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Mobile Payments: The Economic Impact of Today's Financial Payment Tools

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Abstract

This paper examines the causal relationship between the adoption of mobile payment systems and economic growth on a panel of the 19 countries in the Eurozone. To do this it relies heavily on previous studies examining the relationship of cashless payment systems in general, using Real GDP as a proxy for economic growth. To determine this relationship this paper executes several tests to determine the manner of the nature of the adoption of these payment systems, with a focus on determining the existence of a long-run equilibrium. To ascertain the specific effect of mobile payment systems, this paper proposes the use of the value of transactions utilizing Electornic Money and the Mobile Payment-Enabled Operating Systems' market share as proxies by which to measure the economic activity produced by mobile payment systems. To test the validity of this claim, correlation and causal tests are performed, followed by the inclusion and update to the existing regression models that are tailored to deal with cashless payment systems in general. This paper finds evidence that supports the literature's conclusion of the existence of a long-run positive relationship between the adoption of cashless payments and Real GDP, and this relationship can be extended to the entirety of the Eurozone as opposed to just a few highly developed member states. Further, this paper finds that E-Money and Mobile Payment-Enabled Operating Systems' market share can be considered causally related, thus the interaction between these two represent a powerful variable to measure the impact of mobile payment systems in a macroeconomic fashion. Lastly, in the regressions performed in this paper, a statistically significant positive relationship between the adoption of mobile payment systems and Real GDP growth is found.

Keywords: Cashless, Mobile Payment, Electronic Money, Eurozone

Introduction

Despite numerous advances in technology, when speaking of the medium by which we settle payments, this field has remained largely untouched until that is, the introduction of cards and the ability to perform telegraphic transfers in the late 20th century. While cashless payment systems had long been a fixture of the global economy in the form of cheques, it was only with the introduction of cards (credit and debit cards) that this fixture gained true preeminence, and while it has not been

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universally adopted these new forms of cashless payments have become one of the developmental goals of a number of developing and developed economies, such as Nigeria's 2012 push for the adoption of cashless payments (mainly cards) by the Central Bank (Yaqub, Bello, Adenuga, & Ogundeji, 2013), the more recent push from Indonesia to adopt mobile cashless systems (Agusta, Joshua Widjaja, 2018), and Japan's latest move to promote the adoption of mobile payment systems (Backed et al., 2017). In general however, most government financial institutions at the very least regard the adoption of cashless payment systems as a desirable objective, even if they do not outright put policies in place to promote it. These new forms of cashless payments have become so preeminent to policymakers partly because of the slew of normative benefits that are said to come with them:

1. The reduced transaction costs, not only in the actual fee of transacting but also on the time cost saved from not using ATMs or bank cashiers. (Oyewole, Gambo, Abba, & Onuh, 2013)
2. The increase in government tax revenue and financial transparency since it is assumed that cashless payment platforms incentivize formal ownership of bank accounts.(Oyewole et al., 2013)
3. As well as a financial stimulus, because of this generally perceived requirement of a bank account by cashless payment systems (Koç & Dusansky, 2009), normally a significant amount of cash in an economy remains immobile, lost or ineffectively used. If this cash were to be transferred into bank accounts and used directly from them as the users find the need for it, an additional boon for cashless systems can be found by increasing the efficiency of the circulation of money (Berentsen, 1998; Devlin, 1995).
4. To the criminal and political, because of the individual authentication methods used in cashless platforms it is also assumed that they would de-incentivize thieving, and because of the prior mentioned assumed bank account requirement and therefore also logging it would increase the risk for illicit payments. (Moshi, 2012; Oyewole et al., 2013).

It is against this backdrop that mobile payment systems have emerged as a forerunner of financial innovations in the realm of payment settlements. Melding the ability to transact without the use of cash, with the ability to carry mobile wallets separate from formal financial institutions. Mobile payments encompass a highly diverse set of transaction platforms, that have emerged in tandem with the globalizing popularity of the smartphone. These mobile payments represent the target of this paper, with regards to their economic impact.

