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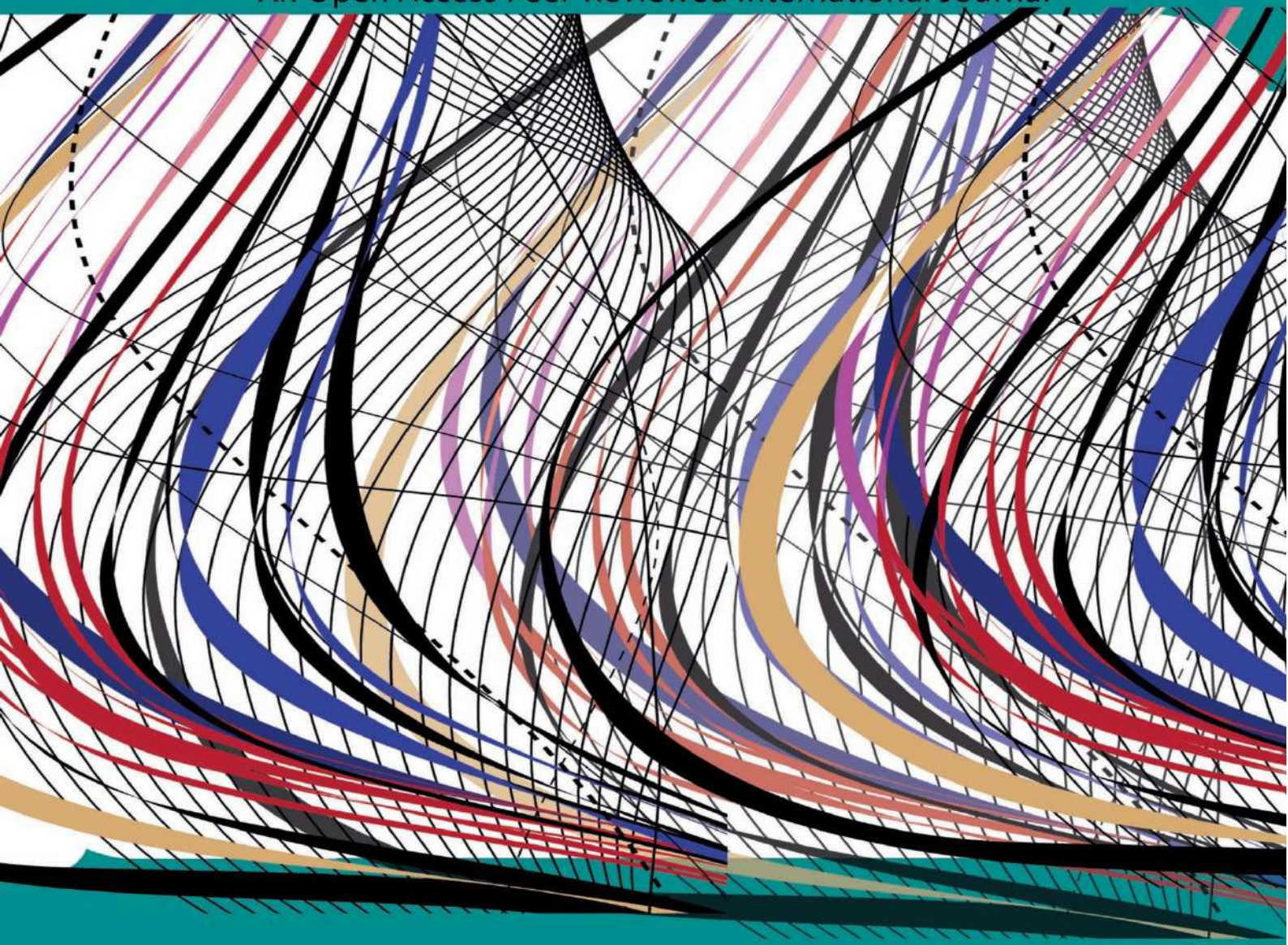

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# FOREWORD

I am pleased to put into the hands of readers Volume-7; Issue-10: October 2021 of "**International Journal of Advanced Engineering, Management and Science (IJAEMS) (ISSN: 2454-1311)",** an international journal which publishes peer reviewed quality research papers on a wide variety of topics related to Science, Technology, Management and Humanities. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release print issue also, but this decision the journal issue will be available in various library also in print and online version. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind. This journal has DOI (Digital Object Identifier) also, this will improve citation of research papers.

I thank all the authors of the research papers for contributing their scholarly articles. Despite many challenges, the entire editorial board has worked tirelessly and helped me to bring out this issue of the journal well in time. They all deserve my heartfelt thanks.

Finally, I hope the readers will make good use of this valuable research material and continue to contribute their research finding for publication in this journal. Constructive comments and suggestions from our readers are welcome for further improvement of the quality and usefulness of the journal.

With warm regards.

**Dr. Dinh Tran Ngoc Huy**
Editor-in-Chief
November, 2021

# ***Editorial Board/ Reviewer Board***

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# Field Survey of Defects in RC Bridges

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***Abstract***— *Egypt has a large road network on which more than 3,000 bridges are in service. To provide for safe and functional bridges, periodic inspection and assessment of bridge condition is essential. This paper presents the results of a part of on-going research project in which seven RC bridges in Egypt were visually inspected in 2019 and 2020. The inspection results are used to survey the types and quantities of defects that are common in different elements of RC bridges. The defects that were surveyed in the current investigation include spalling of concrete with and without exposed rebar; wear and pothole in wearing surface; distortion and connection in metal railing; crack, delamination and spalling in median barrier; and wear, spalling and settlement in curbs and sidewalks. The inspection results are further used to determine the densities of these defects in the main elements of RC bridges. Discussion is also made on the evolution of defects with aging of bridges.*

***Keywords***— ***Bridge, Defects, Visual Inspection, Condition Rating.***

## I. INTRODUCTION

According to GARBLT (2015b), Egypt has a road network of more than 64,000 km across the country, on which more than 3,000 bridges are in service. The reinforced concrete (RC) bridges represent approximately 90% of the bridges in Egypt (GARBLT 2015b). Moreover, the road networks and their bridges have increased largely during the last decade. These bridges differ in type, capacity, age and condition. Accidents occur because of deterioration or failure of roads or bridges. Since 1992 and for 20 years, the victims of roads and bridges in Egypt counted approximately 245000 people dead and 73000 injured. This represents 25 times the global rate (Al-Ahram 2015).

Over their lifetime, bridges deteriorate as a result of structural damage and/or material degradation and other causes. Therefore, timely action for maintenance, repair or rehabilitation is essential. This provides for safe and functional bridges. This necessitates a management tool to effectively inspect, manage and maintain bridges within imposed constrains (mainly budgetary constraints). A reliable bridge management system (BMS) for inspecting, managing and maintaining the bridge networks in Egypt has not yet been established. Inspections are usually made in response to warnings received from sources very often outside the bridge network system, or as a result of obvious inadequacy of a bridge to fulfill its expected function. Many bridges in Egypt suffer from major problems because of insufficient periodic inspection and maintenance (Elfahham 2016). This is mainly attributed to the shortage of skilled and well-trained human resources and equipment that are necessary for proper inspection and assessment of the conditions of bridges (GARBLT 2015b). The problem is exacerbated by the unavailability of clear strategy to conduct periodic inspection and maintenance in the right time.

Therefore, maintenance and management of the existing bridges has been a great concern for the Egyptian government and the public alike. In collaboration between the General Authority for Roads, Bridges and Land Transport (GARBLT) and Japan International Cooperation Agency (JICA), a number of bridges were inspected in the period 2013–2015 for the purpose of establishing inventory data of the bridges on regional roads of the country. This has been challenged by the scarcity of bridges' data and the large number of bridges in the network that needed much efforts and time to be surveyed

(Elfahham 2016). Since 2015 several bridges on the railway network have been inspected through collaborations between the National Authority for Egypt's Railways and Egyptian universities. This has been made for the purpose of evaluating the structural conditions of these bridges and proposing schemes for appropriate maintenance and repair works. The Board of Governors in 2015 established a working group to coordinate between the Ministry of Transportation and the Ministry of Higher Education for the development of a strategy and executive program for the evaluation and maintenance of the bridges in Egypt.

Research efforts have been made to establish systems for bridge management in Egypt (e.g., Abu-Hamd 2006; Abbas 2012; GARBLT 2015a; Elfahham 2016; Mansour et al. 2019). These efforts have contributed to the community of bridge engineering and management in Egypt. However, the developed systems have not accounted for important factors such as material vulnerability (Abbas 2012; GARBLT 2015a; Elfahham 2016), inspection quality (Abbas 2012; GARBLT 2015a; Elfahham 2016), environmental conditions (Abbas 2012, Final Seminar 2015), aging (Abbas 2012; Final Seminar 2015; Elfahham 2016), functional efficiency and client requirements (GARBLT 2015a). Moreover, the applicability of these systems has not been evaluated especially in terms of the inspection method and outputs, effect of environmental conditions on bridge deterioration, and bridge defects that are common in Egypt.

Inspection of bridges is an essential element of any BMS especially for aged and deteriorated bridges. Assessment and rating of bridges are based on the results of adopted inspection. The accuracy of bridge condition assessment relies heavily on the quality of inspection (Branco and de Brito 2004; Rashidi and Gibson 2011). Therefore, the heart of a BMS is the database derived from regular inspection and maintenance activities. The integrity of a BMS is directly related to the quality and accuracy of the bridge inventory and physical condition data obtained through field inspections (AASHTO 1994).

This paper presents the results of a part of on-going research project that aims at establishing a practical BMS for the RC bridges in Egypt. The main objectives of this project include the development of database of bridge deterioration data with time, determination of appropriate inspection methodology and period, determination of the factors that significantly affect the deterioration of bridges and evaluation of their effects, determination of the bridge defects that are common and critical, and evaluation of bridge deterioration with age. The current paper presents the results of visual inspections made in 2019 and 2020 on seven RC bridges in Egypt. These results are used to quantitatively evaluate the defects in the elements of the bridges. Discussions are made on the common types of defects, their causes and their evolution with time.

