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Research Paper

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Obese's People Role in Brazilian Advertising: an Analysis on Fit Consumer´s Perspective

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The way media presents fat people in ads is the focus of this paper. We analyzed, from the perspective of non-fat individuals the role played by fat people in Brazilian TV commercials. Therefore, there were one focus group with people who have seen advertisements in which the protagonist was a fat guy. There was initially a content analysis of a collection of commercial as well as the content of the discussions in which it was built a map of the social representation of 'being fat' in these messages. The analyzes stressed that these protagonists present themselves in order to provoke laughter through humor. Because of this, stigmas as 'comical', 'weird' and 'weak' are formed from their stereotypes and roles. The question that remains is how far these interpretations may affect the brand image conveyed, considering that the obesity phenomenon is present in everyday life of most consumers.

Key words: Television commercials, fat people, stigma.

INTRODUCTION

Today, the body shape is a common theme, being the main topic in several conversations among individuals of different social and economic levels. The point is that such discussions are often influenced by actions that originate from slant marketing advertising actions. This fact brought the interest in this study, as well as the ability to generate further discussion on the topic, it will be possible to understand how some marketing practices in advertisement are constituted through the disadvantage of this social condition considered as not ideal. Since this is a topic that in one hand tends to favor a particular segment (market) and on the other

hand can provide 'malaise' to a social group of individuals (fat or obese people), it is believed that the present study lies in the perspective of transformative consumer research (TCR).

It is known that western culture values thinness based mainly on the findings of biomedicine that turned the concept of a fat body in a synonymous not only of bad health, but in a 'dehumanized body', a pejorative moral bankruptcy. This is because at any other time the slim and svelte body was so in evidence (Sudo and Luz, 2007).The perfect body is a trend topic and present debates on television and commercials, articles published

in magazines, newspapers, internet and other types of media, always highlighting diets, perfect shape body, the fears of getting fat and how not to get fat. It is assumed here that the media tends overall, to promote a thin body as 'ideal' and the fat one as 'not ideal' (stigmatized) (Goffman, 1988). If this is a valid premise, the discussion here presented is relevant because communication, in its various ways, is a powerful tool to manipulate images and information. So if a fat person is not within the optimum standards, he/she may come under pressure of contemporary society and not be accepted as adequate to do television work, in this case, advertisements, for example, because of an image that could possibly generate negative assessments by target consumer. However, when they are hired to participate in advertising work, which role is played by them as protagonists? And how thin consumers perceive and evaluate the roles of fat people on TV ads? Those questions are of interest in this paper.

Media is biased, and it usually communicates, what seems to be more interesting, attractive and profitable for its viewers. The selling of information considers the impact that this kind of pressure has on public health, to carry the sense of a model or unattainable standard of beauty and the mistreat of obesity, placing it just as a problem of 'greed carelessness or laziness". In this context, the stereotype created over the years by the figure of a fat person is assumed to be a „ill" one, in some cases, becomes a „sloppy" (Felippe et al. 2004), 'damaged' (the popular meaning of 'idiot' or 'nonsense'), 'unable', 'clumsy' person that make promises of weight loss at every New Year's Eve. Obesity, while stigmatizing, produces discrimination, prejudice and social exclusion. But this issue is more complex than imagined, because for years researchers have considered it as a public health problem (Hunte and Williams, 2009; Puhl and Heuer, 2010; Santos and Scherer, 2011).

It is assumed also that when communications are established and interpreted through mechanisms that instigate discrimination and prejudice, its essence can negatively influence the evaluation of the company and the product by consumers, especially when communication is built with the image of people perceived as more vulnerable. This way, taking into account that Brazil is a very sensual country where people expose themselves on the beaches, during carnival, on the soap operas, and so on, and also that obesity is growing among Brazilians, we found here an opportunity to analyze, from the perspective of skinny consumers, the role played by fat people in commercials aired on television in Brazil.

Skinny, yes! fat, no!

Discussions about prejudice in social relations, manly at work environment, are not new. From 1960s, in the United States, studies related to employment discrimination were widely publicized due to the increase demand of women and physical disabled persons looking to work full time. Moreover, even not fitting on these characteristics, obesity was considered a kind of 'disability' which referred to prejudices, then awakening the interest of researchers (Bellizzi and Hasty, 1998). In Brazil, only in 1986 the debate was strengthened through the creation of the Brazilian association for the study of obesity (ABESO), whose aim is to bring together professionals from different areas to bring awareness about issues related to obesity, including discrimination (ABESO, 2012).

Earlier studies indicated that obese people were seen as objectionable, weak-willed, lazy, unreliable, incompetent and disgusting (Staffieri 1967; Lerner and Gellert, 1969; Weiss, 1980). Weiss (1980),for example, pointed that obese ones tended to be associated with laziness and dependence, indicating that this association would remain for many years, which was later confirmed by the analyzes of Klassen (apud 1987, Bellizi and Hasty, 1998). Those authors have shown that people who are overweight are characterized as lazy, sloppy, un-disciplined, unreliable, unhealthy, clumsy (without self care), insecure but happy (extroverted). Thus, relating these characteristics to the logic of the market, fat people are rarely associated with job success, ability and competence to properly develop a task (Bellizi and Hasty, 1998).

In this perspective, some authors have called the attention to the fact that the facial or physical appearance could be linked to success or failure in organizations, suggesting because of that, they have to work closely on individuals stereotypes (Dickey-Bryant et al. 1986; McAdams et al., 1992 Apud Bellizi; Hasty, 1998; Puhl and Brownell, 2003), which somehow reinforced the need to have people with good looks in the organizational environment. For example, McAdams et al. (1992) reported that, due to the appearance, the most attractive persons in terms of stature, weight and facial appearance were the most likely to earn higher incomes and have better opportunities in companies. Other studies also have reported weight discrimination at work. For instance, Gortmaker et al. (1993) have shown that individuals who are overweight often suffer detrimental social and economic consequences. This seems to still be a trend: increasing of the discrimination due to new standards and media influence on the accepted body fit. Ziolkowski (1994) reinforces this argument showing that those who are overweight are less likely to get a good job and when they are employed, are hardly promoted and generally earn lower wages when compared to thin peers.

The literature also reveals a possible association between obesity and lower intelligence, suggesting that obese individuals may be intellectually disadvantaged when compared to the non-obese persons (Sargent and

Blanchflower, 1994; Elias et al.,, 2003). Puhl and Brownell (2003) consider that only through a deep understanding of weight stigma and debate on its different perspectives of analysis, one can reflect on and document its social and psychological as well as reveal their effects on health and well- be. Consequences of prejudice against obesity, like social isolation may trigger the exacerbation of obesity increasing the likelihood of over-eating, sedentary lifestyle, and as result, bringing problems at work, and consequently financial losses. Thus, while such connections are postulated to health imbued with aspects prejudiced in this, it is clear that discrimination continue to be part of everyday life for overweight individuals (Gortmaker et al., 1993; Puhl and Brownell, 2003).

Discussion about the media and Its contribution to the obesity stigma

Those individuals who are aligned to the positive characteristics will be inserted in the category of 'normal', while those w h o h a v e negative attributes w e r e associated with the category of 'abnormal' or 'stigmatized' (Goffman, 1988). There are many manifestations of negative attitudes, including the way in which people who are overweight are portrayed by the media. As examples, linked to fat jokes are common on television and the characters who are overweight are viewed quite negatively in movies and cartoons (Puhl and Brownell, 2003). The point is that is not something that is static at the moment are watching and such attitudes may generate future consequences and it can now be considered 'normal' social relationships.

There are two approaches in the discussions on mass communication suggest that it is likely that there are negative impacts when portraying differences between fat and thin people in media (Harrison, 2000; Greenberg et. al, 2003). The first is that such images will accumulate over time and eventually may lead to true negative expectations in society. The second is that some evidence supports the argument that by watching television people can pass to discriminate obese people from their stereotypes (Harrison, 2000). As an example of concern for the present and future, in a study of elementary school children, Harrison (2000) showed that children, who watched more television programs, were more likely to attribute negative stereotypes to an overweight woman.

Greenberg et.al (2003) conducted a detailed analysis of one thousand and eighteen characters of the main commercial and popular television programs of six major North American television networks. The objective was to analyze the representation of overweight and fat people on primetime television. The results revealed that fat women were less likely to be attractive, interact with

romantic partners and show physical affection. The male obese characters were less likely to interact as romantic partners, talk about dating, being involved with behaviorally oriented tasks (example, interactions of leadership) and were often seen eating and being used as an 'humor object'.

METHODOLOGICAL ISSUES

We adopted a qualitative perspective driven by interpretive guidance (Denzin, 1978; Godoy, 1995) in search to achieve the paper objective. The research was conducted in two stages: the first one, we selected and analyzed fifty commercial, available on the internet that has be aired in open TV in Brazil on between 1992 to 2012, in which the protagonist was a actor. It was found in the selection of the ads that each one presented similarities in their structures. This way, it, was decided to work with twenty commercials that portrayed different situations, in an effort to have more diversity of situations and possible different roles played by the fat persons. In the second stage, of the research, we proceeded with a focus group formed by eleven participants that considered themselves as thin persons (Morgan, 1997; Queiroz, 1991).

Regarding the categories analyzed we defined preliminarily three relevantones. Thus, based on the literature, followed by some adaptation to the context studied, the following categories were established: the role played in advertising (Harrison, 2000; Greenberg et. al, 2003), stereotypes created by the obese figure (Weiss, 1980; Dickey-Bryant et al. 1986; McAdams et al.,1992 Apud et al., 1998; Puhl and Brownell, 2003; Felippe, et al., 2004), obesity image and stigma (Staffieri 1967; Lerner and Gellert, 1969; Weiss, 1980; Crandall, 1994; Roehling, 1999), all described in accordance with the vision of the participants. Finally, analysis of the content of the videos and data collected in the focus group, were performed.

ANALYSIS AND RESULTS

Regarding the profile of the subjects (focus group participants), majority has a undergraduate degree; four are female and seven are males; age are between twenty and fifty- five years old; all work in the commercial area of private sector companies; monthly household income on average of two thousand dollars; and they were classified as thin, based on weight and height patterns (parameters of the health ministry Brazil, 2013).

The initial analysis showed that almost all the protagonists of advertising messages selected were male. In just two commercials (Renault Logan – car and *Matte Leão* – a Tea brand) the character was a fat woman, but they were not playing the main role. This leads to a conclusion, considering what Brown and Bentley-Condit (1997 Apud et al.,, 2007) point. They claim that in the dictatorship of thinness, women are more affected than men, and more socially critized for being out of shape. Because of that, we suppose that to avoid criticism and possible negative outcomes, companies exclude working with obese women in commercial. This way, predominately obese males were

portraited in the analyzed TV ads, playing the role of the sloppy, goofy person, fulfilling expectations of what to expect of a fat person: to be loud and funny.

The role played by obese people in ads

A lot of laughs and giggles! It was the manner in which the focus group participants behaved during the presentation of advertising messages. But after the observation of the commercials, some comments were coming out and unanimously, subjects indicated that fat people were being 'used' to cause laughs, acting like clowns. Through the comment of a participant, the group started to agree that the protagonists were actually in disadvantaged situations. One of the focus group, participant stated:

"In none of these commercials I've seen some of these actors starring a good, positive scene..." [P7]. Another one commented: "The obese character is always associated to ridicule or compared to a bad product..." [P7] (The letter "P" represents the participants of the focus group and the number is each individual).

Comments from participants on the focus group indicate that despite the fact of the 'funny' factor predominate in commercials. Other negative aspects in which the obese protagonists are submitted are not perceived at first sight. For example, during the discussions, a participant said:

 "... when I saw the first TV ad I did not attempt to see the role that the fat actor exerted, but after the second ad, I began to realize that although they are funny, they experience many difficult and awkward situations" [P7]. The weird – or strange - image of obese people is noted in the Greenpeace's ad. As seen in the descriptions, a Michael Jackson's song start to play, and then a fat man appears, dancing and wearing a plastic jacket, accompanied by two other lean men. After that, the message: "Strange? Strange is who wears linen clothes, but has plastic attitude. Don't think disposable, act sustainable". The ad shows that the stranger is not only related to the clothing bag, but also on who is wearing it. In this case, if it was a thin man with perfect body would the ad create the same feeling of strangeness? Something to think about when considering that fat people are viewed as disgusting, are censored and perceived as strangers.

The observed features are common in the roles played by fat people in advertising and are aligned with the findings of Weiss (1980). Moreover, it is observed that the roles were predominant the cheerful and outgoing perpective, but this is achieved due to the way the obese

persons are considered clumsy, insecure and unhealthy (for example, see Bellizi and Hasty, 1998). Thus, some stereotypes are created and the social existent prejudice is reinforced by the media discourse.

Stereotypes created by the image of an obese character

It was observed that the stereotypes that lead to stigmas are often reinforced by the media, in this case, by the advertising messages. Stereotypes like funny lead to laughter, but at the same time it may generate negative evaluations by the audience, like it has happened to the focus group participants. According to the an overall analysis of the participant comments:

"...It's funny the role they play, but the problem is that whenever they are in a difficult situation, I tended to see them acting like fools and clumsy...thinking better... I'm not sure if this is cool" [P11]. Another participant highlights: "...now on second thought, I do not understand why they accept to make fun of themselves ...I think there are several ways to portrait humor and I don't think I need to associate the obese person to being ridiculous in a attempt to call public attention ..." [P11]. "...I agree! The companies should avoid this kind of association of the image of fat people, considering that they suffer prejudice everywhere in their social lives" [P7].

At the first moments, the participants were not critical with regard to the roles played by fat people on advertisements. However, during the focus group, the subjects began to analyze the different presented situations and, while agreeing that humor was the central to all the TV ads, item because of the characters characteristics (stereotypes), the participants began to see the complexity of these associations. The image that stood out from the ads was funny people doing acting in a ridiculous way. The companies sold a negative image of obese people. "...Some commercial sells a negative image of obese persons and this is considered funny by those who see them ...I think it's funny ...everyone does ...but it seems that what stay in mind is that every fat person it's like that, even in real life..." [P2]. This reinforces prejudice and bullying. Companies should be more responsible and try to avoid perpetuating pain in a group of consumers that are usually forgotten in their marketing actions in a respectful and responsible way.

