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Dissertation/Project Coversheet

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1 Introduction

Cash has existed in physical form for millennia, with use spanning from as early as the 7th Century BC (Peachey, 2016) through to the present day. Though, are we nearing the end of physical money's reign? Major economies already have extremely high rates of demonetisation which is the reduction out of cash use in an economy. Sweden is predicted to become fully cashless by 2023 (Arvidsson, 2019). The United Kingdom, Finland and Norway are not far behind (Best, 2022); cash seems to be deep in its saturation period, making way for alternative forms of transaction methods such as credit/debit cards, mobile and QR payments. The zero-point, cashless society, is rapidly approaching and it is time for leaders and policymakers to take this into consideration when they plan the future of their nations. Meanwhile, worldwide, the number of people in absolute poverty (defined by the World Bank as those earning below US$1.90 per day purchasing power parity [PPP]) has fallen over the past few decades from 1.9 billion in 1990 to 900 million in 2013 (Roser and Ortiz-Ospina, 2013). This suggests that global income inequality between countries has declined. Whilst this number continues to fall, intranational inequality is rising in many parts of the world; the United Nations (2020) states that 70 per cent of the world population is being subject to rising inequality. The areas seemingly most affected by this are developed economies such as those in the US and Europe while areas such as Latin America see falling income disparities (Atkinson, 2015). These channels of study have helped to motivate the research question proposed in this paper: Does demonetisation have an impact on income inequality?

The methodological approach used to answer this question is fixed effects panel regression conducted on data which is drawn from sources such as the World Bank World Development Index and the European Commission. The sample selected spans 29 countries across Europe over the period of 2011 - 2018. Panel analysis allows for the dynamic nature of the relationship to be examined over a wide range of countries at different stages in their demonetisation process. Alongside this, there is a secondary question which contributes to the literature, following from studies from Siregar (2020) and Demir et al. (2022) in which they investigate whether the relationship depends on the level of national economic development. The other contributions of this paper are the more up-to-date data, effect of demonetisation and complete panel analysis in Europe, previous studies have used only partial panel data (Demir et al., 2022), or limited their scope of study to a single country (Alderson and Nielson, 1997; Chen et al. 2016). Additionally, this paper is the first to study the direct link between demonetisation rate and income inequality in Europe. Robustness and sensitivity checks also contribute to the literature. Overall, the paper finds a negative relationship between the log demonetisation rate and the log Gini index with a 1% increase in demonetisation correlating with a 0.017% fall in the Gini index in the following year, statistically significant at the 95% confidence level. The paper also finds that this relationship holds for high-income countries, though for low- to middle-income countries the reverse relationship exists, a 1% increase in demonetisation in low- to middle-income countries led to a 0.343% rise in the Gini index on average.

The paper is set out as follows: in chapter 2, a review of the main theoretical channels of literature is conducted, followed by a critical discussion. Chapter 3 is the methodology section, regression models are specified, testable hypotheses are proposed, as well as potential causes and solutions to endogeneity bias. Sample and variable selection is discussed, summary statistics of collated data showcased and finally a mention of limitations. Chapter 4 contains the results of the initial regressions, then the impact of national economic development followed by robustness and sensitivity tests. Chapter 5 concludes the paper with a summary, limitations, policy recommendations and guidance to further research.

2 Literature Review

2.1 Introduction to literature review

Constant developments in the technological and financial sectors have seen a surgency in the uptake of electronic transfers of payments and in many regions cash has been left on the back foot (Arvidsson, 2019; Rahman, Ismail and Bahri, 2021; UK Finance, 2021). Contemporaneously, recent trends of income inequality have, worryingly, been on the rise in the developed world (Atkinson, 2015; Cingano, 2014). Section 2.2.1 looks at income inequality, 2.2.2 reviews demonetisation and digital financial inclusion (DFI), 2.2.3 frames the empirical and theoretical relationship between the variables. 2.3 critically discusses literature and 2.4 summarises and concludes.

2.2 Main review

There are two main fields of study that will be reviewed: income inequality including trends, factors of determination, and comparison of different regions; and demonetisation, this is in the form of direct demonetisation through saturation of physical denominations of cash and via the rise of DFI and financial technology (FinTech).

2.2.1 Income inequality

Income inequality is the measure of how unevenly income is distributed amongst a given population, in recent decades, the level of income inequality has been on the rise (UN, 2020). Seemingly, the regions seeing the greatest rises are developed economies (Atkinson, 2015). One measure of income inequality is the share of income held by the top 10% of earners; Figure 1 shows that from 1980 to 2017, the top 10% have commanded a greater portion of national incomes across Europe.

Figure 1 – Top 10% Income Shares in European Countries, 1980-2017

Source: Blanchet et al., 2019, p.30

Empirical studies have found disadvantages to a rising income inequality which motivate further research around the topic; Rowlingson (2011) finds links between increased income inequality and a worsening in health, while Cingano (2014) finds that a higher Gini index can be correlated with less opportunities for obtaining skills which can stunt wages for the lowest paid workers and can limit economic output of workers which diminishes economic growth of nations. Alderson and Nielson (1997; 2002) conducted studies on the US, finding several determinants of income inequality such as urbanisation rate, industrial employment and unemployment which will be used as control variables in the model specification of this paper. However, Satz and White (2021) mention critiques of inequality policy intervention such as the idea from Okun (1975) that there is a trade-off between equality and efficiency in society. He proposed the "leaky bucket" (Okun, 1975, pp. 91-95) in which attempts at alleviating inequality would be inefficient and money would 'leak' during redistribution of cash from the rich to the poor, through tax or other government intervention.