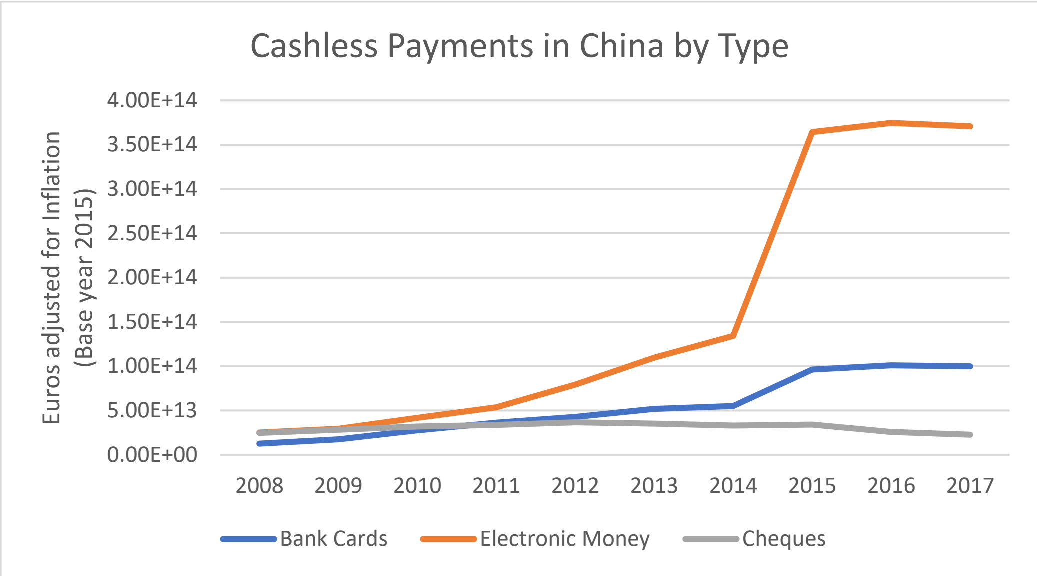
To a large extent the empirical literature surrounding the discourse on cashless systems either assumes these benefits outright, like the various studies evaluating the advance towards a cashless society (Ewa Abbas, 2017), or is focused primarily and almost solely on a microeconomic study of this benefit, like Wakamori & Welte's study (2017) they found a statistically significant proof that the adoption of cashless systems boosted consumer spending, meaning based on the study it was found people were more likely to part with cash if they transacted through a cashless medium. The few macroeconomic empirical studies that have been conducted looking into the question of the economic impact of cashless payment systems come either from the perspective of credit cards being the cyclical reports published by Moodi Analytics (Zandi, Koropeckyj, Singh, & Matsiras, 2016; Zandi, Singh, & Irving, 2013), or more generally cashless payment systems and their economic effect (Tee & Ong, 2016). It is starting from these studies that this paper will seek to test a long-run causal link between the adoption of mobile payment systems and economic growth.

Mobile Payment Systems

Mobile Payment systems allow users to transact without the use of credit cards, cash, cheques, or anything but the ubiquitous item that is a smartphone. To perform these transactions a payment platform is required, which provides a settlement system by which the transaction can take place. The way by which these payment systems go about making this a reality, as mentioned before varies greatly. Some platforms like Samsung Pay relay on the infrastructure already in place for credit cards, using credit card information to electronically perform a “swipe” of the digital credit card stored in the phone (Alimirucchi, 2017). This makes this platform accepted everywhere where bank cards are accepted. However, because of this property, payment platforms such as this will not appear in the data available for this paper as the transactions mentioned above would be counted into the aggregate payments by credit card. Instead this paper will be looking at mobile payment platforms that possess digital wallets and will be focusing on Electronic Money (E-Money) and Operating System’s market share as proxies for mobile payment usage.

A fundamental question being tested by this paper is the question of critical mass, the concept is fairly common in the literature of payment systems. It is the idea that payment systems are only truly useful and attractive but until they are widely accepted as a legitimate means of payment (Dinh, Nguyen, & Nguyen, 2018). This is the primary reason why so many innovative payment schemes have failed to achieve true relevance in the broader economy. The question addressed as a by-product of this research then is: if mobile payment systems generate enough economic activity to even be able to achieve statistically significant outcomes this early into their adoption cycle.

E-Money has long been present in economies around the globe as a source of cashless transactions, this can be visualized by services such as PayPal (Schulte, 2017). Yet throughout the years its always been marginal at best. It is only in the last decade with the rise in popularity of smartphones that E-Money has become statistically significant, and this is most evident in China where E-Money have skyrocketed in tandem with the rise and popularization of smartphones overtaking any other means of payment, as shown in graph 1.



