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Removing the Zero Lower Bound on Nominal Interest Rates in the Case of the European Central Bank

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Abstract

Nowadays, Central Banks of developed economies are limited to use their policy rates in recessions due to the existence of the zero lower bound. Since the 2008 financial crisis, unconventional monetary policies have been used to overcome the limits on conventional monetary policy. In a future recession, the available unconventional monetary policy instruments could be insufficient. Hence, the return to conventional monetary policy effectiveness is essential for the Central Banks to be ready for the next recession.

This dissertation outlines a feasible plan for the European Central Bank to remove the zero lower bound in order to be able to implement deeply negative nominal interest rates. The European Union law framework and the technical changes for the implementation of this plan are analysed. Regarding European legislation, the changes seem feasible to implement.

At the technical level, the proposal is for the European Central Bank to dissociate cash from electronic money. Consequently, the European Central Bank would create a dual local currency system through the issuance of a Central Bank Digital Currency (E-euro) and implement a conversion rate between the E-euro and the Euro. Specifically during the period of negative interest rates, the European Central Bank could introduce a two-tier system for remunerating excess reserve holdings of the E-Euro, authorize banks to introduce a spread on conversion rate, subsidize small deposit accounts with zero rates, and use a careful communication strategy.

JEL codes: E42, E43, E44, E52, E58

Keywords: Conventional Monetary Policy, Zero Lower Bound, Negative Interest Rates, European Central Bank

Resumo

Atualmente, os Bancos Centrais das economias mais desenvolvidas estão limitados a usar as suas taxas de juro diretoras em recessões devido à existência da *zero lower bound*. Desde a crise financeira de 2008, políticas monetárias não convencionais têm sido utilizadas para ultrapassar os limites da política monetária convencional. Numa futura recessão, os instrumentos de política monetária não convencional poderão ser insuficientes. Assim, o regresso da eficácia da política monetária convencional é essencial para os Bancos Centrais estarem preparados para a próxima recessão.

Esta dissertação traça um possível plano para o Banco Central Europeu remover a *zero lower bound* a fim de implementar taxas de juro nominais profundamente negativas. São analisados o enquadramento legislativo da União Europeia e as alterações técnicas para a implementação deste plano. No que diz respeito à legislação europeia, as alterações parecem possíveis de serem implementadas.

A nível técnico, a proposta é que o Banco Central Europeu dissocie as notas e moedas metálicas da moeda eletrónica. Consequentemente, o Banco Central Europeu pode criar um sistema dual de moeda local através da emissão de uma Moeda Digital do Banco Central (E-euro) e implementar uma taxa de conversão entre o E-euro e o Euro. Especificamente durante o período de taxas de juro negativas, o Banco Central Europeu pode introduzir um sistema de dois níveis para remunerar o excesso de reservas do E-euro, autorizar os bancos a introduzir um *spread* na taxa de conversão, subsidiar os pequenos depósitos com taxas de juro zero e usar uma estratégia de comunicação cuidadosa.

Códigos JEL: E42, E43, E44, E52, E58

Palavras-chave: Política Monetária Convencional, *Zero Lower Bound*, Taxas de Juro Negativas, Banco Central Europeu

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List of Abbreviations and Acronyms

BIS	Bank for International Settlements
BoE	Bank of England
BoJ	Bank of Japan
CBDC	Central Bank Digital Currency
CNB	Czech National Bank
DNB	Danmarks Nationalbank
EC	European Commission
ECB	European Central Bank
ELB	Effective Lower Bound
EU	European Union
Fed	Federal Reserve
IMF	International Monetary Fund
MNB	Central Bank of Hungary
MRO	Main Refinancing Operations
NIRP	Negative Interest Rate Policies
QE	Quantitative Easing
SNB	Swiss National Bank
US	United States
ZLB	Zero Lower Bound

1. Introduction

Central banks conduct monetary policy to achieve macroeconomic objectives[1] that promote sustainable economic growth. Conventional monetary policy involves the management of money supply and interest rates to respond to economic shocks, to stimulate the output of the economy and to achieve the objectives set by the monetary policy authorities. In developed economies, the price stability and the guarantee of a stable financial system are the main objectives of a Central Bank.

During the 2008 financial crisis, Central Banks cut sharply their interest rates to respond to this shock and to sustain the economy. In the advanced economies, interest rates reached historically low levels of zero or near-zero. In the years following this crisis, Central Banks of these economies implemented different instruments of unconventional monetary policy to fight this recession in alternative to cuts on nominal interest rates. According to Bernanke (2020), a combination of quantitative easing and forward guidance can provide the equivalent of 300 basis points of policy space. At the same time, some economies experienced periods of negative interest rates. In recent years, advanced country Central Banks have raised or were considering raising interest rates (Agarwal & Kimball, 2019). However, the shock caused by the coronavirus pandemic has forced Central Banks to back down in their decisions and some have cut their interest rates even further.

Business cycle downturns are inevitable and the future is full of opportunities for them to occur. The Great Lockdown[2] shows us that recessions could occur rapidly with historical and severe impacts in the global economy. According to Agarwal and Kimball (2019), policy rates have been cut by 500-600 basis points during recessions in advanced countries. At present, policy rates in more advanced countries are close to zero to make cuts of that dimension. The existence of the nominal zero lower bound (ZLB) makes it impossible for Central Banks to enter deeply into negative territory and to implement negative interest rates. In most major industrial economies, short-term nominal interest rate – policy rate – is the conventional instrument of monetary

[1] In a report of the Bank for International Settlements (BIS, 2009), price stability is the dominant legal objective in 33 of the 45 central banks studied. Other objectives referred in the central banks' legislation are related to economic growth, financial stability, full employment, and stable exchange rates.

[2] "The Great Lockdown" term was used by the IMF in April 14, 2020 to refer to quarantines and social distancing practices implemented around the world to contain the coronavirus pandemic. See IMF (2020).

policy (Bernanke, Reinhart, & Sack, 2004). At the same time, the existence of cash (coins and banknotes) – which pays a nominal interest rate of zero – makes it impossible for short-term nominal interest rates to be pushed below zero. At this point, the economy as a whole faces a liquidity trap and, hence, the conventional monetary policy loses its capacity to promote economic growth. According to Krugman (1998), as the nominal interest rate is essentially zero, economic agents consider money – cash, bank deposits, and reserves – and bonds as perfect substitutes. Consequently, the zero lower bound turns out to be a limitation on the conduct of conventional monetary policy during severe recessions. This dissertation addresses the removal of the zero lower bound on nominal interest rates.

Unconventional monetary policy could be insufficient to face a severe economic downturn. The return to full capacity conventional monetary policy is a necessary condition for Central Banks to face a recession with the same capacity as in the past. Removing the zero lower bound on nominal interest rates is needed, even if unconventional monetary policy instruments remain available. This dissertation will review the proposals for removing the zero lower bound on nominal interest rates that exist in the literature. The state-of-the-art on these proposals is still insufficiently systematized, despite the great attention that has been given to this topic by academia. The pros and cons of each proposal will be evaluated with a view to compare their prospective effectiveness. In addition, at the moment, it does not seem that exist an explicit action plan by the European Central Bank (ECB) to face an economic recession in the context of the zero lower bound through the use of policy rates. Following the systematic review of these proposals, the feasibility of removing the zero lower bound on nominal interest rates by the European Central Bank will addressed through an outline of the necessary legal and technical steps.

The dissertation proceeds as follows. In Chapter 2, after the Introduction, the problem of the zero lower bound is briefly explained through well known literature contributions based on the IS-LM model and the 3-equation New Keynesian model. Chapter 3 introduces the different proposals for removing the zero lower bound on nominal interest rates and confronts their pros and cons. Chapter 4 outlines a feasible plan with the changes in European Union legislation and the technical implementation of a possible proposal to remove the zero lower bound by the European Central Bank. Finally, in the Conclusion, the main remarks and some limitations of this dissertation are exposed.

2. The Zero Lower Bound Problem

The existence of a zero lower bound on nominal interest rates was considered as a problem of the past, mainly in the United States during the years of the Great Depression (1929-1930s) (Ullersma, 2002). During these years, the United States faced the risk of the monetary policy being constrained by the zero lower bound on the main policy rate. Nevertheless, the attention given to the ZLB problem by economists disappeared from academia in the following decades.

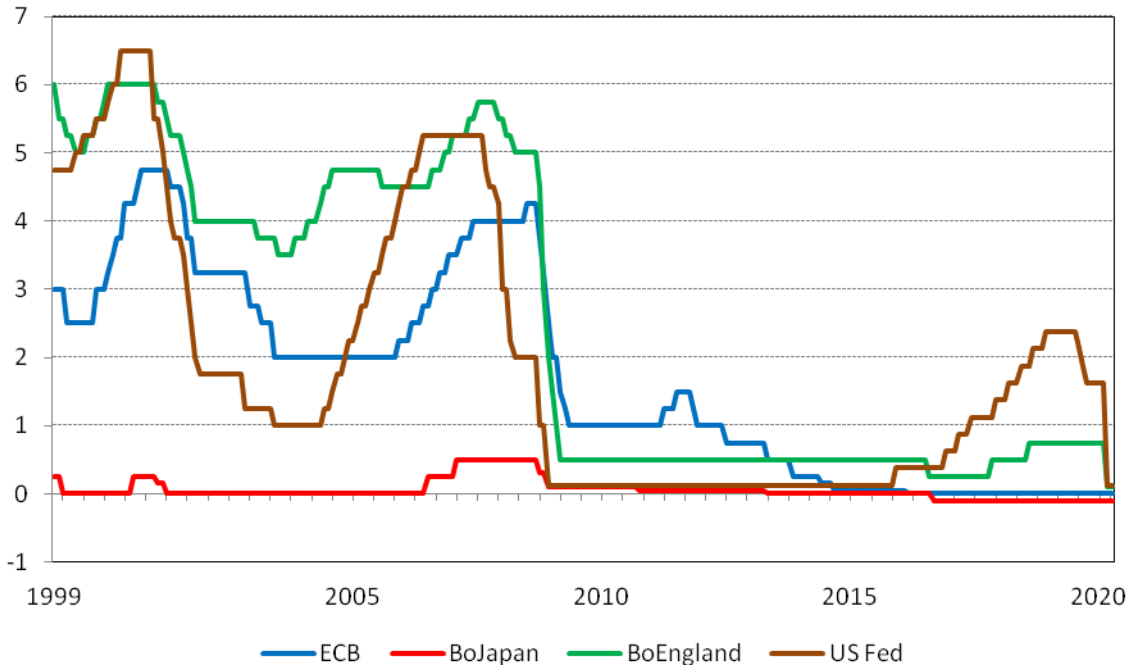
In the 1970s, the collapse of the Bretton Woods system and the two oil shocks caused a decade of higher inflation in the industrialised economies. After the inflationary waves, the 1980s and 1990s were marked by a low but stable inflation rate. Therefore, the monetary policy authorities of advanced economies were able to achieve the most desired objective, price stability. At the same time, the fall in the inflation rate coincided with a decline in the monetary policy interest rates (Ullersma, 2002).

The period of economic stagnation in Japan during the 1990s revived the attention to the zero lower bound problem within academia. The ZLB was seen for some generations of economists as a "relic of the Depression era" (Bernanke et al., 2004). However, a new era of monetary policy began in advanced economies. Consequently, the ZLB became more than an academic concern (Goodfriend, 2000). In Japan, the strategy assembled by the Bank of Japan (BoJ) to fight the chronic deflation led to the short-term nominal interest rate being close to the zero level. As shown in Figure 1, this situation has been perpetuated during the last decades, and nowadays, this policy rate is slightly negative. According to Krugman (1998, 1999b) and Svensson (2000) (*apud* Ullersma, 2002), a similar situation could occur in the US and the Euro area. The reason for this statement was the structural decline in nominal interest rates in the 1980s and 1990s.