Image and stigma

What image do the focus group participants have from obese protagonists after watching the ads? The
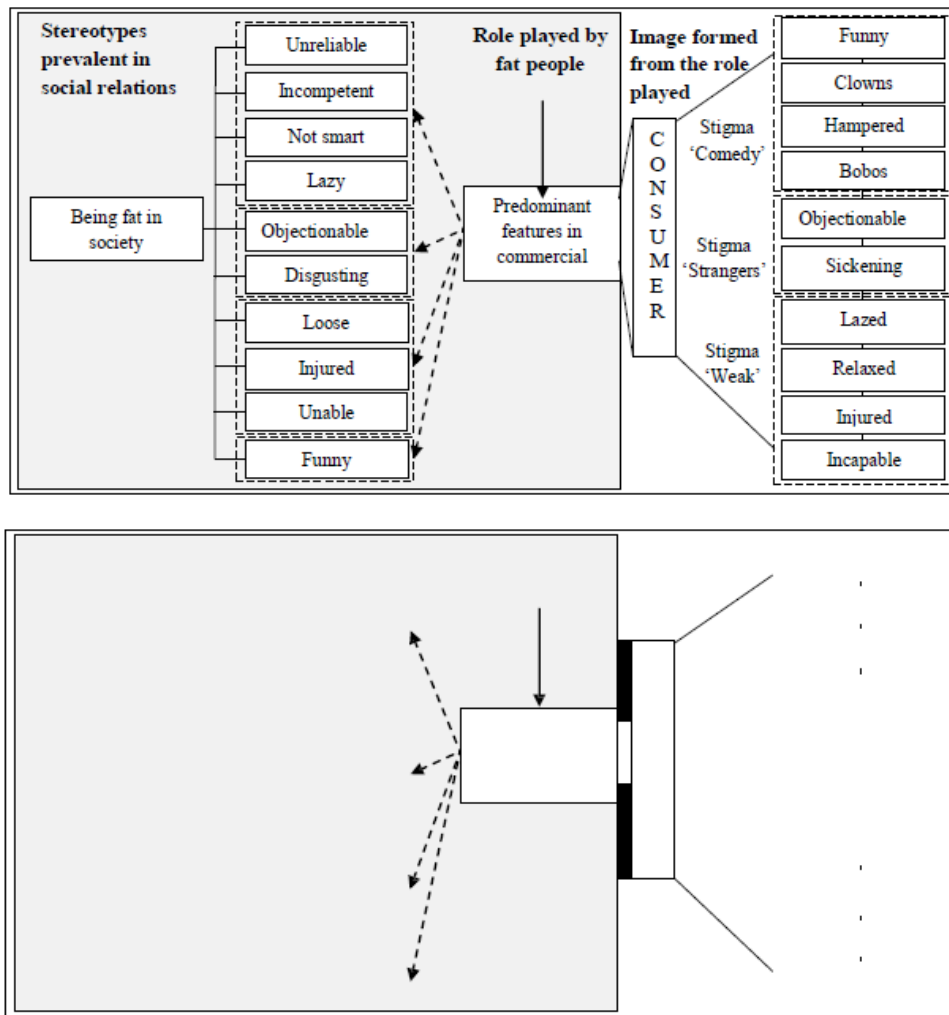
Figure 1. Being fat, society, their roles in commercial and consumer image

participants' responses were:

"Fat people are funny and silly, are unable to properly develop a task and liars, they are ugly, horrible, strange, but funny, the only way of drawing audience attention is by laughter, because there is no beauty at all, they have to be goofy to sell the company's products. Fat ones are used by the thin ones mockery because they are fools, and they don't fit in the beauty standards". There were also comments like:

"The fat person is fat because he/she wants to" [P4]. Crandall (1994) states that there is still a widespread perception that obese individuals are responsible for their own condition. This is because the gain or loss of weight is under personal control, creating the idea that the obese ones don't have self control, self discipline and are totally lazy (Staffieri 1967; Lerner and Gellert, 1969; Weiss and Caprio, 2005). This tends to reinforce the

belief that the cause of obesity is the result of uncontrolled impulses and behaviors (Roehling, 1999). This is a social prejudice reinforced by the ads here analyzed, that do not take into account the complexity of the obesity phenomena.

Social representation of fat people on Ads in the perspective of lean consumers

To better understand the social representation of obese people in the perceptions of lean consumers (focus group participants), we designed a map of this representation as shown in Figure 1. It separates in a quadrant the prevalent stereotypes the social relations related to being fat and their exercised roles in advertising. The stereotypes were extracted from the literature review, which are grouped in the lower quadrant in gray color (as the main characteristics predominate in

commercials analyzed).

In the first group of variables inserted in the Figure, the inserted characteristics of fatty predominant in all ads, are all related to mood, such as: Funny, clowns, clumsy and silly. In the literature review the stereotype of funny rarely appears on the findings of several studies (example Elias, et al., 2003). But in this study, funny was the most prevalent due to the exaltation of this feature in ads as a way to attract audience attention (use of humor on communication that can be socially dangerous if not properly used). The most associated stigma, related to obese roles, it was the 'comical' one. In the second group of variables the stereotypes were reprehensible and disgusting, also related to the idea that when a fat person is interested on something he/she supposedly will not get due to his/hers condition (to be fat is to be handicapped). Stigma related to the role of obese linked to these characteristics was called 'strange'.

Moreover, in the third group of variables according to the analysis results, it was found that in participants view, characteristics as lazy, sloppy, damaged, weak and unable. Based on these data, Figure 1 was structured.

CONCLUSIONS

Based on the analysis of advertisements and reports participants in this research, it was found that the roles played by fat people in Brazilian TV ads are linked directly to a comedy act. The association of stereotypes of being fat already present in social relations it is stressed in the ads, and the prejudice due to the way in which they exercised their roles and their physical appearance, it is seen as a way to reinforce the stigmas associate to obesity in our society. This way, based on focus group results participants see the ad as a form to continue to perpetuate prejudice. Obese people exert roles as ads protagonists in which ways that their image is used to attract consumer attention by ridicule (through stereotyped characters), which tends, on account of this condition, be interpreted as comical, and sometimes, as politically incorrect. It was found in our study that stigmas such as 'comical', 'weird' and 'weak' are formed from the stereotypes related to obesity and roles developed in the material analyzed (TV ads).

For participants of our research, the TV advertises had some reports of negative interpretation, even after some of them who have initially found the commercials funny. From the time that they come to realize what it is really behind the "funny" part of the ads, it is possible to see the prejudice discourses the communication brings about obesity. At the end, negative associations are made to the company and its products presented in the ads. When communications are established and interpreted through mechanisms that instigate discrimination and prejudice, its essence can negatively influence the evaluation of the company and the product by consumers. While the discussions about the perfect body can generate social problems by its inherent stigma, it is also believed that not everything that is produced by marketers is of extreme interest to consumers and society. Marketing campaigns tend to exalt deliberately physical patterns such as the 'ideal' (skinny), placing about 'not ideal' (obese), the mask of ridiculous, not acceptable in society nowadays. The question that remains is how far these interpretations may affect the brand image conveyed, considering that the obesity phenomenon is present in everyday life of most consumers.

This study searched to contribute to the dissemination of transformative consumer research in the Brazilian context, because to investigate a group of consumers neglected or treated prejudiced in marketing communications; provoking a discussion that is not always what's funny, like humor, this devoid of prejudice veiled, causing pain and grief psychological specific groups of consumers. Same it investigated only Brazilian ads, we believe that the obesity phenomena and how fat people are presented in ads, reinforcing stigmas associated to their condition, it is a global problem that every society is trying to cope and searching for solutions to solve it.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Abeso (2012). "Associação Brasileira para o Estudo da Obesidade". History, Available at: http://www.abeso.org.br/pagina/296/historico.shtml

Bellizzi JA, Hasty RW (1998). "Territory assignment decisions and supervising unethical selling behavior: The effects of obesity and gender as moderated by job-related factors". J. Pers. Selling Sales Manage. 18(2):35-49. http://www.tandfonline.com/doi/abs/10.1080/08853134.1998.10754129#.U3x029JdVQ0

Brown PJ, Bentley-Condit VK (1997). "Culture, evolution and obesity". In: Bray G. A., Bouchard C., James W. P. T. (orgs.), Handbook of obesity. New York: Marcel Dekker pp.143-155.

Crandall CS (1994). "Prejudice against fat people: Ideology and self-interest". J. Pers. Soc. Psychol. 66(5):882-882. http://dx.doi.org/10.1037/0022-3514.66.5.882

Denzin NK (1978). "The research act: a theoretical introduction to sociological methods". 2., New York, McGraw-Hill Book Company.

Dickey-Bryant L, Lautenschlager GJ, Mendoza JL, Abrahams N (1986). "Facial Attractiveness and Its Relation to Occupational Success". J. Appl. Psychol. 71(1):16-19. http://dx.doi.org/10.1037/0021-9010.71.1.16

Elias MF, Elias PK, Wolf PA, D'agostino RB (2003). "Lower cognitive function in the presence of obesity and hypertension: the Framingham heart study". Int. J. Obesity 27(2):260-280. http://dx.doi.org/10.1038/sj.ijo.802225

Felippe FML, Friedman R, Alves BS, Cibeira GH, Surita LE, Tesche C

(2004) "Obesidade e mídia: o lado sutil da informação". Revista Acadêmica do Grupo Comunicacional de São Bernardo 1(2):1-5.

Godoy AS (1995). "Introdução à pesquisa qualitativa e suas possibilidades". Revista de Administração de Empresas. 35(2):57-63.

Greenberg BS, Eastin M, Hofshire L, Lachlan K, Brownell KD (2003) "Portrayals of Overweight and Obese Individuals on Commercial Television". Am. J. Public Health 93(8):1342-1348.

Goffman E (1988)."Estigma". 4, São Paulo: LTC.

Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH (1993). "Social and economic consequences of overweight among adolescents and young adults". New England J. Med. 329(14):1008-1012.

Harrison K (2000). "Television viewing, fat stereotyping, body shape standards, and eating disordered symptomatology in grade school children". Commun. Res. 27(5):617-640. http://dx.doi.org/10.1177/009365000027005003

Hunte HER, Williams DR (2009). "The association between perceived discrimination and obesity in a population-based multiracial and multiethnic adult sample". American Journal of Public Health, United States, Washington 99(7):1285-1292. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2696650/

Klassen ML (1987). "The cognitive basis of social judgment: the role of stereotypical beliefs in the processing of information about obese and thin people". Doctoral dissertation, Departament of Psycology, Kansas State University.

Lerner RM, Gellert E (1969). Body build identification, preference, and aversion in children. Dev. Psychol. 1(5):456-462. http://dx.doi.org/10.1037/h0027966

McAdams T, Moussavi F, Klassen M (1992). "Employee appearance and the Americans with Disabilities Act: An emerging issue?" Employee Responsibilities Rights J. 5(4):323-338.

Morgan DL (1997). "Planning focus groups". Portland State University, 2, http://www.sagepub.com/books/Book6652

Puhl RM, Brownell KD (2003). "Psychosocial origins of obesity stigma: toward changing a powerful and pervasive bias". The International Association for the Study of Obesity. Obesity Rev. 4:213-227.

Puhl RM, Heuer CA (2010). "Obesity stigma: important considerations for public health". Am. J. Public Health 100(6):1019-1028. http://www.ncbi.nlm.nih.gov/pubmed/20075322

Queiroz MIP (1991). "Variações sobre a técnica do gravador no registro da informação viva". São Paulo: T. A. Queirós.

Roehling MV (1999). "Weight-based discrimination in employment: psychological and legal aspects". Pers. Psychol. 52(4):969-1017.

Santos AM, Scherer PT (2011). "Reflexões acerca das políticas públicas no enfrentamento a obesidade no Brasil". Sociedade em Debate 17(1):219-236. http://revistas.ucpel.tche.br/index.php/rsd/article/view/692

Sargent JD, Blanchflower DG (1994). "Obesity and stature in adolescence and earnings in young adulthood. Analysis of a British birth cohort". Arch. Pediat Adol. Med. 148(7):681-687.

Serra GMA, Santos EM (2003). "Saúde e mídia na construção da obesidade e do corpo perfeito". Ciência Saúde Coletiva 8(3):691-701.

Staffieri JR (1967). A study of social stereotype of body image in children. J. Pers. Soc. Psychol. 7(1):101-104.

Sudo N, Luz MT (2007). "O gordo em pauta: representações do ser gordo em revistas semanais". Ciência Saúde Coletiva 12 (4):1033-1040.

Weiss E (1980). Perceived self-infliction and evaluation of obese and handicapped persons. Percept. Motor Skills 50:1268.

Weiss R, Caprio S (2005). The metabolic consequences of childhood obesity. Best Practice & Research Clinica

Full Length Research Paper

Volatility behaviour of BRIC capital markets in the 2008 international financial crisis

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Brazil, Russia, India and China (BRIC) are pointed as the most probable countries to enter the select group of industrialised countries, also appearing among the world's twelve largest economies. The main objective of the present study is to assess whether the capital market behaviour of the BRIC's emerging countries in the 2008 international crisis had already been equivalent to that of industrialised countries (USA, Japan, United Kingdom, and Germany). Three univariate approaches were applied for modelling the market volatilities (GARCH, EGARCH and TARCH). The results showed similar behaviours between both market groups regarding the presence of persistent effects of shocks on volatility, volatility asymmetry, and delayed volatility reaction to market changes. The BRIC's markets showed less persistence to volatility shocks, less asymmetry, and faster reactions of volatility to market changes.

Key words: Volatility, BRIC, emerging markets, GARCH models, financial crisis.

