The effect of competition on safety management to reduce risk in banking

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Abstract: The purpose of this research is to investigate safety management issues in relation to competition, using a game theoretical model. It seems that competition is a key factor in characterising the decision-making process as to whether safety management should be conducted. Therefore, in this research, the following two questions are considered. The first question is whether a relationship between competition and safety management exists because the reality of this link remains an open question. As a corollary, we investigate how the level of competition affects the conduct of safety management if such a relationship does exist. The second question involves identifying the types of conditions required to realise the outcome in which all firms conduct safety management.

Keywords: safety management; competition; game theoretical model.

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1 Introduction

To prevent serious accidents, many firms conduct safety management with the aim of enhancing their levels of safety quality. For example, they install computer security systems to prevent the leakage of consumers’ private information and sprinkler systems
to prevent fire damage. Safety management can reduce the likelihood of accidents and/or lower the damage expected to be caused by accidents.

Although safety management plays an important role in reducing risk, it is costly. Thus, some firms neglect safety management even when it is a legal requirement. Because it is important to establish whether safety management responsibilities are being neglected before accidents actually occur, we need to investigate the conditions under which all firms voluntarily implement safety management. Many factors underlie a firm’s decisions in this regard; this research focuses mainly on the effect of competition, as represented by the number of firms, on safety management. Accordingly, we investigate whether a relationship between competition and safety management exists, and if it does, the manner in which competition affects the conduct of safety management.

The principal reason for analysing the effect of competition on safety management is as follows. Undoubtedly, competition is a key factor in discussing important economic issues such as pricing mechanisms and business strategies. It would seem that safety management is no exception. However, the relationship between competition and safety management is difficult to analyse, because each firm makes its own strategic decisions in relation to the cost and benefit aspects as described by Pauly (2004). Indeed, competition is found to provide incentives as well as disincentives to conduct safety management.

To clarify this aspect, suppose that the level of competition is high, that is, the number of firms is large. In this situation, when an accident occurs, it is highly likely that any firm that neglects safety management is ultimately forced out of the market because there are many alternative firms available. Hence, in order to avoid this negative outcome, firms with many competitors have a strong incentive to conduct safety management.

On the other hand, cost of conducting safety management is high relative to profit margins because each firm’s market share is tiny and profit margins are narrow. From this perspective, firms with many competitors have little incentive to conduct safety management.

In summary, competition has opposing effects on the voluntary conduct of safety management. Table 1 summarises the incentive and disincentive for conducting safety management when the level of competition is high and low. Thus, it is not obvious as to whether the incentive for promoting safety management is large when the level of competition is high. It may occur that the relationship between competition and safety management is obscured by the offset between incentive and disincentive.

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The purpose of this research is to investigate these safety management issues in relation to competition, using game theoretical modelling. The remainder of this paper is organised as follows. First, we conduct a literature review and present contribution of this research and two research questions. Secondly, the model analysis investigating the relationship between competition and safety management is undertaken and two main results are shown. Thirdly, concluding remarks that summarise the results and describe the limitations of this research is described. An appendix explains the mathematical model used.

2 Literature review

Among previous studies on competition between banks, many have investigated the relationship between competition and financial stability. The results derived from previous studies are ambiguous. Boyd and De Nicolo (2005) insisted that the relationship between competition and financial stability is positive. Schaeck et al. (2009) confirmed that a more competitive market improved the financial stability of banks in 38 countries. Fiordelisi and Mare (2014) derived a positive relationship between competition and financial stability in European cooperative banks. In contrast, Hellman et al. (2000) showed that the relationship between competition and financial stability is negative. Beck et al. (2006) confirmed that a less competitive market improved the financial stability of banks in 69 countries. Fungáčová and Weill (2013) estimated that an increase in the level of competition led to lower financial stability of banks in Russia.

Furthermore, Caminal and Matutes (2002) demonstrated that it is unclear whether bank failure increases in a competitive market. Martinez-Miera and Repullo (2010) showed that both ‘too little’ and ‘too much’ of a competitive market triggered a relatively high probability of bank failure.