2.2.2 Demonetisation and digital financial inclusion

Demonetisation, in its most direct form, is the reduction in physical money supply in an economy. The latest large-scale example of this type of demonetisation from a government body is the case of India in 2016. Large note denominations of 500 Indian Rupees (INR) and 1000 INR were removed from circulation and replaced with new notes. The effectiveness of this approach by the Indian government has been criticised (Srouji, 2020; Kushawa, Kumar and Abbas, 2018) with the intervention benefits being superseded by a diminished growth in GDP, spike in unemployment and very little change to the circulation of cash in the economy. Rogoff (2016) sets out how he believes successful demonetisation should occur by the removal of large denomination notes while pushing for the uptake of digital payment methods and promotion of a more efficient tax system in the aim of tackling the shadow economy. The world consists of many different economies which span a wide range of stages in the process of demonetisation; Arvidsson (2019) predicts that Sweden will be virtually fully cashless by the year 2023. The UK, Finland and Norway have only marginally higher cash usage rates (Best, 2022).

As cash usage falls, assuming demand remains the same, other forms of payment such as debit/credit cards, mobile payments and QR payment must be on the rise. It seems that this is the case in most major economies as the value of digital payments in the Euro area rose from €3813 million in 2011 to €10177 in 2018 (ECB, 2021). As digital payments are on the rise, the behavioural impact this has on consumers must be considered. Agarwal et al. (2019) found, through natural experiments, that digital payment methods induce over-spending; monthly spending rises by 3% when using digital methods when compared to cash use. Srouji (2020) finds that without suitable access to these digital payment methods, and an over-reliance on cash, demonetisation can have drastic negative impacts on the economy and its inhabitants. Instead of simply pushing an economy into cashless territory as happened in India in 2016, it may be beneficial for digital payments and cash to simultaneously grow in use; so instead of being two extremes, they are complementary elements.

2.2.3 Theoretical and empirical relationship

Several formal studies have found links between the rise of DFI and inequality, though the nature of the effect is ambiguous. Kling et al. (2022) propose a theory that an increased level of DFI would give low-income earners the ability to borrow funds which could then be put into education and skill development, meaning they can command higher wages, thus reducing income inequality. Yue et al. (2022) also suggest that a fall in cash is leading to uptake of DFI and credit markets. Empirical data around this topic supports the idea that DFI and income inequality has a negative relationship, though the reason has not been fully established. Demir et al. (2022) found that an increase in adoption of Financial Technology (FinTech) led to a reduction in income inequality. The methodology employed is a multivariate panel regression similar to that used in this paper; inequality being the dependent variable. They found that a 1 unit increase in FinTech adoption leads to a 0.071 unit reduction in the Gini index (Demir et al. 2022). There was an extension to the study by repeating regressions on different sample groups dependent on development. Both Demir et al. (2022) and Siregar (2020) concluded that for high-income economies, a rise in DFI led to a reduction in the Gini index whilst for low- to middle-income economies, increased DFI leads to a slight increase in the Gini index. The proposed reasoning was that low- to middle-income countries may not have sufficient financial and technological infrastructures in place to be able to exploit the gains in inequality reduction which comes from the increased DFI (Srouji, 2020; Demir et al. 2022).

2.3 Critical discussion

The framework of previous studies has been important as a guide to the focus of this paper, though it is unable to provide an answer to the proposed research question. There are gaps in the literature which, when filled, may provide a clearer picture between the links between demonetisation and income inequality. Studies thus far have focused primarily on the importance of DFI (Siregar, 2020; Demir et al., 2022; Omar and Inaba, 2020) which can be argued is only a side product, resulting from the reduction in cash usage which is taking place across many major economies (UK Finance, 2021; Best, 2022; ECB, 2021) and so direct study of the relationship between demonetisation and income inequality is needed. This is a gap in the literature the paper intends to fill. Additionally, previous studies have lacked robustness and sensitivity checks on their findings, these are necessary for completeness of analysis. Also, few studies have focused attention of the natural group of Europe in this context and so this will be the area of focus in this paper. The paper will also extend the approach taken by Demir et al. (2022) and Siregar (2020) and investigate the relationship between demonetisation and income inequality over different national economic development levels. Another contribution of the paper is to utilise a full panel dataset for analysis where previous studies have opted for time series (Chen et al., 2016; Alderson and Nielson, 1997) or lack some years in their panel (Demir et al., 2022).

2.4 Conclusion

There are two main branches of literature surrounding this study, though there is synthesis between the two, the DFI and demonetisation literature provides useful insights which can relate to the sphere of income inequality. Cash is on a downtrend whilst income inequality still trends upwards in the developed world. Recent findings on the relationship between DFI, cash and income inequality (Demir et al., 2022; Siregar, 2020) suggest that further research is needed in this area to fill this gap in the literature. Therefore, the aim of this study is to attempt to rectify this and begin to shed light upon the relationship between demonetisation and income inequality while implementing techniques and theory formed from previous studies.