INTRODUCTION

International financial crises are revealing. Within the context of a large-scale crisis, the behaviour of both emerging and industrialised markets is distinct. There are aspects clearly showing the maturity level of markets and economies of the affected countries.

Propagation of a crisis occurs through the naturally existing linkage among the countries' markets. This linkage occurs in various fronts, either by means of external trade, international private investments or even sovereign capital flows. Under normal conditions, transactions between countries occur around what one considers to be a balance platform, which is dynamic and consists of economic variables related to exchange parities, interest

rate levels, inflation, foreign currency reserves, production, consumption, income, among others. Under crisis conditions, however, value and parity references are lost, governments become protectionist, and capital flows occur for preserving and honouring positions only, curiously seeming to be more aligned as if there was a greater integration of the investors' behaviour around the world.

Under global balance conditions, it is notorious the difference in the financial market characteristics between emerging countries and those with mature and stable economies. When hit by a global financial crisis, however, the financial markets face some common effects such as increase in volatility, capital flight of variable income

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assets, rise in interest rates with increased risk, and reduction of investments in view of the uncertainties. Governments tend to take preventive measures in order to avoid economic recession symptoms while adopting limiting policies for inflationary movements and oscillations in the exchange relationship with the world's main currencies.

With regard to the capital markets, some aspects are widely known about such differences between emerging and industrialised economies, especially in the scientific milieu. Bekaert and Harvey (1997) have appropriately demonstrated that there are four aspects differentiating the behaviour of asset returns in the emerging capital markets compared to industrialised economies, namely: higher mean returns; low return correlation; higher predictability of the behaviour of returns from asset variations; and greater volatility.

This latter aspect, the greater volatility in the emerging capital markets, has important implications for two crucial factors in any economy: capital cost and option value of waiting to invest. Both effects jeopardise the economic development. The former burdens the ventures, making most of them unviable, whereas the latter delays invest-ment decisions.

Under the conditions imposed by an international financial crisis, the volatility of all markets tends to increase and, curiously, the behaviours of volatility and returns among the markets tend to show a greater similarity. In fact, the markets seem to exhibit higher levels of interdependence and contagious effects.

There are many studies exploring these phenomena. Among them, one can cite the study by Bekaert and Harvey (1997) investigating the reasons which make volatility different between emerging countries, the study by Alper et al. (2009) assessing the predictability of the market volatility behaviour in ten emerging countries by comparing them to industrialised economies in the context of the 2008 crisis, and the study by Chukwuogor and Feridun (2007) analysing the volatility behaviour of fifteen countries, both emerging and industrialised ones, during the crisis which affected Asia and Russia, including the Internet bubble.

Understanding the volatility behaviour of the capital markets is important because it is directly related to capital costs, investment decisions, and leverage levels from investors and companies. These three elements (that is; capital cost, investments, and leverage) have an impact on the development of any economy. Studies on the behaviour of volatility and returns of financial assets in emerging and industrialised markets have indicated the following findings: emerging markets are more volatile than industrialised ones; there are differences between the volatility behaviours of emerging markets, which decrease in the periods of international financial crisis; there is a low return correlation between the assets of emerging and industrialised markets; there is an

asymmetric relationship between returns and volatility at highs and lows, which is a phenomenon usually seen in emerging markets during international financial crises; the phenomenon of interdependence between emerging and industrialised markets is significantly increased during global financial crises; contagious effects between financial markets are more likely to occur from Indus-trialised countries towards the emerging ones.

Although several studies have corroborated these findings on capital markets elsewhere (mainly those published over the past 30 years, as econometric and statistical techniques had been improved and markets highly integrated by important technological advances), changes in the world's economic, financial, and political scenarios have been very significant.

By focusing on the BRIC countries, especially Brazil, the issues motivating the elaboration of the present study have been raised by the confrontation between the known capital market characteristics of emerging and industrialised countries, with the BRIC countries in the threshold of becoming developed. These issues are the following: a) If the emerging markets are more volatile than the industrialised ones, are the BRIC markets less volatile today, with volatility closer to that of industrialised countries? b) If there is an asymmetric relationship bet-ween returns and volatility at highs and lows, which is noticeable in emerging markets during international financial crises, did this phenomenon occur in the last global crisis in 2008 at levels different from those seen in industrialised markets?

Therefore, the objective of the present study was to assess whether the capital market behaviour of four emerging countries (BRIC) had already been equivalent to that of industrialised economies during the last global financial crisis (US sub-prime crisis in 2008).

Technically, this work can bring contributions and innovations to the field based on the following points: a) this is a current study, as the phenomena being analysed refer to the period comprising the last great international financial crisis in 2008; b) this is the first study focusing on the issue whether BRIC countries could be considered already developed in terms of capital market behaviour; and c) this is a timely study, as BRIC countries have recently entered the select group of G-20 not only because of their GNP but also because the finance ministers and central bank chairmen of the major hit countries announced, on the 25th September 2009, that the G-20 would be the new Permanent Council for International Economic Co-operation, replacing that formed by the G-8 representatives.

LITERATURE REVIEW

Asymmetry of returns and volatilities

The studies investigating the asymmetry in the behaviour

of returns and volatilities in the stock markets of many countries have shown that it appears in three forms: a) as an effect of the price variation on volatility; b) as a reversion phenomenon depending on the prices of assets; and c) as a variation of return correlation of different assets or market indexes. These three aspects of the asymmetry are especially detected in periods of domestic or global financial crisis.

The first manifestation of asymmetry is the most robust and studied of the three forms. Volatility increases more after negative shocks on the market (that is; when prices and returns fall) than after positive shocks of the same intensity.

Studies on the stock market of several countries have shown that when a negative impact (bad news, crises) hits the assets of a given market, the returns fall and volatility increases. On the other hand, when positive impacts (good news, optimism) occur, returns tend to rise and volatility tends to decrease. However, for an impact of same intensity (positive or negative), the negative effects are greater for both returns and volatility. That is, with the market falling, returns fall more rapidly and volatility increases more than when the market is at high. In addition, several studies showed that the correlation between stock markets of different countries also has an asymmetrical behaviour. In periods of falling prices (ex: financial stress, crises), the correlation between markets seems to be higher than that in periods of rising prices. Since the seminal publications by Black (1976) and Christie (1982), other studies on the negative asymmetric relationship between returns and volatilities have been conducted over the past decades, such as Schwert (1989); Campbell and Hentschell (1992); Glosten et al. (1993); Shields (1997); Bekaert and Wu (2000); Chiang and Doong (2001), Daouk (2001); Venetis and Peel (2005); Shamsuddin (2008), Badhani (2009) and Chang (2009). However, as stated by Daouk (2001; p.2), "volatility is still a puzzle".

Daouk (2001) has pointed to the existence of four arguments, or models, which try to explain the asymmetry between returns and volatility. The first argument is based on studies by Black (1976) and Christie (1982). Black hypothesised that financial leverage for companies might explain, at least partially, such a relationship. For the same author, when a company becomes more leveraged, the value of its net worth tends to fall, and vice-versa.

Schwert (1989) and Glosten et al. (1993) have addressed the second explanation for the phenomenon of asymmetry. According to them, the stock return volatility of a company would be probably related to the expected future cash flow volatility. If there is an increased expectancy among investors regarding the cash flow to be generated, the value of the company tends to fall and consequently perceived risk and volatility tend to be high.

The third argument is associated with the risk premium.

The hypothesis is that an increase in the volatility of unexpected returns will also provoke increase in the future expected volatility, meaning a higher perceived risk and demands for higher premiums. This idea is also called volatility feedback. The studies conducted by Pindyck (1984) and French et al. (1987) were pioneers in investigating such an argument. If this argument is valid, then the variation in the volatility of future expected returns is the factor promoting changes in stock prices, reducing them as a way of compensating for the high risks assumed. The idea of feedback volatility intrinsically depends on the existence of a great volume of information available to a high number of investors, a *sine qua non* condition for the assessment of future volatility and significant price movement.

The fourth argument explaining the asymmetry is associated with the investors' position during the periods of financial crises. When such a crisis occurs, asset prices fall heavily and quickly. In this new pessimistic context, investors change their behaviour as they negotiate under stressful conditions, thus increasing the market volatility. This idea has been more explored in the recent years by researchers elsewhere.

Verma and Verma (2005) have also identified four possible origins for asymmetries between behaviours of returns and volatilities in the international markets. The first one would be related to differences in expected returns between the investors in view of potential impacts or changes in the international stock markets. If, for example, a small decrease occurs in the US stock market – which is an international reference, the other markets may be even more affected, mainly the emerging economies, by the fear or "disappointment" among the investors. Through this reasoning, the psychological effect on investors resulting from the changes in American market is more important for the asymmetry magnitude than the intensity of the change itself. Odier and Solnik (1993) and Erb et al. (1994) are among the first authors studying such a phenomenon.

The second possible origin of these asymmetries would be the use of investment strategies based on incomplete, irrelevant and/or distorted information. Foreign investors, in the absence of full specific information about a given market, could be led to assume biased positions as a result of the effect of irrational and/or subjective decisions. A typical example of such behaviour occurs with emerging markets. In fact, many foreign investors tend to see emerging markets indistinctly if they are unable to obtain full specific information about a given market and its assets, mainly in financial stressful conditions. Studies by Harvey (1995) and Aitken (1996) have explored this issue.

The third possible origin of asymmetries between returns and volatilities would involve the existence of an unidentified risk component embedded in the prices of international stock markets. Because the relationship

between any risk component and stock returns are not linear, a priced unidentified risk component can result in volatility imbalance in markets experiencing highs and lows. Studies by Pettengil et al. (1995) and Fletcher (2000) were pioneers in investigating this behavioural feature between risk and returns in stock markets.

With regard to both latter arguments on asymmetry origin, the one based on mistaken strategies due to lack of precise information and the one based on the existence of an unidentified risk component, there is a very interesting joint explanation or variant investigated by several researchers. According to Grossman (1988), Gennotte and Leland (1990), Jacklin et al. (1992), Romer (1993), Berry and Howe (1994), and Johnson and Westberg (2004), among others, the majority of investors are neither well informed nor sufficiently so. This fact creates conditions to change the opinions on the fair value of each asset as new information is taken into account by each investor. When the market is hit by some type of impact, either positive or negative, it is natural to expect investors to re-evaluate their positions, with part of them probably making negotiations to adjust their investment portfolios. As the business volume grows, information which had not been regarded or propagated is then perceived and incorporated into the prices. This process can provoke rapid and acute changes in prices, which particularly occur in situations of crisis with generalised decrease in negotiated assets. Here, is a probable origin for the asymmetry between returns and volatilities.

The fourth and last possible explanation for such asymmetries, according to Verma and Verma (2005), is related to the manifestation of investors, which is psychologically based. In general, they react more to falls than to rises in the market prices. Even though the average investor has more difficulty in booking the loss, but being in a rush to make gains, both pessimism and panic diffuse much faster than optimism. In fact, markets fall much faster than rise. The irrational behaviour caused by fear and aversion to risk is different from the self-conflicting behaviour seen during those periods when markets are at high, even considering the irrationalities generated by greed. Asymmetry would come from this behavioural imbalance. Studies by Hong and Stein (1999) and Gervais and Odean (2001) are important references on this issue.

In sum, some interesting considerations can be high-lighted regarding studies on the phenomenon of asymmetry of returns and volatilities. They are the following: a) the phenomenon of asymmetry is particularly detected in periods of domestic or international financial crisis; b) The literature points out at least eight arguments to explain the occurrence of asymmetry, which is based on technical aspects such as company leverage as well as behavioural financial issues; c) the volatility increases more after negative (that is; when prices and returns fall)

Table 1. Countries and equity index analyzed.

Developed		Emerging	
Country	**Index**	**Country**	**Index**
USA	S&P 500	Brazil	Ibovespa
Japan	Nikkei 225	Russia	RTSI
UK	FTSE 100	India	BSE Sensex
Germany	DAX 30	China	SSE 180

than positive shocks of the same intensity; d) the emerging markets are more volatile than the industrialised ones; e) The investors react faster and more intensively to negative than positive impacts; f) Unexpected news can affect prices in short and very short term, whereas bad news have a greater impact on prices during negative than positive phases; g) price reaction to the news tends to last more during positive (prices tending to rise) than negative (prices tending to fall) phases; h) volatility of returns tends to increase during negative phases.

METHODOLOGY

Data source and treatment

Data used in the present study are the historical series of market stock indexes of eight countries (Table 1). The series are formed by daily closing prices covering a 5-year period from 2006 to 2010, totalising 1,301 observations for each one of the eight indexes. This period of time involves the global financial crisis occurring in 2008, including two years before and two years after. Data are secondary, being generated and organised by stock markets and divulged by several information agents elsewhere, such as Bloomberg, Econo-mática, Reuters, Yahoo Finance, among others.

Countries whose markets were analysed are divided into two groups: one formed by major industrialised economies (USA, Japan, United Kingdom. and Germany) and other formed by the main emerging economies (Brazil, Russia, India and China), which comprise the so-called BRIC block.

The historical series of stock market indexes were converted into historical series of logarithmic returns.

Data analysis

Analysis of the behaviour of returns and their volatilities, which had been obtained from the stock market indexes selected for the present study, was performed based on the ARIMA (p,d,q) and GARCH (p,q) model families. The former was used for returns and the latter for volatilities. The first procedures regarding the data involved statistical descriptive analysis of the series and characteristics of their distributions, stationary and non-stationary behaviours, and linearity.

With regard to the series of financial returns, the random com-ponent (also called prediction error term, residue, or innovation) of ARIMA model (p,d,q,) adjusted for each series is expected to have mean zero, with no correlation between a given observation and past observations. Although error terms are no correlated, they are not independent either. This fact enables a GARCH model (p, q) to reproduce its generating mechanism.

After obtaining the series characteristics, the next step was to estimate the ARIMA models (p,q,d) by using auto-correlation

Table 2. Coefficients of GARCH models - developed markets.

