and Rice (2014) build a regression based on survey data on US banks using the Survey of Small Bank Finance. The authors test for the “type of bank serving as the “main” relationship bank for small businesses with different firm and owner characteristics”. Second, they test for the “strength of these main relationships by examining the probability of multiple relationships and relationship length as functions of main bank type and financial fragility, as well as firm and owner characteristics”. The regression results are often not consistent with the conventional paradigm. The authors conclude by suggesting that large banks are perhaps using new lending technologies, such as scoring, the use of collateral, in order to offset the potentially less detailed personal knowledge they have of borrowers.

What is the main reason for financial exclusion?

Demirgüç-Kunt et al. (2015) estimate that around two billion people do not have access to formal financial services, or 38% of adults in the world. In the lower income segments, more than 50% of adults in the poorest households are unbanked. The authors show that the three main reasons for being unbanked include the costs associated with bank accounts, distances traveled to reach a bank or financial agent,

and the various requirements involved in opening a financial account. Those three reasons alone explain 73% of the cases of unbanked people. World Bank (2013) shows that 34% of firms in developing economies have a bank loan, versus 51% in developed markets. For firms, especially small and medium-sized enterprises, improving access to credit is likely to have significant growth effects. The authors explain that technological advances hold promise in the expansion of financial inclusion, provided transaction costs are lowered. Likewise, the World Bank (2016) estimates that “200 million enterprises in developing economies are still constrained in terms of financing, even though small and medium enterprises generate the greatest number of new jobs, employ the largest number of people in aggregate”. The authors flag the central role that retailers can play: “not only in increasing consumer acceptance of such payments, but [retailers] can also contribute to improved supply chain efficiency by paying their suppliers electronically and, ultimately, can encourage financial inclusion” (WORLD BANK, 2016).

The Global Financial Inclusion database provides in-depth data showing how people save, borrow, make payments and manage risk (WORLD BANK, 2013). The Findex database was launched with a first survey in 2011. The 2014 edition shows that 62% of adults worldwide have an account. Between 2011 and 2014, 700 million adults became account holders. At this pace, “by 2020, there will only be 1 billion excluded adults” (LASCELLES; MENDELSON; ROZAS, 2014). The survey shows that in developing countries, “1.3 billion adults with an account pay utilities bills in cash and more than half a billion pay school fees in cash”. The report stresses that when people participate in the financial system, they are better able to start and expand businesses, invest in education, manage risk and absorb financial shocks.

Being financially excluded is linked to income level: the richest 20% of adults in developing countries are more than twice as likely to have a formal account as the poorest 20%. Yet, while the poor do not have the same access to financial products as wealthier individuals, their need for financial services may be even greater. Research shows that access to savings products – and, in particular, to “commitment” savings, in which individuals restrict their right to withdraw funds until they have reached a self-specified goal – can have important benefits beyond simply increasing one’s amount of

savings: it can also help empower women, increase productive investment and consumption, raise productivity and incomes, and increase expenditures on preventive health (BETTER THAN CASH ALLIANCE, 2014).

Research also focuses on the determinants of formal accounts. Allen et al. (2012) explore the “individual and country characteristics associated with financial inclusion” and the “policies that are effective among those most likely to be excluded: poor, rural, female or young individuals”. The authors find that greater financial inclusion is associated with lower account costs, greater proximity to financial intermediaries, stronger legal rights, and more politically stable environments.

Beatriz and Morduch (2005) shows how microfinance was designed to overcome some barriers existing in traditional financial services, especially credit markets. Such barriers include asymmetries of information and transaction costs. Financial innovation played a key role to increase access to finance (BADER and SAVOIA, 2013).

We mentioned earlier that financial inclusion is much broader and ambitious than just providing formal bank accounts. Likewise, we caveat the difference between financial inclusion and financial depth. Financial depth typically considers macro data at the level of a country, such as the total level of credit in an economy, but depth does not consider whether that credit is spread over a large or small subset of the population, which inclusion considers. Most often, data on depth is easier and less costly to obtain than data of inclusion. Demirgüç-Kung and Singer (2017) also notes that “not all financial products are equally effective in reaching development goals, such as reductions in poverty and inequality.”

2.2 Why financial inclusion matters?

The case for inclusion is both political and economic.

The **political** current suggests that inclusive societies can be seen as more fair and allow people to fulfill their potential (RAWLS, 1971; RAWLS, 1988). John Rawls builds his theory of justice in contrast to the utilitarian view. Rawls defines a hypothetical initial state, where the wealth of the economy has not been shared, and all participants in a society agree on the essential basic treatment that should be offered to each of

them. This “veil of ignorance” allows to define the basic level of inclusion and comfort that an individual would accept in a given society. The elegance of his theory is that it is not based on a religious or philosophical pre-requisite, but is pragmatic. Rawls underlines that his theory of justice is political in essence, and not metaphysical. His theory can be defined as an implementation of the game theory to a view of justice, and is based on a principle of fairness. The basic principles of justice “are the principles that rational and free persons concerned to further their own interests would accept in an initial position of equality as defining the fundamentals of the terms of their association.”

Authors have also linked the emergence of a middle class, loosely linked to inclusion, to benefits in terms of institutions and adoption of democracy. Chun et al. (2016) find empirical support for the hypothesis that a rising middle class would have led to democratization around the globe. Earlier, Pressman (2007) detailed in a reference article his views on the middle class, and its contribution to “economic growth, as well as social and political stability”.

The **economic** arguments can be divided into three broad groups. Essentially, the economic arguments vary on the mechanism by which financial inclusion leads to a positive outcome for society. Levine (1997), in a seminal paper, showed that previous literature focused more on the relationship with money and growth, and analyzed the channel between financial development and economic growth. According to him, the financial system is a “real” sector, and does not respond passively to economic growth. The author suggests a “positive, first-order relationship between financial development and economic growth”.

The first and most studied set of arguments links financial inclusion with **higher economic growth and a reduction in poverty** (BECK and DEMIRGÜÇ-KUNT, 2008; CULL; DEMIRGÜÇ-KUNT; LYMAN, 2012; DEMIRGÜÇ-KUNT; SINGER, 2017). The current consensus is that financial inclusion has a positive impact on a host of well-being and economic development metrics, such as income generation or protection from hardship. The literature “suggests that under normal circumstances, the degree of financial intermediation is not only positively correlated with growth and employment, but it is generally believed to causally impact growth”, due to lower transaction costs and better distribution of capital and risk across the economy (CGAP, 2015). Financial

inclusion can favor disadvantaged and poor people by allowing them to increase their income and the probability of being employed (BRUHN; LOVE, 2014). Access to financial services allows people to invest in their education, finance projects or businesses. A transaction or deposit account can be the stepping-stone to full financial inclusion, providing a pathway to a broader range of financial services provided through stronger and more diverse financial institutions. Emerging evidence indicates that access to financial services through formal accounts can enable individuals and firms to smooth consumption, manage risk, and invest in education, health and enterprises. Authors investigate the effect of access to finance on job growth in 50,000 firms across 70 developing countries and find that “increased access to finance results in higher employment growth, especially among micro, small, and medium enterprises” (AYYAGARI et al., 2016).

Despite the still relatively small, albeit growing, number of randomized evaluations, consensus is that financial services do have a positive impact on a variety of microeconomic indicators related with development, including self-employment business activities, household consumption, and well-being (CGAP, 2015; BAUCHET et al., 2011; ANGELUCCI; KARLAN; ZINMAN; 2013). The impact varies across individual financial product categories. Randomized controlled trials to-date have largely been conducted at individual product levels, whereas some observers would argue that research ought to measure whether access to a broad range of services improves household ability to make appropriate choices. Controlling for other relevant variables, almost 30 percent of the variation across countries in rates of poverty reduction can be attributed to cross-country variation in financial development (BECK; DEMIRGÜÇ-KUNT; LEVINE; 2007). Authors also find that women fare better than men in terms of increasing their individual income (GONZALEZ; RIGHETTI; DI SERIO, 2014).

The second is a variation on the first argument, and links financial inclusion with a **reduction in inequalities**. Indeed, higher financial inclusion impacts disproportionately more the poorer segments of the population and therefore can contribute to reduce inequality. While a reduction in poverty rates is good *per se*, a reduction in inequality has also been demonstrated to have positive effects on society. In fact, research suggests

that equal societies reach higher growth rates and achieve higher income levels and more stable growth (EASTERLY, 2001). Easterly finds that a “higher share of income for the middle class and lower ethnic divisions are associated with higher income and higher growth”. He also finds evidence that the middle class consensus leads to “more education, better health, better infrastructure, better economic policies, less political instability, less civil war and ethnic minorities at risk, more social “modernization” and more democracy.” The reflexion on inequalities has recently experienced a renewed focus with historic analyses on the distribution of income and wealth (PIKETTY, 2014).

The third argument links higher financial inclusion with a **better efficiency of policymaking and stability**. With higher access to financial services, levels of formality increase in the economy and more people fall within the reach of government policies. Authors highlight a relationship between financial inclusion and sought-after policy outcomes, such as women empowerment, health, education, gender equality, and peace (HAN and MELECKY, 2013, KLAPPER; EL-ZOGHBI; HESS, 2016). Broad access to bank deposits can have a positive effect on financial stability. Klapper and Singer (2014) note that by moving away from cash payments to digital to distribute government wages and cash transfers such as pensions, “governments can cut costs and reduce leakage”. By including a larger part of the population into the formal financial system, governments increase the potential impact of economic policymaking (CULL; EHRBECK; HOLLE, 2014). Wider inclusion and lower levels of informality also make monetary policy more effective.

As a result of this impressive and growing body of research, financial inclusion has become in the past three decades a growing focus of public policy. At the G20 Summit in Seoul in 2010, financial inclusion was recognized as one of the main pillars of the global development agenda. The World Bank Group also launched an initiative to reach Universal Financial Access (UFA) by 2020. Financial inclusion is often cited as one of the key motivations behind government-owned financial institutions (DE ARAUJO and CINTRA, 2011). The Maya Declaration was launched in 2011 in Riviera Maya, Mexico (ALLIANCE FOR FINANCIAL INCLUSION, 2014). The document has become an important international framework for including the unbanked in order to “unlock their full economic and social potential while contributing to reduced income disparities,

inclusive development and overall national financial stability” (AFI, 2014).

2.3 What are the dangers of financial inclusion?

However, research also shows that financial inclusion has not always met its claimed objectives. In particular, the risks of excessive or inadequate financial inclusion have led policy makers to focus not just on access and usage, but also to add two other dimensions to financial inclusion: depth and capabilities. As discussed earlier, depth allows to offer a wide variety of financial services and shy away from the focus on credit. Capabilities, in turn, put the emphasis on the abilities of consumers to select, identify and use services that are tailored to their needs.

In some cases, evidence does not support a statistically relevant relationship between financial inclusion and poverty reduction. In a widely publicized research, Angelucci, Karlan and Zinman (2013) highlight that data from Mexican microcredit did not show a statistically relevant correlation between access to credit and higher revenues or financial resilience of borrowers.

Authors analyze some causes of over-indebtedness, and underline in particular the responsibility of microlenders. Rhyne (2001) notes the responsibility of consumer lenders and excessive credit offering in the Bolivian microfinance crisis. Some authors add that the “emerging field of behavioral economics has identified biases that can lead borrowers to take on more debt than is good for them”. In some more extreme cases, high growth in microcredit has led to multiple lending, defined as borrowers taking credit from multiple sources at once, excessive leverage for households, leading to massive consumer defaults, and tragic incidents in some instances, as in the case of India in 2010 (DE MARIZ; REILLE; ROZAS, 2011). Morocco, Bosnia and Pakistan have also experienced episodes of massive consumer delinquencies in microcredit, and authors have recommended that microfinance institutions improved their marketing and underwriting, designing “products that better match client needs and cognitive abilities”, improving credit reporting, and developing “early warning systems” (CGAP, 2011). Countercyclical policies can also bear risks when using credit to support consumption (BONOMO; BRITO; MARTINS, 2015).

Adding to the literature linking financial development and growth, Cermeno and Roa (2013) state that the Global Financial Crisis calls to revise those links. The authors explain that countries with a stronger financial system experience higher growth, but the mechanism remains unclear. Cermeno and Roa note that “traditional economic models derived from Arrow-Debreu do not incorporate asymmetries of information and therefore do not include financial institutions in the drivers of growth,” those models consider capital accumulation and technological change as drivers of growth. The authors present another stream of thinking, which shows that financial institutions thrive due to information and transaction costs and that underdeveloped financial system lead to credit rationing (LEVINE, 2005; LA PORTA et al., 2000).

Moreover, research shows an endogenous relationship between the depth of the financial system and growth instability. Sahay et al. (2015) flag that “financial inclusion increases economic growth up to a point” and that “evidence shows that financial stability risks increase when access to credit is expanded without proper supervision”. On the flip side, the authors nuance that “in contrast to credit access, increasing other types of access to financial services does not impact financial stability adversely”. If credit seems to have a bell-shaped impact on growth, other financial services such as savings or payments have a linear relationship.

We believe a key contribution of our research is to characterize the relationship between payments and growth, and highlight the quality dimension of payments.

2.4 Inclusion through which products?

There are many faces to financial inclusion. We break down inclusion depending on the products and channels considered. Some widely studied mechanisms of inclusion have consisted in microcredit concession by non-bank financial institutions and public banks, transfers and payment capabilities offered via mobile connectivity, government transfers offered via electronic payments and banking correspondents, or life micro insurance policies.

There is a well-established literature on the functions of banks. The traditional definition of financial intermediation focuses on its credit function. Klein (1971) developed a theory of the banking firm and shows that banks are not simply allocators of

capital and differ from funds in that they can perform other functions such as deposit-taking and payments. Diamond (1984) defends that banks perform a necessary function of delegated monitoring of borrowers. In fact, lender would not be able to perform that function or would free ride. Kashyap, Rajan, Stein (2002) expand on the role of banks and argue that it makes sense for banks to offer both credit and deposits under one roof, as those may be the “manifestations of one primitive function: the provision of liquidity”. The authors also note potential synergies between functions.

In terms of products, the literature on financial inclusion has followed the traditional literature on banking and has focused mostly on credit, highlighting the long track record of microcredit. Research has shown that microfinance is evolving and becoming more complex, offering more products (LASCELLES; MENDELSON; ROZAS, 2014). More recent research has highlighted the risks of excessive credit concession and the importance of other financial services, such as savings, insurance, such as life, agricultural crops, and property and casualty, and electronic payments. This last category of electronic payments includes transfers from and to people, corporates and governments, and international transfers such as remittances.

Savings are an essential financial service for poorer households. Women’s World Banking (2014) notes that for poor women, access to a safe place to save and build assets is as important as access to loans. The authors explain that women “play an accepted and expected role in the household as money managers, juggling day to day needs while making sure that school fees are paid and health emergencies are covered”. While incomes can be low and unpredictable, female head of households manage to “save on average 10 to 15 percent of their income”. In poorer communities, saving mechanisms are often informal and unreliable. Poorer segments tend to save at home, by buying excess inventory for their businesses, or livestock. They also rely on neighborhood savings clubs. The small amounts are often seen as the main barrier for consumers to bring their savings to a bank branch, especially as the time spent to deposit the cash is a real disincentive. Mas (2009) notes that the cash-in and cash-out capabilities offered by financial institutions or cooperatives are essential for consumers to be willing to save with official mechanisms; in other words, it must be easy, cost-efficient and convenient to make deposits or withdraw cash. Experiments with mobile

banking in Africa show the potential that new technology offer for savings and transfers. Authors note that M-Pesa has allowed to “increase meaningfully financial inclusion in Kenya” (DE MARIZ, 2013), where a “fifth of Kenya’s GDP is now estimated to flow through this service alone and close to two thirds of the adult population report using mobile payments” (MONEY..., [s.d.]).

Insurance is another important channel for financial inclusion and can offer an important financial mechanism to protect consumers against unforeseen hardship. Life insurance is a commonly offered product. Banco Compartamos in Mexico is one of the largest microinsurers globally and includes life microinsurance coverage in every credit operation. In the case of a borrower’s death, the credit is forgiven and her family receives a cash amount of 15,000 pesos, meant to cover burial expenses. In fact, on top of the emotional challenge brought by death, the departure of a household member, in particular a breadwinner, can be a financially insurmountable event for families. In a Brazilian context, authors note that microinsurance represents a very large untapped market, which requires regulatory adjustment (GONZALEZ; VIDAL; CHRISTOPOULOS, 2013). Authors also note the potential of green microfinance, linking microcredit to the rising concern of climate change, as the lower income segments of the population are most vulnerable to climate change (GONZALEZ and MOSER, 2015).

In the case of **payments**, the current literature underlines the benefits of cash light economies. Several countries have launched public policies directed at increasing the use of electronic payments, and therefore reducing the reliance on cash. For governments, cash light economies bring several benefits, such as the reduction in informality, an increase in fiscal revenues, increased access to a wide range of financial services, an increase in domestic savings, more effective monetary policy, and a reduction in the cost of handling cash. The existing literature classifies payments in nine categories according to the sender and the recipient. The different types involve people, companies and government.

Table 2 - Types of payments

Payer \ Payee	Consumer	Business	Government
Consumer	P2P	P2B	P2G
Business	B2P	B2B	B2G
Government Agency	G2P	G2B	G2G

Source: Author, adapted from the World Bank Group, 2015. P = Person, B = Business, G = Government.

The literature highlights the still large opportunity from G2P and B2P to shift to electronic payments (WORLD BANK, 2015a). The World Bank calls for leveraging on “government payment programs to promote financial inclusion”, as “the large volume of payments issued by governments, as well as the nature of some specific programs like social spending programs, represents an opportunity to promote or facilitate financial inclusion on a large scale” (WORLD BANK, 2012). Several governments have taken the opportunity of redistribution programs to include a payment component into existing public policies. In Brazil, the Bolsa Familia program attends 12.4 million recipients throughout the country (WORLD BANK, 2012). The program “seeks to reduce poverty and inequality” and “break the intergenerational transmission of poverty by conditioning these transfers on beneficiary compliance with human capital requirements”, such as “school attendance, vaccines, pre-natal visits” (LINDERT et al., 2007). This is the largest conditional redistribution program in the developing world and the government decided to make those transfers electronically. There are over 32,000 points where benefits can be withdrawn, and 65% of benefits are received at lottery points. G2P payments reduce the administrative cost of the program for the government and offer an entry point into the financial system for recipients. According to the World Bank, “moving to electronic payment and consolidating four programs into one reduced administrative cost from 14.7% to 2.6% of the value of the grants disbursed”.

That said, existing research shows that Bolsa Familia has not been a successful entry point for financial services (WORLD BANK, 2015a). The Bolsa Familia program delivers financial assistance to nearly a third of the total population, and 99% of the

recipients receive digital payments into a card or bank account, representing a public policy success. However, the poorer the household, the more likely they are to withdraw their full transfer at once, as opposed to using their bank account for cash management. Among Brazilian adults receiving government transfers, 88% withdraw all the money right away.

Likewise, while other international experience has been successful for G2P, they have failed in developing domestic microsavings. In Colombia, the Daviplata program launched by privately-owned bank Davivienda has not met the results initially expected. Daviplata is responsible for the electronic transfer and disbursement of payments by the Colombian central government to public servants, military and retirees. Research has shown that a large part of the transfers are then withdrawn in full by recipients, thereby limiting the benefits of constituting savings and inclusion at large.

By contrast, another Colombian experiment in P2G and B2G has shown clear success. The Colombian banking sector and a private clearing house (ACH Colombia) have developed over the past decade an online payment instrument, which is embedded in government and business websites and allows “businesses and consumers to authorize electronic payments directly from their bank accounts to government agencies and to other businesses” (MARULANDA and MELTZER, 2016). In the past five years to 2013, the number of “payments made this way had increased by more than tenfold to almost a million a month”. The online tool is known as Secure Online Payments (Pagos Seguros en Línea, PSE), and is a private sector innovation that was supported by the Colombian government.

In Mexico, Masino and Niño-Zarazúa (2014) assess the impact of the electronic payment system of Mexico’s *Oportunidades* program. The authors find that switching from cash payments to electronic payments delivered via a bank account has several consequences. Following the change, “participation in informal saving arrangements was reduced, the frequency of remittance reception increased and, when hit by idiosyncratic shocks, beneficiaries of bank accounts were more likely to use savings rather than contracting loans or reducing consumption to cope with the events”.

Authors also assess the success of a G2P program in Mexico with its two simultaneous dimensions: a move towards electronic payments and towards centralized

payments. In 2012, “97% of pension payments were made by electronic transfers” (BABATZ, 2013). The unification and digitalization of payments to government employees, retirees and social transfers was a wide success. By digitizing and centralizing its payments, the Mexican government has “saved US\$1.27 billion per year”, equivalent to “3.3% of all its total expenditure on wages, pensions and social transfers”. Savings came in the form of “float revenues, with no more anticipation in payment, lower transaction fees, and less leakage and operational errors”.

2.5 Inclusion through which channels?

We now consider the different channels of distribution of financial products. Select government-owned banks have played a key role for inclusion. This was sometimes aligned with core policy objectives of the controlling shareholders. Select countries also allowed or demanded that traditional banks offer simplified products to their customers. Those products, such as a basic checking account, are sometimes offered for free and require less paperwork.

