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ORIGINAL ARTICLE

Gambling bank behaviour, incentive mechanism, and sanctions: A two-stage model

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Abstract
This article analyses the optimal punishment structure set by a regulator in banking markets under asymmetric information. Relying on a theoretical model, we analyse whether a decreasing, constant, or increasing sanction scheme deters potentially repeated offences in banking. We find that an increasing punishment structure is efficient in reducing gambling bank behaviour. This holds if and only if the regulator's detection probability is low or the amount gambled by the bank, if it would cheat, is high. With this paper, we provide justification for the current policy practice.

Keywords Banking · Excessive risk · Moral hazard · Enforcement · Repeat offenders

JEL classification D82 · G21 · K42

Introduction

Banking supervision and sound regulation are critical because they ensure the stability of the financial system and avoid bank failures.[1] For instance, there are regulations that force banks to have a minimum amount of equity. In addition, sound regulation should ensure the bank reports the true equity amount. Bank regulators have various instruments available, such as setting financial fines for misconduct.[2] A recent example, especially on bank risk behaviour, is that the European Central Bank imposed a financial penalty on a German bank where the required capital was not determined correctly because of cheating.[3]

A regulator generally has more instruments available, for instance, setting the rules for capital or liquidity requirements, risk buffers and the power to audit and supervise banks. The focus of this paper lies on the regulatory tool of setting sanctions. We therefore analyse different sanction schemes. An increasing punishment scheme is characterized by higher punishment for a repeated offence, whereas a decreasing (respectively, constant) punishment scheme is characterized by lower (resp., uniform) sanctions for a repeated offence (see e.g. Dana [18] or Emons [21]).

The Basel Committee on Banking Supervision provided international banking regulation standards, the so-called Basel III standards, for banks managing their risks as well as monitoring techniques that should be implemented in a global setting.[4]

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1 See, for example, Taskinsoy [50], who analyses the possible causes of different financial and economic crises.

2 See, for instance, Köster and Pelster [31], who analyse financial penalties for banks based on a database of 671 financial sanctions on 68 banks between 2007 and 2014. Also, Sakalauskaitė [48] analyses the failures of 30 large banks, including, for example, compliance failures, misrepresentations or money laundering and finds 763 failures with the starting date of the misconducts being between 1998 and 2010. Bertsch et al. [10] use Consumer Financial Protection Bureau (CFPB) complaint data and machine learning to identify bank misconduct.

3 See the article in Handelsblatt by Osman, Y., on March 6, 2023, URL: https://www.handelsblatt.com/finanzen/banken-versicherungen/banken/bankenaufsicht-ezb-verhaengt-millionenstrafe-gegen-die-helaba/28976806.html.

4 The Basel Committee currently consists of 45 members from 28 countries. For instance, the European Union is currently represented by the European Central Bank and the European Central Bank Single Supervisory Mechanism. The USA is currently represented by the Board of Governors of the Federal Reserve System, the Federal Reserve Bank of New York, the Office of the Comptroller of the Currency and the Federal Deposit Insurance Corporation. Germany, for

For the European Union, there exists a framework that provides standards concerning sanctions: according to European Union Council Regulation No. 2532/98 combined with No. 1024/2013, the regulator should take into account the repetition of offences. A guideline shows how to set pecuniary penalties depending on the severity and extent of the offence [25]. Each offence should be treated with consideration of aggravating or mitigating circumstances. According to this guideline, the European Central Bank classifies the impact of the breach, the degree of misconduct and sets the base amount. This amount could then be increased or reduced pursuant to the respective case.

In the USA, the regulatory institution, e.g. the Office of the Comptroller of the Currency (OCC) or the Federal Reserve (Fed), implements enforcement actions and imposes financial penalties. In Europe, this is the European Central Bank together with the national authorities.

In almost all developed countries under banking regulation, the regulator has some incentives to curb illegal bank activities. For instance, this is the case when the bank tries to push its short-term returns in an illegal way at the expense of the stability of the financial system. The regulator (or the national government, in particular) bears the cost of such illegal activities if the stability of the financial system is at risk. We therefore take a cross-jurisdictional view in our paper.

There is an open debate about whether repeated offenders should be punished more harshly or not. For instance, in early 2022, the director of the Consumer Financial Protection Bureau (CFPB) Rohit Chopra, expressed his wish that big banks that repeatedly violate the law should face harsh penalties.[5] Despite the special treatment of big banks, e.g. extra capital-requirements or risk-management frameworks,[6] Chopra [16] described how big firms and banks may violate the law but are not punished as severely as small ones. In his speech, he named examples of financial firms where the Consumer Financial Protection Bureau sanctioned repeat offences.[7] Chopra (2022) described how regulators, in addition to financial sanctions, should impose other punishments. For example, the Federal Reserve Board imposed a growth limit on Wells Fargo in addition to financial sanctions. This could be interpreted as an increasing punishment scheme.

Especially in developed jurisdictions like Europe or the USA, it seems that the current policy practice is to use increasing sanction schemes.[8] An increasing sanction scheme is well described by the 'three strikes' law in the USA.[9]

The 'three strikes' law states that the third offence is punished with up to 25 years' imprisonment, even if the crime itself would require a lower sentence. Another example is found in the 'German juvenile criminal law' in §16a JGG. Since 2013, a juvenile offender may face imprisonment as a supplement to the suspended sentence. This could be interpreted as a tightening of juvenile punishment.[10]

A current example is Deutsche Bank, which is being fined by the Federal Reserve for so-called 'unsafe and unsound practices, also concerning anti-money laundering orders and compliance issues. There were already fines in 2015 ($58 million) concerning compliance issues. In 2017 ($41 million), the bank was fined because of deficiencies in monitoring and concerning anti-money laundering rules. In July 2023, the Fed fined $186 million because the previously identified deficiencies had not yet been remedied.[11] This could be interpreted as an example of an increasing sanction scheme for a financial institution.

We analyse whether increasing, decreasing or constant sanctions are efficient to deter the gambling behaviour of a representative bank under asymmetric information and moral hazard. A regulatory institution is able to impose sanctions on a gambling bank. According to European Union Council Regulation No. 2532/98 and No. 1024/2013, when determining penalties, the regulator should take into account the repetition of offences.

