Research in International Business and Finance 47 (2019) 386–397

Contents lists available at ScienceDirect

Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

Accounting standards and banking regulation: Some effects of divergence☆

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ARTICLE INFO

Keywords:
Banks
Banking regulation
Accounting standards
Risk-management
Derivatives

ABSTRACT

This paper examines the impact of divergence between accounting standards and banking regulation – for example, when banks' assets are marked-to-market for regulatory purposes but not for accounting purposes. I build a model that examines divergence in connection with risk-management by banks. The model shows that divergence results in a risk-management trade-off – using derivatives to hedge has regulatory benefits but accounting costs, or vice versa. Banks thus hedge to a lesser extent. Hence, a negative shock is more likely to make banks insolvent. More generally, the model identifies a mechanism by which divergence can have undesirable "real effects."

1. Introduction

After the 2007–8 financial crisis, banking regulators voiced concerns that certain accounting standards might have exacerbated the crisis and might be unsuitable for regulatory purposes more generally (e.g., Bernanke, 2009). However, Laux and Leuz (2009, 2010) and Barth and Landsman (2010) point out that to the extent that accounting standards do have effects that are undesirable from a regulatory point of view, banking regulators can and do modify banks' accounting numbers for regulatory purposes – for example, when determining regulatory capital. Such adjustments appear to have become more common following the 2007–8 crisis and could become even more important going forward. For example, in the United Kingdom, the Prudential Regulatory Authority is thinking about requiring banks to maintain a separate set of regulatory accounts in addition to their IFRS-based accounts (The Select Committee on Economic Affairs, 2015).

The aim of this paper is to examine some effects of regulatory adjustments that result in "divergence" between the banking regulations and accounting standards banks face. Prior studies show how accounting standards such as fair-value accounting can affect banks' investment decisions – for example, by leading to asset sales in financial crises (e.g., Cifuentes et al., 2005; Allen and Carletti, 2008; Plantin et al., 2008). Other studies show how banking regulations such as capital requirements can affect banks' investment decisions – for example, by reducing lending in recessions (e.g., Hancock and Wilcox, 1995; Peek and Rosengren, 1995; Gambacorta and Mistrulli, 2004). However, to the best of my knowledge, no studies focus on the impact on banks of divergence between accounting standards and banking regulation. As a consequence, in this paper, I attempt to take a first step toward a better understanding of divergence.

I build a model that examines how divergence affects banks' risk-management practices. Theoretically, Diamond (1984) shows that to exploit their comparative advantage in monitoring borrowers' credit risk, banks should hedge their systematic risk (e.g.,

☆ Thanks to John W. Goodell (the editor), an anonymous referee, and participants at the GSOM Emerging Markets Conference 2017 for useful comments on this paper.

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https://doi.org/10.1016/j.ribaf.2018.08.011
Received 10 October 2017; Received in revised form 27 August 2018; Accepted 30 August 2018
Available online 05 September 2018

interest-rate risk). Empirically, Carter and Sinkey (1998), Gorton and Rosen (1995), and Purnanandam (2007) find that certain risk-management practices – using derivatives – are beneficial for banks, while Aebi et al. (2012) find that banks that had stronger risk-management practices performed better during the 2007–8 crisis. Moreover, a casual inspection of banks' annual reports suggests risk-management is an important issue for virtually all banks. Hence, examining divergence in connection with risk-management lets the model focus on an issue with high relevance for most, if not all, banks.

The model examines risk-management in connection with the hedging programs of banks. The point of departure of the model is that banks' hedging programs have multiple objectives, not just one. One objective is to reduce earnings volatility. A large body of evidence suggests reducing volatility in earnings is an important objective for firms. For example, in a survey by Graham et al. (2005), 78 percent of chief financial officers stated they would sacrifice economic value to reduce earnings volatility. Moreover, other studies document that firms hedge with the specific goal of reducing volatility in earnings (e.g., Brown, 2001). The second objective is to preserve franchise value by reducing the probability of insolvency. The notion that franchise-value concerns can lead banks to take less risk – for example, by hedging – likewise is well-documented in prior studies, discussed in Section 2.1.

In the model, as in practice, divergence arises because earnings and regulatory capital are not necessarily determined in the same manner. Banks invest in loans and in derivatives used to hedge the interest-rate risk on these loans. Banks have two motives to hedge this interest-rate risk: to reduce earnings volatility, where higher volatility increases funding costs for the loans (e.g., by increasing perceived credit risk), and to preserve franchise value by decreasing the probability of insolvency. Earnings volatility depends on accounting earnings, whereas the probability of insolvency depends on regulatory capital. Consistent with current practice, the derivatives always are marked-to-market for earnings and capital. Under divergence, the loans are marked-to-market for capital but not for earnings. Under convergence, the loans are marked-to-market both for earnings and for capital.

The model has two main results. First, hedging is weakly lower under divergence relative to convergence. Under divergence, hedging has both a cost and a benefit. Since the loans are marked-to-market for capital, hedging reduces the net decline in capital if the loans decline in value. Banks thus are less likely to be declared insolvent by a banking regulator (i.e., to lose their franchise value), a benefit. However, the loans are not marked-to-market for earnings. As a result, banks have an unhedged accounting exposure on the derivatives. Hence, hedging increases volatility in earnings, a cost. By contrast, under convergence, hedging is strictly beneficial. Hedging still reduces the probability of insolvency. Moreover, since the loans are marked-to-market for earnings, hedging reduces earnings volatility on the loans rather than increasing volatility. Consequently, banks hedge more under convergence.

This result captures one effect of divergence: risk-management decisions – in particular, using derivatives to hedge – with regulatory benefits have accounting costs, or vice versa. Banks thus hedge less. Consequently, the probability of insolvency is higher under divergence. Because banks hedge less, any given decline in value for banks' loans leads to a larger decline in regulatory capital, and so banks are more likely to be declared insolvent by the regulator. Furthermore, even if banks were to remain solvent, this larger decline in capital could reduce banks' lending capacity. In this way, divergence could worsen a "credit crunch" in a recession (Bernanke et al., 1991; Hancock and Wilcox, 1995; Peek and Rosengren, 1995). Both of these effects are undesirable.