Research and case studies have shown that banks do not have an exclusive responsibility when it comes to financial inclusion, as a number of other agents have effectively offered financial services to customers. This is the case of non-banks financial institutions (NBFI), which are financial institutions that fall under a lighter regulatory framework and typically cannot raise retail deposits. NBFI, along with other institutions such as asset managers, are sometimes described as the shadow banking system. The shadow banking system is defined as the group of agents that can offer funding to individuals and corporates outside of the traditional regulated banking sector (FISH and WHYMARK, 2015). In Mexico, the Central Bank estimates that the shadow banking represents close to 10% of total GDP in terms of loans, while the regulated banking system represents 20% of GDP in terms of total credit. In Brazil, the Central Bank estimates that a restricted definition of the shadow banking system represents 6.7% of total banking assets. The Brazilian Central Bank characterizes the shadow banking as funds that are subject to a risk of run and where a transfer of credit risk takes place (BANCO CENTRAL DO BRASIL, 2015a).

Other channels of distribution of financial products have emerged over the recent decades. Brazil has played a key role in the successful and transformational growth of banking correspondents. Correspondents, sometimes called agents, perform a limited number of financial services, following domestic regulations and are a major example of branchless banking (CHRISTOPOULOS; GONZALEZ; AZEVEDO MARQUES, 2015). Those services typically include payments of bills (such as utilities and phone), cell phone top ups and deposits. Brazil counts 295 thousand banking correspondents, which compares with 22.3 thousand full banking branches, according to Central Bank data as of August 2017. Correspondents are in most cases small retail stores, gas stations and other locations open to the public. Correspondents solve partly the problem of the limited geographical presence of branches and bring many benefits to their local customer base, in particular convenience, and to the correspondent herself, in the form of an additional form of revenues. However, banking correspondents usually do not provide more complex financial services such as credit.

Other countries have adopted and expanded the concept of banking correspondents, such as Mexico or India. In India, authors note the daunting challenge in size and scope to include the lower income segments. The government and Reserve Bank of India have taken “initiatives to spread banking services such as expanding the number of rural bank branches, allowing the banking correspondent model and adoption of technology” (GWALANI and PARKHI, 2014).

Additionally, the latest technological advances along with regulatory innovation have allowed the emergence of new electronic providers of financial services. The sector of financial technology (FinTech) has seen outstanding growth rates in the past five years. As an illustration, Banco Bradesco invested R\$5.4bn in technology just for the year of 2016 (BRADESCO, 2017). The main focus of FinTech so far has been on payments and transfers. However, lending and insurance have seen the emergence of new models, using technology to better assess client risk or to develop more agile distribution channels (DE MARIZ, 2016). The growing power and sophistication of computers has led to the rise of scoring systems based on big data. Importantly, banks have developed the understanding of their clients not just based on negative credit history, but more and more on positive data. Positive data coming from deposit,

transfers, payments in general and credit amortization have allowed banks to define a more accurate portrait of their clients, thereby refining the pricing of risk at the individual level. While banks and insurance companies used to price risk in aggregate, financial institutions and FinTech now assess risk at the level of the individual and only for the use of the product that is made. For example, some insurance companies offer an auto insurance coverage with a premium that is calculated based on the characteristics of the individual and only based on the number of kilometers actually driven.

Finally, FinTech blurs the border between banking services and capital markets. The revolution brought about by FinTech consists in weakening the need for financial intermediaries such as banks. In the case of equity crowd funding, electronic platforms allow companies to list part of their capital to a fragmented base of investors. Crowd funding essentially serves as another solution for scarce capital and lending (DE MARIZ, 2016). The advent of new platforms and innovative fundraising options is also bringing new challenges to regulators. In particular, the blurred picture between credit and capital markets is not without resemblance with the past financial crisis (ADRIAN and SCHIN, 2010).

3 ELECTRONIC PAYMENTS AND FINANCIAL INCLUSION

3.1 Why focus on electronic payments?

The academic literature places the emphasis on credit, insurance, accounts and sometimes savings, but the research around payments is incipient. There is a large body of research focusing on access to credit as a key mechanism for financial inclusion and an essential step towards more stable and widespread development. For example, the reference Findex research at the World Bank defines three main measures of financial inclusion (WORLD BANK, 2013). *Formal account* refers to the fact that the individual has an account either at a financial institution or through a mobile money provider. *Formal saving* refers to the fact that the individual saved, using an account at a financial institution in the past 12 months. *Formal credit* refers to the fact that the individual borrowed from a financial institution in the past 12 months. We argue that a fourth vector of financial inclusion needs to be considered: the payment vector.

There are two perspectives to analyze financial intermediation: the institutional one focuses on the type of financial intermediaries, including their setup and legal status. The functional perspective looks at the financial products and services that are being offered. In a classic article, Merton (1995) adopts the functional perspective, since he notes that “functions of banks have been remarkably stable through time and geography”. He writes that the “primary function of any financial system is to facilitate the allocation of economic resources, both spatially and temporally”. Merton defines six core functions of financial systems, and underlines that the first function is to provide a “payments system for the exchange of goods and services”.

The figure below illustrates our thinking about financial inclusion, along two axes. One axis focuses on four product types, namely payments, savings, credit, and insurance. Those are the financial services used by consumers and most relevant to financial inclusion. In this research, we place the emphasis on payments.

The second axis focuses on three dimensions, namely access, usage and quality, which are they key attributes of inclusion.

We do not treat the “account” metric in our matrix, as we see accounts as an

entry point, and not a product per se. In fact, customers do not extract utility or satisfaction from owning an account at a bank or mobile provider. The utility is attached to products, such as the ability to save on this account or to make payment into or out of this account.

Figure 1 - Financial inclusion defined in 4 products and 3 dimensions

Dimension of inclusion / Product	Access	Usage	Quality
Credit	-	-	-
Insurance	-	-	-
Savings	-	-	-
Payments	-	-	-

Source: Author.

Electronic payments include money transfers and online transfers, card-based instruments, such as debit, credit or prepaid cards, and e-money (WORLD BANK, 2016). Electronic payments, also referred to as digital payments, are often opposed to cash usage and payments by checks. Electronic payments can be done in the real world at brick-and-mortar stores with plastic cards, or online via mobile phones or the Internet in “non-present transactions”, as in the case of e-commerce transactions or online transfers and online payments of bills, such as *boletos* in Brazil.

We detail below three reasons why the analysis of electronic payments is necessary.

First, payments have been less studied, but they play a critical role. Payments are essential in any economic transaction involving exchange of services and goods but also in the case of government transfers or remittances. Lascelles, Mendelson and Rozas (2014) underlines that “convenient payment systems increase the efficiency of economic transactions” and “create an environment in which all citizens can be productive”. Likewise, researchers from the World Bank explain that “not all financial products are equally effective in reaching development goals, such as reductions in poverty and

inequality". According to them, "current evidence suggests that the biggest impacts come from savings accounts – provided that they are inexpensive and serve a specific purpose – and digital payments" (DEMIRGÜÇ-KUNT; SINGER, 2017). The World Bank (2016) explains that payment aspects include owning a transaction account to perform all payment needs and safely store some value. While 40% of the population worldwide still does not have an account, transaction accounts are "the cornerstone for providing electronic payment services".

Analyzing payments systems are important for economic models. Costs incurred for payments, both direct and indirect, go against the efficient, rational and frictionless classical economic theory. An essential goal of electronic payments is to reduce the friction, with better convenience and cost for users. Studying payment systems is of particular interest when considering new institutional economics. Authors have noted: "the practical applicability of the neoclassical modeling approach is now challenged by at least two alternative theoretical paradigm". First, "New Institutional Economics, focuses explicitly on transaction costs, taxes, computational limitations, and other frictions". The other paradigm: "Behavioral Economics, introduces non-rational and systematically uninformed behavior by agents" (MERTON; BODIE, 2004). Electronic payments bring higher efficiencies into the system and reduce this friction. Humphrey, Pulley and Vesala (1996) analyze 12 European countries, and estimate a reduction in operating costs of €32 billion, or 0,38% of GDP, between 1987 and 1999, driven by the 36% increase in electronic payments and 32% increase in ATM in the total segment of payments. According to Banco Central do Brasil (2007), fully migrating to electronic payments would generate a cost saving of 0,7% of GDP, using 2005 data, or approximately R\$15 billion.

Second, electronic payments represent a very large market. The World Bank (2016) estimates the "global market opportunity for expanding the adoption of electronic payments by merchants is large, estimated at \$19 trillion of payments made and accepted in cash and checks by micro, small and medium retailers (MSMRs) in 2015". The authors calculate that in 2015, "MSMRs made and accepted around \$34 trillion in supplier payments, wages and salaries, and customer payments." This total amount of \$34 trillion is split between \$15 trillion that were made electronically and the remaining \$19 trillion in cash and checks. There are two legs to digitalize at the level of merchants: funds they receive as payments and payments they make to employees or suppliers.

Grocery retailers have a higher usage of cash and checks. Latin America represents \$3.5trillion, of which just 46% is already electronic. This compares with an average of 71% for high-income OECD countries. The authors add that B2B transactions (Business to Business) represent a large opportunity, and that new models are emerging for online payments.

Table 3 - The size of electronic payments globally: Global Payments by Micro-, Small- and Medium-Sized Retailers (estimated values, 2015)

	Total payments (\$, trillions)	of which electronic (\$, tr)	% of electronic
Global	34	15	44%
High-income OECD	11.1	7.9	71%
Latin America & the Caribbean	3.5	1.5	43%
Middle East & North Africa	1.3	0.4	30%
Sub-Saharan Africa	1.5	0.4	25%
Eastern Europe and Central Asia	3.1	1.3	46%
East Asia & Pacific	9.5	2.7	31%
South Asia	4	0.8	20%

Source: World Bank (2016, p.6).

Third, the rise of electronic payments is a key aspect of growing financial inclusion. Research links higher financial inclusion with the growth of electronic payments and the reduction in the usage of cash. Attaining high levels of financial inclusion requires aggressive policies that promote cash-light societies. In that sense, a group of global institutions launched the Global Cash Alliance in order to help move

countries to cash-light economies, develop electronic payment and transfer systems and get the benefits related to cashless economies (BETTER THAN CASH ALLIANCE, 2015).

However, we note that a higher usage of electronic payments is not always synonymous for deeper financial inclusion. This is the classical difference between financial depth and financial inclusion. In fact, a small numbers of citizens could simply be using their electronic payments more often and impact the overall measure of financial depth. Financial depth considers macro indicators such as the quantity of electronic transactions per period, or the number of branches or ATMs per 100,000 inhabitants. The rationale behind analyzing depth or access is that financial institutions would only invest in their network in order to serve a larger number of end-users: higher usage would be synonymous with a larger number of users. Indicators of usage include the percentage of adults with an account at a formal financial institution, and are typically captured via surveys. Financial inclusion considers that more citizens use a specific product. This is why macro data on electronic payments has to be used in conjunction with other indicators to infer financial inclusion. In the case of Brazil, deeper financial inclusion can be inferred from a larger usage of electronic payments, and is evidenced by survey data on mobile bank accounts usage. Research, such as the Report on Financial Inclusion by the Brazilian Central Bank, shows that the growth in electronic payments usage has gone hand in hand with deeper financial inclusion, which is “reflected in the rising number of adults with some banking relationship” (BANCO CENTRAL DO BRASIL, 2015a, p10).

3.2 Quality dimension applied to payments: benefits and shortcomings of electronic payments

Academic research has stressed the importance of payments, but there has been very little commentary of the limitations and shortcomings of payments systems and infrastructure. It may well be that payments infrastructure is in equilibrium, but that this equilibrium is unfavorable or unfair to one party. We highlight that the classic definition of financial inclusion comprises the three dimensions of access, usage and quality. We

will provide a descriptive analysis of access and usage of payments in a following section. In this section, we stress the **quality dimension of payments**.

The literature most often refers to the third dimension of inclusion as “ quality” (ROA, 2015; BANCO CENTRAL DO BRASIL, 2015a), while some authors prefer the term capability (CSFI, 2014). Can payments be detrimental to users? What are the characteristics of good quality payment systems? What best practices can be shared when establishing new payment systems and regulations? Understanding the quality dimension of payments is essential.

Claessens (2006) explains: “access refers to supply, whereas use is the intersection of the supply and demand schedules”. We defend that quality is the missing link between access and usage, quality is the catalyst that converts the potential access to actual usage. There are various aspects of quality, including availability, convenience, affordable cost, range, type, speed, design, consumer protection or reliability. If citizens have access to the payment capability, why would they not use them? What constrains their usage?

Figure 2 - Typical representation of the three dimensions of inclusion: access, usage, and quality

Source: Author.

Assessing the quality dimension of payments can mostly be approached via surveys. As we analyze the usage of electronic payments and cash, it is worth detailing the benefits and drawbacks, both real and perceived by consumers. We refer to a unique survey of hundreds of small merchants in Brazil (DE MARIZ, 2017a). In this study, the authors interviewed 505 merchants, across industry sectors, across regions, and across business sizes in Brazil. Through an extensive questionnaire with more than 50 questions, the authors assess consumer and merchant preference for each payment type, be it debit, credit, check or cash. In the list of benefits of cash usage, customers spontaneously quote the convenience and discounts offered in cash payments as the two main attributes. As for other financial services, poverty is a key barrier for usage.

Figure 3 - Payment mode acceptance at Brazilian merchants

Source: Author, adapted from De Mariz (2016).

Additionally, we reference separate lists of advantages and drawbacks for each payment mode compiled by the World Bank (2016), Banco Central do Brasil (2013) and Schuh and Stavins (2009, 2011). The World Bank lists the main barriers to access and usage of accounts: the high fees, low-income levels, informality, and poor perception on banks. Low usage is due to economic but also to attitudinal reasons. The World Bank defines the four elements of infrastructures that effectively support financial inclusion: 1) interoperability and coverage, 2) accessibility, 3) efficiency and standardization, 4)

safety and reliability. Some authors also note that advantages of cash include anonymity, convenience, universal acceptance and instantaneous settlement (MAS, 2015). Money ([s.d.]) notes the advantages of electronic payments, in particular mobile payments, including transparency, security, privacy, speed, cost saving, and better financial management.

The literature usually lists the advantages of electronic payments and cash. Most of the comments on the quality dimension have been rather superficial and focused on the customer abilities, relating to the theme of financial education.

We prefer a different methodology, which we define as user-centric. Rather than focus on the payment mode, we start from the **benefit** that the user is looking for and analyze which method of payment can be most appropriate. We comment on the six characteristics, especially applied to the Brazilian case. Depending on the country, the type of user or the situation, either cash or electronic payments can prove more beneficial to the user. Our approach considers both the merchant and the cardholder, while most of the literature considers only one side of the equation. This suggests that our user-centric methodology of preferring characteristics rather than payment mode is more appropriate.

Contrary to the traditional representation that financial inclusion is based on a tripod of access, usage and quality, we believe quality is a key catalyst between the two other dimensions.

Figure 4 - The six characteristics of quality applied to payments

Source: Author.

Table 4 - The six characteristics of quality: detailed view and related attributes

	Attributes	Illustration
1	Cost	Explicit costs such as merchant discount rate and card fees. Cost of cash usage relating to cash management and safekeeping. Cost related to crime and fraud in cash and checks, such as security, forged money and unfunded checks.
2	Benefits	Explicit benefits such as rewards and loyalty points. Implicit benefits for the merchant, such as the possibility to gather data for business intelligence. Implicit benefits for the cardholder, such as the possibility to establish a credit history. Depending on the respondent, cash or cards help better control personal finances and spending.
3	Ease of use	Wide acceptance, ease to swipe and process, convenience of carrying cards or cash. Development of FinTech for new capture, such as near-field communication (NFC). Cards can be more suitable for recurring payments and online purchases.
4	Speed	Speed to approve the transaction. Speed for the financial settlement of the transaction, be it debit cards, credit cards, or online bank transfers. Cash presents the advantage of immediate settlement but needs to be transported to a bank to earn interest and be safe.
5	Security	Card payments offer the ability to track transaction information, confirm, revoke, cancel transactions in case of errors or frauds. Ability to report on transactions and maintain audit trails, providing full transparency. Grow businesses and activities out of informality through transparency, and fight criminal activities.
6	Privacy	Avoid undue use of payment information and maintain due anonymity. Cash is seen as preserving personal information.

Source: Author.

Cost

Cost associated with payment modes can be explicit or implicit. Electronic payments imply an explicit cost for merchants, in the form of a merchant discount rate paid by the merchant to the companies participating in the card ecosystem, such as the card acquirer, processor, brand and issuer. In Brazil, the merchant discount rate revolves around 2.20% of the transacted volumes for credit transaction and 1.50% for debit transactions. This compares unfavorably with developed countries, where discount rates reached 1.20% for credit, and a flat fee plus 0.30% for debit transactions (DE MARIZ, 2017b). For a cardholder, the cost associated with a card consists in card fees paid to the card issuer, most likely a bank. Card fees depend on the type of plastic card

and the benefits it provides. Contrary to the merchant discount rate, card fees paid by the cardholder are fixed in nature and do not depend on transacted volumes. Card fees in Brazil ranged between R\$40 and R\$140 as of December 2016 based on fees charged for Visa, MasterCard and Elo plastics.

Figure 5 - Gross merchant discount rate (merchant's cost for card acceptance)

Source: Brazilian Central Bank, Author. Gross = interchange + net discount rate. Merchant discount rate is a percentage paid on each transaction volume.

Figure 6 - Cost of using card payments for the cardholder (annual card fees in R\$)

Source: Brazilian Central Bank, Author. Data for Elo for March 2012 was estimated by us.

That said, merchants and customers tend to underestimate the implicit costs of cash and checks. Those costs include cash management, safety and fraud. Different studies suggest that banning cash would immediately lift GDP by 0.7% (BANCO CENTRAL DO BRASIL, 2007), to 1% (GARCIA-SWARTZ; HAHN; LAYNE-FARRAR, 2008), due to lower cost of cash management. In the case of checks, frauds related to unfunded checks represented 6% of total cleared checks, according to the Central Bank, a percentage that has been remarkably high and stable over time.

Cash payments are common in the informal economy, for tax evasion purposes, and sometimes explain the discounts or rebates offered to customers when they pay in cash. In Brazil, Regulation MP764/2016 authorized merchants to charge different prices depending on the means of payment, thereby giving an incentive for higher cash usage. This law is contrarian to the trend observed in most countries, where authorities have actually incentivized the use of electronic payments against cash. The main justifications for the regulations were to put pressure on card companies to lower their prices, as well as avoid cross-subsidies. In fact, a single price policy leads cash-payers – most often from lower income - to subsidize card-payers – most often from higher income

segments. The regulator therefore decided to privilege a social motivation, against a goal of tax and payment efficiency.

Figure 7 - Evolution of unfunded checks in Brazil: losses remain high for merchants accepting checks

Source: Author.

Benefits

From the point of view of the cardholder, direct benefits of card usage include the rewards and loyalty points accumulated in the case of credit cards. Rewards have experienced a meaningful growth in Brazil in the recent past in absolute terms. Another explanation for card usage for the cardholder is the possibility to build its credit score, which often proves essential for the subsequent approval of credit application. Credit scoring is built not only via negative information on credit repayment, but also via from positive information, such as timely payments of bills or patterns of payments and savings.

From the point of view of merchants, the use of electronic payments allows to gather information and intelligence on customer trends and preferences. Big data allows to offer customers special rebates or offers and increase traffic at the point of sale, using past information on electronic payments – something that cash payments would not permit. Demirgüç-Kunt and Singer (2017) notes that electronic payments enable retailers to develop “a comprehensive solution for managing their business, such as

better inventory and sales management”. Small merchants are “more likely to adopt electronic payments if they are combined with other services and business intelligence”: the value proposal needs to be strong, with big data allowing for business intelligence or facilitating their access to credit. Offering intelligence and services on top of payment solutions is a global trend in the acquiring and processing industry, as evidenced by the recent product development and acquisitions of Ingenico and Cielo. We find that the argument on managing inventory is not quite convincing, as cash payment does not hinder inventory management, but we stress the importance of sales management, which card payments facilitate.

An explanation for the preference for cash usage, especially during times of economic downturn, has to do with consumer behavior. Brazilian consumers often express that they have a better control of their personal finances when using cash.

Figure 8 - Spending by card issuers in loyalty programs and rewards, as a percentage of total card volume

Source: Central Bank of Brazil.

Ease of use

There is conflicting evidence from surveys about which payments mode users find easier. “Ease of use” includes elements such as the wide acceptance of electronic payments, the ease to swipe and process a payment, or the convenience of carrying around cards or cash. Card acceptance at the point of sale has become widespread and

is captured via the “access” dimension of inclusion. Acceptance also includes a technology component, as downtime prevents electronic transactions to be processed, especially in rural areas, with poor network connectivity. Downtime has often more to do with telecommunication infrastructure than with payment choice. Some research stresses that users find cash payment easier, as it is universally accepted and does not require a reliance on infrastructure. Other research stresses that users value the convenience of carrying a plastic card in their wallet and not needing to withdraw physical cash.

As financial technology allows making electronic payments in a more convenient way, for example via near-field communication or biometry, ease of use should become a widely accepted characteristic of electronic payments. Electronic payments and card payments stored in online wallets are particularly useful for recurring payments, for services such as UBER. In the case e-commerce, electronic payments only allow concluding online purchases.