3 Methodology and Data

3.1 Introduction to methodology

This study uses a dynamic regression of panel data for empirical analysis of how demonetisation across Europe is influencing income inequality. Section 3.2 states the research plan, 3.3 sets out the model, 3.4 contains the proposed hypotheses, 3.5 explains potential endogeneity bias, 3.6 describes the sample selection process, 3.7 is variable selection, 3.8 shows summary statistics and 3.9 concludes and states limitations.

3.2 Research plan and reasoning

There was initial research into previous studies around demonetisation and inequality to find key variables of interest, sources of data, and methods implemented. Studies from Alderson and Nielson (1997; 2002), Omar and Inaba (2020), Siregar (2020), Park and Mercado (2018), Demir et al. (2022) and Kuznets (1955) were instrumental in developing the model of income inequality against demonetisation. The demonetisation variable was created through transformed annual data of cash usage across countries from 2011-2018.

3.3 Model specification

In order to analyse the effect of demonetisation on income inequality, the following model is used as in equation 1):

$$ln(GINI_{i,t}) = \beta_0 + \beta_1 ln(DEMONETISATION_{i,t}) + \sum_{k=1}^{K} \rho_k X_{k,i,t} + f_i + \varepsilon_{i,t} \quad (1)$$

Where $\ln ln\left(GINI_{i,t}\right)$ refers to the natural log of the Gini index, $\ln ln\left(DEMONETISATION_{i,t}\right)$ refers to the natural log of level of demonetisation. $X_{k,i,t}$ refers to a set of control variables which have been commonly used to investigate income inequality. These variables are: Log ATMs per 100,000 people, Log urban population (% of total population) (Kuznets, 1955; Alderson and Nielson, 1997), Log commercial bank branches per 100,000 people, GDP per capita (in 2015 US$), GDP per capita squared, Log unemployment, Log employment in industry (% of total employment), Log employment in agriculture (% of total employment), Log growth of employment in the high-tech sector (% of total employment), and a time variable. There is also the inclusion of a fixed effects variable f_i to control for country-invariant effects. Lastly, $\varepsilon_{i,t}$ is the error term, which is assumed to have a zero-mean, be normally distributed and is exogenous to the independent variables. More explanation of chosen control variables is given in section 3.7.3.

The model is going to be split into 6 equations: 1) Pooled OLS, 2) Fixed Effects Model, 3) FEM on lagged values, 4) Pooled OLS (R), 5) FEM (R) and 6) FEM on lagged values (R). Note (R) indicates the use of robust standard errors.

3.4 Testable hypothesis

The focal point of this paper is to investigate whether demonetisation has an impact on income inequality, hence the following hypotheses have been formed:

H_0: *There is no relationship between demonetisation and the Gini index* ($\beta_1 = 0$)

H_1: *There is a relationship between demonetisation and the Gini index* ($\beta_1 \neq 0$)

The alternate hypothesis, H_1, is nondirectional, indicating a two-tail test. There is theoretical ambiguity surrounding whether this relationship should be positive or negative. Demir et al. (2022) find that DFI, aided by FinTech alleviates income inequality whilst Siregar (2020) suggests that it is dependent on the stage of development at which the economy lies; DFI tends to increase income inequality in low- and middle-income countries while high-income countries benefit from DFI with reduced income inequality. The decision rule will be the calculated p-value for the coefficient of the log of the demonetisation rate in the regression results, the significance level will be, $\alpha = 5\%$ as this is the standard set for statistical interpretation (Fisher, 1925).

3.5 Potential endogeneity bias

There are several potential sources of endogeneity bias that could impact the accuracy of results of the study:

Omitted variable bias (OVB) is caused by not including important variables, often when there are unobservable variables are correlated with included variables leading to erroneous interpretations of what is driving inequality. This paper attempts to alleviate this bias by including a carefully selected set of variables adapted from previous studies. The fixed-effects model (FEM) is chosen to be implemented to control for country-specific individual effects. FEM is chosen as we assume the unobservable individual effects are correlated with the independent variables.

Errors-in-variables bias comes from mistakes in the measurement and collection of data. While all the data used in this study is second-hand and thus not able to be controlled. This cause of error could be an issue resulting in biased results, for example if the approximation used for demonetisation rate by Best (2022) is not accurate.

Simultaneous causality bias is the result of multi-determination of the dependent variable with one (or more) independent variables. This is where the dependent variable causes a change in an explanatory variable but at the same time the explanatory variable causes an effect on the dependent variable (Zaefarian et al., 2017). An example could be that demonetisation is causing a reduction in income inequality, however also a reduced income inequality could be causing an uptake in digital technology and thus greater demonetisation. To mitigate the impact of this source of bias, a set of lagged values of the explanatory variables will be introduced to the regression model. This will allow causality effects to be captured, this technique is also utilised by Chen et al., (2016).

Instrumental variables (IVs) are an alternate method used to compensate for endogeneity bias by finding a variable correlated with the main explanatory variable, demonetisation, whilst not correlated with the Gini index. Though finding an appropriate instrument with data available for the sample group was not possible, therefore IV was not used in this study.