The 2008 financial crisis brought the first signs that the economies of Eastern Europe and the USA could face the ZLB problem. The massive cuts of the short-term nominal interest rate led to the major Central Banks being constrained by the ZLB. In Figure 1, the years following the financial crisis were marked by policy rates in a range between 1 % and 0 %. In the same period, some small European economies – Denmark, Sweden and Switzerland – experienced periods of negative nominal interest rates.

In recent years, the Bank of England and the US Federal Reserve initiated a trajectory of normalization of monetary policy by raising their policy rates, as shown in Figure 1. The 2012 sovereign debts crisis in the Euro area forced the ECB to maintain the policy rate at a zero level. However, the unexpected and asymmetrical shock caused by the coronavirus pandemic forced all intents of raising monetary policy rates to be dropped. The Great Lockdown led all Central Banks in advanced economies to cut policy rates that were still on positive territory. Therefore, it can be seen in Figure 1 that all major Central Banks are now facing the zero lower bound problem within their economies.

Figure 1. Monetary policy rates[3] of major Central Banks



Source: BIS (2020)

Chapter 2 is divided into three sections. Section 2.1 proceeds to the identification of the zero lower bound and the liquidity trap through the IS-LM model. Section 2.2 explores the deflation trap according to the 3-equation model. Section 2.3 follows the article of Ullersma (2002) in order to expose the four approaches of dealing with the ZLB.

[3] The monetary policy rates mentioned in Figure 1 refer to: interest rate of the main refinancing operations (ECB); interest rate applied to the complementary deposit facility (BoJapan); bank rate (BoEngland); Fed funds target (US Fed).

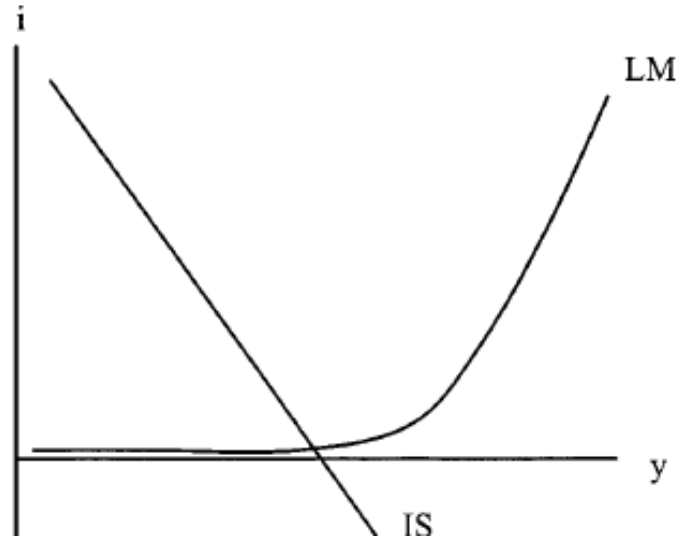
2.1. The IS-LM model: from the past to the present

The first reference to the presence of the zero lower bound on nominal interest rates appears in the literature by Fisher (1896). Irving Fisher identified that the existence of money which could be hoarded – without costs and risks – makes it impossible for the interest rate in money to fall below zero.

Four decades later, the existence of a liquidity trap problem in monetary policy is introduced in the literature by the work of Keynes (1936). According to Keynes, it is possible that the interest rate (short-term nominal interest rate) falls to a certain level – zero bound – where the preference for liquidity is "virtually absolute" when the majority of economic agents prefer to detain their wealth in the form of cash than hold bonds with "yields so low a rate of interest". At this point, the monetary policy authority loses its effective control over the interest rates. In consequence, the Central Bank intends to stimulate the economy through the increase of money supply, but without any effect on interest rates. Despite the efforts of the Central Bank, economic agents prefer to hold the additional liquidity in cash than use this in consumption and investment. According to Krugman (1998), a liquidity trap occurs within the economy because economic agents consider bonds and money as perfect substitutes. In this situation, it is indifferent for economic agents to hold cash or bonds, as the return of these assets is practically equal. Therefore, the rationale behind this behaviour is that economic agents prefer to hold a liquid asset – cash – with a nominal interest rate of zero rather than hold a less liquid asset – bonds – which may have a negative nominal interest rate.

The IS-LM model was developed by Hicks (1937) as a mathematical interpretation of the macroeconomic theory presented in the work of Keynes (1936), later extended and popularized within academia through the work of Hansen (1953). The IS curve correlates aggregate demand with the nominal interest rate, which ensures equilibrium in the market of goods and services, considering the remaining variables constant. The LM curve results from combinations of the nominal interest rate and aggregate demand that guarantee equilibrium in the money market. Thus, changes in monetary policy shift the LM curve, while fiscal policy shift the IS curve (Krugman, 2000). The intersection of the IS curve and the LM curve represents the simultaneous equilibrium in money and goods markets.

Figure 2. IS-LM model and the liquidity trap



Source: Krugman (2000)

Through the representation of the IS-LM model, it is possible to observe the ineffectiveness of conventional monetary policy in a situation of zero lower bound with a liquidity trap. During a downturn, monetary policy authorities reduce the short-term nominal interest rate to stimulate aggregate demand. However, when the policy rate hits the zero level, the Central Bank faces the zero lower bound problem. The nominal interest rate cannot be negative. Otherwise, cash would dominate bonds as an asset (Krugman, 2000). As said above, cash and bonds become perfect substitutes. Demand for cash becomes infinitely elastic and the leftmost parts of the LM curve are flat. Considering that the intersection of the IS curve and the LM curve occurs in the flat region as shown in Figure 2, then changes in money supply – which moves the LM curve to the right – will have no effect on the nominal interest rate. Monetary policy is ineffective and the economy enters a liquidity trap. Therefore, successive increases in money supply increase the liquidity of the economy without any effect on the output or interest rates.

In the next section, following closely the 3-equation New Keynesian model presented by Carlin and Soskice (2015), the danger of an economy entering into a deflation trap will be discussed. At the same time, there will be a focus on understanding how the existence of a zero lower bound could lead an economy to be stuck in a deflationary spiral.

2.2. The danger of a deflation trap

Central Banks pursue the objective of price stability in their economies. For this, they set a target for the inflation rate at a low but positive level of 2%, for example. This allows for the desired price stability, as well as avoiding the risk of an economy to fall into a deflation trap.

A deflation trap can emerge in an economic downturn. In a situation of a weak aggregate demand, the Central Bank reduces the nominal interest rate to stimulate aggregate demand through investment and consumption. However, problems arise due to the existence of the zero lower bound. It may be the case that the required real interest rate to stabilize aggregate demand cannot be achieved since the nominal interest rate cannot be reduced below the zero level. Consequently, conventional monetary policy becomes ineffective to stimulate aggregate demand.

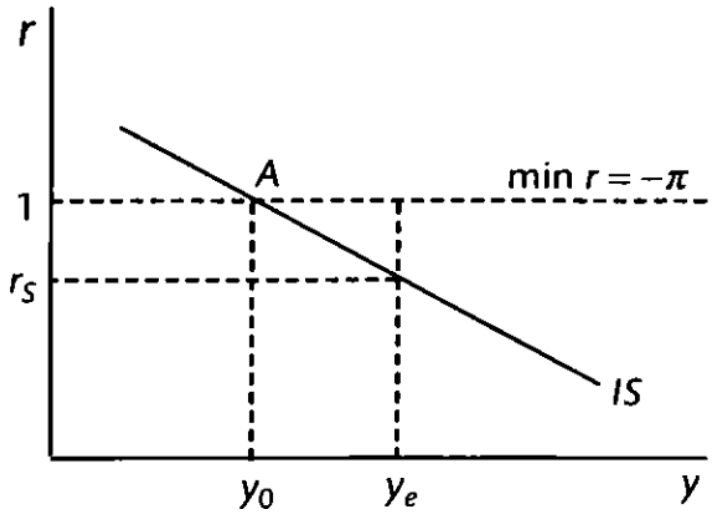
In order to understand how a deflation trap could emerge, the use of the Fisher equation is essential. The equation describes the relationship between the nominal and real interest rates and the expected rate of inflation, as shown below:

$$i = r + \pi^E$$

The Central Bank responds to an economic shock by adjusting the nominal interest rate (i) in order to affect the real interest rate (r) and, lastly, to affect the aggregate demand through the IS curve. In order to do this, the Central Bank takes into account the expected rate of inflation. Neverthelss, as explained in the last section, the nominal interest rate cannot fall below zero. Therefore, if $\min i = 0$, then $\min r \geq -\pi^E$.

Figure 3 shows a situation where the economy is facing the zero lower bound on nominal interest rates. Considering Fisher's equation and an expected inflation rate of -1%, the minimum real interest rate (r) attainable is 1%. However, the stabilizing real interest rate (r_s) is below the minimum achievable rate of 1%, and then the economy is at point A with an output of y_0. Attending to the position of the IS curve, the optimal point of the economy should be the point with the real interest rate of r_s and the output of y_E. However, this is not possible because r cannot be reduced below 1%. Therefore, conventional monetary policy is ineffective to achieve the equilibrium level and the economy is stuck at point A with a depressed level of output (y_0).

Figure 3. The Zero Lower Bound on the nominal interest rate



Source: Carlin and Soskice (2015)

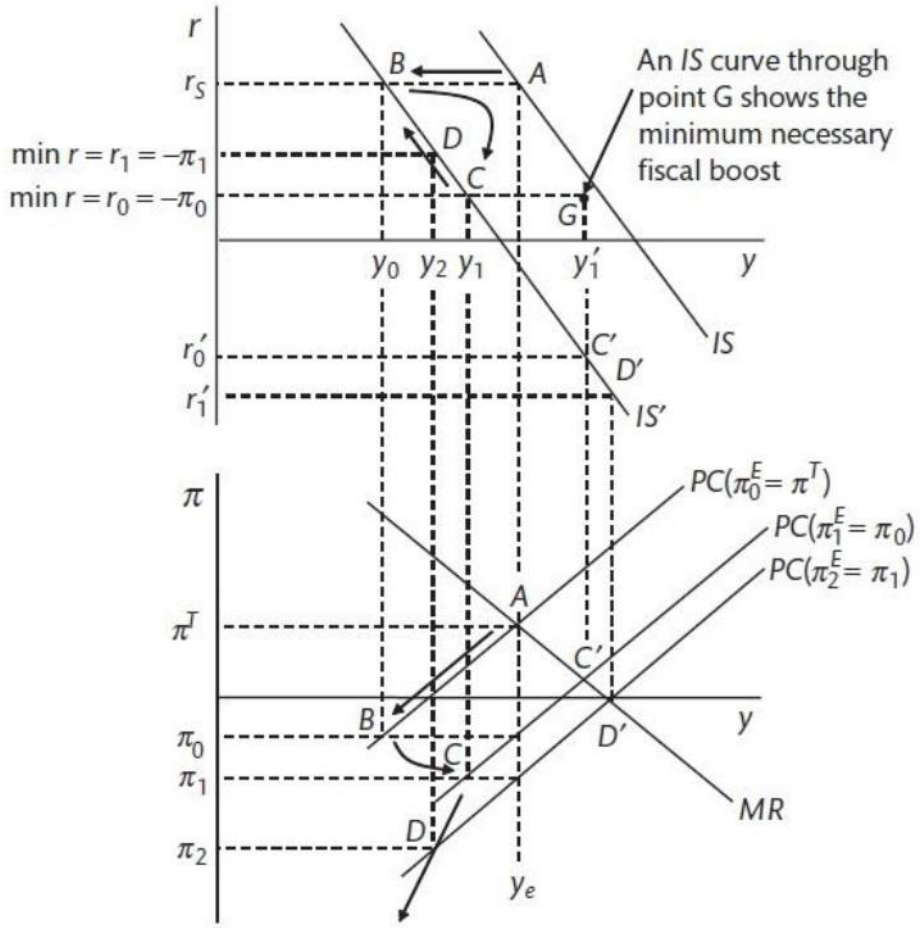
The perpetuation of a weak aggregate demand situation will lead to even more negative inflation rate expectations and, on the other hand, to a higher real interest rate. In some cases, the real interest rate could be too high to stimulate private sector demand and to get the economy back to equilibrium (Carlin & Soskice, 2015). However, this situation is the opposite of what monetary authorities want to achieve, which is a sufficient reduction in real interest rates to avoid the deflation trap.

