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Monetary policy normalization, central bank profits, and seigniorage

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Abstract

This paper advances a simple framework explaining how monetary policy normalization ("exit policies") may impact central bank profits and seigniorage formation with further implications for central bank transfers to the government. The cases of seven central banks of major and smaller economies serve as an illustration. The notion of the break-even point is applied to study the financial situation of these institutions for the period of 2014-2020. During the normalization process, interest rate increases may adversely affect profit changes, and through transfers may have an impact on the fiscal space available to the governments, creating political economy concerns. Possible remedies are discussed together with accompanying policy dilemmas.

Keywords: central bank profit, seigniorage, break-even point, monetary policy normalization, exit policies

JEL classification: E52, E58, E59

1. Introduction

Central banks which implemented unconventional monetary policies usually have serious problems when it comes to exiting them, i.e. "normalizing" their policies. These problems are typically of a macroeconomic nature and are well documented in official publications and research studies.

In this paper, however, we concentrate on a factor of a different nature which may also influence the specifics of "exit policies". It has to deal with the financial situation of a central bank attempting to normalize its monetary policy.

We show that policy normalization is posing challenges for central banks' potential for generating positive financial results (profits), and – consequently – the size of transfers (remittances) to the governments. To demonstrate this, we propose a framework for central bank profit formation extending an earlier model advanced by the authors (Polański and Szadkowski 2020; Polański and Szadkowski 2021). In particular, despite the fact that central banks are not profit maximizing entities, we apply the concept of the break-even point referring to a zero profit situation – a notion, to the best of our knowledge, not used so far to study central bank finances. On the empirical side, we stress the developments during 2014-2020 in seven central banks – four from larger economies (the Bank of England, the Bank of Japan, the Eurosystem and the US Federal Reserve System) and three from smaller countries (Narodowy Bank Polski, the Swedish Riksbank and the Swiss National Bank).

Similarly to many other studies, we emphasize the key challenge of diminished central bank transfers for the fiscal situation of governments during normalization.[1] However, the framework of central bank finances and the break-even point analysis allows us to put this problem into a different, yet simple, perspective. First, we demonstrate how policy rate increases may negatively influence the financial position of central banks. Second, we estimate the room for manoeuvre of central banks when it comes to increasing policy rates, which provides an orientation on how much a central bank can increase its rates until it stops recording a profit (other factors influencing the financial result being constant). Third, we show in more detail the

[1] See e.g. Bassetto and Messer (2013); Carpenter et al. (2015); Hall and Reis (2015); Del Negro and Sims (2015); Reis (2015); Kjellberg and Vestin (2019); Cavallo et al. (2019); Buiter (2021); Tanaka (2021) provides an overview of the academic discussion.

factors behind the size of the aforementioned possible room for manoeuvre, i.e. the determinants of central banks' financial results and, ultimately, transfers to the government. Fourth, we analyse the possible solutions to mitigate the problem of diminished profits and transfers while stressing that there are no easy remedies. Consequently, monetary policy and political economy factors will play a major role and pressures on central bank independence may be witnessed in the process of policy normalization.

The article proceeds as follows. In the next section we set the empirical scene by showing the developments in the seven above-mentioned central banks as concerns their profits, seigniorage and transfers to the government in the period from 2003 to 2020; the full model underlying these calculations – and showing the links between the variables – is briefly sketched in the Appendix to the paper. Section 3 outlines the basic central bank profit formation model, encompassing the break-even point idea, to be used to study the impact of policy normalization. Section 4 provides an empirical analysis based on this model and elaborates on the impact of exit policies on central banks' profits. Thereafter, Section 5 discusses some policy dilemmas and suggestions. In the last section, we present the main takeaways from our analysis.

2. Central banks' profits and seigniorage after 2007

What happened to central banks' profits, seigniorage and transfers to the governments since the start of unconventional policies in 2008? Table 1 succinctly presents the development of these variables from 2003 to 2020, i.e. also for the final part of the period known as the "Great Moderation" (until mid-2007). For the years 2003-2019, the table summarizes our earlier research on the seven central banks' finances (Szadkowski 2019; Polański and Szadkowski 2020; Polański and Szadkowski 2021); numbers for 2020 are presented for the first time, however. Data for financial results and transfers are directly extracted from official central bank documents, while numbers for seigniorage – i.e. the income stemming from currency issuance – being an unobservable variable, are estimates based on an equation provided in note two of the table (and in the Appendix).[2] As the Eurosystem does not publish a consolidated income statement (profit and loss accounts), it is worth stressing that in this case all three variables were estimated. (The underlying data and calculations can be provided on request.)

[2] It should be stressed that there are different definitions of seigniorage; see their overview in Polański and Szadkowski (2020: Appendix 1). We use a narrow definition of seigniorage; for a broad one and its implications see, for example, a recent paper by Cukierman (2021).

Table 1: Profits, seigniorage and transfers to government in the seven central banks during the 2003-2020 period and its three subperiods (yearly averages as per cent of current GDP)

Central bank	Variable	2003-2020	2003-2007	2008-2019	2020
Bank of England	profits	0.07	0.13	0.05	0.01
	seigniorage	0.06	0.12	0.04	0.00
	transfers	0.07/0.39[a]	0.13	0.05/0.48[a]	0.00/0.64[a]
Bank of Japan	profits	0.15	0.12	0.14	0.27
	seigniorage	0.08	0.10	0.08	0.07
	transfers	0.13	0.11	0.13	0.26
Eurosystem	profits	0.18	0.10	0.21	0.16
	seigniorage	0.12	0.12	0.13	0.03
	transfers	0.14	0.09	0.17	0.14
Federal Reserve System	profits	0.38	0.21	0.44	0.42
	seigniorage	0.19	0.21	0.19	0.16
	transfers	0.37	0.19	0.44	0.42
Narodowy Bank Polski	profits	0.20	0.06	0.23	0.40
	seigniorage	0.15	-0.13	0.25	0.28
	transfers	0.25	0.25	0.23	0.38
Riksbank	profits	0.10	0.01	0.15	-0.09
	seigniorage	0.03	0.02	0.03	0.00
	transfers	0.14	0.18	0.12	0.14
Swiss National Bank	profits	1.24	1.77	0.98	1.84
	seigniorage	0.22	0.41	0.13	0.26
	transfers	0.61	1.34	0.28	0.85

Note: (1) "profits" are financial results as reported by central banks (in the case of the Swiss National Bank distributable annual result); (2) "seigniorage" (S) are estimates calculated according to the equation: $S = IA - E$, where "IA" stands for income on central bank assets equivalent to cash issuance reported in central banks' balance sheets, and "E" are the overall costs of cash issuance (see also the Appendix); (3) "transfers" are net remittances (allocations) to the government (in the cases of the central banks of Belgium, France, Japan, the Netherlands, Portugal, Slovakia and the United Kingdom they include paid income tax as well). For more, see Polański and Szadkowski (2021).

[a] The Bank of England Asset Purchase Facility Fund (BEAPFF) remittances to the government are included. (The BEAPFF was created in 2009.)

Source: own calculations based on the central banks' annual reports and AMECO database (GDP data as of 11 November 2021).

The main conclusions from Table 1 and our earlier research can be stated as follows.

First, seigniorage in real terms (i.e. as a share of GDP) remained relatively stable during the whole period, usually below 0.4 per cent of GDP, while after 2007 central banks' profits (and related transfers) tended to increase. The latter was particularly visible in the group of larger economies, while in the smaller economies central banks' profits tended to be more volatile (particularly in Poland and Switzerland).

Second, in most cases seigniorage remained the main factor underlying central banks' profit formation; the growing difference between them primarily reflecting the expansion of central banks' balance sheets after 2007, which had a stronger impact on profits than the interest rates and rates of income on central bank assets, which were declining over time, on balance.

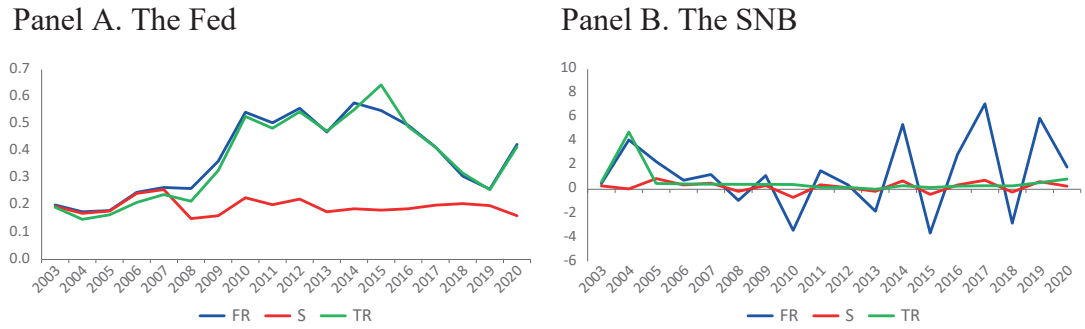
Third, not annually, but in the longer horizon, seigniorage was entirely transferred to the governments (transfers were larger than seigniorage).