	USA			JAPAN		
	GARCH	TARCH	EGARCH	GARCH	TARCH	EGARCH
ω	5.88E-07	7.41E-07	-0.270134	8.59E-07	2.63E-06	-0.289884
α_1	0.033125	-0.057898	-0.181363	0.025197	-0.121540	-0.161171
α_2	-	-	0.313424	-	0.103715	0.274685
β_1	1.694814	0.978210	0.980710	2.725544	0.926032	0.976826
β_2	-0.730440	-		-3.098475	-	-
β_3	-	-		1.696287	-	-
β_4	-	-		-0.351185	-	-
γ_1	-	0.142697	-0.156847	-	0.146786	-0.137565
γ_2	-	-	-	-	-	-
D	Normal	Normal	GED	Normal	t-Student	t-Student
AIC	-6.146348	-6.187862	-6.256279	-5.672106	-5.722504	-5.721695
BIC	-6.118230	-6.159743	-6.220126	-5.623690	-5.682158	-5.681349

	United Kingdom			Germany		
	GARCH	TARCH	EGARCH	GARCH	TARCH	EGARCH
ω	1.86E-06	2.16E-06	-0.272624	2.00E-06	5.41E-06	-0.340112
α_1	0.113546	-0.099971	0.117803	0.065925	-0.138326	-0.113879
α_2	-	0.098989	-	-	0.052720	0.258647
α_3	-	-	-	-	0.075542	-
β_1	0.881146	1.229677	0.979681	1.414678	0.860736	0.973687
β_2	-	-0.318134	-	-0.489594		-
β_3	-	-	-	-		-
β_4	-	-	-	-	-	-
γ_1	-	0.156581	-0.150371	-	0.228623	-0.134602
α_1	-	-	-	-	-	-
D	Normal	Normal	GED	Normal	t-Student	Normal
AIC	-6.103503	-6.157187	-5.896091	-6.152409	-5.984069	-5.948956
BIC	-6.055660	-6.097384	-5.859916	-6.100611	-5.931816	-5.904742

function (ACF) and partial auto-correlation function (PACF) of each series. These functions offer an indication of the number of lags p and q of the models by assessing the occurrence of serial auto-correlation.

After estimating the ARIMA models (p,d,q), ACF and PACF were obtained for the resulting series of quadratic residues. One procedure needed for this step is to perform a test in order to detect the presence of heteroscedasticity in the series of residues. Ljung-Box-Pierce test and Q-test were used for doing so. ACF and PACF, which were applied to quadratic residues, provide an indication of the number of lags p and q in the GARCH model (p,q) suitable for estimating the volatility.

However, the estimation of parameters for ARIMA (moving average) and GARCH (conditional variance) models frequently face convergence problems. ACF and PACF are tools capable of mini-mising such a problem by detecting a simpler and consistent model for description of serial data. For financial assets, these functions usually reveal that on return series data are not correlated while quadratic errors present correlation, that is, the series variance can be shaped by a GARCH process.

The estimated ARIMA and GARCH models have been validated by analysing the residue series with Ljung-Box-Pierce test and Q-test. These tests show whether the residues in the modelled series follow an i.i.d.(identically and independently distributed) process, whether distribution respects a normal (Gaussian) distribution, and whether they exhibit any serial correlation or any volatility conglo-merate. If such conditions are met, then it means that the model is consistent.

RESULTS AND DISCUSSION

Tables 2 and 3 show the GARCH model coefficients esti-mated for industrialised and BRIC markets, respectively.

Table 3. Coefficients of GARCH models - bric markets.

	BRAZIL			RUSSIA		
	GARCH	TARCH	EGARCH	GARCH	TARCH	EGARCH
ω	6.48E-06	9.78E-06	-0.420672	3.74E-06	7.04E-06	-0.246332
α_1	0.085905	-0.047034	0.152288	0.051521	0.055211	0.180939
α_2	-	0.061803	-	-	-	-
β_1	0.898373	0.879836	0.962398	1.970208	0.882069	0.985494
β_2	-	-	-	-1.553377	-	-
β_3	-	-	-	0.525955	-	-
β_4	-	-	-	-	-	-
γ_1	-	0.160715	-0.146592	-	0.109790	-0.086983
γ_2	-	-	-	-	-	-
D	t-Student	GED	GED	GED	t-Student	t-Student
AIC	-5.319275	-5.364676	-5.362411	-5.087882	-5.089375	-5.086742
BIC	-5.295413	-5.332860	-5.334572	-5.047964	-5.053448	-5.050815

	INDIA			CHINA		
	GARCH	TARCH	EGARCH	GARCH	TARCH	EGARCH
ω	4.08E-06	3.73E-06	-0.444837	4.29E-06	4.15E-07	-0.177477
α_1	0.119715	0.043136	0.231936	0.055966	0.009822	0.123484
α_2	-	-	-	-		-
β_1	0.875978	1.303795	0.966584	0.936439	1.734650	0.988229
β_2		-0.395896	-	-	-0.742872	-
β_3	-	-	-	-	-	-
β_4	-	-	-	-	-	-
γ_1	-	0.093220	-0.136250	-	0.109256	-0.117426
γ_2	-	-	-	-	-0.113460	0.110712
D	GED	Normal	GED	Normal	Normal	t-Student
AIC	-5.520192	-5.456404	-5.539118	-5.009255	-5.024040	-5.046412
BIC	-5.488157	-5.420365	-5.503079	-4.989221	-4.991985	-5.066434

The coefficients are relative to the three models presented as follows.

GARCH

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \beta_2 \sigma_{t-2}^2 + \beta_3 \sigma_{t-3}^2 + \beta_4 \sigma_{t-4}^2$$

TARCH

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \beta_1 \sigma_{t-1}^2 + \beta_2 \sigma_{t-2}^2 + \beta_3 \sigma_{t-3}^2 + \gamma_1 d_{t-1} \varepsilon_{t-1}^2 + \gamma_2 d_{t-2} \varepsilon_{t-2}^2$$

EGARCH

$$\ln(\sigma_t^2) = \omega + \alpha_1 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \alpha_2 \left| \frac{\varepsilon_{t-2}}{\sigma_{t-2}} \right| + \beta_1 \ln(\sigma_{t-1}^2) + \gamma_1 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \gamma_2 \frac{\varepsilon_{t-2}}{\sigma_{t-2}}$$

The first important aspect in the coefficient analysis is that all of them (all models for all markets) have resulted in statistically significant values of 5% (set as reference).

In the GARCH and TARCH models, all values for constant ω resulted in numbers very close to zero (10^{-5} order) as well as in negative numbers for EGARCH models

Table 4. β coefficients of GARCH models.

Coeficientes β			
Market	**GARCH**	**TARCH**	**EGARCH**
USA	0.964374	0.978210	0.980710
JAP	0.972171	0.926032	0.976826
UK	0.881146	0.911543	0.979681
GER	0.925084	0.933951	0.964189
BRA	0.899870	0.879993	0.979275
RUS	0.890281	0.882069	0.985494
IND	0.875978	0.907899	0.966584
CHI	0.936439	0.991778	0.988229

Table 5. α coefficients of GARCH models.

Coeficientes α			
Market	**GARCH**	**TARCH**	**EGARCH**
USA	0.033125	-0.057898	0.132061
JAP	0.025197	-0.017825	0.113514
UK	0.113546	-0.000982	0.117803
GER	0.065925	-0.010064	0.144768
BRA	0.085905	0.014769	0.152288
RUS	0.051521	0.055211	0.180939
IND	0.119715	0.043136	0.231936
CHI	0.055966	0.009822	0.123484

Table 6. Sum of α and β coefficients of the GARCH models.

Sum $\alpha + \beta$			
Market	$\sum_{i=1}^{q} \alpha_i + \sum_{i=1}^{p} \beta_i$	**Market**	$\sum_{i=1}^{q} \alpha_i + \sum_{i=1}^{p} \beta_i$
USA	0.997499	BRA	0.984278
JAP	0.997368	RUS	0.994307
UK	0.994692	IND	0.995693
GER	0.991009	CHI	0.992405

Table 7. γ coefficients of GARCH models.

Market	**γ Coefficients**	
	TARCH	**EGARCH**
USA	0.142697	-0.156847
JAP	0.146786	-0.137565
UK	0.156581	-0.150371
GER	0.228623	-0.134602
BRA	0.160715	-0.146592
RUS	0.109790	-0.086983
IND	0.093220	-0.136250
CHI	-0.004204	-0.006714

(which was already expected as the model uses variance logs).

The values of lag coefficients β indicate that shocks on conditional variance are persistent, that is, they cause an effect which takes a long time to dissipate. It is common that financial series with daily periodicity have persistence coefficients above 0.8. The results showed that coefficients β seem to meet this expectancy in all models for all markets, resulting in values greater than 0.8. Table 4 shows this in particular.

The values of coefficients α (from error term) show the intensity of reaction of volatility to market movements. If the coefficient is high, it means that reactions are intense. Markets with high coefficients α and low coefficients β are those in which volatility changes rapidly and intensively, but with effects dissipating rapidly. On the other hand, markets with low coefficients α and high coefficients β are those in which volatility reacts less intensively, but with effects lasting longer. It is common that financial series with daily periodicity have coefficients α below 0.2. In fact, all values of coefficients α met this expectancy, as shown in Table 5.

In GARCH models, the sum of coefficients α and β should be smaller than the unit if the return processes are stationary. The GARCH models estimated for all markets meet this condition. However, as shown in Table 6, the sum of coefficients α and β for seven of the eight markets is around 0.99. The exception was the Brazilian market (0.984278). This close proximity to unit may indicate that market volatility predictions do not follow the reversion patterns at the long-term average level of volatility. This result suggests that an integrated GARCH model can be tested to better shape the series or that asymmetric GARCH models should be used, which was the option adopted here.

The coefficients γ of TARCH and EGARCH models detect the effect of asymmetry on market volatility clusters. Such an asymmetry occurs because, in general, volatility increases more when asset prices fall as compared to when they rise. The conventional GARCH models (symmetric) are not able to differentiate unexpected returns between positive and negative, thus justifying the use of asymmetric GARCH models (TARCH and EGARH) in the present study.

All values of coefficients γ of TARCH models were found to be positive and significantly different from zero (Table 7), except for the Chinese market. This indicates the presence of volatility asymmetry in seven of the eight markets. In addition, all values of coefficients γ of

Table 8. α, β e γ coefficients.

Coefficient	model	Developed markets		BRIC markets	
		Average	Standard deviation	Average	Standard deviation
α	GARCH	0.059448	0.040144	0.078277	0.031565
	TARCH	-0.021690	0.025099	0.030735	0.021948
	EGARCH	0.127037	0.014233	0.172162	0.046240
β	GARCH	0.935694	0.041798	0.900642	0.025805
	TARCH	0.937434	0.028724	0.915435	0.052455
	EGARCH	0.975352	0.007621	0.979896	0.009633
γ	TARCH	0.168672	0.040390	0.089880	0.068985
	EGARCH	-0.144850	0.010528	-0.094130	0.063820

EGARCH models were negative and significantly different from zero, indicating that negative shocks on market volatility have a more acute effect compared to that of positive ones. Again, the Chinese market exhibited a value of coefficient γ very close to zero despite being statistically significant.

When observed as a whole (Table 8), the values of coefficients α, β and γ, obtained as simple means for the groups of industrialised and BRIC markets, reveal some interesting aspects. Coefficient α (error term), which shows the intensity of reaction of volatility to market movements, tends to be small in the group of Industrialised markets although such values were found to be small in both groups. In addition, this coefficient is negative for all industrialised markets when their volatilities are modelled by TARCH. By using the same model, coefficients α for all BRIC markets were found to be positive. This result suggests that volatility in Industrialised markets is contrarily affected (positive/negative) compared to variance innovations occurring in immediate past periods, whereas for BRIC markets such an effect is of the same magnitude.

Even though lag coefficients β, which indicate persistent shocks on conditional variance, are high in all markets, GARCH and TARCH models had higher values for industrialised markets than for BRIC emerging ones. This result shows that impacts on industrialised markets took longer to dissipate.

Seven of the eight markets analysed, except China, have clearly presented the effect of volatility asymmetry in which negative shocks on market volatility had a more intense effect than that of positive shocks. Nevertheless, the values of coefficient γ of TARCH and EGARCH models are higher (in module) for industrialised markets, thus revealing a greater effect of asymmetry on their volatility behaviour. Interestingly, the values of coefficient

γ for the Brazilian market (0.16 and -0.14) were shown to be similar, on average, to those for industrialised markets, suggesting a behaviour closer to that of the latter, at least regarding this aspect.

Conclusion

A new pattern of behavior of capital markets of the BRIC countries, closer to that have the most developed economies in the world, can mean significant changes in destinations of foreign capital flows, in the attitude of international investors, the cost of capital for these countries and their businesses, leverage levels prevailing in these economies, the composition of investment portfolios in investment volumes, finally, in crucial respects to the consolidation of a new map of the distribution of wealth, economic stability profile, and vectors of development, growth and technological advancement in the world. To show the behavior of capital markets of the BRIC countries is already similar, or closer, the behavior of developed markets, this study examined the period surrounding the international financial crisis of 2008, two important aspects: it is during crises the differences and similarities between emerging and developed markets, are lighter, and because the crisis is recent (some experts even believe that she has finished) and coincided with the historical event and innovative invitation to the BRIC countries to make up the select group called G20 and the new Council Permanent International Economic Cooperation (replacing the council formed by representatives of the G8), not only reached the level of GDP, but the importance of their economies.