The second result is that lending is weakly lower under divergence. Under divergence, the loans are marked-to-market for capital, and so hedging reduces the probability of insolvency. As a consequence, hedging at least some of the interest-rate risk on the loans can be optimal. However, since banks have an unhedged accounting exposure on the derivatives, any hedging increases earnings volatility, in turn increasing funding costs on the loans. As a result, lending is less profitable, inducing less lending. By contrast, under convergence, hedging is strictly beneficial. Hence, banks hedge all of the interest-rate risk on the loans. Because the loans are marked-to-market for earnings, this hedging policy eliminates volatility in earnings. Funding costs thus are lower under convergence. As a result, banks lend more.

The model's most general insight is that divergence between accounting standards and banking regulation can affect banks' risk-management and investment decisions, potentially in negative ways. One point worth stressing is that the analyses in this paper do not suggest that divergence necessarily is undesirable. Accounting standards and banking regulation have different objectives. Consequently, to the extent that accounting standards are not suitable for regulatory purposes, adjusting banks' accounting numbers to determine regulatory capital has benefits. However, the analyses in this paper do identify some costs of divergence. From the point of view of a banking regulator, accounting for these and other potential costs when deciding whether to alter the accounting information of banks for regulatory purposes could be useful.

The primary contribution of this paper is to highlight some potential effects of divergence between accounting standards and banking regulation. The impact of accounting standards and, separately, of banking regulation on the operating decisions of banks has been examined in previous studies. However, to the best of my knowledge, this paper is the first that focuses on the impact of divergence between accounting standards and banking regulation. I examine only one aspect of divergence – its impact on the investment and risk-management decisions of banks. Divergence likely has additional effects – some positive, some negative. A welfare analysis of the overall costs and benefits of divergence is beyond the scope of this paper. Still, this paper identifies certain trade-offs divergence creates and how these trade-offs could affect banks' investment and risk-management decisions. Consequently, this paper is a useful first step toward understanding the impact of divergence.

The rest of this paper is as follows: an overview of the model is in Section 2. Analyses are in Section 3. A synopsis and discussion of the model's results are in Section 4. Concluding remarks are in Section 5.

2. Model overview

2.1. Hedging, earnings volatility, and franchise value

The model's starting point is that banks' hedging programs have multiple objectives. Smith and Stulz (1985), Froot et al. (1993), and Stulz (2013) describe some of the factors that can lead firms to hedge. The model examines two such factors. One is earnings volatility. Even when firms are risk-neutral, earnings volatility can be costly because higher volatility could lead external parties (e.g. creditors) to view a firm as riskier (Trueman and Titman, 1988)). Hence, the firm's cost of capital could be higher. In line with this reasoning, Francis et al. (2004) find that smoother earnings are correlated with a lower cost of equity, though McInnis (2010) finds no such link. Another potential cost of volatility is tax-related. Due to tax-function convexity, to the extent that earnings and taxable income are the same, volatility in earnings increases the present value of expected tax liabilities (Smith and Stulz, 1985; Nance et al., 1993; Graham and Smith, 1999).

In addition, firms themselves seem to believe earnings volatility could lead external parties to perceive the firm as riskier or could be costly in other ways. As a result, reducing earnings volatility is a vital objective (Graham et al., 2005). Consistent with this notion, prior studies find that reducing earnings volatility is an important factor that leads firms to hedge. Brown (2001) conducts a case study of a firm and finds that the firm's hedging program is driven in part by its desire to decrease earnings volatility, while Stulz (2004) reports on a survey where 28 percent of firms claim the main reason they use derivatives is to reduce earnings volatility. Finally, banks themselves state that reducing earnings volatility is a central risk-management objective (Buehler and Santomero, 2008).

The second factor in the model that induces banks to hedge is to preserve franchise value by reducing the probability of insolvency. Marcus (1984) argues that a higher franchise value can induce banks to take less risk. Empirically, prior studies find that higher franchise values are linked with less risk-taking (Keeley, 1990; Brewer and Saidenberg, 1996; Konishi and Yasuda, 2004; Jiménez et al., 2010) and with a more-robust capital structure (i.e., with using more equity) (Demsetz et al., 1996). Although not focused specifically on the link between franchise values and hedging, the central implication of these studies is that franchise-value concerns lead banks to act in a more prudent way (i.e., to take less risk). One way banks can do so is to hedge. In hedging, banks can reduce their exposure to negative shocks that otherwise could result in insolvency. Consistent with this reasoning, Purnanandam (2007) finds that the hedging of interest-rate risk is more common by banks that face a higher probability of financial distress.

To sum up, banks face two costs that hedging can mitigate. First, when earnings volatility is higher, creditors punish banks by charging higher funding costs. To make the model more concrete, I focus on earnings volatility in connection with funding costs, but the exact reason why volatility is costly is not important; all that matters is that volatility is costly in some sense. Second, a banking regulator seizes banks that do not have sufficient regulatory capital. In this situation, banks lose their franchise value. The model examines how divergence affects banks' hedging programs in connection with these two important but separate and distinct risk-management objectives – reducing earnings volatility, and preserving franchise value by reducing the probability of insolvency.

2.2. Divergence

The model's core feature is that banks are punished by creditors for earnings volatility and by a banking regulator for lacking sufficient regulatory capital. Creditors focus only on earnings, while the regulator focuses only on capital. As a consequence, banks are evaluated on two separate metrics – earnings and capital. Divergence arises when earnings and capital are not determined in the same manner. At present, divergence between accounting standards and banking regulation is relevant in relation to several accounting standards. I describe some of these standards in Section 4.3. However, in the model, to focus on accounting standards that are easy to understand and that are relevant for most banks, I focus on divergence relating to fair-value accounting. The model's results, and the intuition behind these results, are the same regardless of the type of standard examined or of how divergence arises. What matters is that two external parties evaluate banks on two separate metrics – earnings and capital – that do are not necessarily determined in the same way.