Fourth, (i) the structure of the balance sheets (in particular, the share of foreign-currency-denominated assets), (ii) so-called accounting policies followed by central banks, (iii) transfer smoothing regulations as well as (iv) many one-time factors,[3] played an important role in shaping the variables under discussion.

[3] For example, the negative seigniorage in 2003-2007 in the case of Poland was mainly due to the strong appreciation of the domestic currency in 2004, the year Poland joined the EU, resulting in a decrease in income on assets that year (included in the calculation of both seigniorage and the financial result), which was absorbed by releasing the revaluation account, i.e. unrealized gains of foreign exchange appreciation accumulated before Poland's accession to the EU (included only in the calculation of the financial result). Moreover, the average profit for the first subperiod showed an extremely low level as compared to transfers to the government, mainly due to the loss recorded in 2007. For a more detailed discussion on the factors and mechanisms underlying the development of the three variables in the seven central banks see Polański and Szadkowski (2020, 2021).

Without aiming to be exhaustive, in order to illustrate these points in more detail, let us have a closer look at only the two polar cases: the Federal Reserve System (Fed) and the Swiss National Bank (SNB). See Figure 1.

Figure 1: The Fed and the SNB: financial results, seigniorage and transfers to the government, 2003-2020 (in % of GDP)



Note: as in Table 1. "FR" stands for financial result (profit/loss), while "TR" for transfers.

Source: as in Table 1.

The left panel from Figure 1 shows the annual changes of the three variables under consideration for the Fed. It can be easily seen that seigniorage was roughly stable while both financial results (Fed's profits) and transfers showed major changes after the start of the Great Financial Crisis in the second half of 2008. Their increases lasted until the mid-2010s, when the Fed decided to increase interest rates (end of 2015) and shrink its nominal balance sheet (October 2017). Consequently, interest rate costs for the Fed increased (on the liabilities items of its balance sheet), while incomes – from its assets – remained roughly stable. In 2020, with the Covid-19 pandemic, profits and transfers quickly increased again as a result of the return to unconventional measures (quantitative easing, interest rate cuts to almost zero).

Panel B, for the SNB, tells a very different story. First, let us observe that the scale of the vertical axis largely differs from the one in Panel A; for the latter it is in decimals, while for the SNB it is in full percentages reflecting the fact that SNB's assets surpassed 100 per cent of GDP in the second half of the 2010s (in 2015, the Fed's total assets amounted to almost 25 per cent of GDP, declining subsequently,

however, in 2020 they reached 27.6 per cent of GDP[4]). Second, in the case of the SNB, both financial results (in particular) and seigniorage estimates (to a smaller extent) display a "wave" (or "sinusoidal") pattern. Transfers, however, remained relatively stable (with the exception of 2004, when the SNB enjoyed a strong additional income resulting from the sale of gold, and of 2013, when no remittances were made), gently increasing at the end of the period.

There are several reasons explaining this different situation between the Fed and the SNB. First, as Switzerland is perceived by investors as a "safe haven", the SNB faced a strong inflow of foreign currencies, its foreign reserves becoming the third largest in the world (World Bank 2021), which strongly increased its assets while changing their composition so that they became almost entirely composed of foreign-currency-denominated instruments (in the Fed's case the share of foreign assets is negligible). Second, consequently, exchange rate fluctuations of the Swiss franc became of crucial importance for all variables studied, especially for profits and seigniorage, leading to their increasingly volatile pattern. Third, this instability would not be possible if the SNB had not implemented accounting rules applying the "mark-to-market" principle to almost all components of its assets, as a result of which any change in their valuation directly impacts the financial result; this is obviously not the case of the Fed (Archer and Moser-Boehm 2013: 79-83). Last but not least, being this our fourth observation, the SNB relies on a largely arbitrary transfer smoothing mechanism (i.e. based on periodic political agreements) for its profit remittances to the government, which to a certain degree separates actually transferred amounts from the current central bank's financial result.[5]

[4] For 2020, the pandemic-recession year, this ratio increased for all the studied central banks as their nominal balance sheets grew strongly, while their countries' GDPs declined. The SNB continued to be the leader with a balance sheet of almost 132 per cent of GDP.

[5] A transfer smoothing mechanism, although of different construction, is also in place in Sweden (since late 1980s), often leading to somewhat paradoxical situations. For example, as can be seen in Table 1, the Riksbank in 2020 showed a loss (mainly because of creating a financial risk provision), vanishing seigniorage (due to a strong decline in cash usage) and positive transfers to the government (as the smoothing mechanism of transfers is based on a five-year rolling average of past financial results which were mostly positive from the mid-2000s). It is also worth mentioning that in 2019 Narodowy Bank Polski (NBP) adopted a kind of transfer smoothing mechanism based on exchange rate differences.

Against this background an important question emerges for the future: how will the observed variables behave in response to the normalization of monetary policies?

3. Conceptual framework

To proceed, we must introduce some basic arithmetic of central bank finances. Below, first, we discuss central bank profit origination issues; next, we move to the concept of the central bank break-even point.

3.1. Central bank profit formation

We start with an accounting-based model generalizing the logic of profit creation in a context of a highly simplified central bank balance sheet. See Table 2.

Table 2: Simplified balance sheet of a central bank

Assets	Liabilities
NFR	C
B	R
	K

Note: NFR – net foreign reserves, B – bonds, C – cash, R – commercial bank reserves, K – capital (equity, net worth).

Source: own elaboration.

Without going into accounting details, let us shortly characterize the economic meaning of the variables in Table 2. "*NFR*" stands for net foreign reserves, i.e. overseas-issued financial instruments. Thus, we explicitly assume an open economy setting. "*B*" are bonds, i.e. domestic debt instruments, most often national government's obligations (for example, as purchased during quantitative easing – or QE – operations).

On the liability side of the central bank balance sheet, the situation is more complex. Two different approaches can be taken. The first one, stressing the monetary liabilities (i.e. monetary base components): (1) cash in circulation (*C*), legal tender, and (2) reserves (*R*), which can in turn be divided in two subgroups: required and excess reserves.[6] The two types of liabilities differ not only physically and legally, but

[6] This is a traditional, textbook and regulatory, approach. Among the studied banks there are, however, differences as concerns reserves, the most serious being the cases of the Bank of

also in terms of income generation: cash is a non-interest bearing instrument, while reserves can be remunerated (differently for the two subgroups).

Another possible perspective to look at central bank liabilities is by applying the remuneration criterion. Therefore, we can differentiate between non-interest bearing liabilities and interest bearing liabilities. Both cash and central bank capital, i.e. its equity (*K*), are interest-rate free liabilities; it is sometimes even suggested that the note (cash) issue is akin to capital for central banks (Archer and Moser-Boehm 2013: 33-34). Interest bearing liabilities are mostly commercial bank reserves, which are nowadays typically remunerated, and in what follows – for short – we will simply call "reserves".[7] Cash and equity provide interest-free funding to monetary authorities, being usually the main source of financing their current expenses, i.e. the operational costs of a central bank, transfers to the government and – when necessary – transfers increasing central bank's equity.[8]

Before going further, we should stress in the context of the second perspective, that in the last decades, starting already in the 1990s, commercial bank reserves at the central bank became initially partly and over time sometimes fully remunerated, although in the period under consideration in some cases this remuneration was in practice of zero per cent or even negative. Following the 2008 crisis, with the start of unconventional policies, in particular QE, the tendency to make reserves pay interest accelerated. Emblematically, the Fed in the fall of 2008 started the policy of remunerating interest on excess reserves (IOER).[9]

England and the Riksbank. In the case of the former, which does not formally impose required reserves, banks hold resources under the Cash Ratio Deposit Scheme; until almost the end of the 1990s, the ratio was voluntary and since then it has been set by the government (James 2020: 118 and 424-425). See also Buiter (2021: 31). In the case of the Riksbank, reserve requirements were reduced to zero in 1994 (Kjellberg and Vestin 2019: 26). Thus, in the time period under consideration, the Riksbank *de facto* did not impose reserves, although according to law it could do it (Riksbank Act 2016: Chapter 6, Article 6).

[7] As the name suggests "interest bearing liabilities" also consist of other central bank balance sheet items generating financial costs for the bank, such as central bank bills or bonds. Obviously commercial banks can invest their reserves in them, i.e. these central bank bills (bonds) act as a substitute or an alternative for reserves.

[8] Also, for paying dividends to private shareholders when applicable (e.g. as in the case of the Bank of Japan or the SNB).

[9] For the background of this decision (and the results of its implementation) see Hogan (2021).