Graph 1. Source: Payment and Clearing Association of China.

Here in Graph 1, the year 2009 can be seen as the year in which the value of E-Money payments skyrocketed. This is also the year of the introduction of the first iPhone. As mentioned before this is replicated not just in China, but in most countries, and is the initial motivating factor in seeing E-Money as a potential proxy for the economic activity coming from mobile payment systems. This hypothesis will of course be subjected to causal statistical tests across the panel data.

In summary this choice of E-Money as a proxy for mobile payment systems is based on our choice of subject being mobile payment platforms that contain the option for a digital wallet, and the observation that while E-Money includes non-mobile payments, most of the payments reflected in the E-Money statistic seems to reflect mobile payments or rather, mobile balances. To confirm this hypothesis, correlation and causation tests will be carried out with the growth Mobile Payment-Enabled Operating systems, to confirm that the growth witnessed in E-Money payments can be attributed to the growth of mobile payment systems.

Objectives and Relevance

This paper will be seeking to accomplish three major research objectives:

1. In taking inspiration and being instructed by Tee and Ong's research (2016) on the effect of cashless payment systems on 5 European economies, the first objective of this paper will be to update the results with recent data up to 2017 (The original paper's time period was from 2004 – 2013).
2. Secondly this paper would like to expand these tests and models to cover the entirety of the Eurozone.

3. Using E-Money, alongside an added variable to describe the market share of mobile-payment-enabled operating systems as proxies for mobile payment systems, this paper will test for the long-term economic impact of mobile payment systems.

In so doing this would represent the first empirical macroeconomic research on the economic impact of mobile payment platforms.

Data and Timescales

In order to serve these objectives, this paper will be utilizing the payment data for the 19 countries of the Eurozone, within the period of 2000 – 2017. The summary of the variables included being:

VARIA-BLES	LABELS		MEAN	STD.	OBSERVATIONS
RGDP	Real Gross Domestic Product	overall	4.51E+11	6.91E+11	N = 337
		between		6.86E+11	n = 19
		within		1.65E+11	T-bar[2] = 17.7368
CHEV	Value of Cheque Payments	overall	2.77E+11	4.90E+11	N = 319
		between		4.59E+11	n = 19
		within		1.76E+11	T-bar = 16.7895
BV	Value of Payments Using Bank Cards (Credit + Debit)	overall	5.38E+10	8.81E+10	N = 341
		between		8.38E+10	n = 19
		within		3.27E+10	T-bar = 17.9474
TTV	Value of Telegraphic Payments	overall	7.11E+12	1.65E+13	N = 342
		between		1.44E+13	n = 19
		within		8.64E+12	T-bar = 18
EV	Value of Electronic Money payments	overall	8.02E+10	1.86E+11	N = 342
		between		1.71E+11	n = 19
		within		8.21E+10	T-bar = 18
OS	Mobile-Payment Enabled Operating systems (Android + iOS)	overall	16.15211	14.87664	N = 152
		between		6.14242	n = 19
		within		13.61374	T-bar = 8
OSI	Integrated Variable of Operating Systems and E-Money	overall	6.12E+09	2.26E+10	N = 333
		between		8.88E+09	n = 19
		within		2.08E+10	T-bar = 17.5263

Table 1. Summary of Variables

[2] T-bar here, is the average observations within each panel. That is, N represents the number of total observations, n the number of panels (the 19 countries of the Eurozone) and T- Bar the average number of obsevartions from each country.

The source of this data is primarily the European Central Bank (ECB) Data Warehouse, with the data concerning the different payment methods; cheques, bank cards, telegraphic transfers, and E-Money, all being sourced from the ECB. The Real GDP data is sourced from the World Bank, with the operating system data being sourced from the globalstats website. All variables are represented in Euros with the exception of the data on operating systems which is represented as a percentage from 1-100.