## II. BACKGROUND

### 2.1 Condition Rating and Inspection

The condition of any component of a bridge may have an impact on the integrity or safety of the structure (e.g., Laman and Guyer 2010; Sutton et al. 2013). Therefore, the condition of a bridge and its elements must be inspected or monitored and evaluated regularly. This ensures the safety and functionality of bridges or determines the priorities for maintenance, repair or rehabilitation. Having sufficient inventory data such as traffic volume information, structural characteristics and bridge sketches as well as reliable data gathered through inspection, the condition of a bridge can be assessed (e.g., Suksuwan and Hadikusumo 2010; Adhikari et al. 2012).

Visual inspection (VI) is considered as the basic and prevalent technique of bridge inspection (e.g., Gattulli and Chiaramonte 2005; Liu et al. 2011). The funds, time and efforts involved in experimental investigations render VI more practical and appealing for bridge inspection. Currently available BMSs such as the earliest Pontis (Thompson et al. 1998) and BRIDGIT (Hawk and Small 1998; Small 2002) as well as the Finnish (Söderqvist and Veijola 1998), Danish (Lauridsen et al. 1998), German (Haardt 2002) and Japanese (Miyamoto et al. 2000) BMSs rely primarily on information obtained through visual inspection. The objective of VI is to evaluate the physical condition of a bridge. It is usually done on a routine basis by inspectors to detect and evaluate the deterioration and spot damages on the different structural elements of a bridge; most bridge defects (such as cracks, spalls and leaching) can be visually detected.

### 2.2 Common Bridge Defects

Bridges deteriorate because of many potential causes. Examples of such causes include chloride contamination, freeze-thaw, alkali-silica reaction, ettringite formation, collision damage, overload damage, carbonation, chemical attack, moisture absorption, differential foundation movement, design and construction deficiencies, temperature changes and fire damage (FHWA 2012). These causes result in defects in the elements of bridges. For the purpose of assessing the condition of a bridge, the defects need to be surveyed through inspection.

Several efforts have been made to survey and classify the common defects of RC bridges. Suksuwan and Hadikusumo (2010) used historical VI data of bridges in Thailand to survey and classify the types of defects that

potentially contribute to the deteriorations of different bridge elements. This was supported by suggestions and recommendations from interviews with experts. They reported that the common defects in columns include cracking of concrete because of shrinkage and temperature variation, scaling and wearing of concrete cover, porous material because of deteriorated and aged concrete, delamination of concrete cover, spalling and popouts of concrete cover. For deck slab, the defects include porous material because of deteriorated and aged concrete, spalling and popouts of concrete cover, potholes of the bridge deck, cracks and spalls around expansion joint of slabs, cracks and spalls at the end of deck over the cap beam, corrosion, and rusting of reinforcing steel. As for the wearing surface, the defects include friction loss because of polished aggregate, raveling because of loss of adhesion, corrugation of asphalt concrete surface and damaged patching of repaired area.

Rashidi and Gibson (2011) reported that the common defects of concrete bridges may be classified into discoloration, efflorescence, cracking and spalls, corrosion of non-prestressed reinforcement or deterioration of the prestress system and delamination. Moufti (2013) reported that the defects that are common in RC bridge elements include the following:

- Structural concrete elements: scaling, corrosion of reinforcement, pop-outs, cracking, delamination/ spalling, erosion and wet areas.
- Wearing surfaces: cracking, potholes, rutting, rippling and loss of bond.
- Drainage systems: pipe breakage, loosening/deterioration of components or connections or fasteners.
- Bearings: cracking, deformations, scouring/scratches, corrosion and bending/cracking of anchor bolts/welds.

Elfahham (2016) reported the following defects in concrete bridges: concrete cracking, concrete carbonation, concrete efflorescence, chloride contamination, alkali-Silica reaction (ASR), reinforcement steel corrosion, deteriorated joint seal, deteriorated expansion joint, defective drainage system, defective lighting unit, defective connections, defective prestressing cable anchors, misalignment, settlement, scour, leakage, dirt and debris, deck traffic impact (load capacity), deck deflection, deck delamination/spalling, substructure traffic impact, superstructure traffic impact.

However, little effort has been made to evaluate the densities of the defects that are common in the different elements of RC bridges. This is important in assessing the severity of the condition of a bridge element. Tuttle (2005) conducted visual inspections and survey of defects in sections of bridge decks. The defects were compiled with photographs. The types and locations of the defects were documented on defect survey worksheets. Measurements were taken on the top surfaces of the decks. The records included crack width and locations of delamination and potholes. These records were used to calculate the average crack density, crack severity and pothole density.

## III. INSPECTION METHODOLOGY

In the current investigation, seven RC bridges (B1–B7) were visually inspected. The bridges are located on the ring road in the Greater Cairo as shown in Fig. 1. The ring road is a peripheral road connecting the governorates of the Greater Cairo. The seven bridges were selected for this investigation because of two main reasons: (1) many defects were clearly visible in the bridges at the time of inspection, and (2) they are located on the ring road which is a vital and important road in Cairo. The inventory data of the seven bridges are summarized in Table 1. They consist of general information, bridge characteristics and environmental conditions. The general information include the bridge number, bridge name, city, district, road name, year built, obstacle/crossing, previous owner, current owner, previous inspection and previous MR&R. The bridge characteristics include the structure type, material, construction method, length, width, vertical clearance, median width, sidewalk width, number of lanes, design load and general planning. According to Rashidi (2013), the environmental conditions include the environmental actions that cause chemical and physical deterioration of concrete. The degradation mechanism is usually related to the interaction between the environment and the material. The interaction with the environment is usually associated with climatic condition, air, aggressive soil cause, chemical reaction within concrete and human actions.

B2, B5 and B7 consist of two, six and single spans, respectively. All spans of the three bridges were inspected. B1 consists of three spans. A single span of B1 was inspected. B6 consists of sixteen spans. A single span of B6 was inspected. Both of B3 and B4 consist of five spans. The spans of B3 and B4 were inspected**.** Inspection included all the visible components which are the deck, superstructure and substructure. The foundations of the bridges could not be inspected. Inspection was made in two stages. The first was made from under the deck of a bridge. This consisted of visual inspection of the bottom of the deck, superstructure and substructure. For the superstructure, the beams/girders were inspected. However, the bearings were not clearly visible and

therefore could not be inspected. As for the substructure, the piers, bents, pier walls, pier caps and abutments were inspected. The foundations could not be inspected. In the second stage, inspection was made on the top surface of a bridge. This consisted of inspection of the wearing surface, railing, median barriers, curbs/sidewalks and expansion joints.

The seven bridges were inspected twice: in July 2019 and August 2020. The defects were surveyed for every inspected element. The characteristics of each defect were also recorded and described. The defects were then classified according to AASHTO (2011) and NJDOT (2015). A metric laser was used to measure the dimensions of a defect, such as the length and width as well as the depth if any. The severity of a defect was described on the basis of the guidelines of AASHTO (2011) and NJDOT (2015). It is worth mentioning that the inspection methodology and guidelines of AASHT (2011) and NJDOT (2015) are followed in most of the reported studies and inspections as they provide for reduced subjectivity and uncertainty.

## IV. INSPECTION RESULTS

Examples of the defects surveyed in the inspections of the girders of B6 and deck slab of B7 in 2020 are shown in Figs. 2 and 3, respectively. The results of the visual inspection made in 2019, for example, are summarized in Tables 2 through 4. The total number of defects in each element of the seven bridges is shown in Table 2. Table 3 shows the types of defects in each element of the seven bridges. However, the number of each defect type is shown in Table 4 for every element of the seven bridges. In the remaining part of this section, the results of the inspections made in 2019 and 2020 are presented and described for each defect.

### 4.1 Spalling Density

The percentage of spalling density (SD) was calculated for the inspected decks, girders, piers, pier caps and abutments of the seven bridges (B1 through B7). It was calculated following the method of AASHTO (2011). For decks, it was calculated by dividing the quantity of spalling in square meters by the total area of deck. However, for girders it was calculated by dividing the quantity of spalling in meter by the total length of girders. For bents/piers it was calculated by dividing the quantity of spalling in square meters by the total area of bents/piers. For pier walls it was calculated by dividing the quantity of spalling in square meters by the total area of pier walls. For abutments it was calculated by dividing the quantity of spalling in meter by the total length of abutments.

The calculated SD is represented in Figs. 4 and 5 for the inspections of 2019 and 2020, respectively. No spalling was observed in the decks of B2, B5 and B6. For the decks of the other bridges, it is seen that SD ranges from 0.003 to 0.32%. Significant SD was observed in the girders of all bridges. It ranges from 2.67 to 76.30%. The greatest percentages were observed in the girders of B3 and B4. For the bents, piers and pier walls, the figures show no spalling for B1, B4 and B6. However, for the other bridges, the percentage ranges from 0.04 to 0.49%. No spalling was observed in the pier caps of all bridges. For the abutments, SD of approximately 6.25% was observed only in B5.

A comparison between the results in Figs. 4 and 5 shows useful observations on the effect of time (aging) on SD in RC bridges. For decks, very small increases of SD are observed. It increased from 0.0 to 0.09%, 0.0 to 0.05% and 0.32 to 0.40% in the decks of B2, B6 and B7, respectively. No increases were observed in the decks of the other bridges. However, for girders significant increases of SD were observed in most of the inspected bridges. SD of girders increased from 3.10 to 7.60%, 4.16 to 6.92%, 66.60 to 79.90%, 7.36 to 22.29% and 20.20 to 24.25% in B1, B2, B3, B6 and B7, respectively. No significant increases were observed in the girders of B4 and B5. For the bents, piers and pier walls very small increases of SD were observed because of time. SD increased from 0.29 to 0.58%, 0.0 to 0.15% and 0.0 to 0.03% for B3, B4 and B6, respectively. No increases were observed for the other bridges. Figures 4 and 5 show no appreciable increase of SD in the pier caps and abutments for all the inspected bridges.