The results showed that the BRIC markets, over that period, had higher volatility (higher levels of risk) that the developed markets. This finding is consistent with virtually all the studies that evaluated this aspect of the

emerging markets, especially the studies of Shin (2005), Singh et al. (2008) and Park (2010). The group of BRIC markets have also shown similar behaviours compared to those of the group of industrialised markets regarding presence of persistent effects of shocks on volatility, presence of volatility asymmetry, and slower reaction of volatility to market variations. However, there are visible differences in the intensity of each one of these phenomena. The BRIC markets showed less persistence to volatility shocks, less asymmetry, and faster volatility reactions to market variations. The general conclusion is that the capital markets of the BRIC countries still do not behave like those of developed markets.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Aitken B (1996). Have institutional investors destabilized emerging markets? Working Paper n. 96/34. Washington, DC: International Monetary Fund – IMF.

Alper CE, Fendoglu S, Saltoglu BM (2009). Volatility forecast performance under market stress: evidence from emerging and developed stock markets. Working Paper 04/2009. Turkey: Bogazici University, Department of Economics.

Badhani KN (2009). Response asymmetry in return and volatility spillover from the US to Indian stock market. IUP J. Appl. Financ. 15(9):22-45.

Bekaert G, Harvey CR (1997). Emerging equity market volatility. J. Financ. Econ. 43:29-77

Bekaert G, Wu G (2000). Asymmetric volatility and risk in equity markets. Rev. Financ. Stud. 13:1-42

Berry DB, Howe KM (1994). Public information arrival. J. Financ. 49(4):1331-1346.

Black F (1976). Studies of stock prices volatility changes. Proc. Bus. Econ. Stat. pp.177-181.

Campbell JY, Hentschel L (1992). No news is good news: an asymmetric model of changing volatility in stock returns. J. Financ. Econ. 31(3):281-318.

Chang CY (2009). The volatility's asymmetrical reaction to serial correlation: evidences from America e Taiwan cases. Int. Res. J. Financ. Econ. 28:98-103

Chiang TC, Doong SC (2001). Empirical analysis of stock returns and volatility: evidence from seven asian stock markets based on TAR-GARCH model. Rev. Quant. Financ. Account. 17:301-318.

Christie A (1982). The stochastic behaviour of common stock variance: value, leverage and interest rate effects. J. Financ. Econ. 10(4):407-432.

Chukwuogor C, Feridun M (2007). Recent emerging and developed European stock markets volatility of returns. Eur. J. Financ. Bank. Res. 1(1).

Daouk H (2001). Two essays on the response of volatility to returns. Indiana University 192p. http://books.google.com.ng/books/about/Two_Essays_on_the_Response_of_Volatility.html?id=jgIzOAAACAAJ&redir_esc=y

Erb CB, Harvey CR, Viskanta TE (1994). Forecasting international equity correlations. Financ. Anal. J. 50:32-45.

Fletcher J (2000). On the conditional relationship between beta and return in international stock returns. Int. Rev. Financ. Anal. 9:235-245.

French KR, Schwert GW, Stambaugh RF (1987). Expected stock returns and volatility. J. Financ. Econ. 19:3-30.

Gennotte G, Leland H (1990). Market liquidity, hedging, and crashes. Am. Econ. Rev. 80(5):999-1021.

Gervais S, Odean T (2001). Learning to be overconfident. Rev. Financ. Stud. 14:1-28.

Glosten L, Jagannathan R, Runkle D (1993). On the relation between the expected value and the volatility of the nominal excess return on stocks. J. Financ. 68(5):1779-1801

Grossman SJ (1988). An analysis of the implications for stock and futures price volatility of program trading and dynamic hedging strategies. J. Bus. 61(3):275-298.

Harvey CR (1995). Predictable risk and returns in emerging markets. Rev. Financ. Stud. pp.773-816.

Hong H, Stein JC (1999). A unified theory of underreaction, momentum trading and overreaction in asset markets. J. Financ. 54:2143-2184.

Jacklin CJ, Kleidon AW, Pfleiderer P (1992). Underestimation of portfolio insurance and the crash of october 1987. Rev. Financ. Stud. 5(1):35-63.

Johnson WC, Westberg JM (2004). The effect of news on volatility: a study of IPOs. Working Paper. Michigan State University.

Odier P, Solnik B (1993). Lessons for international asset allocation. Financ. Anal. J. 49:63-77

Park JW (2010). Comovement of Asian stock Markets and the U.S. influence. Global Econ. Financ. J. 3(2):76-88.

Pettengil G, Sundaram S, Mathur I (1995). The conditional relation between beta and return. J. Financ. Quant. Anal. 30:101-116.

Pindyck RS (1984). Risk, inflation, and the stock market. Am. Econ. Rev. 74(3):334-351.

Romer D (1993). Rational asset-price movements without news. Am. Econ. Rev. 83(5):1112-1130.

Schwert W (1989). Why does stock market volatility change over time? J. Financ. 44:1115-1153

Shamsuddin AF (2008). Asymmetric volatility in emerging south asian equity markets. Working Paper. University of New Castle, Australia.

Shields KK (1997). Stock return volatility on emerging eastern european markets. The Manchester School Supplement pp.118-138.

Shin J (2005). Stock returns and volatility in emerging stock markets. Int. J. Bus. Econ. 4(1):31-43.

Singh P, Kumar B, Pandey A (2008). Price and volatility spillovers across north-american, european and asian stock markets: with special focus on Indian stock market. Working Paper, n. 20081204. Indian Institute of Management. http://203.200.225.141/iimam/assets/snippets/workingpaperpdf/2008-12-04Priyanka.pdf

Venetis IA, Peel D (2005). Non-linearity in stock index returns: the volatility and serial correlation relationship. Econ. Modelling 22:1-19.

Verma R, Verma P (2005). Do emerging equity market respond symmetrically to US market upturns and downturns? Evidence from Latin America. Int. J. Bus. Econ. 4(3):193-208.

Full Length Research Paper

Impact of supplier technology innovation on supply chain efficiency based on revenue-sharing contract

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This study constructs a two-period supply chain model consisting of two suppliers and one retailer using a revenue-sharing contract. Considering random investment cost, the impact of supplier competition on innovation strategy is analyzed and the equilibrium strategy of suppliers' technology innovation game as well as the optimal revenue-sharing contract is derived. It is found that technology innovation degree influences supplier competition, technology innovation strategy and the form of the optimal revenue-sharing contract. Supplier innovation can improve retailer's profit, but it may reduce supplier's profit as well as the supply chain efficiency due to the uncertainty of investment cost and supplier competition.

Key words: Technology innovation, revenue-sharing contract, supply chain efficiency, game analysis.

INTRODUCTION

As corporation competition intensifies and market environment becomes more changeable, the importance of supply chain management keeps growing. Many companies try to optimize supply chain contract to avoid double marginal effect in the price-only contract (Lariviere and Porteus, 2001), so as to achieve supply chain co-ordination and improve supply chain efficiency. Revenue-sharing contract is one of the supply chain coordination contracts, which has a simple form and wide application in several industries, such as automobile manufacturing industry (Foros et al., 2009), E-commerce (Chen et al., 2010), film production (Palsule-Desai, 2012), video rental

(Cachon and Lariviere, 2005) etc.. When using revenue-sharing contract, the supplier sells the product to the retailer with a lower wholesale price, as the retailer com-pensates the supplier with a certain ratio of the sales revenue. However, most studies of revenue-sharing contract assume the supplier's production technology remains unchanged, ignoring the impact of supplier tech-nology change on revenue-sharing contract efficiency. As the speed of products upgrade quickens and the lifecycle of production technology reduces, supplier technology innovation is very common in various industries (Bartel et al., 2005).

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In recent years, more and more enterprises increase their R&D investment to strengthen the cost advantage and their role in global supply chain (Nassimbeni and Sartor, 2007; Su et al., 2008). Supplier technology innovation strategy influences production cost and investment cost, which affects supply chain members' profits and the whole supply chain efficiency as well as the form of revenue-sharing contract (Bonaccorsi and Lipparini, 1994; Narayanan and Raman, 2004). What is the optimal form of a revenue-sharing contract considering supplier technology innovation? What is the impact of technology innovation on supply chain efficiency? These are the questions that have not been addressed in previous literature and are the focus of our paper.

In competing environment, the supplier needs to take into account the competitor's behavior in the process of decision making (Altug and Ryzin, 2013). In addition, new technology always has uncertain investment cost and uncertain lifecycle. However, competition and technology cost uncertainty, which has great impact on the revenue-sharing contract efficiency, is not considered in existing studies. In our study, we try to analyze competing suppliers' technology innovation behavior, and further explore the impact of supplier competition and technology change degree on revenue-sharing contract efficiency considering technology cost and technology lifecycle uncertainty. Specifically, in this study we will focus on the following issues: Under a two supplier-one retailer supply chain structure, what is the optimal technology innovation strategy of two competing suppliers using revenue-sharing contract? What is the impact of technology change degree on the competition and profits of the suppliers? What is the optimal revenue-sharing contract？How does supplier technology innovation affect supply chain efficiency?

Literature Review

Under the price-only contract, supply chain is a decentralized system, where retailer makes the order decision with the target of optimizing his own profit rather than the whole supply chain. Thus, the order quantity under a decentralized supply chain is smaller than that under a centralized one, making the supply chain uncoordinated (Lariviere and Porteus, 2001). Perakis and Roels (2007) provide a quantitative analysis of the supply chain efficiency gap between price-only contract and co-ordinated contract under different supply chain structures. Revenue-sharing is a coordinated supply chain contract with simple form and is equivalent to many other co-ordinated supply chain contract. A detailed analysis can be found in Cachon and Lariviere (2005)'s study. For a multi-supplier-one-retailer supply chain structure, revenue-sharing can also achieve supply chain co-ordination, and increase supply chain each member's profit to obtain a Pareto optimal (Gerchak and Wang,

2004). In a one-supplier-two-retailer supply chain, Kong et al. (2013) explore the potential of revenue-sharing contracts to facilitate information sharing in a supply chain and mitigate the negative effects of information leakage. They find out that the incentives of the supplier and retailers are better aligned under a revenue-sharing contract, as opposed to under a wholesale-price contract. The above research assumes that supplier has a steady technology level, and gets a result that the revenue-sharing parameter (the ratio of retailer's revenue to the whole product sales revenue) has no impact on the supply chain efficiency. However, how to choose an appropriate revenue-sharing parameter is of great importance for enterprises in real life (Yao et al., 2008). Palsule-Desai (2012) has found that the revenue-sharing parameter influences supply chain efficiency, and the optimal revenue-sharing parameter is a function of retailer's whole sales revenue.

Technology innovation can be classified into discrete type and continuous one according to the characteristics of technology innovation process (Xu and Li, 2007). As technology change is always uncertain, thus continuous technology innovation is often characterized by a Markov process (Gjerde et al., 2002; Liu and Özer, 2009), while a discrete technology innovation is depicted by a binomial distribution (Li et al., 2003). When new technology appears in the industry, the supplier makes a decision about whether to adopt the new technology or how many products to produce using the new technology. As specialization division develops, the trend of adopting new technology from an external party becomes more significant, especially in high-tech industries such as telecommunication (Ransbotham and Mitra, 2010; Schmidt and Porteus, 2000). The adoption of new technology is often reflected by the decrease of supplier production cost. With an assumption that new production technology cuts down production cost, Schmidt and Porteus (2000) discuss how to achieve the target of becoming a technology leader in a competitive environment with the lowest cost. Kim (2000) studies the problem of optimizing an incentive mechanism of technology adoption, where the results show that supplier technology innovation can reduce manufacturer's raw material purchasing cost in a supply chain coordinated technology innovation mechanism. Wagner and Bode (2014) focus on the factors that contribute to suppliers' technology innovation through empirical study, and find that contract length and the relationship between the supplier and the retailer may affect supplier's technology innovation strategy.

In real life, suppliers often compete with each other to obtain orders from the retailer, thus to choose an appropriate supplier is an important decision for the retailer (Xia et al., 2008). Ho et al. (2010) provide a review about the research on supplier selection, which has found that supplier production cost and wholesale price are critical factors in the process of supplier selection. Suppliers are often characterized by operation performance terms of
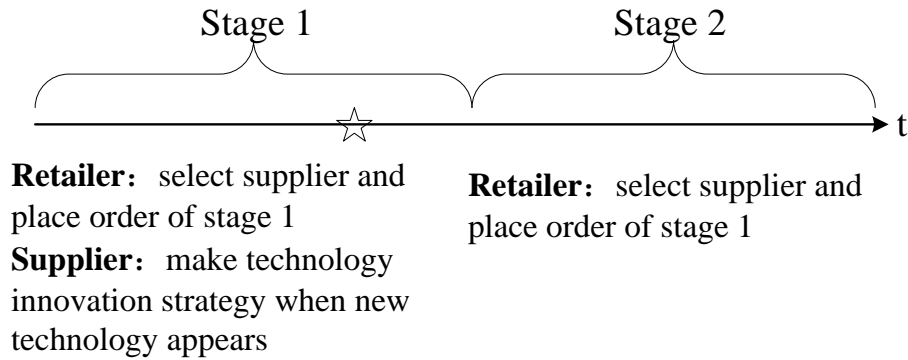
Figure 1. Sequence of event.

cost, delivery time, service level, or quality (Qian, 2014). In competitive circumstances, innovation is the key to the survival of enterprises and in recent ten years, to recognize a supplier with high innovation ability is an important task for the retailers (Schiele, 2006). In addition, supplier's investment on technology innovation and his innovation capability are also key factors in the retailer's supplier selection process (Petroni and Panciroli, 2002).

Although supplier technology innovation has a big impact on supply chain coordination and supply chain efficiency; so far scholars have used the assumption that supplier has unchanged production technology in their study on revenue-sharing contract. The studies on supplier technology innovation are mainly focusing on the coordination and optimization of supplier technology innovation mechanism, with few researches discussing the impact of competing suppliers' technology innovation on revenue-sharing contract. Different from the above studies, we would like to investigate the issue about how will the two factors, which are supplier competition and supplier technology innovation degree, affect the suppliers' equilibrium technology innovation strategies and the supply chain revenue-sharing contract efficiency.