I focus on divergence in the context of banks' investment and risk-management decisions. Banks invest in assets and in derivatives used to hedge certain risks on these assets. Because the model focuses on earnings volatility, I discuss the accounting regime only with respect to earnings; I disregard balance-sheet effects. The derivatives always are marked-to-market for earnings and capital, in line with current practice.[1] The accounting and capital treatment of the assets are as follows:

- in one convergence regime, referred to as the "benchmark" regime, the assets are valued under historic cost for both earnings and capital;
- in another convergence regime, referred to as the "convergence" regime, the assets are valued under fair value for both earnings and capital; and
- under the divergence regime, the assets are valued under historic cost for earnings and under fair value for capital.

[1] In principle, banks can avoid having to include in earnings and capital gains and losses on a derivative by designating the derivative as a hedging instrument. However, anecdotally banks often claim that satisfying the criteria required to use hedge accounting is difficult (e.g., see JP Morgan's 2014 10-K, p. 204). Hence, in the model, I ignore hedge accounting, though Section 4.3 has a discussion of hedge accounting and endogenous accounting decisions more generally in connection with divergence.

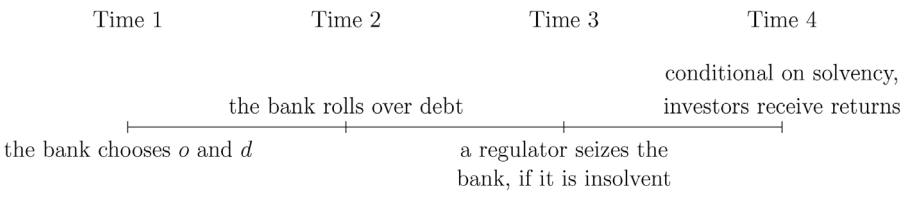

Fig. 1. Model timeline.

The model compares banks' investment and risk-management decisions under divergence to the regimes where accounting standards and banking regulations are aligned.

To make the model more concrete, view banks' assets as securities classified as available-for-sale (AFS): Prior to Basel III, AFS securities were valued under historic cost for earnings and for capital, as in the benchmark regime. However, Basel III requires AFS securities to be marked-to-market for capital (Basel Committee on Banking Supervision (BCBS, 2011b, p. 13, footnote 10), though the implementation of this provision has varied between jurisdictions. The accounting treatment of AFS securities is the same as before. Hence, at present, AFS securities are governed under the divergence regime. The convergence regime, then, can be interpreted as a type of counterfactual, under which AFS securities are marked-to-market for earnings as well as for capital.

2.3. Time-1 lending

A timeline is in Fig. 1. The model consists of four dates and a representative risk-neutral bank that maximizes expected returns. To ensure that the model focuses in as simple a way as possible on how divergence affects the bank's investment and risk-management decisions, I make the following assumptions:

- the bank's capital structure is exogenous;
- apart from how earnings volatility affects the cost of debt, the bank's cost of capital is exogenous; and
- apart from its accounting and regulatory exposures, the bank has no other exposures to hedge.

These assumptions could be relaxed without affecting the model's main results, but the model would be more complex. At time 1, the bank invests in o units of loans that mature at time 4. A banking regulator requires o to be at least k-percent funded by equity. By assumption, the bank chooses not to hold a buffer of equity in excess of k. Hence, o is k-percent funded by equity and $[1 - k]$-percent funded by debt. The debt is not government-insured and always is valued under historic cost, for both earnings and capital. $r > 0$ is expected returns on o net of any exogenous costs of debt and equity. To simplify the results, lending has diminishing returns, and so the bank faces the quadratic-cost function $x(o) = \frac{\theta o^2}{2}$.

To make the model more concrete, suppose each "unit" of o is a well-diversified portfolio of loans: In this case, the bank has only systematic risk on o. Assume further that these loans are fixed-rate loans: When o is marked-to-market, because the debt is valued under historic cost, the bank has a long position in interest rates with respect to earnings and capital – a decline in interest rates increases earnings and capital, while an increase in rates reduces earnings and capital. In this sense, the bank faces interest-rate risk on o. The model would have the exact same meaning if the interest-rate risk on o were interpreted in terms of other types of systematic risk (e.g., foreign-exchange risk). Throughout, I use "duration," denoted by u, to refer to the interest-rate risk on each unit of o. The bank may use derivatives to hedge u; I introduce the derivatives in Section 2.5.

2.4. insolvency risk (franchise value) and earnings volatility

The bank faces two types of punishment. One is regulatory. At time 3, and only at time 3, the regulator examines the bank's solvency by assessing the net decline in capital relative to the size of the balance sheet, o. When o is marked-to-market for capital, ignoring the derivatives for now, the regulator declares the bank insolvent with probability $p = p(\frac{ou}{o}) = p(u)$, $\frac{\partial p}{\partial u} \equiv p_u > 0$. This specification of $p(u)$ has the following interpretation – when duration is higher, any given increase in interest rates results in a larger decline in capital. Hence, the regulator is more likely to declare the bank insolvent. In the case of insolvency, the regulator seizes the bank, and returns to shareholders are 0. The bank thus loses its franchise value. Furthermore, because the bank's debt is not government-insured, creditors are not repaid. If the bank is solvent, nothing happens, and at time 4, the bank makes principal and interest payments to creditors and gives the remaining cash flows to shareholders.

The second is market punishment. The bank has to refinance its debt at time 2. Between times 1 and 2, interest rates change throughout, and the bank reports earnings over "multiple" periods. Creditors use earnings volatility to draw inferences about the bank's credit risk (e.g., Trueman and Titman, 1988). When volatility in earnings is higher, creditors view the bank as riskier. As a consequence, insolvency at time 3 is seen as more likely – creditors think the probability of being repaid is lower. Hence, creditors charge a higher interest rate, i. Creditors focus on total volatility relative to the size of the balance sheet. Consequently, when o is marked-to-market for earnings, and still ignoring the derivatives, $i = i(ou/o) = i(u)$, $\partial i/\partial u \equiv i_u > 0$. This specification of i means that when duration is higher, any given changes in interest rates lead to higher earnings volatility. Creditors thus perceive the bank as riskier and charge a higher interest rate as a result.