### 4.2 Spalling Density without Exposed Rebar

The percentage of spalling density without exposed rebar (SDOER) was calculated for the inspected decks, girders, piers, pier caps and abutments. The calculation of SDOER was exactly the same way as that of SD; SDOER is only for the spalling without exposed rebar. The calculated SDOER is represented in Figs. 6 and 7 for the inspections of 2019 and 2020, respectively. For the decks, SDOER ranges from 0.003 to 0.25%. No SDOER was observed in the girder of B5. For the girders of the other bridges, SDOER ranges from 0.55 to 76.30%. For the bents, piers and pier walls, SDOER of approximately 0.04 and 0.49 was observed only in B2 and B5, respectively. No SDOER was observed in the abutments of all bridges.

A comparison between the results in Figs. 6 and 7 indicates the effect of time (aging) on SDOER. For decks, very small increases of SDOER because of time are observed. It increased from 0.0 to 0.009% and 0.006 to 0.042% in the decks of B6 and B7, respectively. No

significant increases are observed in decks of the other bridges. However, for girders, SDOER increased from 0.55 to 2.10% and 66.60 to 79.90% in B2 and B3, respectively. No significant increases are observed in the girders of the other bridges. Figures 6 and 7 show no appreciable increase of SDOER in the bents, piers and pier walls and abutments for all the inspected bridges.

### 4.3 Spalling Density with Exposed Rebar

The percentage of spalling density with exposed rebar (SDWER) was calculated for the inspected decks, girders, piers, pier caps and abutments. The calculation of SDWER was exactly the same way as that of SD; SDWER is only for the spalling with exposed rebar. The calculated SDWER is represented in Figs. 8 and 9 for the inspections of 2019 and 2020, respectively. No significant SDWER can be seen in the decks of B3 and B4. For the decks of the other bridges, SDWER of approximately 0.002 and 0.31% is observed in B1 and B7. No significant SDWER can be seen in the girders of B3, B4 and B7. For the girders of the other bridges, SDWER ranges from 2.00 to 5.76%. For the bents, piers and pier walls, SDWER of approximately 0.29% was observed only in B3. For the abutments, SDWER of approximately 6.25% was observed only in B5.

A comparison between the results in Figs. 8 and 9 reveals the effect of time (aging) on SDWER in RC bridges. For decks, very small increases of SDWER are observed. It increased from 0.0 to 0.09%, 0.0 to 0.04% and 0.31 to 0.36% in the decks of B2, B6 and B7, respectively. No increases are observed in the decks of the other bridges. However, for girders significant increases of SDWER are observed in most of the bridges. It increased from 2.00 to 6.94%, 3.61 to 4.82%, 5.67 to 22.08% and 0.0 to 5.00% for B1, B2, B6 and B7, respectively. For the bents, piers and pier walls very small increases of SDWER are observed because of time. It increased from 0.29 to 0.58%, 0.0 to 0.15% and 0.0 to 0.03% for B3, B4 and B6, respectively. No increases are observed for the other bridges. Also, no significant increase of SDWER can be seen in the abutments for all the inspected bridges.

### 4.4 Wear and Pothole Densities in Wearing Surface

The percentages of wear and pothole densities were calculated for the inspected wearing surfaces of B1 through B7. They were calculated following the method of AASHTO (2011). Wear density was calculated by dividing the quantity of wear in square meters by the total area of the wearing surface. Pothole density was calculated by dividing the quantity of pothole in square meters by the total area of the wearing surface. The calculated wear density is represented in Fig.10 for the inspections of 2019. It is seen that the wear density ranges from 50 to 100%. No significant pothole was observed in the wearing surfaces of all bridges in 2019. A comparison between the results of the inspections in 2019 and 2020 shows no appreciable increase of the wear density in the wearing surface for all the inspected bridges. However, a very small increase of the pothole density was observed because of time in the wearing surface of B2 only. It increased from 0.0 in 2019 to 0.03% in 2020.

### 4.5 Distortion and Connection Densities in Metal Railing

The percentages of distortion and connection densities were calculated for the inspected metal railings of the seven bridges. The distortion density was calculated by dividing the quantity of distortion in meter by the total length of metal railing. The connection density was calculated by dividing the quantity of connection in meter by the total length of metal railing. The calculated distortion and connection densities for the inspections of 2019 are represented in Figs. 11 and 12, respectively. It is seen that the distortion density ranges from 0.38 to 15.00%. No connection was observed in the metal railings of B2, B4 and B7. For the metal railings of the other bridges, the connection density ranges from 0.43 to 0.69% (see Fig. 12). A comparison between the results for the inspections of 2019 and 2020 shows no appreciable increase of distortion and connection densities in the metal railings for all the inspected bridges.

### 4.6 Cracks, Delamination and Spalling Densities in Median Barrier

The percentages of crack, delamination and spalling densities in median barrier were calculated for the seven bridges following the method of AASHTO (2011). The defect (crack, delamination or spalling) density was calculated by dividing the quantity of defect in meter by the total length of median barrier. As for the inspections of 2019, a crack density of approximately 1.89% was observed only in the median barrier of B1; there is no median barrier in B5. No delamination was observed in the median barriers of all bridges. No spalling was observed in the median barriers of B1, B3, B4 and B6. Spalling densities of approximately 5.00 and 6.82% were observed in the median barriers of B2 and B7, respectively. The inspections of 2020 indicated small increases of crack and delamination densities in the median barrier of B1. The crack density increased from 1.89 in 2019 to 5.03% in 2020. The delamination density increased from 0.0 in 2019 to 3.14% in 2020. No appreciable increase of spalling density was observed in 2020 in the median barriers of all bridges.

### 4.7 Wear, Spalling and Settlement Densities in RC Curbs and Sidewalks

The percentages of wear, spalling and settlement densities were calculated for the inspected RC curbs and sidewalks following the method of AASHTO (2011). The defect (wear, spalling or settlement) density was calculated by dividing the quantity of defect in meter by the total length of the RC curbs and sidewalks. The calculated wear and spalling densities of 2019 are represented in Figs. 13 and 14, respectively. It should be mentioned that the sidewalk of B1 was newly constructed at the time of inspection in 2019. Also, no defects were observed in the RC curbs and sidewalks of B6 in 2019. Figure 13 shows that the wear density ranges from 95.00 to 99.33%. Figure 14 also shows that the spalling density ranges from 0.67 to 5.00%. The inspections of 2020 revealed no appreciable increase in the wear, spalling or settlement in the RC curbs and sidewalks for all bridges. Also, because of planned expansion works no sidewalk was constructed in B7 in 2020.

## V. ANALYSIS AND DISCUSSION

### 5.1 Spalling Density

On the basis of the results in Figs. 4 and 5, Table 5 summarizes the minimum, maximum and average values of SD for the inspected bridge elements. It is seen that SD in decks ranges from 0.0 to 0.32% with an average of 0.08% in 2019. However, it ranges from 0.0 to 0.40% with an average of 0.11% in 2020. It is worth mentioning that Tuttle (2005) reported SD of 0.42% for deck slabs. This is highly consistent with the above results. For girders, SD ranges from 2.67 to 76.30% with an average of 25.77% in 2019. It ranges from 2.67 to 79.90% with an average of 31.42% in 2020. As for the bents, piers and pier walls SD ranges from 0.0 to 0.49% with an average of 0.14% in 2019. In 2020, it ranges from 0.0 to 0.58% with an average of 0.21%. For abutments, SD ranges from 0.0 to 6.25% with an average of 1.56% in 2019 with no change in 2020.

The results in Figs. 4 and 5 reveal the following:

- For the deck slabs, the results of 2019 show that SD is the greatest for B7 (0.32%). Then, it decreases in order for B1 (0.25%), B3 (0.003%), B4 (0.003%), B2 (0.00), B5 (0.00) and B6 (0.00). The results of 2020 show that SD is the greatest for B7 (0.40%). Then, it decreases in order for B1 (0.25%), B2 (0.09%), B6 (0.05%), B3 (0.003%), B4 (0.003%) and B5 (0.00).
- For the girders, the results of 2019 indicate that SD in 2019 is the greatest for B4 (76.30%). Then it decreases in order for B3 (66.60%), B7 (20.20%), B6 (7.36%), B2 (4.16%), B1 (3.10%) and B5 (2.67%). However, the results of 2020 indicate that SD is the greatest for B3 (79.90%). Then, it decreases in order for B4 (76.30%), B7 (24.25%), B6 (22.29%), B1 (7.60%), B2 (6.92%) and B5 (2.67%).
- As for the bents, piers and pier walls, the results of 2019 show that SD is the greatest for B5 (0.49%). Then, it decreases in order for B3 (0.29%), B2 (0.04%), B1 (0.00), B4 (0.00) and B6 (0.00). The results of 2020 show that SD is the greatest for B3 (0.58%). Then, it decreases in order for B5 (0.49%), B4 (0.15%), B2 (0.04%), B6 (0.03%) and B1 (0.00).
- For the abutments, SD was observed only in B5 (6.25%) in 2019. No change was experienced in 2020.

A careful investigation and monitoring of the inspection sites indicated that spalling of concrete in the inspected bridges is attributed to several causes as follows:

- For the decks, spalling was attributed to rusting reinforcement as well as previous repair and development works.
- For the girders, spalling was attributed to several causes that include: age of bridge, impact by trucks, fire, environmental conditions and geometrical characteristics of bridge such as superelevation in bridge alignment. A truck impacts the bottom of a girder if the truck height exceeds the clear height of a bridge. The investigation and inspection revealed clear symptoms of impact at the bottom of the girders of B1, B2, B6 and B7. The spalling of concrete at the girders of B6 and B7 was significantly greater than that of B1 and B2. Impact may happen also in case of existence of asphalt overlay on the road below a bridge
- For the bents, piers and pier walls of B2, spalling was attributed to the cleaning works and equipment that were routinely done around the bridge. For B3 and B4, environmental factors and uncontrolled garbage were the main causes. For B5, spalling was caused by fire at the location of the bridge.