The 3-equation New Keynesian model (Carlin & Soskice, 2015), is a useful tool to observe how the zero lower bound on nominal interest rates could set a tremendous danger for an economy to enter into a deflation trap. Moreover, this model can help explain situations in which a negative aggregate demand shock can lead to the same effect.

Figure 4 represents the IS curve in the upper panel and the Philips curve (PC) in conjunction with the Monetary Rule curve (MR) in the lower panel. In period 0, the economy starts at point A. The economy is hit by a large and permanent negative shock in aggregate demand which shifts the IS curve to the IS' curve and the economy moves from point A to point B, as shown in Figure 4. The shock has reduced the output of the economy ($y_0 < y_e$) and inflation ($\pi_0 < \pi^T$). Indeed, inflation becomes negative (deflation), and then, point B is not on the Central Bank's Monetary Rule curve. The MR curve shows the optimal way in which the Central Bank responds to shocks, considering its objectives/preferences. Given its position regarding the Phillips curve trade-off, the MR

curve constitutes the desired combination of output and inflation that minimize the Central Bank's loss function. In other words, the MR curve represents the monetary policy of the Central Bank. Given the forecasted Phillips curve (PC) ($\pi_1^E = \pi_0$), the Central Bank wants to choose the optimal point C' on their MR curve, which requires setting a real interest rate of r_0'. However, r_0' is below the minimum real interest rate that can be achieved by setting a nominal interest rate of zero. Consequently, the Central Bank can only achieve $r_0 = -\pi_0$. Thus, the economy ends period 0 with inflation at π_0, output at y_0 and real interest rate at r_0.

Figure 4. The Deflation Trap and the 3-equation New Keynesian model



Source: Carlin and Soskice (2015)

In period 1, the lower r_0 boots investment and increases output. However, output is still below the equilibrium at y_1 and the economy moves to point C, as shown in Figure 4. This level of output is far from the optimal point of y_1', which leads inflation to fall to π_1.

The Central Bank's forecasts for the next period are that the Phillips curve will move to PC ($\pi_2^E = \pi_1$). Considering this PC, then the optimal point is D', back on the MR curve, which requires setting the real interest rate at r_1'. Nevertheless, the Central Bank can only achieve $r_1 = -\pi_1$, considering the restriction of the zero nominal interest rate. Thus, the economy ends period 1 with inflation at π_1, output at y_1 and real interest rate at r_1.

From period 2 onwards, the higher r_1 dampens aggregate demand and reduces output (y_2) and inflation (π_2), which causes the economy to move to point D, as shown in Figure 4. When this happens, the economy enters into a deflation trap. In each future period, inflation falls further, which leads to a continuous increase in the minimum real interest rate (min r) that the Central Bank can achieve. Consequently, a higher real interest rate causes a reduction in the output. Thus, the higher the reduction in aggregate demand, the higher the inflation fall. In other words, the economy is caught in a vicious cycle and conventional monetary policy is ineffective to stop this deflationary spiral in the economy. As shown in Figure 4, the economy will not return to its medium-run equilibrium through conventional monetary policy. Therefore, the danger of a deflationary spiral in an economy explains why policy makers strive to avoid this situation (Carlin & Soskice, 2015).

The deflationary spiral situation could be avoided if the real interest rate was negative in period 0. However, this is not possible due to the existence of the zero lower bound. Through the IS-LM model and the 3-equation New Keynesian model, it was possible to recognize that the existence of the zero lower bound on nominal interest rates constrains conventional monetary policy and limits the capacity of Central Banks to act in an economic downturn. Therefore, in order to solve this issue with the zero lower bound, the economy can either hope for an uncertain positive shock (fiscal, private or external) in the aggregate demand, or actions should be taken to overcome the zero lower bound problem (Buiter & Panigirtzoglou, 2003).

2.3. Dealing with the zero lower bound problem

In a situation where the Central Bank is bounded by the zero lower bound, the need for concrete solutions is necessary to restore the full capacity of monetary policy. Ullersma (2002) describes four approaches present in the literature to deal with the ZLB

problem – Krugman's view, Meltzer's monetarist view, Svensson's "foolproof" way, and the abolition of the zero bound.

Regarding Japan's liquidity trap, Krugman (1998) argues that raising inflation expectations is a way for the Japanese economy and other economies to overcome the zero lower bound problem. A few years before, Summers (1991) stated that a low level of average inflation and a low level of inflation expectations imply a low short-term nominal interest rate. Hence, a higher inflation target can reduce the real interest rate and boost Japan's economic performance. However, Krugman's idea of implementation could be impossible to perform. According to Buiter and Panigirtzoglou (1999), creating inflation expectations when economic agents believe in the commitment to price stability by the monetary policy authorities can lead to a loss of confidence. In addition, the simple announcement of an inflation target is not enough to improve inflation expectations (Svensson, 2000). This idea requires a complete and extensive communication policy by the Central Bank. Nevertheless, if the Central Bank's credibility is affected by the change in the monetary policy's objective, then the confidence of economic agents in the commitment to higher inflation will be viewed with suspicion.

Meltzer's monetarist view is another approach to deal with the zero lower bound problem. Monetarists argue that monetary easing can still be successful with short-term nominal interest rates in a context of the zero lower bound. This view of the relevance of monetary transmission channel differs from other transmission channels that "focus on the transmission mechanisms of monetary policy through relative price adjustments of non-monetary assets that are imperfect substitutes in investors' portfolios" (Ullersma, 2002). Other monetarists focused on the importance of the credit channel in the monetary policy transmission process (Bernanke & Gertler (1995), (apud Ullersma, 2002)). However, Ullersma draws attention to the issue of credibility. Monetary easing will only be effective if economic agents have confidence in the future. Otherwise, the liquidity provided for monetary easing will be hoarded instead of used in investment and consumption. Consequently, the economy could be caught in a liquidity trap.

The Svensson's "foolproof" way is in line with the monetarist view. Svensson (2000) includes the use of the exchange rate channel as a solution when the economy is constrained by the zero lower bound. The idea is to devaluate/depreciate the currency in order to increase inflation expectations, then the exchange rate becomes the main

monetary policy instrument. At the same time, this strategy requires the adoption of a price-level target and a temporary exchange rate peg to avoid an economic overheating. However, Svensson's "foolproof" way has some problems. In a first path, the expected real exchange rate depreciation will raise real interest rates with limited maturities relative to global real interest rates (Swank (2001), (*apud* Ullersma, 2002)). Another problem is the risk of retaliation by the trading partners' economies putting in danger the monetary policy strategy. The devaluation/depreciation of currency can be understood by its trading partners' economies as an attempt to make the exports of this economy more competitive in the international market. Therefore, if trading partners' economies also want to devaluate/depreciate their currency to maintain their competitiveness, then the use of the exchange rate channel could become ineffective to overcome the zero lower bound.

Finally, the solution of the abolishing the zero bound is presented by Ullersma (2002) through the "so-called Gesell money" explored in the works of Buiter and Panigirtzoglou (1999), and Goodfriend (2000). This concept and other proposals to remove the zero lower bound on nominal interest rates are presented in more detail in Chapter 3.

3. Proposals to Remove the Zero Lower Bound on Nominal Interest Rates

Central Banks have no upper limits for their policy rate, but they cannot go far beyond the lower limit of zero. The existence of the zero lower bound restricts the use of the conventional monetary policy. According to Fisher (1930), if a commodity could be stored without costs over time, then the rate of interest could never fall below zero. Economic agents would prefer to hold cash with a zero nominal return instead of having an asset with a negative nominal interest rate. Therefore, cash is the reason why nominal interest rates fail to go below zero.

In the years following the 2008 financial crisis, Central Banks in advanced economies implemented unconventional monetary policies – quantitative easing (QE), credit easing, and forward guidance – to overcome the limits on conventional monetary policy imposed by the zero lower bound on short-term nominal interest rates. According to Bernanke (2020), quantitative easing and forward guidance proved effective in providing the equivalent of 300 basis points of policy space during periods in which policy rates were constrained by the zero lower bound. Nevertheless, according to Agarwal and Kimball (2019), policy rates have been cut by 500-600 basis points during recessions in advanced economies. Following model simulations, Williams (2009) claims that an additional 400 basis points of policy rate cuts following the 2008 financial crisis would have brought unemployment and inflation to steady-state values more quickly in the US economy. However, the existence of the zero lower bound does not allow these actions. According to Williams, the limitation of the zero lower bound would have had a cost of $1.8 trillion in forgone US output over the four years that followed the 2008 financial crisis.

Elbourne, Ji, and Duijndam (2018) defend that unconventional monetary policy shocks have relatively small effects on output and inflation in the Euro area. Kocherlakota (2019) raises some concerns about the effectiveness of forward guidance and quantitative easing during long periods when an economy is stuck at the lower bound. Moreover, the author makes some considerations about the increase of the inflation target, as such announcement could affect the credibility of the Central Bank. These concerns are also shared by Rogoff (2016, 2017b). Furthermore, the implementation of quantitative easing

could face some challenges in the future. The assets available to be purchased by the Central Bank are limited and their investment quality decreased during recessions. Consequently, Central Banks may have to accept riskier assets in order to proceed with their purchases. Thus, the increase of Central Banks' balance sheets with riskier assets could affect financial stability.

Unconventional monetary policy tools helped economies to sustain the output and to avoid deflation in recent years. However, in a recession, these tools might not be sufficient for Central Banks to achieve their inflation targets and to stimulate the output. As seen above, the 300 basis points that unconventional monetary policy tools have replaced in nominal interest rates cuts may not be enough in a recession. As stated by Ellison and Tischbirek (2014), Central Banks are better able to stabilize output and inflation with an adequate coordination of conventional and unconventional monetary policy instruments. Therefore, monetary policy cannot be made only with unconventional monetary policy instruments. In developed economies, the return of conventional monetary policy to Central Banks is increasingly necessary for the preparedness for a next recession. Thus, deeply negative nominal interest rates are an increasingly necessary instrument in the toolbox of Central Banks. As stated by Rogoff (2017b), breaking the zero lower bound will not make "an aging economy young, nor will it transform an economy with low productivity growth into a powerhouse of innovations". Nevertheless, deeply negative nominal interest rates are necessary to provide Central Banks with sufficient ammunition to fight deep recessions.

Chapter 3 is divided into five sections. In section one, the recent experiences with negative interest rates are assessed based on contributes present in the literature. The following three sections proceed to review of the proposals to remove the zero lower bound on nominal interest rates. Each of these three sections includes a confrontation of the main pros and cons of the implementation of the proposal under review. Section five addresses the effectiveness of each proposal, as well as some estimates of costs and benefits involved.