Real GDP is presented by Nominal GDP in Euros adjusted for inflation with the base year being 2015, in this context being a proxy for economic performance. CHEV represents the value of payments done using cheques within the calendar year, and BV is the value of the summation of Credit Card payments and Debit Card payments with and without E-money functions within the calendar year. For telegraphic transfers "also known as electric fund transfers, are payments made through real-time request or offline, TTV is computed by summing up the credit and transfers from the respective countries" (Tee & Ong, 2016). E-Money is the remaining value stored at the end of the period in electric devices or online wallets. Summing up each of these variables would equal a total of "Value of Cashless Payments" reported by each country.

The operating system variable is reflective of the market share of all operating systems across all devices whose data are collected by Globalstats. This means this variable can be expressed as:

$$\frac{market\ share\ of\ Android + iOS\ (Iphones)}{Android + iOS + Windows + Mac\ OS + Blackberry + Windows\ Phones + others} \tag{1}$$

These two operating systems, Android and iOS, have been chosen purposely. While smartphones of different operating systems are still in use, in particular, Windows Phones and Blackberry OS enabled phones, and while the mobile payment platforms here discussed have no theoretical technical impediment to being offered in these alternatives, at least for the major payment platforms worldwide these are only offered officially within these two options, Android and/or iOS. Beyond this limitation, Android and iOS cover more than 99% of the market share of Mobile Operating systems, with an outlier being Japan which is the only country with a statistically significant Blackberry Market share in 2017. Furthermore, mobile payment systems are not offered across devices, meaning payment systems are not available to be used with computers even if users tried. This makes the OS variable a good indicator of smartphone ownership and usage in each country.

Methodology

To accomplish each of the research objectives enumerated previously, this paper proposes to follow three different models. To update the literature and generalize its conclusions this paper will be starting using the following model from the paper published by Tee & Ong (2016):

$$RGDP_{ct} = \beta_{1c} + \beta_{2c}TTV_{ct} + \beta_{3c}BV_{ct} + \beta_{4c}CHEV_{ct} + \beta_{5c}EV_{ct} + e_{ct} \quad (2)$$

This model is tailored for the examination for the long-run relationship of the different payment systems and economic growth proxied as RGDP. The simplicity of the model is due in part to the nature of the task at hand, that being examining a long-run relationship (20 years in this case), where if examining for more short term changes, additional control variables would be required; however, it is also due to the nature of the subjects, the Eurozone, with a number of homogenized economic factors, but more importantly all stable, developed countries.

Using this literature model (2) with the data of the 5 countries used in the literature (France, Austria, Belgium, Germany, and Portugal) first updating the results with a newer timeframe, and secondly expanding the area covered by the model to the entire Eurozone. Incorporating later, the Operating systems variable, which alongside E-Money will be used as a proxy for the usage of mobile payment systems, model (3) will be used;

$$RGDP_{ct} = \beta_{1c} + \beta_{2c}TTV_{ct} + \beta_{3c}BV_{ct} + \beta_{4c}CHEV_{ct} + \beta_{5c}EV_{ct} + \beta_{6c}OS_{ct} + e_{ct} \quad (3)$$

In a final instance, an Integrated variable of OS and E-Money will be used to combine the effects of these two within a single variable. This new variable OSI is meant to be taken as a measure of the economic activity that results from the use of mobile payments within E-Money. Thus it results in the model (4). Here, because of the constraint of the OSI variable, the E-Money variable (EV) is replaced with OSI instead of being added to avoid multi-collinearity among these variables.

$$RGDP_{ct} = \beta_{1c} + \beta_{2c}TTV_{ct} + \beta_{3c}BV_{ct} + \beta_{5c}CHEV_{ct} + \beta_{6c}OSI_{ct} + e_{ct} \quad (4)$$

The viability of this model rests in proving to the extent possible that the observation, that Smart Mobile devices (proxied as Market share in OS) in an economy cause the rise of Electronic Money Transaction (EV), if this is done satisfactorily OSI can be taken to represent a decent measure of the economic activity that results of mobile devices.

Autocorrelation can be assumed but will be tested among all regressions, as a response to this all regressions will be run with the robust option. In order to test the causality of the relationships here enumerated and avoid spurious regressions, all series will be subjected to unit root tests as well as Pedroni tests for long-run equilibrium, using the Im, Pesaran and Shin (IPS) test and the ADF-Fisher panel unit root test. These two tests will be seeking to verify the existence of stationary data sets, data sets with a stable variance, and mean.