### 5.2 Spalling Density without Exposed Rebar

Table 6 shows that SDOER in the deck slabs ranges from 0.0 to 0.25% with an average of 0.04% in 2019 with no significant change in 2020. For girders, SDOER ranges from 0.00 to 76.30% with an average of 23.76% in 2019.

However, it ranges from 0.00 to 79.90% with an average of 25.49% in 2020. As for the bents, piers and pier walls SDOER ranges from 0.00 to 0.49% with an average of 0.09% in 2019 with no change in 2020. This indicates that SDOER in girders is largely greater than that in deck slabs.

For deck slabs, Fig. 6 shows for the inspections of 2019 that SDOER is the greatest for B1 (0.25%). Then, it decreases in order for B7 (0.01), B3 (0.003%), B4 (0.003%), B2 (0.00), B5 (0.00) and B6 (0.00). However, Fig. 7 shows for the inspections of 2020 that SDOER is the greatest for B1 (0.25%). Then, it decreases in order for B7 (0.04%), B6 (0.009%), B4 (0.003%), B3 (0.003%), B2 (0.00) and B5 (0.00). As for the girders, SDOER for the inspections of 2019 is the greatest for B4 (76.30%). Then, it decreases in order for B3 (66.60%), B7 (20.20%), B6 (1.60%), B1 (1.06%), B2 (0.55%) and B5 (0.00). However, SDOER for the inspections of 2020 is the greatest for B3 (79.90%). Then it decreases in order for B4 (76.30), B7 (19.25%), B2 (2.10%), B1 (0.66%), B6 (0.21%) and B5 (0.0). For the bents, piers and pier walls, it is seen for the inspections of 2019 that SDOER is the greatest for B5 (0.49). Then, it decreases to 0.04% for B2 and 0.00 for B1, B3, B4 and B6. SDOER did not experience significant changes in the period from July 2019 to August 2020.

### 5.3 Spalling Density with Exposed Rebar

Table 7 summarizes SDWER the inspected elements of the seven bridges. It shows for the inspections of 2019 that SDWER in deck slabs ranges from 0.0 to 0.31% with an average of 0.06%. However, for the inspections of 2020, it ranges from 0.0 to 0.36% with an average of 0.07%. For girders, SDWER ranges from 0.0 to 5.76% with an average of 2.01% in 2019. However, it ranges from 0.0 to 22.08% with an average of 5.93% in 2020. As for the bents, piers and pier walls, SDWER ranges from 0.0 to 0.29% with an average of 0.05% in 2019. It ranges from 0.0 to 0.58% with an average of 0.13% in 2020. For abutments, SDWER ranges from 0.0 to 6.25% with an average of 1.56% in 2019 with no significant change in 2020.

For deck slabs, Fig. 8 shows for the inspections of 2019 that SDWER is the greatest for B7 (0.31%). Then, it decreases to 0.002% for B1 and 0.00 for B2, B3, B4, B5 and B6. For the inspections of 2020, Fig. 9 shows that SDWER is the greatest for B7 (0.36%). Then, it decreases in order for B2 (0.09%), B6 (0.04%), B1 (0.002%), B3 (0.00), B4 (0.00) and B5 (0.00). As for girders, SDWER for the inspections of 2019 is the greatest for B6 (5.67%). Then, it decreases in order for B2 (3.61%), B5 (2.67%), B1 (2.00%), B3 (0.00), B4 (0.00) and B7 (0.00). For the inspections of 2020, SDWER is the greatest for B6 (22.08%). Then, it decreases in order for B1 (6.94%), B7 (5.00%), B2 (4.82), B5 (2.67%), B3 (0.00) and B4 (0.00). For bents, piers and pier walls, SDWER of 0.29% was observed only in B3 in 2019. However, for the inspections of 2020, SDWER is the greatest in B3 (0.58%). Then, it decreased in order for B4 (0.15%), B6 (0.03%), B2 (0.00) and B5 (0.00). For abutments, SDWER of 6.25% was observed only in B5 in 2019. It did not experience significant change in the period from July 2019 to August 2020.

### 5.4 Wear and Pothole Density in Wearing Surface

Table 8 indicates that the wear density in wearing surface ranges from 50 to 100% with an average of 71.43% for both inspections of 2019 and 2020. Figure 10 shows that the wear density in 2019 was approximately 100% for B3, B4 and B5, while it was approximately 50% for B1, B2, B6 and B7. The wear density did not experience significant change in the period from July 2019 to August 2020. Table 8 also shows that no pothole in the wearing surface was experienced in 2019. However, in 2020 it ranges from 0.0 to 0.03% with an average of 0.01%. This indicates that the density of wear is greater than that of pothole in wearing surfaces

### 5.5 Distortion and Connection Density in Metal Railing

Table 9 shows that the distortion density in metal railing ranges from 0.38 to 15.00% with an average of 5.00% in both of 2019 and 2020. However, the connection density ranges from 0.0 to 0.69% with an average of 0.34% in both of 2019 and 2020. This implies that the distortion density is greater than the connection density in metal railing. Figure 11 shows for the inspections of 2019 that the distortion density is the greatest for B2 (15%). Then, it decreases in order for B6 (7.78%), B1 (5.82%), B7 (4.55%), B5 (1.10%), B4 (0.39%) and B3 (0.38%) in both of 2019 and 2020. Figure 12 shows for the inspections of 2019 that the connection density is the greatest for B6 (0.69%). Then, it decreases in order for B1 (0.63%), B3 (0.63%), B5 (0.43%), B2 (0.00), B4 (0.00) and B7 (0.00). No significant changes in distortion or connection were experienced in the period from July 2019 to August 2020. Accident damage was the main cause for the defects in metal railing.

### 5.6 Crack, Delamination and Spalling Density in Median Barrier

Table 10 shows that the crack density in the median bridge barrier ranges from 0.0 to 1.89% with an average of 0.32% in 2019; cracks were observed only in B1. However, it ranges from 0.0 to 5.03% with an average of 0.84% in 2020. It is also seen in Table 10 that no delamination was experienced in the median barrier in 2019. However, the

delamination density ranges from 0.0 to 3.14% with an average of 0.52% in 2020. The inspection results of 2019 show that the spalling density in the median barrier ranges from 0.0 to 6.82% with an average of 1.97% in both of 2019 and 2020. The spalling density was the greatest for B7 (6.82%). Then, it decreased to 5.00% for B2 and 0.00 for B1, B3, B4 and B6. It is seen that density of spalling is greater than that of cracks. In addition, the density of cracks is greater than that of delamination. The cause for these defects in the median barrier was most likely impact of vehicles.

### 5.7 Wearing, Spalling and Settlement Density in Curbs and Sidewalks

The survey results of the defects in the curbs and sidewalks are summarized in Table 11.

The wear density ranges from 0.0 to 99.33% with an average of 69.83% in 2019. However, it ranges from 0.0 to 99.33% with an average of 65.19% in 2020. The spalling density ranges from 0.0 to 5.00% with an average of 1.60% in 2019. In 2020 it ranges from 0.0 to 5.00% with an average of 1.48%. It is seen that settlement density ranges from 0.0 to 99.33% with an average of 28.15% in 2019. However, it ranges from 0.0 to 99.33% with an average of 16.56% in 2020.

Figure 13 shows for the inspections of 2019 and 2020 that the wear density in the curbs and sidewalks is the greatest for B5 (99.33%). Then, it decreases in order for B4 (98.68%), B3 (98.13%), B7 (97.70%), B2 (95.00%), B1 (0.00) and B6 (0.00). As shown in Figure 14, the spalling density is the greatest for B2 (5.00%). Then, it decreases in order for B7 (2.30%), B3 (1.88%), B4 (1.32%), B5 (0.67%), B1 (0.00) and B6 (0.00) in 2019 and 2020. Table 11 indicates that among the defects of the sidewalk, the wear density is the greatest, the spalling density is the lowest, and the settlement density is intermediate. The main cause for the defects in the median barrier was most likely the traffic and impact of vehicles.

## VI. CONCLUSIONS

The results of visual inspections made in 2019 and 2020 on seven RC bridges in Egypt are presented and discussed in this paper. The age of the inspected bridges is approximately 35 years. The inspection results were used to quantitatively survey the types and quantities of defects in the different elements of RC bridges. On the basis of the presented results and discussions, the main conclusions that can be drawn include the following:

- The common defects that were surveyed in the 35 year bridges are spalling of concrete with and without exposed rebar; wear and pothole in wearing surface; distortion and connection in metal railing; crack, delamination and spalling in median barrier; and wear, spalling and settlement in curbs and sidewalks.
- The density of concrete spalling in deck slabs and girders ranges from 0.00 to 0.40% and 2.67 to 79.90%, respectively. In bents, piers and pier walls it ranges from 0.0 to 0.58%. In abutments it ranges from 0.0 to 6.25%. The spalling of concrete in deck slabs is attributed to rusting reinforcement and previous repair and development works, while that in girders is attributed to age of bridge, impact by trucks, fire, environmental conditions and geometrical characteristics of bridge. For bents, piers and pier walls, spalling is attributed to cleaning works and equipment, environmental factors and fire.
- The density of wear and pothole in wearing surface ranges from 50.00 to 10.00% and 0.00 to 0.03%, respectively.
- The density of distortion and connection in metal railing range from 0.38 to 15.00% and 0.0 to 0.69%, respectively. Distortion and connection in metal railing are most likely attributed to damage by accidents.
- The density of crack, delamination and spalling in median barrier ranges from 0.0 to 5.03%, 0.0 to 3.14% and 0.0 to 6.82%, respectively. These are likely attributed to the impact of vehicles.
- The density of wear, spalling and settlement in curbs and sidewalks ranges from 0.0 to 99.33%, 0.0 to 5.00% and 0.0 to 99.33%, respectively. These defects are most likely attributed to the traffic and impact of vehicles.