3.6 Sample selection

The sample selected for this study is made up of 29 countries which meet the criteria which is set out as follows: they are a member of the European Union, and/or member of the European Single Market, and/or member of the European Customs Union (as of December 31st, 2019).[1] The choice of quantitative panel analysis was decided due to its advantages of greater accuracy in the inference of results, there are greater observations over both time and countries which provides greater degrees of freedom and a greater sample variability than those of which are covered in cross-sectional or time series methods (Hsiao, 2007). The region of study is restricted to the region of Europe as it is a natural group with a broad range of development which will aid analysis into the importance of economic development. Some countries had to be removed from the dataset due to their limited reporting and availability of data for analysis. A total of 36 countries and territories fit the above criteria, this includes all 27 EU member states (including the UK as they were still a member as of 31st December, 2019), except Bulgaria, Hungary and Malta who lacked enough data, 5 non-EU members of the Customs Union, of which Andorra, Monaco, San Marino and Akrotiri and Dhekelia had to be ejected due to insufficient data and 4 non-EU members of the Single market, of which, Liechtenstein was ejected due to lack of available data. It should also be noted that Croatia had its accession to the EU on July 1st, 2013, part way through the timeline of focus, though it is included in the analysis. Furthermore, Ukraine has been added to the sample as there was sufficient data available and should aid analysis.

A large sample was chosen so the panel data has a larger number of observations, this can give more accurate findings, raising statistical power and

[1] Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and United Kingdom

reduces the risk of a Type I error (rejecting the null hypothesis incorrectly) or Type II error (failing to reject the null hypothesis incorrectly) when analysing the results (Hallahan and Rosenthal, 1996; Rothman, 2010). These 29 countries contribute 225 observations ranging from 2011 to 2018. The panel is 97.5% balanced, this is unlikely to be a problem regarding analysis, though a check on this will be performed for robustness in section 4.3. Although the resources were available for some of the data to be reported monthly or even daily, all data in this study is conveyed annually for simplicity and ease of comparison.

Several factors were considered before finally concluding that the timeline of this study would be the years 2011 to 2018. Firstly, there was a lack of data beyond the year 2018, so these years had to be removed from analysis. Similarly, the years prior to 2011 had no data on the level of cash use and so this was the logical starting point of the study. Another reason for this timeline is that the years prior to 2011 were deemed to likely be influenced by the effects caused by the global financial crisis of 2007/08, this was not the focus of the study and so have been removed. Finally, previous studies have not used data which is as up-to-date as is used in this study, adding to the contributions of the paper.

3.7 Variable selection

3.7.1 Dependent variable

The dependent variable, natural log of the Gini index is used as a proxy for income inequality. There are several measures of income inequality: the Gini index, a 0-100 scale where 0 represents perfect equality and 100 represents perfect inequality; top 10% share of income vs bottom 50% share of income; the Palma ratio which is a ratio comparing the top 10% of earners' share of income against the bottom 40% of earners' share. While each have their own advantages, the method of measuring inequality chosen for this study is the Gini index as it is the most used in previous research, is publicly available, and is useful for inter-regional comparisons between countries. The data for income inequality was collected from the World Bank (2022).

3.7.2 Independent variables

Cash usage in domestic transactions has been transformed using econometric software, STATA, to be used as a proxy of the demonetisation rate of countries as cash use is taken from 100% to form a new demonetisation variable. The variable is bound between 0 and 100 and represents the percentage of transactions using non-cash payments. As there is no true data on the level of cash use, the data used is an approximation based upon several indicators calculated by Best (2022): Value of ATM cash withdrawals, value of over-the-counter cash withdrawals; value of card payments; value of e-money payment transactions. This is the main independent variable as the proposed research hypothesis is examining the effect of demonetisation on income inequality.

3.7.3 Control variables

The control variables include those used in previous studies surrounding (digital) financial inclusion and income inequality. The control variables selected for use in this study are applied to reduce the error term, raising the accuracy of analysis on the relationship between the independent variable and dependent variable. This is due to the control variables' ability to account for potential endogeneity issues by reducing the omitted variable bias.

$GDPpc_{i,t}$ represents the Gross Domestic Product per capita (2015 US$), this is included as there is a theoretical link between the level of inequality in a society and the national product per head as formulated by Kuznets (1955) with the theory that inequality initially rises as the country becomes wealthier and then peaks and reverses with inequality contracting after a certain level of GDP per capita is reached. The source for this is the World Bank (2022).

$BANKS_{i,t}$ *and* $ATMs_{i,t}$ are two controls, commercial bank branches per 100,000 people and Automated Teller Machines per 100,000 people respectively. These have been grouped together as they are a partial proxy for the level of financial inclusion. The source for this is the World Bank (2022).

$u_{i,t}$ represents the unemployment in the country (as a % of the total labour force), this could have a positive correlation with the Gini index as the greater the proportion of unemployment, the greater the disparity between the incomes of the richest and poorest in society. The source for this is the World Bank (2022).

$BIRTH_{i,t}$ is the number of births per woman in the given year. Micevska (2001) finds that this variable could be correlated with income inequality as the greater the income inequality, the fertility rate decreases if income falls below a certain threshold. However, study by Zak (1999) contradicts this, finding that greater inequality actually raises the aggregate number of births. The source for this is the World Bank (2022).

$URBAN_{i,t}$ is the urban population (% of total population). Kuznets (1955) theorised urban regions are more likely to have higher income inequality as the population ranges from the richest in society to the most destitute. Chen et al. (2016) also validates this theory empirically. The source for this is the World Bank (2022).