After performing these tests and finding proof of non-stationarity, a Pedroni panel cointegration test will be carried to confirm the existence of a long-run equilibrium. The estimated residuals for the cointegration tests following model (2) being as follows:

$$\hat{e}_{ct} = RGDP_{ct} - \hat{\beta}_{1c} - \hat{\beta}_{2c}TTV_{ct} + \hat{\beta}_{3c}BV_{ct} + \hat{\beta}_{4c}EV_{ct} + \hat{\beta}_{5c}CHEV_{ct} \quad (5)$$

$$\Delta\hat{e}_{ct} = \rho\hat{\mu}_{ct-1} + \sum_{k=1}^{k_c}\gamma_{ck}\Delta\hat{\mu}_{ct-k} + v_{ct}$$

With all models (2), (3), (4) all being tested. With γ_{ck} and k_c being allowed to vary. The null hypothesis (Ho) is that there is no cointegration within the model. Thus after being able to reject the null hypothesis in the first difference and establishing the presence of cointegration, we can safely take the regression at level to represent an approximation of the long-run equilibrium. This model is not designed to explain short term changes in RGDP. For this reason, the added step of performing regressions with residuals is obviated and the focus shifted entirely to the long-run equilibrium.

After these tests, the results of our fixed effect regression model will be showcased, as the Fully Modified Ordinary Least Squares model used in the literature is inapplicable in our case, since our panel includes a large number of countries as well as time-periods. This model afterwards, will be subjected to a granger causality test to further the reliability of the results.

Findings and Results

According to the research objectives delineated previously the results will be shown for 3 series, to update the model, the second to expand the said model to the entire EU and the third to localize the effect of mobile payment systems using E-Money and Operating systems as proxies.

Updating the Literature

Table 2 represents the results of the unit root tests taken on the variables from the literature applied only to the 5 countries that were tested in the literature, (Tee & Ong, 2016) those being Austria, Belgium, France, Germany and Portugal. The results of the tests show a failure to reject the null hypothesis at level, which is that all panels contain a Unit Root, which suggests nonstationary at level, with the opposite being true on first difference which indicates at least some stationarity at first difference.

	IPS UNIT ROOT TEST				ADF-FISHER UNIT ROOT TEST			
	At Level		First Difference		At Level		First Difference	
VARIABLE	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend
RGDP	4.1574	-0.5008	-3.4797***	-3.0727***	2.6267	14.6771	36.699***	38.146***
CHEV	2.397	-0.6686	-4.342***	-3.359***	4.5646	11.7962	49.577***	39.9294***
BV	8.1436	1.5129	-1.2765*	-2.4064***	0.0238	8.247	15.3715*	29.4527***
EV	3.2956	3.7319	-2.3969***	-2.6507***	0.7245	0.9307	30.9217***	40.0978***
TTV	0.114	0.4519	-6.7444***	-5.7613***	7.6208	9.6405	81.8878***	67.3473***

*Table 2. Existing model Unit Root tests on 5 countries: Austria, Belgium, France, Germany, and Portugal, Model (2). *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

The IPS tests show that the panel variables have a Unit Root at level, and the ADF-Fisher Unit Root Test reveal the presence of nonstationarity. This leads us to the set of cointegration tests, the Pedroni, and Kao cointegration tests. These are searching for the long run equilibrium within nonstationary sets of data. The results of these tests are shown in Table 3.

	MODIFIED PHILLIPS-PERRON T	PHILLIPS-PERRON T	AUGMENTED DICKEY-FULLER T	UNADJUSTED MODIFIED DICKEY-FULLER T	UNADJUSTED DICKEY-FULLER T
KAO TEST	-0.9378*	-1.3624**	0.9122*	-3.7278***	-2.6603***
PEDRONI	2.131***	-1.0213*	-0.9182*		

*Table 3. Kao & Pedroni Cointegration Tests of the 5 country panel. *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

Here the rejection of all hypothesis implies cointegrated data sets, and therefore possess a long-term equilibrium. This confirms the results glimpsed in the literature and updates these results with more contemporaneous data.

A long-term statistical equilibrium exists between the adoption of cashless payment systems and Real GDP. A long-term equilibrium as shown in the unit root tests can not be discerned in the short term.

All the Euro-Zone

Following the success of updating and verifying results from the literature we move on from the restriction of 5 countries to the entirety of the Euro-zone being comprised of 19 countries.