Speed

Speed can be included in the characteristic of “ease of use”, but we decided to treat it separately, due to its utmost importance for merchants. A key characteristic of cash payments is their immediate settlement, since the payer is relieved from a debt, and the payee enjoys cash in hand instead of a receivable.

Due to slow legacy payment systems, most countries, including many developing countries, settle financial transaction in one or more days. In Brazil, debit card transactions settle on the following day (T+1), while credit card transactions settle one month later (T+28, on average), implying a large cost in terms of working capital for merchants. In fact, merchants accumulate receivables in the case of credit card transactions. This leads merchants to anticipate the credit card receivables with financial institutions for close to 20% of card volumes, paying a discount rate in order to accelerate the financial settlement of card payments.

While card transactions can be slow for Brazilian merchants, bank online transfers and payments in Brazil are among the fastest globally, with close to immediate financial settlement.

The speed characteristic suggests that financial settlement of transactions in Brazil has found an equilibrium that is often unfavorable to merchants.

While cash settles immediately, the lifecycle of physical coins and notes does not stop at the time of the transaction, as merchants often need to bring this physical to a bank branches, for security reasons, to settle debt, or to start earnings interest income on those cash balances. Therefore card payments can be more practical for users provided the settlement period is reduced.

Security

In the list of benefits of card usage, customers spontaneously quote the safety concerns related to carrying cash. This is particularly true in Brazil where the risk of crime and theft is elevated. On the side of the drawbacks of cash, Mas (2015) underlines the absence of record, and therefore the impossibility to recover. This is relevant in the case of frauds or errors, as the absence of an audit trail for cash payments prevents to revert a transaction. The ability to report on transactions can be a requirement for merchants and made easier with electronic payments. Defining audit trails allow to comply with tax rules, in particular. Audit trails are essential to grow businesses out of informality and fight criminal activities.

For merchants, the use of cards brings security, as card-present payments are covered by the issuing bank in the case of defaults. In other words, if the payer is not able to settle a card payment, the merchant has certainty to receive her funds from the issuer, most often the bank that issued the plastic card. Contrary to card-present payments, in the case of online purchases or card-not present payments, the merchant incurs the cost of defaulted payers.

Figure 9 - Crime index in Brazil: number of intentional violent deaths per 100,000 inhabitants

Source: Forum Brasileiro de Seguranca Publica, Author.

Privacy

In Brazil or emerging markets, concerns around privacy are not mentioned in the preference for cash. This appears to be more of a concern in developed countries, where electronic payments are widespread, such as Scandinavia. The concern for privacy stems from the legitimate desire of users to not contribute their personal data and preferences to merchants and service providers without their consent. In fact, data on payments can be used by companies to map preferences and design products and special offers.

The legitimate concern for privacy is often in conflict with the necessity to offer safe payment modes and avoid informality, tax evasion and criminal activities.

3.3 Determinants of the usage of electronic payments, according to the literature

There is a vast literature on the availability, adoption and use of payment modes and the usage of electronic payments in developed countries. We find different currents in the literature of drivers of payments.

We note, together with Von Kalckreuth, Schmidt and Stix (2009) that the first stream of research underlines the relative costs of cash and card usage. Another camp

takes the role of consumer preferences or payment attributes into account. Finally, some papers explicitly account for transaction characteristics.

Research in developing countries is more limited, probably due to smaller data samples and currency volatility, with some exceptions for Nigeria (BAYERO, 2015), Uruguay (LLUBERAS and SALDAIN, 2015), Chile (ADAM, 2000), Kenya (ODEDRA; NAMUSONGE; NAMBUZWA, 2016), Thailand (HATAISEREE and BANCHUEN, 2010), Hungary (BODI-SCHUBERT, 2010) and a regional study for Africa (ZINS and WEILL, 2016). Using dataset from the Survey of Uruguayan Household Finances, Lluberas and Saldain find that “households are intensive in their use of cash while the use of credit and debit cards is low and stable”. The authors find that transaction characteristics are the most relevant driver of payment choice. Consumer socio-demographics, such as age and education, play a smaller role, as well as supply side factors, such as card acceptance at stores. The authors note that “about 30% of transactions in Uruguay are made using either credit cards, debit cards, bank transfers or direct debit, the figure is 51% in Turkey and 73% in Chile, countries with similar level of income per capita”. Zins and Weill (2016), use the World Bank’s Global Findex database on 37 African countries to perform probit estimations. The authors find that “being a man, richer, more educated and older favor financial inclusion with a higher influence of education and income”. Importantly, they also show that “mobile banking is driven by the same determinants as traditional banking”, suggesting that mobile banking is not a more inclusive channel. Zins and Weill (2016) observe that “the determinants of informal finance differ from those of formal finance”.

Most papers use regressions with ordinary-least-squares to identify the determinants of the use of select payment modes. Other papers use a logit model, where a dichotomous outcome is analyzed: whether electronic payment usage or preference for cash. Independent variables used in the literature include consumer characteristics, such as consumer preference and socio-demographics, point-of-sale characteristics, such as type of merchant, size of transaction, card acceptance and, in the case of international comparisons or longitudinal analyses, some country characteristics, such as macroeconomic variables, regulations, or innovation. We detail in a latter section of our research the full list of variables encountered in the literature.

A seminal paper by Humphrey, Pulley and Vesala (1996) analyzed the determinants of the choice of payment instruments, after comparing datasets from 13 industrialized countries between 1987 and 1993. Using payment aggregated data, the authors build a statistical model with seven independent variables to determine the evolution of five types of payment modes. Their analysis suggests that the movement towards electronic payments is “uniform and unmistakable” across countries and can lead to a meaningful reduction in social cost, as the “cost of electronic payments is one third to half the cost of other payment means”. Several types of variables are studied: price and income, GDP, equipment, cash holding per person, payment availability (point of sale: POS), Automated Teller Machine (ATM) and, finally, institutional variables (crime, concentration of the five largest banks). The econometric results show in particular a positive effect of the POS and ATM on the use of payment cards.

Carow and Staten (2000) attempt to explain consumers’ payment option to use cash, debit, credit cards or gasoline credit cards. The authors used a survey of US gasoline credit cardholders in 1992. They base their analysis on demographic and credit characteristics. Consumers are more likely to use cash when they have less education, lower incomes, are middle-aged and hold more credit cards.

Boeschoten (1998) uses data from a panel survey over the 1990-1994 period, on Dutch households. The author demonstrates the importance of transaction size.

Mantel (2000), Stavins (2001) and Hayashi and Klee (2003) also highlight the role of socio-demographic and technological factors on the propensity to use electronic payment systems or the probability of them being used.

Mantel (2000) develops a framework to describe why consumers pay bills electronically. Using US national survey data, the author shows that wealth, personal preferences and certain demographic factors are significant to explain the use of electronic bill payments.

Stavins (2001) uses survey data from US households in order to evaluate the effects of consumer characteristics on the probability of using different electronic payment systems. The results show a strong effect of demographic characteristics on consumers’ use of payment instruments.

Hayashi and Klee (2003) use data on US consumers, in particular from Internet

users in order to test consumers' propensity to adopt new technologies (debit cards, electronic bill payment). According to the results, consumers who use new technology or computers are more likely to use electronic forms of payment, and the characteristics of the transaction such as the transaction value and the physical characteristics of the points of sale (such as the absence of a cashier or the availability of self-service) determine the payment choice.

Rysman (2007) deals with network effects in payments. The author shows the existence of single homing effects, corresponding to the concentration of spending on a single payment network, and a positive feedback loop between consumer usage and merchant acceptance.

Klee (2006) relates the use of payment instruments with household characteristics using survey data for the United States. The author finds that debit card use increases with income and education. She attributes the income effect to households gaining access to financial services, but also to the substitution between other forms of payment and debit cards. The paper also finds a positive relation between age and convenience card use, but a negative relation with debit card use.

Borzekowski and Kiser (2008) use US data and estimate a rank-ordered logit for payment instruments' attributes: older households have less utility for electronic and liquid attributes, attributes associated with debit cards. Cohen and Rysman (2013), using a panel of consumers, find a negative relation between age and card use. On the other hand, they find a positive relationship between income and cards and checks use, while the relation with cash is negative. Klee (2008) supports this hypothesis as she finds that debit card use increases with income, while cash, checks and credit card use decreases.

Some research focuses on supply side factors. Rysman (2007) flags the existence of a positive feedback loop between consumer usage of a credit card and its acceptance by merchants. The rationale behind this result is that consumers value more a specific credit card if it is widely accepted by merchants, and vice versa.

More recent research focuses on transaction characteristics. Bounie and Francois (2006) provide a complete revision of the early literature on the topic. They use a unique dataset of 11,945 payments made from March to May 2005 in France and

estimate the “determinants of the probability of a transaction being paid by cash, check or bank card at the point of sale”. The authors find that transaction size is determinant, as well as type of good and spending place. Transaction characteristics take center stage in their analysis.

Von Kalckreuth, Schmidt and Stix (2009) use a dataset that combines transaction information with survey data on payment behavior of German consumers. They note that “cash still accounts for an astounding 82% of the volume and for 58% of the value of all direct payment transactions”, based on BundesBank data. The authors try to explain how consumers chose the payment mode and why cash remains so prevalent in Germany. Using a two-stage empirical framework, which explains ownership of credit cards and then the use of cash, they show that cash usage follows rational decision-making. Contrary to the common literature, the authors find that age *per se* is not a driver of payment choice. They also find that “the possession of a credit card, notably in addition to a debit card, does not significantly affect the use of cash in Germany, indicating that credit cards and debit cards are close substitutes” (VON KALCKREUTH; SCHMIDT; STIX; 2009).

Schuh and Stavins (2011) use data from a US survey on consumer payment behavior, which they deem nationally representative. The authors estimate Heckman two-stage regressions on the adoption and use of seven different payment instruments. They find that “characteristics of payments are important in determining consumer payment behavior, even when controlling for demographic and financial attributes”. Those characteristics include record keeping or security. They also find that the cost associated with a payment mode is found to significantly affect payment use. This paper confirms the findings of earlier papers (SCHUH and STAVINS, 2010; SCHUH and STAVINS, 2011) analyzing payment characteristics to explain the reduction in check usage, also based on a two-stage model, on the adoption and then use of payments. The authors explain their use of the methodology: the “Heckit procedure allows a different set of explanatory variables to predict the binary choice (adoption) from those that predict the continuous choice (use)”. According to them, this procedure “is appropriate in the presence of sample selection bias and heteroscedasticity”. Schuh and Stavins show that payment characteristics, along with the number of payment

instruments, tend to have larger, more significant effects on usage than demographic and income-related variables.

O'Brien (2015) uses a dataset from the Federal Reserve 2012 Diary of Consumer Payment Choice, which includes all the "recorded financial transactions of approximately 2,500 individuals who participated in the diary during their variously assigned three consecutive-day periods within the month of October 2012". Using regressions of datasets based on a questionnaire and a diary, the author finds that transaction size is a key determinant and "cash continues to play a large role as a payment instrument especially in lower value transactions for all demographic groups".

Arango, Hogg and Lee (2012) study why cash is still a popular payment method in Canada, using a bivariate logit model. They use data from the 2009 Methods of Payment Survey, a household survey specifically designed to study payment instrument choice by Canadian households. In the survey, about "6,800 participants completed a questionnaire with detailed information regarding their personal finances, as well as their use and perceptions of different payment methods". Additionally, "3,500 participants completed a 3-day diary recording information on each transaction, including the value and the payment instrument chosen". Even though debit and credit cards account for close to 80 per cent of all transactions in terms of total value, "cash is still the predominant payment method in terms of volume, accounting for 54 per cent of all transactions". The authors find that cash is used mostly because it is widely accepted by merchants, it is easy to use and has a low marginal cost. The results largely confirmed the results found in Arango, Huynh and Sabetti (2011), where the choice of the payment mode is found to be dependent on transaction size and rewards.

Bagnall et al. (2014) measure consumers' use of cash by harmonizing payment diary surveys from seven countries, using a logit model. The seven diary surveys were conducted in 2009 (Canada), 2010 (Australia), 2011 (Austria, France, Germany, and the Netherlands), and 2012 (the United States). The authors find that "the use of cash is strongly correlated with transaction size, demographics, and point-of-sale characteristics, such as merchant card acceptance and venue" (BAGNALL et al., 2014). Consumer preference is also quoted as a significant driver.

There are a number of empirical papers on other aspects of the payment card

industry. Ausubel (1991) provides an excellent overview of the industry and argues that consumers underestimate the probability that they will make interest payments on their purchases, leading to high interest rates and persistent industry profits. Ausubel (1999) works with a randomized credit card offers by a major industry participant and confirms the role of adverse selection in the market by showing that low quality credit card offers draw pools of respondents with worse observable and unobservable characteristics, leading to more defaults. Calem and Mester (1995) provide evidence from the Survey of Consumer Finance in favor of Ausubel's hypothesis.

There are separate literatures discussing the role of payment cards in consumer debt and bankruptcy (GROSS and SOULELES, 2002) and the substitution of electronic payments for cash (SNELLMAN, 2006; HUMPHREY; PULLEY and VESALA, 1996). We do not delve into these issues here.

It is worth noting a recent current of research, based on **consumer diaries** and individual transaction data, already mentioned in some studies above. Despite the growing literature on the demand for payment instruments, data on individual consumer payment behavior are difficult and costly to obtain. A segment of the literature has focused not just on consumer surveys, but also on the rich data and insights coming from consumer diaries. Consumer surveys gather information on consumer habits, preferences and socio-demographics characteristics via a questionnaire. Those surveys have gained in frequency and details since the first ones commissioned in the US in a systematic manner in the 1990s. Consumer diaries are more recent – and costly – and consist in asking consumer to record all the transactions done during a period of time, typically a few days, as well as asking those same consumers some questions about their characteristics and preferences. Such diaries are particularly helpful to analyze actual transactions, as opposed to recorded or self-reported information from surveys. Diaries are also more complete as they aim at capturing all payment modes, including cash.

3.4 Electronic payments and the demand for money

There is a very rich literature on the determinants of the demand for money and cash. A large part of this research is written by Central Banks, for whom understanding the issuance and monitoring of currency in circulation is essential. Interestingly, the Bank of England, one of the most open to financial innovation, expects cash to remain important in the future (FISH and WHYMARK, 2015). We detail here the nuances between the analysis of electronic payments and the determinants of money, highlighting that the first one is far from being just the mirror or complement of the second theme. Money in circulation corresponds to coins and banknotes. In the case of England, money in circulation represents close to 4% of GDP, with coins representing 3% of total money and banknotes the remaining 97%. Money is used for hoarding and for transactional purposes. Studies in the UK showed that 18% of people hoarded cash "to give comfort against potential emergencies".

Baumol (1952) applies a principle of "inventory control analysis" to the theory of money. He analyzes the transaction demand for cash that is dictated by rational behavior, which corresponds to holding a cash balance that can "do the job at minimum cost". The model considers the interest rate on money and the broker fee for cash withdrawal as the two drivers of the demand for cash. Inventory models, such as Baumol's, highlight the function of cash as a means of payment.

Other authors have added other dimensions to cash demand, such as a precautionary motivation, speculation and hoarding. In portfolio models (TOBIN, 1956), wealth and the relative return of other financial and real assets are also drivers of the demand for cash. Many subsequent models extend the Baumol (1952) - Tobin (1956) models "where interest rates, income, and the acquisition costs of cash including shoe leather costs, determine the supply of money" (AMROMIN and CHAKRAVORTI, 2007).

More recent literature emphasizes the drivers of the demand for cash, including Mulligan and Sala-i-Martin (2000), Attanasio, Guiso, and Jappelli (2002), Bounie and Francois (2008), Lippi and Secchi (2009), and Briglevics and Schuh (2014).

Cusbert and Rohling (2013) studied the effect of the financial crisis of 2008 on the demand for cash in Australia. The authors found that this demand "increased

significantly in the last quarter of 2008 (12 per cent), mainly due to the raise in the demand for large denomination notes". This raise was associated with precautionary motives, "originated because of the uncertainty on the financial health of banks during the crisis period". The demand for money due to precautionary reasons according to Keynes has a different meaning, and consists in the demand for money used to make unexpected expenditures. Keynes defines the precautionary cash balances as those held "to provide for contingencies requiring sudden expenditures and for unforeseen opportunities of advantageous purchases, and also to hold an asset of which the value is fixed in terms of money to meet a subsequent liability in terms of money" (KEYNES, 1936, p.196). In Keynesian economics, precautionary demand is one of the determinants of demand for money (and credit), the others being transactions demand and speculative demand. The precautionary demand for money refers to real balances held for use in a contingency. As receipts and payments cannot be perfectly foreseen, people hold precautionary balances to minimize the potential loss arising from a contingency. The precautionary demand is dependent on the size of income, the availability of credit, and the rate of interest.

Amromin and Chakravorti (2007) analyze the "change in transactional demand for cash resulting from greater usage of debit cards in 13 countries from 1988 to 2003". They note that "while check usage declined and has almost disappeared in some countries, the stock of currency in circulation has not declined as fast". The authors try to separate the use of cash as a payment mode, from its use for the purpose of store of value, which are its two traditional functions, on top of being a unit of value. In fact, they note that high-denomination bank notes are usually used for store of value, and explain that 60% of the total currency in circulation in US dollars is held outside of the United States, where it has limited acceptance. Interestingly, they identify that one of the drivers of the demand for cash is technological innovations, a variable the authors call TREND.

The theory on the demand for cash highlights the main benefits of cash, such as the convenience, universal acceptance, anonymity, or seigniorage revenues for the issuer of banknotes and coins. Another part of the literature lists the costs of cash usage, from reduced fiscal revenues driven by higher informality, the cost and inconvenience of withdrawing cash from automated teller machine (ATM) and bank

branches, security concerns (against thefts) and cost of printing, handling and management.

Snellman (2006) study the impact of the banking market structure on the choice of payment means, using panel data from 20 countries in 1988-2003. In particular, the authors analyze how the density of ATMs influences the use of cash or cards for payments. The authors find that a higher number of ATMs is linked to higher usage of cash. We note that other papers find mixed results on this relationship between ATMs and cash in circulation. A higher density of ATMs can lead to higher precautionary withdrawals, or conversely, customers can feel that they do not need to hold as much cash as it is readily available.

There are several parallels between the demand for cash and the demand for electronic payments, such as cards. However, there are two key differences. First the demand for cash highlights the function of cash as a store of value, and not just of payment. Other functions of money appear, such as speculation and precaution. Second, while cash and electronic payments are the most important payment means, they together do not form the entire market of payments. Other means coexist, such as checks, prepaid cards (in particular for food and transportation), automatic debit (for recurring bills), or invoices (*boletos* are popular in Brazil). This suggests that conclusions drawn from the analysis of cash demand cannot lead to direct take-aways for electronic payments.

3.5 Electronic payments and the credit market

The credit channel has been a key focus of the literature on microfinance and financial inclusion, as credit is typically presented as an important segment where market failures can be observed. The literature on credit channel details the steps of the transmission of policies and shocks. When analyzing the market of electronic payments, understanding credit trends and barriers becomes relevant for the usage of credit cards. In fact, credit cards are used as both a means of credit and of payment.

Stiglitz (1989) stressed the importance of asymmetries of information in the credit market, explaining that screening and monitoring of clients are two essential functions of

financial institutions. Loans are different from other goods and markets, since they are not contemporaneous: money is repaid in the future, loans are heterogeneous, they bear information problems. Stiglitz and Weiss (1992) developed a theory of credit rationing. According to the model, charging a higher interest rate can reduce profits for a lender, as the interest rate (price of money) does not play its normal clearing function. The authors advance two reasons for the negative correlation: an adverse selection and an incentive effect. For Stiglitz and Weiss, policymakers should essentially be concerned with the level of investment. However, there are two steps to influence the investment variables, from the monetary aggregate to credit, and then from credit to investment.

Romer et al. (1990) also suggest that monetary policy impacts the total stock of deposits, but there is no clear channel between monetary policy and the stock of credit.

Castelar Pinheiro and Moura (2003) argue that asymmetries of information (cost of screening and monitoring) have led to the market segmentation into retail, middle market, corporate. Those asymmetries mean that some borrowers are "informationally captured" and credit bureaus can reduce those asymmetries.

In a critical paper, Beck, Demirgüç-Kunt and Peria (2011) engage in the debate on the nature of financing for SMEs. Using data for 91 large banks from 45 countries, the paper finds that the availability and conditions for SME lending is similar across bank types. The authors show that SME lending needs not be based only on "relationship lending". Consistent with these results, the authors "find few significant differences in the extent, type, and pricing of SME loans across bank types". Instead, they find significant differences across developed and developing countries, driven by differences in the institutional and legal environment" (BECK; DEMIRGÜÇ-KUNT; PERIA, 2011). Beck, Demirgüç-Kunt and Peria show that the small and domestic private banks are not more likely to finance SMEs because of a competitive advantage in "relationship lending", defined as a "type of financing based primarily on soft information gathered by the loan officer through continuous, personalized, direct contacts with SMEs, their owners and managers, and the local community in which they operate". In fact, large domestic banks and foreign banks have increased the use of credit scoring and collateralized lending or leasing to offer credit to SMEs, under arm-length relationships.