In 2008/2009, in countries which started large scale asset purchases, there was a switch from a situation of structural liquidity deficit (i.e. scarcity of reserves) to a situation of structural liquidity surplus (i.e. large excess reserves) in the banking sector (Berentsen et al., 2018).[10] Consequently, there has also been an important change in the method of managing market interest rates as the interest rates on bank reserves, i.e. on central bank liabilities, became *de facto* the policy rate (Markets Committee 2019: 24 and 45; Hartmann and Smets 2018: 43-44, 54 and 70-71). (Before the unconventional policies were implemented, such a role was usually played by the rate on liquidity-providing open market operations, i.e. registered on the asset side of the central bank balance sheet.) Simplifying the currently existing operational frameworks of central banks, we may assume – given that they typically provide several accounts to commercial banks[11] – that the weighted average interest rate on reserves (i_R) is close to the central bank policy rate (i_{CB}) and moves in the same direction with it.[12] Thus, in what follows, $i_R \cong i_{CB}$.

Assuming the above characteristics of central bank balance sheet items and central bank tools, we can write the following central bank profit (financial result) equation:

$$FR = [i_A \cdot (C + K) + (i_A - i_{CB}) \cdot R] - OC, \tag{1}$$

where the symbols are: FR – financial result (central bank profit/loss), i_A – average rate of income on assets, i_{CB} – average interest rate on commercial banks reserves close to the central bank policy rate (e.g. the reference or bank rate), OC – operational costs.

[10] This statement refers to all six central banks under consideration from developed economies, which are studied in the paper. In Poland, however, surplus liquidity was paramount since the start of the post-communist transition (Polański 1994). Thus, the Polish central bank in the 1990s introduced money bills to neutralize (absorb) the excess liquidity in the banking sector. Under such conditions, the NBP rate on its bills became its main policy rate.

[11] Including central bank bills (bonds) and repurchase agreements.

[12] As Cavallo et al. (2019: 277) stress in the US context: "The IOER [interest on excess reserves] is tightly linked to the federal funds rate."

Equation (1) exhibits two interest rates. The central bank rate (i_{CB}) is a policy rate which is set administratively by the central bank's decision making body on the basis of its expectations regarding macroeconomic developments; thus, it is a fixed, fully controlled, rate. This is not the case of the rate of income on assets (i_A) as it is shaped by many factors, the central bank (past) interest rate being only one of them; other factors, including in particular the exchange rates and monetary policies of foreign countries whose instruments are in the portfolio of the central bank under consideration, are also relevant, depending on the relative size of the *NFR*.[13] In other words, i_A from a perspective of central bank finances must be treated as largely exogenous (at least in the short and medium-term),[14] while i_{CB} is a current monetary policy parameter.

The last variable in Equation (1) are operational costs (*OC*). These are non-interest expenses, i.e. wages and salaries, other personnel expenses, costs of services provided to the bank, and depreciation and amortization. We abstract from central bank operating income (e.g. fees for services provided) since it is typically negligible.

In this context, let us also mention that in this paper we assume the financial independence of central banks in an economic sense, by which we understand the circumstances where operational costs of a central bank (*OC*) are entirely covered by its current income and capital, so that the bank neither has to be recapitalized (subsidized) by the government, nor has to resort to financing itself by monetary base creation resulting from a negative financial result (a loss).[15] The first situation would most probably lead the central bank to ask the government for financial resources, limiting in practice its independence, while the second situation could lead to an acceleration of inflation, i.e. to unperforming its typical mandate, which could turn into political economy problems also resulting in limiting central bank independence.

[13] Compare the cases of the Fed and the SNB discussed in Section 2.
[14] In further empirical analysis we calculate i_A as the actual total income earned by a central bank on assets (including interest rates, price and exchange rate differences, if foreseen by accounting policies as income) related to the average total assets.
[15] Such situations are sometimes termed in the literature as "central bank insolvency" (see for example Del Negro and Sims (2015: 9) and Cavallo et al. (2019: 267 and 288); see also Hall and Reis (2015: 11)). On the financial technicalities behind the second mentioned situation see Kruszewski and Szadkowski (2021: 25-30).

At this point a question may arise: where is seigniorage in Equation (1)? According to our narrow approach, seigniorage creation is cash-based and seigniorage income results from average income on assets (both *NFR* and *B*) equivalent to the value of issued cash (*C*). Thus, seigniorage (*S*) is seigniorage income diminished by costs of cash issuance (*E*), an element of operational costs. Therefore, in algebraic terms:

$$S = i_A \cdot C - E. \tag{2}$$

Hence, as already suggested in Section 2 and the Appendix, under the central bank financial independence assumption, seigniorage is entirely a subset of its financial result.[16]

Obviously, central bank profits are positive when:

$$[i_A \cdot (C + K) + (i_A - i_{CB}) \cdot R] > OC. \tag{3}$$

Equations (1)-(3) show, among others, that in modern central banks seigniorage is just one, albeit often crucial, source of their profits; for a more elaborated argument see Polański and Szadkowski (2020, 2021). What is more, since we study financially independent central banks, these equations can also be used to conduct a break-even analysis of a central bank.

3.2. The central bank break-even point

The break-even point (BEP) is a well-known concept in corporate finance, a tool typically used in the context of non-financial institutions management (see e.g. Brigham and Houston 2015). The concept has not been used in central banking for the simple reason that monetary authorities are institutions aiming at public goals and are not profit maximizing entities. On the other hand, however, generating positive financial results is in the longer run a prerequisite for central banks' sustainable

[16] The above point may be considered as obvious, but this was not the case before central bank financial independence became widespread (see e.g. Klein and Neumann 1990 or Cukrowski and Fischer 2003).

transfers to the government. (If this is not the case, political economy problems are likely to appear.) Indeed, recent studies suggest (see Goncharov et al., 2022) that modern independent central banks tend to prefer slightly positive profits, as best protecting their independence. Therefore, if not explicitly, at least intuitively, the central bank staff must search for a BEP.

In what follows, thus, we propose to apply the notion of the BEP to study the finances of the seven central banks under scrutiny. As suggested, these banks are financially independent institutions; because of this, the application of the BEP analysis allows for some insights.

Let us start by recalling that the BEP concept refers to a situation where the profit of a company is zero as a result of the equalization of its total revenues and total costs. Hence, it cannot be applied in a straightforward way to a financial institution such as a central bank. For the sake of clarity, we look at two variants of the BEP, which we label as BEP1 and BEP2.

In the case of the BEP1, we abstract from operational costs (*OC*), which means that we only deal with financial revenues and financial costs of a central bank. Therefore, in a closed economy setting, Equation (1) becomes *de facto* similar to what is known in commercial bank management as the net interest income or interest margin (Rose 1999: 138-139):

$$[i_A \cdot (C + K) + (i_A - i_{CB}) \cdot R] = 0. \quad (4)$$

Under this framework the revenues of the central bank are expressed by the term $[i_A \cdot (C + K + R)]$, while its costs are $i_{CB} \cdot R$. Consequently, after re-arranging, BEP1 is set by the following equation:

$$\frac{i_{CB}}{i_A} = \frac{C+K+R}{R}. \quad (5)$$

Equation (5) means that the BEP1 is set by the ratio of the central bank policy rate (i_{CB}) to the rate of income on central bank assets (i_A) at the level defined by the total central bank liabilities (C+K+R) and its remunerated liabilities (R). The BEP1

ratio tells how many times the central bank rate (i.e. the interest rate on remunerated liabilities) can be larger than the rate of income on central bank assets, so that the central bank profit becomes zero. If the rise of i_{CB} leads to it exceeding this point, central bank loss could appear (in practice, depending on the size of existing central bank financial risk provisions). More generally, according to Equation (5), the higher the share of cash and equity in the balance sheet, the higher the central bank policy rate can be (relative to actual i_A) until the bank records no profit, i.e. until a BEP is reached.

In the case of the BEP2, we introduce one more cost item, namely the operational costs (OC). Thus, Equation (4) becomes:

$$[i_A \cdot (C + K) + (i_A - i_{CB}) \cdot R] - OC = 0, \tag{6}$$

while BEP2 condition is:

$$i_{CB} = \frac{i_A \cdot (C + K + R) - OC}{R}. \tag{7}$$

Equation (7) states that the BEP2 level of central bank rate (i_{CB}) is set by the variables mentioned in BEP1 and the operational costs. If the central bank implements an i_{CB} above the level resulting from the fraction on the right hand side of the equation, central bank loss appears.