	IPS UNIT ROOT TEST				ADF-FISHER UNIT ROOT TEST			
	At Level		First Difference		At Level		First Difference	
VARIA-BLE	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend
RGDP	5.626	-0.6816	-5.67***	-4.19***	20.4189	68.3589	137.2199***	112.786***
CHEV	0.4787	-0.6825	-4.58***	-2.60***	77.0928***	42.1368	94.5516***	71.5559***
BV	13.311	3.7092	-1.576**	-1.1773*	1.7248	31.5351	63.3738***	64.3316***
EV	8.87	5.5326	-2.62***	-2.211**	26.1973	27.3684	121.0684***	114.185***
TTV	-1.11***	1.3116	-5.55***	-4.10***	95.4269***	27.8122	112.3961***	91.1002***

*Table 4. Unit Root tests on the Data of All 19 Eurozone countries. *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

Overall, the unit root tests' result remains similar in table 4 as in table 2. Even as Cheque payments (Chev), and Telegraphic Transfers (TTV) in the ADF-Fisher unit root tests were both able to reject the null hypothesis at level, the lack of rejection in the intercept implies the inability to call these variables stationary with statistical significance. With the same being applied to TTV in the IPS Unit Root Test, these clarified results allow us to safely progress towards Table 5 and the cointegration tests.

	MODIFIED PHILLIPS-PERRON T	PHILLIPS-PERRON T	AUGMENTED DICKEY-FULLER T	UNADJUSTED MODIFIED DICKEY-FULLER T	UNADJUSTED DICKEY-FULLER T
KAO TEST	2.2679**	2.9509***	3.8759***	1.2345*	1.7482**
PEDRONI	**3.7692*** **	-1.6262**	-1.8437**		

*Table 5. Kao & Pedroni Cointegration Tests incorporating the entirety of the Eurozone (2). *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

It is here in the series of cointegration tests that a significantly higher degree of certainty can be ascertained as to the existence of a long run equilibrium between Real GDP, and cashless payments adoptions. With each of the different tests improving on the results of just the 5 countries.

Incorporating Mobile Payment systems

Having incorporated the entirety of the EU into the test and ascertained the existence of a long run equilibrium. We will then move to the incorporation of the data concerning market share of operating systems. This variable (OS) represents the summation of Android and iOS market share vis-à-vis the entirety of the digital ecosystem, including Windows and Mac OS for example. So it is a variable that in this context is meant to represent the degree to which the members of an economy own mobile payments-enabled operating systems.

In the first instance this paper would make use of pairwise correlation with sigma value, as well as a panel granger causality test. To confirm the hypothesis that E- Money is caused by the growth in Mobile Payments. In Table 6 the results of these two tests can be visualized. In the first order the null hypothesis of the pairwise correlation is that there is no correlation between E-Money and the adoption of mobile payment systems, this null hypothesis can be rejected given the low possibility of error, and we can ascertain that there is a statistically significant correlation between the growth of E-Money, and the adoption of Mobile Payments-Enabled Operating systems.

		GRANGER CAUSALITY TEST	
	Pairwise Correlation	Z-Bar	Z-Bar Tilde
OS ON EV	0.1195**	39.5743***	29.3644***
EV CAUSES OS	-	-	-
OS CAUSES BV	0.0522	-0.3568	-0.4663
OS CAUSES TTV	0.1486*	0.9306	0.6160
OS CAUSES CHEV	0.0354	0.2863	0.0172

*Table 6. Correlation & Causality Tests for OS variable on E-Money, *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

The second part of the test involved using the granger causality test to determine as to whether this correlation reflected a causal relationship. The null hypothesis in this test is that OS does not granger-cause E-Money. This null hypothesis again, can be easily rejected, which means that OS does granger-cause E-Money for at least one of our panel countries.

Moving on to the unit root tests in Table 7 and 8, two variables were included, first the Operating Systems variables, and second, the Interaction variable between OS and E Money.