Model and analysis

Model description

Considering a two-stage supply chain model with two suppliers (supplier N and supplier S), who have different initial production technology levels and one retailer. In each stage, the retailer places an order on one of the two suppliers. Assume in the first stage supplier N is the technology leader, who has lower unit production cost, that is $c_N < c_S$, where c_N and c_S are unit production cost of supplier N and supplier S in the first stage, respectively. The inverse market demand function is $p = a - q$, where p is the product sales price of the retailer, $a > 0$ is the potential market demand and q is retailer's product order

quantity. The sequence of event in the model is shown in Figure 1, where ☆ stands for supplier's new production technology, with a certain probability.

At the beginning of the first stage, the retailer selects his supplier and makes the order quantity decision q_1 for stage one. Retailer's supplier selection decision is shown by equation (1).

$$y_1 = \begin{cases} 1, & \text{if retailer's first-stage supplier is } S; \\ 0, & \text{otherwise.} \end{cases} \quad (1)$$

In the first stage, supplier's new production technology appears with probability γ, where $\gamma \in [0,1]$, and the corresponding technology investment is a random variable κ, with probability density function and cumulative distribution function being $f(\cdot)$ and $F(\cdot)$, respectively. $\kappa \in [0, H]$ and the maximum value of random investment cost is, with the realization of investment cost being K. According to the realized investment cost K, supplier $i (i = N, S)$ makes technology innovation strategy shown as equation (2).

$$x_i = \begin{cases} 1, & \text{if supplier i adopts new technology;} \\ 0, & \text{otherwise.} \end{cases} \quad (2)$$

If supplier adopts new production technology, the unit production cost reduces by δ, where $0 < \delta < c_N$, and expends the corresponding investment cost K. According to supplier's technology innovation strategy, at the beginning of the second stage, the retailer chooses the supplier for the second stage and makes the order decision q_2. Retailer's supplier selection decision for the second stage is shown by equation (3).

$$y_2 = \begin{cases} 1, & \text{if retailer's second-stage supplier is } S; \\ 0, & \text{otherwise.} \end{cases} \quad (3)$$

Supplier's technology innovation strategy

Cachon and Lariviere (2005)'s study shows that when using revenue-sharing contract, the condition of supply chain coordination is supplier i's wholesale price w_i and its unit production cost c_i satisfy equation (4) as follows, $i = N, S$,

$$w_i = \phi c_i \tag{4}$$

where $\phi \in [0,1]$ is revenue-sharing parameter (the ratio of retailer's revenue to the product's whole sales revenue). The supply chain profit allocation to the retailer and the supplier is also decided by ϕ; which means that the ratio of retailer's profit to the supply chain profit is also decided by ϕ.

In the first stage, as supplier N has lower unit production cost, thus according to equation (4), supplier N's wholesale price is lower than that of supplier S, that is $w_N = \phi c_N < \phi c_S = w_S$. Thus, in the first stage, the retailer chooses supplier N, that is $y_1 = 0$. The first stage profit of the retailer and supplier N is shown by equations (7) and (6) as follows,

$$\pi_r(q_1) = \phi R(q_1) - w_N q_1 = \phi[(a - q_1)q_1 - c_N q_1] \tag{5}$$
$$\pi_s^N(q_1) = (1-\phi)R(q_1) + w_N q_1 - c_N q_1 = (1-\phi)[(a-q_1)q_1 - c_N q_1] \tag{6}$$

where $R(q_1) = pq_1 = (a - q_1)q_1$ is the whole sales revenue of the products. The first order derivative of $\pi_r(q_1)$ to q_1 is shown by equation (7).

$$\partial \pi_r(q_1) / \partial q_1 = \phi(a - 2q_1 - c_N) \tag{7}$$

As $\pi_r(q_1)$ is a concave function, using the first order condition we get the retailer's optimal order quantity of the first stage $q_1 = (a - c_N)/2$. Correspondingly, we get the first stage profits of the retailer, supplier N and the whole supply chain, which are shown by equations (8) and (10).

$$\pi_r = \phi(a - c_N)^2 / 4 \tag{8}$$
$$\pi_s^N = (1-\phi)(a - c_N)^2 / 4 \tag{9}$$
$$\pi_{sc} = (a - c_N)^2 / 4 \tag{10}$$

If new production technology does not appear at the end of the first stage, that is $\gamma = 0$, the retailer will surely continue to choose supplier N in the second stage, that is $y_2 = 0$; on the contrary, if new technology appears in the first stage, that is $\gamma > 0$, two suppliers will then make their technology innovation strategies, which are denoted by

x_i ($i = S, N$, and the retailer will make his second stage supplier selection decision y_2. The following proposition shows two suppliers' equilibrium technology innovation strategies and retailer's optimal supplier selection decision of the second stage.

Proposition 1. When $\gamma > 0$, the equilibrium technology innovation strategies of the two suppliers depend on two suppliers' initial production technology gap $c_S - c_N$, technology innovation degree δ and the realized investment cost K,

(i) If $\delta \geq c_S - c_N$, the equilibrium technology innovation strategies of the two suppliers are shown by equation (11),

$$(x_S, x_N) = \begin{cases} (0,1), & \text{if } 0 \leq K \leq M_1; \\ \text{mixed strategy, if } M_1 \leq K \leq M_2; \\ (0,0), & \text{otherwise.} \end{cases} \tag{11}$$

where the mixed strategy is shown by equation (12),

$$(x_S, x_N) = \begin{cases} (1,1), & \text{with probability } p_S p_N; \\ (1,0), & \text{with probability } p_S(1-p_N); \\ (0,1), & \text{with probability } (1-p_S)p_N; \\ (0,0), & \text{with probability } (1-p_S)(1-p_N). \end{cases} \tag{12}$$

Retailer's corresponding second stage supplier selection decision is shown by equation **Error! Reference source not found.**,

$$y_2 = \begin{cases} 1, & \text{if } (x_S, x_N) = (1,0); \\ 0, & \text{otherwise.} \end{cases} \tag{13}$$

(ii) If $0 < \delta < c_S - c_N$, the equilibrium technology innovation strategies of the two suppliers are shown by equation (14),

$$(x_S, x_N) = \begin{cases} (0,1), & \text{if } 0 \leq K \leq M_1; \\ (0,0), & \text{otherwise.} \end{cases} \tag{14}$$

Retailer's corresponding second stage supplier selection decision is shown by equation $y_2 = 0$, where

$$M_1 = \frac{(1-\phi)}{4}\left[(a - c_N + \delta)^2 - (a - c_N)^2\right], M_2 = \frac{(1-\phi)}{4}(a - c_S + \delta)^2,$$

$$p_N = \frac{(a - c_S + \delta)^2 - 4K/(1-\phi)}{(a - c_S + \delta)^2},$$

$$p_S = \frac{(a - c_N)^2 - (a - c_N + \delta)^2 + 4K/(1-\phi)}{(a - c_N)^2}.$$

Proof. Retailer's supplier selection decision and the profits of supply chain members of the second stage under different supplier technology innovation strategy combination are shown in Table 1. Two suppliers'

Table 1. Retailer's supplier selection decision and supply chain members' profits of the second stage.

	$x_N = 1$	$x_N = 0$	
$x_S = 1$	$y_2 = 0$ $\pi_r = \phi(a - c_N + \delta)^2 / 4$ $\pi_s^S = -K$ $\pi_s^N = (1-\phi)(a - c_N + \delta)^2 / 4 - K$	If $\delta \geq c_S - c_N$, $y_2 = 1$ If $\delta < c_S - c_N$, $y_2 = 0$	$\pi_r = \phi(a - c_S + \delta)^2 / 4$ $\pi_s^S = (1-\phi)(a - c_S + \delta)^2 / 4 - K$ $\pi_s^N = 0$ $\pi_r = \phi(a - c_N)^2 / 4$ $\pi_s^S = -K$ $\pi_s^N = (1-\phi)(a - c_N)^2 / 4$
$x_S = 0$	$y_2 = 0$ $\pi_r = \phi(a - c_N + \delta)^2 / 4$ $\pi_s^S = 0$ $\pi_s^N = (1-\phi)(a - c_N + \delta)^2 / 4 - K$	$y_2 = 0$ $\pi_r = \phi(a - c_N)^2 / 4$ $\pi_s^S = 0$ $\pi_s^N = (1-\phi)(a - c_N)^2 / 4$	

equilibrium technology innovation strategies depend on initial production technology gap $c_S - c_N$, technology innovation degree δ and the realized investment cost K, which are discussed as follows.

(1) If $\delta \geq c_S - c_N$, supplier's technology innovation strategy depends on investment cost K. As $a \geq c_S + 2\delta \geq 3c_S - 2c_N \geq 2c_S - c_N$; it is easy to find that $M_1 \leq M_2$.
For $0 \leq K < M_1$, the equilibrium technology innovation strategy is $(x_S, x_N) = (0,1)$; for $M_1 \leq K < M_2$, the equilibrium technology innovation strategy is a mixed strategy. Assume supplier S adopts new technology ($x_S = 1$) with probability $p_S \in [0,1]$, while supplier N adopts new technology ($x_N = 1$) with probability $p_N \in [0,1]$. According to the definition of Nash equilibrium, supplier i gets the same profit under strategy $x_i = 0$ or strategy $x_i = 1$, where $i = S, N$. Thus we can get two equations shown as (15) and (16).

$$-4Kp_N + \left[(1-\phi)(a - c_S + \delta)^2 - 4K\right](1 - p_N) = 0 \quad (15)$$

$$(1-\phi)(a - c_N + \delta)^2 - 4K = (1 - p_S)(1-\phi)(a - c_N)^2 \quad (16)$$

Solving equation (15) and equation (16), the expression of p_S and p_N are as shown in proposition 1.

For $K \geq M_2$, the equilibrium technology innovation strategy is $(x_S, x_N) = (0,0)$.

If $\delta \geq c_S - c_N$, technology change degree is relatively large. Retailer's supplier selection decision is made according to two supplier's technology innovation strategies. When the equilibrium technology innovation strategy is $(x_S, x_N) = (1,0)$, retailer's supplier selection

decision of the second stage is $y_2 = 1$; otherwise, $y_2 = 0$.
(2) If $0 < \delta < c_S - c_N$, supplier's technology innovation strategy also depends on investment cost K.
For $0 \leq K < M_1$, the two suppliers' equilibrium technology innovation strategy is $(x_S, x_N) = (0,1)$。
For $K \geq M_1$, the two suppliers' equilibrium technology innovation strategy is $(x_S, x_N) = (0,0)$.

If $0 < \delta < c_S - c_N$, technology change degree is relatively small, thus supplier S will not adopt new technology. No matter whether supplier N adopts new technology, the retailer gets higher profit from supplier N; thus retailer's supplier selection decision of the second stage is $y_2 = 0$.

From proposition 1 we find that when technology innovation degree is small, even if supplier N does not adopt new technology and supplier S adopts new technology, supplier N can still keep the technology leading advantage. Thus, supplier N only needs to trade off between investment cost and revenue to decide whether to adopt new technology. However, when technology innovation degree is big, supplier N needs to consider supplier competition in the process of making technology innovation strategy. Particularly, when investment cost is in the range of $M_1 \leq K < M_2$, supplier S adopts new technology with probability $p_S(1 - p_N)$ while supplier N does not adopt new technology, which makes supplier S the technology leader, and the retailer will choose supplier S for the second stage. Considering the competition threat of supplier S, supplier N will thus make an irrational technology innovation decision, that is adopting new technology to guarantee the sales opportunity for the second stage even if investment cost is bigger than the revenue brought by the new technology.

According to suppliers' equilibrium technology innovation strategies, with the consideration of random

investment cost and the probability of technology change, the two-stage profits of supply chain members and the supply chain two-stage efficiency are shown by proposition 2.

Proposition 2. Considering a revenue-sharing contract with supplier technology change. When $\delta \geq c_S - c_N$, the two-stage profits of the retailer, supplier N and supplier S are shown as equations (17) and (19), and the supply chain two-stage efficiency is shown by equation (20).

$$\Pi_r = \frac{\phi(a-c_N)^2}{2} + \frac{\phi\gamma\delta^2(2a-2c_N+\delta)^2}{4(a-c_S+\delta)^2}F(M_1) - \frac{8\phi\gamma(2a-c_S-c_N+\delta)(c_N+\delta-c_S)}{\left[(1-\phi)(a-c_N)(a-c_S+\delta)\right]^2}\int_{M_1}^{M_2}F(x)xdx$$
$$+\frac{\phi\gamma\delta(2a-2c_N+\delta)}{4}F(M_2) - \frac{\phi\gamma(c_S-c_N)(2a-c_S-c_N+2\delta)(a-c_S+\delta)^2}{4(a-c_N)^2}F(M_2)$$
$$+\frac{\phi\gamma\delta(2a-2c_N+\delta)}{(1-\phi)(a-c_N)^2}\int_{M_1}^{M_2}F(x)dx \tag{17}$$

$$\Pi_s^N = \frac{(1-\phi)}{2}(a-c_N)^2 + \gamma\int_0^{M_2}F(x)dx - \frac{(1-\phi)\gamma}{4}\left[(a-c_S)^2 - 2\delta(c_S-c_N)\right]F(M_2) \tag{18}$$

$$\Pi_s^S = 0 \tag{19}$$

$$\Pi_{sc} = \Pi_r + \Pi_s^N \tag{20}$$

When $0 < \delta < c_S - c_N$, the two-stage profits of the retailer, supplier N and supplier S are shown as equation (21) to equation (23), and the supply chain two-stage efficiency is shown by equation (24).

$$\Pi_r = \frac{\phi(a-c_N)^2}{2} + \frac{\phi\gamma\delta(2a-2c_N+\delta)}{4}F(M_1) \tag{21}$$

$$\Pi_s^N = (1-\phi)(a-c_N)^2/2 + \gamma\int_0^{M_1}F(x)dx \tag{22}$$

$$\Pi_s^S = 0 \tag{23}$$

$$\Pi_{sc} = \frac{(a-c_N)^2}{2} + \frac{\phi\gamma\delta(2a-2c_N+\delta)}{4}F(M_1) + \gamma\int_0^{M_1}F(x)dx \tag{24}$$

