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Central Bank Capital and Credibility: A Literature Survey

Atsushi Tanaka
(School of Economics, Kwansei Gakuin University)

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SCHOOL OF ECONOMICS

KWANSEI GAKUIN UNIVERSITY

1-155 Uegahara Ichiban-cho
Nishinomiya 662-8501, Japan

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Atsushi Tanaka [†]

School of Economics, Kwansei Gakuin University

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Abstract

Research on central bank capital and credibility evolved from the interests of developing countries to those of developed countries after the global financial crisis of the late 2000s. There is growing concern about central bank balance sheets at exit from quantitative easing. This paper surveys the literature in such a context. It starts by citing early literature which suggests that a central bank with insufficient capital may be pressured to pursue an inflationary policy at a time of crisis that jeopardizes its credibility. A theoretical analysis of this problem is carried out by the use of the central bank budget constraints and its intertemporal variant, leading to discussions on the solvency of the central bank. Several central banks make fiscal transfers to the government, and their solvency situation is influenced by whether a central bank has fiscal transfers to and from the government.

Keywords. central bank, solvency; financial strength; monetary policy; quantitative easing

JEL Classifications: E52, E58

[†] School of Economics, Kwansei Gakuin University
Address: 1-155, Uegahara Ichiban-cho, Nishinomiya, Hyogo 662-8501, Japan
E-mail: atanaka@kwansei.ac.jp

1. Introduction

The intent of this paper is to review the literature on capital and credibility of the central bank. Over the last decade, central banks in major countries have been adopting aggressive unconventional monetary policies, and concerns about their balance sheets have been rising. This paper discusses the literature in the same setting.

If a central bank is faced with a substantial loss due to a negative financial shock, its capital decreases or may even become negative, which is said to jeopardize the bank's credibility. The question then has to be addressed as to why a central bank needs sufficient capital and how insufficient capital is harmful to the bank's reputation.

A number of recent research papers on this topic have concentrated on developing countries, as some of these countries have experience of central bank failure due to foreign-exchange or banking-sector crises. For example, Leone (1994) studied the losses of central banks by analyzing 14 Latin American countries.

Central banks in developed countries have not been considered to be facing such a problem. However, a number of them have begun an aggressive unconventional monetary policy, which has put them at risk of having to face substantial losses as they exit the policy. The first central bank to introduce an unconventional monetary policy was the Bank of Japan (BOJ) in 1999. In their studies, Ueda (2004) and Cargill (2005, 2006) addressed the concern about the BOJ's balance sheet which was affected by the unconventional policy.

In 2008, "Lehman Shock" struck global financial markets. The central banks in developed countries, such as the Federal Reserve (Fed) and the European Central Bank (ECB), introduced an unconventional policy. In the 2010s, further papers about central bank balance sheets in developed countries were beginning to get published.

The studies cited in this paper have various motivations, but are arranged here to support the context of central bank capital and credibility. Section 2 reviews the early literature concerning central bank capital. Without sufficient capital, a central bank cannot implement an appropriate monetary policy, and that puts its credibility at risk. Empirical studies focusing on capital and policy performance are also summarized in this section. Section 3 deals with the development of a theoretical framework for the instant study. Initially, the central bank budget constraints that create adjustments in the bank balance

sheet are addressed, and then its intertemporal version which leads to discussions on solvency is presented. Several studies on bank behavior to prevent insolvency were also studied. Section 4 reviews the literature on fiscal transfers to and from the government.

2. Capital and Monetary Policy

2.1. Need for Capital

Central banks are usually in good financial health. Their monopolistic power of issuing money brings them an immense amount of seigniorage. Nevertheless, some central banks are forced to bear substantial losses due to quasi-fiscal practices, including acquisition of government's foreign debt or the assets of distressed financial institutions at unfavorable rates[1]. When these losses are significantly high, the capital of the central bank would reduce or even become negative.

Since the introduction of unconventional monetary easing, there has been growing concern in developed countries regarding central bank capital. A central bank may suffer a large loss on exiting quantitative easing (QE) and after it as well[2]. Let Table 1(a) be an expanded balance sheet of the central bank by QE. The bank had acquired a large number of assets, mainly long-term government bonds, to supply the monetary base. When exiting the QE, the bank must dramatically reduce its monetary base. One such strategy is to sell some of the assets. At the exit, however, a rise in the overall interest rate immediately results in a bank bearing an immense realized capital loss because of lower selling prices.