$INDUSTRY_{i,t}$ and $AGRICULTURE_{i,t}$ are the % of total workforce that work in industry and agriculture respectively. Theory suggests that the lower the employment rate is in the industrial sector, the greater the income inequality (Mehic, 2018). Contrasting to this, Kuznets (1955) assumed that the agricultural sector was the most equal in terms of income and so the larger the proportion of agriculture, the greater the weighting of this sector and so inequality will fall, having a negative effect on the Gini index (Alderson and Nielsen, 2002). The source for this is the World Bank (2022).

$TECH_{i,t}$ is the annual change in employment in the high-tech sector (in percentage points of total employment). This variable is used as a proxy for the effect of skill-based change in an economy which literature suggests has an influence on income inequality (Fernandez, 2002). The source for this is Eurostat (2019).

The use of the natural log for the variables is used as it helps with extreme points in the data and eases comparison as regression coefficients then represent percentage change and is used by Omar and Inaba (2020) and Siregar (2020).

3.8 Statistical description of data

The summary statistics of the variables used in testing are reported in Table 1. The lowest Gini value was 24 in Ukraine in 2014, the highest was 42.9 in Turkey 2015. The highest demonetisation rate was 91.3% in Iceland in 2018, the lowest was 1% in Greece in 2011. The lowest unemployment was 2.01% in Czech Republic in 2019, whilst the highest was 27.5% in Greece in 2013. The lowest urbanisation rate was 52.9% in Slovenia in 2011, the highest was 98.0% in Belgium in 2018. These summary statistics help to motivate the use of a panel model as dynamic nature can be analysed across a large array of economies which have a wide variability in many factors.

Table 1 – Summary statistics table

Variable	Obs	Mean	Std. Dev.	Min	Max
Gini	225	31.235	4.116	24	42.9
Demonetisation	192	48.928	24.498	1	91.3
Tech growth	196	.047	.231	-.6	.7
GPDpc	225	35471.186	24050.108	2124.662	108307.89
GDPpc_sqr	225	1.834e+09	2.442e+09	4514190	1.173e+10
Birth rate	225	1.596	.218	1.21	2.137
Urban rate	225	73.47	12.54	52.883	98.001
Industry%	225	23.696	6.188	10.76	38.45
Agriculture%	225	6.271	6.194	.99	29.71
ATM	225	84.689	35.481	31.69	191.193
Banks	225	29.937	18.078	.43	88.42

Source: Author's own computation based on data described in section 3.7
Notes: Obs is number of observations, Std. Dev. is standard deviation

3.9 Conclusion and limitations

There were some limiting factors with the econometric method. Firstly, there was a lack of data availability for some countries, specifically for the variables: $GINI_{i,t}$, $DEMONETISATION_{i,t}$ and $BANKS_{i,t}$. This led to some countries having to be ejected from the subject set (mentioned in section 3.6) as there was insufficient data which could have compromised analysis. Also, the primary independent variable of focus, $DEMONETISATION_{i,t}$, is the approximate level of cash use in each country (as a % of all transactions) subtracted from 100 (100 representing an economy only using cash). This restricts the accuracy of the analysis of this study and there is a chance that the methods used to calculate this could lead to endogeneity bias if there were errors in the measurement or approximation of this data. Finally, publicly accessible data on alternative measures of income inequality such as the Palma ratio for the sample are not available which limits the ability to perform robustness checks.

This chapter provides reason as to why the dynamic panel regression method is used for analysis of the interaction between income inequality and demonetisation in Europe. Sources of potential bias and solutions are noted. The data collection process, variable and sample selection were discussed. Theory surrounding the topic in question is ambiguous (Srouji, 2020; Siregar, 2020; Demir et al., 2022), the results of this analysis will be able to bring further evidence to either support or dispute the theory of demonetisation influencing income inequality. Chapter 4 will discuss the results from the analysis, and hypotheses set out in section 3.3 will be tested.

4 Results

4.1 Introduction to results

The following chapter is following from the methodology section; the model has been regressed and outputs are compiled. Section 4.2.1 will go over the main results: direction, size, and significance of coefficients, 4.2.2 explores the impact of national economic development on the relationship. Section 4.3 will discuss the robustness and sensitivity of results and 4.4 will provide a summary and concluding statements.

4.2 Main results

4.2.1 Initial results

Table 2 - Estimated coefficients of model 1)