For a bank to invest in excessive risk-taking, fraud, or misconduct, this must generate high economic gains. Or, as Agrawal et al. [1] mentioned, the cost of avoiding total fraud is too high. In our paper, we focus on financial institutions or banks. Financial institutions are different from non-financial institutions because of their capital structure, regulatory issues and complex business structures. Banks primarily use deposits for their investments. This could create an incentive for risky

Footnote 4 (continued)
example, is currently represented by the Deutsche Bundesbank and the Federal Financial Supervisory Authority (Bank for International Settlements, https://www.bis.org/bcbs/membership.htm).

[5] See the article in The New York Times by Flitter, E., on March 28, 2022, URL: https://www.nytimes.com/2022/03/28/business/cfpb-banks-regulation.html.

[6] The framework for large US banks is described in SR letter 12-17/CA letter 12-14. Also, the Bank for International Settlements [8] has an updated framework for global systemically important banks.

[7] See the speech by Rohit Chopra on March 28, 2022, URL: https://www.consumerfinance.gov/about-us/newsroom/reining-in-repeat-offenders-2022-distinguished-lecture-on-regulation-university-of-pennsylvania-law-school/ and Chopra [16]. Chopra (2022) points to Citigroup, JPMorgan Chase, Wells Fargo or American Express, firms that are punished 3–5 times by the CFPB.

[8] See, for example, Dana [18], Emons [21–23] and Anderson et al. [4], which deal with the question of what an optimal sanction scheme should look like. We provide a discussion on that in the literature review.

[9] See California's 'three strikes' law as of Penal Code 667.

[10] The United States Clean Water Act serves as another example where the maximum punishment shall be doubled for further offences, 33 U.S.C. §1319 (c) (2)–(3).

[11] See Fed, 13.07.2023, URL: https://www.federalreserve.gov/newsevents/pressreleases/enforcement20230719a.htm.

behaviour as depositors are insured with deposit insurance, at least to some extent. Therefore, depositors are less likely to affect banks' risk-taking behaviour (see, Blum [11], Demirgüç-Kunt and Huizinga [19] or Anginer et al. [5].[12] Banks' excessive risk-taking can cause negative spillover effects in the financial sector and this requires particular regulation.

We develop a repeated game of asymmetric information where a bank may engage in illegal activities, which we label 'gambling behaviour'. In our framework, when the bank gambles, this means that it reports higher equity than allowed to push returns (in the short term). In general, gambling behaviour could also be represented by other illegal activities that could be used to increase profits, e.g. excessive risk-taking, financial misreporting, money laundering, or other kinds of fraud to gain additional returns.

The bank regulator represents the will of the government and cannot observe the bank's gambling. She sets optimal fine levels in order to deter gambling and prevent excessive risk-taking. If business fails, this could have negative externalities on connected banks that could possibly result in high economic and social damage when huge parts of the financial sector are negatively affected [26].[13]

This paper asks if the established practice of an increasing sanction mechanism holds for the banking sector. We find that an increasing punishment structure is efficient in reducing gambling bank behaviour if and only if the regulator's detection probability is low or the amount gambled by the bank, if it would cheat, is high.

This result is driven by the potential influence of sanctions on the decision-making process. The bank's payoff depends on the decisions made in the first period as well as in the second period. Bank behaviour is therefore influenced not only by any sanctions paid but also by whether the bank obtains hidden gambling gains. These gains from gambling can be additionally invested in the second period, which increases the incentive for truthful behaviour in period 2.[14]

Under low detection probability, to incentivize a bank that was detected gambling for the first time, sanctions have to be higher in period 2, when the bank expects low detection probability again. When the bank was detected in period 1 with a high detection probability, a lower sanction is needed to incentivize truth-telling in period 2. A different treatment of first and repeated offences is possible and depends on detection probability as well as the amount gambled by the bank if it would cheat.[15]

The main difference between our model and the existing literature is that the benefit from gambling is not necessarily the same across periods and across all decision alternatives. Also, the sanction amount itself depends on the sanction paid a period before because the sanction is defined as a percentage of the profits. Profits adjust over the periods and are possibly higher when there was undetected gambling in the previous period. This is also true if we only consider parts of the bank's business and the corresponding profit share.

The remainder of this article is organized as follows. "Related literature" section provides an overview of the related literature, whereas "The model" section describes the model. In "Sanctions and comparative statics" section, we present our main results as well as various comparative statics. "Extensions" section extends the framework to study regulatory learning and the possibility of insolvent banks. Finally, concluding remarks and policy implications follow in "Conclusion and policy implication" section.

Related literature

There are a certain number of papers, starting with Becker [9], that study whether or not an increasing sanction mechanism is efficient to deter criminal behaviour. In Becker [9], the amount of illegal offences is determined by the probability of detection of a crime, the amount or length of the punishment and the form (e.g. imprisonment, financial penalties). Furthermore, the costs of deterring crimes as well as the costs caused by the harm of an offence have to be considered. A rational offender commits a crime if the expected utility exceeds the utility gained through compliance. The expected utility when committing a crime is the utility gained without apprehension and the utility gained when there was apprehension and punishment, weighted with the probability of detection.

The papers most closely related to ours are Emons [21, 22]) and Dana [18], which analyse repeated sanctions in a dynamic setting. In Emons [21], an individual can commit

[12] Depositors are only insured up to a certain amount. As there is heterogeneity across depositors, some hold deposits below the insurance coverage and it is possible that they make their deposit decisions independently of the banks' risk-taking behaviour.

[13] The bank is able to have some risk, but excessive risk can yield high social damage if a failure of the banking sector occurs. According to EU directives 2019/878 and 2019/879, risk should be reduced to improve the safety and soundness of the banking sector.

[14] We can think of the two periods as either bank internal (a change in bank management could influence bank behaviour and this reflects the second period's behaviour) or external (change in regulation), or just interpret it as a period of time as long as the limitation period has not expired.

[15] We do not account for the reputational costs of the bank after public announcements of misconduct, as, for example, Karpoff and Lott [30]. They find a negative impact of the bad news on the bank's or firm's stock performance. Köster and Pelster [31] find the opposite effect and interpret that investors expect the bank executives to improve their behaviour. They also found that investors assumed the sanctions paid were lower than the gains obtained from bad behaviour.

one crime in each of two periods. The offender's available assets serve as a limit for the fine. This results in a declining sanction scheme: the fine for a first offence has to be set as high as the entire offender's wealth and the repeated offence fine is zero.[16] It does not hold if the harm of the second offence is large and the regulator wants to deter the second crime [22]. Dana [18] assumes an increasing detection probability for repeat offenders and that a sanction should be equal to the harm of a crime.