2.5. Time-1 hedging

At time 1, at the same time it chooses o, the bank chooses d, the percentage of the duration on o to hedge with derivatives. For brevity, I use d to refer to duration and to the derivatives themselves. d matures at time 4. While the bank has a long position in interest rates on o, it has a short position on d – for d, a decline in interest rates reduces earnings and capital, while an increase increases earnings and capital. The extent of this short position depends on d. For example, $d = 0.4$ means duration on d is 40 percent of duration on o. Hence, when o is marked-to-market, portfolio-level duration is $u[1 - 0.4] = u0.6$. $d = 1$ means the bank hedges all of the interest-rate risk on o, and so portfolio-level duration is $u[1 - 1] = 0$; $d = 0$ means that the bank does not hedge at all, and so portfolio-level duration is $u[1 - 0] = u$. To keep the model as simple as possible, I make the following assumptions:

- expected changes in interest rates over the life of the derivatives (i.e., between times 1 and 4) are 0, and so expected returns from hedging are 0;
- the bank does not use d either to speculate or to "overhedge," and so $o \leq d \leq 1$; and
- the bank faces no margin requirements, counterparty credit risk, or basis risk on d.

These assumptions could be relaxed without affecting the model's primary results.

p and i depend on portfolio-level duration – interest-rate exposure on o and d after taking into account any offsetting effects between the long position on o and the short position on d. d always is marked-to-market for earnings and capital. The treatment of o and the resulting specifications for p and i under the three regimes introduced in Section 2.2 are as follows:

- Benchmark: o is valued under historic cost for earnings and capital. Hence, $p = p(ud)$, and $i = i(ud)$.
- Convergence: o is marked-to-market for earnings and for capital. Hence, $p = p(u[1 - d])$, and $i = i(u[1 - d])$.
- Divergence: o is marked-to-market for capital, but it is valued under historic cost for earnings. Hence, $p = p(u[1 - d])$, and $i = i(ud)$.

In the benchmark, the bank has neither an accounting nor a regulatory exposure on o. d thus has no exposures to offset – the bank simply has an accounting exposure and a regulatory exposure on d. Under convergence, the bank has an accounting and a regulatory exposure on o. The bank can use d to offset these exposures – to use the short position in interest rates on d to offset the long position on o. Under divergence, the bank has a regulatory exposure on o, but not an accounting exposure. Consequently, while the bank can use d to mitigate the regulatory exposure on o, doing so results in an accounting exposure on d. Under each regime, $p(0) = 0$, $i(0) = 0$, and $p(u) > 0$ and $i(u) > 0\ \forall u > 0$.

One final assumption is that creditors cannot infer, or conjecture, the bank's equilibrium choice of d. If creditors could do so, they could use their conjectured value of d rather than earnings volatility to assess the bank's credit risk – to determine the bank's portfolio-level duration and the probability of insolvency that results. In this case, earnings volatility would not be costly for the bank. This outcome, where earnings volatility is not costly, could be excluded by making the plausible assumption that instead of using d only to hedge, the bank could use d either to hedge or to speculate and that creditors cannot draw inferences about the bank's equilibrium derivative use – for example, because of a lack of information about the bank's expectation of changes in interest rates. These effects could be introduced into the model without affecting any results, but to keep the model as simple as possible, I simply stipulate that creditors cannot infer the bank's equilibrium choice of d.[2]

3. Analyses

3.1. "Alignment" – the benchmark and convergence regimes

Below, the super-scripts B, C, and D denote equilibrium values under the benchmark regime, convergence, and divergence, respectively; an asterisk denotes a "generic" equilibrium value. The bank maximizes the pay-off function $U(\cdot)$, which has the same structure across each regime but differs with respect to p and i:

$$\text{Benchmark:} U^B(o, d) = o\left[r - [1 - k]i(\text{ud}) - \frac{\theta o}{2}\right][1 - p(\text{ud})] \tag{1}$$

$$\text{Convergence:} U^C(o, d) = o\left[r - [1 - k]i(u[1 - d]) - \frac{\theta o}{2}\right][1 - p(u[1 - d])] \tag{2}$$

$$\text{Divergence:} U^D(o, d) = o\left[r - [1 - k]i(\text{ud}) - \frac{\theta o}{2}\right][1 - p(u[1 - d])]. \tag{3}$$

[2] This set-up has the implication that earnings volatility is costly for banks. This implication is consistent with the studies cited in Section 2.1. In addition, as discussed in Section 2.1, the model could be modified so that rather than increasing funding costs for the loans, higher earnings volatility increases the present value of expected tax liabilities. Given this alternative set-up, all of the results would be the same, for the same reasons.

Table 1
Comparison of o^*, d^*, and p.

Regime	o^*	d^*	p
Benchmark	$\frac{r}{\theta}$	0	0
Convergence	$\frac{r}{\theta}$	1	0
Divergence			
Outcome 1	$\frac{r}{\theta}$	0	$p(u)$
Outcome 2	$\frac{r-[1-k]i(\mathrm{ud}^D)}{\theta}$	$0 < d^D < 1$	$p(u[1-d^D])$
Outcome 3	$\frac{r-[1-k]i(u)}{\theta}$	1	0

For convenience, Table 1 shows o^*, d^*, and p under each regime. In this section, I focus on the regimes where accounting standards and banking regulation are aligned – the benchmark and convergence regimes. Proposition 1 compares o^*, d^*, and p under these two regimes.

Proposition 1. *Lending and the probability of insolvency are the same under the benchmark and convergence regimes. However, the bank's hedging decision differs – in the benchmark, the bank does not hedge at all (i.e., it chooses $d = 0$), but under convergence, the bank hedges in full (i.e., it chooses $d = 1$).*

I focus first on the hedging decision of the bank. The second-order condition with respect to d, $\partial^2 U/\partial d^2$, is the same in the benchmark regime as under convergence. Taking $\partial^2 U/\partial d^2$ for Eqs. (1) and (2),

$$\frac{\partial^2 U^B}{\partial d^2} = \frac{\partial^2 U^C}{\partial d^2} = 2o^*[1-k]u^2 i_u p_u > 0. \tag{4}$$

As a result, d^* is a corner solution – under the benchmark and convergence regimes, the bank either hedges fully or does not hedge at all.