Insert Table 1 around here.

Bernanke (2009) proposed an alternative exit strategy. It was to absorb the excessive monetary base by offering liabilities with interest rates that were high enough to discourage private banks from using them. Table 1(b) displays the balance sheet while this technique is used by the central bank[3]. Unlike the asset-selling strategy, the bank will

[1]See Leone (1994), p. 745 for more examples of losses.
[2]Not only exiting QE but also implementing credit easing can cause losses, but this paper focuses on the case of exiting QE.
[3]Bernanke (2009) suggested two options for this exit strategy. One is using reverse repos, and the other is offering high interest-bearing term-deposits to private banks. The latter

not automatically incur a significant loss at exit. However, it continues to bear the responsibility of paying a substantial sum of interest, which gradually erodes the capital of the bank.

Stella (1997) discussed in depth why central banks are in need of capital. Whether it is a central bank or a private bank, negative capital does not automatically cause the bank to fail. It runs for as long as it has liquidity. If it is a private bank, negative capital plunges the bank into a lack of liquidity, which causes the bank to fail. If it is a central bank, the bank will never be short of liquidity because it can generate liquidity by issuing money. However, issuing money means unintended monetary easing. If the bank continues to produce losses, then continuing to issue money would only accelerate inflation. The central bank cannot therefore implement an appropriate monetary policy, which damages its credibility.

As Dalton and Dziobek (2005) looked at some of the past setbacks, a central bank suffers from a significant capital reduction when it is struggling with any economic crisis. Ize (2005) developed a quantitative framework for central bank accounting and explored the capital and credibility of some troubled central banks by applying the framework to their cases. Ize (2007) also used the framework to explore numerous central banks including financially sound ones.

When vulnerable to losses, the central bank will continue to generate losses as a result of significant loss during a crisis that accelerates inflation. Stella (2003, 2005) argued that the central bank has to have "financial strength" to prevent such a situation.

2.2. Evidence of Policy Performance

In order to find proof of a negative relationship between the financial strength of a central bank and inflation, it is necessary to have data on its financial strength. A simple approach is to use the ratio of capital to total assets. However, as central bank accounting varies across countries and changes over time, it is difficult to provide a consistent collection of data.

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case does not reduce excess reserves but neutralize them. Since the funds in such term-deposits are not used for private bank lending, they are included in the interest-bearing liabilities, not in the monetary base, in this paper.

For adjustment, Stella (2008, pp. 15-17) proposed adding "Other Items Net (OIN)" to the capital of the central bank in the International Financial Statistics. OIN is the "not explicitly identified" net liability, and Stella (2008) argued that capital is less than it appears to be if a central bank has a negative OIN. He calculated the ratio of capital plus OIN to total assets and compared the countries with a negative ratio to those with a positive ratio. He found that the former countries had a higher rate of inflation.

Klüh and Stella (2008) have probably carried out the first econometric analysis on this topic. They regressed inflation on the ratio of capital plus OIN to total assets as well as other variables. Similar analyses were also carried out by Benecká *et al*. (2012) and Perera *et al.* (2013). However, Adler *et al.* (2012) have followed a rather different approach. They investigated whether a reduced financial strength would limit the conduct of monetary policy. They used the deviation of the realized interest rate from the estimated optimal level as a measure of monetary policy constraints and regressed it on the capital plus OIN ratio.

They all found strong evidence of a negative relationship between financial strength and inflationary policy, with the exception of Benecká *et al.* (2012), whose findings showed a lack of robustness, and indicated that a decreasing or negative capital would jeopardize the credibility of the central bank[4]. All of them have also established differences between developing countries or those with higher inflation and developed or those with lower inflation. The negative relationship was found to be stronger in the former countries, and it was non-linear.

3. Solvency

3.1. Budget Constraints

To explore how a reduced financial strength causes higher inflation, it is necessary to examine a central bank budget constraint. For this purpose, consider the case in Table 1(b): exiting QE with high interest-bearing liabilities.