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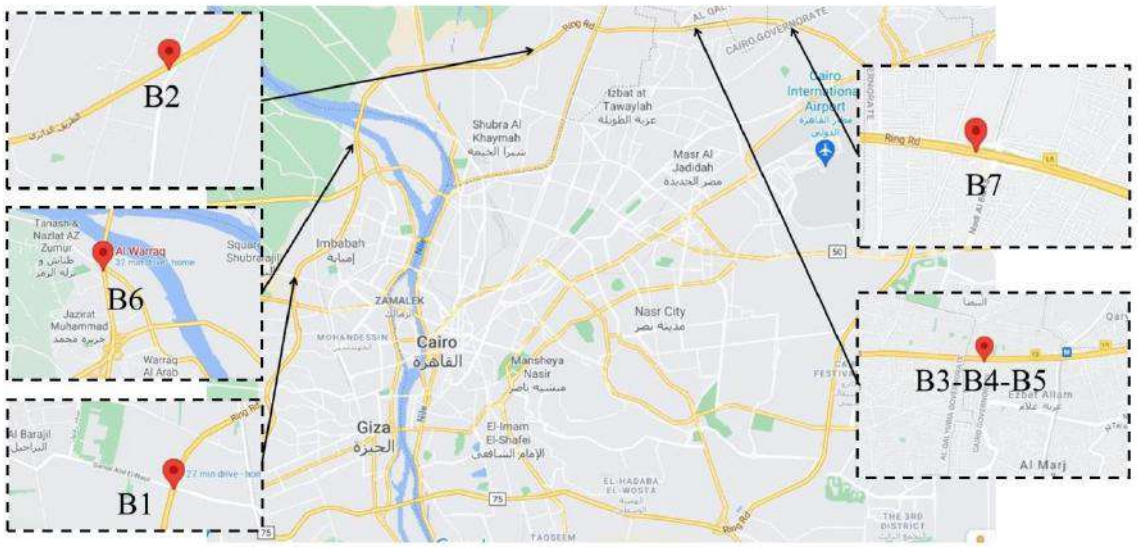


*Fig.1: Map locations of seven inspected bridges on the ring road of the Greater Cairo*