	(1) OLS	(2) FEM	(3) FEM lags	(4) OLS (R)	(5) FEM (R)	(6) FEM lags (R)
lndemonet	0.010	-0.016**	.	0.010	-0.016*	.
	(0.520)	(0.045)	.	(0.461)	(0.075)	.
gdppc	-0.000	-0.000	.	-0.000*	-0.000	.
	(0.130)	(0.178)	.	(0.074)	(0.353)	.
gdppc_sqr	0.000*	0.000	.	0.000**	0.000	.
.	(0.077)	(0.166)	.	(0.030)	(0.362)	.
lnu	0.083***	0.033*	.	0.083****	0.033	.
	(0.001)	(0.081)	.	(0.000)	(0.141)	.
lnbirth	0.141*	-0.001	.	0.141*	-0.001	.
	(0.066)	(0.988)	.	(0.082)	(0.993)	.
lnurban	0.028	0.468	.	0.028	0.468	.
	(0.697)	(0.263)	.	(0.711)	(0.243)	.
lnindustry	-0.094*	0.032	.	-0.094**	0.032	.
	(0.090)	(0.755)	.	(0.040)	(0.780)	.
lnagri	0.055****	0.048*	.	0.055***	0.048	.
	(0.001)	(0.060)	.	(0.001)	(0.289)	.
lnatm	0.047**	0.014	.	0.047***	0.014	.
	(0.011)	(0.651)	.	(0.005)	(0.705)	.
lnbanks	0.057****	-0.046**	.	0.057****	-0.046*	.
.	(0.000)	(0.022)	.	(0.000)	(0.060)	.
lntech	-0.037	0.140****	.	-0.037	0.140***	.
	(0.158)	(0.000)	.	(0.196)	(0.002)	.
L.lndemonet	.	.	-0.017*	.	.	-0.017**
	.	.	(0.055)	.	.	(0.031)
Constant	-5.689	3.818	-1.157	-5.689	3.818	-1.157
	(0.462)	(0.485)	(0.845)	(0.467)	(0.461)	(0.828)
Observations	187.000	187.000	160.000	187.000	187.000	160.000
adjusted R2	0.465	0.196	0.216	0.465	0.321	0.360
Prob > F	.	0.000	0.000	.	0.000	0.000

2(*p*-values in parentheses
* p<0.10, ** p<0.050, *** p<0.010, **** p<0.001

Source: author's own computation based on data described in section 3.7
Notes: (R) indicates the model is using cluster-robust standard errors; lndemonet is the coefficient of log demonetisation, L.lndemonet is the lagged coefficient of log demonetisation, all other lagged results are omitted for clarity; adjusted R2 is adjusted R^2; prob > F is result of F-test to check for significance of FEM values.

Table 2 gives a comprehensive view of the coefficients which were produced in the regressions. Below each coefficient, in parentheses, are the standard errors of each variable and the p-value is indicated by number of asterisks (*) next to the coefficient. The scale for p-values is displayed below Table 2, with the higher the number of asterisks, the greater the degree of statistical significance. The dependent variable of all models is $ln(GINI_{i,t})$ which is the focal point of this paper. The independent variable of focus is $\ln ln\left(DEMONET_{i,t}\right)$. Equations 1), 2), 4) and 5) look at the present value of demonetisation whereas equations 3) and 6) focus on the lagged values in order to account for simultaneous causality bias. As the independent variable is the natural log of demonetisation and the dependent variable is the natural log of the Gini index, analysis of all 6 equations will come in the form of a 1% rise in demonetisation leading to a β% change in the Gini index; where β is the coefficient computed and displayed in Table 2. The range of estimated correlation is +0.010% (in the Pooled OLS equations, 1) and 4)) to -0.017% (in the lagged FEM equations, 3) and 6)). The size of the effect is relatively small but not zero. The result with most importance in this paper is that of model 6); it accounts for endogeneity bias through use of FEM, controls for simultaneous causality bias via lagged values, and has robust standard errors. Therefore, the main finding of the paper is that a 1% increase in demonetisation across Europe, on average, leads to a 0.017 decrease in the Gini index. This suggests that as there is a shift towards a cashless society, income inequality is easing, resulting in a more even distribution of earnings across the population. One potential cause is that as people use less cash, they are likely to use substitutes such as banking, either formal banking or online/mobile banking; Yue et al. (2022) state this allows for borrowing of finance and Kling et al. (2022) suggest people will use this credit to fund education and so they improve skills and can command higher wages, thus reducing income inequality. The p-value of the demonetisation coefficient in model 6) is 0.032 and so the null hypothesis that there is no relationship between demonetisation and the Gini index, can be rejected with 95% confidence. The size of the effect is noticeable at a 0.017% decrease to the Gini index for a 1% rise in demonetisation; whilst this could seem small, falling income inequality is encouraging as there are links between lower income inequality and less health problems (Rowlingson, 2011), increasing economic growth and an improvement to skills and work proficiency in lower income families (Cingano, 2014). Implications and suggestions for policymakers will be explored in chapter 5 of the paper.

The control variables indicate some significant results which corroborate findings from previous studies: A 1% rise in the proportion of industrial employment as a percent of total employment leads to a reduction in the Gini index by 0.363%, statistically significant (ss) at the 99% confidence level, in line with theory from Kuznets (1955) and Alderson and Nielson (1997). A 1% rise in the number of banks per 100,000 people on average would lead to a 0.023% reduction in the Gini index. This supports the idea that more access to cash and financial inclusion is beneficial for reducing income inequality. Whereas a 1% rise in growth in employment in the high-tech sector leads to a 0.136% rise in the Gini index, ss at 99.9% confidence level. This could be due to the gap between the upper percentiles and the bottom percentiles of earners widening as those in the high-tech industries will be earning vast amounts compared to those in low-skilled industries who will earn the lowest in the economy. Finally, although it is not found to be statistically significant in the favoured model, urbanisation is found to have a large effect on income inequality, a 1% rise in proportion of total population living in urban areas leads to, on average, a rise in the Gini index of 0.599%. This supports the findings from Chen et al. (2016) who concluded that increased urbanisation would cause a rise in income inequality due to marginalisation of those who are unable to find work, and the rise in extremely high-paying jobs which extenuate disparities in pay.