There is a competing paper from Miceli [35] studying sanction structure in the presence of so-called 'unknown offenders' who unwittingly commit a crime. The author finds an increasing sanction scheme to be the second-best way to deter repeated crimes when the proportion of unknown offenders in the total population is high enough. The paper also uses a two-period model and takes into account imperfect detection. That means the offender is caught with some probability.

Further papers are close to ours. Polinsky and Shavell [42, 43] find the optimal sanction scheme depends on offence history, with a more severe punishment for the second offence as this will already deter the first offence. Mungan [39] allows for learning effects on the offender's as well as the law enforcer's side. Individuals will transfer the decision to the second period, thereby avoiding the repeat offender's fine in Mungan [40].

Other related papers are, for example, Burnovski and Safra [14], who assume a fixed cumulative sanction and analyse changes in the fine structure. Rubinstein [47], Chu et al. [17], Emons [23], or Mungan [40] consider the possibility that a first-time offender commits a crime by mistake. Funk [27] and Miceli and Bucci [36] consider the effect of stigma. Mungan [41] allows for imperfect detection and considers an informal sanction (stigma) as well as a formal sanction. Eggert et al. [20] allow the offender's wealth to differ. Miles and Pyne [37] analyse imperfect deterrence: only some criminals are deterred. Endres and Rundshagen [24] found that due to the final round effect, decreasing as well as escalating penalty schemes can reduce punishment costs (compared to a uniform scheme). Buehler and Eschenbaum [13] analyse a rent-seeking principal in their model.[17]

The above-mentioned papers define the high (low) sanction as being larger or equal (lower) to the benefit of the crime. In our paper, we analyse the sanction amount that is incentive-compatible for any period. After determining the incentive-compatible sanctions, we analyse whether those sanctions are indeed different from one another across periods and if this shows an increasing, decreasing or constant sanction scheme. Our analysis differs from the general law enforcement model as we allow for different but incentive-compatible sanction levels over both periods. This is comparable to having high sanctions in both periods in the more standard models, but they generally do not allow for the sanction base (i.e., the per-period return) to vary across periods, which is what drives our result.

We adapt the general framework of repeat offenders to consider punishment in the context of the banking sector. In our two-period setting, we analyse whether increasing, decreasing or constant sanctions are efficient to deter the gambling behaviour of a representative bank. A regulatory institution is able to impose sanctions on a gambling bank. According to European Union Council Regulation No. 2532/98 and No. 1024/2103, when determining penalties, the regulator should take into account offence repetitions.

The model

We study a two-period game $t = \{1, 2\}$ with a representative bank and a regulatory institution. A risk-neutral bank manager is running the bank. The bank has the option to take excessive risk, henceforth 'gamble'. In the model, we picture this as the bank's possibility of presenting higher equity than is true. This could also be interpreted as misconduct in reporting or fraud to gain additional returns. In real life, this could be, for instance, any deception in the use of internal models to calculate required capital, money laundering, or shadow banking.

A bank regulator tries to prevent and punish gambling behaviour. We are interested in the sanction structure the regulator uses to prevent any gambling. The regulator sets three fine levels: the fine paid by a detected offender in the first period, the fine paid by a first-time-detected offender in the second period, and the fine paid by a twice-detected offender in the second period.[18] In our framework, the sanction is paid once per period and the enforcement procedure does not overlap with the next period.

Let us now derive the structure of the game. The regulatory institution detects gambling bank behaviour only after performing a 'high quality' audit and with an exogenously given probability $\theta \in [0, 1]$,[19] After the bank's gambling

[16] There are other papers where decreasing sanction schemes might be optimal under some conditions; see Burnovski and Safra [14], Mungan [39], Anderson et al. [4], or Eggert et al. [20].

[17] We follow Hellmann et al. [28], Repullo [45] and Andersen and Harr [3] in their modelling of the incentives a representative bank has to take excessive risk.

[18] For analysing incentive-compatibility, we first allow for a different treatment of a first offender in periods 1 and 2. The interpretation of this feature of the sanction scheme established by Polinsky and Shavell [42] is problematic as it privileges 'senior' first offenders over 'young' first offenders. We later do not allow for such a distinction.

[19] We assume that this probability remains the same across both periods. In an extension in "Extensions" section we consider regulatory learning and that the probability of detection in period 2 extends that of period 1, i.e. $\theta_2 > \theta_1$.

behaviour is detected, the regulator imposes a non-negative fine $s_{\text{th}} \in [0, 1]$ in period t as a share of the bank's profit, where subscript $h = \{1, 2\}$ denotes the offence history.[20] That means that s_{11} corresponds to a fine level for offences detected in the first period, s_{21} implies detection of a first offence in period 2. When there was detection of an offence in the first period, s_{22} denotes the sanction for a repeated offence.

At the beginning of the game, the regulator announces s_{th} and commits to her policy.[21] In each period, the bank chooses the extra level of equity that it pretends to have, x_t, that is, the amount it gambles. We assume that the bank's choice is binary and that $x_t = \{0, \bar{x}\}$, with $\bar{x} > 0$, for all t.[22] The occurrence of $\bar{x} > 0$ indicates a level that is no longer tolerated by the regulator. Profits or losses of the first period realize, and then the bank again decides whether to report the true or false equity amount in period 2, facing potential sanction s_{2h}.

Representative bank The representative bank has an equity endowment of E_1 that is assumed to be the basis for the capital requirement.[23] In each period, it mobilizes a volume of deposits of kE_t, increasing in equity. Facing a capital requirement $k \geq 1$ leads the bank to hold enough equity capital. k is exogenously fixed without loss of generality as the bank would minimize equity in the absence of regulation. Due to high opportunity costs r, equity capital is more costly to raise than deposits under an interest rate i (i.e. $r > i$), both of which are exogenously given.[24] The bank invests its total assets; we follow Hellmann et al. [28] or Repullo [45] in the method of modelling the bank's investment basis.

The bank decides to report its true equity, realizing a return, denoted with γ, or to gamble and additionally gain $(\gamma k - ik)x_t$. Let the value of x_t be efficiently chosen by the bank.[25] Further, assume that supplementary deposits are invested in risky assets. Let π_t denote the bank's profit in each period,

$$\pi_t = E_t(\gamma + \gamma k - ik - r) + (\gamma k - ik)x_t, \tag{1}$$

where the first term represents the ordinary effective profit margin and the second term the additional profit margin of a gambling bank (if $x_t > 0$).