A central bank exits QE at *t*=0, and it decreases the monetary base from H_{-1} to H_0 by $L_0 = H_{-1} - H_0$, where H_t and L_t are the monetary base and high interest-bearing

[4]Hampl and Havranek (2018) deny the negative relationship. They check the precedent literature and claim that there is a publication bias.

liabilities at *t,* respectively. The bank profit π_t at *t* is

$$\pi_t = r_A A - r_L L_t - C, \tag{1}$$

where A is the asset holdings accumulated during the QE. Because a central bank cannot change its asset holdings easily in Table 1(b), A is assumed to be constant for simplicity in this paper. r_A and r_L are the interest rates on A and L_t respectively, while C is the bank's operating cost[5].

This section assumes that there is no fiscal transfer to or from the government, which is discussed in section 4, so all the profit is added to the bank capital K in the next period.

$$\Delta K_t = \pi_{t-1} = r_A A - r_L L_{t-1} - C, \tag{2}$$

where Δ denotes a change from the previous period to the present. A denotes the long-term bonds accumulated during the low interest rate period of QE, while L_t is used for short-term liabilities acquired when the interest rates were rising at the time of exit and after it as well. Therefore, r_L is much higher than r_A, which may cause π to become negative, and K to shrink.

The budget constraint at each *t* is

$$A - H_t - L_t = A - H_{t-1} - L_{t-1} + \pi_{t-1},$$

and it becomes,

$$\Delta L_t = -\Delta H_t - \pi_{t-1} = -\Delta H_t - r_A A + r_L L_{t-1} + C. \tag{3}$$

If the central bank suppresses an increase in H_t, it will expand L_t. This causes an increase in $r_L L_t$, which is the interest burden at *t*+1, only to accelerate the expansion in L, causing even more burden of interest in future. To avoid this, the central bank needs to accelerate the expansion in H, causing higher inflation in future.

This tradeoff between increased burden of interest and higher inflation is eased if K_0, the capital at the exit, is large. Given H_0 and L_0, A is larger if K_0 is larger, which brings more profit and less ΔL_t. Thus, banks with large K_0 can be said to have enough financial strength to maintain the ability to control inflation even at a negative shock such

[5]The reserves are assumed to bear no interest in this paper. Some central banks, including the Fed, the ECB, and the BOJ, pay interest on reserves or a part of reserves. Their main purpose is to place a lower limit on short-term interest rates, and so the interest rate on reserves is not high enough to prevent private banks from using them like r_L. Introducing such a low interest rate on reserves to the framework does not change any important implications discussed in this paper.

as exiting QE.

The budget constraints result in intertemporal changes in the balance sheet of the central bank. Ize (2005) developed a quantitative framework for a central bank with budget constraints and examined capital adjustments in some cases of distressed central banks. Cincibuch *et al.* (2009) expanded the framework by introducing more factors affecting the balance sheet such as changes in foreign exchange rate. Bindseil *et al.* (2004) used the budget constraints and Taylor rule as a behavior of the central bank and combined them with a simple macro-economic model to determine inflation in order to run some simulations. Their results revealed that the initial size of the capital of the central bank was important. Reis (2013a) also used the budget constraints to address the role of the ECB.

The budget constraints are used to explore the possible outcomes of exiting QE, such as, presenting the detailed simulations under some scenarios for the Fed to exit QE, as done by Carpenter *et al.* (2015), Greenlaw *et al.* (2013), Christensen *et al.* (2015)[6], and Iwata and Japan Center for Economic Research (2014) estimated the BOJ's cost under some scenarios after exiting QE, while Fujiki and Tomura (2017) presented results of some simulations regarding the BOJ exiting QE. Their results displayed variation, but none of them recorded an exploding monetary base in the United States or Japan.

3.2. Intertemporal Budget Constraints and Solvency

The central bank budget constraints show the time paths of capital and other items in the balance sheet of a central bank. Now, the question arises about the feasibility of various time paths, which implies finding a time path that keeps a central bank solvent while conducting an appropriate monetary policy.

Reis (2015) argued that the no-Ponzi game condition must be satisfied for solvency. To see this, the framework in subsection 3.1 is used. The budget constraint at each *t*, equation (3), must be satisfied for all $t \geq 1$. Both sides of equation (3) are multiplied by $(1 + r_L)^{-t}$, and they are summed up from $t = 1$ to ∞.