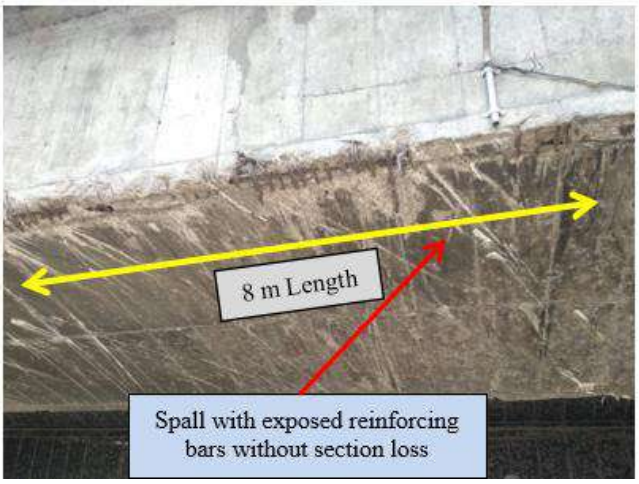


*Fig.2: Example defects in girder of B6*

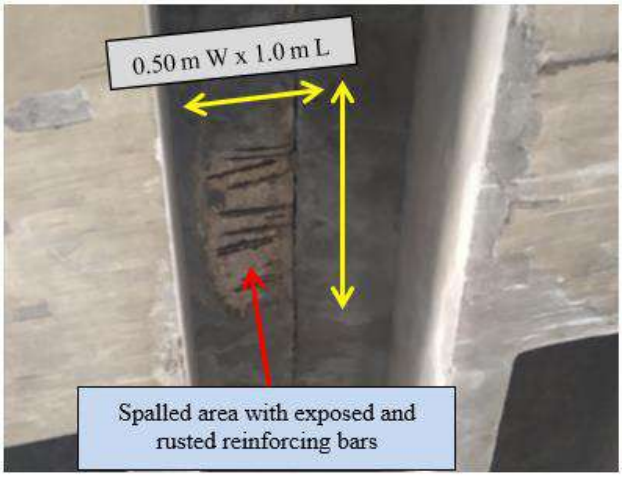


*Fig.3: Example defects in deck slab of B7*

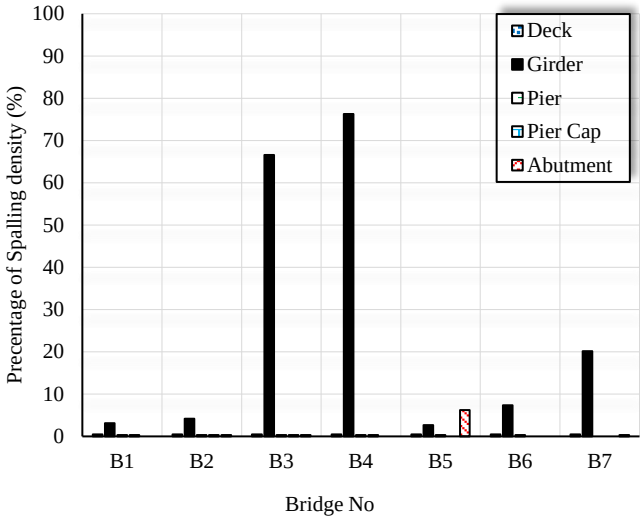


*Fig.4: SD for elements of seven bridges inspected in July 2019*

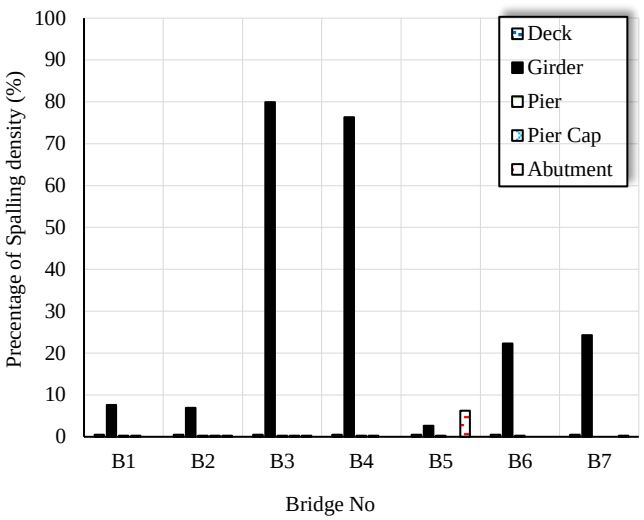


*Fig.5: SD for elements of seven bridges inspected in August 2020*

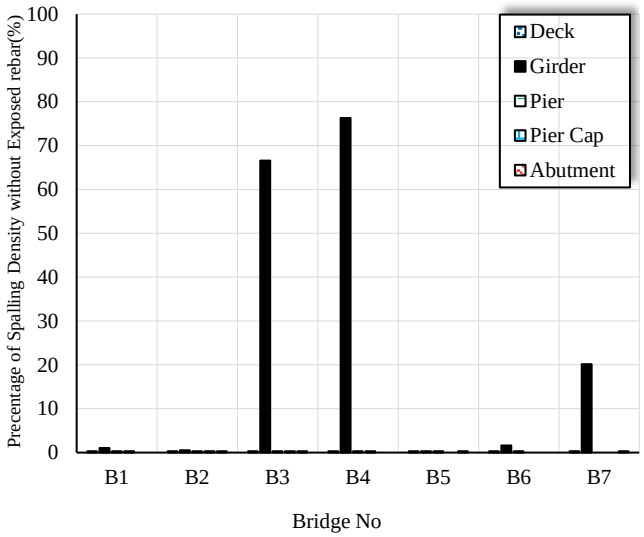


*Fig.6: SDOER for elements of seven bridges inspected in July 2019*

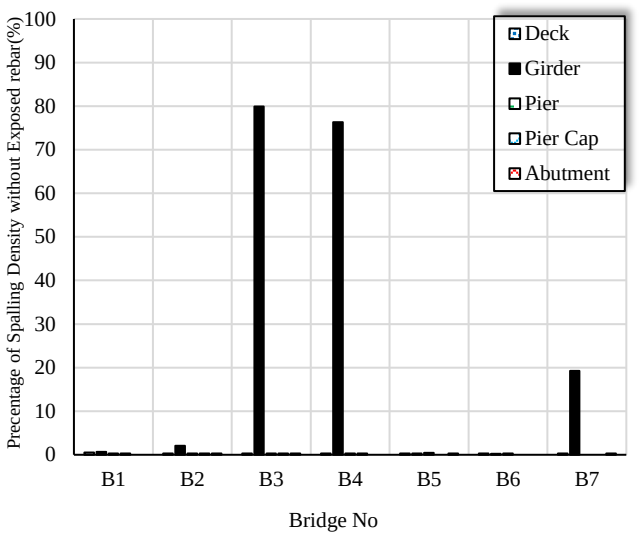


*Fig.7: SDOER for elements of seven bridges inspected in August 2020*

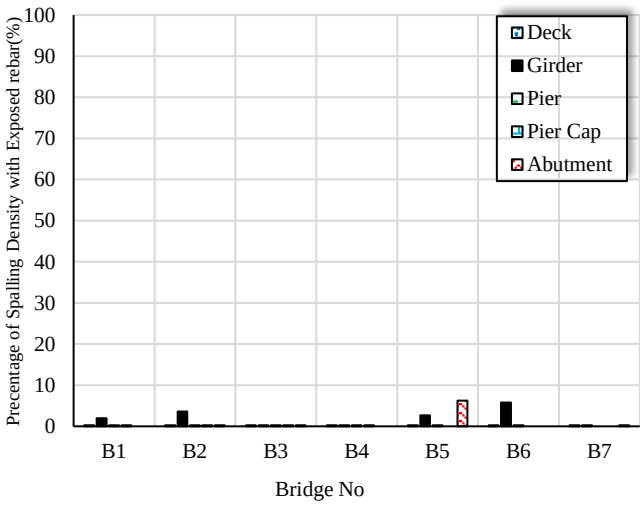


*Fig.8: SDWER for elements of seven bridges inspected in July 2019*

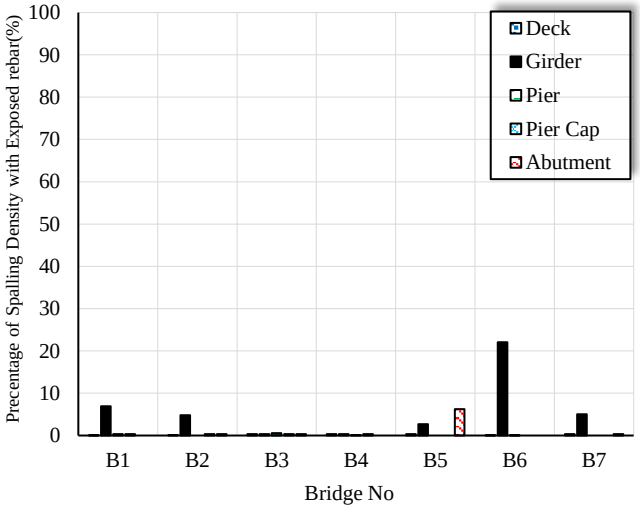


*Fig.9: SDWER for elements of seven bridges inspected in August 2020*

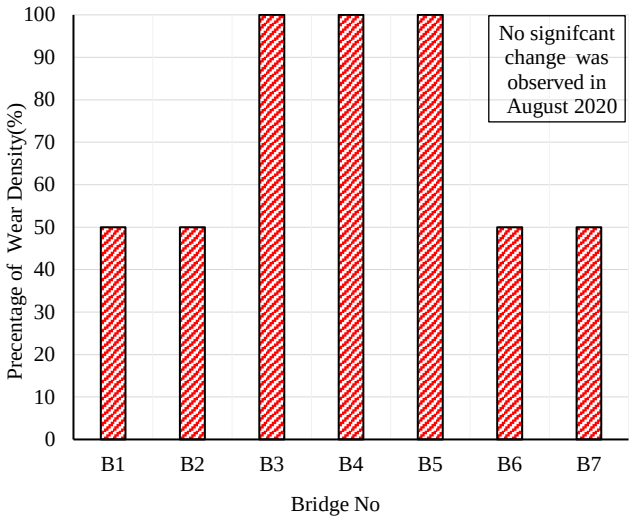


*Fig.10: Wear density in wearing surfaces of seven bridges inspected in July 2019*

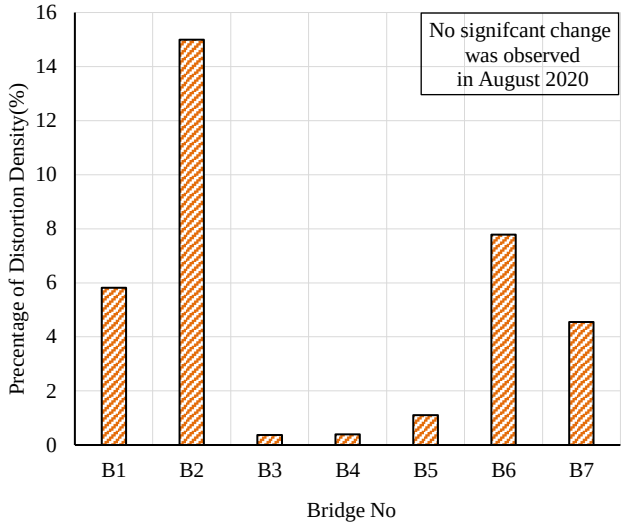


*Fig.11: Distortion density in metal railing of seven bridges inspected in July 2019*

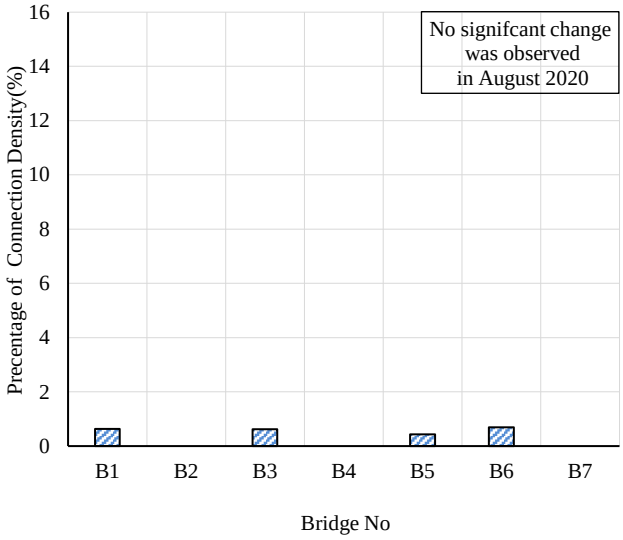


*Fig.12: Connection density in metal railing of seven bridges inspected in July 2019*

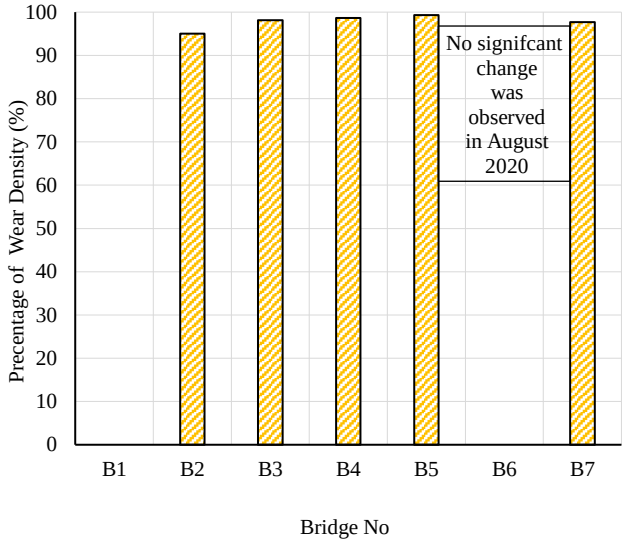


*Fig.13: Wear in RC curbs and sidewalks of seven bridges inspected July 2019*

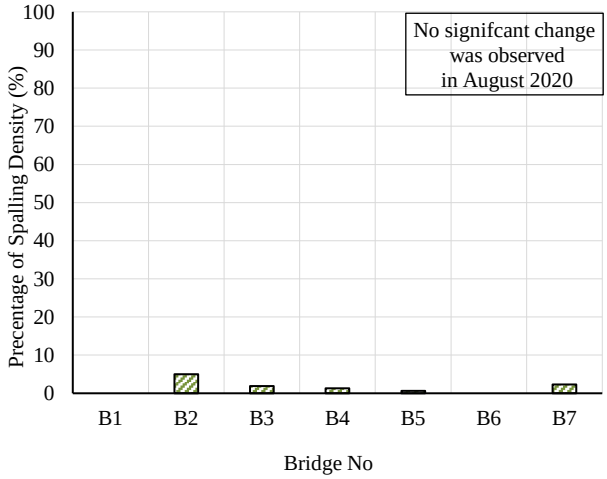


*Fig.14: Spalling density in RC curbs and sidewalks of seven bridges inspected in July 2019*

*Table 1. Inventory data of seven inspected bridges on the ring road of the Greater Cairo*

| Bridge No | B1 | B2 | B3 | B4 | B5 | B6 | B7 |
|---|---|---|---|---|---|---|---|
| **Bridge Name** | El Barajil | Bahteem | El Marg "part1" | El Marg "part 2" | El Marg "one way" | El Warraq | El Zakah |
| **Location** | El Barajil | Bahteem | El Marg | El Marg | El Marg | El Warraq | El Zakah |
| **City** | Giza | Qalyubia | Cairo | Cairo | Cairo | Qalyubia | Cairo |
| **District** | Embaba | East Shubra Al-Khaimah | El Marg | El Marg | El Marg | El Warraq | Al Salam |
| **Road Name** | Ring road | Ring road | Ring road | Ring road | Ring road | Ring road | Ring road |
| **Year Built** | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 | 1986 |
| **Obstacle/Crossing** | Road way | Road way | Road way | Road way | Road way | water way | Road way |
| **Previous Owner** | Ministry of Housing | Ministry of Housing | Ministry of Housing | Ministry of Housing | Ministry of Housing | Ministry of Housing | Ministry of Housing |
| **Current Owner** | GARBLT | GARBLT | GARBLT | GARBLT | GARBLT | GARBLT | GARBLT |
| **Previous Inspection** | Yes | yes | Yes | yes | unknown | yes | yes |
| **Previous MR&R** | Yes | yes | Yes | no | unknown | yes | yes |
| **Structure Type** | Tee-beam type | Tee-beam type | Bulb –tee beam type | Bulb –tee beam type | Box- girder type | Box- girder type | Tee-beam type |
| **Material** | RC | RC | Prestressed | Prestressed | RC | Prestressed | RC |
| **Construction Method** | Conventional | conventional | conventional | conventional | conventional | conventional | conventional |
| **Length (m)** | 17.5 | 19.0 | 40.0 | 38.0 | 150.0 | 36.0 | 22.0 |
| **Width (m)** | 39.3 | 61.0 | 50.0 | 50.0 | 9.0 | 50.0 | 44.0 |
| **Clearance (m)** | 5.0 | 5.1 | 5.3 | 5.3 | - | 5.6 | 5.3 |
| **Median Width (m)** | 0.5 | 0.5 | 0.5 | 0.5 | N0 | 0.5 | 0.5 |
| **Sidewalk Width (m)** | 1.5 | 1.5 | 1.5 | 1.5 | 1.2 , 0.8 | 1.5 | 1.5 |
| **No. of Lanes** | 8 | 8 | 8 | 8 | 2 | 8 | 8 |
| **No. of Spans** | 3 | 2 | 5 | 5 | 6 | 16 | 1 |
| **Design Load (t)** | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| **General Planning** | Horizontal | Horizontal | Vertical | Vertical | Horizontal | Vertical | Horizontal |
| **Environment** | High | High | Medium | Medium | High | High | High |