We define $\psi \equiv (\gamma k + \gamma - ik - r)$ and $\chi \equiv (\gamma k - ik)\bar{x}$ for clarity of exposition. Both terms are strictly positive, $\chi > 0$ and $\psi > 1$. A positive χ implicitly assumes that the bank has specific information on how to gain additional returns. $\psi > 1$ ensures that for a truth-telling bank to stay in business, it must generate at least its investments as revenue. The bank maximizes its payoff Π given by:

$$\Pi = \pi_1 - \theta s_{11}\pi_1|_{x_1=\bar{x}} + \pi_2 - \theta s_{2h}\pi_2|_{x_2=\bar{x}} \geq 0. \tag{2}$$

To fulfil the bank's participation constraints, θs_{th} must not exceed unity.

Equity capital in period 2 is the profit of period 1 less potential penalties,

$$E_2 = \pi_1 - \theta s_{11}\pi_1|_{x_1=\bar{x}}. \tag{3}$$

With true equity declaration or without detection of the first period's gambling, E_2 is determined by π_1, the profit of period 1.

Regulator A regulatory institution wants to prevent the bank from gambling at the high level $\bar{x}$, and therefore tries to rule out any gambling. If bank failure occurs (with a probability of ρ) and the gamble is unsuccessful, the economic and social damage will be a multiple m of the level the bank invests in gambling and should therefore be impeded. Due to moral hazard and the possible contagion effects of a bank failure, social costs in general are systemic and huge [33].

A regulatory institution chooses her regulatory instrument s_{th} at the beginning of the game and commits to this policy. The regulator identifies gambling with a detection probability θ after a successful audit. This is costly to her because regulatory supervision generates sunk costs $c(\theta)$ per

[20] This determination of the sanction amount is one of two specified in the guide of the European Central Bank [25]: Guide to the Method of Setting Administrative Pecuniary Penalties pursuant to Article 18(1) and (7) of Council Regulation (EU) No 1024/2013, at para. 2.3. There is a legal maximum for the fine. The amount must not exceed 10% of the total annual turnover, or alternatively, twice the amount from the violation's profits or losses avoided.

[21] See Azmeh [6], who empirically shows that supervisors need some time to adapt and adjust regulations. For a sample of 57 developing countries, soft adjustments in regulation have a higher impact on financial stability than fast adjustments. Mention that adjustments in sanctions could be faster than adjustments in detection probability. To improve the latter, there is a need for better and higher-skilled employees, which is not always immediately possible. Setting those parameters at the beginning of the game shows how time-consuming it is to adjust them, especially when it is about established laws.

[22] This model analyses whether or not the bank gambles and does not ask 'how much' gambling as this level is assumed to be optimally chosen. With reference to private gambling decisions, this is treated as binary; see, for instance, Albers and Hübl [2] or, more recently, Watanapongvanich et al. [51].

[23] In order to keep the calculations of the model simple, the equity endowment is taken as the basis for calculating the amount of the deposits allowed. See the Basel regulatory framework, Chapter RBC20, for the detailed calculation of the regulatory capital. Along with that, Chapter CAP10 of that framework describes the criteria for regulatory capital to be qualified.

[24] See Hellmann et al. ([28], p. 151) who give a revealed-preference argument: 'If capital truly had no opportunity cost, then the problem of moral hazard in banking would not be so prevalent as it remains

Footnote 24 (continued)

today, because regulators would simply ensure that banks hold sufficient capital to induce prudent investment, and banks would willingly comply.'

[25] See Rousseau [46], where the regulated firm is described as selecting an optimal level of violation.

period. The cost function is strictly convex in θ with $c(0) = 0$ and $c'(\theta), c''(\theta) > 0$. This could be explained by an increase in personnel costs when increasing the punishment probability. The total social and economic costs C over both periods are determined by the supervisory costs, if the regulator is able to obtain sanctions and the harm of gambling:

$$C = 2c(\theta) - \theta s_{11}\pi_1|_{x_1=\bar{x}} - \theta s_{2h}\pi_2|_{x_2=\bar{x}} + \rho m(\gamma k - ik)[x_1 + x_2]|_{x_i=\bar{x}}. \tag{4}$$

The regulator minimizes total costs C and tries to prevent banks from gambling. The regulatory institution obtains bank information from past examinations and experiences. Nevertheless, the regulator lacks the bank's private information about investment strategy, portfolio design and true equity. This problem remains critical to regulatory design.

Incentive-compatibility For the regulator, it is essential to figure out the incentive constraint preventing the bank from gambling, i.e. $\Pi|_{x=0} \geq \Pi|_{x=\bar{x}}$. An indifferent bank is assumed to report truthfully. We solve the game backwards, starting in the second period. Each period, the bank decides whether to gamble or not and can therefore adjust its investment strategy between audits. If the regulator detects gambling, she sanctions the bank. Subsequently, the bank again decides between true or untrue reporting and with probability θ the bank will be sanctioned after gambling.

We depict the sanction probability as nature in the decision tree that the bank faces at the beginning of period 1 and this is represented in Fig. 1 in "Appendix A.1". Incentive-compatibility must hold for every decision node a, b and c in period 2 (Fig. 1). The associated expected payoffs of the bank that are assigned to the respective end node are listed in the table in "Appendix A.2".

In node a we compare the bank's payoffs at end nodes 1 and 2. We further compare 3 to 4 and 5 to 6. The sanctions must be chosen such that there is an incentive for the bank to report truthfully in both periods. The threat of a repeated sanction only exists in node b. Here, the regulator has already detected gambling in period 1.

The bank has private information about potential gambling gains and the regulatory institution is prone to making mistakes and incorrectly determining the efficient sanction amount. Too high punishment threatens the bank's economic survival. Nevertheless, too low punishment inhibits any deterrence and results in gambling.

Sanctions and comparative statics

To apply subgame perfection, we examine four different sanction structures to determine whether the bank is deterred or not.

Subgame perfection We now explain the logic of the incentive-compatible sanctions and the strategy choice of the bank applying subgame perfection and refer to the table concerning the social costs in "Appendix A.3". If both sanctions are high and satisfy the bank's incentive-compatibility, the bank will be deterred in period 2. Due to backward induction, the bank will also be deterred in period 1. Hence, it declares true equity in both periods. Total costs amount to $2c(\theta)$.