The logic of the BEP1 and BEP2 is illustrated in Figure 2. It shows four scenarios:

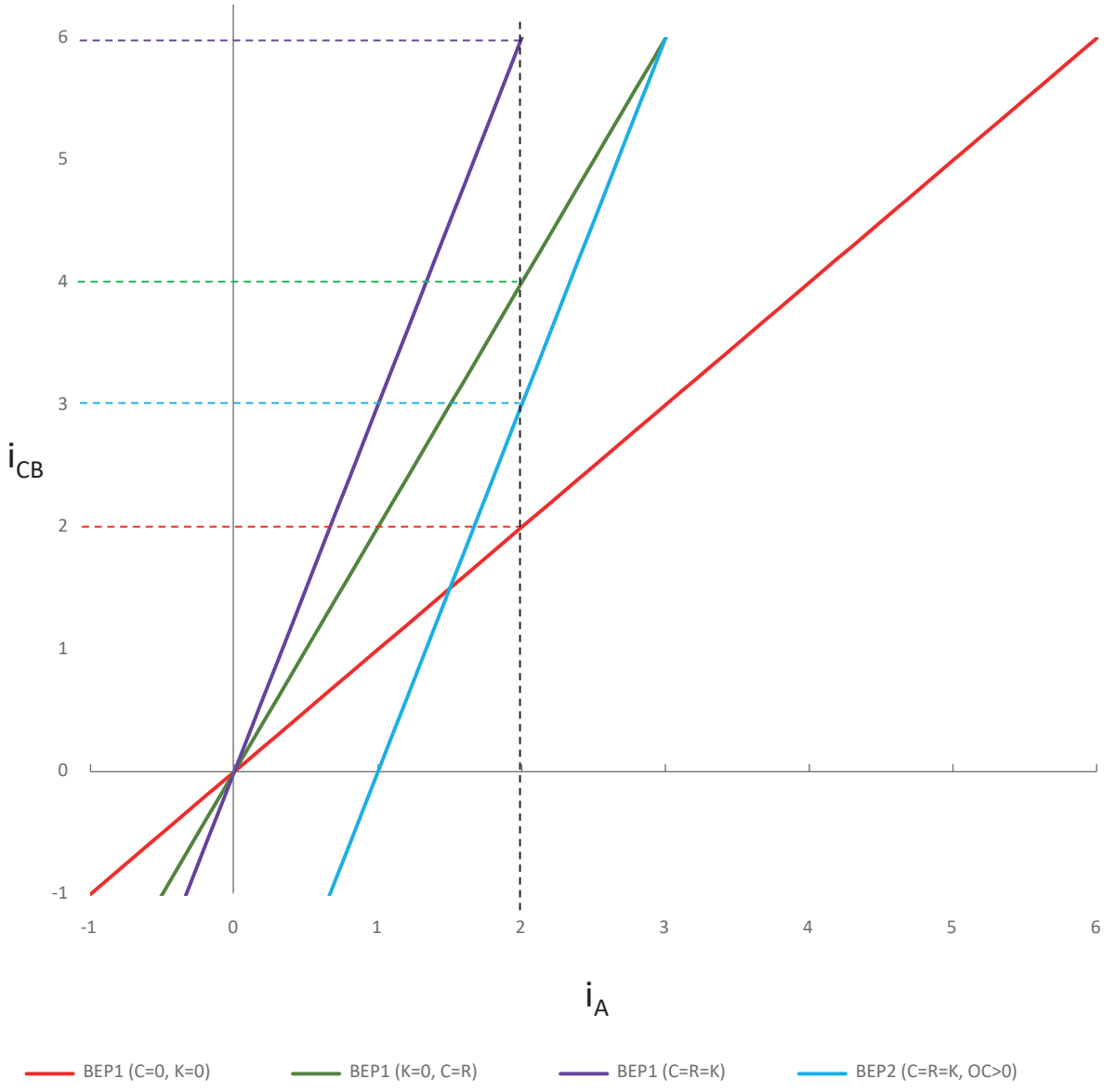
(1) when there is no cash and no equity, i.e. there are no unremunerated liabilities in the central bank balance sheet ($C = 0, K = 0$);

(2) when half of the central bank liabilities are due to cash issued and there is no equity ($K = 0, C = R$);

(3) when 1/3 of the liabilities consist of cash and another 1/3 of equity (i.e. 2/3 of the balance sheet consist of unremunerated liabilities)($C = R = K$); and

(4) when 2/3 of the balance sheet consists of unremunerated liabilities ($C = R = K$), and operational costs are taken into account ($OC > 0$).

Figure 2: Four different scenarios of the central bank break-even point (BEP1, BEP2)



Note: $FR > 0$ (profits) are below the lines; $FR < 0$ (losses) are above the lines. FR – financial result of a central bank.

Source: own elaboration.

When interpreting Figure 2, we start with the assumption that at the beginning the rate of income on assets is the same as the central bank's rate and is equal to 2 per cent. In the case of all four lines, central bank profits appear below the line, while in the opposite situation above the line losses emerge. In the first scenario, i.e. of no

unremunerated liabilities, the BEP1 shows a situation where both interest rates are at all times equal ($i_{CB} = i_A$). Under the remaining scenarios, an increase in the central bank rate (i_{CB}) above the rate on central bank's assets (i_A) does not lead to a negative financial result until a certain threshold is met. This BEP threshold depends on the relation between remunerated assets and liabilities and – in scenario 4 – also on the level of operational costs. In the case with cash only (scenario 2), a central bank can increase interest rates by 2 p.p. above the rate of income on assets (from 2 per cent to 4 per cent) until it stops recording profits, while in the case of cash and equity (scenario 3), the central bank can raise interest rates by 4 p.p. (from 2 per cent to 6 per cent) until it records zero profits (the potential to increase the central bank rate is shown by horizontal dotted lines). The BEP2 in scenario 4, which takes into account operational costs of a central bank, shows that these costs diminish the potential (or space) for a central bank rate increase.

This analysis shows that both seigniorage as well as income on equity are a sort of buffer that protects the financial results of central banks from recording losses, while operational costs have an opposite impact and can lead to a loss. Thus, cash and equity (central bank zero interest rate liabilities) provide more space (vis-à-vis the rate of income on assets) to increase the policy interest rate.

In what follows, based on the above approach, we discuss the impact of monetary policy normalization on the profits of the seven central banks.

4. Monetary policy normalization and central banks' profits: empirical analysis

4.1. The meaning of "policy normalization"

As a result of the sequence of crises started in 2007, the Covid-19 pandemic being an additional important factor, by 2020-2021 interest rates became extremely low, often negative, both in nominal and real terms, in developed as well as in most emerging economies. This situation of a very low interest rate environment was mainly achieved by central bank's actions; first, by zero and negative nominal interest rate policies (ZIRP and NIRP, respectively); second, by QE-type operations (together with new expanded lending operations in some cases), which led to highly bloated balance sheets of central banks. Of course, there were important differences among policies pursued: not all the studied banks implemented NIRP-type policies (i.e. the Bank of England, the Fed and NBP) as well as not all of them implemented QE (formally, the SNB purchases of foreign assets have been just exchange rate interventions, i.e. those were mostly acquisitions of foreign public debt[17]). Furthermore, some central banks introduced QE operations very late (NBP only in 2020[18]), while others did so before the period studied (the Bank of Japan as early as in 2001).

By mid-2021, the general picture of the seven monetary authorities was of highly expanded central bank balance sheets (in the cases of Japan and Switzerland surpassing the value of their GDP; see also Section 2) and unusually low interest rates. In some countries many market rates of return became negative too.

Given these circumstances, "policy normalization" means exiting from these ultra-loose monetary policies and a return to more traditional conditions. It is doubtful that a return to the values of before the 2007 crisis is possible at all, given for example the estimates of the declining natural (neutral) interest rates.[19] However, while interest rates must rise during exit policies sooner rather than later, the "normalization" of the size of central banks' balance sheets will be a more complicated and protracted process; a glimpse at the volume and development of central banks' balance sheets

[17] Although the SNB (together with the Bank of Japan) is well-known for holding a large equity portfolio.
[18] For more see Arena et al. (2021) and Hertel et al. (2022).
[19] On the latter see, e.g. Platzer and Peruffo (2022) and Bielecki et al. (2022).

leads to the conclusion that they will remain at high levels for at least a longer period of time (Hauser 2021[20]).

Thus, it seems justified to assume that central banks' balance sheets will persist at elevated levels for rather a longer time, in most cases with asset portfolios (mostly fixed income debt securities) purchased at low yield in the past, while banks increase their interest rates, albeit rather slowly. The discussion on and practice of exit strategies suggest that the order of operations may vary somewhat, while having a different impact on the economy (Dilts Stedman and Gulati 2021). However, the dominant approach seems to be a gradual scaling back of QE (so-called "tapering") as the initial move (as was the Fed's case in 2013-2017), followed by interest rate increases (the Fed started them in 2015) and balance sheet nominal reduction (started by the Fed in 2017).[21]

At the turn of 2021-2022, in light of accelerating inflation, most of the studied central banks announced the scaling back of their QE programmes (the Fed, the Riksbank, the Eurosystem, the Bank of Japan, the Bank of England) and some raised their rates (NBP six times in the last quarter of 2021 and the first quarter of 2022, together with halting its QE operations in autumn 2021; the Bank of England increased rates in December 2021 and two times in the first quarter of 2022; the Fed finally raised its rates in mid-March 2022). The SNB, however, continued purchasing foreign instruments, without changing its record low rates (-0.75 per cent in the case of the policy rate). Also, the Bank of Japan, the Eurosystem and the Riksbank neither started to reduce their balance sheets, nor increased their rates until the end of the first quarter of 2022.