[6]Instead of capital, these studies simulate the Fed's "deferred asset", which is a negative liability for losses. See footnote 8.

$$\sum_{t=1}^{\infty}(1+r_L)^{-t}[\Delta L_t - r_L L_{t-1}] = -\sum_{t=1}^{\infty}(1+r_L)^{-t}\Delta H_t - \sum_{t=1}^{\infty}(1+r_L)^{-t}(r_A A - C)\,. \quad (4)$$

This reduces to,

$$\lim_{t\to\infty}(1+r_L)^{-t}L_t = L_0 - \frac{r_A A - C}{r_L} - \sum_{t=1}^{\infty}(1+r_L)^{-t}\Delta H_t\,. \quad (5)$$

Unlike H_t, L_t are the liabilities to be paid back. Therefore, the no-Ponzi game condition is

$$\lim_{t\to\infty}(1+r_L)^{-t}L_t \leq 0, \quad (6)$$

which must be satisfied for solvency.

The no-Ponzi game condition is satisfied if the right-hand side of equation (5) is non-positive. The third term is the seigniorage, and with a negative sign, the term is non-positive unless the bank continues to shrink the monetary base even after the exit. If $r_A A - r_L L_0 - C \geq 0$, then the right-hand side is non-positive. In this case, the central bank can set ΔH_t at any non-negative value, which implies that the solvency does not restrict the monetary policy. If $r_A A - r_L L_0 - C < 0$, then the bank needs some seigniorage to keep the right-hand side non-positive. If such ΔH_t is larger than the appropriate monetary policy requirement, the solvency restricts the monetary policy and forces it to be inflationary. More K_0 is equivalent to more A with the same L_0, which makes $r_A A - r_L L_0 - C$ larger, and thus the initial size of capital is an important factor for financial strength in this framework.

It depends on $r_A A - r_L L_0 - C$ whether monetary policy can be restricted or not. This explains the non-linear relationship between financial strength and inflationary policy, empirical evidences of which are found in the literature discussed in subsection 2.2.

Some studies combine the central bank intertemporal budget constraints with a macroeconomic model based on the microeconomic optimal behavior of the private sector. The dynamic optimization of the private sector needs the transversality condition. It states that the private sector does not accumulate its asset holding too fast, preventing the central bank liabilities from exploding, as posited by De Negro and Sims (2015, p. 5). In the

framework of this paper, L are the liabilities of the central bank and the assets held by the private sector; thus the transversality condition is

$$\lim_{t\to\infty}(1+r_L)^{-t}L_t = 0. \tag{7}$$

If the transversality condition (7) is satisfied, the no-Ponzi game condition (6) is satisfied. De Negro and Sims (2015), Benigno and Nisticò (2015) use the central bank's intertemporal budget constraints and the macroeconomic model with the transversality condition to examine cases in which a central bank cannot conduct an appropriate monetary policy if it tries to stay solvent[7].

The no-Ponzi game condition (6) allows the value to be negative, which violates the transversality condition (7). In this case, the central bank can transfer $\tau_t \geq 0$ to the government as many central banks actually do.

$$\Delta L_t = -\Delta H_t - \pi_{t-1} = -\Delta H_t - r_A A + r_L L_{t-1} + C + \tau_t. \tag{3'}$$

By adjusting τ_t, the bank can avoid a negative L. The transfer to the government is a topic in section 4, including the case of $\tau_t < 0$ fiscal support for a central bank.

The losses of a central bank are covered by seigniorage, which may lead to inappropriate monetary policy and thus inflation. However, the bank may not be able to issue the monetary base enough to cover the losses unless the monetary base is sufficiently demanded. Buiter (2007) argued that seigniorage increases with inflation, but reaches a maximum and then decreases, and he calls it a seigniorage Laffer curve.

3.3. Behavior to Avoid Insolvency

The no-Ponzi game condition makes it possible to research situations in which a central bank cannot remain solvent if it conducts an appropriate monetary policy. The question that needs to be answered is how to avoid such cases.

Some studies analyze the precautionary actions of the central banks to avoid potential insolvency. Berriel and Mendes (2015) set a lower bound for the capital of a central bank to run the simulations. Berriel and Bhattarai (2009) included the capital, as

[7] Bassetto and Messer (2013) use the intertemporal budget constraint and the macroeconomic model without optimal behavior of the private sector, but implicitly assume the no-Ponzi game condition.

well as inflation and output, in its policy objective function. Bhattarai *et al.* (2015) considered the transfer of the bank to the government as a part of its policy objective function, where the bank will seek to keep its profit positive in order to allow transfers, even though its research interest is not in solvency.