3.1. Recent Experiences with Negative Nominal Interest Rates

In recent years, the Danmarks Nationalbank (DNB), the European Central Bank, the Swiss National Bank (SNB), the Swedish Riksbank, the Bank of Japan, and the Central Bank of Hungary (MNB) implemented negative interest rate policies (NIRP) to provide additional monetary policy stimulus (Arteta, Kose, Stocker, & Taskin, 2018). The goal of these Central Banks was to explore the lower limits of short-term nominal interest rates.

The data suggests that the policy rates that had passed to negative territory failed to pass-through to deposits and lending rates, and there was even an increase in the latter (Bech and Malkhozov (2016); Eggertsson, Juelsrud, and Wold (2017); Eggertsson, Juelsrud, Summers, and Wold (2019)). Negative nominal interest rates can reduce bank profits and aggregate output. According to Brunnermeier and Koby (2018), this contractionary effect in lending occurs when "banks' assets revaluation from duration mismatch is more than offset by decreases in net interest income on new businesses, lowering banks' net worth and tightening their capital constraints". However, Jobst and Lin (2016), Arteta et al. (2018), and Lopez, Rose, and Spiegel (2020) argue that the effect of NIRP had limited effects on bank profitability and financial stability. Furthermore, negative interest rates had a positive impact on aggregate output through the reduction on bank funding costs and the increase in asset prices. Honda and Inoue (2019) declare that the introduction of the NIRP in January 2016 had significant expansionary effects on the Japanese economy. Therefore, there is no clear unanimity in the literature about the effects of recent experiences with negative nominal interest rates.

These recent experiences showed the possibility that the lower limit of the nominal interest rates could be below zero. The empirical findings of Witmer and Yang (2016), and Kolcunova and Havranek (2018) consider that the Effective Lower Bound (ELB) could be negative due to all costs of insuring, storing and transporting of the physical banknotes and coins. However, the focus should be on the problem of cash holdings, which limit Central Banks' capacity to set their policy rate in negative territory as much as sometimes is necessary. Therefore, the mainstream literature continues to refer to the problem as the zero lower bound, even after taking into account that the actual lower limit may be somewhat below zero.

During the NIRP experiments, negative interest rates have probably never exceeded the effective lower bound of the respective economies. Consequently, the reaction of economic agents to these negative rates might have been the same if the cut in interest rates had happened on positive territory. As stated by Lilley and Rogoff (2019), no country has made changes that allow the implementation of deeply negative interest rates of minus 200 basis points or more. Moreover, these moves were implemented within existing operational frameworks (Bech & Malkhozov, 2016). Thus, the recent experiences of negative interest rates should not be considered as effectively removing the ZLB.

The following there sections proceed to review of the proposals to effectively remove the zero lower bound on nominal interest rates. A brief introduction of these proposals and their authors is presented in Table 1.

Table 1. Summary description of the proposals to remove the zero lower bound

Proposals	**Brief definition**	**Authors**
Tax on Base Money	The tax on base money follows the concept of "stamped currency" proposed by Silvio Gesell. The tax is intended to extend negative nominal interest rates to base money in order to avoid the hoarding of cash.	Gesell (1916) Goodfriend (2000) Buiter (2009) Mankiw (2009)
Complete or Partial Abolishment of Cash	The complete abolishment of cash aims to remove all banknotes and coins, while the partial version only removes high-denomination banknotes.	Buiter (2009) Rogoff (2015, 2016, 2017c)
Dissociating Cash from Electronic Money	The idea of decoupling cash from electronic money intends to separate the different functions of money. In a dual local currency system, cash acts as a medium of exchange and unit of account, and electronic money serves as a unit of account.	Eisler (1932) Buiter (2009) Agarwal and Kimball (2015)

Source: Author's elaboration

3.2. Tax on Base Money

3.2.1. Concept and historical framework

The idea of a tax on base money – cash and commercial bank deposits held in the Central Bank's reserves – to overcome the zero lower bound is not a novelty. Gesell (1916) introduced this proposal through the concept of "stamped currency". The proposal has been supported by Fisher (1933) and Keynes (1936) in the context of the Great Depression.

According to Gesell's proposal, the "paper-money currency" loses part of its face value every week. In order to keep the face value, the holder needs to attach a stamp to the banknote. The stamp is nothing more than a fee equal to the depreciation rate of the "paper-money currency" during the period considered. The intention of Gesell's proposal is to avoid economic agents to hold money at home, instead of using it on consumption and investment. Economic agents have an incentive to use the "paper-money currency" before the time limit and, at the same time, to avoid the taxation. Consequently, this leads to a negative rate of return and the negative nominal interest rates are transmitted to the whole economy. Then, with the lower limit of zero removed, Central Banks could use conventional monetary policy to revive borrowing and to stimulate aggregate demand (Ilgmann & Menner, 2011).

In the small Austrian town of Wörgl, the town's mayor Michael Unterguggenberger implemented an experiment based on the monetary theories of Gesell in mid 1932. The town faced an enormous local unemployment during the Great Depression. The experiment started with the issuing of "Certified Compensation Bills". The holders of these bills should buy a special stamp every month to put on the note in order to keep its face value (Helleiner, 2003). The idea was according to the concept of "stamped currency" proposed by Gesell (1916). In order to avoid the payment of the stamp, economic agents spent the notes quickly by paying the periodic taxes earlier. Therefore, the rapid circulation of the notes generated a tremendous economic boom with an increase in government projects, employment and economic activity throughout the town. The experiment was known as the "Miracle of Wörgl". However, this experiment ended abruptly after the intervention of the Austrian National Bank on September 1, 1933.

Gesell's proposal was forgotten for many decades. However, the interest in "taxing money" was renewed through Japan's Experience in the 1990's, when conventional monetary policy was innefective in fighting deflation and recession (Ilgmann & Menner, 2011). In recent literature, some authors advocated that Gesell's proposal of tax on base money could be a solution to overcome the zero lower bound on nominal interest rates (Buiter and Panigirtzoglou (1999, 2003), Goodfriend (2000), Fukao (2005), Buiter (2005, 2009)). At the same time, a "carry tax on money" would also help to escape or even to avoid a liquidity trap.

Goodfriend (2000) proposed that the floor of the short-term nominal interest rate should be determined by the "carry tax on money". During a period when the short-term nominal interest rate is pressed against the lower limit, the Central Bank could adjust the "carry tax on money" as much as necessary. Goodfriend highlights that the "carry tax" should be implemented in the same way on electronic form of money (bank reserves and bank deposits) and on physical form of money (cash). Otherwise, banks would store reserves as vault cash and people would not lend money if the negative interest rate on loans was higher than the cost of storing cash. In order to implement the "carry tax" on all forms of money, Goodfriend suggests that a magnetic strip must be attached in each banknote. The objective is that the magnetic strip records the moment at which the banknote was withdrawn from the banking system. Then, when the banknote is deposited again, the "carry tax" is paid according to the time it has been in circulation.

Another variant to Goodfriend's idea is to give an expiration date to each banknote (Buiter, 2009). After the expiration date, the banknotes would no longer be accepted in transactions. Mankiw (2009) explored the operational implementation of this variant through a lottery scheme based on the serial numbers of the banknotes. On a specific day of the year, the Central Bank would randomly choose a number between 0 and 9. Then, all banknotes ending in that number would be worthless.

Fukao (2005) proposed a version of Gesell's proposal to promote Japan's economic recovery and escape from the deflation trap. The tax should not be applied only on base money, but on all government-backed financial assets such as government bonds, postal savings or cash. Furthermore, stamps on banknotes should be replaced by a fee applied during the exchange of old banknotes with new ones.

3.2.2. Pros and Cons of Tax on Base Money

The main advantage of applying a tax on base money is to remove the zero lower bound. At the same time, this proposal avoids the possibility of a liquidity trap occurring and the dangers of an economy to enter into a deflation trap. According to Menner (2011), these are not the only advantages of a tax on base money. The "Gesell tax" increases the monetary efficiency with a maximization of consumption, investment, output, steady state capital stock, and welfare at moderate levels. Menner advocates that in a recession scenario, a tax on base money could have the same effect as large fiscal stimulus, but without the effects of the crowding out of private consumption and investment.

The implementation of a tax on base money faces some challenges. Keynes (1936) warns that the tax may be impractical if base money is not the only asset to provide liquidity services. Imposing a tax on base money could lead economic agents to substitute base money for assets such as foreign money, jewellery or precious metals. However, Goodfriend (2000) advocated that Keynes thought in terms of a permanent tax. The tax should be seen as a temporary measure. In order to be effective and less onerous, the tax on base money would be imposed if the monetary policy becomes constrained by the zero lower bound. The implementation period should be short and relatively infrequent in time. Otherwise, the tax could be seen as permanent. Then, it could not occur the necessary spending and lending to boost aggregate demand and, finally, increase inflation expectations. At the same time, Goodfriend makes a comparison between the tax on base money and inflation. During decades, "currency and noninterest bearing deposits" were taxed by inflation and reserve requirements, but were never replaced as medium of exchange. Therefore, following the requirements of a short and occasional tax, the risk of base money being replaced by other assets to provide liquidity services is minimized.

Dahlberg (1938) draws attention to the illegality of the proposal. In some jurisdictions, the implementation of a tax on base money could require a review of the legislation. Economic agents are quite resistant to legislative changes that involve new taxes. However, considering the economic and social consequences of a deflation trap, the resistance of the public and legislators to change laws will be quickly overcome.

Hart (1948) alerts to the fact that the negative nominal interest rates might be hard to be accept by the public. The public can find strategies to avoid paying the tax. Considering the idea of a magnetic strip proposed by Goodfriend (2000), it may not be effective if economic agents know when the banknotes were withdrawn. Indeed, they will avoid depositing these banknotes in order not to pay the tax on base money.

Goodfriend (2000) draws attention to two more concerns. The first is the regressivity of the tax. However, Goodfriend states that the taxation must occur from a certain level. Below this level, people would be exempted from the negative interest consequences of the tax through a government rebate financed out of the tax proceeds. The second concern is the effects on private wealth, mainly of the elderly. In order to avoid this, Goodfriend defends the implementation of a program to encourage the public to adjust their portfolios to the possibility of negative nominal interest rates. The responsibility of this program could be assumed by the Central Bank through its economic education programs.

Fukao (2005) stresses that the tax will have very strong effects on Japanese expenditures. People will seek to hold assets with higher returns and without taxation, such as consumer durables, corporate bonds, foreign bonds, real estate, and stocks. In other words, it will have a movement from taxable assets to all the non-taxable assets. Banks will also follow this movement. This decision in the bank system will stimulate bank lending activities. Nonetheless, this move could create pressures on financial stability. The increase in riskier assets in portfolios will make the financial system weaker in a downturn. Furthermore, Fukao states that the tax will depreciate the yen exchange rate against foreign currencies. Therefore, Japanese exports will be more competitive in the international markets. On the other hand, exchange rate depreciation will increase the cost of imports. However, considering the export profile of the Japanese economy, trade benefits will outweigh the costs associated with more expensive imports.