Some other studies have focused on the relationship between competition and safety quality among hospitals. The level of safety quality is often represented by the mortality rate for acute myocardial infarction. It is natural to expect that this rate will decrease when a hospital implements safety management. Just like the previous studies about banks, the results derived from studies on hospitals are also ambiguous. Kessler and McClellan (2000) estimated a positive relationship between competition and safety quality in USA. Cooper et al. (2011) demonstrated a positive relationship between competition and safety quality after reforms in the National Health Service (NHS) in England. Pan et al. (2015) showed that the relationship between competition and quality is positive in China. In contrast, Scanlon et al. (2008) indicated that competitive situation might not contribute to raise (safety) quality in health maintenance organisations. Propper et al. (2008) showed that the relationship between competition and safety quality is negative in the NHS internal market. Brekke et al. (2010) showed that positive relationship between competition and (safety) quality is overrated in static model when marginal cost is increasing. Furthermore, Brekke et al. (2011) developed more generalised analytical model and found ambiguous relationship between competition and (safety) quality. Palangkaraya and Yong (2013) suggested that the relationship between competition and safety quality is negative if the quality is indicated by 30-day mortality rate and positive if the quality is indicated by 30-day unplanned readmission rate in Australia. Colla et al. (2014) indicated that the relationship between competition and
safety quality depends on diseases that are related to demand elasticity and profitability in the US Medicare program.

3 Contribution of this research

In some analytical models, ‘quality’ has various meanings. For example, Brekke et al. (2010, p.511) states as follows. “The purchase of MR-machines and CT-scanners improve diagnosing, which in turn will increase the treatment quality. Hospitals invest also in human capital in order to improve quality: they spend money on training of their medical staff, they hire highly skilled physicians (specialists) and nurses, etc. Finally, hospitals invest in facilities to improve, say, the quality of theaters, rooms, catering, etc.” In this context, we feel that purchasing medical machines and investing in human capital are possibly connected to safety quality, but improving theatres, rooms, and catering are not. In order to clearly indicate the meaning of quality in the model, our research focuses only on safety quality that reduces the likelihood of the accident.

Furthermore, In the Hotelling model that was used in Brekke et al. (2010, 2011), quality is regarded simply as an element that improves a consumer’s utility. However, safety management sometimes relates the possibility that consumers exit from a particular supplier. For example, suppose a certain bank is exposed to have neglected safety management. This bank may not be able to keep operating because it has lost its trustworthiness and many consumers would withdraw their deposits from it.

This research builds a model in which safety management is related to a firm’s ability to remain in its market in the long run. Thus, the contribution of this research is to initiate a discussion in which safety quality is a variable indicating the probability of remaining in (exiting from) a market.

4 Research questions

In this research, the following two questions are considered.

The first question is whether a relationship between competition and safety management exists. If the level of competition affects a firm’s decision to conduct safety management, then the regulator, which is the supervisor of safety management, needs to maintain levels of competition that promote safety management. If, however, controlling the level of competition does nothing to promote safety management, the regulator needs to consider other factors in supervising the market. In addition, we investigate how the level of competition affects the conduct of safety management if such a relationship exists.

The second question is about the types of conditions required to realise the outcome in which all firms conduct safety management. For example, suppose that the market size, which is measured by potential demand, is large. On the one hand, we propose that firms will have a tendency to conduct safety management, because they can anticipate receiving large profits even in a large market over the long run. On the other hand, we also propose that firms have a tendency to avoid conducting safety management, because their competitive edge – derived from saving on safety management costs and their consequent ability to offer relatively cheaper prices – will be very large and such firms can expect to receive huge profits in the short run.
5 The model

5.1 The methodology

In this research, the model is applied to analyse the relationship between competition and safety management. The model is based on game theory as a standard part of microeconomics. The reasons for employing a game theoretical model are as follows.

First, it is certain that a firm’s decisions on conducting safety management strongly depend on economic factors. We have already mentioned that saving safety management costs and avoiding negative outcome for neglecting safety management are principal motivations in deciding whether to conduct safety management.