4.2.2 Impact of national economic development

Siregar (2020) and Demir et al. (2020) have found that DFI had different effects for low- to middle-income countries than high-income countries on the Gini index. Following from this work, development has been factored into this paper by performing an additional subset of regressions with a set of income constraints. The definition for a middle-income country is having a GNI per capita of between $1026 and $12,375 (World Bank, 2019), so the new variable GNI per capita was added from the World Bank database and regressions of equation 6) were computed subject to the constraints: High-income, GNI per capita > $12,375 and low & middle income, GNI per capita < $12,375. The results are shown in Table 3.

Table 3 – Effects of country income on regression results

$ln(GINI_{i,t})$	(1) High-income (>$12,375pc)	(2) Low & Middle-Inco me (<$12,375pc)
$L.ln(DEMONETISATION_{i,t})$	-0.0218*** (0.007)	0.343*** (0.043)
Observations	143	19

Standard errors in parentheses
*p<0.100, **p<0.050, ***p<0.010, ****p<0.001
Coefficients to 3 significant Figures
Source: Author's own computation based on data described in section 3.7.
Note: $L.ln(DEMONETISATION_{i,t})$ is the lagged variable of the natural log of demonetisation.

Column (1) of Table 3 shows the results after repeating regression on only high-income countries from the sample. In line with the previous findings in Table 2, demonetisation has a negative correlation with the Gini index, the statistical significance of the coefficient has increased and is now significant at the 99% confidence level. The magnitude of the effect has increased to 0.022.

On the other hand, column (2) of Table 3 is the output when constraining the regression to only middle-income and below countries. The sign is now positive which suggests that increasing demonetisation rates leads to an increase in the Gini index. The size of the effect is also greater, a 1% rise in demonetisation rate leads to a 0.343% increase in the Gini index. This result is also statistically significant at the 99% confidence level. This seems to corroborate the findings that Demir et al. (2020) and Siregar (2020) found when researching the effects of DFI on income inequality. One reason for this could be that in low- and middle-income countries, as cash usage falls, there may not be sufficient alternative financial infrastructure to support those who do not currently have access to online and digital payment methods which leads to worsening income disparities in these countries (Srouji, 2020). Although, it must be noted that there was a small sample size for low- to middle-income countries in this study, as shown in Table 3, this result is computed from only 19 observations and so further research may be required to validate this result in the context of European countries.

To check whether the primary equation, 6), proposed in chapter 3 fits the model correctly, after regression was completed, diagnostic tests were performed through STATA. Firstly, an F test was carried out between the pooled Ordinary

Least Squares (OLS) model, 1), and the Fixed Effects model (FEM), 2). The p-value of this test was 0.000 meaning the added individual effects are significant and so FEM is preferrable over the pooled OLS model. Comparing the models using cluster-robust standard errors (SE) with those using standard SEs, it can be said that the SEs are slightly smaller when robust. They are relatively similar in size though which suggests that heteroscedasticity amongst variables is low.

4.3 Robustness and sensitivity

The findings presented in section 4.2 are useful up to a point though there may be concerns for the reader of reliability. To this end, the model and its variables will be the subject of robustness and sensitivity checks in this section. Firstly, to check whether the relationship between demonetisation and the gini coefficient is robust, a correlation matrix was formed to check for potential multicollinearity between explanatory variables. Variables with any values of correlation above 0.500 were ejected from the model (unemployment, birth rate, GDP per capita and GDP per capita squared) and the regression is repeated, the results are shown in Table 4.

Table 4 – Outputs of model 1) without potentially multicollinear variables

$\ln(GINI_{i,t})$	Coefficient	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
L.Demonetisation	-0.023	0.008	-3.030	0.003	-0.038	-0.008	***
L.Tech growth	0.129	0.032	4.040	0.000	0.066	0.192	****
L.Urban	1.263	0.534	2.370	0.019	0.207	2.320	**
L.Industry	0.035	0.113	0.310	0.758	-0.189	0.259	.
L.Agriculture	0.003	0.035	0.080	0.935	-0.066	0.071	.
L.ATM	0.014	0.041	0.340	0.731	-0.067	0.096	.
L.Banks	-0.057	0.019	-3.050	0.003	-0.093	-0.020	***
Time	-0.009	0.003	-3.710	0.000	-0.014	-0.004	****

Adjusted R-squared	0.961	Observations	161
F-test	938.295	Prob > F	0.000

** p<0.100, ** p<0.050, *** p<0.010, **** p<0.001*
Values to 3 decimal places
Source: Author's own computation based on data described in section 3.7
Notes: L. represents lagged values of variables; all explanatory variables are in natural log form; St. Err. is Standard Error; Conf is Confidence; Sig is statistical significance; SD is Standard Deviation.

Table 4 shows that the coefficient for the natural log of demonetisation has fallen from -0.017 in the original model to -0.023 signifying that the weight of the effect has become greater when removing these variables. A 1% rise in demonetisation in year *t-1* leads, on average, to a fall in the Gini index of 0.023% in year *t*. Additionally, the p-value is smaller, at 0.003, the effect is now significant at the 99% confidence level.

A sensitivity check for the unbalanced nature of the sample is performed; as demonetisation is the main explanatory variable, all observations with empty cells of this variable are removed, and the regression is repeated. The result of this is exactly in line with the results obtained in model 6), all control variables gave the same size (to 3 decimal places) and direction coefficients. Therefore, the unbalanced panel data does not cause issues within the model used in this study.