If both sanctions are low and not incentive-compatible, the opposite holds; the bank will not be deterred in either period and will gamble in both of them. Total costs are derived in nodes 4 and 6, respectively, with the costs being higher when there was hidden gambling without any sanctions obtained (node 6).

Now let us consider decreasing sanctions. Starting in the second period, it depends on whether there was a detection of gambling in period 1 or not. If the bank's gambling was detected in period 1, the bank had to pay the high sanction and may then gamble again in period 2. The low sanction for repeat offences does not deter the bank in the second period. Total costs are defined for node 4. If the bank was not detected in period 1, it does not gamble in period 2. The high and incentive-compatible sanction in period 2 deters the bank's gambling behaviour. This refers to the total cost of end node 5. End node 1 is reached if the bank tells the truth in period 1. Gambling is then deterred under an incentive-compatible first sanction.

Consider instead the increasing sanction scheme. It also depends on detection in period 1. When gambling was detected in period 1, the bank might not gamble again in period 2 under incentive-compatible repeated sanctions and social costs are then defined for node 3. On the other hand, if gambling was not detected in period 1, the bank will not be deterred in period 2 because of the low first offender's sanction. Social costs are defined for node 6. If the bank told the truth in period 1, gambling might not be deterred in period 2. Moving back to period 1, the bank will therefore gamble in the first period.

As there was no deterrence under low sanctions in either period, this scheme is dominated by the others when at least some deterrence is preferred, possible and achievable. The results above are in line with the general model of repeat offenders; see, for instance, Chu et al. [17] or Miceli [34].

Considering the total costs, the minimum is $2c(\theta)$ and therefore only achieved at end node 1. This node could be reached by setting, in both periods, high and incentive-compatible sanctions. At the risk of high social costs referring to nodes 4 or 5, respectively, node 1 could also be reached under decreasing sanctions, but only when there was no detection of gambling in period 1.

We now want to find incentive-compatible sanctions. They differ between the history-dependent gambling choices of the bank. We therefore need different minimum sanction levels in each decision node of Fig. 1. Hence, we first derive the sanction amounts necessary for each node to obtain true equity reporting. As a result, node 1 and truth-telling can be obtained.

Sanctions Whether the bank is deterred or not depends on how the sanctions are defined. The benefit from gambling could be transferred to the next period as it increases the amount the bank is able to invest (even legally). This requires analysing the bank's incentive more specifically. For each decision node of the second period pictured in Fig. 1, we now calculate the sanction required to obtain true equity reporting.

In node a the incentive-compatible sanction that ensures the payoff of end node 1 to be greater or equal to the payoff of end node 2, we find:

$$s_{21}^{a} \geq \frac{\chi}{[E_1\psi^2 + \chi]\theta} \equiv \underline{s}_{21}^{a}. \tag{5}$$

$\underline{s}_{21}^{a}$ corresponds to the minimum sanction threshold of node a. With any sanction higher than or equal to $\underline{s}_{21}^{a}$, the bank reports truthfully. This holds true for the case when there was true reporting in period 1. Any fine exceeding this threshold $\underline{s}_{21}^{a}$ would deter in the same way. Stigler [49] informally explains that first offenders could commit a crime by accident and should therefore be punished less than repeat offenders. Among others, Chu et al. [17] explain this effect analytically. We do not account for the social costs obtained by too harsh penalties but rather focus on the minimum sanction needed for deterrence.[26]

There is an upper bound the sanction must not exceed, as otherwise the bank's participation constraint, Eq. (2), is not fulfilled. That is, $\theta s_{\text{th}} \leq 1$. Concerning decision node a, threshold $\underline{s}_{21}^{a}$ deters gambling as a first-offender in period 2.

We now study the case when there was gambling without detection in period 1, decision node c. Here, the incentive-compatible minimum sanction is given by:

$$s_{21}^{c} \geq \frac{\chi}{[(E_1\psi + \chi)\psi + \chi]\theta} \equiv \underline{s}_{21}^{c}. \tag{6}$$

$\underline{s}_{21}^{c}$ describes the first-offenders' minimum sanction threshold in the second period. A comparison of these thresholds concerning nodes a and c gives $\underline{s}_{21}^{a} > \underline{s}_{21}^{c}$ and we can thus state the following.

Lemma 1 *The threshold of the incentive-compatible minimum sanction for a bank not to gamble as a first-offender in the second period must be higher for true equity reporting compared to hidden gambling in period* 1. *This is because the truthful bank has not gained any additional revenue through gambling.*

Proof Comparing Eqs. (5) and (6), this gives $\chi\psi > 0$, thus $\underline{s}_{21}^{a} > \underline{s}_{21}^{c}$. This is true for $\chi > 0$ and $\psi > 1$. □

The sanction has to be higher for a bank that did not gamble in the period before compared to a bank that gambled in the period before. As the regulator cannot distinguish between both cases, the threshold must be at least $\underline{s}_{21}^{a}$. This is because the lawful bank has no additional revenues from gambling. Whereas a gambling bank that was able to hide its behaviour gained some supra-normal profits. With additional returns due to hidden gambling, the lower the sanction must be for the bank to report the true value in the following period.

We have neglected the case of repeated sanctions so far. Let us now consider node b in Fig. 1. The regulator detects gambling behaviour in period 1, that is, the incentive-compatible minimum sanction amount to prevent a repeated offence depends on the amount already paid, s_{11} as well as detection probability in period 2. Comparing the payoffs of end nodes 3 and 4, we obtain:

$$s_{22} \geq \frac{\chi}{[(1 - s_{11})(E_1\psi + \chi)\psi + \chi]\theta} \equiv \underline{s}_{22}. \tag{7}$$

The threshold $\underline{s}_{22}$ to deter a repeated offence is depicted in the equation above and depends on s_{11}. To see whether the impact is positive or negative related, we differentiate Eq. (7) with respect to s_{11} and this derivative is positive. We can thus state the following result. □

Proposition 1 *For a bank that was detected gambling in period* 1, *the minimum sanction amount to obtain true equity reporting in period* 2 *depends on the sanction already paid* (s_{11}). *Any increase in the first-offenders' minimum sanction increases the threshold* $\underline{s}_{22}$.