Despite these varying approaches to policy normalization, below we propose to concentrate, as suggested by our model (Section 3), on the main factors influencing the financial results of central banks, i.e. their rates (policy rates and the rates of income on central banks' assets), the size of the central banks' balance sheets

[20] This author also mentions the impact of the possible adoption of Central Bank Digital Currencies as a factor further increasing the size of central bank's balance sheets.
[21] We stress the experience of the Fed; however, some other central banks also made certain attempts at normalizing their policies, i.e. the Bank of Japan (2006-2008), the Riksbank (2010-2011), the Bank of England (2018-2019), and the Eurosystem (2011, 2018-2019).

(including explicitly the volume of cash in circulation, equity and commercial banks' reserves), and their operational costs.

4.2. Central banks' room for manoeuvre

Using the simple model developed in Section 3, we can estimate now by how much the studied central banks could increase their policy rates, given their estimated BEPs, until they stop recording profits. Or, to put it differently, we can show what their potential room for manoeuvre was taking into account the structure of their balance sheets, the current rate of income on assets, and the level of operational costs. We do this for the period 2014-2020, i.e. encompassing the years when the Fed conducted exit policies (started at the very end of 2013) and the pandemic-recession year of 2020, which resulted in a further expansion of central banks' balance sheets and changes in their structures.

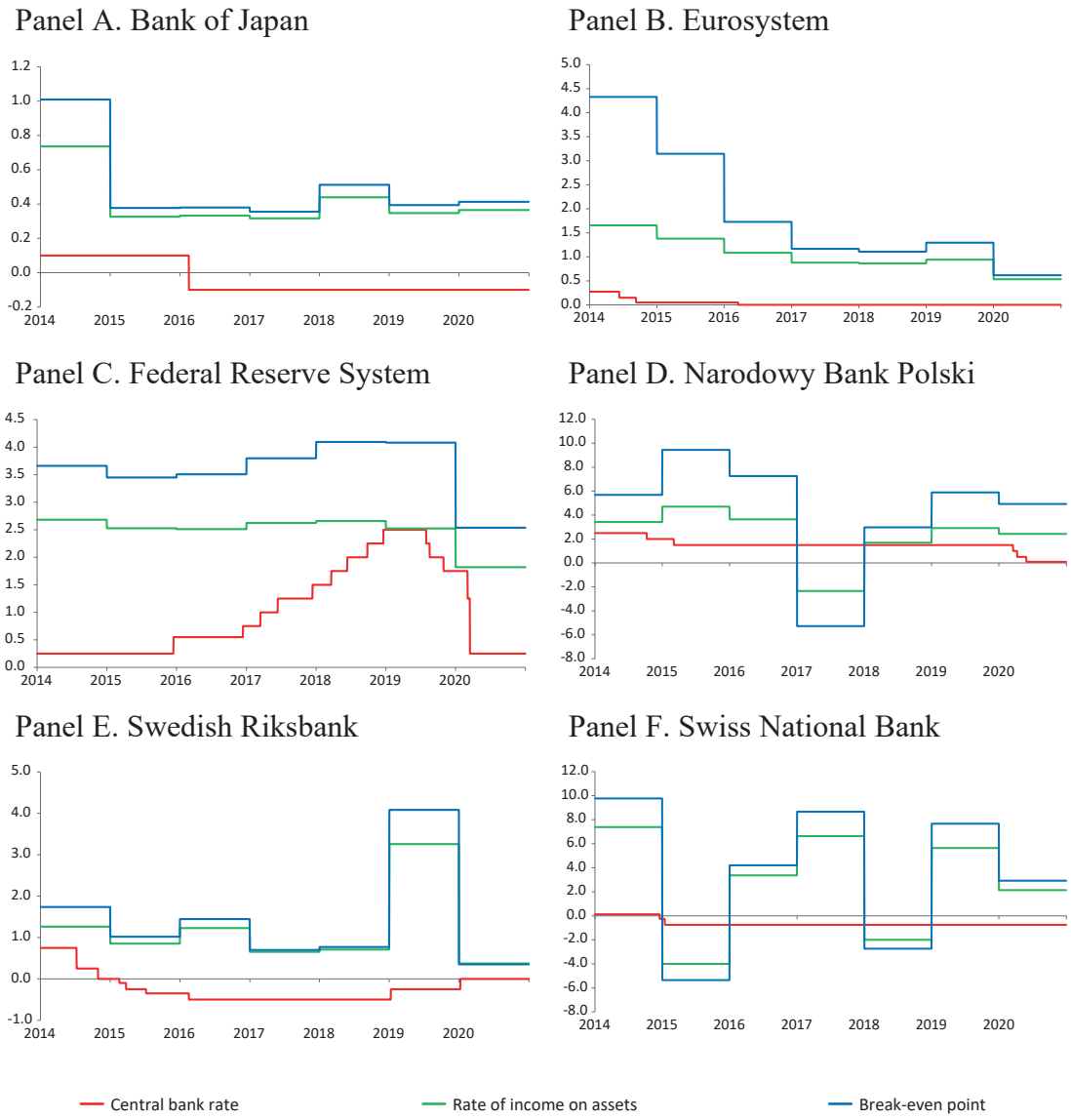
In what follows, however, we analyse in more detail only the cases of six central banks from our sample. The Bank of England (BoE) is omitted for two reasons. First, it does not publish information about its Banking Department's[22] profit and loss account in disaggregated form (i.e. it presents only net interest income instead of interest income on assets and interest expenses on liabilities separately as other central banks do), and, thus, there is no possibility to calculate the BEP. Second, and more importantly, the BoE has no securities in its balance sheet acquired through QE operations. These securities are registered in the balance sheet of the Bank of England Asset Purchase Facility Fund Limited (BEAPFF), a subsidiary company of the BoE indemnified by HM Treasury to implement QE operations (see note "a" in Table 1; for more see also BoE 2021: 148). Consequently, both BoE's assets and liabilities are in practice remunerated by the same policy rate (Bank Rate). This is due to the fact that the main asset of the BoE, the loan to the BEAPFF to purchase QE assets, and reserves of commercial banks are paid at the Bank Rate.[23] So, in the balance sheet of

[22] As it is well-known, for accounting purposes, the BoE is split in two departments: the Issue Department and the Banking Department. It is the latter which deals with QE implementation.
[23] The same applies to the Covid Corporate Financing Facility Limited (CCFF), another BoE subsidiary, established in 2020. Its aim is to purchase private short-term debt (commercial papers), and similarly to the BEAPFF it is indemnified by HM Treasury. The CCFF size and profits, however, are very small relative to BEAPFF's and we ignore it in our analysis.

the BoE *per se* there is no interest rate mismatch between assets and liabilities and there is no resulting interest rate risk. This implies that an interest rate increase does not threaten the BoE with a loss. Nonetheless, this also signifies that the interest rate risk has been moved to the government (HM Treasury). The BEAPFF transfers its profits to the government, while its loss would mean the need to transfer resources back. In the last case, it is the government that would take the burden resulting from interest rate increases.

All these latter remarks also indicates that there is no major economic rationale to calculate the BEP for the BoE. Accordingly, we concentrate on the remaining six central banks (see Figure 3).

Figure 3: Six central banks' policy rates, their rates of income on assets and the break-even point (BEP2), 2014-2020 (in %)