Authors (BERGER and UDELL, 1994; BERGER et al., 2005) also refute the common wisdom that small banks are better positioned to service small enterprises. The authors formulate and test hypotheses about the role of bank type – small versus large, single-market versus multimarket, and local versus non-local banks – in banking relationships. The conventional paradigm suggests that “community banks” – small, single-market, local institutions – are better able to form strong relationships with informationally opaque small businesses, while “megabanks” – large, multimarket, nonlocal institutions – tend to serve more transparent firms. If this is correct, banking consolidation could be an issue. Based on two types of tests, using the 2003 Survey of Small Business Finance (SSBF), the results are often not consistent with the conventional paradigm. Large banks are perhaps adding to relationship the use of new lending technologies.

The ample literature on the topic of credit suggests that there are asymmetries of information that can lead sub-segments of the economy to not have access to credit. Research also shows that the ideal providers of those financial services are not necessarily small local banks. New tools based on technology can lead larger banks to extend more credit to smaller companies, such as merchants, in turn facilitating their use of electronic payments.

3.6 The challenge of regulation

The regulatory challenges posed by payments are very different from questions raised by other financial services such as credit or insurance, which are directly related to systemic risk. There is an ample literature on regulations focused on capital, liquidity and banking risk (BANK OF INTERNATIONAL SETTLEMENTS, 2013, BANK OF INTERNATIONAL SETTLEMENTS, 2014, KLOMP and DE HAAN, 2012). Authors have largely documented the relationship between market liberalization and banks vulnerability (STIGLITZ, 1999). In some cases, we argue that Brazil and Latin American countries present a more robust regulation than developed economies, in line with Giráldez-Puig and Berenguer (2013). While the regulatory challenges relating to payments are varied and complex, we consider four key themes for regulators:

- 1- Reducing informality;
- 2- Allowing innovation,
- 3- Fostering financial inclusion, and
- 4- Collaboration.

Through Law n.12.865 of 13 October 2013, the Brazilian Central Bank became the formal regulator of the payment sector in Brazil, including payment institutions and payment schemes (BANCO CENTRAL DO BRASIL, 2015b). The regulatory framework includes institutions involved with deposits, withdrawals, transfers and payments. The Brazilian Central Bank (2015b) highlights that payments can be an entry door to other financial services, such as savings, insurance, and credit. The report also highlights the large potential of prepaid cards and mobile payments.

Reducing informality is a particularly important policy objective connected with regulation and payments, allowing for a wider tax base in countries with sometimes fragile fiscal situations, while also being a first step to bringing public services and welfare coverage to vulnerable citizens. In Brazil, formal employment implies that the worker is an employee with a signed employment booklet. The absence of the booklet implies that the employment relationship is not covered by the Labor Code, leading to a lack of social protection. This leads to precarious employment and lack of social protection. Authors note that “according to the 1999 annual national household survey (PNAD), the rate of social security evasion in the private sector amounted to 62 per cent of the 64 million persons employed in this sector, up from 53 per cent in 1985” (INTERNATIONAL LABOR OFFICE, 2002). Informality is more prevalent for women than men, and particularly present in agriculture (90 per cent) and construction (72 per cent). The same authors highlight that there is a link between poverty and the informal economy. Financial inclusion can be a powerful tool to reduce the size of the informal economy. While there has been a lot of focus on credit, the authors underline the important of other products, such as savings.

Figure 10 - Proxy for informality: percentage of self-employed

Source: OECD, Author, 2010 data for Brazil was missing, we extrapolate from 2009-2011.

Innovation is another decisive challenge for regulators, as regulators try to strike the proper balance between risk and innovation (SANTANA, 2014). Innovation, such as mobile payments or payments by crypto-currency, increased competition and can be tools for inclusion. Ignacio Mas notes that with those innovations, the “end game is to make grids safer, more convenient, more contestable, and cheaper, especially for small transactions” (MAS, 2015). Regulators aim at defining rules that balance different sets of policy objectives. Innovation can be essential to include more citizens into the formal financial system, reducing informality and bringing benefits to people, as we have described above. On the flip side, excessive innovation potentially bears systemic risk, as in the case of shadow banking. Risks can also include other themes that are relevant to policymaking such as consumer protection. Schydrowsky (2015) adds that “the Digital Finance Revolution is the greatest technological change that has happened to payments systems since the invention of paper money”. Relevant guidance for striking the appropriate balance between a protective and an innovation-ready environment is reflected in the Payment Aspects for Financial Inclusion (PAFI) report, in guiding principle 2 on the legal and regulatory framework. It states: “The legal and regulatory

framework underpins financial inclusion by effectively addressing all relevant risks and by protecting consumers, while at the same time fostering innovation and competition.” Authors flag that innovation is “reconfiguring” the financial industry (BADER, 2007).

Fostering financial inclusion is also a growing objective of regulations. While innovation is a powerful tool to reach higher inclusion, it is not the only one. Regulators have developed simplified regulatory requirements to allow smaller or emerging financial institutions and users to adopt financial services while complying with a minimum set of rules. Regulators have increased their effort to connect their policy objectives with financial inclusion, and have acknowledged that some [...] categories of institutions may be regulated differently from banks as long as they do not hold, collectively, a significant proportion of deposits in a financial system” (BANK OF INTERNATIONAL SETTLEMENTS, 2015).

The literature also highlights the need to coordinate different regulatory bodies. For example, Borio (2014), in his analysis of financial stability and monetary policy, stresses the need to consider the monetary, prudential and fiscal policies together.

Finally, avoiding policies that incentivize the use of cash is also desirable. The Brazilian government has permitted differentiated pricing based on payment type, allowing merchant to offer discounts for cash and debit card payers, as opposed to credit card. Countries, such as Colombia and Argentina do the opposite, offering discounts for sales paid with electronic payments. Argentine retailers that accept card payment can claim a tax discount for the cost of the terminal. Similar policies in Korea have led card payments to increase from 5% of personal consumption expenditures to more than 50% in 2009 (GUEDES FILHO et al., 2011).

4 DESCRIPTIVE ANALYSIS: ARE ELECTRONIC PAYMENTS RECEDING IN BRAZIL?

In the previous sections, we reviewed the academic literature to list the benefits that financial inclusion could bring to citizens and we focused on the payment segment. The evidence around benefits has helped elevate financial inclusion to a widely accepted objective of financial policy. We also showed some cases where evidence was mixed, the impact of financial inclusion was not clear and sometimes detrimental to users, as in the case of microcredit.

Electronic payments are part of the problematic on financial inclusion and there is a growing body of research on access to and usage of electronic payments. We detailed in the previous section that the lower usage of cash and increase in electronic payments bring several benefits to citizens. Brazil is the third largest market for electronic payments globally, behind the US and the Eurozone.

4.1 Electronic payments in Latin America

According to the Findex survey, 51% of adults in Latin America report having a bank account (WORLD BANK, 2013). Latin America has a high usage compared to other developing countries, with a large share of payments made in debit, credit and mobile. Brazil is the country in Latin America with the highest bank account penetration. Mobile banking remains rare in Latin America, according to the survey, even though we expect that statement to change meaningfully on the next survey, as Brazil has experienced a strong growth in mobile banking capabilities.

That said, 10% of the unbanked globally are in Latin America, or about 200 million people. The World Bank (2013) identified three main reasons for not having a bank account: respondents state that they do not “not have enough money”, “accounts are too expensive”, they see “no need” for it. Moreover, one fourth of people with an account either have a dormant or low-use account. The Findex made questions about types of payments grouped into three categories: income (wage, government transfers, sale of agricultural products), payments of bills (utilities, school), domestic remittances

(people to people). In developing economies, 41% of respondents reported receiving their wage payments into an account. An overwhelming majority uses the account for cash management purposes, not just to withdraw the wage. The poorer the household, the more likely they are to withdraw all at once.

In Brazil, the Bolsa Familia is a case study in G2P transfers, as the program delivers financial assistance to nearly a third of the total population, and 99% of the recipients receive digital payments into a card or bank account (WORLD BANK, 2015b). In Brazil, among the 15% of adults receiving government transfers, 88% receive them into an account. However, 88% withdraw all the money right away in Brazil: the use of bank accounts for cash management purposes is limited. In fact, CSFI (2015) explains that “universal financial access is not full financial inclusion”. Globally, although the number of accounts has grown, the number of active users has not. When looking at other developing countries, the single biggest jump in financial inclusion happened in Kenya, thanks to mobile banking.

Financial inclusion in Brazil improved over the past 50 years. This is true across financial products. In the 1970s, Brazil became a leader in financial innovation, when it implemented banking correspondents, a model that would be replicated in several other countries. Banking correspondents perform select simple financial tasks, and consist typically of smaller retailers, gas stations or lottery stores. They complement the existing insufficient network of bank branches. The most popular types of transactions performed by correspondents consist in utilities bills payments, transfers, top-ups of cell phones and disbursement of government benefits. Hansen and Sulla (2013) highlight the very fast growth in credit in Latin America in the past decade, driven by consumption, mortgages and construction. While the growth can look worrisome, the authors also note that the credit market experienced a de-dollarization and has shown signs of lengthening maturity. Montoro (2012) explains that credit markets in Latin America were resilient during the Global Financial Crisis due to strong macroeconomic situations and the potential to implement countercyclical policies.

The literature on financial inclusion follows three dimensions: access, usage and quality. We indicate below a series of statistics for Brazil in a global perspective. We note that Brazil stands roughly in the middle of the sample of countries, with an adoption

of payments well above 50%, while other financial products such as insurance, credit and long-term savings are well below 50%.

Table 5 - Financial access in Brazil: Metrics for adoption and degree of usage of financial products

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Automated Teller Machines (ATMs) per 100,000 adults	108	111	113	118	115	114	116	115	114
Borrowers at commercial banks per 1,000 adults	95	104	149	203	233	367	391	397	400
Branches of commercial banks per 100,000 adults	18	19	19	18	19	20	20	21	21
Depositors with commercial banks per 1,000 adults	438	465	474	531	613	639	620	614	581
Loan accounts with commercial banks per 1,000 adults	326	384	505	646	823	2,034	2,276	2,297	2,255
Outstanding deposits with commercial banks (% of GDP)	43	46	44	45	45	40	38	35	33
Outstanding loans with commercial banks (% of GDP)	26	29	30	32	34	37	39	41	42

Source: IMF, Financial Access Survey: <http://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C&slid=1390030341854>, last accessed on July 10, 2017, World Bank Findex.

Empirical studies suggest that the adoption of financial services is not a linear function of the level of development of the economy. In fact, to the same level of GDP of capita, correspond several empirical percentages of usage of electronic payments (RAMIREZ; VASQUEZ; PEREDA, 2015).

4.2 Electronic payments in Brazil: progress and limits

Brazil is the second largest market globally for electronic payments, behind the US, and ahead of China. In fact, high inflation in the 1980's and 1990's and banking consolidation have led banks to invest heavily in technology, especially in fast and secure systems. Moreover, a high level of frauds also pushed issuers and acquirers to invest in technology. The deep reform of the Brazilian Payment System (SPB) in April 2002 is an important regulatory development in this process. Globally, the transition from cash and checks to electronic payments potentially represents a very large business challenge and opportunity.

The payment market is a classic example of a two-sided market. Rochet and Tirole (2003) explain that “to succeed, platforms in industries such as software, portals and media, payment systems and the Internet, must get both sides of the market on board”.

The Brazilian card market is marked by a high level of concentration, which is a direct result of the concentration of the banking and credit markets. In fact, two card acquirers share close to 90% of the card market. Moreover, Brazilian card acquirers, such as Cielo or Rede, perform a much wider variety of services than in other markets such as the US. For example, Brazilian acquirers perform services from the issuance of cards (typically performed by banks in other markets), to the affiliation of merchants, processing of information, anticipation of receivables and rental of points-of-sale equipment. It would not be uncommon to find four or five different companies fulfilling those tasks in the US market.

Figure 11 - Schematic view of the payment ecosystem

Source: Author, Visa, MasterCard, Elo, VeriFone.

The Brazilian card market is also marked by a higher level of pricing and higher profitability. Authors have found a relationship between banking concentration and high

level of margins, in the financial services market (DEMIRGÜÇ-KUNT and HUIZINGA, 1999). Moreover, D'Erasmus (2013) shows that a lower cost of financial services leads to higher levels of formalization and higher levels of credit in Brazil.

The regulatory framework has evolved rapidly in Brazil over the past decade. While the focus of policy makers and companies was to incentivize the penetration of card products, by affiliating more merchants, a more recent focus on the contestability of the market and high prices paid by users has risen.

There are several drivers for the higher usage of electronic payments, such as regulation and technological advance. Behind the larger adoption of electronic payments, we highlight the growth in formal employment and government-to-people payments, with transfers made on formal bank accounts. We note also successful policy programs incentivizing cardholders to use plastic cards and receiving tax rebates for fiscal receipts. Bader (2007) underlines important behavioral drivers of higher usage of electronic payments and the importance of rewards being offered by bank issuers. The author bases his study on psychological analysis, relying on the classification of archetypes popularized in the Myers-Briggs test.

Studies on rewards denote the inefficiencies brought by those incentives to credit card usage. Schuh, Sty and Stavins (2010) find that reward programs generate an “implicit monetary transfer to credit card users from non-card (or cash) users”. This is because merchants usually set a unique price for all users. They estimate that in the US, on average, “each cash-using household pays \$149 to card-using households and each card-using household receives \$1,133 from cash users every year”. Moreover, “because credit card spending and rewards are positively correlated with household income, the payment instrument transfer also induces a regressive transfer from low-income to high-income households”.

Innovation is playing a key role in the payment industry, with the potential to radically change the way we make purchases or transfer funds. Innovation and FinTech have the potential to bring meaningful efficiency gains for the participants of the payment ecosystem, and to end-users in particular. No doubt that financial technology will offer a vast and growing topic for future research, adding to the existing literature of

banking efficiency, which has mostly focused on size and deregulation to explain gains in efficiencies (ABBOTT; WU; WANG, 2013, BARROS and WANKE, 2014).

However, while Brazil has made enormous progress towards financial inclusion since the 1970s, we ask whether financial inclusion has reached a limit, based on various datasets of usage of banking services.

Electronic payments have gained share in the overall market of payments. The Brazilian Central Bank dedicates a section of its annual Report on Financial Inclusion to payments (BANCO CENTRAL DO BRASIL, 2015a). Interestingly, the regulator includes transfers in the category of electronic payments, and notes that transfers represent the most used electronic payment mode. Transfers include products known as available electronic transfers (Transferências Eletrônicas Disponíveis: TEDs), credit documents (Documento de Crédito: DOC) and invoices (boletos). The last category of invoices is the largest one: there are close to 10 million “boletos” liquidated on a daily basis. Cards, be it credit or debit, be it present or not-present, are progressively replacing cash and checks. Presencial payments mean that the customer or cardholder is physically present at the merchant location to make his payment. The Central Bank notes a large increase in card not-present payment models, such as payments through call centers or online payments. Internet transaction represented 39.2% of total transactions in 2010, while mobile transactions represented an additional 10%. In the case of not-present payments, an active credit card is still required, but not the use of a point-of-sale terminal. Until 2013, credit cards were used more frequently than debit cards. The curve then inverted with debit cards being the most used electronic payment mode, in terms of number of active plastic cards and in terms of number of transactions. The Central Bank explains that the rise in debit card usage suggests the substitution of cash and check payments by debit, which is viewed as more cost effective and secure (BANCO CENTRAL DO BRASIL, 2015a).

Figure 12 - Active credit and debit cards (in millions)

Source: Brazilian Central Bank.

Table 6 - Number of payment transactions, with non-cash instruments (millions of transactions)

	Check	Debit card	Credit card	Pre-paid	Direct debit	Transfer
2008	1,963	2,136	2,546	-	569	6,651
2009	1,803	2,445	2,808	-	4,263	7,158
2010	1,675	2,948	3,314	-	3,584	7,717
2011	1,590	3,508	3,836	-	4,135	8,443
2012	1,439	4,129	4,473	-	4,358	9,074
2013	1,297	4,908	5,020	-	4,953	9,588
2014	1,165	5,627	5,367	-	5,557	9,561
2015	1,018	6,467	5,559	-	5,427	10,084
2016	879	6,837	5,858	4.0	5,336	10,214

Source: Brazilian Central Bank, Report of Financial Inclusion (2015a).

Following a steady period of increase in electronic payments, the share of payments over the total of personal consumption expenditures has stagnated over the past two years. Anecdotal evidence suggests that card holders are shying away from credit cards payments to prefer debit and cash usage, mostly to avoid credit and indebtedness. Another anecdotal reason mentioned in surveys comes from the

perception that cardholders can better control their personal finances when paying in cash (DE MARIZ, 2017a). The percentage of personal household consumption divided by total consumption stands at 28% in Brazil.

Figure 13 - Comparison of the usage of cash, checks and electronic payments for personal consumption expenditures in select countries

Source: UN, BFA, 2015. Reserve Bank of Australia 2010, 2010.

Figure 14 - Evolution of the usage of electronic payments for personal consumption expenditures (PCE)

Source: Bradesco.

Likewise, while the number of issued cards continues to increase, the number of active cards grows at a slower pace. The percentage of activation started to decrease after 2010 (BANCO CENTRAL DO BRASIL, 2015a). Credit or debit cards are considered active when there has been at least a transaction in the 12 months preceding the reporting date.

Table 7 - Number of issued and active cards, average ticket and penetration of cards

	2010	2011	2012	2013	2014	Trend 2010-2014
Debit cards (issued, thousands)	226,246	252837	282114	289327	293488	29.7%
Debit cards (active, thousands)	77,641	84432	96061	105486	111873	44.1%
Debit card transactions, average ticket (R\$)	68	66	64	63	61	-10.0%
Active debit cards / adults with a banking relationship (%)	71.7%	74.0%	80.0%	83.8%	85.5%	19.2%
Credit cards (issued, thousands)	161,358	150502	149601	157228	157936	-2.1%
Credit cards (active, thousands)	81,676	76948	75123	78914	83713	2.5%
Credit card transactions, average ticket (R\$)	122	119	112	108	105	-13.7%
Active credit cards / adults with a banking relationship (%)	75.5%	67.40%	62.50%	62.70%	64.00%	-15.2%

Source: Brazilian Central Bank.

To understand the limits of financial inclusion and the use of financial services, Roa (2015) underlines that demand factors are as important as supply factors. Supply side studies focus on access, such as the geographical location of ATMs and bank branches, or the cost of access to financial services, such as high commissions or minimum balances. Studies on the demand side integrate behavioral explanations. The author emphasizes that the lack of confidence and financial knowledge can be more important than supply factors. It is not only the lack of income that determines a low level of participation into the financial sector, other factors play a role, such as a distrust of financial institutions. The use of cash remains widespread, especially for salary payments (GUEDES FILHO et al., 2011). The Brazilian Central Bank (2013) notes an increase in the use of cash between 2010 and 2013.

Figure 15 - Payment method for salaries in Brazil (economically active population)

Source: BANCO CENTRAL DO BRASIL (2013).

Innovation and technology are key enhancers of electronic payments. As noted already, the use of card not-present channels has increased meaningfully in the past

decade for all types of financial transactions, not just payments. Card not-present channels include call centers, the internet, cell phones and tablets. In 2014, 52.3% of all transactions were done via those remote channels. Since 2010, the use of internet banking has experienced an annual growth of 16.4% *per annum*, on average, representing 39.2% of total transactions. Since 2010, the mobile channel has experienced the fastest growth, with a growth of 202.4% p.a., representing 10% of total transactions in 2014. Overall, transactions undertaken via remote channels grew 20.8% in 2010-2014, compared with 5.8% of presencial channels. Convenience, growing trust from customers, and security protocols explain the strong growth in those channels. That said, the transactions involving non-presencial channels are often used for transactions that do not involve the transfer of funds; 80.8% of non-presencial transactions corresponded to account balance inquiries. Those channels represent a large growth opportunity, according to the Central Bank.

Table 8 - Number of transactions by type of channel

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	25,133	27,146	31,104	35,475	40,541	44,539	49,664	55,457	60,618
Internet (home and office banking)	7,300	8,342	10,571	12,797	15,558	17,740	19,466	19,726	20,275
ATM	8,007	8,113	8,545	9,262	10,102	10,627	10,953	10,977	10,168
Mobile and tablets	65	96	62	196	821	2,290	5,143	10,800	16,726
Branches	5,806	6,391	7,460	8,683	9,062	8,651	8,787	8,875	8,146
Banking correspondents	2,318	2,591	2,905	3,174	3,417	3,686	3,944	3,910	4,223
Call center	1,636	1,613	1,562	1,362	1,581	1,546	1,370	1,169	1,080

Source: Brazilian Central Bank.

For presencial channels, ATMs represent the preferred option, representing 46.7% of presencial transactions. 53.1% of transactions done via presencial channels involve some kind of transfer of funds. 75.5% of cash withdrawals were made at ATMs. Naturally, cash-in and cash-out transactions, such as cash withdrawals and deposits, happen via presencial channels. Branches and ATMs have the same share at 42% of all deposits, with the remainder being done at banking correspondents.