As it has been discussed in few studies, if a central bank is faced with insolvency, it must find a way to restore solvency while keeping inflation as small as possible. Benigno and Nisticò (2015) included a variety of numerical examples of the optimal pathways of the monetary base to minimize the policy objective function of inflation and output. Tanaka (2018, 2019) introduced a dynamic optimization model for the central bank and set out the optimal path to minimize the policy objective function of inflation. More research is needed in this area, since such optimal pathways need to be taken into account when designing the exit strategy for QE.

4. Relation with the Government

4.1. Fiscal Transfer

Several central banks have the provision to transfer to the government as long as the bank's profit is positive and bank's insolvency relies on this provision. Hall and Reis (2015) defined three forms of insolvency: period insolvency, rule insolvency, and intertemporal insolvency. Period insolvency refers to the rule that the government collects all the profit when it is positive. Under this rule, central bank insolvency is typically unavoidable when the profit is negative, even for one period. Rule insolvency refers to the rule that the government takes all the profit but defers the transfer if it is negative in order to allow the bank to restore solvency[8]. Intertemporal insolvency is based on the no-Ponzi game condition and, in the case of a fiscal transfer, the condition corresponding to equation (6) can be derived from equation (3').

Conversely, if the central bank receives fiscal transfers from the government, it allows the bank to stay solvent and to conduct an appropriate monetary policy. In the framework of section 3, equation (3') shows that negative τ helps lower ΔL and ΔH.

[8]The Fed has this rule. Losses are not recorded as decrease in capital but increase in "deferred asset," which is a negative liability. When it restores profitability, the Fed starts paying back the deferred asset to the government until the asset becomes zero. See Carpenter *et al.* (2015), subsection 2.1.5.

With full support from the government, a central bank always stays solvent, as stated by Reis (2013b, 2015).

Hall and Reis (2015) looked at the solvency of the central bank in compliance with different rules for fiscal transfers to and from the government. Benigno and Nisticò (2015) have taken into account the fact that fiscal support comes from taxes and argued that it depends on the scale of central bank's loss whether the fiscal support enables the bank to avoid inflation. Berentsen *et al.* (2016) concluded that the best exit strategy from QE depends on whether or not a central bank receives fiscal support.

Many central banks have no definite procedure for obtaining fiscal transfers from the government. Establishing a rule is necessary to prevent insolvency, but it is also important to consider its effect on the independence of the central bank. Fiscal support may weaken the bank's independence from the government, and Stella (1997, 2003, 2005), Bindseil *et al.* (2004), and Ueda (2004) were among early studies voicing such concern.

4.2. Monetary Policy to Help the Government

There is comprehensive literature on monetary and fiscal policy coordination, and Buiter (2007) addressed this in the sense of central bank solvency. Various other studies have looked at the prospect of alleviating government debt. Reis (2018) addressed various mechanisms for a central bank to alleviate government debt and concluded that its scope was limited. Rigon and Zanetti (2018) provided a model showing that the central bank is facing a tradeoff between inflation and output stability and government debt stability. They found that monetary policy with debt stabilization is sub-optimal relative to policy without debt stabilization.

It is also discussed whether central banks really do or do not reduce government debt. Orphanides (2017, 2018) looked at the alleviation of the Fed, the BOJ, and the ECB following the global financial crisis, and concluded that both the Fed and the BOJ helped improve the government debt dynamics, while the improvement by the ECB depends on the country in the Eurozone. Franta *et al.* (2018) performed an econometric analysis to examine the scale of the central bank's accommodation of debt-financed government spending in six developed countries before the crisis, and found out that the monetary

policy was accommodative in the U. S. and partially in Japan, but not in the others.

5. Conclusion

This study surveyed the literature on the capital and credibility of the central bank. Research in this area had evolved from the interests of developing countries to those of developed countries following the global financial crisis of the late 2000s. There is growing concern about their balance sheets as they exit QE, and this paper has looked at the literature in such a context.

Early studies addressed the need for capital for the central bank to conduct an appropriate monetary policy. They claimed that the central bank needs to have "financial strength," and capital is an essential factor for strength. Without adequate strength, the central bank is vulnerable to losses and may have limited option but to follow an inflationary policy that jeopardizes its credibility. The empirical studies cited here provide evidence of a negative relationship between capital and inflation.