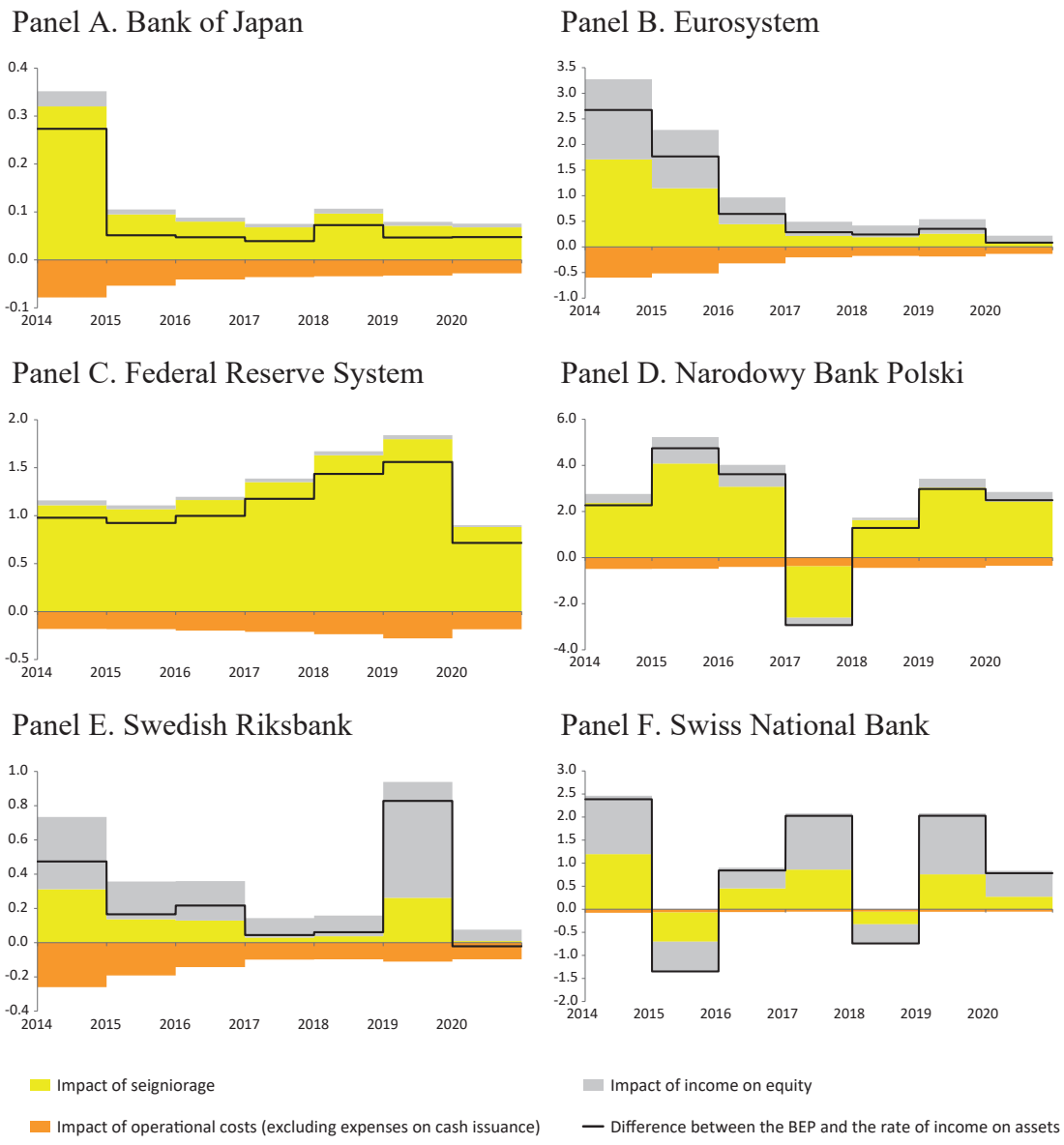
Note: central bank rates are: Bank of Japan – uncollateralized overnight call average target rate; Eurosystem – main refinancing rate; Fed – Fed funds target rate (upper limit); NBP – reference rate; Riksbank – repo rate; SNB – policy rate.
Source: own calculations based on annual reports of the central banks.

As shown in Figure 3, the break-even point (BEP2) is usually above the rate of income on assets. The exception is cases when central banks recorded losses (e.g. the banks from smaller countries where losses resulted mainly from negative foreign

exchange differences). Under such circumstances, the BEP can be lower than the rate of income on assets.

The typical situation of the BEP above the rate of income on assets suggests a positive impact of unremunerated liabilities, i.e. cash and equity, on central banks' financial results. However, more exactly, how large is the positive impact of these factors and the negative impact of the operational costs on central banks' financial results? To answer these questions let us analyse Figure 4.

Figure 4: The difference between the break-even point (BEP2) and the rate of income on assets, and factors shaping it, 2014-2020 (in p.p.)



Note: The difference between the BEP and the rate of income on assets (black line) is split into three factors:

- seigniorage (in yellow) – positive impact – is calculated according to Equations (2) and (7) as follows: $\frac{i_A \cdot C - E}{R}$,
- income on equity (in grey) – positive impact – is calculated according to Equation (7) as follows: $\frac{i_A \cdot K}{R}$,

– operational costs that exclude expenses on cash issuance (in orange) – negative impact – is calculated according to Equation (7) as follows: $-\left(\frac{OC-E}{R}\right)$.

Source: as in Figure 3.

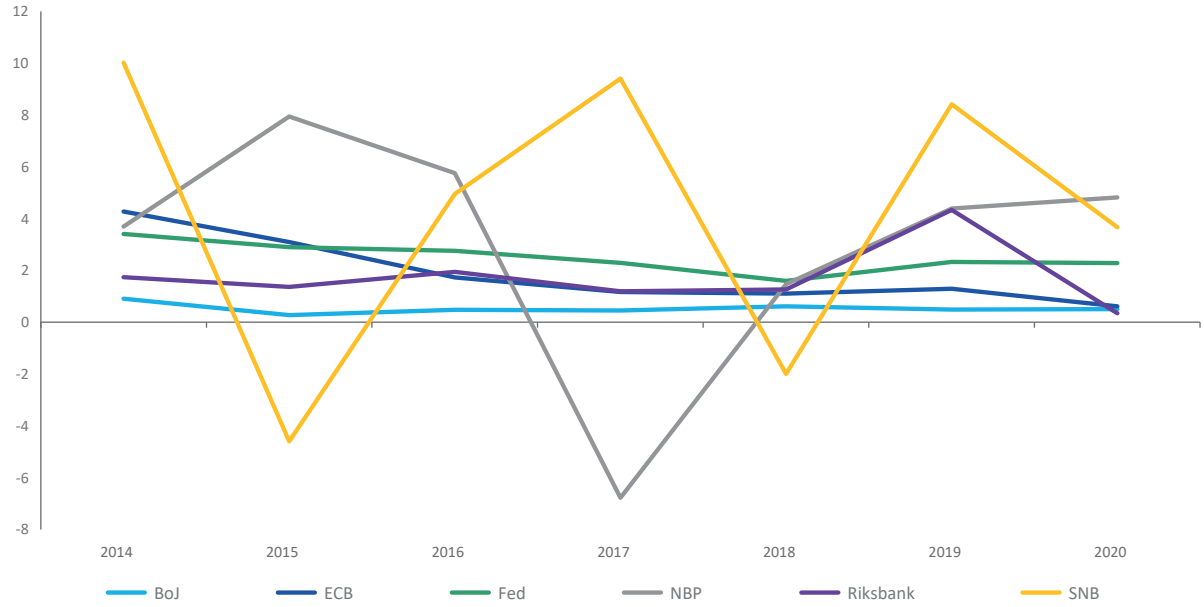
Seigniorage (in yellow) played a dominant role in shaping the difference between the BEP and the rate of income on assets in the cases of the Fed (Panel C), NBP (Panel D), the Bank of Japan (Panel A), and to a lesser degree in the Eurosystem (Panel B), while the impact of equity (in grey) was related mainly to the SNB's operations (Panel F).

The situation is not so obvious for the Riksbank (Panel E), though. Until 2019 the income on equity was the main factor behind the difference between the BEP and the rate of income on assets. This is because cash was steadily vanishing in Sweden and equity became the main source of unremunerated liabilities. However, in 2020 due to the huge increase in the balance sheet total (by more than 40 per cent), while equity and cash increased in nominal terms by much less (by 10 per cent and 1 per cent, respectively), the situation changed dramatically and the BEP became almost equal to the rate of income on assets. In fact, as Panel E of Figure 4 shows, it was slightly below the rate of income on assets, which means that seigniorage and income on equity together were not able to cover the operational costs[24] (in orange) of the central bank.

Leaving aside for a while the Riksbank case of 2020, what is then the room for manoeuvre for the central banks, given their financial situation, when it comes to increasing their policy rates? Figure 5 provides a tentative answer based on the data for the period from 2014 to 2020.

[24] Excluding expenses on cash issuance.

Figure 5: Maximum possible increase of policy rates allowing for central banks' profits given their balance sheet size and composition, 2014-2020 (in p.p.)



Source: as in Figure 3.

Figure 5 tells us how much central bank interest rates could had been increased during the years 2014-2020, before the bank stops recording a profit, given the size and structure of its balance sheet together with the current rate of income on assets[25] as well as the level of its operational costs (and assuming the negligibility of other incomes and expenses), i.e. under the *ceteris paribus* clause. The lines for each central bank were computed as the difference between the break-even point (BEP2) and the central bank rate shown in Figure 3. Thus, the three points below zero (the SNB in 2015 and in 2018; NBP in 2017) represent negative values (losses) recorded by these two banks.[26]

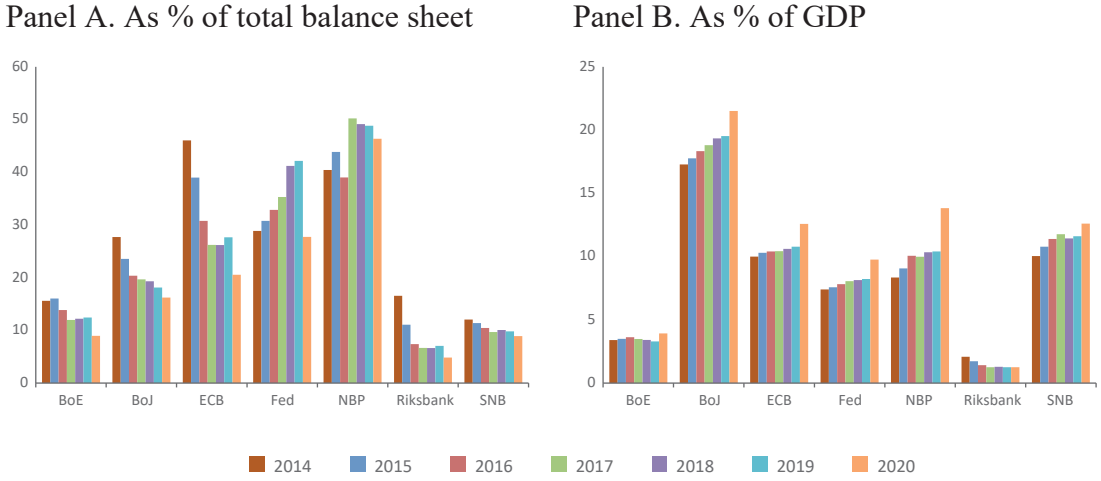
When we look at the space for the increase of central banks' reference rates until they stop recording positive financial results, as calculated for the 2020, the biggest difference between the BEP and the actual reference rate is for NBP and the

[25] On the determinants of the rate of income on analysed central banks' assets, see Polański and Szadkowski (2021: 403-407).
[26] Actually, the Riksbank also suffered a loss in 2020 (see Table 1). It was mainly due to the aforementioned transfer of funds to the financial risk provision; however, transfers to/from the risk provision are not captured by our model.