The transactions and administrative costs should be considered during the process (Buiter and Panigirtzoglou (1999, 2003), Buiter (2009)). Cash is considered as a fiat bearer bond – the holder identity is anonymous to the issuer and the ownership can be transferred by delivering the coins and banknotes. Thus, it is very difficult to tax an asset where its owner is not known. Furthermore, the worth of fiat money depends on the confidence in the issuer and how much the public is willing to exchange for it. Considering that the

public gives the same value to expired cash and cash with legal tender status, this can seriously compromise the effectiveness of the tax. In order to ensure that cash without legal tender status does not continue to circulate, Buiter (2009) defends a penalty to the holders of expired cash. However, this will require a constant surveillance of all coins and banknotes. Economic agents would live in a police state under constant checks and searches. The operational implementation of a tax on base cash could be unpractical. The constant monitoring of cash is an illiberal policy and unlikely to be popular (Buiter, 2009).

The problems associated with a fiat bearer bond and the payment of a negative interest are irrelevant when the other component of the monetary base is considered – the commercial bank deposits held in the Central Bank's reserves. These assets are registered financial claims, i.e., the issuer knows the identity of the holder. Therefore, the implementation of negative nominal interest rates on commercial bank reserves with the Central Bank is no more difficult than it is for commercial banks accounts to pay negative interest (Buiter & Panigirtzoglou, 2003).

3.3. Complete or Partial Abolishment of Cash

3.3.1. Literature on cash abolishment

The existence of cash with a zero interest rate severely constrains the implementation of negative nominal interest rates, as economic agents will prefer to hold cash rather than an asset with a negative rate of return.

Buiter (2009) proposes the abolishment of all coins and banknotes in an economy. The base money would be secured by commercial bank deposits held in the Central Bank's reserves. Then, the Central Bank could apply negative interest rates without the risk of commercial bank deposits being converted into cash.

The solution proposed by Buiter would imply a transformation of the society into a cashless economy. Cash would no longer be used in any economic transaction. In a more nuanced approach, Rogoff (2015, 2016, 2017c) proposed instead a "less-cash" economy. The idea is to very gradually remove large-denomination banknotes from circulation. Coins and low-denomination banknotes would continue to be used in small transactions.

However, the complete abolishment of all coins and banknotes is not disregarded in Rogoff's ideas. Through this proposal, Rogoff aims to achieve two major goals. The first is to increase the costs of insurance, transport and storage of banknotes. The costs of hoarding 1 million in notes of 200 euros is not the same as hoarding the same amount in notes of 5 euros. Therefore, economic agents have less incentive to hold cash during a period of negative interest rates. The second goal is to fight crime, tax evasion and the underground economy. Currently, most transactions of greater value are made through electronic means. Cash is mainly used in transactions of lesser value. Thus, the use of banknotes of high-denomination is associated to criminal activities. Rogoff's ultimate purpose is not to affect legal transactions, but to prevent large and anonymous transactions.

In his book, Rogoff (2016) presents a plan[4] with three major guidelines for phasing out most banknotes. The first is to hinder the existence of anonymous transactions on a large scale and to avoid the hoarding of cash. The second point is related to the speed of the transition. Rogoff defends a period of transition of at least 10-15 years for the implementation of the plan. This is an important point. As stated by Rogoff, this period avoids "excessive disruption and gives institutions and individuals time to adapt". At the same time, this gradualism will allow the rise of new technologies to substitute banknotes or even cash as medium of exchange. Lastly, in the third guideline, Rogoff focuses on not excluding the "poor and unbanked individuals". Cash is usually the only asset that the poorest classes in society use as medium of exchange and store of value. Thus, Rogoff defends the access of "poor and unbanked individuals" to free basic debit accounts or equivalents, such as smartphones. The cost of this measure must be supported by the government, as stated by Rogoff.

In the Eurozone, the Governing Council of the European Central Bank announced the end of the production and issuance of 500 euro banknotes (ECB, 2016). The reason for this decision was the frequent use of this banknote in illegal activities. However, this measure may lead to a double effect. By removing 500 euros banknotes, the removal of other large-denomination banknotes or the complete abolishment of euro banknotes and coins may be a real possibility. In the future, the implementation of the proposal to abolish cash may be simpler and more justified by using the ECB decision as a case study.

[4] In order to study Rogoff's plan and some concerns about its implementation in greater detail, the reading of Chapter 7 ("A Plan for Phasing Out Most Paper Currency") in Rogoff (2016) is recommended.

3.3.2. Pros and Cons of the Complete or Partial Abolishment of Cash

The complete or partial abolishment of cash makes it more difficult to hold large amounts of wealth in the form of banknotes and coins. The complete abolishment of cash removes the zero lower bound. Consequently, the risk of a liquidity trap occurring and the dangers of an economy entering a deflation trap become a simple theoretical hypothesis. On the other hand, the partial abolishment of cash only reduces the lower bound. Nevertheless, this simplifies fights against corruption, money laundering, tax evasion, financing of terrorism, and other criminal activities. According to Rogoff (2015), over 50% of cash in most countries is used to hide transactions. Criminals are very smart and tenacious in looking for alternatives to cash in order to pursue their illegal activities. However, this would greatly limit the movement of wealth between the underground economy and the formal one. The alternative for transactions in the formal economy is the commercial bank deposits held in the Central Bank's reserves. Nevertheless, the electronic traceability of bank deposits by law enforcement and tax authorities makes it not the mean of choice for illegal transactions.

Buiter (2009) highlights an important issue about the Central Bank's ability to implement negative interest rates in the commercial bank deposits held in the Central Bank's reserves. The interest rate can be zero, positive or negative without significant administrative costs, because these deposits are electronic and registered financial instruments. At the same time, Buiter makes a note regarding the loss of welfare of this proposal. Considering that cash and deposits are perfect substitutes in providing liquidity services, then there will be no welfare loss in the economy.

The loss of seigniorage gains is one of the main reasons for Central Banks not to phase cash out (Buiter (2009), Rogoff (2015, 2016)). Central Banks print banknotes with a certain economic cost for each one, usually lower than its face value. Then, banks pay the face value of these banknotes to the Central Bank. The difference between the face value of the banknote and the cost of production is seigniorage. At the same time, the loss of seigniorage could jeopardize the operational performance and the independence of the Central Bank (Rogoff, 2015). The revenues of seigniorage are an important source of income to the Central Bank's budget. This allows the Central Bank to hire the most

competent experts in the field and avoids its operational performance from being restricted by Government financing. However, as stated by Rogoff (2015), the loss of seigniorage can be compensated if accompanied by an increase in demand for "electronic central bank reserves".

Privacy is another of the main concerns that opponents of this proposal point out (Ilgmann and Menner (2011); Beer, Birchler, and Gnan (2015); Krueger and Seitz (2018); Dowd (2019)). In a cashless economy, all financial transactions would be registered in an electronic database. Governments can access this database and block bank accounts of institutions and individuals who they disapprove. This control could affect the basic civil rights of people. Rogoff (2016) argues that the existence of low-denomination banknotes and coins is sufficient to address all concerns regarding privacy, security and emergencies. Nevertheless, as stated above, the existence of low-denomination banknotes does not allow the removal of the ZLB. An effective solution to the privacy problem in a cashless society is needed. In advanced economies, Central Banks are usually independent of governmental authorities. Therefore, the database of electronic transactions must be under the protection of the Central Bank. No entity should have access to this database, not even the government. Only courts will be able to access this information through well-argued court requests. Furthermore, the restriction on making transactions should only be accepted by the Central Bank if it is proven that these bank accounts are used for illicit activities.

The risk of digital systems failing can jeopardize the entire economy (Ilgmann and Menner (2011); Beer et al. (2015); Dowd (2019)). Cash diversifies the options of the transactions' system. However, economies are totally exposed to cyber attacks, computer bugs, and other technological risks (Rogoff, 2015). The entire banking system and ATM machines would be compromised if other electronic systems are down. The argument that a cashless society puts the economy at risk is weak. People have the possibility to have cash at home to respond to an emergency, but that does not mean they do. According to Rogoff (2016), the most important disaster preparedness tool is a smartphone. Usually, everyone has a smartphone, and through apps that allow P2P payments it is still possible to make transactions. In that sense, apps should be developed to work under a technological breakdown or an emergency. However, governments can provide a mean of exchange only for emergencies, such as checks. The economy can continue working even under a breakdown or an emergency and without cash.

Ilgmann and Menner (2011) draw attention to a problem that is often overlooked in the discussion concerning the end of cash: psychological factors. When someone talks about money, the first image which comes into anyone's mind is the one of coins and banknotes. At the same time, governments use cash as a means of propaganda to transmit national values throughout the world. Coins and banknotes are designed with national symbols, historical figures, monuments, national achievements or even with the bust of the ruler. As stated by Rogoff (2015) in the case of the euro, "the symbolic value of the euro, as a flag for nascent European institutions, is hard to overstate". Therefore, the Central Bank's education programs play an essential role in educating economic agents for the transition to a cashless economy. A measure of this magnitude without the public's acceptance and government support will be impossible to implement by the Central Bank.

Another relevant aspect is the importance of cash in times of financial crisis and distrust in the financial system. According to Krueger and Seitz (2018), the demand for cash increases during periods of instability and discredit in the banking system. In a transition to a cashless society, the Central Bank and the government must guarantee the safety of deposits in a situation of possible collapse of the financial system. The trust in the electronic payment system is necessary for economic agents to remain calm. Otherwise, money holders will invest in other assets that provide more safety for their wealth.

The economy could face the risk of another currency be used within domestic borders during a process of reducing or eliminating the use of cash. However, this risk could be easily minimized through an international cooperation of the major global currencies (Rogoff (2015, 2016)). The agreement between economies must pass through a coordination that allows the control of large movements of foreign cash at the entrance of national borders. Rogoff even proposes the creation of an international treaty to remove large-denomination banknotes from the major global currencies.

Some authors argue that there is a war on cash (Hummel (2017), (White, 2018), Dowd (2019)). However, as stated by Rogoff (2017d), the existence of a war on cash is an exaggeration. At its most, it is "a war on big bills in advanced economies" than an open war against all coins and banknotes. Hummel (2017) and White (2018) use India's Demonetization Experiment of 2016 to attack Rogoff's proposal of removing large-denomination banknotes. First of all, it is important to explain the circumstances of the Indian experiment. On November 8, 2016, the Prime Minister of India, Narendra Modi,

announced the demonetization of high-denomination banknotes of 500 and 1000 rupees, with immediate effect. The holders of these banknotes would have 50 days to deposit their old banknotes in the bank or to exchange them for new banknotes of 500 and 2000 rupees. The banknotes of 500 and 1000 rupees represented 86% of cash supply in India. At the same time, cash was presented in roughly 90% of all transactions in the country. The government's goals were to fight tax evasion, eliminate black money owned through illegal activities, eradicate counterfeit cash, and to promote a cashless Indian economy. In the subsequent weeks, 99% of the demonetized cash returned to the national banks. Consequently, the government failed in its goals of taxing undeclared income and black wealth (Lahiri, 2020). Nevertheless, Lahiri declares that this experiment had a positive impact in the degree of the digitalization of Indian economy.

The Indian experiment showed the need of avoiding overnight decisions. The Indian demonetisation experiment is not the best example of a process of a complete or partial abolishment of cash. First, the 500 and 1000 rupees banknotes were replaced by the new banknotes of 500 and 2000 rupees. Second, the 1000 rupees banknote was substituted by the 2000 rupees banknote with a higher denomination. Moreover, an experiment of a few months is not strong enough to be compared to an extremely gradual process of 10/15 years defended by Rogoff (2016, 2017c, 2017d). However, the results of the India's Demonetization Experiment of 2016 should be taken into account as a possible experiment for the end of cash.