Secondly, it is well known that game theory is a powerful tool in analysing interactions among firms. Shy (1995, p.11) argues that “game theory is especially useful when the number of interactive agents is small, in which case the action of each agent may have a significant effect on the payoff of other players”. Each firm prospects other firms’ decisions as it chooses whether to conduct safety management, because other firms’ decisions affect the competitive environment, including cost structures, and thus influence a firm’s own (expected) profit.

Furthermore, the game theoretical approach per se has the following advantages.

First, in many cases, using game theoretical models makes it relatively easy to understand the purpose of the research and how its results are derived, because much of the explanation is expressed in mathematical terms. The analysis used in game theoretical models can thus help to clarify research ambiguities.

Secondly, there are many kinds of formal game theoretical models, as competition is a critical area for research in economics. Thus, a vast number of research approaches exist, some of them being very popular, such as the Cournot and the Stackelberg models. From this viewpoint, we find that there are extensive fundamentals available for building a game theoretical model.

5.2 The model structure

In this section, the model is briefly described. The mathematical explanations of the model are in the Appendix.

Suppose that there are identical firms in a given market. The greater the number of firms there are in this market, the higher is its level of competition. Each firm then plays the following two-stage game.

In the first stage, each firm chooses whether to conduct safety management. Firms that conduct safety management incur a cost. It is assumed that conducting safety management is a legal obligation for all firms. Then, firms that are exposed to have neglected their legal obligations (‘exposed firms’) are punished and may be forced out of the market. Each firm contemplates selling its own product for as long as it remains in the market. In the model, firms choose whether to conduct safety management based on the present values of the expected profits from conducting or avoiding safety management.

A firm neglecting to conduct safety management is more likely to be forced out of business when the number of firms in the market is larger, because there are more alternatives available. Furthermore, an exposed firm may be subjected to market exit pressures such as boycott action. The degree of this pressure will naturally be different in each industry. For example, banks might be expected to experience severe pressures,
because the degree of differentiation in deposits among banks is very small and the level of safety management is very closely connected to whether individuals are in safe possession of their deposits. Hence, the model assumes that the probability that an exposed firm will remain in the market depends on the number of firms and the degree of pressure to exit the market.

In the second stage, each firm chooses its quantity. For example, in hospitals, the number of treatments is equivalent to the quantity in the model. Furthermore, according to a result from Kreps and Scheinkman (1983), quantity can represent each firm’s capacity if all products or services are identical. Thus, in the model, quantity can also be interpreted as the number of doctors or beds.

It is difficult to derive the complete set of possible outcomes for this model, because there are many different situations in which some firms conduct safety management while other firms do not. However, our focus is to confirm whether there is an outcome in which all firms conduct safety management and to discuss the characteristics of such an outcome. Thus, we limit our attention to analysing the situation in which all firms conduct safety management.

6 The main results

From the computation of this model, the following two results are derived. The mathematical explanations of the model are in the Appendix.

Result 1: The relationship between competition and safety management is indeterminate, because there are three possible cases. In the first case (Case 1), all firms conduct safety management when the level of competition is moderate. In the second case (Case 2), all firms conduct safety management when the level of competition is low. In the third case (Case 3), there is no possibility of realising the outcome in which all firms conduct safety management, regardless of the level of competition.

Result 2: When the firms are not too myopic, the following results are derived. First, if potential demand is not too low, the safety management cost is small, and the discount factor and the degree of pressure to exit the market are large, all firms conduct safety management when the level of competition is low. Secondly, if potential demand is not too low and safety management cost, discount factor, and the degree of pressure to exit the market are intermediate, all firms conduct safety management when the level of competition is moderate.

The first result implies that a relationship between competition and safety management exists in some situations, but no relationship between them in others. In addition, even where the relationship is confirmed, how the level of competition affects the conduct of safety management is indeterminate.