Proof According to proposition 1, when $\delta \geq c_S - c_N$, the two-stage profits of the retailer and two competing suppliers depend on investment cost, which are shown from equation (25) to equation (27).

$$\pi_r = \begin{cases} \frac{\phi}{4}\left[(2-\gamma)(a-c_N)^2 + \gamma(a-c_N+\delta)^2\right], & \text{if } 0 \leq K < M_1; \\ \frac{\phi}{4}\left[(2-\gamma)(a-c_N)^2 + \gamma p_N(a-c_N+\delta)^2\right] + \frac{\phi\gamma}{4}p_S(1-p_N)(a-c_S+\delta)^2 \\ \quad + \frac{\phi\gamma}{4}(1-p_S)(1-p_N)(a-c_N)^2, & \text{if } M_1 \leq K < M_2; \\ \frac{\phi}{2}(a-c_N)^2, & \text{if } M_2 \leq K < H. \end{cases} \tag{25}$$

$$\pi_s^N = \begin{cases} \frac{(1-\phi)}{4}\left[(2-\gamma)(a-c_N)^2 + \gamma(a-c_N+\delta)^2\right] - \gamma K, & \text{if } 0 \leq K < M_2; \\ \frac{(1-\phi)}{2}(a-c_N)^2, & \text{if } M_2 \leq K < H. \end{cases} \tag{26}$$

$$\pi_s^S = \begin{cases} p_S(1-p_N)\left[(1-\phi)(a-c_S+\delta)^2/4 - K\right], & \text{if } M_1 \leq K < M_2; \\ 0, & \text{otherwise.} \end{cases} \tag{27}$$

Therefore, when $\delta \geq c_S - c_N$, the two-stage profits of the retailer and two suppliers under revenue-sharing contract are shown as equations (28) and (30).

$$\Pi_r = \frac{\phi}{4}\int_0^{M_1}\left[(2-\gamma)(a-c_N)^2 + \gamma(a-c_N+\delta)^2\right]dF(x) + \frac{\phi}{2}\int_{M_2}^{H}(a-c_N)^2 dF(x)$$
$$+\frac{\phi}{4}\int_{M_1}^{M_2}\left[(2-\gamma)(a-c_N)^2 + \gamma p_N(a-c_N+\delta)^2 + \gamma p_S(1-p_N)(a-c_S+\delta)^2\right]dF(x)$$
$$+\frac{\phi}{4}\int_{M_1}^{M_2}\gamma(1-p_S)(1-p_N)(a-c_N)^2 dF(x) \tag{28}$$

$$\Pi_s^N = \int_0^{M_2}\left\{\frac{(1-\phi)}{4}\left[(2-\gamma)(a-c_N)^2 + \gamma(a-c_N+\delta)^2\right] - \gamma x\right\}dF(x) + \frac{(1-\phi)}{2}\int_{M_2}^{H}(a-c_N)^2 dF(x) \tag{29}$$

$$\Pi_s^S = \int_{M_1}^{M_2}p_S(1-p_N)\left[\frac{(1-\phi)}{4}(a-c_S+\delta)^2 - x\right]dF(x) \tag{30}$$

When $0 < \delta < c_S - c_N$, the two-stage profits of the retailer and two suppliers also depend on investment cost, which are shown in equations (31) and (33).

$$\pi_r = \begin{cases} \frac{\phi}{4}\left[(2-\gamma)(a-c_N)^2 + \gamma(a-c_N+\delta)^2\right], & \text{if } 0 \leq K < M_1; \\ \frac{\phi}{2}(a-c_N)^2, & \text{if } M_1 \leq K < H. \end{cases} \tag{31}$$

$$\pi_s^N = \begin{cases} \frac{(1-\phi)}{4}\left[(2-\gamma)(a-c_N)^2 + \gamma(a-c_N+\delta)^2\right] - \gamma K, & \text{if } 0 \leq K < M_1; \\ \frac{(1-\phi)}{2}(a-c_N)^2, & \text{if } M_1 \leq K < H. \end{cases} \tag{32}$$

$$\pi_s^S = 0 \tag{33}$$

Thus, when $0 < \delta < c_S - c_N$, the two-stage profits of the retailer and two suppliers under revenue-sharing contract are shown as equations (34) and (36).

$$\Pi_r = \frac{\phi}{4}\int_0^{M_1}\left[(2-\gamma)(a-c_N)^2 + \gamma(a-c_N+\delta)^2\right]dF(x) + \frac{\phi}{2}\int_{M_1}^{H}(a-c_N)^2 dF(x) \tag{34}$$

$$\Pi_s^N = \int_0^{M_1}\left\{\frac{(1-\phi)}{4}\left[(2-\gamma)(a-c_N)^2 + \gamma(a-c_N+\delta)^2\right] - \gamma x\right\}dF(x) + \frac{(1-\phi)}{2}\int_{M_1}^{H}(a-c_N)^2 dF(x) \tag{35}$$

$$\Pi_s^S = 0 \tag{36}$$

From proposition 2 we find that, as supplier N's potential competitor, under a certain condition, supplier S will replace supplier N, become the technology leader and obtain the second stage order opportunity. Therefore, a competitive environment will affect the technology leader's technology innovation strategy, and influence supply chain efficiency. For supplier N, in order to guarantee the sales opportunity of the second stage, when investment cost is bigger than revenue, he still will adopt new technology with a rather big probability. For example, when $M_1 \leq K < M_2$, new technology cost is bigger than revenue, considering the competition of supplier S, supplier N still adopts new technology with probability p_N. As for the retailer, supplier competition increases supplier N's technology innovation probability,

which can improve retailer's expected profit. Therefore, the aim of retailer's supplier evaluation and selection process is to intensify supplier competition so as to improve his own profit. From the above analysis, we can also find that the competition between suppliers plays a positive part in the improvement of supply chain product technology.

As competing suppliers' technology innovation behavior has impact on revenue-sharing contract efficiency, we would like to find out the optimal contract form (the optimal revenue-sharing parameter) in this circumstance so as to improve the supply chain efficiency.

Corollary 1. There exists an optimal revenue-sharing parameter ϕ^* which makes revenue-sharing contract achieve the highest efficiency in supplier technology change environment; and when technology change degree is small ($0 < \delta < c_S - c_N$), revenue-sharing contract efficiency decreases in ϕ with the optimal revenue-sharing parameter being $\phi^* = 0$.

Proof. According to proposition 2, when technology change degree is small, revenue-sharing contract efficiency is shown as equation (37).

$$\Pi_{sc} = \frac{(a-c_N)^2}{2} + \frac{\phi\gamma\delta(2a-2c_N+\delta)}{4}F(M_1) + \gamma\int_0^{M_1}F(x)dx \quad (37)$$

Take the first order derivative of Π_{sc} to ϕ, we get the result shown as equation (38).

$$\frac{\partial\Pi_{sc}}{\partial\phi} = -\frac{\phi\gamma\delta^2(2a-2c_N+\delta)^2}{16}f(M_1) < 0 \quad (38)$$

Thus, when technology change is small, revenue-sharing contract efficiency is a decreasing function of ϕ and thus the optimal revenue-sharing parameter is $\phi^* = 0$.

When technology change degree is big, revenue-sharing contract efficiency is shown as equation (39).

$$\Pi_{sc} = \frac{(a-c_N)^2}{2} + \frac{\phi\gamma\delta^2(2a-2c_N+\delta)^2}{4(a-c_S+\delta)^2}F(M_1) + \frac{\gamma\delta\left[2\phi a - 2c_N + \phi\delta + (2-2\phi)c_S\right] - (1-\phi)\gamma(a-c_S)^2}{4}F(M_2)$$

$$- \frac{\phi\gamma(c_S-c_N)(2a+2\delta-c_S-c_N)(a-c_S+\delta)^2}{4(a-c_N)^2}F(M_2) - \frac{8\phi\gamma(2a-c_S-c_N+\delta)(c_N+\delta-c_S)}{(1-\phi)^2(a-c_N)^2(a-c_S+\delta)^2}\int_{M_1}^{M_2}F(x)xdx$$

$$+ \frac{\phi\gamma\delta(2a-2c_N+\delta)}{(1-\phi)(a-c_N)^2}\int_{M_1}^{M_2}F(x)dx + \gamma\int_0^{M_2}F(x)dx \quad (39)$$

Therefore, the revenue-sharing contract efficiency Π_{sc} is a function of revenue-sharing parameter ϕ, and thus exists the optimal revenue-sharing parameter ϕ^*, which can be found from the first order condition of equation (39).

From corollary 3 we find that when technology change degree is small, supplier N makes a cautious and rational technology innovation decision without considering the competition of supplier S. Theoretically, to

achieve the highest contract efficiency, the best revenue-sharing parameter is $\phi^* = 0$, with the aim of encouraging supplier N to adopt new technology. That explains the improvement of supplier production technology plays a critical role to the increase of supply chain efficiency. When technology change degree is big, however, revenue-sharing parameter has impact on supplier's technology innovation strategy, thus influences supply chain efficiency. In the following section, we will provide a detailed numerical analysis about the optimal revenue-sharing parameter and its impact on supply chain efficiency when the technology change degree is big.

Numerical analysis

From the analysis of section 3, we find that supplier's technology innovation behavior influences revenue-sharing contract efficiency. In this section, we would like to investigate the impact of new technology appearance probability, revenue-sharing parameter and potential market demand on supplier's technology innovation behavior and supply chain efficiency. As technology investment cost is uncertain, we will do the numerical analysis when κ follows a uniform distribution, that is $\kappa \sim U[0, H]$ and an exponential distribution, that is $\kappa \sim e(\lambda)$, respectively. In addition, as technology change degree influences supplier's technology innovation strategies, thus we will analyze the problem when technology change degree is small, that is $0 < \delta < c_S - c_N$ as well as technology change is big, that is $\delta \geq c_S - c_N$. As the analysis in section 3 shows that supplier S's expected profit is 0, thus in this section we concentrate on the profits of supplier N and the retailer. For brief expression, the supplier in this section stands for supplier N.

Impact of supplier technology innovation on supply chain members and revenue-sharing contract efficiency

The parameters in the numerical analysis are as follows, $c_S = 15$, $c_N = 12$, $\delta = 8$ (big technology innovation), $\delta = 2$ (small technology innovation), $\lambda = 0.005$, $H = 1000$ (From several groups of numerical studies we find that when parameters change we can still get the results).

Tables 2 and 3 show the profits of supplier and retailer as well as the supply chain efficiency, using revenue-sharing contract when revenue-sharing parameter is big ($\phi = 0.8$) and small ($\phi = 0.2$, respectively. We can find that supplier technology innovation is always beneficiary to the retailer, while it may decrease supplier's profit and the whole supply chain efficiency

Table 2. Impact of supplier technology innovation on revenue-sharing contract when $x^2=0.8$.

	$\kappa \sim U[0,H]$		$\kappa \sim e(\lambda)$		No technology innovation
	Big technology innovation	**Small technology innovation**	**Big technology innovation**	**Small technology innovation**	
Supplier's profit	227	231	227	223	230
Retailer's profit	936	922	1126	923	921
Supply chain efficiency	1163	1153	1353	1146	1151

Table 3. Impact of supplier technology innovation on revenue-sharing contract when $x^2=0.2$.

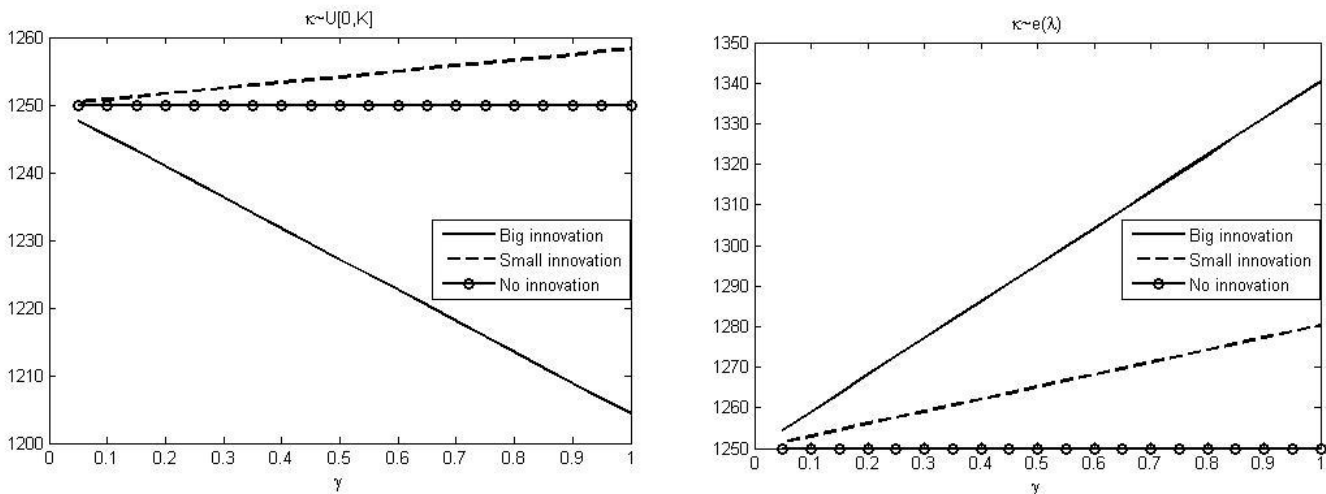|	$\kappa \sim U[0,H]$		$\kappa \sim e(\lambda)$		No technology innovation
	Big technology innovation	**Small technology innovation**	**Big technology innovation**	**Small technology innovation**	
Supplier's profit	864	923	927	923	922
Retailer's profit	245	231	297	232	230
Supply chain efficiency	1109	1154	1224	1155	1152

Figure 2. Impact of new technology appearance probability on supply chain efficiency.