Finally, the implementation of the proposal to abolish cash could be an unpopular idea. In order to remove the zero lower bound, the transition requires a cashless economy as a final goal. Therefore, a complete plan with a gradual implementation should be presented by the Central Bank to all entities, and their support is vital. No one should be left out during the implementation of this proposal. Furthermore, it is essential that the risks mentioned above are taken in to consideration and that the necessary financial infrastructure is well developed. The Central Bank's communication needs to be objective, clear and easily understood by all economic agents. Otherwise, the implementation of this proposal can face impassable challenges and the ultimate goal of a cashless economy may never be achieved.

3.4. Dissociating Cash from Electronic Money[5]

3.4.1. The concept of a dual local currency system

Money has the function of playing the role of medium of exchange, store of value, and unit of account. The proposal to decouple cash from electronic money aims to separate the different functions of money. Cash would take on the role of medium of exchange and store of value. Through a dual local currency system, electronic money would act as a unit of account.

The first reference to the separation of the different functions of money goes back to the work of Eisler (1932). Eisler proposes the separation of the function of medium of exchange and store of value from the function of unit of account. The "current money" with the function of medium of exchange and store of value is used exclusively for small transactions. The other payments would be made with "money banco" through cheques or bank transfers. According to Eisler, prices should be fixed in "money banco". Therefore, the "money banco" is used inside the banking system and the "current money" outside of it. "Money banco" is money in every sense, except for not having a physical form (Rogoff, 2016). Nevertheless, the central motivation of Eisler's ideas is to protect the economy from the negative effects of inflation.

The idea of separating the different functions of money is also supported by Einaudi (1953) and Gaitskell (1969). These authors even consider that this decoupling can be an additional instrument at the service of Central Banks. However, also identified by Ilgmann and Menner (2011), the use of this proposal to remove the zero lower bound does not seem to be a concern for these authors.

In recent decades, Eisler's ideas emerged as a proposal for removing the ZLB on nominal interest rates (Boyle (2002), Davies (2004), Buiter (2005, 2007, 2009), Agarwal and Kimball (2015), Goodfriend (2016) and Assenmacher and Krogstrup (2018)). Nevertheless, the focus will be on the work of Buiter (2009), Agarwal and Kimball (2015), and Assenmacher and Krogstrup (2018). These authors present plans for the implementation of the dissociation of cash and electronic money.

[5] Following the definition present in Agarwal and Kimball (2019), the term *electronic money* refers to "credit balances in an account held in the books of the Central Bank, or in the books of a commercial bank".

Buiter's adaptation of Eisler's ideas suggests the abolition of the old currency and its replacement by a new currency. The suggestion is presented for the specific case of the Eurozone. The first step is to remove the euro currency through the withdrawing of all euro banknotes and coins. However, the electronic form of euro currency will not be affected. The next step is to introduce the new currency wim – Buiter uses this term as a tribute to the first ECB president, Wim Duisenberg. According to Buiter, the electronic euros will retain their unit of account function for wages and price contracts. Therefore, the zero lower bound will no longer exist in the euro currency, because it will be in the wim currency. The new currency wim will work as medium of exchange and store of value. Furthermore, Buiter mentions that the ECB should set a spot and forward exchange rate between the euro currency (electronic money) and the wim currency (cash). Initially, the euro and the wim are exchanged at par. In the following periods, the exchange rate reflects the positive or negative nominal interest rate of euro.

Agarwal and Kimball (2015) propose a simpler mechanism through a "time-varying paper currency deposit fee" between the Central Bank and private banks. The intention is to create a "crawling-peg exchange rate" between cash and electronic money. According to the authors, this exchange rate should be imposed at the Central Bank's cash window[6] and not directly on households, companies or banks. Considering that the Central Bank sets a negative interest rate on electronic money, the temporary "crawling-peg exchange rate" should reflect this on cash. Therefore, during the negotiation at the cash window, the Central Bank trades cash for electronic money at discount (below par) with private banks. Consequently, the value of cash and electronic money move in tandem. On the other hand, if private banks intend to deposit cash at the cash window, then a fee (above par) must be paid by them. This would avoid the withdrawal of cash during times of negative interest rates.

The period of negative interest rates will not be unlimited in time. At the end, the Central Bank could raise interest rates above zero. Therefore, the exchange rate between cash and electronic money must return to par. The path forward must be a decision based on the monetary policy strategy of each Central Bank. Agarwal and Kimball (2015) present four options available for the Central Bank's return to parity: "swift return to par", "gradual

[6] Following the definition of Agarwal and Kimball (2015), the Central Bank's cash window refers to "the facility through which the central bank and commercial banks interact to bring cash in to and out of circulation".

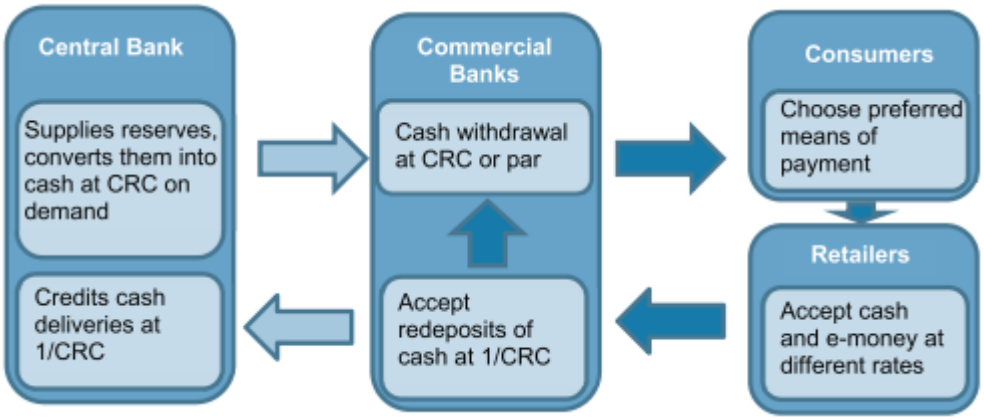
return to par", "Friedman rule", and "seignorage without inflation". In the "swift return to par", the transition to parity is a quick process. However, this quick movement creates a differential between cash (below par) and electronic money (par). Economic agents anticipating such a move will store large amounts of cash in order to take capital gains at the moment when cash and electronic money are exchanged at par. The "gradual return to par" and "Friedman rule" define that the interest rate on cash must be keep equal to a target rate during the process until parity is reached. In the "gradual return to par", the speed of transition is fast, but keeping in mind that the zero lower bound does not cause problems during the process. As stated by the authors, the "Friedman rule" can be implemented independently of the rate of inflation existent in electronic money. Finally, the "seignorage without inflation" consists in depreciating cash to earn seigniorage gains without concerns of inflation in electronic money. Nevertheless, the spread between cash (below par) and electronic money (par) is a similar mechanism to Gesell's tax.

Assenmacher and Krogstrup (2018) present a setup and operating framework based on the work of Agarwal and Kimball (2015). The authors follow the same approach in dissociating cash and electronic money, and establishing a conversion rate in the Central Bank's cash window. At the same time, it is assumed that the interest rate on cash should be equal to the interest rate on electronic money. In order to ensure that this mechanism works, the authors suggest that the conversion rate should be adjusted daily. Furthermore, after the period of negative interest rates has ended, Assenmacher and Krogstrup refer that the Central Bank must have a clear communication of the plan for the return of cash and electronic money to par in order to avoid speculation and increase transparency.

The transmission of the conversion rate through the rest of economy raises some concerns regarding the behaviour of economic agents, legal issues, and other types of questions. At the same time, the cost of a dual local currency system must be taken in account, but the lack of empirical relevant historical episodes makes such analysis difficult (Assenmacher & Krogstrup, 2018). However, these concerns and possible costs of such proposal will be explored in more detail in the next sections.

According to Assenmacher and Krogstrup (2018), the transmission of the conversion rate to consumers and retailers should be a decision of banks and not dictated by the Central Bank. In Figure 5, the authors show how the transmission process should work. Moreover, this rate must be applied in the same way in withdraws and cash deposits.

Figure 5. Transmission of the Cash Reserve Conversion rate (CRC) in the economy



Source: Assenmacher and Krogstrup (2018)

In recent years, several Central Banks have been studying the possibility of issuing a Central Bank Digital Currency (CBDC)[7]. The CBDC could be defined as an electronic form of the Central Bank's money to be used by households and companies to make payments and store value (BoE, 2020). The fact that the CBDC is backed by fiat money distinguishes it from cryptocurrencies, which have a decentralized control. However, this does not invalidate that the CBDC can be issued through a technology similar to the blockchain used in cryptocurrencies. Currently, the issuance of the CBDC by the Central Bank through digital tokens – circulating in a decentralised way without central ledger – has been considered in the same way as the CBDC offer in deposit accounts with the Central Bank (Bordo and Levin (2017), Bindseil (2019)). As stated by Bordo and Levin (2017), the existence of a form of Distributed Ledger Technology (DLT) allows the verification of the ownership chain of each token and the validation of the payment transactions without the direct intervention of the Central Bank. Furthermore, the CBDC could be universally accessible, fixed in nominal terms, and valid as legal tender for transactions (Bordo & Levin, 2017). Therefore, the CBDC fulfils the three functions of money: medium of exchange, store of value, and unit of account.

[7] In a survey of the Bank for International Settlements (Boar, Holden, & Wadsworth, 2020), 10% of Central Banks surveyed – that represent 20% of the world's population – are likely to issue a CBDC in the short term for the general public. Furthermore, 80% of the 66 Central Banks surveyed are engaging in some sort of work related to CBDCs. Some examples of surveyed Central Banks are the Bank of Canada, the Bank of England, the Bank of Japan, the European Central Bank, the Sveriges Riksbank or the Swiss National Bank (ECB, 2020a).

3.4.2. Pros and Cons of Dissociating Cash from Electronic Money

The proposal of dissociating cash from electronic money suggests that it is technically feasible and does not require drastic changes in current mandates and operating frameworks of Central Banks (Assenmacher & Krogstrup, 2018). Moreover, this proposal allows the removal of the ZLB without significant structural changes in the economy such as the implementation of a tax on base money or the abolishment of cash. Therefore, the Central Bank could use conventional monetary policy tools to stabilize the economy. At the same time, without the ZLB, the inflation target can be revised.

The immediate advantage of this proposal is the preservation of a role for cash. Although cash loses its role as a unit of account for electronic money, it will continue to play the function of medium of exchange and store of value. Therefore, the concerns about eliminating cash from the economy lose their relevance. Even privacy concerns are addressed through the use of technologies such as distributed ledges technology (DLT). The fully reversibility of the dual local currency system is another relevant advantage of this proposal. This is a favourable point not only when comparing to other proposals to remove the ZLB, but also comparing to unconventional monetary policies, such as the raise of the inflation target.

Dissociating cash from electronic money solves some of the disadvantages mentioned in the tax on money and complete or partial abolishment of cash. However, the effects on private wealth, the loss of seigniorage gains and the risk of digital systems failing remain as concerns that must be taken into account. It is important to mention that some solutions to minimize these disadvantages have been developed previously. Regarding the private wealth, Goodfriend (2000) suggested the adjustment of portfolios to the possibility of negative nominal interest rates during the implementation of a tax on base money. Agarwal and Kimball (2019) defend that banks could provide zero interest rates on small deposits accounts during periods of negative interest rates to reduce the political costs and the public's displeasure. According to the authors, the zero rates on small deposits accounts would be subsidized through interest on reserves. Therefore, the preparation of private agents for the negative interest rates and the protection of small depositors are necessary to minimize possible public opposition to this proposal.