The second result finds that when the firms are not too myopic, potential demand is not too low, the cost of safety management is not too high, the discount factor is not too low, and the degree of pressure to exit the market is not too low, there exists the possibility of realising the outcome in which all firms conduct safety management.
7 Concluding remarks

7.1 Findings

In this research, we investigated safety management issues in relation to competition, using game theoretical model. Two main questions were considered, the first being whether a relationship between competition and safety management exists; we also investigated how the level of competition affects the conduct of safety management if such a relationship does exist. The second question considers what kinds of conditions are required to realise the outcome in which all firms conduct safety management. Our two main findings are as follows.

The first result implies that a relationship between competition and safety management exists in some cases, but not in others. Furthermore, even if the relationship is confirmed, how the level of competition affects the conduct of safety management is indeterminate.

The second result implies that when the firms are not too myopic and potential demand is not too low, the cost of safety management is not too high, the discount factor is not too low, and the degree of pressure to exit the market is not too low, there exists the possibility of realising the outcome in which all firms conduct safety management.

Both results can explain the actual situations in banks as follows. The first result can provide useful insight to the regulator who can then control the number of banks in the market. The regulator has to carefully monitor which case is realised. For example, if Case 1 is realised, the regulator has to aim the moderate number of banks in the market. In relation to the second result, the following points can be presented. First, the scale of potential demand is larger because the financial market is expanding worldwide especially in recent years. Secondly, the safety management cost decreases because of the innovation in banks. For example, the innovation in information technologies enhances the cost efficiency to protect depositors’ private information from cyberattacks. Thirdly, it is natural that banks operate with a long-term view. Fourthly, the banks face severe market exit pressures because the degree of differentiation in deposits among banks is very small and consumers would want to withdraw their deposits after the neglect of safety management is exposed. From these four points, we can say that Case 2 holds the tendency to realise in the actual banking industry scenario.

7.2 Limitations

There are several limitations to this research. In this section, three main limitations are discussed.

First, we only examined the situation in which all firms conduct safety management. For a more sophisticated analysis, one could examine a scenario in which only some firms conduct safety management. In addition, firm heterogeneity was not considered. It would be interesting to know whether different results would be obtained if safety management costs and discount factors were to differ between firms.

Secondly, we must not forget that building a model strictly represents ‘a part of’ the real situation, because the mathematical model cannot include too many factors and variables from the real situation. There are issues not mentioned in the model that may affect firms’ decisions. Thus, we insist that our research contributions are only applicable in the limited situations depicted by the model.
Thirdly, we know that this type of model analysis is less suitable for investigating individual cases, because it is difficult to represent specific situations in mathematical terms. Qualitative analysis may be more suitable in such instances, because case study and interview methods, rather than mathematical models, are more likely to yield meaningful results in considering individual cases. Whether results from the model would be applicable in a particular case is still an open question. Some new factors and variables may be required to explain safety management in individual firms or industries, although the results from model analysis including this research would be useful. In summary, a combination of quantitative and qualitative analysis is important to shed light on the actual relationship between competition and safety management.

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References


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**Appendix**

**A1 Notation and assumptions**

In this formulation, \( n \geq 1 \) represents the number of identical firms in a market. Thus, the level of competition becomes higher when \( n \) becomes larger. The safety management cost per unit quantity is denoted by \( c > 0 \). For simplicity, other costs are ignored. The variable \( z \in [0,1] \) represents the probability that an ‘exposed’ firm, which has been exposed to have neglected safety management, remains in the market. It is also assumed that \( z = 1/n \), where \( \gamma \geq 1 \) represents the degree of pressure to exit the market. When \( \gamma \) is large, the degree of pressure to exit the market is high.

We let \( q_j^M \geq 0 \) and \( q_j^N \geq 0 \) represent the respective quantities produced by firm \( j \in \{1, 2, \ldots, n\} \) when safety management is conducted (denoted by the subscript \( M \)) and when safety management is not conducted (denoted by the subscript \( N \)).

The demand function is assumed to be linear as follows:

\[
p_i = a - \sum_{j=1}^{n} q_j^i,
\]

where \( p_i \geq 0 \) is price, the intercept \( a > 0 \) represents potential demand in the market, and \( i \in \{M, N\} \). The potential demand represents the total possible number of purchased products or services, because the value of \( a \) is the maximum demand that can be realised in the case where \( p_i = 0 \).