Table 9 - Type of transactions by type of channel (2016, in thousands)

	Branch	ATM	Call center	Banking correspondent	Intern, home and office banking	Mobile, tablet
Payment of invoice (boleto)	982,939	769,103	8,301	2,808,289	2,039,932	555,006
Account balance	681,857	3,885,771	644,315	297,254	8,102,460	12,826,663
Deposit	606,018	715,202	-	376,116	-	-
Loan	348,668	101,110	6,421	23,146	146,329	100,444
Other financial transactions	309,050	15,271	10,049	1	1,203,304	16,423
Other non-financial transactions	4,531,737	1,004,224	403,706	157,688	7,288,061	2,942,962
Cash withdrawal	471,139	3,449,018	-	559,457	-	-
Money transfer	214,406	228,320	7,651	1,193	1,494,887	284,254

Source: Brazilian Central Bank.

Evidence also suggests that the ownership and usage of cards is associated with higher income levels.

Table 10 - Percentage of card ownership by income segment (2009)

	Total	A/B	C	D/E
Card	67%	81%	64%	36%
Credit	45%	61%	38%	20%
Debit	53%	70%	49%	19%
Bank account (% of population)	67%	82%	64%	33%

Source: Guedes Filho et al. (2011), Tendencias Consultoria.

Table 11 - Use of cash and other payment methods in Brazil, by ticket size (2010)

Ticket size	Cash	Other payment methods	Other payment methods (A/B segment)
<R\$10	99%	1%	2%
R\$10-20	92%	8%	12%
R\$20-50	78%	22%	32%
R\$50-100	64%	36%	54%
R\$100-500	54%	46%	67%
>R\$500	54%	46%	68%

Source: Brazilian Central Bank (2013), Guedes Filho et al. (2011), Tendencias Consultoria.

At the global level, a higher GDP per capita is associated with a higher usage of electronic payments. The social ascension and reduction in poverty rates has come hand in hand with higher levels of banking penetration and the inclusion of millions of Brazilian citizens into the middle class. The banking and payments sector grew at a fast pace until 2013. In the following period, between 2013 and 2017, the inclusion into the middle class decelerated, while the banking sector also grew at a slower pace. Payments grew at an average rate of 10.3% in 2014-2017, versus 21.5% in 2007-2014.

Figure 16 - Metrics for adoption and degree of financial products

Source: World Bank Group, 2015a, adapted by author.

The past 15 years have witnessed the emergence of a new middle class. Ravallion notes that between “1990 and 2005, economic growth and global distributional shifts allowed an extra 1.2 billion people to join the developing world's middle class”, most of them in Asia (RAVALLION, 2010). With the recent downturn evidenced in Brazil, lower production and higher unemployment, a portion of this new middle class is at risk of falling back into poverty, we call them the new vulnerable class. The World Bank estimates that the number of poor Brazilian could jump by an additional 2.5 to 3.6 million

people in 2017, due to the economic downturn (MAXIMO, 2017). There is a growing literature that emphasizes the risks faced by this new middle class (BIRDSALL; LUSTIG; MEYER, 2014).

Kamakura and Mazzon (2013) note that income is a necessary but insufficient indicator of socio-economic status. The authors consider the education, occupation, access to public services, and assets accumulated through life. The authors analyze in details the conceptual and methodological features of different Brazilian classifications, concluding that classifications based on permanent income present the highest degree of predictability, “allowing researchers and marketers to segment and study markets based on a valid, and reliable criterion of socioeconomic stratification.”

Table 12 - World Bank data on poverty levels

Region	Poverty line (PPP\$/day)	Num of poor (mil)	Population (mil)
East Asia and Pacific	1.90	147.2	2041.6
Europe and Central Asia	1.90	10.3	480.8
Latin America and the Caribbean	1.90	33.7	603.6
South Asia	1.90	309.2	1649.3
Sub-Saharan Africa	1.90	388.8	911.5
Developing world	1.90	897.3	6026.2

Source: World Bank Group, PovcalNet Archive. Data for the Middle East and Africa was suppressed, as survey data coverage was too low.

Empirical studies have showed that social classes are transitory states (PLANO, 2012). In particular, the literature has focused on the intra-generational social ascension of people who are not yet firmly established in the middle class and are at risk of falling back below poverty levels. This class is sometimes described as the “strugglers”, and we call them the new vulnerable class, by opposition to the new middle class. There is an extensive literature on the new middle class, especially when it comes to emerging markets, such as China, India, or Brazil. By contrast to the period of 1994-2012, indicators show that the trends of poverty reduction and financial inclusion may be receding, or at least have slowed down. Birdsall, Lustig and Meyer (2014) identify a “group of people in Latin America that are not poor but not middle class either—namely

“strugglers” in households with daily income per capita between \$4 and \$10, at constant 2005 PPP (BIRDSALL; LUSTIG; MEYER, 2014). The authors define absolute levels to analyze this segment, and note that the strugglers will “account for about a third of the region’s population over the next decades”. Strugglers run the risk of falling back into poverty and being marginalized. Importantly, Birdsall note that the “cash transfers they receive are largely offset by indirect taxes” and that “the benefit of schooling and other in-kind transfers they receive is questionable after adjusting for quality”.

4.3 Electronic payments in Brazil: a SWOT analysis

We present an analysis of strengths, weaknesses, opportunities and threats, following the methodology of Porter (1979). We build the SWOT from the point of view of card companies, namely card acquirers.

Table 13 - SWOT Analysis for the card industry

<p>Strengths</p> <ul style="list-style-type: none"> - Concentrated market suggests possible pricing power against suppliers and clients; - Integrated market with acquiring and processing steps; - Secular trend of adoption of electronic payments by the population; 	<p>Weaknesses</p> <ul style="list-style-type: none"> - Smaller acquirers and card processors are gaining market share, undercutting pricing; - As a scale business, the card industry experiences high fixed costs and operating leverage can only be captured with higher volumes;
<p>Opportunities</p> <ul style="list-style-type: none"> - Card companies can strengthen their relationship with merchants and offer a more tailored and relevant service, as opposed to just a payment solution; - Card companies can use their current cash generation to buy small competitors, especially with different technologies. 	<p>Threats</p> <ul style="list-style-type: none"> - Technological innovation and FinTech could reinvent the payment ecosystem, dis-intermediate current companies and reduce margins; - The regulator and policy makers are aggressively looking for ways to make the industry more contested and cut prices for end-users, impacting in particular revenues from equipment rental (POS), merchant discount rate, and prepayment rate paid by merchants.

Source: Author.

5 STATISTICAL ANALYSIS: WHAT ARE THE DRIVERS OF ELECTRONIC PAYMENTS IN BRAZIL?

We rely on quantitative methodologies to assess the drivers of electronic payments in Brazil over time. We used the R and STATA 2014 software to run most statistical tests. We use EXCEL and GRETTL for most descriptive analysis and charts. A first set of analyses will help us explain the drivers of electronic payments in the past. We will use a principal component analysis. A second set of analyses will help us predict future trends in electronic payments, and identify what drivers best predict future volumes of cards. For this second set of tests, we will use auto regressive models (ARIMA and SARIMAX).

5.1 Methodology

Our methodology follows the 5 steps described below:

1- Build the time series and provide descriptive statistics;

- a. Time series of electronic payments in Brazil, adjusted for inflation;
- b. Descriptive analytics;
- c. Establish stationarity (ADF test);
- d. Review models used in the literature;

2- Regression analysis;

- a. List explanatory variables based on the review of the literature;
- b. What are the drivers of electronic payments in Brazil, based on regression?

3- ARIMA model;

- a. An innovative approach: ARMA models;
- b. Estimate parameters for AR and MA and select best model;

4- SARIMAX model;

- a. Why use PCA?
- b. Select variables based on 6 filters;
 1. Exclusion of incomplete series;
 2. Reduction based on PCA for multi-collinearity;

3. Test of Granger causality;
4. Test of co-integration (Johansen test);
5. Test of exogeneity;
6. Solve issue of multi-collinearity;
- c. Estimate parameters for AR and MA and select best model;

5- Conclusion

- a. Explain: drivers of electronic payments in Brazil based on PCA;
- b. Compare ARIMA/SARIMAX models in the validation period;
- c. Predict use of electronic payments.

Figure 17 - 5 steps in our methodology

Source: Author

5.2 Time series of electronic payments in Brazil. Descriptive statistics

5.2.1 Time series of electronic payments in Brazil

Our sample consists in monthly card data from January 2007 to March 2017, as reported by the Brazilian Card Association ABECS, corresponding to 123 monthly observations. ABECS reports overall card volumes (transactions in millions of Brazilian reais) and several dimensions or subsets of card volumes. We deflate the time series with the IPCA, as reported by the Central Bank. Our dependent variable is continuous.

5.2.2 Descriptive statistics

There are no breaks in the time series. We present a standard statistical analysis below.

Table 14 - Standard statistics

Mean	58,334
Median	56,791
Minimum	17,664
Maximum	118,940
Standard deviation	26341
C.V.	0.45156
Skewness	0.17864
Ex. Kurtosis	-1.2003
5% percentile	21580
95% percentile	97806
Interquartile range	49766
Missing obs.	5

Source: Author, Summary statistics, using the observations 1 – 128 for the variable 'TotalVolume' (123 valid observations).

Figure 18 - Chart with level (card volume, in R\$ thousands, per month)

Source: Author.

Figure 19 - Chart with first difference in level

Source: Author.

Figure 20 - Chart with log difference of level

Source: Author.

Based on the figures above, there is a strong case for using a seasonally adjusted first difference in log volumes of electronic payments.

We take another look at the data and consider growth in volumes.

Figure 21 - Card volumes (R\$m, per month)

Source: Author. Volumes adjusted for inflation are rebased as of January 2007.

Figure 22 - Growth in card volumes (12 month rolling)

Source: Author.

If we take one data point, the month of March 2017 is the latest in the time series and saw a full amount in card transactions for the month of R\$98,197mn, or roughly speaking R\$98 billion. The following chart gives a clear visual understanding of the sharp slowdown experienced in the sector. We consider 12-month rolling growth rate in

order to account for seasonality, as the Christmas is typically very strong for card usage. While transacted card volumes have continued to increase, the growth rate has come down meaningfully from 26% in January 2009 to 6% in March 2017. The time series also suggests two rebounds or improvement in growth in November 2009 and May 2013.

If we consider the number of transactions, as opposed to transacted volumes, the conclusion of a visual analysis would be similar.

Figure 23 - Growth in the number of card transactions (12 month rolling)

Source: Author.

The ratio of transaction volumes and the number of transactions is the average transaction size, or ticket. The average ticket has increased from R\$71 in January 2007 to R\$91 in March 2017, or a growth of 27.5%. Over the same time period, accumulated inflation was 83.6% in Brazil, based on the IPCA inflation index calculated by the Statistics Institute IBGE.

Figure 24 - Average ticket per transaction (R\$)

Source: Author.

5.2.3 Establish stationarity (Augmented Dickey-Fuller test)

We perform the Augmented Dickey-Fuller test (ADF) to confirm if the time series has a unit root. Performing the test on the levels indicates that the hypothesis H_0 that the series has a unit root and presents stationarity can be rejected. We therefore adjust the time series by calculating the difference of the logs and run the ADF test on the difference. The ADF test shows that the time series with first difference of levels presents stationarity. We show below the autocorrelation graph for the time series of first difference (AC). If a time series is stationary then its autocorrelogram should decay quite rapidly from its initial value of unity at zero lag. If the time series is nonstationary then the autocorrelogram will only die out gradually over time.

Figure 25 - Autocorrelogram of levels

Source: Author, STATA 2014.

Figure 26 - Autocorrelogram of first difference

Source: Author, STATA 2014.

5.2.4 Review of models used in the literature

A large part of the literature focuses on the choice of a means of payment. The focus, especially in research papers produced by Central Banks, is to quantify and predict the use of cash, while considering electronic payments as an alternative payment method. The logical consequence of this research focus is that most models in the literature on payments study binary outcomes. We find a number of analyses based on logit, probit or heckit models, in order to estimate the probability of choosing cash versus non-cash alternatives, either debit or credit, at the point of sale. In many cases, electronic payments are simply considered as a byproduct of cash usage. For example, in the model by Bagnall, the utility function of using cash versus non-cash solutions is dependent on a list of observable variables and a logit error term. The variables used in the regression are (i) transaction size, (ii) cash balances, (iii) socio-demographic characteristics (age, income, education), (iv) consumer perceptions of ease of use, acceptance, and cost, and (v) POS transaction characteristics (card acceptance and type of purchase) and a logit error (BAGNALL; PULLEY; VESALA, 2016).

Other papers focus on electronic payments alone and commonly use the Ordinary least squares methodology (OLS) and variations on the theme. In their research analyzing the determinants of the demand for cash in Peru from 2002 to 2013, Ramirez, Vasquez and Pereda (2015) use both a linear and a non-linear model with monthly data. They note that the adjustment of the linear model used was low, even though the assumptions of the ordinary least square (OLS) were fulfilled (RAMIREZ; VASQUEZ; PEREDA; 2015). The non-stationary variables were run in first differences. According to the authors, the poor results of the linear model could be explained by the existence of a “non-linear relation between electronic payments and its determinants”. Another possible explanation is that the estimated parameters are not constant during the analyzed period, a phenomenon known as switching regimes, which is common for longer time series. Considering the poor results of the OLS, the authors use a Markov switching models (MSM), which calculates a set of parameters for each period (regime) in a time interval. The authors explain that “due to the uncertainty of the exact moment

in which this shift occurs, the regime change is considered a random variable; and, its future occurrence depends on a probability.” Another way to consider the MSM approach is to understand a time series as “an ensemble of stationary processes with different distribution functions”.

5.3 Linear regression

5.3.1 List of explanatory variables based on the review of the literature

Individual data typically has been sourced in consumer surveys and consumer diaries. For diaries, consumers write down every transaction processed during a predefined number of days. We are not aware of such a diary being available with data from Brazilian consumers. In developed countries, several surveys exist and vary in their scope and length. The literature based on surveys and diaries regresses the adoption or use of payment instruments to a list of independent variables, including consumer characteristics, payment characteristics, and preferences.

Our approach is different. Due to scarce individual consumer data, we base our analysis on panel data at the macro level. We focus on electronic payment means and ignore determinants of cash usage. We regress the use of electronic payments against a list of independent variables. Those variables are similar to the ones used in individual consumer data.

Following the literature, we define four blocks of variables:

1. access to payment modes,
2. macro factors,
3. transactions characteristics,
4. consumer preference and socio-demographics.

To the extent of our knowledge, those **four** blocks group all the drivers developed in the literature to determine the adoption and use of payment instruments. As mentioned before, we are only interested in the *use* of electronic payments, and not their *adoption* or the preference for electronic payments over cash.

In fact, we do not model the adoption of payment instruments, and assume that the adoption of electronic payments is a prerequisite for the use of those payments. We then refine those four large blocks or categories into a larger universe of more specific variables or metrics.

Due to limitations of the data set on consumer choices at the individual level, we do not include variables such as consumer socio-demographics or consumer preference into our model. We acknowledge the limitations of our model and suggest that this theme be studied in further research. Nevertheless, we believe that macroeconomic data allow interesting conclusions on payment instruments choices.

We present below a table recapitulating the variables observed in the literature. We group them into four large categories: access to payment modes, macro factors, transaction characteristics, and consumer preferences and socio-demographics.

Table 15 - Categorization of variables and references in the literature

Category	Metric	Reference	Finding
Access to payment modes	Level of card ownership	Bagnall (2016)	The use of cash may be negatively correlated with the level of card ownership.
	Financial and non-financial incentives/costs	Fish and Whymark (2015); Arango et al (2011)	Incentives include price differentiation and loyalty programs (rewards), being positively correlated with card usage.
	Access to cash: density and cost of ATM terminals	Alvarez and Lippi (2013)	The relationship between cash balances and cash usage is unclear, which could simply relate to consumer preference. Alvarez and Lippi (2013) suggest that a high density of ATMs can lead to higher cash holdings and higher cash usage. Bank of England (2015) suggests fees for ATM withdrawals may lead to lower cash usage.
Macroeconomic factors	Macroeconomic conditions	Briglevics and Schuh (2014); Schuh and Stavins (2014); Bagnall (2016)	Briglevics and Schuh (2014) find that lower US rates lead to higher cash holdings. Schuh and Stavins (2014) analyze the business cycle, considering GDP, output gap, inflation, and rates, and find that U.S. consumers increased their use of cash after the crisis. Bagnall (2016) also considers the size of the shadow economy.
Transaction characteristics	Transaction size	Klee (2008); Bouhdaoui and Bounie (2012); von Kalckreuth, Schmidt, and Stix (2014); Arango, Huynh, and Sabetti (2011); Whitesell (1989)	Size is positively correlated with card usage.
	Card acceptance by merchants, density of POS	Bagnall (2016); Fish and Whymark (2015)	Higher usage of cash is associated with lower levels of card acceptance at the point of sale.
	Sector of activity	Bagnall (2016), Cohen and Rysman (2013), Klee (2008)	The breakdown of spending by sector impacts the preference for cards or cash.
Consumer preference and socio-demographics	Behavioral aspects: convenience, preference, cash balances	Borzekowski, Kiser, and Shaista (2008); Ching and Hayashi (2010); Schuh and Stavins (2010); Arango, Huynh, and Sabetti (2015); Bagnall (2016) and Stix (2013)	Consumers' views on certain payment instrument attributes can be viewed as proxies for consumer preferences. Such attributes include the desire to better control personal finances, or a low trust in banks.
	Age, Income, education	Daniels and Murphy (1994); Boeschoten (1998); Von Kalckreuth, Schmidt, and Stix (2014); Cohen and Rysman (2013)	There is no clear correlation with age.:Von Kalckreuth et al. (2014) and Cohen and Rysman (2013) suggest age is not a determinant variable. There is evidence that cash usage declines with higher income and education

Source: Author.

Based on the revision of the literature mentioned above, we source a number of corresponding time series for Brazil. For each variable, we define a proxy that is most pertinent, considering available data. We present below a definition and conceptual justification for each variable, as well as the periodicity of available data. We regress those panel sets between 2007 and 2017. We indicate in the table below the specifics of the data sample and sources.

Table 16 - List of independent variables, source and periodicity

Category	Variable	Description	Source	Periodicity
Dependent variable	$U(EP)_{it}$	Use of electronic payment, i defines the type of electronic payment (debit or credit), and t stands for the date		
Access to payment modes	CARD	Number of cards issued and active, by type of card	BACEN	Q
	ATM	Ease of cash withdrawals, defined as the number of Automated Teller Machine (ATM)	BACEN, IMF	A
	CASH	Cash balance of consumers, defined as savings account, or cash in circulation held by agents	IBGE	M
	CARDCOST	Fee paid by the cardholder to the bank	BACEN	Q
	COST_CARDHOLDER	Lending rate on credit cards offered by banks	BACEN	M
	POS	Card acceptance by merchants, defined as the number of active POS equipment with card readers for 100,000 inhabitants	BACEN	A
Macro factors	CRIME	Consumer preference can be influenced by security concerns, which we capture with a proxy of crimes per 100,000 inhabitants. The rising use of chip-and-pin is also an indicator of protection against fraud and crime	OBSERVATORIO	A
	POVERTY	Higher income has been associated with higher use of electronic payments	WORLD BANK	A
	INFLATION	In developed countries, low inflation has been associated with higher cash usage	IBGE	M
	RATE	Low rates have also been associated with higher cash usage in developed countries	IBGE	M
	BANK CREDIT	The growth in credit concession can be a driver of payments usage, though we flag endogeneity concerns	BACEN	M
	TREND-INNOVATION	Technology and innovation can drive increased use, such as through the growth of e-commerce and non-presential payments (online, mobile banking). Share of card-not present transactions	BACEN	Q
	MARKET	Market value of companies listed on Bovespa is an indicator of overall wealth	IBGE	M
	WORKFORCE	Level of employment	IBGE	M
	INFORMALITY	Percentage of self employed, international comparison	OECD	A
	RETAIL SALES	Level of retail sales	IBGE	M

Category	Variable	Description	Source	Periodicity
	$U(EP)_{it}$	Use of electronic payment, i defines the type of electronic payment (debit or credit), and t stands for the date		
Transaction characteristics	INSTALLMENT	Share of purchases paid in installments (quantity and value) indicates the propensity to take credit	BACEN	Q
	SIZE	A larger size of transactions has been found to be a driver of electronic payment. We analyze the average transaction size as the systemic level. While data on individual transactions would be preferable, we assume that a rising average goes hand in hand with a rising median transaction	ABECS, BACEN	M, Q
	REWARD	Financial rewards have been associated with a larger use of electronic payments	BACEN	Q
	SECTOR	The sector of activity of the points of sale is relevant for the use of payments	IBGE	M
	COST_MERCHANT	The incentive to the merchant can impact the card acceptance or propensity of merchants to offer card payments, cost is captured through the merchant discount rate (MDR), rate paid by the merchant at every transaction	BACEN	Q
Customer preference and characteristics	AGE	Percentage of <15year-old, >65 year-old, international comparison	OECD	A
	BEHAVIOR	Usage of Premium cards	BACEN	Q

Source: Author.