*Table 2. Number of defects in elements of seven bridges inspected in 2019*

| BRIDGE ELEMENT | B1 | B2 | B3 | B4 | B5 | B6 | B7 |
|---|---|---|---|---|---|---|---|
| **Deck** | 8 | 0 | 4 | 1 | 0 | 0 | 5 |
| **Girder** | 12 | 19 | 15 | 20 | 6 | 17 | 36 |
| **Pier, Bent or Pier Wall** | 0 | 3 | 2 | 2 | 2 | 0 | - |
| **Pier Cap** | 0 | 0 | 0 | 0 | - | - | - |
| **Abutment** | - | 0 | 0 | - | 2 | - | 0 |
| **Bearing** | 20 | 30 | 20 | 20 | 14 | 16 | - |
| **Wearing Surface** | 1 | 1 | 2 | 2 | 1 | 1 | 1 |
| **Bridge Railing** | 2 | 2 | 2 | 1 | 4 | 3 | 1 |
| **Median Barrier** | 1 | 2 | 0 | 0 | - | 0 | 2 |
| **Curbs/Sidewalk** | 0 | 2 | 2 | 2 | 3 | 0 | 3 |
| **Expansion Joint** | 0 | 0 | - | - | 2 | - | 0 |
| **Drainage** | | | | | | | |

*Table 3. Type of defects in elements of seven bridges inspected in 2019*

| Bridge Element | B1 | B2 | B3 | B4 | B5 | B6 | B7 |
|---|---|---|---|---|---|---|---|
| **Deck** | Spalling, Exposed Rebar | - | Spalling, Exposed Rebar | Spalling | - | - | Spalling, Exposed Rebar |
| **Girder** | Spalling, Exposed Rebar | Spalling, Exposed Rebar, Patched Area | Spalling, | Spalling | Spalling, Exposed Rebar | Spalling, Exposed Rebar, Patched Area | Spalling, Exposed Rebar, Patched Area |
| **Pier or Bent or Pier Wall** | - | Spalling | Spalling, Exposed Rebar | Spalling, Exposed Rebar | Spalling | - | - |
| **Pier Cap** | - | - | - | - | - | - | - |
| **Abutment** | - | - | - | - | Spalling, Exposed Rebar | - | - |
| **Bearing** | Movement "Minor Restriction" | Movement "Minor Restriction" | Movement "Minor Restriction" | Movement "Minor Restriction" | Movement "Minor Restriction" | Movement "Minor Restriction" | - |
| **Wearing Surface** | Wear "Minor Roughness" | Wear "Minor Roughness" | Wear "Minor Roughness", Rutting | Wear "Minor Roughness", Rutting | Wear "Minor Roughness" | Wear "Minor Roughness" | Wear "Minor Roughness" |
| **Bridge Railing** | Connection, Distortion | Distortion | Connection, Distortion | Distortion | Connection, Distortion | Connection, Distortion | Distortion |
| **Median barrier** | Cracks | Spalling, Exposed Rebar | - | - | - | - | Spalling, Exposed Rebar |
| **Curbs/Sidewalk** | - | Spalling, Wear | Spalling, Wear | Spalling, Wear | Spalling, Settlement, Wear | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Expansion Joint** | - | - | - | - | Debris Impaction | - | - |
| **Drainage** | | | | | | | |

*Table 4. Numbers of defect types in elements of seven bridges inspected in 2019*

| Element Description | Spalling | Exposed rebar | Patched Area | Movement | Wear | Pothole | Distortion | Connection | Settlement | Cracks | Debris impact |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deck "R.C Top-Flange"** | 12 | 6 | 0 | | | | | | | | |
| **R.C Closed Web/Box Girder** | 98 | 19 | 9 | | | | | | | | |
| **RC Pier Wall** | 7 | 2 | 0 | | | | | | | | |
| **RC Open Abutment** | 1 | 1 | 0 | | | | | | | | |
| **Disk Bearing** | | | | 120 | | | | | | | |
| **Wearing Surface** | | | | | 9 | 0 | | | | | |
| **Metal Bridge Railing** | | | | | | | 10 | 5 | | | |
| **Median barrier** | 2 | 2 | | | | | | | 1 | | |
| **RC Curbs &Sidewalks** | 4 | | | | 4 | | | | | 1 | |
| **Assembly Joint without Seal** | | | | | | | | | | | 1 |
| **Compression Joint Seal** | | | | | | | | | | | 1 |

*Table 5. Statistical values of SD in RC bridges inspected in 2019 and 2020*

| Date | Value | Deck | Girder | Bent/Pier/ Pier wall | Pier Cap | Abutment |
|---|---|---|---|---|---|---|
| July 2019 | Minimum | 0.0 | 2.67% | 0.0 | 0.0 | 0.0 |
| | Maximum | 0.32% | 76.30% | 0.49 | 0.0 | 6.25% |
| | Average | 0.08% | 25.77% | 0.14% | 0.0 | 1.56% |
| | Standard Deviation | 0.14 | 31.90 | 0.21 | 0.0 | 3.13 |

| | | | | | | |
|---|---|---|---|---|---|---|
| August 2020 | Minimum | 0.0 | 2.67% | 0.0 | 0.0 | 0.0 |
| | Maximum | 0.40% | 79.90% | 0.58% | 0.0 | 6.25% |
| | Average | 0.11% | 31.42% | 0.21% | 0.0 | 1.56% |
| | Standard Deviation | 0.16 | 32.90 | 0.25 | 0.0 | 3.13 |

*Table 6. Statistical values of SDOER in RC bridges inspected in 2019 and 2020*

| Date | Value | Deck | Girder | Bent/Pier/ Pier wall | Pier Cap | Abutment |
|---|---|---|---|---|---|---|
| July 2019 | Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Maximum | 0.25% | 76.30% | 0.49% | 0.0 | 0.0 |
| | Average | 0.04% | 23.76% | 0.09% | 0.0 | 0.0 |
| | Standard Deviation | 0.09 | 33.46 | 0.20 | 0.0 | 0.0 |
| August 2020 | Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Maximum | 0.25% | 79.90% | 0.49% | 0.0 | 0.0 |
| | Average | 0.04% | 25.49% | 0.09% | 0.0 | 0.0 |
| | Standard Deviation | 0.09 | 36.59 | 0.20 | 0.0 | 0.0 |

*Table 7. Statistical values of SDWER in RC bridges inspected in 2019 and 2020*

| Date | Value | Deck | Girder | Bent/Pier/ Pier wall | Pier Cap | Abutment |
|---|---|---|---|---|---|---|
| July 2019 | Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Maximum | 0.31% | 5.76% | 0.29% | 0.0 | 6.25% |
| | Average | 0.06% | 2.01% | 0.05% | 0.0 | 1.56% |
| | Standard Deviation | 0.12 | 2.21 | 0.12 | 0.0 | 3.13 |
| August 2020 | Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Maximum | 0.36% | 22.08% | 0.58% | 0.0 | 6.25% |
| | Average | 0.07% | 5.93% | 0.13% | 0.0 | 1.56% |
| | Standard Deviation | 0.13 | 7.58 | 0.23 | 0.0 | 3.13 |

*Table 8. Statistical values of wear and pothole density in wearing surface of RC bridges inspected in 2019 and 2020*

| Date | Value | Wear | Pothole |
|---|---|---|---|
| July 2019 | Minimum | 50% | 0.0 |
| | Maximum | 100% | 0.0 |
| | Average | 71.43% | 0.0 |
| | Standard Deviation | 26.73 | 0.0 |
| August 2020 | Minimum | 50% | 0.0 |
| | Maximum | 100% | 0.03% |
| | Average | 71.43% | 0.005% |
| | Standard Deviation | 26.73 | 0.01 |

*Table 9. Statistical values of distortion and connection densities in metal railing of RC bridges inspected in 2019*

| Date | Value | Distortion | Connection |
|---|---|---|---|
| July 2019 | Minimum | 0.38% | 0.0 |
| | Maximum | 15% | 0.69% |
| | Average | 5.00 % | 0.34% |
| | Standard Deviation | 5.27 | 0.33 |

*Table 10. Statistical values of cracks, delamination and spalling density in median barrier of RC bridges inspected in 2019 and 2020*

| Date | Value | Cracks | Delamination | Spalling |
|---|---|---|---|---|
| July 2019 | Minimum | 0.0 | 0.0 | 0.0 |
| | Maximum | 1.89% | 0.0 | 6.82% |
| | Average | 0.32% | 0.0 | 1.97% |
| | Standard Deviation | 0.77 | 0.0 | 3.11 |
| August 2020 | Minimum | 0.0 | 0.0 | 0.0 |
| | Maximum | 5.03 | 3.14% | 6.82% |
| | Average | 0.84% | 0.52% | 1.97% |
| | Standard Deviation | 2.05 | 1.28 | 3.11 |

*Table 11. Statistical values of wear density in RC curbs and sidewalks of RC bridges inspected in 2019 and 2020*

| Date | Value | Wear | Spalling | Settlement |
|---|---|---|---|---|
| July 2019 | Minimum | 0.0 | 0.0 | 0.0 |
| | Maximum | 99.33% | 5.00% | 99.33% |
| | Average | 69.83% | 1.60% | 28.15% |
| | Standard Deviation | 47.73 | 1.74 | 48.07 |
| August 2020 | Minimum | 0.0 | 0.0 | 0.0 |
| | Maximum | 99.33% | 5.00% | 99.33% |
| | Average | 65.19% | 1.48% | 16.56% |
| | Standard Deviation | 50.52 | 1.88 | 40.55 |

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# Margin Analysis of Marketing, Julung-Julung Fish (Hyporhamphus Affinis), in Kinabuhutan Village, West Likupang District, North Minahasa Regency