(We obtain the same conclusion by altering the parameters several times). This is because if supplier adopts new technology, the production cost decreases. When using revenue-sharing contract, the wholesale price then also reduces and the retailer can increase market demand by cutting down the sales price of the product, thus increasing the expected profit the retailer. However, due to the supplier's irrational technology investment strategy caused by supplier competition, in some circumstances, the investment cost exceeds revenue, resulting in a lower supply chain efficiency and less supplier's expected profit.

Impact of parameters on revenue-sharing contract efficiency

Impact of new technology appearance probability

Impact of new technology appearance probability on revenue-sharing contract efficiency is shown in Figure 2. As it can be seen, when technology innovation is small, competition does not exist between suppliers; therefore, technology innovation will improve supply chain efficiency, which is a function of new technology appearance probability. When technology innovation is big, impact of
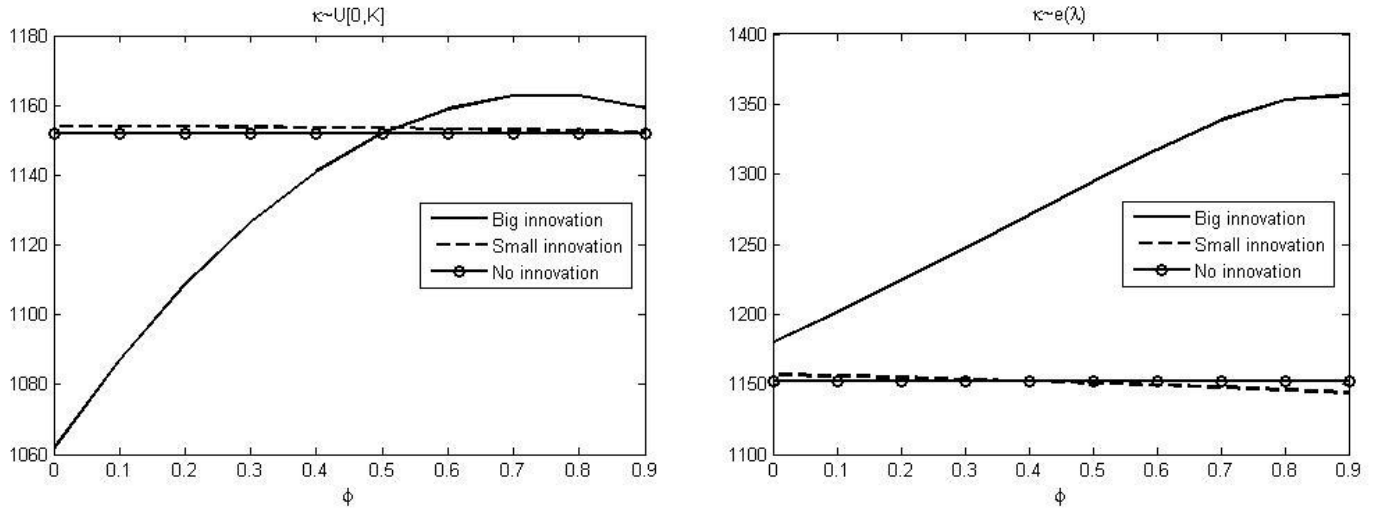
Figure 3. Impact of revenue-sharing parameter on supply chain efficiency.

new technology appearance probability on revenue-sharing contract efficiency is influenced by investment cost probability distribution. When investment cost follows an exponential distribution, supply chain efficiency is an increasing function of new technology appearance probability; while when investment cost follows a uniform distribution, supplier technology innovation decreases supply chain efficiency and supply chain efficiency is a decrease function of new technology appearance probability.

Therefore, a small degree of technology innovation is not influenced by investment cost and can improve supply chain efficiency; on the contrary, when technology innovation degree is big, supplier competition exists and impact of supplier N's irrational technology innovation decision on supply chain efficiency is affected by investment cost. When investment cost follows exponential distribution, new technology brings revenue that exceeds the investment cost, thus technology innovation can improve supply chain efficiency; while when investment cost follows uniform distribution, investment cost exceeds the revenue brought by the new technology, resulting in a lower supply chain efficiency.

Impact of revenue-sharing parameter

Impact of revenue-sharing parameter on revenue-sharing contract efficiency is shown in Figure 3. It can be found in the figure that revenue-sharing parameter has similar impact on supply chain efficiency under different investment cost distribution function. When technology innovation degree is relatively big, supply chain efficiency is a concave function of revenue-sharing parameter; while when technology innovation degree is small, supply chain

efficiency decreases in revenue-sharing parameter. A small technology change eliminates the competition between suppliers, and from corollary 1, we find that supply chain efficiency is a decreasing function of revenue-sharing parameter. This is because when supplier competition does not exist, supplier makes a careful technology innovation strategy; thus when supplier has higher revenue, he will be more active to adopt new technology, resulting in higher supply chain efficiency.

When technology innovation degree is relatively big, competition exists between suppliers. By numerical analysis, we find that the optimal revenue-sharing parameter is in the range of $\phi^* \in (0,1)$. In competing environment, in order to avoid supplier N's irrational investment and the corresponding cost, the revenue-sharing parameter should not be set too high; meanwhile, the revenue-sharing parameter should not be too low, so as to inspire the supplier to adopt new technology. Therefore, the optimal revenue-sharing parameter ϕ^* is decided by trading-off between the investment cost caused by irrational investment and the opportunity cost caused by giving up adopting new technology.

Impact of potential market demand

Impact of potential market demand on revenue-sharing contract efficiency is shown in Figure 4. As it is shown by the figure, when investment cost follows different distribution functions, the revenue-sharing contract efficiency always improves as the potential market demand increases. In addition, supplier technology innovation can improve supply chain efficiency, which also increases as technology innovation degree increases.
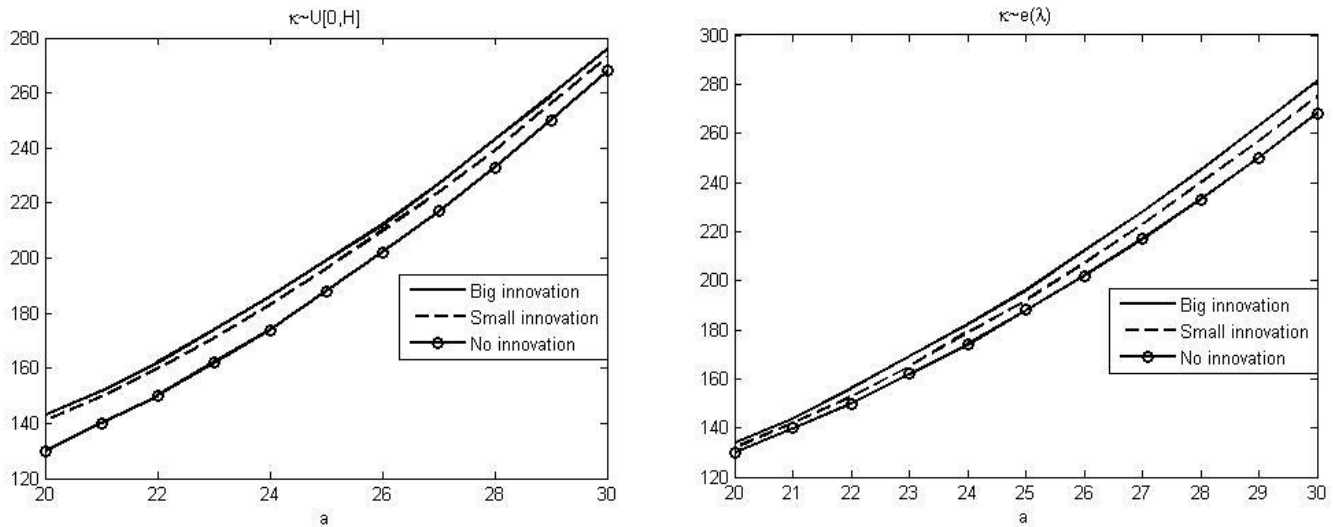
Figure 4. Impact of potential market demand on supply chain efficiency.

Besides, impact of supplier technology innovation on supply chain efficiency becomes more significant as the potential market becomes larger. This shows that for different sizes of market demand, supplier technology innovation can always improve supply chain efficiency, which also increases in technology innovation degree.

Conclusion

This study analyzes the impact of competing supplier technology innovation on the revenue-sharing contract efficiency. A two supplier-one retailer two-stage supply chain model is constructed with different initial technology levels of the two suppliers. The equilibrium technology innovation strategies of two suppliers and the optimal revenue-sharing contract are analyzed. In addition, we discuss impact of new technology appearance probability, revenue-sharing parameter and potential market demand on supply chain efficiency. The results show that when technology innovation degree is big, suppliers need to trade-off between investment cost and revenue and make decision with the consideration of competition between the suppliers, which may decrease supply chain effi-ciency. However, when technology innovation degree is relatively small, there is no need to consider supplier competition, and technology innovation is always beneficial to supply chain efficiency. Different with the existing research, this study shows that the revenue-sharing parameter affects the supply chain efficiency of revenue-sharing contract when considering supplier technology innovation and the optimal revenue-sharing parameter is influenced by the degree of technology change. Therefore, it is necessary to make an appro-priate revenue allocation scheme considering different degree of technology innovation, so as to improve supply chain efficiency. It should be pointed out that we do not consider the downstream supply chain competition; thus the future studies should be on a supply chain consisting of multiple retailers and the impact of supplier technology innovation on revenue-sharing contract efficiency. In addition, the impact of technology innovation on other forms of supply chain contract, such as sales-rebate contract, buy-back contract, etc. is also a research direction worth studying.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

Altug MS, Ryzin G (2013). Product quality selection: Contractual agreements and supplier competition in an assemble-to-order environment. Int. J. Prod. Economics 141(2):626-638.
Bartel A, Lach S, Sicherman N (2005). Outsourcing and technological change. National Bureau of Economic Research, http://www.nber.org/papers/w11158.
Bonaccorsi A, Lipparini A (1994). Strategic partnerships in new product development: an Italian case study. J. Prod. Innov. Manage. 11(2):134-145.
Cachon GP, Lariviere MA (2005). Supply chain coordination with revenue-sharing contracts: Strengths and limitations. Manage. Sci. 51(1):30-44.
Chen J, Cheng H, Lin I (2010). On channel coordination under price-

dependent revenue-sharing: can eBay's fee structure coordinate the channel & quest. J. Oper. Res. Soc. 62(11):1992-2001.

Foros Ø, Hagen KP, Kind HJ (2009). Price-dependent profit sharing as a channel coordination device. Manage. Sci. 55(8):1280-1291.

Gerchak Y, Wang Y (2004). Revenue-Sharing vs. Wholesale-Price Contracts in Assembly Systems with Random Demand. Prod. Oper. Manage. 13(1):23-33.

Gjerde KAP, Slotnick SA, Sobel MJ (2002). New product innovation with multiple features and technology constraints. Manage. Sci. 48(10):1268-1284.

Ho W, Xu X, Dey PK (2010). Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. Eur. J. Oper. Res. 202(1):16-24.

Kim B (2000). Coordinating an innovation in supply chain management. Eur. J. Oper. Res. 123(3):568-584.

Kong G, Rajagopalan S, Zhang H (2013). Revenue sharing and information leakage in a supply chain. Manage. Sci. 59(3):556-572.

Lariviere MA, Porteus EL (2001). Selling to the newsvendor: An analysis of price-only contracts. Manuf. Service Oper. Manage. 3(4):293-305.

Li S, Loulou R, Rahman A (2003). Technological progress and technology acquisition: Strategic decision under uncertainty. Prod. Oper. Manage. 12(1):102-119.

Liu H, Özer Ö (2009). Managing a product family under stochastic technological changes. Int. J. Prod. Econ. 122(2):567-580.

Narayanan V, Raman A (2004). Aligning incentives in supply chains. Harvard Bus. Rev. 82(11):94-102.

Nassimbeni G, Sartor M (2007). Sourcing in China: a typology. Int. J. Prod. Econ. 107(2):333-349.

Palsule-Desai OD (2012). Supply chain coordination using revenue-dependent revenue sharing contracts. Omega 41(4):780-796.

Perakis G, Roels G (2007). The price of anarchy in supply chains: Quantifying the efficiency of price-only contracts. Manage. Sci. 53(8):1249-1268.

Petroni A, Panciroli B (2002). Innovation as a determinant of suppliers' roles and performances: an empirical study in the food machinery industry. Eur. J. Purchasing Supply Manage. 8(3):135-149.

Qian L (2014). Market-based supplier selection with price, delivery time, and service level dependent demand. Int. J. Prod. Econ. 147:697-706.

Ransbotham S, Mitra S (2010). Target age and the acquisition of innovation in high-technology industries. Manage. Sci. 56(11):2076-2093.

Schiele H (2006). How to distinguish innovative suppliers? Identifying innovative suppliers as new task for purchasing. Ind. Market. Manage. 35(8):925-935.

Schmidt GM, Porteus EL (2000). Sustaining technology leadership can require both cost competence and innovative competence. Manuf. Service Oper. Manage. 2(1):1-18.

Su Q, Shi JH, Lai SJ (2008). Study on supply chain management of Chinese firms from the institutional view. Int. J. Prod. Econ. 115(2):362-373.

Wagner SM, Bode C (2014). Supplier relationship-specific investments and the role of safeguards for supplier innovation sharing. J. Oper. Manage. 32(3):65-78.

Xia Y, Chen B, Kouvelis P (2008). Market-based supply chain coordination by matching suppliers' cost structures with buyers' order profiles. Manage. Sci. 54(11):1861-1875.

Xu SH, Li Z (2007). Managing a single-product assemble-to-order system with technology innovations. Manage. Sci. 53(9):1467-1485.

Yao Z, Leung SC, Lai K (2008). The effectiveness of revenue-sharing contract to coordinate the price-setting newsvendor products' supply chain. Supply Chain Management: Int. J. 13(4):263-271.

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