Table 17 - List of independent variables

ACCESS	COUNTRY CHARACTERISTICS	TRANSACTION CHARACTERISTICS	SOCIO-DEMOGRAPHICS
CARD_OWNERSHIP	CRIME	INSTALLMENT	AGE
ATM	POVERTY	SIZE	BEHAVIOR_PREFERENCE
CASH_IN_CIRCULATION	INFLATION / RATE	REWARD	EDUCATION
COST_CARDHOLDER	BANK CREDIT	RETAIL_SECTOR	GENDER
CREDITCOST	TREND_INNOVATION	COST_MERCHANT	
POS	MARKET		
	WORKFORCE		
	RETAIL_SALES		
	INFORMALITY		

Source: Author.

5.3.2 Regression results

We build a regression between a set of independent variables and card volumes. We include a dummy for the month of December, to account for the seasonality that we observed in the data set. Practically, December corresponds to the holiday season and explains the different pattern of consumption for the month.

We run the regression for our full set of 70 independent variables. We rely on the AIC and QME figures to identify the single variable with the best fit.

Table 18 - AIC and QME for the variables of the regression

	vars _reg	r2	r2_saz	aic_simple	aic_saz	QME_simple	QME_saz
i_igpm	3	0.94	0.95	760	758	344,908,119	327,704,915
vl_poup	6	0.97	0.98	694	656	50,626,144	47,295,242
avg_pap_moeda	7	0.95	0.98	743	639	41,802,413	33,298,579
vl_pap_moeda	9	0.95	0.98	725	659	42,866,877	39,630,975
cd_pea	11	0.97	0.98	672	631	101,657,617	64,435,555
vl_emp_tt	12	0.87	0.88	839	852	194,603,203	216,855,750
vl_emp_cc	13	0.95	0.96	738	728	40,891,521	NA
vl_emp_ncc	14	0.86	0.9	846	829	154,242,404	59,449,843
tx_ocup	15	0.73	0.71	918	920	400,768,799	391,578,449
i_vendas_medico	23	0.88	0.93	825	797	377,044,964	377,311,323
rec_vendas_varejo_fixo	29	0.62	0.59	952	958	507,590,582	477,937,902
rec_vendas_varejo_saz	30	0.65	0.67	944	958	528,326,546	556,714,751
cred_personal	45	0.98	1	589	469	3,971,554	2,091,058
cred_credc_fin	49	0.95	0.97	713	687	119,552,053	127,408,088
cred_credc_purchase	50	0.97	0.98	660	625	8,224,951	8,121,355
cred_credc_tt	51	0.96	0.97	691	670	7,225,602	7,054,702
cred_leas_tt	52	0.61	0.62	933	949	8,010,529	10,084,657
payroll_public	56	0.98	1	590	481	3,245,497	550,335
payroll_private	57	0.96	0.97	697	680	85,306,797	87,639,401
payroll_retirees	58	0.96	0.97	691	671	32,914,502	26,752,402
payroll_non	59	0.96	0.97	703	693	69,163,215	69,402,194
cred_penetration	60	0.95	0.96	712	708	19,308,606	15,390,908
cred_stock_public	61	0.96	0.97	713	693	11,472,156	5,707,856
cred_stock_private	62	0.81	0.82	879	893	236,958,936	240,060,228
cred_stock_foreign	63	0.9	0.92	805	811	238,225,355	226,382,445

Source: Author.

We identify the five variables that present the best fit with the lowest AIC:

1. **cred_personal** (stock of personal credit),
2. **payroll_public** (stock of personal credit to public sector employees),
3. **cred_credc_purchase** (stock of individual credit under the credit card modality),
4. **cd_pea** (active population),
5. **avg_papel_moeda** (cash in circulation).

It is self explanatory that credit card lending by the banks is a key driver of card payments. In fact, the trigger of the card lending operation is the same as for the card

payment: the customer is pre-approved for card purchases. This highlights the dual proposal of credit cards, as both a payment means but also a credit tool. This dual characteristic does not apply for debit cards, which are used exclusively as a payment means. Interestingly, the level of the active population presents a stronger fit than other employment measures. Finally, the level of cash in circulation brings an interesting insight into the use of electronic payments.

Figure 27 - cred_personal presents the best fit to the dependent variable (stock of personal credit)

Source: Author.

5.4 ARMA models

5.4.1 An innovative approach: ARMA models

Our approach focuses on the intensity of usage of electronic payments. In fact, we assume that the person has access to and is a user of electronic payments. As far as we know, we believe ARMA models have not been used in the payments literature. ARMA models are based on auto-regressive processes (AR) with order p , and on moving averages (MA) with order q . They are also known as Box-Jenkins models, as they were first described by George Box and Gwilym Jenkins in 1970. ARMA models offer the simplicity of explaining and predicting a variable only through its past values (AR) and past error terms (MA). ARMA models have been commonly used in the literature to predict inflation and other economic variables. ARMA models often consider an integration process and are then referred to as ARIMA models. The integration aims at transforming the dependent variable into a stationary series. ARIMA models are essentially similar to regressions, where current values of a variable can be explained by its past values plus an error. The literature divides the analysis performed in SARIMAX models into three stages, as described by Box and Jenkins (1976). The three stages are identify, estimate and forecast.

The order of an ARIMA model is usually denoted by the notation $ARIMA(p,d,q)$, where:

p is the order of the autoregressive part;

d is the order of the differencing;

q is the order of the moving-average process;

The SARIMA model consists in adding a seasonality factor S to the equation. A general notation for a seasonal ARIMA models is $SARIMA(p,d,q)(P,D,Q)$, where p denotes the number of autoregressive terms, q denotes the number of moving average

terms and d denotes the number of times a series must be differenced to induce stationarity. P denotes the number of seasonal autoregressive components, Q denotes the number of seasonal moving average terms and D denotes the number of seasonal differences required to induce stationarity. We consider a time period of 12 months for each order.

Part of the literature outlines alternative ways to explain seasonality. In that sense, the seasonal factor used in a SARIMA model may not be the best approach to address the challenge of seasonality, and one would prefer the methodology first defined by Fourier. Dickey notes that the innovation of Fourier analysis is to consider time series as a combination of periodic movements. In other words a periodic or non-periodic movement can be thought of in terms of frequency and not in terms of a time series: “there are many time series, for example tidal movements, environmental variables, and even economic series that can be more conveniently modeled in the so-called frequency domain” (DICKEY, [s.d]; AGUIRRE, 1995). Fourier first applied his theory to the explanation of heat propagation and provided a mathematical basis for a physical phenomenon (FOURIER, 1822). The SARIMAX model adds independent variables X to the equation. SARIMAX models therefore explain current values of a variable via its past values, past error terms, a seasonal factor, exogenous variables and an error term.

The **SARIMAX model** is best explained in the following equation:

$$Y_t = \phi_1 Y_{t-1} + \dots + \phi_p Y_{t-p} + \theta_1 \varepsilon_{t-1} + \dots + \theta_q \varepsilon_{t-q} + \beta_{1t} X_{1t} + \dots + \beta_{1t-n} X_{1t-n} + \dots + \beta_{wt} X_{wt} + \dots + \beta_{wt-m} X_{wt-m} + \varepsilon_t \quad (1)$$

Where:

Y_t is the difference in levels for Z_t , at t ;

ϕ_i is the **autoregressive** coefficient for order i , with $i=1, \dots, p$;

θ_j is the term for **moving average** for order j , with $j=1, \dots, q$;

X_{kt} is the **exogenous variable** k at time t , with $k=1, \dots, w$;

β_{kt} is the **parameter** associated with exogenous variable k at time t , with $k=1,\dots,w$;

ε_t is the error term of the model.

The SARIMAX model is based on the following hypotheses:

- The expected value of ε_t is zero: $E(\varepsilon_t)=0$;
- Homoscedasticity: $\text{Var}(\varepsilon_t) = \sigma_e^2$ for every value of t ;
- Residuals are not correlated: $E(\varepsilon_t \varepsilon_s) = 0$ for every $t \neq s$;
- Independent variables present weak exogeneity at time t , or else, there is no correlation between the independent variable and the error term: $E(X_t \varepsilon_t) = 0$;
- Residuals follow a normal distribution: $\varepsilon_t \sim N(0, \sigma_e^2)$

5.4.2 Estimate models and select best model

ARIMA is an approach of univariate forecasting. We define three steps for the ARIMA model.

- 1- We identify the order of integration for the ARIMA model;
- 2- We estimate a list of models, testing several values for $AR(p)$ and $MA(q)$;
- 3- We forecast future periods, and select the model that displays the best fit, under the OLS method, for the validation period;

Figure 28 - ARIMA steps

Source: Author

Mentz, Morettin and Tolo (1998) recommend an iterative process to estimate the ARIMA model and the use of parameters of small order (1 or 2). Following the initial step of data collection and examination, our methodology also follows the steps suggested by Meyler, Kenny and Quinn (1998, p32): “determining the order of integration; model identification; diagnostic checking; and, forecast performance evaluation.” “The approach which is considered to be most robust is to retain a range of models, which perform satisfactorily at the model identification and diagnostic checking phases, for use in forecast performance evaluation. This approach is open to criticism of ‘model mining’, but since forecast performance is the overriding objective, this approach can be justified.” The authors analyzed inflation patterns and concluded: “over a short horizon, forecast statistics from multivariate models are unlikely to outperform in any significant way the forecast statistics presented here for a relatively simple ARIMA model” (MEYLER; KENNY; QUINN, p29). In our model estimation, we also highlight the principle of parsimony, which recommends a preference for low orders of 1 or 2 used in models. Moreover, considering that our time series is relatively short, we prefer not to use high lags.

In the third step of performance evaluation, we break down our time period of 10 years into two parts. We estimate models based on the time period comprised between

January 2007 and December 2015, equivalent to 108 months or data points. We then compare those values with the actual observed values for a time period that was not included in the model estimation: the validation period ranges from January 2016 to March 2017, and comprises 15 data points.

Figure 29 - Modeling and validation periods

Source: Author.

5.4.3 SARIMA results

We first identify the term of integration. With the Amplified Dickey-Fuller test, we find that we are not able to reject the H_0 that the time series of card volumes has a unit root. We therefore calculate the first difference of the time series ($X_t - X_{t-1}$). We use logs to reduce the amplitude of data.

Table 19 - Dickey-Fuller test for levels

	1pct	5pct	10pct	statistic	Ac_Ho_5pct
tau3	-3.99	-3.43	-3.13	-6.95	1
phi2	6.22	4.75	4.07	16.91	0
phi3	8.43	6.49	5.47	24.17	0

Source: Author.

Estimation of models

We first attempt to follow the principle of parcimony and forecast models with low parameters. However, using test on residuals, we find that low parameters lead to large residuals indicating seasonality. We therefore open our analysis to a larger group of possible models.

We estimate a complete list of models, using values for the four terms of 1, 2, or 3. The four terms p , q , I , m were defined in a previous section for models $(\text{SARIMA}(p,1,q)\times(I,0,m))_{12}$. Models are defined for the time series of difference of logs of card volumes. We then forecast data points for the validation period, and compare those forecasts with observed data. Adjusting parameters yield a total group of 54 models. We provide the full AIC and QME information in the Appendix.

Considering the 54 possible SARIMA models: Model 51 presents the best QME, while model 43 presents the best AIC.

Figure 30 - Residuals for Model 43: $\text{SARIMA}(3,1,2)\times(1,0,0)_{12}$

Source: Author.

Figure 31 - Residuals for Model 51: SARIMA(3,1,3)\times(1,0,2)_{12}

Source: Author.

In addition to Models 43 and 51, we also select Models 38, 39, 41, which present low values for QME and AIC. We conduct a test on the residuals for all models, to confirm if residuals correspond to white noise.

Figure 32 - Ljung-Box test on residuals for selected models

Source: Author.

Model 43 does not meet the requisites for white noise of residuals.

Model SARIMA (5,1,2)(1,0,2) is selected following the principle of parsimony. Model 51 presents the best QME, model 43 presents the best AIC. Finally Model 38, 39, 41 are close enough on the selection criteria.

Table 20 - AIC and QME for selected SARIMA models

model	p	q	l	m	aic	qme	SQ(QME)
51	3	3	1	2	-471.5	1235017	1111.3
38	3	1	1	1	-475.1	1914801	1,383.8
39	3	3	1	1	-473.5	1673849	1,293.8
41	3	1	2	1	-473.4	1757015	1,325.5

Source: Author. P is the order of autoregression, q is the order of moving average, l is the seasonal order for the autoregression and m the seasonal order for the moving average.

SARIMA results

We compare the selected models. The R program rebases automatically the time series back to levels (as opposed to the log of differences), facilitating the interpretation of data. As defined above, based on the AIC and QME criteria, Model 51 presents the best fit.

Figure 33 - AIC and QME for selected SARIMA models

Source: Author.

We indicate the area of predictability for each of the models. We highlight that the predicted values are surprisingly close to observed data, evidence of the value of simple SARIMA models. Let us bring this mathematical observation to a real life interpretation. Observed transacted card volumes in Brazil amounted to R\$98,197 billion for the month of March 2017, which represent a volume of R\$52,030 if we adjust for inflation and

rebase the value to January 2007, which is the beginning of our sample. Considering the entire area of predictability (grey zone in the figures below), we find that over a time period of prediction of 15 months, the SARIMA models on average erred by R\$1.1 billion, or 2.1% the level of card volumes, which is an average, with months of higher variability.

Figure 34 - AIC and QME for selected SARIMA models

Source: Author.

5.5 SARIMAX models

5.5.1 Why use PCA?

SARIMAX models incorporate independent variables into ARMA models. We start this section by explaining how we selected and filtered the group of independent variables. We initially built a group 252 time series with independent variables. We applied a list of six filters to select the pertinent variables. Our biggest challenge consisted in solving for multicollinearity. We relied on principal component analysis to help us in the selection.

In order to solve for multicollinearity, we used a robust statistical approach. Principal components analysis is a statistical method used to describe variability among observed, correlated variables, and derive from them a lower number of unobserved variables. For example, it is possible that variations in eight observed variables mainly reflect the variations in three unobserved (underlying) variables. The observed variables are modeled as linear combinations of the potential factors, and an error term. It is one of the most commonly used inter-dependency techniques and is frequent in finance. Each principal component is a linear combination of variables.

Principal components analysis (PCA) is similar to Exploratory Factor Analysis (EFA) in some ways, but bears some important differences. Research has outlined the differences between exploratory factor analysis and principal component (SUHR, 2009). Factor analysis assumes that an underlying causal model exists, whereas PCA is “simply a variable reduction technique”. Principal component analysis employs a mathematical transformation to the original data with “no assumptions about the form of the covariance matrix”. The “aim of PCA is to determine a few linear combinations of weighted observed variables” that can be “used to summarize the data set without losing much information”.

Principal components analysis presents several advantages. The technique of using principal components is especially indicated to reduce a large number of variables in a dataset. This reduces the issue of multicollinearity between variables. In fact, variables are combined within a principal component. On the flip side, using components make

the interpretation of results more complex, since it becomes more difficult to single out the true and unique explanatory power of each variable. The explanatory power of principal components requires some interpretation.

We rely on PCA as a tool to single out the most relevant variables. We first standardize all the variables with a mean of 0, and variance of 1, in order to facilitate the comparison. The first four components explain more than 80% of the variance of card payment volumes. We isolate the first quintile of variables (top 20%) in each of those four variables.

Figure 35 - Proportion of variance of the dependent variable explained by the component (cumulative)

Source: Author.

5.5.2 Selection of variables, based on 6 filters

We sourced a total number of 252 time series, presenting a wealth of data including macroeconomic indicators, demographic and macro factors, financial access indices, credit and retail data, among others. The table below summarizes the different

filters and the resulting selection of three independent variables that met the different filters.

Figure 36 - Summary of filters applied to the list of variables

Source: Author.

- ***Exclusion of incomplete series***

A first filter consists in excluding datasets where data is missing, or series that were interrupted, restated or altered by the data provider. For the purpose of our analysis, we also exclude time series with annual and quarterly data points, and maintain only monthly time series. From the 252 initial time series, we come up with a reduced group of 74 variables.

- ***Principal component analysis***

The first filter we apply to select the proper independent variables relies on principal component analysis (PCA). In fact, our biggest challenge is the multicollinearity of variables, as evidenced by the high correlation and variance inflation factor (VIF). Based on PCA analysis, we isolate the first quintile of variables (top 20%) in enough components to explain 80% of the variability of the dependent variable (4 first components). We select a group of 46 variables with the highest coefficients.

- ***Test of Granger causality***

We then apply the Granger causality test to all variables. We select only those variables that indicate a causality under a 5% confidence range with the dependent variable. This test is used to determine the direction of the causality between several variables, and carries more information than a simple correlation. There is a Granger causal relationship when a past value for variable X helps explain the present value for variable Y. We run the Granger causality test for the variables up to 6 lags, i.e. for time difference of up to six months.

- ***Johansen test of co-integration***

The second test consists in analyzing the long-term relationship between time series and confirm that they are related through the Johansen test. We exclude series that are not co-integrated at 5%. In Johansen test, variables must be non-stationary. Therefore we use the first difference of the variables. We use lags of up to 6 months, as in the previous test.

The Johansen test can be seen as a multivariate generalization of the augmented Dickey-Fuller test. The generalization is the examination of linear combinations of variables for unit roots. The Johansen test and estimation strategy make it possible to estimate all cointegrating vectors when there are more than two variables (DWYER, 2015, p1). The null hypothesis implies no cointegration. We reject the null hypothesis if the trace statistic is superior to the 5% critical value.

- ***Test of exogeneity***

The following filter applied to the large list of independent variables is a test of exogeneity. We exclude variables that do not show weak exogeneity at 10%. A variable is considered exogenous if the error term ε has an expected value equal to zero (WOOLDRIDGE, 2010). The Durbin Watson statistic is a number that tests for autocorrelation in the residuals from a statistical regression analysis. The Durbin-Watson statistic is always between 0 and 4. A value of 2 means that there is no autocorrelation in the sample. Values approaching 0 indicate positive autocorrelation

and values towards 4 indicate negative autocorrelation. We present in the table below a summarized view of the results of the three filters of Granger causality, cointegration and exogeneity.

Table 21 - Summary of filters applied to the list of variables

	Not Causal	Cointegrated	Exogenous weak
vl_selic_acum	0	0	1
tx_ref_jur	0	0	1
vl_poup	0	1	1
avg_pap_moeda	0	1	1
avg_deposito	0	0	1
vl_deposito	0	0	1
cd_pea	0	1	1
vl_emp_cc	0	1	1
i_vendas_varejo	1	1	1
i_vendas_petrol	0	1	1
i_vendas_spmkt_tt	0	1	1
i_vendas_textil	0	1	1
i_vendas_moveis	0	1	1
i_vendas_veic	0	0	1
i_vendas_spmkt_only	0	1	1
i_vendas_other	0	1	1
i_vendas_constru	0	0	1
i_trade	0	1	1
rec_vendas_varejo_saz_ant	1	1	1
vl_vendas_varejo_fixo	0	1	1
vl_vendas_varejo_saz	1	1	1
vl_vendas_varejo_saz_ant	1	1	1
vl_vendas_constru_fixo	0	0	1
vl_vendas_constru_saz	0	0	1
vl_vendas_constru_saz_ant	0	1	1
rec_veic_fixo	0	1	1
rec_veic_saz	0	1	NA
cred_overdraft	0	1	NA
cred_personal	0	1	1
cred_goods	1	0	1
cred_credc_revolving	0	0	1
cred_credc_fin	1	1	1
cred_credc_purchase	1	1	1
cred_credc_tt	0	0	1
cred_tt	0	1	1
payroll_public	0	0	1
payroll_private	0	1	1
payroll_non	0	1	1
cred_penetration	1	0	1
cred_stock_foreign	0	1	1
risk_loans_private	1	0	1
risk_loans_foreign	1	0	1
risk_loans_sys	1	0	1
risk_npl_public	1	0	1
risk_npl_private	0	0	1
risk_npl_foreign	1	0	1

Source: Author. Variables that pass the three tests are maintained, presenting the values (1, 1, 1).

- ***Solve issue of multicollinearity***

Multicollinearity happens when independent variables included in a model present a high correlation. If highly correlated variables are included in the model, the parameters can become instable due to the increased variance of the coefficients. The instability translates into large residuals (MONTGOMERY; PECK; VINING, 2015). We calculate the VIF of all the remaining variables. We consider that values of VIF superior to 10 indicate variables that present multicollinearity. We follow an iterative method to remove variables one by one and calculate the VIF of the remaining group of variables, until we succeed in obtaining VIF values below 10 for every single variable.

Table 22 - Variance inflation factor

Variables	VIF
i_vendas_varejo	1.098585
rec_vendas_varejo_saz_ant	1.110291
vl_vendas_varejo_saz	1.143165
cred_credc_fin	1.046835

Source: Author

- ***What are the selected variables?***

The series of filters, which we described above, leads us to narrow down our list of time series to four independent variables, based on principal component analysis, Granger causality, cointegration, weak exogeneity and absence of multicollinearity.

- 1- **Vendas_varejo**. Those variables correspond to retail sales, approached via an index, volumes or merchants' revenues. The Brazilian Central Bank reports those series on a monthly basis. The series presents a strong and positive correlation with card volumes.
- 2- **Cred_credc_fin**. This variable corresponds to the stock of individual credit, in the credit card financing modality. The financing modality (23% of credit card credit) is opposed to the revolving facility (77% of total). The series presents a strong and positive correlation with card volumes.