The profit levels of firm \( j \) when conducting and not conducting safety management (\( \pi_j^M \) and \( \pi_j^N \), respectively) are

\[
\pi_j^M = (p_m - c) q_j^M
\]

\[
\pi_j^N = p_n q_j^N.
\]
The present values of the expected profits from conducting and not conducting safety management are

\[ \Pi'_m = \frac{1}{1-\delta} \pi'_m, \]  
\[ \Pi'_n = \frac{z}{1-\delta z} \pi'_n = \frac{1}{\gamma n - \delta} \pi'_n, \]

where \( \delta \in (0,1) \) is the discount factor, which is equal to \( 1/(1 + \text{interest rate}) \). When \( \delta \) is low, firms strongly want to obtain profits in the short run and vice versa.

### A2 Deriving the equilibrium

Because we focus on the equilibrium in which all firms conduct safety management, we need only check whether one firm has an incentive to neglect to conduct safety management when \( n-1 \) firms conduct safety management.

When all firms conduct safety management, the first-order condition for profit maximisation is

\[ \frac{\partial \pi'_m}{\partial q'_m} = a - \sum_{i=1}^{n} q'_m - c = 0, \]

where the asterisk represents the equilibrium value. Because all firms are identical, \( q'_m = q'_n = \cdots = q''_n \). From equation (A6), the equilibrium quantity is

\[ q'_m = \frac{a - c}{n+1}. \]

Substituting equation (A7) into equation (A2) yields

\[ \pi''_m = \frac{(a - c)^2}{(n+1)^2}. \]

Thus, from equation (A4), the present value of expected profit when safety management is conducted is

\[ \Pi''_m = \frac{1}{1-\delta} \frac{(a - c)^2}{(n+1)^2}. \]

In contrast, when one representative firm, designated ‘firm 1’, does not conduct safety management, its first-order condition for profit maximisation is

\[ \frac{\partial \pi''_n}{\partial q''_n} = a - \sum_{i=2}^{n} q''_m - 2q''_n = 0. \]

For the remaining firms, the corresponding first-order conditions are

\[ \frac{\partial \pi''_n}{\partial q''_n} = a - c - \sum_{i=2}^{n} q''_m - q''_n = 0, \]
where $k \in \{2, 3, \ldots, n\}$. Because $\tilde{q}_{m} = q_{m}^{2} = \cdots = q_{m}^{n}$, from equations (A10) and (A11), firm 1’s and the other firms’ equilibrium quantities are

$$q_{1}^{*} = \frac{a + (n-1)c}{n+1},$$  \hspace{1cm} (A12)$$

$$\tilde{q}_{m}^{*} = \frac{a - 2c}{n+1}.$$  \hspace{1cm} (A13)

To ensure that the equilibrium quantity is not negative ($\tilde{q}_{m}^{*} \geq 0$), we assume that $a \geq 2c$. By substituting equations (A12) and (A13) into equation (A3), we obtain

$$\pi_{N}^{*} = \frac{\{a + (n-1)c\}^2}{(n+1)^2}.$$  \hspace{1cm} (A14)

Thus, from equation (A5), the present value of expected profit when safety management is not conducted is

$$\Pi_{N}^{*} = \frac{1}{\gamma n - \delta} \{a + (n-1)c\}^2.$$  \hspace{1cm} (A15)

### A3 Comparison

To compare expected profits, we define the following function by using equations (A9) and (A15):

$$f(n) \equiv \Pi_{N}^{*} - \Pi_{N}^{*}.$$  \hspace{1cm} (A16)

If $f(n) \geq 0$, then firm 1 is willing to conduct safety management. Hence, $f(n) \geq 0$ is the condition that must be satisfied for there to be an equilibrium in which all firms conduct safety management. By using equations (A9) and (A15), we can rewrite equation (A16) as

$$f(n) = \frac{1}{(1-\delta)(\gamma n - \delta)(n+1)^2} \left[ (\gamma n - \delta)(a-c)^2 - (1-\delta)\{a + (n-1)c\}^2 \right].$$  \hspace{1cm} (A17)