In the benchmark, hedging is strictly costly, and so $d^B = 0$. Differentiating Eq. (1) with respect to d,

$$\frac{\partial U^B}{\partial d} = o^B\left[-[1-k]\mathrm{ui}_u - \mathrm{up}_u\left[r - \frac{\theta o^B}{2}\right] + 2d^B[1-k]u^2 i_u p_u\right] = 0. \tag{5}$$

Given that the bank has neither an accounting exposure nor a regulatory exposure on o, the bank has on d unhedged exposures with respect to earnings and capital. Hence, changes in interest rates between times 1 and 2 lead to earnings volatility on d, while a decline in interest rates between times 1 and 3 leads to a decline in capital on d, increasing the probability that the regulator declares the bank insolvent; these effects are captured by the first and second term, respectively, in brackets. As a consequence, hedging is strictly costly, and so the bank chooses $d = 0$. When $d = 0$, i and p reduce to

$$i(\mathrm{ud}) = i(0) = 0$$

$$p(\mathrm{ud}) = p(0) = 0.$$

When $i = 0$ and $p = 0$, Eq. (1) reduces to

$$U^B(o, d) = o\left[r - \frac{\theta o}{2}\right]. \tag{6}$$

Differentiating with respect to o and re-arranging the first-order condition that results yields $o^B = r/\theta$, as shown in Table 1.

By contrast, under convergence, hedging is strictly beneficial. Hence, the bank chooses $d = 1$. Differentiating Eq. (2) with respect to d,

$$\frac{\partial U^C}{\partial d} = o^C\left[\mathrm{ui}_u[1-k][1-p(u)] + \mathrm{up}_u\left[r - [1-k]i(u) - \frac{\theta o^c}{2}\right] + 2d^C[1-k]u^2 i_u p_u\right]. \tag{7}$$

In this case, in contrast to the benchmark regime, the bank has both an accounting exposure and a regulatory exposure on o. Hedging thus reduces earnings volatility, in turn reducing the bank's funding costs, while also reducing the net decline in capital if the loans decline in value, in turn reducing the probability of being declared insolvent; these effects are captured by the first and second term, respectively, in brackets. As a consequence, hedging is strictly beneficial. As a result, the bank chooses $d = 1$. When $d = 1$, i and p reduce to

$$i(u[1-d]) = i(0) = 0$$

$$p(u[1-d]) = p(0) = 0.$$

Because the bank hedges in full the interest-rate risk on o, portfolio-level duration is 0, and so both earnings volatility and the probability of insolvency are 0. Consequently, as in the benchmark regime, Eq. (2) reduces to

$$U^C(o, d) = o\left[r - \frac{\theta o}{2}\right]. \tag{8}$$

Differentiating Eq. (8) with respect to o and re-arranging yields $o^C = r/\theta = o^B$.

These results have three main implications. First, under the benchmark and convergence regimes, the bank's optimal lending decision, $o^B = o^C = r/\theta$, is the same, as is the probability of insolvency, 0. This outcome might appear surprising. In the benchmark regime, the bank has neither an accounting exposure nor a regulatory exposure on o, while under convergence, the bank has an accounting and a regulatory exposure on o. However, under convergence, the bank can hedge these exposures. In addition, since the bank does not have any unhedged exposures on d, hedging is strictly beneficial. Hence, the bank optimally hedges in full the interest-rate risk on o. Consequently, portfolio-level duration is 0, and so earnings volatility and the probability of insolvency are 0. As a result, despite having accounting and regulatory exposures on o, the bank lends just as much as in the benchmark regime while also facing the same probability of insolvency.

Second, under convergence, lending and hedging are complements – a marginal increase in d reduces earnings volatility, in turn reducing funding costs on o. As a consequence, o^C is higher. Differentiating Eq. (2) and re-arranging to solve for o^C,

$$o^C = \frac{r - [1 - k]i(u[1 - d^C])}{\theta}. \tag{9}$$

Eq. (9) shows that o^C is increasing in d^C. Because p affects all of the costs and benefits of lending, o^C is independent of p. However, because of the accounting exposure on o and the earnings volatility that results, o^C still depends on d^C. By reducing the accounting exposure on o, the derivatives reduce earnings volatility. Consequently, funding costs on o are lower. In this way, hedging makes lending more beneficial. Hence, the bank lends more.

Third, when o is marked-to-market for capital, the probability of insolvency depends on the bank's optimal hedging decision. Writing p in the benchmark and convergence regimes if hedging were not possible, so that $d = 0$,

p^B, hedging not possible:$p(\text{ud}) = p(0) = 0$

p^C, hedging not possible:$p(u[1 - d]) = p(u) > p^B$.

As a result, imposing a regulatory exposure on o would increase the probability of insolvency relative to the benchmark regime. However, when hedging is possible, the bank can use d to counter this effect – to reduce its regulatory exposure on o, in turn reducing p. Consequently, factors that affect the bank's optimal hedging decision affect the probability that the bank is declared insolvent due to a decline in the value of o. In the next section, I focus on, among other issues, how divergence affects the bank's optimal hedging decision and the implications that result for the bank's probability of insolvency.

3.2. Divergence v. convergence

In this section, I focus primarily on the differences between the divergence and convergence regimes; when necessary, I use "alignment" to refer to both the convergence and benchmark regimes jointly. One difference between divergence and alignment is under divergence, the bank's optimal hedging decision is not necessarily a corner solution – interior solutions are possible. The second partial derivative of Eq. (3) with respect to d is

$$\frac{\partial^2 U^D}{\partial d^2} = -2o^D[1 - k]u^2 i_u p_u < 0. \tag{10}$$

The second-order condition (10) is negative, in contrast to $\partial^2 U/\partial d^2 > 0$ with alignment. o^D thus is a maximum. As a consequence, an interior solution is possible. These diminishing returns to hedging arise because hedging lowers the probability of insolvency but also, by increasing earnings volatility, increases funding costs on o. As a result, franchise value is lower. Hence, the benefits of remaining solvent are smaller.