Proof The derivative of Eq. (7) with respect to s_{11} is positive and gives $\frac{\partial \underline{s}_{22}}{\partial s_{11}} = \frac{(E_1\psi+\chi)\psi\chi}{\theta[(1-s_{11})(E_1\psi+\chi)\psi+\chi]^2} > 0$. This positive relationship shows that an increase in s_{11} increases the threshold $\underline{s}_{22}$. □

Let us now analyse the threshold for the minimum sanction amount to achieve truth-telling in period 1. For incentive-compatibility in the first period, the payoff of end node 1 has to be higher than or equal to that of end nodes 3 and 5, we obtain:[27]

$$s_{11} \geq \frac{\chi}{[E_1\psi + \chi]\theta} \equiv \underline{s}_{11}. \tag{8}$$

As long as the sanction is not lower than the threshold $\underline{s}_{11}$, the bank has no incentive to gamble in the first period. We obtain the threshold to incentivize truthful bank behaviour

[26] We therefore analyse the minimum sanction threshold, similar to Mailath et al. [32] or Emons [22]. In addition, there exists a legal maximum for the fine; see footnote 20.

[27] Payoff of end node 3 equals the one of end node 5, see "Appendix A.1".

in period 1 to be higher than the one to prevent a first offence in period 2 (node a), i.e. $\underline{s}_{11} > \underline{s}^a_{21}$. □

Lemma 2 *To deter a first offence independent of the period we are in, we need a higher minimum sanction than the threshold $\underline{s}^a_{21}$. As $\underline{s}_{11} > \underline{s}^a_{21}$, the threshold $\underline{s}_{11}$ must be reached to obtain incentive-compatibility even in period 1.*

Proof Comparing the thresholds $\underline{s}^a_{21}$ and $\underline{s}_{11}$, we obtain $\underline{s}_{11} > \underline{s}^a_{21}$. Inserting the respective values gives $\frac{\chi}{[E_1\psi+\chi]\theta} > \frac{\chi}{[E_1\psi^2+\chi]\theta}$. Simplifying yields $\psi > 1$. □

If distinction is possible, the regulator could announce a higher sanction for a first offence detected in period 1 than one detected in period 2. This result is in line with Polinsky and Shavell [42], who interpret this as a reward for being honest in period 1. According to the literature, this is rather problematic as it could be interpreted as privileging 'senior' first-time offenders over 'young' first-timers (see Chu et al. [17]). To avoid this problematic interpretation, we set the sanction amount for a first offender to $\underline{s}_{11}$. We further assume that distinguishing between the two periods is impossible; therefore, only the offence history matters.

We now ask whether the efficient sanction scheme is an increasing, decreasing or constant one to efficiently obtain true reporting in each period. We therefore take into account the thresholds that ensure incentive compatibility and deter a first offence as well as a repeated offence. Inserting Eq. (8) into Eq. (7), we solve for the probability at which $\underline{s}_{22} = \underline{s}_{11}$. Any θ smaller (respectively, higher) than the probability obtained yields the efficient sanction scheme to be increasing (resp., decreasing). □

Proposition 2 *We find that increasing sanctions $\underline{s}_{22} > \underline{s}_{11}$ are efficient in reducing gambling bank behaviour if and only if $\theta < \frac{\chi}{E_1(\psi-1)+\chi}$. This is when the detection probability θ is low or the amount gambled by the bank, if it would cheat, is high.*

Proof $\underline{s}_{22} = \underline{s}_{11}$ is equivalent to $\frac{\chi}{[(1-\underline{s}_{11})(E_1\psi+\chi)\psi+\chi]\theta} = \frac{\chi}{[E_1\psi+\chi]\theta}$. Simplifying and solving for θ yields $\theta = \frac{\chi}{E_1(\psi-1)+\chi}$. For $\theta < \frac{\chi}{E_1(\psi-1)+\chi}$ which is the expression above in Proposition 2, we have $\underline{s}_{22} > \underline{s}_{11}$. For $\theta > \frac{\chi}{E_1(\psi-1)+\chi}$, it is $\underline{s}_{22} < \underline{s}_{11}$, respectively. □

When θ is high or the amount gambled if the bank would cheat is low, the efficient sanction structure is a decreasing one ($\underline{s}_{22} < \underline{s}_{11}$). This depends on the amounts of θ and χ as the thresholds $\underline{s}_{11}$ and $\underline{s}_{22}$ are decreasing in θ and increasing in χ.

Lemma 3 *Any increase in θ decreases the thresholds $\underline{s}_{11}$ and $\underline{s}_{22}$. The effect of χ is positive for all minimum sanction thresholds.*

Proof Analysing the derivatives, we obtain $\frac{\partial \underline{s}_{11}}{\partial \theta} = -\frac{\chi_1}{(E_1\psi+\chi)\theta^2} < 0$. The effect of an increase in θ on the repeated minimum sanction threshold $\underline{s}_{22}$ is negative, $\frac{\partial \underline{s}_{22}}{\partial \theta} = -\frac{(E_1\psi+\chi)\chi\psi+\chi^2}{[(1-\underline{s}_{11})(E_1\psi+\chi)\psi+\chi]^2} < 0$. To obtain the effect of χ on the minimum sanction thresholds $\underline{s}_{11}$ and $\underline{s}_{22}$, this effect is positive, we find $\frac{\partial \underline{s}_{11}}{\partial \chi} = \frac{E_1\psi}{[E_1\psi+\chi]^2\theta} > 0$ and $\frac{\partial \underline{s}_{22}}{\partial \chi} = \frac{E_1\psi^2\theta}{[(1-\underline{s}_{11})(E_1\psi+\chi)\psi+\chi]^2\theta} > 0$. With a higher amount gambled if the bank would cheat, the minimum sanction thresholds increase. □

The higher the amount gambled if the bank would cheat, the higher the minimum sanction thresholds announced at the beginning of the game. The higher the regulatory detection probability, the lower the thresholds to deter any gambling. A higher detection probability increases the risk of a gambling bank being caught. This raises the threat and disadvantage of being sanctioned, even if the minimum sanction threshold is low. This result is in line with Becker [9], where an increase in detection probability compensates for a reduction in sanction amount. We can summarize these findings as follows. □

Proposition 3 *The higher χ, an increasing sanction scheme is more efficient, $\underline{s}_{22} > \underline{s}_{11}$. An increasing sanction scheme is incentive-compatible under low detection probability ($\theta < \frac{\chi}{E_1(\psi-1)+\chi}$). Low detection probabilities could be interpreted as lower regulatory costs of deterrence, as an increase in the quality or quantity of audits or regulatory staff would induce higher costs.*

Proof Omitted. □

Proposition 3 explains the rationale for regulators and policymakers to apply an increasing sanction scheme in practice. If the amount the bank would gamble is high or the detection probability is low, the regulator will implement increasing sanctions. The sanction for a repeated offence then exceeds the one for a first offence.