IPS UNIT ROOT TEST

	At Level		First Difference		Second Difference	
VARIABLE	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend
OS	24.5839	8.191	0.7093	-2.4528	-14.7263***	-12.418***
OSI	18.7551	70.3816	-0.0587	-0.7105	-13.7760***	-12.0995***

*Table 7. Operating Systems IPS Unit Root Tests. *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

ADF-FISHER UNIT ROOT TEST

	At Level		First Difference		Second Difference	
VARIA-BLE	Inter-cept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend
OS	0.1626	6.0091	65.0503	38.9704	411.8997***	151.638***
OSI	32.2803	90.2506***	176.1964***	156.1967***	530.8326 ***	316.8486***

*Table 8. Operating Systems ADF-Fisher Unit Root Tests. *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

For the IPS test the results of both variables are similar. It is only possible to reject the null hypothesis on the second difference. This confirms the existence of Unit Roots in all panels, at level and in the first difference. For the ADF-Fisher in contrast, it is possible to reject the null hypothesis for the interacting variable (OSI) in the first difference, similar to all the other cashless payments variables, with both variables being able to reject the null hypothesis on the second difference, implying nonstationarity at level and first difference.

For the Panel Cointegration test the recentness of the advent of mobile payment platforms becomes an obstacle that limits our options significantly, because these tests are looking for a long run equilibrium. Nevertheless, the kao tests does offer a few tentative yet promising results as shown in Table 9.

	UNADJUSTED MODIFIED DICKEY-FULLER T	**UNADJUSTED DICKEY-FULLER T**
KAO TEST	1.0237**	1.5348***

*Table 9. Model Incorporating OS variable, Model (3). *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

The rejection of the null hypothesis in these two tests seems to indicate the existence of a long run equilibrium, but as of the time of writing this paper the data available does not allow for a more robust statistical proof.

By comparison the model using, the interacting variable (OSI) generate very positive results as shown in Table 10.

	MODIFIED PHILLIPS-PERRON T	PHILLIPS-PERRON T	AUGMENTED DICKEY-FULLER T	UNADJUSTED MODIFIED DICKEY-FULLER T	UNADJUSTED DICKEY-FULLER T
KAO TEST	3.0579***	4.1622***	3.8634***	2.3256***	3.0125***
PEDRONI	3.4036***	-3.0034***	-3.0729***		

*Table 10. Kao & Pedroni Cointegration Tests for the Incorporated OSI variable, Model (4). *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

This last cointegration test confirms the existence of a long-term equilibrium when accounting for mobile payment systems which seems to back the tentative results from the Kao test on the OS variable.

Panel Regression and Results

Having concluded these tests, we can proceed to the panel regressions, results are shown in Table 11. Four regression series were done firstly one following the model used for cashless payments on the 5 countries initially, then expanding the model to the entire European Union, and finally two regression sets incorporating the new Operating Systems variable, one simply incorporating it into the model, and the last incorporating the interacting variable of Operating systems market share and E-Money.

PANEL REGRESSIONS RESULTS

RGDP	5 Countries Model (2)	Eurozone Model (2)	Incorporating OS Model (3)	OS and E-Money Incorporated Model (4)
CHEV	0.030839	0.034988	-0.0017	-0.00725
BV	4.663995***	4.26839***	0.168667***	0.218262***
EV	1.028783***	0.282543***	0.003685*	
TTV	0.005635***	0.005971***	0.174105***	0.156573***
OS			0.002222***	
OSI				0.005261**
_CONS	2.21E+11*	1.75E+11***	16.95389***	16.40493
NO. OF OBS	90	140	120	120
R SQUARED	0.6686	0.8125	0.9222	0.9465
OVTEST (F-VALUE)	13.51	23.69	2.19*	0.44

*Table 11. Panel Regression with fixed effect model. *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

The result of incorporating the OS variable directly into the model, which in accordance with our causality and correlation tests did appear to capture to a large degree the effects attributed to E-Money, is noteworthy, this is the reason why we incorporated OS into the E-money variable, and the results show a statistically significant positive relationship between RGDP and Mobile payment systems reflected by the proxies, E-Money, OS, and the integrated variable OSI.

Having done this, the following Table 12 represents the results of the causality tests being performed on the variables of model (4), to further corroborate the results of Table 11. The second column of the table is highlighted in bold to mark the relationship shown in the last column of Table 12, Model (4). The rest of the table is set to further corroborate the results shown in the literature.