I start by analyzing the bank's choice of o. Differentiating Eq. (3) with respect to o and re-arranging yields the following value for the bank's optimal choice of o:

$$o^D = \frac{r - [1 - k]i(\text{ud}^D)}{\theta}. \tag{11}$$

Lemma 1. *Under divergence, lending and hedging are substitutes. The more the bank hedges, the higher is earnings volatility, and so the higher are funding costs for the loans. As a result, lending is less beneficial. Hence, the bank lends less.*

Lemma 1 follows by inspection of Eq. (11), which shows that o^D is decreasing in d^D. Under divergence, as under convergence, the probability of insolvency, p, affects all the costs and benefits of lending. o^D thus is independent of p. However, o^D still depends on d^D because of how d affects funding costs for o. Because o is valued under historic cost for earnings, the bank has an unhedged accounting exposure on d. As a result, the higher is d, the greater is volatility in earnings, and so the higher are funding costs on o, in turn reducing o^D – the more the bank hedges, the less the bank lends. This relationship between o and d contrasts with the relationship between o and d under convergence, where o and d are complements, as discussed in Section 3.1.

Turning to d^D, differentiating Eq. (3) with respect to d, replacing o^D with $\frac{r - [1 - k]i(\text{ud}^D)}{\theta}$ from Eq. (11), and re-arranging yields the following value for d^D:

$$d^D = \left[\frac{-[1-p(u)]}{2\mathrm{up}_u} + \frac{r}{4[1-k]\mathrm{ui}_u}\right]\frac{4}{3}. \tag{12}$$

Proposition 2. *Under divergence, three outcomes are possible for the bank's choice of d:*

Outcome 1: If $\frac{1-p(u)}{2\mathrm{up}_u} \geq \frac{r}{4[1-k]\mathrm{ui}_u}$, *the bank does not hedge at all–*$d^D = 0$.
Outcome 2: If $0 < \frac{r}{4[1-k]\mathrm{ui}_u} - \frac{1-p(u)}{2\mathrm{up}_u} < \frac{3}{4}$, $0 < d^D < 1$.
Outcome 3: If $\frac{r}{4[1-k]\mathrm{ui}_u} - \frac{1-p(u)}{2\mathrm{up}_u} \geq \frac{3}{4}$, *the bank hedges in full–*$d^D = 1$.

Proposition 2 follows by inspection of Eq. (12) and captures the main consequence of divergence – whereas under convergence, hedging is strictly beneficial, so that $d^C = 1$, under divergence, hedging has both a cost and a benefit. The cost, captured by the first term inside brackets in d^D, is that hedging increases earnings volatility, increasing funding costs. Franchise value thus is lower. The benefit, captured by the second term in brackets, is that hedging reduces the probability of insolvency. Proposition 2 shows that under divergence, an interior solution is possible, though the restriction $0 \leq d \leq 1$ implies that corner solutions (i.e., $d^D = 0$ or $d^D = 1$) remain possible.

Proposition 3 compares o^*, d^*, and p under convergence and divergence:

Proposition 3. *Under divergence, the three outcomes for* d^D *have the following properties:*

- *Outcome 1: Hedging is costly, on net, and so* $d^D = 0$. *In this situation, lending is the same as under convergence, but the probability of insolvency is higher.*
- *Outcome 2: Hedging is "modestly beneficial," on net, and so* $0 < d^D < 1$. *Here, the bank lends less than under convergence, and the probability of insolvency is higher.*
- *Outcome 3: Hedging is "highly beneficial," and so* $d^D = 1$. *Here, the probability of insolvency is 0, as under convergence, but lending is lower.*

Convergence thus is preferred to divergence in the following sense: Under convergence, either lending is higher and the probability of insolvency is the same (outcome 3), the probability of insolvency is lower and lending is the same (outcome 1), or lending is higher and the probability of insolvency is lower (outcome 2).[3]

First, consider outcome 1, where o_1^D denotes o^D with outcome 1: When $d^D = 0$, o_1^D becomes

$$o_1^D = \frac{r - [1-k]i(\mathrm{ud}_1^D)}{\theta} = \frac{r}{\theta} = o^C.$$

Because the bank does not hedge, earnings volatility is 0, and so funding costs and thus o are the same under divergence as under convergence. However, when $o^D = 0$, p_1^D is

$$p_1^D = p(u[1-d_1^D]) = p(u) > p^C = 0.$$

Hence, although lending is the same under divergence as under convergence, insolvency risk is higher. The bank has a regulatory exposure on o, but the benefits of hedging this exposure are less than are the costs of the unhedged accounting exposure on d. The bank thus does not hedge this exposure at all. By contrast, under convergence, hedging is strictly beneficial. Hence, the bank chooses $d = 1$, eliminating the regulatory exposure on o.

Next, consider outcome 3: Because $d_3^D = 1$, o_3^D and p_3^D can be written as

$$o_3^D = \frac{r - [1-k]i(u)}{\theta} < \frac{r}{\theta} = o^C$$

$$p_3^D = p(u[1-d_3^D]) = p(0) = 0 = p^C.$$

Hence, when hedging is highly beneficial, the probability of insolvency is 0, as under convergence. However, comparing o_3^D with o^C shows that this positive outcome comes with a cost. Under divergence, the bank has an unhedged accounting exposure on d. Consequently, since $d_3^D = 1$, the bank has earnings volatility, increasing funding costs on o. By contrast, under convergence, the bank has an accounting exposure on o. As a result, setting $d = 1$ eliminates earnings volatility, reducing funding costs. These lower funding costs result in more lending under convergence than under divergence.

The two cases above capture corner solutions – the bank hedges either in full or not at all. For outcome 2, where d^D is an interior solution (i.e., $0 < d^D < 1$), lending is lower under convergence, while p is higher:

$$o_2^D = \frac{r - [1-k]i(\mathrm{ud}_2^D)}{\theta} < \frac{r}{\theta} = o^C$$

[3] From Proposition 1, both lending and the probability of insolvency are the same under convergence as in the benchmark regime. Hence, the benchmark regime is preferred to divergence in the same ways.

$$p_2^D = p(u[1 - d_2^D]) > p^C = 0.$$

Because hedging is modestly beneficial, the bank chooses to hedge some, but not all, of the interest-rate risk on *o*. As a result, the probability of insolvency is lower than for outcome 1, where the bank does not hedge at all, but it is higher than under convergence, where $p = 0$. Likewise, because the bank has an unhedged accounting exposure on *d*, and because the bank sets $d > 0$, the bank has some earnings volatility on *d*. This earnings volatility is less than for outcome 3, where the bank hedges in full, but it is higher than under convergence, where *o* is marked-to-market for earnings and the bank hedges all of the interest-rate risk on *o*, so that earnings volatility is 0. Hence, lending is lower and *p* is higher under divergence than under convergence.