Extensions

We now introduce some extensions of our model to take into account a change in detection probability between both periods and to consider the case of an insolvent bank.

Regulatory learning We now examine the learning on the regulator's side and the possible effect on the bank's gambling decision. With $\theta_2 > \theta_1$, the regulator learns over time.[28] We compare the minimum sanction thresholds for a first-time offender and obtain $\underline{s}_{11} > \underline{s}^a_{21}$. To deter a first

[28] See, for example, Dana [18], who analyses dynamic audit probability depending on offence history, while in our model the regulatory learning is time-dependent.

offence independent of the period we are in, at least the minimum threshold $\underline{s}_{11}$ is needed.[29] Lemma 2 also holds in the case of regulatory learning.

The efficient sanction mechanism is an increasing one when $\underline{s}_{11} < \underline{s}_{22}$ holds. Insert Eq. (8) into (7) and allow for $\theta_2 > \theta_1$, thus giving:

$$E_1\psi(\psi\theta_2 - \theta_1) + \chi(\theta_2 - \theta_1) < \chi\psi\left(\frac{\theta_2}{\theta_1} - \theta_2\right). \tag{9}$$

Equation (9) shows that the effective sanction mechanism depends on the bank's total income (weighted with the probability of detection) and the risk of detection. Consider the case when safe and gambling investments [left-hand side of Eq. (9)] are smaller than the possible loss of additional gambling gains after a detection (right-hand side). Then, an increasing sanction mechanism is efficient. If the sign of the Eq. (9) is reversed, and this is more likely under regulatory learning, then decreasing sanctions are efficient. $\underline{s}_{11} > \underline{s}_{22}$ should be implied (constant sanctions if Eq. (9) holds with equality). We can thus state the following result.

Proposition 4 *Under regulatory learning* ($\theta_2 > \theta_1$), *it could be efficient to implement a decreasing sanction mechanism. But if we assume that the bank has the ability to learn over time to better hide gambling behaviour, detection probability would decrease* ($\theta_1 > \theta_2$). *An increasing sanction scheme would then be efficient to obtain incentive-compatibility.*

Proof Rearranging Eq. (9) we obtain $E_1\psi(\psi\theta_2 - \theta_1) + \chi(\theta_2 - \theta_1) + \chi\psi(\theta_2 - \frac{\theta_2}{\theta_1})$. As the last term is negative for $\theta_2 > \theta_1$ (regulatory learning) and also for $\theta_2 < \theta_1$ (bank learning), the whole expression to be positive is more likely under regulatory learning. When positive, a decreasing sanction mechanism is efficient and $\underline{s}_{11} > \underline{s}_{22}$ should be implemented. If $\theta_2 < \theta_1$, the whole expression is more likely to be negative and an increasing sanction mechanism will be efficient. □

There are two impacts of regulatory learning. With an increase in θ_2, this increases the incentive to gamble in period 1 compared to period 2 (left-hand side of Eq. 9). Additionally, this increases the risk of being detected as a repeat offender in period 2 (right-hand side of Eq. 9).

Insolvent banks We now allow for the failure of the bank's business and introduce a probability of success $\rho_t \in [0, 1]$. If the bank goes bankrupt in the first period, $\rho_1 = 0$ without detection, there is an incentive for the bank to gamble and save itself. Therefore, let the insolvent bank be able to report wrong equity capital in period 2, trying to regain lost capital. This creates a so-called 'zombie-bank'.[30] If not detected, there is a risk of banks' gambling on resurrection. Hence, the sanction threshold to deter gambling in period 2 has to be high, because of the bank's incentive to gamble and recover the losses obtained in period 1.[31]

The regulator who wishes to eliminate zombie-banking must enforce a takeover by a sound and solvent bank or a bank closure in the event of detection.[32] The regulator wants to deter gambling at the high level $\bar{x}$, hence tries to prevent any gambling, $x = 0$. Let π_t^ρ denote the bank's profit function in period t,

$$\pi_t^\rho = \rho_t[E_t(\gamma + \gamma k - ik) + (\gamma k - ik)x_t] - rE_t. \tag{10}$$

Equation (10) shows that when bank business fails ($\rho = 0$), either reporting the true equity or gambling, there is no positive return. The bank generates a loss equal to the opportunity cost of equity. Let $\rho_2 = 1$ as otherwise there is no gambling for resurrection possible.

We solve the game equivalent to the main model by comparing the end nodes. The game is similar to the one in "Appendix A.1" but with additional strands for business failure in period 1. While the return after an unsuccessful period does not depend on the bank's decision to gamble or not, the payoffs are identical in that case. This leads to the following result.

Proposition 5 *The undetected bank with negative equity in period* 1 *has no incentive for truth-telling in the second period, even though it faces a high minimum sanction threshold.*

Proof Comparing the payoff of an insolvent bank under truth-telling in period 2 (i.e. $-rE_1$) with the payoff of gambling in period 2 ($-rE_1 + (1 - \theta\underline{s}_{21})\chi$), truth-telling can only be reached through $\underline{s}_{21} > 1$. By definition of $s_{th}, \theta \in [0, 1]$, the probability of detection combined with the sanction being greater than unity is not possible as the bank's participation constraint is then violated. □

Whenever the bank has negative equity in period 1 (irrespective of the bank's strategy choice), there is an incentive to gamble in period 2 and no sanction mechanism deters this bank from gambling. This solution does not affect the remaining cases derived in the main model. □

[29] This result then also takes into account the problematic interpretation of the Polinsky and Shavell [42] sanction scheme; see above.

[30] This terminology is used in literature to describe an insolvent bank still in operation. Among others, see Kane [29] or, more recently, Calderon and Schaeck [15] as literature on zombie-banks.

[31] See for instance, Baldursson and Portes [7], who describe the banks in Iceland and their collapse after the financial crisis. They explain that banks behave in line with the strategy of gambling for resurrection. On the other hand, banks may decrease their risk after a financial crisis; see, for instance, Bonaccorsi di Patti and Kashyap [12].