Negative interest rates and cash off par could have an impact in the financial sector. Banks and financial companies may have their profitability adversely affected. However, Agarwal and Kimball (2015) argue that the existence of electronic money can avoid this side-effect if the conversion rate and other short-term rates are policy variables under the control of the Central Bank. Under the depreciation mechanism, the authors mention that economic agents still have incentives to put their wealth in commercial banks accounts even during a period of negative interest rates. Thus, the impact on bank profits and bank balance sheets is minimized.

Another disadvantage is the impact on debt contracts. The decline on interest rates could increase the value of debt. Nevertheless, considering that the quicker economic recovery could increase the medium-term real interest rates and lower the medium-term nominal bond price, then negative interest rates may not lead to an increase in the value of debt (Agarwal & Kimball, 2015). Furthermore, the fact that cash can be off par can lead to an incentive in borrowers to repay their debt in cash when cash in cheaper than par (Agarwal & Kimball, 2015). However, the authors refer that this problem could be easily solved through a clause in the legislation that debt contracts should be interpreted as referring to units of electronic money.

Regarding the CBDC in this proposal, the main distinction when comparing to electronic money is to perform the three functions of money. Nonetheless, the CBDC is not a novelty idea and already exists. Commercial bank deposits held in the Central Bank's reserves and other types of digital claims in the form of deposits represent the electronic form of money (Mersch, 2017). The literature that aims to assess the pros and cons of CBDC issuance has been increasing in recent years (Barrdear and Kumhof (2016), Bordo and Levin (2017), Bindseil (2019), BoE (2020), and Kiff et al. (2020)). However, the CBDC and electronic money can be complementary in a transition to a cashless society.

Decoupling cash from electronic money faces some challenges for its implementation. As stated by Assenmacher and Krogstrup (2018), the dual local currency system will require enormous efforts in communication, and changes to the financial and legal system. Nevertheless, it is the proposal to remove the zero lower bound that is simpler to implement and that does not require drastic changes in the *status quo*.

3.5. Effectiveness of the Proposals to Remove the Zero Lower Bound

Table 2 summarizes the pros and cons of each proposal. They share the goal of allowing deeply negative nominal interest rates, but through different approaches. However desirable, it does not seem possible to clearly hierarchize the proposals based on their pros and cons. Nevertheless, the proposal of dissociating cash from electronic money presents some feasibility advantages that may qualify it as the best proposal to break the ZLB.

Table 2. Summary of pros and cons of each proposal

Proposals	Pros	Cons
Tax on Base Money	Avoids the possibility of a liquidity trap and a deflation trap occurring; Increases monetary efficiency; Removes the zero lower bound.	Administrative costs during the taxation period; Increase in portfolio's risk; Negative effects on private wealth; Possibility of illegality in some jurisdictions; Regressivity of the tax; Risk of cash being substituted by other assets in providing liquidity services; Public's acceptance.
Complete or Partial Abolishment of Cash	Avoids the possibility of a liquidity trap and a deflation trap occurring; Combats criminal activities; Removes the zero lower bound.	Lack of confidence in electronic payments system during crises; Loss of seigniorage and privacy in transactions; Possibility of national currency being substituted by a foreign currency; Psychological factors and public's acceptance; Risk of digital systems failing.

Table 2 (continued)

Proposals	Pros	Cons
Dissociating Cash from Electronic Money	Avoids the possibility of a liquidity trap and a deflation trap occurring; Preservation of a role for cash; Removes the zero lower bound without significant structural changes; Technically feasible without drastic changes in mandates and operating frameworks of Central Banks.	Impact in the profitability of the financial sector; Loss of seigniorage; Negative effects on private wealth; Risk of digital systems failing.

Source: Author's elaboration

It is clear that the assessment of the costs and benefits of each proposal would render a much more robust analysis. However, the literature on quantitative estimation of the costs and benefits of deeply negative nominal interest rates is quite limited. Furthermore, state-of-the-art evaluation of the costs and benefits of the different proposals to remove the zero lower bound is even scarcer. Nonetheless, some authors try to estimate possible costs and benefits of breaking the zero lower bound.

Fukao (2005) estimates that a 2% tax on all government-backed financial assets would generate about 30 trillion yen (about 6% of Japan's GDP). Another case is related to the idea already presented of providing subsidized bank accounts for low-income individuals. This could have a cost of $32 billion for 80 million free basic accounts (Rogoff, 2016). Rosl, Seitz, and Todter (2019) consider that the welfare costs of breaking the ZLB through the abolishment of cash are equivalent to negative interest rates on cash holdings. Therefore, an interest rate of -3% on cash holdings would create a welfare loss of around 24 billion euro per year for consumers in the Eurozone. Moreover, the authors estimated that if all components of M3 were reduced in 300 basis points, the welfare loss would be of 228 billion euro for Euro area consumers, equivalent to 2% of the Eurozone's GDP or 700 euro per capita.

Borio, Erdem, Filardo, and Hofmann (2015) analysed 38 economies during the last 140 years to find a link between output growth and deflation. The conclusions show that this link is weak. However, the authors found a stronger link between output growth and asset price deflations. The historical data does not seem to show a clear relationship between output and deflation. Nevertheless, the Japanese deflationary experience showed distortions in many parts of the economy and significant costs on it (Baig, 2003).

Table 3 summarizes the estimations developed for some proposals. Fukao (2005) develops an estimation of the benefits of a tax on base money for Japan's economy. Rogoff (2016) and Rosl et al. (2019) estimate possible costs of cash abolishment.

Table 3. Estimations' summary of some costs and benefits of negative nominal interest rates

Authors	**Costs and Benefits**
Fukao (2005)	A tax of 2% on all government-backed financial assets would generate about 30 trillion yen (about 6% of Japan's GDP).
Rogoff (2016)	Subsidizing free bank accounts for low-income individuals would have a cost of $32 billion for 80 million free basic accounts.
Rosl et al. (2019)	The welfare cost of an interest rate of -3% on cash holdings would be around 24 billion euro per year in Eurozone consumers. Moreover, the reduction in 300 basis points in all components of M3 would have a cost of 228 billion euro for Euro area consumers, equivalent to 2% of the Eurozone's GDP or 700 euro per capita.

Source: Author's elaboration

The literature regarding the pros and cons of each proposal is quite satisfactory. However, the same cannot be said for the costs and benefits. As shown above, the estimations present in the literature are only partial estimations for some of the proposals. This implies a severe limitation to the purpose of establishing a hierarchy of the proposals

and it even impedes and unequivocal statement that removing the zero lower bound will bring more benefits than costs. Nevertheless, given the magnitude of the risks involved in a severe depression, it seems reasonable to assume a significant likelihood that the benefits outweigh the costs of deeply negative nominal interest rates

The feasibility advantages of the proposal to dissociate cash from electronic money as a way to effectively remove the zero lower bound can be subject to a specific case test. In the next chapter, this proposal will be applied to the case of the European Central Bank.

4. Removing the Zero Lower Bound in the Euro Area

The Euro Area's key interest rates[8] are at their lowest historical level. The interest rate on the main refinancing operations (MRO) is 0.00 per cent, the rate on deposit facility is -0.50 per cent, and the rate on the marginal lending facility is 0.25 per cent. Therefore, the Eurozone is facing the zero lower bound on nominal interest rates.

The ECB can make good use of strategy and a feasible plan to break the zero lower bound and to implement deeply negative nominal interest rates. Currently, such a plan does not exist. Even in the literature, plans that analyze the legal and technical steps that allow the removal of the zero lower bound are practically none. The only one that performs this analysis was developed by Katinová (2018) for the specific case of the Czech National Bank (CNB). This case study will be followed closely as a guideline for the next sections.

European law will be followed to assess what changes are needed to implement negative interest rates in the Eurozone. Furthermore, the work of Agarwal and Kimball (2015), Assenmacher and Krogstrup (2018), and Agarwal and Kimball (2019) will serve as support for the plan to decouple cash from electronic money by the ECB.

Chapter 4 is divided into two sections. Section 4.1 explores the European law to assess what changes will need to be put into legislation in order to remove the zero lower bound and implement deeply negative nominal interest rates in the Euro Area. Section 4.2 develops the technical steps that must be followed by the European Central Bank to decouple cash from electronic money.

4.1. Legal framework

The European Central Bank, as an European Union (EU) institution, operates under the European Union law. The ECB's objectives and tasks are described in the Treaty on the Functioning of the European Union and in the Statute of the European System of Central Banks and of the European Central Bank[9].

[8] See ECB (2020b).
[9] See ECB (2020c).

The EU treaties are the basis of all European Union law. Any change to the treaties requires the unanimous agreement of all EU countries. The EU uses a variety of legislative procedures to adopt laws. The procedure followed depends on the type and subject of the proposal. The majority of EU laws are jointly adopted by the European Union Parliament and European Council under proposal of the European Commission (EC). At the same time, national parliaments of EU countries are consulted on all Commission proposals. Moreover, EU law is divided into directives and regulations. The directives must be incorporated by EU countries into national law, but the decision is up to the national parliaments. The regulations and decisions become binding automatically throughout the EU countries on the date at which they take effect[10].

In the following subsections, European law will be analyzed to assess which laws presented in the EU treaties will need to be changed to allow negative interest rates and to decouple cash from electronic money. The focus will only be on the European Union law, as European law overrides the national law of EU countries. The goal of this analysis is to proceed with a set of recommendations that could be adopted by EU institutions.

4.1.1. The legal context of negative interest rates

The implementation of deeply negative nominal interest rates in the Euro Area requires that European law does not pose constrains in this objective. European Union law is sufficiently robust, but it leaves space for European institutions, such as the European Central Bank, to take decisions that fall within their competence and mission.

According to article 12(1) of the Protocol on the Statute of the European System of Central Banks and of the European Central Bank (2016) OJ C202, the Governing Council[11] is responsible for formulating the monetary policy of the European Union, including the key interest rates. Furthermore, European Treaties no longer make any reference to the ECB policy rates. Consequently, the implementation of deeply negative nominal interest rates is only a responsibility and a task of the European Central Bank.

[10] See EC (2020).

[11] According to article 283(1) of the Treaty on the Functioning of the European Union (2016) OJ C202, the Governing Council shall comprise the members of the Executive Board of the European Central Bank and the governors of the national Central Banks of the Member States whose currency is the euro.

The European Central Bank faces no legal restrictions on this matter in the context of EU law. During the transcription for the national law of some Euro countries, specific legal restrictions about negative interest rates could emerge. Nonetheless, this cannot be overlooked. Thus, national laws would be adjusted for the possibility of negative interest rates in the national financial system.

4.1.2. The legal context of electronic money

Dissociating cash from electronic money requires that there is no legal impediment to the possibility of issuing electronic money. Directive 2009/110/EC of the European Parliament and European Council of 16 September 2009 established a new legal basis for the issuance of electronic money in the European Union. According to article 2(1) of this Directive, an "electronic money institution" is a legal person with the authorisation of issuing electronic money. Moreover, in article 2(2), electronic money is defined as a "stored monetary value as represented by a claim of the issuer which is issued on receipt of funds for the purpose of making payment transactions". Thus, it is not only the ECB which can issue electronic money, but also credit institutions, and other financial and non-financial institutions.

First of all, it is important to note that the issuance of electronic money by the ECB already takes place, despite not being called Central Bank Digital Currency (CBDC) (Mersch, 2020). Nonetheless, the focus of this analysis should be in the legal context for the possibility of issuance of a CBDC by the European Central Bank.