This relationship is theoretically explained by the central bank budget constraints. The constraints are also useful for simulating outcomes under various scenarios. Simulation experiments on the Fed and the BOJ indicate that inflation is unlikely to erupt after exiting QE.

The intertemporal version of the budget constraints is extracted, leading to debates on central bank solvency. Some studies use it to examine whether or not a central bank can preserve solvency while conducting an appropriate monetary policy, but there are only a few to investigate optimal pathways of monetary base to restore solvency while keeping inflation as low as possible.

The solvency situation is influenced by whether a central bank has fiscal transfers to and from the government, and the full fiscal support keeps the central bank in position to remain solvent. Several studies explore the likelihood of helping to reduce government debt. The studies cited here are pessimistic, but the coordination of monetary and fiscal policies is discussed in a number of articles on different issues outside the reach of this paper.

In the context of exit from QE, further research is required in the area to explore the optimal paths of the monetary base in the wake of insolvency. Although the above

simulation results show no case of an eruption of inflation in the United States and Japan, their central banks and others are switching their course to reinforce QE in 2020, which is deteriorating their situation. Research in this field leads to the development of effective exit strategies in the future. Moreover, as fiscal support aids central banks, more researches are required to explore the fiscal support rule that maintains the independence of the central bank.

References

Adler, C., Castro, P. and Tovar, C. (2012) Does central bank capital matter for monetary policy? IMF Working Paper No. 12/60.

Bassetto, M. and Messer, T. (2013) Fiscal consequences of paying interest on reserves. *Fiscal Studies* 34(4): 413–436.

Benecká, S., Holub, T., Kadlčáková, N. and Kubicová, I. (2012) Does central bank financial strength matter for inflation? an empirical analysis." CNB Working Papers 3/2012.

Benigno, P. and Nisticò, S. (2015) Non-neutrality of open-market operations. Presented at the 16th Jacques Polak Annual Research Conference hosted by the IMF.

Berentsen, A., Kraenzlin, S. and Müller, B. (2016) Exit strategies for monetary policy. University of Zurich, Department of Economics Working Paper No. 241.

Bernanke, B. (2009) The Federal Reserve's balance sheet: an update," Speech at the Federal Reserve Board Conference on Key Developments in Monetary Policy, October 8.
(http://www.federalreserve.gov/ newsevents/speech/bernanke20091008a.htm)

Berriel, T. and Bhattarai, S. (2009) Monetary policy and central bank balance sheet concerns. *The B. E. Journal of Macroeconomics* 9(1): 1–31.

Berriel, T. and Mendes, A. (2015) Central bank balance sheet, liquidity trap, and quantitative easing." Textos para discussão 638, Department of Economics PUC-Rio (Brazil).

Bhattarai, S., Eggertsson, G. and Gafarov, B. (2015) Time consistency and the duration of government debt: a signaling theory of quantitative easing. NBER Working Paper No. 21336.

Bindseil, U., Manzanares, A. and Weller, B. (2004) The role of central bank capital revisited. European Central Bank Working Paper No. 392.

Buiter, W. H. (2007) Seigniorage. NBER Working Paper No. 12919.

Cargill, T. (2005) Is the Bank of Japan's financial structure an obstacle to policy? *IMF Staff papers* 52(2): 311–334.

Cargill, T. (2006) Central bank capital, financial strength, and the Bank of Japan. *FRBSF Economic Letter* No. 2006–11.

Carpenter, S. B., Ihrig, J. E., Klee, E. C., Quinn, D. W. and Boote, A. H. (2015) The Federal Reserve's balance sheet and earnings: a primer and projections. *International Journal of Central Banking* 11(2): 237–283.

Christensen, J., Lopez, J. and Rudebusch, G. (2015) A probability-based stress test of Federal Reserve assets and income. *Journal of Monetary Economics* 73: 26–43.

Cincibuch, M., Holub, T. and Hurník, J. (2009) Central bank losses and economic convergence. *Czech Journal of Economics and Finance* 59(3): 190-215.

Dalton, J. and Dziobek, C. (2005) Central bank losses and experiences in selected countries. IMF Working Paper 05-72.