[32] See Mitchell [38], who analyses bank recapitalization by the government, or Repullo [44], who allows for a lender of last resort policy.

Conclusion and policy implication

In this paper, we studied how bank gambling behaviour is affected by the amount gambled if the bank would cheat, the sanction thresholds and the detection probability. In our framework, the bank decides between gambling (i.e. too high or unlawful equity reporting) and declaring true equity. We derived incentive-compatible minimum sanction thresholds to ensure the bank reported its true equity. The regulatory institution is able to impose fines on the bank as a share of the bank's profit and wants to deter any gambling. Detection probability and sanction amounts are therefore positive because deterrence prevents harm from bank failure and the social costs then amount to the minimum of $2c(\theta)$.

We analysed whether there exists a sanction scheme for which the bank's incentive constraint holds. We found that an increasing punishment structure is efficient in reducing gambling bank behaviour if and only if the regulator's detection probability is low or the amount gambled by the bank, if it would cheat, is high.

The intuition behind that result is that under low detection probability, to incentivize a bank that was detected gambling for the first time, the sanction has to be higher in period 2, when it expects low detection again. On the other hand, when the bank was detected in period 1 with a high detection probability, a lower sanction is needed to incentivize this bank to tell the truth in the second period.

When we consider the amount gambled if the bank would cheat, the effect is as follows: if this amount gambled would have been high (respectively, low), a higher (resp., lower) sanction for repeated offences is needed to obtain truth-telling.

In our setting, the benefit from gambling in period 2 is lower when there is no detection of gambling behaviour compared to truthful behaviour in period 1 (see e.g. nodes 2 and 5). This is due to the increased level that could be invested in the next period, generated by the gambling gains in the previous period. The bank has lower incentives to lose that additional amount by gambling one more time. However, the sanction amount also depends on the sanction paid before. This is because the base of the sanctions as a percentage of the profit adjusts over the periods.

We extended the model and analysed regulatory learning that increases the probability of detection in period 2. Then, a decreasing sanction mechanism could be efficient. Regulatory learning could increase the incentive to gamble in period 1, but this increases the risk of becoming a repeat offender. To obtain incentive-compatibility, a lower threshold for repeated sanctions is needed on top of the higher detection probability. Additionally, we analysed a bank with negative equity in period 1 and found that it was impossible for the regulator to deter gambling.

The results of this article support the current policy practice described in the guideline of the European Central Bank [25], as the penalties imposed if the bank would cheat depend on the amount gambled and on the offence history. In other words, penalties should therefore be higher the larger the offence and should depend on the repetition. Based on this paper, for financial institutions, increasing sanction schemes is an efficient way to deter gambling.

This work can serve as a theoretical basis for an empirical examination and analysis of the prevailing sanction structure in practice.

A Appendix

A.1 Potential gambling banks' decision tree

See Fig. 1.

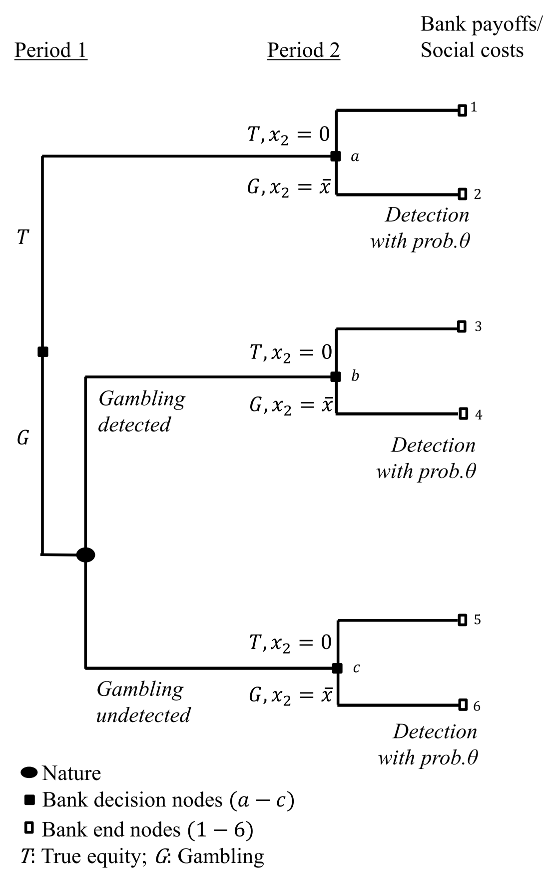

Fig. 1 Potential gambling banks' decision tree

A.2 Bank payoffs

The payoffs of each end node of Fig. 1 are derived as follows:

1 $E_1(\gamma+\gamma k-ik-r)(1+\gamma+\gamma k-ik-r)$
2 $E_1(\gamma+\gamma k-ik-r)+[E_1(\gamma+\gamma k-ik-r)^2+(\gamma k-ik)x_2](1-\theta s_{21})$
3 $[E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1](1-s_{11})(1+\gamma+\gamma k-ik-r)$
4 $[E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1](1-s_{11})+(1-\theta s_{22})[(1-s_{11}) * (E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1)(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_2]$
5 $[E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1](1+\gamma+\gamma k-ik-r)$
6 $[E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1]+(1-\theta s_{21}) * [(E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1)(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_2]$

A.3 Economic and social costs

The economic and social costs of each end node of Fig. 1 are derived as follows:

1 $2c(\theta)$
2 $2c(\theta)-\theta s_{21}[E_1(\gamma+\gamma k-ik-r)^2+(\gamma k-ik)x_2]+\rho m(\gamma k-ik)x_2$
3 $2c(\theta)-s_{11}[E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1](1+\gamma+\gamma k-ik-r)+\rho m(\gamma k-ik)x_1$
4 $2c(\theta)-s_{11}[E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1]+\rho m(\gamma k-ik)[x_1+x_2]-\theta s_{22} * [(1-s_{11})(E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1)(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_2]$
5 $2c(\theta)+\rho m(\gamma k-ik)x_1$
6 $2c(\theta)-\theta s_{2h}[(E_1(\gamma+\gamma k-ik-r)+(\gamma k-ik)x_1) * (\gamma+\gamma k-ik-r)+(\gamma k-ik)x_2]+\rho m(\gamma k-ik)[x_1+x_2]$

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