5.5.3 Estimate models and select best model

A SARIMAX model predicts a value in a response time series of equally spaced variables as a linear combination of its own past values, past errors (also treated as shocks or innovations), and current and past values of other time series. A SARIMAX model expresses the response series as a combination of past values of the random shocks, past errors of random shocks and past values of other input series. In the previous section, we identified a number of independent variables. The selected variables are included in the SARIMAX model, where the dependent variable is the volume of card transactions in Brazil.

We specified models based on the SARIMA models defined in the previous sections with parameters for AR(p) and MA(q), and incorporating exogenous variables with lags ranging from 0 to 2. We build the models using the time period of January 2007 to December 2015, the same modeling period used for the factorial analysis and the ARIMA models. We used the following time period: January 2016 to March 2017, for validation purposes. The validation consisted in comparing the value estimated by the model to the observed value. The lowest QME corresponded to the best model fit. We also check the models for fitness, thanks to an analysis of white noise and autocorrelation of residuals. The test of autocorrelation of residuals indicates whether residuals are correlated, and whether the model presents a good fit.

5.5.4 SARIMAX results

The previous section and six filters led to the selection of four independent variables:

- i_vendas_varejo
- rec_vendas_varejo_saz_ant
- vl_vendas_varejo_saz
- cred_credc_fin

We use the SARIMAX models based on the same parameters as for the SARIMA models defined in the previous section:

- Modelo 43: $\backslash(\text{SARIMA}(3,1,2)\text{times}(1,0,0)_{12}\backslash)$ (lowest AIC);
- Modelo 51: $\backslash(\text{SARIMA}(3,1,3)\text{times}(1,0,2)_{12}\backslash)$ (lowest QME);
- Modelo 38: $\backslash(\text{SARIMA}(3,1,1)\text{times}(1,0,1)_{12}\backslash)$;
- Modelo 39: $\backslash(\text{SARIMA}(3,1,1)\text{times}(1,0,2)_{12}\backslash)$;
- Modelo 41: $\backslash(\text{SARIMA}(3,1,1)\text{times}(2,0,1)_{12}\backslash)$.

We incorporate exogenous variables with lags ranging from 0 to 2. This leads to 54 different models. We present below the AIC and QME for the 10 best models.

Table 23 - Selection of 10 best SARIMAX models, ordered by qme

Model	AR	MA	Sazonal_ AR	Sazonal_ MA	vl_vendas_ varejo_saz	cred_credc fin	QME	AIC
16	3	3	1	2	2	0	2,199,808	(473)
19	3	1	1	1	0	0	1,798,329	(470)
25	3	1	1	1	2	0	1,245,647	(471)
26	3	1	1	1	2	1	1,034,246	(464)
28	3	1	1	2	0	0	1,733,297	(468)
34	3	1	1	2	2	0	1,236,357	(469)
35	3	1	1	2	2	1	940,122	(462)
37	3	1	2	1	0	0	1,769,959	(468)
43	3	1	2	1	2	0	1,166,734	(469)
44	3	1	2	1	2	1	923,752	(462)

Source: Author.

We select the five models that present the best AIC and QME in the validation period. We present the p-values for the coefficients for each model. We highlight in the table in green the statistically significant coefficients, where the p-values are below 10%.

Table 24 - Detailed parameters and p-values of coefficients for selected SARIMAX models

rownames	Fit_16	Fit_19	Fit_25	Fit_26	Fit_28	Fit_34	Fit_35	Fit_37	Fit_43	Fit_44
ar1	-	0.8	0.0	0.9	NaN	0.0	NaN	0.5	0.6	0.8
ar2	-	1.0	0.0	0.9	NaN	0.0	NaN	0.8	0.8	0.9
ar3	0.1	0.7	0.1	0.4	NaN	0.1	NaN	0.5	0.9	0.9
ar4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ar5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
cred_credc_fin	0.2	0.3	0.2	0.5	0.0	0.2	0.5	0.3	0.2	0.5
d1.cred_credc_fin	NA	NA	NA	0.6	NA	NA	0.6	NA	NA	0.6
d1.vl_vendas_varejo_saz	1.0	NA	0.7	0.6	NA	0.7	0.6	NA	0.6	0.6
d2.cred_credc_fin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
d2.vl_vendas_varejo_saz	0.1	NA	0.0	0.0	NA	0.0	0.1	NA	0.1	0.1
ma1	-	0.8	0.2	0.4	NaN	0.2	NaN	0.7	0.9	0.9
ma2	0.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
ma3	0.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
sar1	-	-	-	-	-	-	-	0.0	-	-
sar2	NA	NA	NA	NA	NA	NA	NA	0.6	0.8	0.7
sma1	-	-	-	-	-	-	-	0.2	0.1	0.1
sma2	0.2	NA	NA	NA	NaN	0.9	0.7	NA	NA	NA
vl_vendas_varejo_saz	-	0.0	-	-	0.0	-	-	0.0	-	-

Source: Author.

We note that cred_credc_fin is significant in just one model and several variables were not significant in any of the models. By contrast, vl_vendas_varejo_saz presents significance in all selected models. We remove the variables that present coefficients that are not significant. We present below the selected models.

- Modelo 25. $\text{SARIMA}(3,1,1)_{12} + \text{vl_vendas_varejo_saz}_t + \text{vl_vendas_varejo_saz}_{t-2} + \epsilon_t$
- Modelo 43. $\text{SARIMA}(3,1,1)_{12} + \text{vl_vendas_varejo_saz}_t + \epsilon_t$

- Modelo 34. $(\text{SARIMA}(3,1,1)\times(1,0,1))_{12} + \text{vl_vendas_varejo_saz}_t + \text{vl_vendas_varejo_saz}_{t-2} + \epsilon_t$
- Modelo 16. $(\text{SARIMA}(3,1,3)\times(1,0,2))_{12} + \text{vl_vendas_varejo_saz}_t + \epsilon_t$
- Modelo 19. $(\text{SARIMA}(3,1,1)\times(1,0,2))_{12} + \text{vl_vendas_varejo_saz}_t + \epsilon_t$

Figure 37 - SARIMAX models versus observed data points

Source: Author.

Figure 38 - Area of predictability for the SARIMAX models

Source: Author.

5.6 Conclusion of statistical analysis

5.6 1 How do results compare with expected results?

In a prior section of our research, we detailed the expected explanatory variables for electronic payments, based on a review of the literature. We detail in the table below how our analysis of Brazil confirms or contrasts with the international experience. For a number of variables, only quarterly or annual data points were available, which is why we limit our conclusions to an interpretation based on visual analysis. We provide the full list of time series with annual and quarterly frequency in Appendix 3. The table below summarizes in a simple way where our conclusions matched expected results and the international experience, where data was insufficient to reach any clear conclusion, and, finally where data for Brazil contrasts with our expectations.

Figure 39 - Comparison of results with expected results: summarized view.

A green check signals that results matched expected results. A red cross signals the opposite. N/A signals that data was inconclusive. We circle the signals that present the highest significance.

ACCESS	MACRO CHARACTERISTICS	TRANSACTION CHARACTERISTICS	SOCIO-DEMOGRAPHICS
CARD_OWNERSHIP	CRIME	INSTALLMENT	AGE
ATM	POVERTY	SIZE	BEHAVIOR_PREFERENCE
CASH_IN_CIRCULATION	INFLATION / RATE	REWARD	EDUCATION
COST_CARDHOLDER	BANK CREDIT	RETAIL_SECTOR	GENDER
CREDITCOST	TREND_INNOVATION	COST_MERCHANT	
POS	MARKET		
	WORKFORCE		
	RETAIL_SALES		
	INFORMALITY		

Source: Author.

We detail in the larger table below the key findings of our analysis.

Table 25 - Similarities and differences between the results of our analysis and expected results

Category	Variable	Description of variable	Methodology	Conclusion of analysis vs. expected result	Comment
Access to payment modes / financial access	CARD	Number of cards issued, active, by type of card	Descriptive analysis	Similar	The growth of cards and the percentage of activation has slowed down recently from historically high levels
	ATM	Number of Automated Teller Machine (ATM) is a proxy for the ease of cash withdrawals	Descriptive analysis	Different	The growth of ATMs has slowed down recently from historically high levels. This could suggest that cardholder prefer to hold higher levels of cash in hand
	CASH	Cash balance of consumers, defined as savings account, or cash in circulation held by agents	Statistical filters, with PCA	Different	avg_papel_moeda is one of the variables in the regression. Literature suggests that higher levels of cash go hand in hand with a lower usage of cards. Data for Brazil suggests the contrary, as the correlation between CIC and card volumes is positive. This could be explained by precautionary preference by consumers (preference to hold cash), or by a distrust in banks (history of high inflation, or savings confiscation by banks).
	COST_CARDHOLDER	Fee paid by the cardholder to the bank	Descriptive analysis	Similar	Fees paid by cardholders have decreased in real terms (nominal growth below inflation), adding an incentive for customers to adopt cards
	CREDITCOST	Lending rate on credit cards offered by banks	Descriptive analysis	Similar	Lending rates have remained elevated and increased in the recent past above 70% for individual credit, making access to credit cards more onerous
Macro factors	CRIME	Crimes per 100,000 inhabitants	Descriptive analysis	Similar	Security concerns continue to be a driver of use of electronic payments, as opposed to cash
	POVERTY	Gini coefficient, % of population below poverty rate	Descriptive analysis	Similar	Higher income has been associated with higher use of electronic payments. Poverty rates have experienced a dramatic fall in Brazil over the past decade, but poverty had grown again in the recent past
	INFLATION	IGPM	Descriptive analysis	No conclusion	Low inflation has been associated with higher cash usage. There is no clear conclusion in the case of Brazil.
	RATE	SELIC	Descriptive analysis	No conclusion	Low rates have also been associated with higher cash usage in developed countries. There is no clear conclusion, also because rates remain elevated.
	BANK CREDIT	Credit concession in individual/personal credit	Statistical filters, with PCA	Similar	cred_credc_fin is one of the selected variables. Credit cards have a dual characteristic of access to credit and means of payment, making this variable highly endogenous.

Category	Variable	Description of variable	Methodology	Conclusion of analysis vs. expected result	Comment
Macro factors (cont'd)	TREND-INNOVATION	Growth of e-commerce, non-present payments (online, mobile banking), chip and pin	Descriptive analysis	Similar	Technology and innovation can drive increased use, such as through the growth of e-commerce, non-presential payments (online, mobile banking). Trends over the past decade may explain some of the growth in electronic payments, however, innovation has accelerated in the recent past, while payments growth declined, suggesting a limit to this explanatory variable.
	MARKET	Market value of companies listed on Bovespa	Descriptive analysis	No conclusion	We find that the overall level of wealth, measured by the stock market, have no correlation on payments
	WORKFORCE	Level of employment	Statistical filters, with PCA	Similar	The variable of active population was singled out in the regression, suggesting demographics and employment have a strong relationship with electronic payments.
	RETAIL SALES	Level of retail sales	Statistical filters, with PCA	Similar	Retail sales appear as a strong variable, selected through the 6 filters, suggesting supermarket sales have a strong relationship with electronic payments.
	INFORMALITY	Percentage of self employed	Descriptive analysis	Similar	Brazil remains one of the countries in the OECD with the highest levels of informality: the level of informality has decreased meaningfully over the past decade, possibly going hand in hand with higher usage of electronic payments. However, the formalization process seems to have receded most recently, possibly explaining the slower growth in cards.
Transaction characteristics	POS	Number of active POS equipment with card readers for 100,000 inhabitants	Descriptive analysis	Similar	Card acceptance by merchants increased meaningfully over the past decade, but has slowed down more recently.
	INSTALLMENT	Payments in more than 1 installment	Descriptive analysis	No conclusion	Share of purchases paid in installments (quantity and value) could indicate a propensity to take credit. However, in the case of Brazil, the share of payments by installments have remained constant over the studied period, suggesting that installments have a limited explanatory quality.
	SIZE	Ticket size	Descriptive analysis	Similar	A larger size of transactions has been found to be a driver of electronic payment. We analyze the average transaction size as the systemic level. While data on individual transactions would be preferable, a rising transaction average is expected to lead to higher electronic payment usage, even if the median does not rise. We find that the size of transactions increased meaningfully between 2007 and 2013 and then declined.

Category	Variable	Description of variable	Methodology	Conclusion of analysis vs. expected result	Comment
Transaction characteristics (cont'd)	SECTOR	Sales by sub-sector	Descriptive analysis	Similar	The sector of activity of the points of sale is relevant for the use of payments. We find that some sectors of the economy present high levels of correlation with the use of electronic payments, such as gasoline, supermarkets, medical articles, furniture and white goods. However, those variables did not pass the statistical filters (mostly of multicollinearity) and therefore we did not maintain the sector breakdown as a key driver. We only maintained the overall retail sales statistic.
	REWARD	Total cost of rewards	Descriptive analysis	No conclusion	Financial rewards have been associated with a larger use of electronic payments. We found that rewards remain small and their share of overall volumes has remained relatively stable. Therefore we find that rewards have a limited explanatory power.
	COST_MERCHANT	Merchant discount rate (MDR), rate paid by the merchant at every transaction	Descriptive analysis	Similar	The incentive to the merchant can impact the card acceptance or propensity of merchants to offer card payments. The cost to merchants (merchant discount rate) experienced a meaningful compression between 2008 and 2014 but then remained relatively stable, potentially explaining the change in card growth rates.
Customer preference and characteristics	AGE	Percentage of <15year-old, >65 year-old	Descriptive analysis	Similar	Brazil presents a younger population than developed countries, but the population is aging. This could suggest that age is a factor that explains the adoption of electronic payments.
	BEHAVIOR	Usage of Premium cards	Descriptive analysis	No conclusion	Premium cards have increased continuously throughout the period, suggesting a rise is conspicuous consumption and appeal of rewards. However, their base remains small in the overall sample, making it difficult to find a driver.

Source: Author

In the introduction, we made the hypothesis that the proximity of banking services, the size of transaction and all-in costs are the main drivers of electronic payments in Brazil. Our analysis suggested that proximity of banking services, such as the density of POS and the ownership of plastic cards indeed had a positive relationship with electronic payments. Data also suggest that the size of the transaction and all-in costs, including the cost for the cardholder and the cost for the merchant, had a strong explanatory power. We note that variables such as size, cost for the merchant, or retail sector are part of a larger category of **transaction characteristics**, which has attracted most of the recent interest in the literature on payments.

However, even though those expected hypotheses were confirmed, our statistical analysis showed that other variables had a more relevant weight. In particular, we found that bank lending for credit cards, retail sales, active population and cash in circulation presented a strong and positive correlation with electronic payments. Those variables belong to the category of **macro characteristics**.

5.6.2 Compare models

The regression identified variables related to bank credit card lending, active population and cash in circulation. We expected the SARIMAX models to present a better fit. We speculate that the over specification of the model leads to unstable parameters and that a more simple model like SARIMA presents a better explanatory power. A series of six filters applied to variables singled out bank credit card lending and retail sales as good predictors.

Our analysis suggests that the model that best explains electronic payments in Brazil is their own past history, via auto-regressive models. We find that the SARIMA (3,1,1)(1,0,1) presents an average error of R\$1.4bn (expressed in 2007 Brazilian reais) over the validation period of 15 months, or 2.7% of the level of card volumes during that period.

Using the best SARIMA models, we attempt to predict 2018 card volume trends. Those models estimate that card volume growth reach a range between -7.1% to +9.1% in 2018, in real terms. We incorporate the market expectation for inflation of 4.0% for 2018 (IPCA, as per consensus expectations gathered by the Central Bank as of December, 15, 2017). Models therefore anticipate card volume growth to range between -3.1% and +13.1% in 2018 in absolute terms, or 5.0% on average.

Figure 40 - Prediction of future card volumes with SARIMA models presenting the best fit (R\$, mn)

Source: Author.

Figure 41 - Growth of electronic payments, based on nominal values: past observations and forecasts, based on SARIMA models

Source: Author.

Overall, most of our conclusions were similar to expected results and to the international literature, in terms of existence of relationship and sign of the correlation. In particular we found that a larger active population and higher retail sales were related to higher usage of electronic payments. Our descriptive analysis also found that transaction characteristics, such as the density of POS, the size of transactions, the sector where the transaction took place and cost to the merchant, could explain the preference for card payments. The only variable result that differed meaningfully from expected results came from cash in circulation, which presented a *positive* correlation with electronic payments, a sign that is the opposite of what we expected. It could be an indication of the preference of Brazilian consumers for cash in hand, and a sign of distrust towards the banking sector, as cash may be used for precautionary reasons and as a store of value.

Finally, we found that SARIMA models present a better fit than more complex SARIMAX models, confirming the principle of parsimony and avoiding an overfit.

6 CONCLUSION

In our stated initial objectives, we aimed at explaining the determinants of electronic payments in Brazil. Following a review of the literature and using statistical analysis, we found that four variables presented a good fit with card payments: bank credit card lending, the size of the active population, cash in circulation, and retail sales. We found that the best predictor of electronic payments is the past data points of the time series, using auto regressive models (SARIMA). Simpler SARIMA models proved superior to SARIMAX.

The contribution of our effort is threefold.

First, to the extent of our knowledge, we believe our research is the most in-depth study of payments in Brazil, a sector that transacts close to \$400 billion every year. We found only a small group of academic papers studying emerging markets, where financial inclusion brings the promise of important social development. Payments offer an entry door into financial inclusion in Brazil where more than 50 million citizens do not have a transactional account. Measures that promote payments include simplified accounts, innovative solutions such as mobile banking, and the formalization of the economy with mandatory salary payments on accounts.

Second, we analyze the theme of payments using the three dimensions of financial inclusion: access, usage and quality of financial services. We provided the first detailed analysis on the quality dimension of payments. Most of the literature on financial inclusion has focused on the credit product, and on the dimensions of access and usage. We define quality as the catalyst between access and usage. We showed that the payment industry may well be in equilibrium, but that equilibrium may not favor inclusion. Quality has often been related to the financial capabilities of the customer. We adopt a more detailed approach and list the six dimensions of quality payments and financial inclusion, consisting in cost, benefit, ease of use, speed, security, privacy.

Electronic payments will favor financial inclusion, only if participants address the question of quality.

Third, we relied on original statistical methodologies that have been employed in other scientific fields and that we applied in finance, such as principal component analysis and auto regressive models. Our work confirms some of the conclusions found in the international literature. We found that macro and transaction characteristics presented a good explanatory power to understand payments. Surprisingly, we noted that cash in circulation presented a *positive* correlation with electronic payments, which was unexpected. Our interpretation is that the positive correlation between cash-in-circulation and electronic payments may denote a preference of Brazilian consumers to hold cash and their distrust against the banking system. We believe this sheds a new light on the precautionary principle described by Keynes, defined as cash in hand “to provide for contingencies requiring sudden expenditures and for unforeseen opportunities of advantageous purchases”. In the case of Brazil, we believe the precautionary preference for cash may also be related to memories of bank runs or the freeze of savings accounts mandated by past governments.

We highlight future streams of research. We believe the payments segment would have much to gain from a better understanding of the influence of behavioral economics and the use of big data.