SNB, although their overall pattern is a "wave" ("sinusoidal") as a result of pronounced FX reserves in their assets. Nonetheless, for 2020 these two central banks could have increased their policy rates by 5 p.p. and 4 p.p., respectively, until their profits would have disappeared. The Fed, with the possibility to increase its rate by more than 2 p.p., takes the next place. The following two central banks, namely the Eurosystem and the Bank of Japan, have much less space for raising their rates, i.e. of only about 0.5 p.p. The Riksbank is the least protected central bank among those analysed, as confirmed by the fact that in 2020 (and in 2021 too[27]) it suffered a loss. Indeed, it can be argued that the Riksbank has no room for manoeuvre as regards increasing its interest rate.

The above analysis has shown that from the viewpoint of their financial results some of the studied central banks do not have much room for manoeuvre when it comes to increasing their policy rates. As we tried to demonstrate, the reasons for such a situation are above all linked to the two sources creating a buffer that protects central banks from losses, i.e. cash and equity. For the development of the two factors during the considered period, see Figures 6 and 7.

Figure 6: Cash (as % of total balance sheet and of GDP), 2014-2020

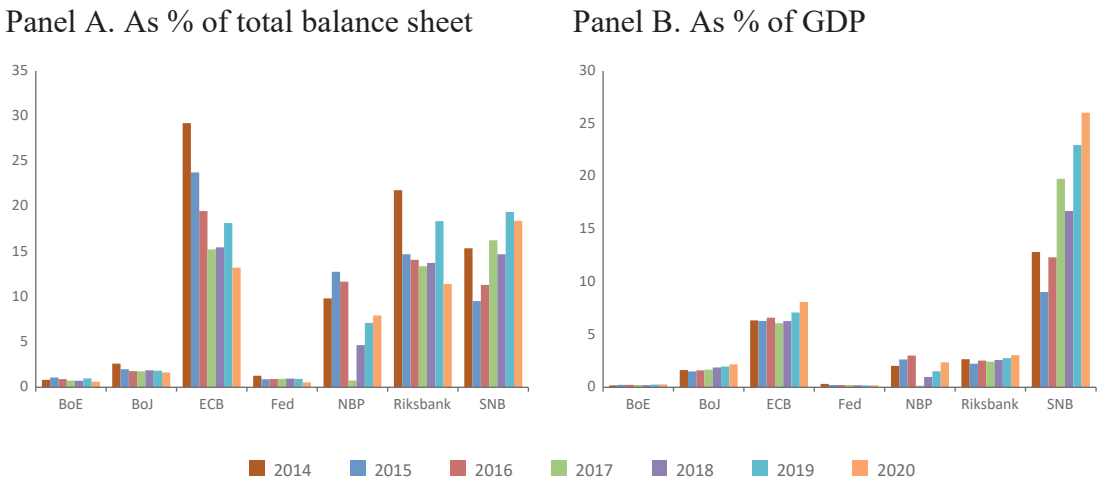


Note: ECB stands for the Eurosystem.

Source: as in Table 1.

[27] Riksbank (2022: 97). Contrary to the 2020 situation (see above footnote), however, in 2021 the Riksbank did not make a financial risk provision transfer.

Figure 7: Central banks equity (as % of total balance sheet and of GDP), 2014-2020



Note: as in Figure 6.

Source: as in Table 1.

As already mentioned, cash and equity provide central banks with interest-free income, i.e. a financial buffer (or shield) safeguarding their profit creation. From this perspective, Figure 6 confirms that the Riksbank is the least protected institution, although Figure 7 points out that it tries to increase its equity. According to the two figures discussed now, the BoE is also not strongly protected by the buffer created by cash and equity. However, as stated before, the BoE's situation is a very peculiar one given the adopted institutional solution (the BEAPFF). The SNB, contrary to the BoE and most other banks, strongly increased its capital position in the second half of the 2010s (Figure 7). The condition of the Eurosystem is also somewhat disputable given the declining role of cash and equity in its balance sheet. As suggested by earlier analyses, the financial situation of the remaining central banks is relatively stable. The Fed, the Bank of Japan and NBP enjoy large financial buffers in the form of cash, while the latter institution additionally recently increased its capital. In the case of the three smaller economies (Poland, Sweden, Switzerland) we must, however, also have in mind the potentially important role of exchange rate fluctuations for their central banks' financial performance (via a volatile rate of income on assets) due to their considerable net foreign reserves (see also Polański and Szadkowski 2021).

5. Discussion and policy dilemmas

The analysis conducted in this paper has shown that from the central bank finances perspective, many of the seven studied monetary authorities have rather restricted room for manoeuvre for increasing their policy rates, although their situation in this respect varies. Thus, a rapid exit policy can adversely affect their financial position with a subsequent impact on transfers to governments. Can this problem be mitigated and how?

Without attempting to solve all the problems arising in this respect, let us discuss the constraints and non-trivial policy dilemmas faced by central banks. In our BEP model we stressed the role of two factors in delivering a financial buffer for protecting central banks from a loss: cash in circulation and the capital of the central bank. As said, they create the buffer because these liabilities are unremunerated and, therefore, they provide a costless source of income to central banks.

Let us start with cash. The demand for cash is determined by the needs of the private sector and, as such, it can be treated as largely exogenously given to central banks. Figure 6, Panel A, showed the declining role of cash in central banks' balance sheets, which can be above all easily explained by their quickly growing assets. The exception was the Fed, which – as mentioned – tried to reduce its balance sheet during the 2014-2019 period; in 2020, however, the share of cash in the balance sheet declined as a result of renewed QE operations. Panel B, presenting the real demand for cash (cash-to-GDP ratio), shows a different trend – of cash increasing for all the studied central banks except the Riksbank.[28] In 2020, in all covered monetary areas, the ratio of cash-to-GDP increased in an abrupt manner as a result of pandemic uncertainty generating additional demand for cash, again with the exception of Sweden. In the remaining areas, the 2020 sharp increase in cash demand meant that the base for seigniorage creation increased (see Equation 2), although in two countries seigniorage values (as part of GDP) approached zero (the United Kingdom and Sweden – see Table 1). The impact of the 2020 events seems to be a one-time phenomenon and, thus, we should expect a return of the long-term trend in the demand

[28] In fact, this trend of cash-to-GDP increases started around 2008. See e.g. Jobst and Stix (2017), Shirai and Sugandi (2019), and Ashworth and Goodhart (2020).

for cash, which may stabilize seigniorage.[29] In this context, it must be stressed that while the rate of income on central bank assets (i_A) should be treated as given in the short- and medium-run, it will gradually rise in the longer-run as central banks' rates are increased, with their assets remaining at elevated levels (and not forgetting the importance of exchange rates fluctuations in smaller countries).

Let us now turn to the second source of interest-free central bank income, i.e. its equity. Figure 7 confirms that in this respect the situation among the studied institutions is very mixed. Both its panels show that in the case of the BoE and the Fed a similar situation of very low equity takes place. In both institutions such a situation is sustainable due to their balance sheet structures: in the case of the BoE, because of the Asset Purchase Facility operation and the resulting no interest rate mismatch between assets and liabilities and, consequently, no interest rate risk; in the case of the Fed – because of the pronounced role of cash and the resulting seigniorage (see Figure 4, Panel C; Table 1; and Figure 1, Panel A).

In the case of other monetary authorities, the equity position differs a lot, but actually all remaining central banks aim at increasing the size of their capital. To see these efforts, it is more advisable to concentrate on Panel B of Figure 7. All of these five banks increased their equity in real terms noticeably from the mid-2010s: in the case of the Bank of Japan relatively modestly (from 1.5 per cent of GDP in 2013 to almost 2.2 per cent of GDP in 2020), while in the case of the SNB, in our sample the institution most exposed to exchange rate and interest rate risks, capital increased from 7.3 per cent of GDP in 2013 to 26 per cent of GDP in 2020).