Del Negro, M. and Sims, C. A. (2015) When does a central bank's balance sheet require fiscal support? *Journal of Monetary Economics* 73: 1–19.

Franta, M., Libich, J. and Stehlík, P. (2018) Tracking monetary-fiscal interactions across time and space. *International Journal of Central Banking* 14(3): 167–227.

Fujiki, H. and Tomura, H. (2017) Fiscal cost to exit quantitative easing: the case of Japan. *Japan and the World Economy* 42: 1–11.

Greenlaw, D., Hamilton, J. D., Hooper, P. and Mishkin, F. S. (2013) Crunch time: fiscal crises and the role of monetary policy." NBER Working Paper No. 19297.

Hall, R. E. and Reis, R. (2015) Maintaining central-bank financial stability under new-style central banking. NBER Working Paper No. 21173.

Hampl, M. and Havranek, T. (2018) Central bank capital as an instrument of monetary policy. EconStor Preprints 176828, ZBW - Leibniz Information Centre for Economics.

Iwata, K. and Japan Center for Economic Research (ed.) (2014) *Quantitative Qualitative Easing* Nikkei Publishing. (in Japanese)

Ize, A. (2005) Capitalizing central banks: a net worth approach. *IMF Staff Papers* 52(2): 289–310.

Ize, A. (2007) Spending seigniorage: do central banks have a governance problem? *IMF Staff Papers* 4(3): 563–589.

Klüh, U. and Stella, P. (2008) Central bank financial strength and policy performance: an econometric evaluation. IMF Working Paper 08/176.

Leone, A. (1994) Institutional and operational aspects of central bank losses. In T. J. T. Baliño and C. Cottarelli (eds.) *Frameworks for Monetary Stability: Policy Issues*

and Country Experiences (pp. 738–755). Washington D. C.: International Monetary Fund.

Orphanides, A. (2017) Central bank policies and the debt trap. *CATO Journal* 37: 223–246.

Orphanides, A. (2018) Independent central banks and the interplay between monetary and fiscal policy. *International Journal of Central Banking* 14(3): 447–470.

Perera, A., Ralston, D. and Wickramanayake, J. (2013) Central bank financial strength and inflation: is there a robust link? *Journal of Financial Stability* 9(3): 399–414.

Reis, R. (2013a) The mystique surrounding the central bank's balance sheet, applied to the European crisis. *American Economic Review* 103(3): 135–140.

Reis, R. (2013b) Central bank design. *Journal of Economic Perspectives* 27(4): 17–44.

Reis, R. (2015) Different types of central bank insolvency and the central role of seignorage. NBER Working Paper No. 21226.

Reis, R. (2018) Can the central bank alleviate fiscal burdens? In D. G. Mayes, P.L. Siklos and J.-E. Sturm (eds.) *The Oxford Handbook of the Economics of Central Banking* (pp. 131-170). New York: Oxford University Press.

Rigon, M. and Zanetti, F. (2018) Optimal monetary policy and fiscal policy interaction in a non-Ricardian economy. *International Journal of Central Banking* 14(3): 389–436.

Stella, P. (1997) Do central banks need capital? *IMF Working Paper* WP/97/83, July.

Stella, P. (2003) Why central banks need financial strength. *Central Banking* 14(2): 23–29.

Stella, P. (2005) Central bank financial strength, transparency and policy credibility. *IMF Staff Papers* 52 (2): 335–365.

Stella, P. (2008) Central bank financial strength, Policy constraints and inflation. IMF Working Paper 08/49.

Tanaka, A. (2018) Monetary base controllability after an exit from quantitative easing. School of Economics, Kwansei Gakuin University Discussion Paper No. 181.

Tanaka, A. (2019) How can a central bank exit quantitative easing without rapidly shrinking its balance sheet? School of Economics, Kwansei Gakuin University Discussion Paper No. 196.

Ueda, K. (2004) The role of capital for central banks. Speech as a member of the Policy Board of the Bank of Japan, at the Fall Meeting of the Japan Society of Monetary Economics, on October 25, 2003.
(http://www.boj.or.jp/en/announcements/press/koen_2003/ko0402b.htm/)

Table 1. Central Bank Balance Sheet

(a) Before an Exit from QE

Assets	Monetary Base
	Capital

(b) At an Exit from QE

Assets	Monetary Base
	Interest-Bearing Liabilities
	Capital