4.4 Summary and Conclusions

Panel regression of the model set out in chapter 3 has led to the finding that as demonetisation rate increases, income inequality is falling. A 1% increase in demonetisation is correlated with a 0.017 fall in the Gini index in the following year, an indicator that income is becoming more equal in the economy. The null hypothesis that there is no relationship between demonetisation and the Gini index can be rejected at the 95% confidence level. Theory from Yue et al. (2022) suggests that as cash use falls, alternative payment methods may be adopted which would contribute to promoting DFI and in turn increased access to credit markets, these could then be used by individuals to borrow or save funds to put into education, with which they can command higher wages thus constricting income inequality in the region (Kling et al. 2019). When the model was split into two groups, high-income countries and low- to middle-income countries, the effect of demonetisation is found to vary. The high-income group sees a negative relationship with a statistical significance to the 99% confidence level. Meanwhile, the low- to middle-income countries saw a relatively large positive relationship between demonetisation and income inequality, with significance to the 99% confidence level. This is in line with previous findings by Demir et al. (2022) and Siregar (2020). Policy implications and suggestions coming from these results will be discussed in chapter 5.

5 Conclusion

Income inequality, a troubling issue should be a concern to all in society. A growing Gini coefficient is a sign that income disparities are on the rise, those in the lowest wage quintiles are dragged further into despair whilst the highest earners in society enjoy ever growing salaries beyond their needs. Trends have shown that income inequality in Europe is rising steadily (Atkinson, 2015; UN, 2020), and at the same time the level of cash use has been falling (Best, 2022). Therefore, the relationship between the two should be established. Previous studies related to the topic have found links between DFI and income inequality

(Park and Mercado, 2018; Omar and Inaba, 2020) though the nature of the effect is dependent on the level of economic development of the country (Demir et al. 2020; Siregar, 2020). Following from these studies, this paper collates a sample of 29 countries across Europe and data for the Gini index, demonetisation rate and a set of control variables across the time period of 2011-2018 into panel form while contributing to the literature by performing robustness and sensitivity checks, using up-to-date data, and formalising a direct link between demonetisation and income inequality. A series of multivariate regressions are performed to determine the correlation between the demonetisation rate and the Gini index. The paper finds a negative correlation between demonetisation and the Gini coefficient, with a 1% rise in demonetisation resulting in a fall in income inequality of 0.017%. The coefficient has a p-value of 0.032 and so is statistically significant at the 95% confidence level. The economic theory surrounding this proposes that as demonetisation is on the rise, people will tend to adopt alternatives such as FinTech and banking (Yue et al., 2022) which opens up credit lines, this in turn allows people to borrow funds to pay for education and gain employment in higher paying jobs, lowering income inequality (Kling et al. 2019).

A secondary subset of regressions was carried out on two different national economic development groups in the sample: high-income countries (>$12,375 GNI per capita) and low- to middle-income countries (<$12,375 GNI per capita), the results from this were that high-income countries had a negative correlation, coefficient of -0.022, whereas low- to middle-income countries had a positive relationship; a 1% increase in demonetisation rate led to an increase in Gini index of 0.343%. This indicates that those in lower income countries are more at risk of rising income inequality due to the shift towards a cashless point. There were some limitations of the study, limited data availability has reduced the scope of the analysis and the main explanatory variable is an approximation which could induce additional bias into results. Despite this, the drawbacks of these have been mitigated by adapting the model and sample by including fixed-effects analysis and time-lagged values of variables which also help to reduce endogeneity problems.

The main concern for policymakers should be to provide access to digital payment methods. This should be done to ensure that people are not subject to digital exclusion, which is where they are not able to keep up with the technological advancements of the economy, especially regarding finances. A suggestion for policymakers is to provide incentives to those currently relying on cash to adopt digital payment methods, this could be in the form of behavioural nudges (Thaler and Sunstein, 2008) or via government subsidy to open a bank account (for first time consumers). The efficiency of these options would have to be evaluated and compared. Even if the "bucket" leaks (Okun, 1975, pp. 91-95), inequality is of utmost importance and so government intervention is worth the expense, as an improvement can result in healthier workers (Rowlingson, 2011; Klein, 2021), contractions in skill deficiencies and sustained economic growth (Cingano, 2014). As well as encouraging uptake of digital payment use, policymakers should not neglect cash users. Whilst digital payment methods grow, they should not be seen as substitutes, and instead they should be seen as complements until sufficient fundamental digital infrastructure is in place (Srouji, 2020).

This paper is just a step in the right direction, it would be useful for furtherance of the field of income inequality and demonetisation to analyse the effects of regional inequality and the wealth of these regions. To study this in depth, more detailed data would be needed beyond the national level which currently is not available for many of the variables used in this paper. In addition to regional inequality, study could be conducted on the impact of the COVID-19 virus on cash use and income inequality as it has been found that this pandemic accelerated demonetisation in many countries (Wisniewski et al., 2021). This may have impacted the Gini index figures and so give a more informed view into this relationship. Alternatively, there is a small group of papers currently studying the behavioural effects of using digital payment methods instead of cash (Pal and Jain, 2018; Agarwal et al., 2019; Park, 2019; Park, Lee and Thomas, 2021) which could be explored further as they seem to suggest that digital payment methods can lead to overspending and more unhealthy habits due to the virtual nature of transaction.

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