Thus, compared to the largely exogenously given cash and the resulting seigniorage, the equity position can be actively shaped by central banks. However, it comes at a cost, ultimately a fiscal cost. Central banks, like any other institutions, can increase their capital by retaining their net income. The extent to which this can be done is usually regulated by law. But leaving apart legal requirements, the crucial point here is that retaining net income in order to increase equity, ultimately means lower transfers to the government, potentially creating political economy dilemmas.

[29] To avoid any confusion let us also stress that we expect that the costs of cash issuance ("E" in Equation 2) will only very gradually decline and in the medium-term can be treated as given.

In 2020 this was clearly visible among some of the banks in our sample. For example, the Riksbank – as already hinted – created its financial risk provision, which contributed to a loss, allowing for transfers only due to the smoothing mechanism in place (Table 1); in the Eurosystem some national central banks have been creating additional provisions against market risk, which in the case of the Bundesbank resulted (for the first time since the late 1970s) in no profit and no transfers to the government.[30]

Therefore, there is no doubt that building buffers against losses by increasing equity (provisions are treated as such) is not as strongly limited by exogenous factors as it is in the case of cash and the resulting seigniorage. But it is limited by the fiscal situation of governments, which in the post-2008 and post-2019 world has become very difficult (see e.g. IMF 2021). And these political economy factors can ultimately be as binding as demand for cash in the case of seigniorage.

Two remaining variables from our central bank BEP formula (Equation 7) have so far not been discussed in this section: operational costs (OC) and reserves (R). Despite serious attempts performed by virtually any central bank to reduce its costs of conducting current operations (including issuance costs), we are inclined to state that there are serious limits to further reducing them, and in the medium-term they should be rather treated as almost given. Furthermore, as suggested by the panels in Figure 4, these costs are usually not of the size permitting their reduction to counterbalance the impact of other factors shaping central banks' BEPs.

Thus, the only variable in the BEP Equation 7 that could be more actively managed by the central bank are reserves (or – broadly – central bank interest-bearing liabilities). Their impact can be influenced in two ways: (i) by reducing either their size, or (ii) by reducing or abolishing their remuneration. However, as argued in Section 4.1, the first option is rather difficult to implement in the short- and medium-term. The second option is also problematic given that interest rates on reserves are not only costs for central banks, but also an instrument of their monetary policy. Different solutions can be imagined here, ranging from, for example, introducing a

[30] Deutsche Bundesbank (2021: 46). The same situation took place for 2021 (Deutsche Bundesbank 2022: 48). See also the case of the Central Bank of Ireland (Doran et al., 2018).

tiering system as concerns interest payments to abolishing remuneration in one or several steps, or some combination of them.[31] In any case, this would have to be worked out together with commercial banks given the cost of exiting the system for them, with an eye on monetary developments.

Other suggestions are also discussed, although it is unclear if they are viable under all jurisdictions. For example, Allen (2021) and Allen et al. (2021) in the UK context propose putting more emphasis on the central bank's balance sheet assets side, by swapping with the government the QE long-term bonds for shorter ones (or even bills). This would allow for a quicker restructuring of commercial banks' assets as it would facilitate them to buy these new, more liquid, securities and, thus, reduce their reserves with the central bank. As said, it is not fully clear if such swap operations can be conducted under different legal frameworks (e.g. in the euro area with strict provisions against monetization of public debt[32]). Undoubtedly, however, such operations, by involving the consent of different parties (the government, the central bank, commercial banks), must be largely political, time consuming, and in fact still entailing some fiscal costs.

Another discussed possibility is that during the period of interest rate normalization, the resulting central bank losses could be covered by fiscal transfers from the government, i.e. capital injections (recapitalization); see discussion on these proposals and related references in Tanaka (2021). Although in the UK in 2019 a one-off operation of this type took place[33], it is hard to imagine the viability of permanent operations of this type, given the paramount difficult fiscal situation and the fact that transfers should be under public and political scrutiny.

Summing up this discussion, during monetary policy normalization central banks are facing major challenges. First, there is the risk of limiting central banks' independence, either formally or informally, due to fiscal tensions involved in the process of normalization. Second, when taking interest rate decisions, central banks'

[31] See also the discussion in Allen (2021: 5-7) and Allen et al. (2021: 5-6).
[32] See e.g. ECB (2021: 95).
[33] Actually, in 2019 the BoE was recapitalized by the government as a result of the new Memorandum of Understanding (HM Treasury 2018) according to which it was needed to increase the Bank's loss-absorbing capacity.

authorities may be aware of the financial results of their choices. In any case, due to the above arguments, it should be expected that monetary policy normalization in developed countries will be a protracted process.

6. Conclusions

The analysis conducted in this paper is based on the idea of the break-even point – a concept, to the best of our knowledge, not applied so far in central banking. We used the notion of the BEP to study central banks' profits and seigniorage developments in the context of monetary policy implemented by seven major central banks since mid-2010s.

Using the BEP concept allowed us to dig into the implications of the normalization process for central bank finances. The results of our analysis suggest the following key points.

As many earlier studies had done before, we stressed the challenge of diminished central bank transfers during the normalization process for the fiscal situation of governments. The BEP analysis, however, permitted us to present this problem in a slightly different perspective, resulting from the framework of central bank finances. Namely, this approach led us to stress the room for manoeuvre of central banks when it comes to increasing policy rates resulting from the size of central banks' balance sheets and their structure. Thus, it is not the macroeconomic situation alone which makes the normalization process problematic.

The adopted framework also allows for further insights as factors shaping the financial situation of central banks and the resulting room for manoeuvre can be discussed in more detail. In particular, our analysis stressed the impact of cash (seigniorage) and capital (income on equity), which constitute a buffer against central bank losses. On the cost side, we showed the role of central bank interest-bearing liabilities (reserves) and operational costs.

Thus, our analysis provided an orientation, under the *ceteris paribus* assumption, on the one hand, on how much a central bank can increase its policy rate until its profit vanishes and, on the other hand, on the factors behind the possible room for manoeuvre in this respect. From this perspective it is clear that the potential for interest rate increases is the largest for the Fed and NBP, mainly due to their stronger seigniorage base (i.e. demand for cash). The SNB and, in particular, the Riksbank, have a much lower seigniorage base, which these institutions attempt to compensate for by increasing their equity. The situation of the Bank of Japan and the Eurosystem,

given their profit developments, is somewhere in between these two groups of central banks. A special case is the BoE, which by embracing an institutional solution aimed at eliminating the interest rate mismatch (the BEAPFF), should not be hampered by its finances to raise its policy rate, as in principle the bank ought to obtain a capital injection from the Treasury when the capital is insufficient as a result of a more restrictive monetary policy.

Our framework also confirms that there are no easy solutions to mitigate the problems discussed. In fact, most of the variables shaping the size of seigniorage and central bank profits, especially in the short run, are largely out of control of the monetary authorities (i.e. cash, equity, operational costs). Thus, only more decisive actions on the remaining variables shaping central banks' profits and transfers to the government, i.e. reserves, could be considered. The simplest, in a purely technical sense, is the reduction of the rate on interest-bearing liabilities. This, however, as argued, can be difficult to achieve both for monetary policy and political economy reasons.

All in all, it should be expected that the normalization of monetary policy and central banks' balance sheets will be a very gradual, time- and finance-consuming process, while pressures limiting central bank independence may be felt.

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Appendix. A simple model of seigniorage and central bank financial result creation and distribution

We follow the approach that links seigniorage creation with cash issuance[34]. Thus:

$$S = IA - E \tag{1A}$$

where: S – seigniorage, IA – income on assets against central bank liabilities in the form of cash, E – expenses of a central bank resulting from cash issuance.

As discussed in the paper (Section 3) seigniorage can be also shown as:

$$S = i_A \cdot C - E \tag{2A}$$

where the new symbols are: i_A – average rate of income on assets, C – cash.

Seigniorage is part of the central bank financial result according to the equation:

$$FR = S + OI \tag{3A}$$

where the new symbols are: FR – financial result (profit/loss), OI – other (non-seigniorage) central bank net income.

The equations describing the process of seigniorage and central bank profit distribution are:

$$FR = \Delta K + TR \tag{4A}$$

$$TR = pr \cdot FR \tag{5A}$$

$$pr = \frac{TR}{FR} \tag{6A}$$

$$FS = \frac{TR}{S} \tag{7A}$$

where the new symbols are: ΔK – amount transferred to the central bank's capital (equity), TR – amount transferred by the central bank to the government, pr – payment ratio, FS – fiscal seigniorage, i.e. "that part of seigniorage which the central bank passes on to the government" (Klein and Neumann 1990: 210).

[34] Arguments in favour of such an approach are presented in detail in Polański and Szadkowski (2020). See the wider discussion on this formula, including the whole model of central bank profit and seigniorage formation and distribution, in Polański and Szadkowski (2021).

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