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APPENDICES

Appendix 1 – Conceptual definition of the independent variables

Table 27: Definition of the independent variables

Variable	Definition	Source
cards_tt	Cards (Total, R\$mnn)	ABECS
vl_empresas_bovespa	7849 - Valor das empresas listadas na Bovespa - u.m.c. (milhões)	BACEN
vl_igpm	IGP-M - Fechamento mensal (%), Código: 1000367, Fonte: IGP; Unidade: %am	FGV
i_igpm	IGP-M - Índice Geral de Preços do Mercado (Fechamento - Número Índice), Código: 200045, Fonte: IGP; Unidade: %am	FGV
vl_selic_acum	Taxa de Juros - Selic acumulada no mês % a.m. (BACEN 4390), Código: 152989	FGV
tx_ref_jur	Taxa Referencial de Juros - TR, Código: 206655	FGV
vl_poup	7836 - Caderneta de poupança (total) - Saldos - u.m.c. (milhões)	BACEN
avg_pap_moeda	1822 - Meios de pagamento - Papel moeda em poder do público (média nos dias úteis do mês) - u.m.c. (mil)	BACEN
avg_deposito	1823 - Meios de pagamento - Depósitos à vista (média nos dias úteis do mês) - u.m.c. (mil)	BACEN
vl_pap_moeda	1825 - Meios de pagamento - Papel moeda em poder do público (saldo em final de período) - u.m.c. (mil)	BACEN
vl_deposito	1826 - Meios de pagamento - Depósitos à vista (saldo em final de período) - u.m.c. (mil)	BACEN
cd_pea	10800 - População em idade ativa - Unidades (mil)	BACEN
vl_emp_tt	10801 - Empregados - Total - Unidades (mil)	BACEN
vl_emp_cc	10802 - Empregados - Com carteira - Unidades (mil)	BACEN
vl_emp_ncc	10803 - Empregados - Sem carteira - Unidades (mil)	BACEN
tx_ocup	Taxa de ocupação	IBGE
i_vendas_varejo	1455 - Sales volume index in the retail sector - Total - Brazil - Index	BACEN
i_vendas_petro	1483 - Sales volume index in the retail sector - Fuel and lubricants - Brazil - Index	BACEN

Variable	Definition	Source
i_vendas_spmkt_tt	1496 - Sales volume index in the retail sector - Hypermarkets, supermarkets, food, beverages and tobacco, Brazil - Index	BACEN
i_vendas_textil	1509 - Sales volume index in the retail sector - Textiles Clothing and Footwear - Brazil - Index	FGV
i_vendas_moveis	1522 - Sales volume index in the retail sector - Furniture and white goods - Brazil - Index	FGV
i_vendas_veic	1548 - Sales volume index in the retail sector - Vehicles and motorcycles spare parts - Brazil - Index	FGV
i_vendas_spmkt_only	1561 - Sales volume index in the retail sector - Hypermarkets and supermarkets - Brazil - Index	FGV
i_vendas_medic	20099 - Pharmac. medical orthop. and perfumery articles - Index	FGV
i_vendas_mgz_news	20101 - Books newspaper, magazines - Index	FGV
i_vendas_pcs	20102 - Office comp./comunic. equip. - Index	FGV
i_vendas_other	20104 - Other art. of personal use - Index	FGV
i_vendas_constru	20105 - Building materials - Index	FGV
i_trade	20106 - Broad trade sector - Index	FGV
rec_vendas_varejo_fixo	IBGE, Pesquisa Mensal do Comércio 2003/jan-2015/set. Receita nominal de vendas no comércio varejista ampliado. Índice base fixa (2011=100) (Número índice)	IBGE
rec_vendas_varejo_saz	IBGE, Pesquisa Mensal do Comércio 2003/jan-2015/set. Receita nominal de vendas no comércio varejista ampliado. Índice base fixa com ajuste sazonal (2011=100) (Número índice)	IBGE
rec_vendas_varejo_saz_ant	IBGE, Pesquisa Mensal do Comércio 2003/jan-2015/set. Receita nominal de vendas no comércio varejista ampliado. Variação mes / mes anterior com ajuste sazonal (Percentual)	IBGE
vl_vendas_varejo_fixo	Volume de vendas do comércio varejista ampliado. Índice base fixa (2011=100) (Número índice)	IBGE
vl_vendas_varejo_saz	Volume de vendas do comércio varejista ampliado. Índice base fixa com ajuste sazonal (2011=100) (Número índice)	IBGE
vl_vendas_varejo_saz_ant	Volume de vendas do comércio varejista ampliado. Variação mes / mes anterior com ajuste sazonal (Percentual)	IBGE
rec_vendas_constru_fixo	Receita nominal de vendas de material de construção - Varejo. Índice base fixa (2011=100) (Número índice)	IBGE
rec_vendas_constru_saz	Receita nominal de vendas de material de construção - Varejo. Índice base fixa com ajuste sazonal (2011=100) (Número índice)	IBGE
rec_vendas_constru_saz_ant	Receita nominal de vendas de material de construção - Varejo. Variação mes / mes anterior com ajuste sazonal (Percentual)	IBGE

Variable	Definition	Source
vl_vendas_constru_fixo	Volume de vendas de material de construção - Varejo. Índice base fixa (2011=100) (Número índice)	IBGE
vl_vendas_constru_saz	Volume de vendas de material de construção - Varejo. Índice base fixa com ajuste sazonal (2011=100) (Número índice)	IBGE
vl_vendas_constru_saz_ant	Volume de vendas de material de construção - Varejo. Variação mes / mes anterior com ajuste sazonal (Percentual)	IBGE
rec_veic_fixo	Receita nominal de vendas de veículos e motos, partes e peças - Varejo. Índice base fixa (2011=100) (Número índice)	IBGE
rec_veic_saz	Receita nominal de vendas de veículos e motos, partes e peças - Varejo. Índice base fixa com ajuste sazonal (2011=100) (Número índice)	IBGE
rec_veic_saz_ant	Receita nominal de vendas de veículos e motos, partes e peças - Varejo. Variação mes / mes anterior com ajuste sazonal (Percentual)	IBGE
cred_overdraft	INDIVIDUAL CREDIT (STOCK) - Overdraft	BACEN
cred_personal	INDIVIDUAL CREDIT (STOCK) - Personal Credit	BACEN
cred_vehicles	INDIVIDUAL CREDIT (STOCK) - Vehicle financing	BACEN
cred_goods	INDIVIDUAL CREDIT (STOCK) - Other Goods Financing	BACEN
cred_credc_revolving	INDIVIDUAL CREDIT (STOCK) - Credit card, Revolving	BACEN
cred_credc_fin	INDIVIDUAL CREDIT (STOCK) - Credit card, Financing	BACEN
cred_credc_purchase	INDIVIDUAL CREDIT (STOCK) - Credit card, Purch.	BACEN
cred_credc_tt	INDIVIDUAL CREDIT (STOCK) - Credit card, Total	BACEN
cred_leas_tt	INDIVIDUAL CREDIT (STOCK) - Leasing Total	BACEN
cred_checks	INDIVIDUAL CREDIT (STOCK) - Discount of checks	BACEN
cred_renegotiated	INDIVIDUAL CREDIT (STOCK) - Renegotiated credit	BACEN
cred_other	INDIVIDUAL CREDIT (STOCK) - Others	BACEN
cred_tt	INDIVIDUAL CREDIT (STOCK) - TOTAL, BACEN: 20570 - Saldo da carteira de crédito com recursos livres - Pessoas físicas - Total	BACEN
payroll_public	PERSONAL CREDIT (STOCK) - Payroll Public Sector Employees	BACEN
payroll_private	PERSONAL CREDIT (STOCK) - Payroll Private Sector Employees	BACEN
payroll_retirees	PERSONAL CREDIT (STOCK) - Payroll Retirees and pensioners	BACEN
payroll_non	PERSONAL CREDIT (STOCK) - Non-payroll	BACEN
payroll_tt	PERSONAL CREDIT (STOCK) - TOTAL	BACEN

Variable	Definition	Source
cred_penetration	CREDIT PENETRATION - % GDP	BACEN
cred_stock_public	CREDIT STOCK - Public Banks	BACEN
cred_stock_private	CREDIT STOCK - Private Banks	BACEN
cred_stock_foreign	CREDIT STOCK - Foreign Banks	BACEN
cred_stock_tt	CREDIT STOCK - TOTAL	BACEN
risk_loans_public	RISK (LLR as % of LOANS) - Public	BACEN
risk_loans_private	RISK (LLR as % of LOANS) - Private	BACEN
risk_loans_foreign	RISK (LLR as % of LOANS) - Foreign	BACEN
risk_loans_sys	RISK (LLR as % of LOANS) - System	BACEN
risk_npl_public	RISK (NPL %) - Public	BACEN
risk_npl_private	RISK (NPL %) - Private	BACEN
risk_npl_foreign	RISK (NPL %) - Foreign	BACEN

Source: Author.

Appendix 2 – Detailed statistics on Brazilian payments (independent variables)

Figure 42: Number of plastic cards issues and active

Source: Brazilian Central Bank, Author

Figure 43: Percentage of activation of plastic cards

Source: Brazilian Central Bank, Author

Figure 44: Number of credit cards issues and active

Source: Brazilian Central Bank, Author

Figure 45: Percentage of activation of credit cards

Source: Brazilian Central Bank, Author

Figure 46: Number of debit cards issues and active

Source: Brazilian Central Bank, Author

Figure 47: Percentage of activation of debit cards

Source: Brazilian Central Bank, Author

Figure 48: Credit cards: volume by modality of cards

Source: Brazilian Central Bank, Author

Figure 49: Credit cards: volume by category of cards

Source: Brazilian Central Bank, Author

Figure 50: Credit cards: volume by modality of cards

Source: Brazilian Central Bank, Author

Figure 51: Debit cards: volume by category of cards

Source: Brazilian Central Bank, Author

Figure 52: Total plastic cards: volume by category of cards

Source: Brazilian Central Bank, Author

Figure 53: Spending by card issuers in loyalty programs and rewards, % of total card volume

Source: Brazilian Central Bank, Author

Figure 54: Credit card: breakdown by number of installments

Source: Brazilian Central Bank, Author

Figure 55: Gross discount rate paid by merchants by type of card

Source: Brazilian Central Bank, Author. Gross = interchange + net discount rate

Figure 56: Share of interchange in the gross discount rate by type of cards

Source: Brazilian Central Bank, Author.

Figure 57: Annual fee paid by the cardholder (R\$) by brand network

Source: Brazilian Central Bank, Author. Data for Elo for March 2012 was estimated by us

Table 28: Electronic transaction value (in R\$, bn) by type

Year	Check	Debit card	Credit card	Direct debit	Transfers
2008	2,554	107	220	133	15,872
2009	2,502	128	263	1,921	15,328
2010	2,691	159	332	2,064	17,223
2011	2,786	196	401	2,470	20,150
2012	2,891	237	465	3,802	25,189
2013	2,917	293	534	5,570	30,235
2014	2,801	348	594	5,026	32,139
2015	2,543	390	653	4,313	33,969

Source: Brazilian Central Bank, Author, Revised data.

Table 29: Share of electronic transaction by channel (considering number of transactions)

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Internet access	29%	31%	34%	36%	38%	40%	39%	36%	33%
ATM	32%	30%	27%	26%	25%	24%	22%	20%	17%
Cell phones	0%	0%	0%	1%	2%	5%	10%	20%	28%
Branches	23%	24%	24%	25%	22%	19%	17%	15%	13%
Banking correspondents	9%	10%	9%	9%	8%	8%	8%	7%	7%
Call centers	6%	6%	5%	4%	4%	3%	3%	2%	2%
Cooperatives	0%	0%	0%	0%	0%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Brazilian Central Bank, Author, Revised data.

Figure 58: Share of electronic transaction by channel (considering number of transactions)

Source: Brazilian Central Bank, Author, Revised data

Appendix 3 – Data on Brazilian financial access and general statistics

Figure 59: Number of merchants affiliated to accept card payments

Source: Brazilian Central Bank, Author

Figure 60: Number of points-of-sale equipment (POS)

Source: Brazilian Central Bank, Author

Figure 61: Number of automated teller machines (ATM)

Source: Brazilian Central Bank, Author

Table 30: Financial access in Brazil

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Automated Teller Machines (ATMs) per 100,000 adults	108	111	113	118	115	114	116	115	114
Borrowers at commercial banks per 1,000 adults	95	104	149	203	233	367	391	397	400
Branches of commercial banks per 100,000 adults	18	19	19	18	19	20	20	21	21
Depositors with commercial banks per 1,000 adults	438	465	474	531	613	639	620	614	581
Loan accounts with commercial banks per 1,000 adults	326	384	505	646	823	2,034	2,276	2,297	2,255
Outstanding deposits with commercial banks (% of GDP)	43	46	44	45	45	40	38	35	33
Outstanding loans with commercial banks (% of GDP)	26	29	30	32	34	37	39	41	42

Source: IMF, Financial Access Survey: <http://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C&slid=1390030341854>, last accessed on July 10, 2017

Figure 62: GINI index

Source: World Bank Povcalnet, Author

Figure 63: Crime index: number of intentional violent deaths per 100,000 inhabitants

Source: Forum Brasileiro de Seguranca Publica, Author

Figure 64: Proxy for informality: percentage of self-employed

Source: OECD, Author, 2010 data for Brazil was missing, we extrapolate from 2009-2011

Figure 65: Proxy for innovation adoption: percentage of population under 18 years old

Source: OECD, Author

Figure 66: Cash in circulation

Source: Brazilian Central Bank, Author: Cash balance of consumers, defined as savings account, or cash in circulation held by agents

Figure 67: Lending rate

Source: Brazilian Central Bank, Author

Figure 68: Inflation rate

Source: Brazilian Central Bank, Author

Figure 69: Policy rate

Source: Brazilian Central Bank, Author

Figure 70: Market value of companies listed on Bovespa

Source: Brazilian Central Bank, Author

Figure 71: Stock of credit to individual in the credit card modality (R\$m)

Source: Brazilian Central Bank, Author

Figure 72: Employee workforce

Source: Brazilian Central Bank: time series 10801, Author

Figure 73: Index of total sales in the retail sector

Source: Brazilian Central Bank: time series 1496, Author

Appendix 4 – Results associated with the regression analysis

Table 31: VIF for the entire set of independent variables. Values above 10 indicate a high level of multicollinearity.

Variables	VIF
cards_tt	2244.00
vl_empresas_bovespa	40.60
i_igpm	1327.03
vl_selic_acum	125.24
tx_ref_jur	32.66
vl_poup	3427.34
avg_pap_moeda	1404.03
avg_deposito	254.21
vl_pap_moeda	1684.30
vl_deposito	94.37
cd_pea	2867.86
vl_emp_tt	2749.97
vl_emp_cc	5944.14
vl_emp_ncc	774.27
tx_ocup	152.44
i_vendas_varejo	4.80
i_vendas_petrol	120.61
i_vendas_spmkt_tt	17808.53
i_vendas_textil	401.81
i_vendas_moveis	421.55
i_vendas_veic	5604.47
i_vendas_spmkt_only	15692.66
i_vendas_medic	201.97
i_vendas_mgz_news	40.66
i_vendas_pcs	45.30
i_vendas_other	273.15
i_vendas_constru	322593.50
i_trade	501491.56
rec_vendas_varejo_fixo	3397.12
rec_vendas_varejo_saz	2482.59
rec_vendas_varejo_saz_ant	144.18
vl_vendas_varejo_fixo	541652.75
vl_vendas_varejo_saz	1815.82
vl_vendas_varejo_saz_ant	114.29
rec_vendas_constru_fixo	Inf
rec_vendas_constru_saz	Inf
rec_vendas_constru_saz_ant	5.61
vl_vendas_constru_fixo	326956.01
vl_vendas_constru_saz	155.28
vl_vendas_constru_saz_ant	16.24
rec_veic_fixo	Inf
rec_veic_saz	Inf
rec_veic_saz_ant	32.07
cred_overdraft	255.72
cred_personal	24173651530.15
cred_vehicles	27602.96
cred_goods	676.72
cred_credc_revolving	69995870.71

cred_credc_fin	22258739.25
cred_credc_purchase	4142330421.95
cred_credc_tt	5808102310.32
cred_leas_tt	22196.66
cred_checks	119.01
cred_renegotiated	691.06
cred_other	77.03
cred_tt	203321.86
payroll_public	5451659584.01
payroll_private	102220559.52
payroll_retirees	1384963789.04
payroll_non	1262582158.85
cred_penetration	526.08
cred_stock_public	6594.04
cred_stock_private	2720.11
cred_stock_foreign	1300.70
risk_loans_public	84.59
risk_loans_private	28.23
risk_loans_foreign	20.29
risk_loans_sys	33.96
risk_npl_public	13.44
risk_npl_private	14.54
risk_npl_foreign	27.77

Source: Author

Figure 74: Regressions for variables presenting the best fit, based on visual analysis

Source: Author

Appendix 5 – Detailed results for ARIMA model

Table 32: AIC and QME for the 54 possible SARIMA models.

Ajuste	p	q	l	m	aic	qme
success: 1	1	1	1	0	-455.13	1346441
success: 2	1	1	1	1	-468.71	2529430
success: 3	1	1	1	2	-467.4	2721873
success: 4	1	1	2	0	-467.13	1734466
success: 5	1	1	2	1	-467.14	2643016
success: 6	1	1	2	2	-468.98	3116181
success: 7	1	2	1	0	-455.14	1829540
success: 8	1	2	1	1	-471.42	2063932
success: 9	1	2	1	2	-470.05	2196719
error: 10	1	2	2	0	NA	NA
success: 11	1	2	2	1	-461.61	3119223
success: 12	1	2	2	2	-467.49	2972035
success: 13	1	3	1	0	-457.17	2088373
success: 14	1	3	1	1	-471.26	1841710
success: 15	1	3	1	2	-469.88	1979281
success: 16	1	3	2	0	-469.83	1408910
success: 17	1	3	2	1	-469.75	1939058
success: 18	1	3	2	2	-467.99	1635542
success: 19	2	1	1	0	-457.18	1532076
success: 20	2	1	1	1	-472.35	2629674
success: 21	2	1	1	2	-471.52	2889860
success: 22	2	1	2	0	-470.91	1788051
success: 23	2	1	2	1	-471.07	2799743
success: 24	2	1	2	2	-468.68	2519536
success: 25	2	2	1	0	-456.8	1605825
success: 26	2	2	1	1	-474.26	2919750
success: 27	2	2	1	2	-473.37	3130564
success: 28	2	2	2	0	-471.9	1777996
success: 29	2	2	2	1	-472.97	3065474
success: 30	2	2	2	2	-470.51	2756639
success: 31	2	3	1	0	-461.15	1850311
success: 32	2	3	1	1	-472.34	3003972
success: 33	2	3	1	2	-471.47	3221820
success: 34	2	3	2	0	-470.77	2342503
success: 35	2	3	2	1	-471.05	3149878
success: 36	2	3	2	2	-468.57	2854090
success: 37	3	1	1	0	-455.59	1718639
success: 38	3	1	1	1	-475.1	1914801
success: 39	3	1	1	2	-473.5	1673849
success: 40	3	1	2	0	-471.35	1703094
success: 41	3	1	2	1	-473.41	1757015
success: 42	3	1	2	2	-471.5	2134344
success: 43	3	2	1	0	-490.89	2627579
success: 44	3	2	1	1	-473.78	3195838
success: 45	3	2	1	2	-471.58	3251200
error: 46	3	2	2	0	NA	NA
error: 47	3	2	2	1	NA	NA
success: 48	3	2	2	2	-468.41	2701861
success: 49	3	3	1	0	-461.5	1699478
success: 50	3	3	1	1	-472.84	1283307
success: 51	3	3	1	2	-471.5	1235017
success: 52	3	3	2	0	-467.9	1774921
success: 53	3	3	2	1	-468.97	3071136
success: 54	3	3	2	2	-469.12	1419713

Source: Author

Appendix 6 – Detailed results for SARIMAX model

Table 33: AIC, QME values for estimated SARIMAX models

ID	AR	MA	Sazonal_AR	Sazonal_MA	vl_vendas_varejo_saz	cred_credc_fin	QME	AIC
1	3	2	1	0	0	0	2487471.6	-462.7069
2	3	2	1	0	0	1	3756837.8	-455.79
3	3	2	1	0	0	2	2318024.7	-448.702
4	3	2	1	0	1	0	2578556.9	-453.9237
5	3	2	1	0	1	1	3093610.1	-446.5847
6	3	2	1	0	1	2	1713020.3	-439.3901
7	3	2	1	0	2	0	2157994.2	-461.4236
8	3	2	1	0	2	1	1965577	-447.1051
9	3	2	1	0	2	2	2723542.3	-446.7726
10	3	3	1	2	0	0	2876150.3	-469.3715
11	3	3	1	2	0	1	NA	NA
12	3	3	1	2	0	2	1151511.2	-455.8979
13	3	3	1	2	1	0	3703152.9	-469.6815
14	3	3	1	2	1	1	3535275.3	-462.2874
15	3	3	1	2	1	2	1448122.3	-455.2905
16	3	3	1	2	2	0	2199808.1	-473.347
17	3	3	1	2	2	1	1718118	-464.8005
18	3	3	1	2	2	2	1749542.1	-457.4206
19	3	1	1	1	0	0	1798329.4	-470.0688
20	3	1	1	1	0	1	1908634	-462.5143
21	3	1	1	1	0	2	489698.8	-455.3137
22	3	1	1	1	1	0	2625997.8	-469.391
23	3	1	1	1	1	1	2477702.1	-461.8902
24	3	1	1	1	1	2	626059.6	-454.6441
25	3	1	1	1	2	0	1245647.3	-471.3937
26	3	1	1	1	2	1	1034245.8	-463.7943
27	3	1	1	1	2	2	681481.3	-456.3081
28	3	1	1	2	0	0	1733297.2	-468.3311
29	3	1	1	2	0	1	1935008.8	-460.9074
30	3	1	1	2	0	2	469940	-453.6068
31	3	1	1	2	1	0	2555724.5	-467.5835
32	3	1	1	2	1	1	2406410.1	-460.2148
33	3	1	1	2	1	2	588878.9	-452.8546
34	3	1	1	2	2	0	1236357	-469.4276
35	3	1	1	2	2	1	940121.7	-461.8812
36	3	1	1	2	2	2	744308.8	-454.5479
37	3	1	2	1	0	0	1769958.5	-468.3643
38	3	1	2	1	0	1	NA	NA
39	3	1	2	1	0	2	457655.3	-453.6055
40	3	1	2	1	1	0	2104289.4	-464.6591
41	3	1	2	1	1	1	NA	NA
42	3	1	2	1	1	2	579150.3	-452.8462
43	3	1	2	1	2	0	1166734.1	-469.1401

44	3	1	2	1	2	1	923752.1	-461.8696
45	3	1	2	1	2	2	659111.7	-454.4104
46	5	2	1	2	0	0	2345644	-465.5951
47	5	2	1	2	0	1	3812666	-461.8575
48	5	2	1	2	0	2	884848.6	-450.6072
49	5	2	1	2	1	0	3217946.6	-464.415
50	5	2	1	2	1	1	4681421.1	-461.2748
51	5	2	1	2	1	2	1113460.6	-449.5401
52	5	2	1	2	2	0	1789496.7	-467.4844
53	5	2	1	2	2	1	1754377.4	-459.9438
54	5	2	1	2	2	2	1354192.3	-452.2893

Source: Author

END.