Proposition 3 is driven by a trade-off between hedging, lending, and insolvency risk that arises under divergence. Under divergence, lending and hedging are substitutes. As a result of the unhedged accounting exposure on the derivatives, hedging increases earnings volatility. The resulting rise in funding costs reduces lending. Although the bank can avoid this decline in lending by hedging less, any decline in hedging increases insolvency risk. Similarly, a rise in hedging reduces insolvency risk but also increases funding costs. Hence, using derivatives to achieve both desirable outcomes – to reduce both funding costs and insolvency risk – is not possible. By contrast, under convergence, lending and hedging are complements, and so this trade-off is not present – hedging reduces both earnings volatility and the probability of insolvency. The bank thus hedges more. This increase in hedging affects the bank's optimal lending decision and the equilibrium probability of insolvency.

4. Discussion

4.1. Synopsis

The analyses in Section 3 show how divergence affects banks' risk-management decisions. Under divergence, hedging has regulatory benefits but accounting costs, or vice versa, while under convergence, such accounting-regulatory trade-offs are absent. Banks thus hedge more under convergence. Moreover, since banks' equilibrium lending decision and the probability of insolvency depend on banks' equilibrium hedging decision, divergence results in a trade-off between hedging, lending, and insolvency risk. As shown in Proposition 3, banks can reduce the probability of insolvency by hedging more, but at the cost of increasing volatility. The rise in funding costs that results reduces lending. Alternatively, banks can reduce volatility by hedging less. The resulting decline in funding costs increases lending, but the decline in hedging necessary to reduce volatility increases the probability of insolvency. Hence, reducing both earnings volatility and the probability of insolvency is not possible. By contrast, under convergence, this trade-off is not present.

From a regulatory perspective, one potential limitation with a regulatory framework that corresponds to the benchmark regime is that when banks' assets are valued under historic cost, banks may "hide" losses – for example, in the model, no matter how much the bank's loans decline in value between times 1 and 3 due to an increase in interest rates, the regulator never declares the bank insolvent. Allowing banks to hide losses in this way has been cited as a factor that worsened the savings-and-loan crisis in the United States in the late 1980s (e.g., Breeden, 1991; European Central Bank (ECB, 2004, p. 10). Consequently, one natural response might be simply to require banks to mark-to-market their assets for regulatory purposes. In this way, regulators could reduce the danger of having fundamentally insolvent banks "gamble for redemption" or take risks in other ways.

However, the analyses in Section 3 suggest the effects of banking regulations could depend not only on the regulations themselves but also on the interactions between a given regulation and relevant accounting standards. Consider the case of valuing the assets of banks under fair value instead of historic cost when determining regulatory capital: The analyses in Section 3 indicate that the impact on banks of such a change could depend on the prevailing accounting regime. If banks' assets were marked-to-market for accounting purposes, the only effect of such a change could be to result in more hedging. By contrast, if banks' assets were valued under historic cost for accounting purposes, investment could decline, while the probability of insolvency could rise. Similar reasoning could apply for other banking regulations that differ from relevant accounting standards, although the exact impact of divergence on banks likely would depend on the relevant banking regulation and accounting standards and, in addition, on how divergence arises.

To focus on divergence, the model considers only two risk-management aims: to reduce earnings volatility, and to reduce the probability of insolvency. As a result, the model implies that with no accounting exposure or regulatory exposure, banks have no reason to hedge and thus would not hedge at all (Proposition 1). Quantitatively, this implication is extreme. This implication could be weakened by giving banks other risk-management objectives. For example, suppose banks use derivatives to hedge liquidity shocks (e.g., Purnanandam, 2007) as well as accounting and regulatory exposures: In this case, even in the benchmark regime, with no accounting or regulatory exposures, banks might hedge some. However, qualitatively, the model's results would be the same even if banks had other risk-management objectives. The essential point is that under divergence, the net benefits of hedging are lower. Hence, on the margin, divergence induces banks to hedge less relative to convergence. In this respect, divergence has a negative effect on banks' risk-management practices.

The impact of divergence in inducing banks to hedge less can have at least two negative effects. One is explicit in the model. When banks' assets are marked-to-market for regulatory purposes, a decline in hedging results in a larger decline in regulatory capital for any given decline in value for banks' assets. Hence, if a shock reduces the value of banks' assets, banks are more likely to become insolvent. The second is not explicit in the model but reflects the same mechanism as the first effect. Prior studies show that in recessions, a decline in capital can force banks to reduce lending (Hancock and Wilcox, 1995; Peek and Rosengren, 1995; Gambacorta and Mistrulli, 2004). One way banks can limit any such declines in capital is by hedging. As a result, by inducing banks to hedge less, divergence could amplify a credit crunch in a recession even if banks remain solvent.

4.2. Empirical implications

The model's primary empirical implication is that when accounting standards and banking regulation are the same, banks hedge more than when accounting standards and banking regulation "diverge." One way to test this implication would be through a cross-country comparison of banks' hedging strategies before and after a change in accounting standards or in banking regulation that either creates or removes divergence for banks in some countries, but not for banks in other countries. In some cases, different countries have different accounting standards or banking regulation – e.g., Kara (2016). Such variation in accounting standards and banking regulation could be exploited to examine how divergence affects the hedging strategies of banks.

For example, consider banks in two countries, A and B, and assume first the following: In year t, accounting standards and banking regulation are different in both Country A and Country B. As a result, in year t, banks in both Country A and Country B face a divergence regime. Next, assume that between year t and year $t + 1$, accounting standards or banking regulation change in a way where accounting standards and banking regulation in year $t + 1$ are the same in Country A but are different in Country B. In this case, in year $t + 1$, banks in Country A face a convergence regime – in Country A, in year $t + 1$, accounting standards and banking regulation are the same. However, in year $t + 1$, banks in Country B face a divergence regime – in Country B, in year $t + 1$, accounting standards and banking regulation are different.