Because $1/((1-\delta)(\gamma n - \delta)(n+1)^2) > 0$, the sign of $f(n)$ is the same as the sign of $(\gamma n - \delta)(a-c)^2 - (1-\delta)\{a + (n-1)c\}^2$. Hence, we must determine the sign of the following quadratic function:

$$g(n) \equiv (\gamma n - \delta)(a-c)^2 - (1-\delta)\{a + (n-1)c\}^2.$$  \hspace{1cm} (A18)

Let the two numbers that satisfy $g(n) = 0$ be denoted by $\underline{n}$ (the smaller value) and $\overline{n}$ (the larger value). From equation (A18), $\underline{n}$ and $\overline{n}$ are

$$\underline{n} = \frac{(a-c)(\gamma a - (2 + \gamma - 2\delta)c - \sqrt{b})}{2c^2 (1-\delta)},$$  \hspace{1cm} (A19)
\[ \bar{n} = \frac{(a - c)(\gamma a - (2 + \gamma - 2\delta)c + \sqrt{h})}{2c^2(1 - \delta)}, \]  
\[
where
h \equiv \gamma^2 a^2 - 2\gamma ac (2 + \gamma - 2\delta) + c^2 \left\{\gamma(4 + \gamma) - 4\delta(\gamma + 1 - \delta)\right\}.
\]

Because \( g(n) \) is concave, \( g(n) \geq 0 \) is possibly realised in the range \( n \in [\bar{n}, \bar{n}] \). Hence, the characteristics of \( g(n) \) are defined by one of the following three cases:

**Case 1**: The number of firms such that all firms conduct safety management is \( n \in [\bar{n}, \bar{n}] \).
In this case, all firms conduct safety management when the total number of firms is neither large nor small.

**Case 2**: The number of firms such that all firms conduct safety management is \( n \leq \bar{n} \).
In this case, all firms conduct safety management when the number of firms is small.

**Case 3**: There is no equilibrium in which all firms conduct safety management, regardless of the number of firms.

### A4 Conditions for the three cases

Which case emerges is determined by two conditions. The first is the condition that \( n \) and \( \bar{n} \) are real numbers. If equation (A21) is negative, then \( n \) and \( \bar{n} \) are imaginary numbers. In this case, \( g(n) < 0 \) for all \( n \), and Case 3 prevails. Thus, \( h \geq 0 \) represents a necessary condition for the existence of an equilibrium in which all firms conduct safety management.

The second condition relates to the sign of \( g(n) \) when \( n = 1 \), which we denote by \( g(1) \).
From equation (A18), \( g(1) \) is
\[
g(1) = (\gamma - \delta)(a - c)^2 - (1 - \delta)a^2.
\]

Let \( \hat{n} \) denote the number of firms that maximises \( g(n) \). Determining the characteristics of equation (A22) requires the following lemma:

**Lemma 1**: \( \hat{n} \geq 1 \) if \( h \geq 0 \).

**Proof**: It follows from equation (A18) that
\[
\frac{\partial g(n)}{\partial n} = \gamma(a - c)^2 - 2(1 - \delta)c\{a + c(\hat{n} - 1)\} = 0
\]
\[
\Rightarrow \hat{n} = \frac{(a - c)\left\{\gamma(a - c) - 2(1 - \delta)c\right\}}{2(1 - \delta)c^2}.
\]

Equation (A23) implies that \( \hat{n} \) is a monotonically increasing function of \( \gamma \). Thus, to establish the proof, we need only analyse the case in which \( \gamma = 1 \). In this case, equation (A23) can be written as
\[
\hat{n} = \frac{(a - c)\left\{(a - c) - 2(1 - \delta)c\right\}}{2(1 - \delta)c^2}.
\]
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Equation (A24) implies the following condition for \( \hat{n} \geq 1 \):

\[
(a-c)[(a-c)-2(1-\delta)c] - 2(1-\delta)c^2 \geq 0
\]
\[
\Rightarrow (a-c)^2 - 2(1-\delta)ac \geq 0.
\] (A25)