GRANGER CAUSALITY TESTS

CAUSATION ↱	RGDP	BV	CHEV	TTV	OSI
RGDP	-	1.2824	-0.0402	1.0870	-
BV	**3.9875*** **	-	1.9926*	-0.2794	-
CHEV	**5.2642*** **	3.5283***	-	1.7497*	-
TTV	**3.8586*** **	3.3765***	4.2605***	-	-
OSI	**2.1355** **	2.8153***	5.7184***	0.0306	-

*Table 12. The result of the Granger Causality tests performed on model (4). *, **, *** representing rejections of the null hypothesis at 0.1, 0.05, and 0.001 respectively.*

Here all variables committed to Model (4) have been found to be in a granger causal relationship with RGDP. This is the only relationship that this paper sets out to showcase; however, the rest of the results of the table further corroborate the results found in the literature. The different types of payment do appear to affect one another.

Discussion and Limitations

The regression results of Table 11 show a distinct positive relation between RGDP and all payment systems, a relationship that we can call a long run cointegrated equilibrium. This is further complimented by the results of the causality tests in Table 12. It is worth noting the coefficient of the Value of Bank Cards consistently being the largest across all models, particularly our improved model (4). This does not necessarily indicate an increased benefit to bank cards over other forms of payments, rather it could be caused by bank cards achieving a “critical” mass required to more fully benefit from their adoption. When looking at the effect of the economic activity that comes from Mobile Payment Systems (OSI) based on the model with the low levels of penetration in the EU, it seems to have a positive relationship with RGDP.

The choice of RGDP in the literature as well as in this paper as the proxy for “economic impact” is based on the different normative assertions, that while benefit arising from transaction costs might be more easily seen perhaps on Consumption; the benefit of increased government oversight, as well as the increased financial efficiency could be more easily seen by other metrics. RGDP promises to be able to observe holistically the effect of the cashless payment systems in the economy. Furthermore, a study covering these two alternate benefits would require the creation of entirely new models of analysis, and as such, is beyond the scope of this paper, although it would be an area of interest upon which to expand the existing field of study.

A further limitation of this methodology is the reliance on the different statistical tests, as the Unit root tests, the Pedroni tests, and the granger causality tests require an exceptionally balanced panel data. They also require at least 9 periods of observation to be successfully performed. This is the reason the paper by Tee & Ong (2016) chose those 5 European countries in a particular time. The fact that we can now expand on these findings with a data set covering 10 additional years of data, and being able to cover the entirety of the eurozone is a testament to both the increasing reliability of the publication of data in the EU, and the limitations of this methodology. As it would be unthinkable to perform a similar research in any other area of the world due to the gaps in the data.

To perform an impact assessment over other regions of the world would require instead a short-term model tailored specifically to that cause, including a range of additional control variables, and lacking on the statistical weight given by the tests here performed. This is the primary reason this paper opted to focus on a single region, with a single model receiving minor tweaks and modifications to tailor it towards mobile payment systems.

In the section about mobile payment systems it was mentioned as well the issue with "critical mass" and while Europe as a region remains with a relatively low adoption rate of Electronic Money, it is in general one of the most cashless economies in the world, dwarfing, for example, the United States, Japan, or South Korea when it comes to cashless payments overall. Part of the reason for the reliability of the model here proposed lies in this unusual attribute.

Conclusion

All research objectives have been accomplished to the degree that can be hoped for. In the first instance, this paper confirmed prior results, confirming the existence of a long-run equilibrium in the relationship between Real GDP and cashless payment systems within the 5 countries studied; Germany, France, Belgium, Austria, and Portugal. This paper was also able to expand these results covering the entire 19 countries of the Eurozone, with similar significant results. Across the Eurozone there exists a statistically significant long-run equilibrium in this relationship between economic growth and the adoption of cashless payments.

For the major innovation of this study, it was established a granger causal relationship between E-Money and Mobile Operating Systems confirming the hypothesis that the growth of E-Money could be directly attributed to the growth in popularity of Mobile Payment systems, making these two variables important proxies in determining the economic impact of mobile payment systems.

The incorporated variable for both E-Money and Operating Systems showed a similar long-term equilibrium in the cointegration test. With all cashless payment systems showing positive statistically significant results in the regressions performed with the notable exception of cheques. The interacting variable of E-Money and Operating Systems reveal a positive and statistically significant relationship with Real GDP.

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