The model predicts that hedging by banks in Country A would increase from year t to year $t + 1$ relative to hedging by banks in Country B. In year t, banks in both Country A and Country B face a "divergence" regime – for banks in both countries, accounting standards and banking regulation differ. However, in year $t + 1$, banks in Country A no longer face a divergence regime – in year $t + 1$, in Country A, accounting standards and banking regulation are the same. Hence, banks in Country A have a stronger incentive to hedge. Conversely, banks in Country B still face a divergence regime in year $t + 1$. As a result, banks in Country B still have weaker incentives to hedge. Consequently, hedging by banks in Country A should increase from year t to $t + 1$ relative to hedging by banks in Country B.

4.3. Endogenous accounting and regulatory choices

Throughout, I take as exogenous the accounting and regulatory regimes banks face. However, in certain situations, a bank may choose the accounting treatment of its financial instruments. Consider the fair-value option: Banks may use this option to apply fair value to an asset that otherwise would be valued under historic cost. In the context of the model, under divergence, banks could eliminate the accounting cost of hedging (i.e., the increase in earnings volatility) by choosing to apply fair value to the loans. In doing so, banks would face the same situation as under convergence – in addition to reducing the probability of insolvency, hedging would reduce earnings volatility on the loans instead of increasing earnings volatility. Alternatively, banks could, if certain criteria are met, classify the derivatives as a hedging instrument. In this situation, banks would face no (or less) earnings volatility on the derivatives, mitigating the accounting costs of hedging.

However, in other situations, banks cannot avoid the effects of divergence. Consider debt valuation adjustments (DVA): DVA is a valuation adjustment on derivative liabilities and is required under US GAAP and IFRS. For the biggest US banks, DVA has been on the order of $ 1 billion per year (data source: annual reports) and, anecdotally, is among the primary drivers of earnings volatility (Ernst and Young, 2012). However, in contrast to earnings, DVA is excluded from regulatory capital (Basel Committee on Banking Supervision (BCBS, 2011a). Furthermore, banks may not choose to include DVA in capital. As a consequence, banks face a similar situation as under divergence. Banks could reduce earnings volatility on DVA by hedging, but hedging would give rise to an unhedged regulatory exposure on the hedging instrument. Alternatively, banks could avoid the unhedged regulatory exposure by not hedging, but not hedging would result in earnings volatility due to DVA. Banks have no way to avoid this trade-off.

Furthermore, divergence cannot be avoided when regulators impose an exposure with no accounting analog, or vice versa. Consider credit valuation adjustments (CVA): CVA requires banks to adjust the value of derivative assets for any changes in the credit risk of a derivative counterparty. Such changes are reflected in earnings and capital. In this respect, accounting standards and banking regulation are similar. However, Basel III requires a "CVA Value-at-Risk," or "CVA VaR," capital charge on the volatility of CVA (Basel Committee on Banking Supervision (BCBS, 2011c). CVA VaR has no accounting analog. Although banks may reduce CVA VaR by hedging, because banks have no CVA VaR accounting exposure, hedging results in earnings volatility on the hedging instrument. Although banks can avoid earnings volatility by not hedging, not hedging leaves banks with the greatest possible CVA VaR capital charge. This CVA-related divergence is alleged to have contributed to a € 94 million loss by Deutsche Bank in the first half of 2013 (Carver, 2013).

As a result, situations where banks themselves can "undo" the impact of divergence via accounting or regulatory choices can be viewed as a type of special case. Certain provisions in US GAAP and IFRS can enable banks to move from divergence to convergence, if desirable, in a limited number of cases. However, in other cases, as with the CVA VaR capital charge, banks cannot do so. Moreover, as a rule, banks have limited discretion, if any, in determining the regulatory treatment of financial instruments.[4] Consequently, in most cases, divergence is exogenously imposed on banks. In such cases, banks face trade-offs such as those identified in the model – for example, where risk-management decisions with regulatory benefits have accounting costs.

[4] In some cases, a bank can indirectly determine an asset's regulatory treatment by its accounting decisions. For example, if a bank applies the fair-value option to an asset, the asset is valued under fair value also for regulatory purposes, even if the asset otherwise would have been valued under historic cost.

5. Conclusion

This paper focuses on the impact of divergence between accounting standards and banking regulation – when banking regulators make adjustments to banks' accounting information for supervisory purposes, such as determining regulatory capital. An example of divergence is when banks' assets are marked-to-market for regulatory purposes but not for accounting purposes. The central insight of the paper is that divergence can lead to a risk-management trade-off – using derivatives to hedge can have regulatory benefits but accounting costs, or vice versa. Hence, banks hedge less than when accounting standards and banking regulation are aligned. This outcome could have several negative effects – for example, because banks hedge less, a shock that reduces the value of the assets of banks is more likely to make banks insolvent. More generally, regulatory adjustments to banks' accounting numbers could affect banks' operating decisions in undesirable ways.

This paper has three limitations that could be examined in future research. One is that I do not perform a welfare analysis of the total costs and benefits of divergence. I consider only one cost of divergence – its negative effect on banks' risk-management practices. Divergence likely has additional effects, some positive, some negative. Since the net benefits of divergence likely depend in part on the specific accounting standard and piece of banking regulation that divergence is relevant for as well as on how this divergence arises, a general welfare analysis of divergence could be difficult. Still, attempting to balance the costs and benefits of divergence in connection with even a single accounting standard or piece of banking regulation could yield further insights into the impact of divergence.

The second is that I consider only the "real effects" of divergence – how divergence affects banks' lending and risk-management decisions. However, divergence could affect also how external parties (e.g., creditors) interpret the information in banks' financial statements and regulatory reports – for example, by leading to conflicting signals between accounting and regulatory information. Suppose banks' assets were marked-to-market for regulatory capital but not for earnings: A decline in the value of these assets would reduce capital but would not affect earnings. As a result, the joint information content of these two metrics – earnings and capital – could be different than when the accounting and regulatory treatment of banks' assets are aligned. The analyses in this paper do not address this issue.

The third is that I do not examine empirically the impact of divergence. Given the lack of prior research on divergence, I focus in this paper on identifying, first, a mechanism through which divergence could affect banks and, second, some effects divergence could have through this mechanism. As a consequence, to focus on these issues as closely as possible, I do not examine empirically the impact of divergence. However, empirical analyses (e.g., such as those discussed in Section 4.2) of the impact of divergence would be an interesting topic for future research.

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