Furthermore, when \( \gamma = 1 \), equation (A21) can be written as

\[
h = a^2 - 2ac(3-2\delta) + c^2 \left\{ 5 - 4\delta(2-\delta) \right\}
\]
\[
= (a-c)^2 - 2(1-\delta)ac - 2(1-\delta)c \left\{ a - 2(1-\delta)c \right\} \geq 0.
\] (A26)

To show that \( \hat{n} \geq 1 \), we must establish that \( h \geq 0 \) is sufficient to satisfy equation (A25). Equation (A26) and \( a \geq 2c \) imply that \( 2(1-\delta)c \left\{ a - 2(1-\delta)c \right\} > 0 \). Hence, condition (A25) is satisfied if \( h \geq 0 \), Q.E.D.

From the lemma, we find Cases 1 and 2 emerge when \( g(1) < 0 \) and \( g(1) > 0 \), respectively. The following represents a summary.

If \( h \geq 0 \) and \( g(1) < 0 \), Case 1 prevails.

If \( h \geq 0 \) and \( g(1) > 0 \), Case 2 prevails.

If \( h < 0 \), Case 3 prevails.

The three cases are illustrated in Figure A1. From Figure A1, Result 1 can be found.

**Figure A1** \( g(n) \) in the three cases
In order to derive Result 2, comparative statics analysis must be conducted. The conditions given by \( h \) and \( g(1) \) include the four exogenous variables \( a, c, \delta \) and \( \gamma \). From equations (A21) and (A22), we obtain the following comparative statics:

\[
\frac{\partial h}{\partial a} = 2\gamma \{ \gamma(a-c) - 2(1-\delta)c \}, \quad \text{(A27)}
\]

\[
\frac{\partial h}{\partial c} = -2 \left\{ 2(1-\delta)\gamma(a-2c) + \gamma'(a-c) + 4\delta(1-\delta)c \right\} < 0, \quad \text{(A28)}
\]

\[
\frac{\partial h}{\partial \delta} = 4\gamma \{ \gamma(a-c) + (2\delta - 1)c \} > 0, \quad \text{(A29)}
\]

\[
\frac{\partial h}{\partial \gamma} = 2(a-c) \{ \gamma(a-c) - 2(1-\delta)c \}, \quad \text{(A30)}
\]

\[
\frac{\partial g(1)}{\partial a} = 2 \{ (\gamma-1)(a-c) - (1-\delta)c \}, \quad \text{(A31)}
\]

\[
\frac{\partial g(1)}{\partial c} = -2(\gamma - \delta)(a-c) < 0, \quad \text{(A32)}
\]

\[
\frac{\partial g(1)}{\partial \delta} = (2a-c)c > 0, \quad \text{(A33)}
\]

\[
\frac{\partial g(1)}{\partial \gamma} = (a-c)^2 > 0. \quad \text{(A34)}
\]

Although the signs of equations (A27) and (A30) are ambiguous, both are positive if \( \delta \geq 1/2 \). However, the sign of equation (A31) remains ambiguous whatever the value of \( \delta \). Table A1 summarises the comparative statics results.

From Table A2, Result 2 can be confirmed.

<table>
<thead>
<tr>
<th>Table A1</th>
<th>Comparative statics results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( a )</td>
</tr>
<tr>
<td>( h )</td>
<td>+</td>
</tr>
<tr>
<td>( g(1) )</td>
<td>( ? )</td>
</tr>
</tbody>
</table>

Table A2: The effect of the exogenous variables

<table>
<thead>
<tr>
<th>Table A2</th>
<th>The effect of the exogenous variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( a )</td>
</tr>
<tr>
<td>Large</td>
<td>Case 1 or Case 2</td>
</tr>
<tr>
<td>Moderate</td>
<td>Case 1</td>
</tr>
<tr>
<td>Small</td>
<td>Case 3</td>
</tr>
</tbody>
</table>