According to article 128(1) of the Treaty on the Functioning of the European Union (2016) OJ C202, the ECB has the exclusive right to authorise the issuance of euro banknotes. Moreover, these banknotes are the only ones with the status of legal tender within the EU. The legislator could include the CBDC in this definition. The ECB should be the only one with the exclusive right to authorise the issuance of a CBDC. At the same time, only the CBDC issued by the European Central Bank could have the status of legal tender within the Euro Area. This specification is essential for the credibility of the new currency and to avoid the competition of cryptocurrencies.

In article 22 of the Protocol on the Statute of the European System of Central Banks and of the European Central Bank (2016) OJ C202, the ECB and national Central Banks may provide facilities and ensure efficient payment systems. Therefore, the responsibility of designing and creating the facilities for the issuance of a CBDC in the context of a dual local currency system might be developed by a joining force of the ECB and national Central Banks.

European law does not pose any additional legal impediment in implementing deeply negative nominal interest rates and in decoupling cash from electronic money, as far as it was possible to assess. However, some constrains in national law of EU countries may be found. Through directives or regulations, EU countries must incorporate the changes in EU law to allow the implementation of deeply negative nominal interest rates and a dual local currency system in Euro countries. After these legal considerations, the technical steps to remove the zero lower bound are addressed next.

4.2. Implementation of the plan to remove the Zero Lower Bound

The plan outlines the possible implementation of the proposal to dissociate cash from electronic money by the European Central Bank. This requires the fulfilment of two technical steps, as shown in Chapter 3 through the development of the idea proposed by Agarwal and Kimball (2015) . The first is to give the function of unit of account exclusively to electronic money. The second step is to create a conversion rate between cash and electronic money.

4.2.1. Electronic money as unit of account

In the dual local currency system, electronic money would act as a unit of account. Thus, prices, wages contracts and other nominal contracts in the Euro Area would be defined in units of electronic money.

Assenmacher and Krogstrup (2018) suggest, concerning the operational framework, that Central Banks divide the monetary base into two separate domestic currencies: cash and reserves. As mentioned in the last chapters, these reserves are deposits' accounts held within the Central Bank. However, during a crisis, a problem could emerge for commercial banks and financial stability. In a moment of great uncertainty, economic agents could decide to move their deposits from accounts held with commercial banks to accounts with the Central Bank. The possible massive movement of deposits can create an additional pressure on the financial system, precipitating its downfall. In order to avoid this situation, the European Central Bank would introduce a new currency: the E-euro. This new currency would act as a unit of account, while the Euro would continue to play the role of medium of exchange and store of value. The idea of a digital currency is not a novelty. A well-developed project for a Central Bank Digital Currency is the E-krona by the Sveriges Riksbank (Riksbank, 2020). As shown in Chapter 3, other Central Banks, including the European Central Bank, are developing studies for the possibility of issuing a Central Bank Digital Currency in their jurisdictions.

In Chapter 3, the definition of the BoE (2020) refers that the CBDC could be used to make payments and store value. The use of the E-euro as a medium of exchange and store of value is acceptable. However, it is important that the function of unit of account is exclusive to the E-euro. The Euro may only be used as medium of exchange and store of value. Thus, the retailers would have their prices available in terms of E-Euro and, after the application of the conversion rate, in terms of Euro. The acceptance of coins and banknotes of Euro, and digital payments in Euro and E-Euro requires a well-established infrastructure of digital payments. At the same time, the ECB could reinforce the development of technologies of digital payments and establish an effective communication by declaring the legal tender of the E-Euro.

The introduction of the E-euro may raise some concerns in the Eurozone economic agents. The first is the legal and regulatory challenges of this CBDC. However, through the law modifications mentioned in section 4.1 and the declaration of the legal tender of the E-Euro, the ECB can overcome this concerns without major difficulties. Another concern is privacy and cybersecurity. As shown in Chapter 3, the introduction of a form of Distributed Ledger Technology (DLT) allows the security of transactions. However, any digital system is exempt from attempts of criminal activities or the violation

of its technological integrity. The ECB must always closely monitor developments of new technologies and solve problems that may arise with the functioning of the E-euro.

The E-euro is far from fully protected from risks and challenges. Nonetheless, as stated by Bordo and Levin (2017), a CBDC could "transform all aspects of the monetary system and facilitate the systematic and transparent conduct of monetary policy".

4.2.2. The conversion rate

The second technical step to dissociate cash from electronic money is the establishment of a conversion rate between the Euro and the E-euro. However, the implementation of this rate should only occur during periods of negative nominal interest rates. In the remaining periods, the two currencies would be exchanged at par.

Prices, wages contracts and other nominal contracts are defined in E-euro. The corresponding value in Euro is the same in periods of positive nominal interest rates or even in periods of zero nominal interest rates. In periods of negative nominal interest rates in E-euro, the conversion rate is activated to reflect in Euro the negative nominal interest rates, especially on cash. In withdrawals of Euro banknotes and coins, the value on cash is discounted according to the nominal interest rate at the moment. For example, an economic agent decides to withdraw 100 euros but, considering an interest rate of minus 3%, he only receives 97 euros. In deposits of cash, a fee equal to the interest rate is paid.

Assenmacher and Krogstrup (2018) suggest that the conversion rate should be continuously adjusted, preferably daily. However, the ECB only needs to adjust the rate as much as necessary to achieve its objectives.

4.2.3. Addressing challenges during the period of negative nominal interest rates

The period of negative nominal interest rates can bring a set of situations and challenges that must be taken into consideration by the ECB. The goal of this subsection is to address those challenges and possible recommendations for the ECB to face this period.

The pressures on the financial sector could increase during this period, especially on its profitability. Bindseil (2019) suggests a two-tier system for remunerating excess reserve holdings of CBDC in order to avoid the risk of structural disintermediation of banks, the centralization of the credit allocation process within the Central Bank, and the risk of facilitating systematic runs on banks in crisis. This system already exists in the European Central Bank and it has been operational since 30 October 2019. The idea of the two-tier system is to exempt credit institutions from remunerating part of their excess reserve holdings at negative interest rates on the deposit facility. Thus, the recommendation is to implement the two-tier system during the period of negative nominal interest rates.

Assenmacher and Krogstrup (2018) refer that the business of converting cash into electronic money and vice versa for costumers could be an additional source of income for banks. The implementation of a spread on the conversion rate might increase the revenues. Therefore, this idea could be taken into consideration by the ECB in order to minimize the impacts of negative interest rates.

During the period of negative interest rates, the savers might consider that their private health is being expropriated. In a financial crisis, there is usually a collapse in housing and equity prices. However, as stated by Rogoff (2017a), the capacity of the Central Bank to implement deeply negative nominal interest rates would help to sustain the expectations of higher growth and inflation in the future. Thus, the long-run interest rates should go up, instead of decreasing. Moreover, Agarwal and Kimball (2019) suggest the subsiding of zero rates for small deposit accounts. The recommendation for the ECB is to use its communication channels and its educational programs to explain this situation to the economic agents, especially to the savers. At the same time, the creation of a system to protect small deposit accounts is recommended. In fact, all economic agents would be affected by negative interest rates. However, it is important that the effort of each economic agent is made in an equitable way.

Agarwal and Kimball (2019) refer the importance of using communication tools to overcome political challenges in implementing negative interest rates. Communication would be the most important tool of the ECB before and during the period of negative interest rates. In the preparation for this period, the European Central Bank make explicit that the negative interest rates will be used as much as necessary. At the same time, the dual local currency system and its mechanisms would be carefully explained to all economic

agents. During the period of negative interest rates, it is extremely important that the ECB is able to maintain a careful communication strategy to answer all doubts, challenges and problems that could arise in the markets. As stated by Agarwal and Kimball (2019), the communication plan of a Central Bank should include three steps. To the specific case of the ECB, the first is to access the markets' perception about the effective lower bound and use this as a policy instrument. The second is convincing the markets that the ECB has the tools to eliminate the effective lower bound and manage the associated side effects. The last is convincing the markets that the ECB has the tools to minimize the costs of negative interest rates in some parts of the economy. At the same time, it is also important to convince the markets that the conversion rate already works. Following an objective and careful communication strategy, the European Central Bank can implement deeply negative nominal interest rates and establish a dual local currency system.

In Table 4, the steps and recommendations for the implementation of this plan by the European Central Bank are outlined.

Table 4. Guidelines for the implementation of the plan by the ECB

Period	**Tasks**
Before the period of negative nominal interest rates	Implementing the recommended changes in the EU legal framework
	Issuing the E-euro, developing the technological infrastructures for its use and assigning the legal tender to the E-euro
	Setting the conversion rate between the E-euro and the Euro
During the period of negative nominal interest rates	Implementing and adjusting the conversion rate
	Implementing the two-tier system for remunerating excess reserve holdings of the E-euro and the spread on the conversion rate
	Subsiding small deposit accounts
During both periods	Clear communication strategy following the three steps proposed by Agarwal and Kimball (2019)

Source: Author's elaboration

5. Conclusion

The existence of a zero lower bound on nominal interest rates constrains the Central Banks to use their policy rates in fighting deep recessions. Currently, the Central Banks' toolbox is limited, especially in the use of its main instrument: the short-term nominal interest rate.

In the years that followed the 2008 financial crisis, Central Banks in advanced economies implemented unconventional monetary policy instruments to overcome the limits on conventional monetary policy. These instruments helped to stimulate the output and avoid deflation during this period. Nevertheless, the confrontation of different contributions present on the literature showed that Central Banks could have gone further in their response to the financial crisis. In a future recession, the available unconventional monetary policy instruments could be insufficient. Therefore, the return to conventional monetary policy is essential in order to be ready for the next recession.

Removing the zero lower bound on nominal interest rates is the next phase in the construction of the monetary policy of the future. This dissertation proceeded to a review of the three proposals to remove the zero lower bound present in the literature. The confrontation of the pros and cons of each proposal allowed concluding that dissociating cash from electronic money may be the best proposal to eliminate the zero lower bound. However, this analysis faced a limitation when failing to assess the costs and benefits of each proposal, as the existing literature develops only partial estimations for some proposals. Therefore, for a more robust analysis, the existence of a literature that assesses all the costs and benefits of each proposal would be needed.

The main goal of this work was to develop a possible plan for the European Central Bank to remove the zero lower bound. This plan aimed to analyze the legal and technical changes necessary for the implementation of deeply negative nominal interest rates in the Eurozone. In order to achieve this goal, the plan defends some legal changes in European Union legislation and the implementation of the proposal of dissociating cash from electronic money. In this sense, the European Central Bank could create a dual local currency system through the issuance of a Central Bank Digital Currency (E-euro). Consequently, the E-euro would act as unit of account, while the Euro would continue to

perform the functions of mean of exchange and store of value. Moreover, a conversion rate between the two currencies would be implemented during periods of negative interest rates. This conversion rate would prevent the hoarding of cash by the Eurozone economic agents. At the same time, the plan addresses some recommendations for the period of negative interest rates. The main recommendations to the European Central Bank are the introduction of a two-tier system for remunerating excess reserve holdings of the E-Euro, authorizing banks to introduce a spread on conversion rate, the subsiding of zero rates for small deposit accounts, and a careful communication strategy.

Regarding next steps to develop this research and overcome some of its limitations, several projects can be suggested. One direction is to estimate the costs and benefits of the implementation of this plan by the European Central Bank and to extend the analysis to other Central Banks. In addition to the legal and technical requirements that have been considered in this work, the political feasibility of implementing deeply negative nominal interest rates in all the Euro Area countries needs also be addressed. In the context of modern monetary policy, further research is needed on the effectiveness of conventional monetary policy compared to unconventional monetary policy, as well as on the possible conflicts and limitations of the simultaneous use of conventional and unconventional instruments.

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