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***Abstract*****—** *The purpose of this study was to determine the number of marketing channels and the amount of margin in each marketing channel to determine the efficiency of marketing and the added value received by each marketing actor of Julung-Julung fish in Kinabuhutan Village. The population in this study were fishermen catching julung-julung fish, fish processors, middlemen and retailers. Data was collected using the census method for fishermen and fish processors, while traders used purposive sampling. The data collected in the form of primary data and secondary data. Primary data collection techniques with observation and interviews. The data obtained were analyzed using quantitative descriptive analysis and qualitative descriptive analysis. Quantitative descriptive analysis using marketing margin analysis.*

*Based on the research results, it is known that there are only 2 marketing channels for fresh julung-julung fish in Kinabuhuta Village, namely from fishermen to consumers and from fishermen to fish processors. Both channels have a marketing margin of 0 which means that the channel is efficient because the price paid by consumers is the same as that received by fishermen. The marketing channels for smoked Julung-Julung fish are 4 marketing channels with marketing areas, Kinabuhutan, Likupang, Bitung, Airmadidi, Manado and Tomohon. Based on the results of the margin analysis, it is known that the farther the distance between producers and consumers, the longer the marketing channel and the larger the marketing margin, making it more inefficient. In this study, the marketing channel no. 1 with the marketing area to Tomohon is inefficient because the price paid by the final consumer is the most expensive so that the largest marketing margin is Rp. 12,000,-. While the most efficient which is marketed in the production area is channel 4 because the margin is 0. The added value received by fishermen is Rp. 4,500, -. Per 20 fish, the fish processing producer is Rp. 7,850,-, while the middlemen and retailers vary according to the marketing area. The lowest marketing costs are those that are marketed in the production area in Kinabuhutan, namely 0 and the largest is the farthest, Tomohon.*

***Keywords*****—** ***Julung-Julung fish, Marketing margin, Kinabuhutan.***

## I. INTRODUCTION

Problems in the field of marketing that need immediate attention are related to efficiency and marketing margins for fishery products especially capture fisheries. Fishermen have had a low bargaining position compared to middlemen who have market information. The greater the difference between the price at the fisherman's level and the price paid by the final consumer is an indication that the marketing channel is increasingly inefficient and the fisherman receives a smaller share. The family's economic limitations require women fishermen, including their children, to work in coastal areas.

Kinabuhutan is a village located on a small island in the West Likupang sub-district, North Minahasa Regency, North Sulawesi Province. The majority of the residents of Kinabuhutan Village work as fishermen, so that the people

of Kinabuhutan Village depend on marine products for their lives. The marketing of the catches of fishermen in Kinabuhutan Village is very influential on the economy.

In the fishery product marketing system, there is a conflict of interest from three main pillars, namely producers who want high prices, while consumers want low prices and marketing institutions that want maximum profits. The problem then is that in the marketing of fishery commodities, especially Julung-Julung fish, based on empirical studies, it is shown that the parties who are most disadvantaged are fishermen, while traders in general get bigger profits or in other words the market system is still far from the principle of justice. Marketing efficiency is the main base of the objectives to be achieved in any fishery product marketing system. In general, a marketing system is said to be efficient if it is able to deliver products from the producer level to the hands of final consumers by satisfying the interests of all stakeholders in marketing fairly according to the level of their respective sacrifices. From this description, it is very important to conduct a study of how much margin the fishermen receive in each marketing channel of julung-julung fish in Kinabuhutan Village.

This study aims to determine the number of marketing channels and the amount of margin in each marketing channel to determine the efficiency of marketing and the added value received by each marketing actor of Julung-Julung fish in Kinabuhutan Village. It is hoped that this research can increase fishermen's awareness of the importance of knowing the margins in each marketing channel. The smaller the marketing margin, the more efficient the marketing chain, so that it can lead to an increase in fishermen's income which will be followed by an increase in the welfare of the people in Kinabuhutan Village in general and fishermen in particular.

## II. RESEARCH METHODS

The basis of this research is survey research. The survey method is a research conducted to obtain facts from existing phenomena and to seek factual information, whether about institutions, social, economic, or political aspects of a group or an area (Nazir 2003).

The population in this study was divided into 4 groups, namely Julung-Julung fishermen, Smoked Julung-Julung fish processors, middlemen and retailers. The total population of fishermen owners is 31 people so that a 50% sample is taken, namely 16 people using random sampling, the population of Julung-Julung fish processors is only 3 people so that all of them are taken or use the census method, while for middlemen and retailers using purposive sampling method, namely only take 1 middleman and 1 retailer in each marketing channel based on the city of marketing destination. The data collected is in the form of primary data and secondary data. Primary data was collected through observation and interviews guided by questionnaires, while secondary data was collected by citing existing data at the village office and other agencies related to this research.

The data analysis used is quantitative descriptive analysis and qualitative descriptive analysis. Qualitative descriptive analysis is data processing that is carried out through logical considerations with systematic author languages. The analyzed data is then interpreted with logical considerations using the author's systematic languages by referring to references related to research results, journals (Fathoni, 2006). While quantitative descriptive analysis uses Margin Analysis

**Calculating Marketing Margin (Hanafiah, 1986)**

$$Mi = Hi - Hi\text{-}1$$

description:

**Mi** = Margin at the 1st intermediary trader caught by fisherman A (Rp/unit)

**Hi** = Selling price of the 1st intermediary trader caught by Fisher A(Rp/unit)

**Hi-1**= Purchase price of the 1st intermediary trader caught by Fisher A (Rp/unit)

**Calculating Total Marketing Profits (Hanafiah, 1986)**

$$KM = MP - BP$$

description:

**KM** = Total marketing profit (Rp/unit)

**MP** = Marketing Margin (Rp/unit)

**BP** = Total marketing costs (Rp/unit)

## III. RESEARCH RESULT

**State of the research area**

Kinabuhutan Village is one of the coastal villages located on a small island called Kinabuhutan Island and is included in the Likupang Barat sub-district, North Minahasa Regency. The average population of Kinabuhutan Village works as a fisherman and most of them are traditional fishermen. One of the catches of fishermen in Kinabuhutan Village is Julung-Julung fish or in the local language called Roa fish. The catch obtained by fishermen must be marketed as soon as possible

**Marketing Margin at fisherman level**

There are 329 fishermen in Kinabuhutan Village with 31 fishing boat owners and each only owns one fishing boat. Usually in one fishing boat unit it takes 7 to 10 fishermen as crew members

The cost of catching fish in Kinabuhutan Village consists of fixed costs and variable costs. Fixed costs are depreciation costs and maintenance costs for investment items such as boats or ships, nets, machines and others. The composition of fixed costs incurred is as shown in table 1.

*Table 1. Fixed Costs of Julung-Julung Fishing Business (H. brasiliensis) per Trip*

| No | Description | Price (Rp) | Age Economical (Year) | Depreciation (Rp) | Treatment (Rp) | Fixed Cost (Rp) |
|---|---|---|---|---|---|---|
| 1 | Boat | 20.000.000 | 20 | 1.000.000 | 600.000 | 1.600.000 |
| 2 | Nets | 25.000.000 | 10 | 2.500.000 | 200.000 | 2.700.000 |
| 3 | Machine | 40.000.000 | 10 | 4.000.000 | 200.000 | 4.200.000 |
| 4 | Baskets | 130.000 | 3 | 43.000 | | 43.000 |
| 5 | Anchor | 200.000 | 2 | 100.000 | | 100.000 |
| 6 | Paddles | 50.000 | 4 | 12.500 | | 12.500 |
| 7 | Sibu-sibu | 150.000 | 2 | 75.000 | | 75.000 |
| | | | **Total/years** | | | **8.730.500** |
| | | | **Total/month** | | | **727.550** |
| | | | **Total/trip** | | | **30.300** |

Source: Primary Data Processed, 2020

Variable costs are the total costs incurred to obtain factors of production that can be changed in number. Variable costs in the fishing effort of julung-julung (H. brasiliensis) can be seen in Table 2

*Table 2. Variable costs per trip in the Julung-Julung (H. brasiliensis) Fishing Business.*

| No | Description | Variable cost |
|---|---|---|
| 1 | Labor wages | 126.000.000 |
| 2 | BBM @ Rp.10.000 | 24.000.000 |
| 3 | Water refill@ Rp.10.000 | 960.000 |
| 4 | Coolbox @ Rp.35000 | 105.000 |
| **Total/year** | | **151.065.000** |
| **Total/month** | | **12.588.750** |
| **Total/trip** | | **524.531** |

Source: Primary Data Processed, 2020

The total cost is the total cost incurred in the fishing business of Julung-Julung (H. brasiliensis). The total cost per trip is calculated by adding up the fixed costs per trip and variable costs per trip so that the results are as shown in table 3

*Table 3. Total cost per head of the Julung-Julung (H. brasiliensis)*

| No | Description | Amount (Rp) |
|---|---|---|
| 1 | Fixed Fee (Rp) | **30.300** |
| 2 | Variable Costs(Rp) | **524.531** |
| | Total/trip (Rp) | **554.831** |
| | Average result per trip (tail) | **11.250** |
| | Total Cost per head (Rp) | **49,3183** |

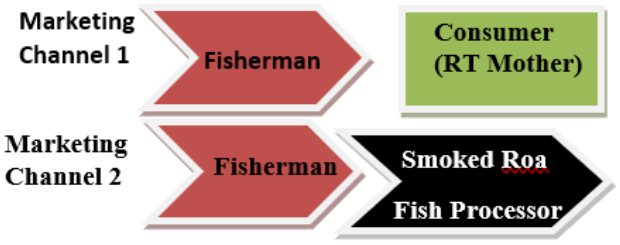
Source: Primary Data Processed, 2020

The total catch of fishermen per trip is at least 500 fish and at most 20,000 fish so that the average catch per trip is 11,250 fish so that the costs incurred to catch a crayfish are Rp. 554,831 divided by 11,250 which is Rp.49,3183 or rounded up to Rp.50,-. The catch of julung-julung fish is sold per head for Rp. 500, -. Thus the fishermen get a profit of Rp. 450, - per fish.

The catch of julung-julung fish in Kinabuhutan Village is only marketed in Kinabuhutan Village, because it is constrained by the perishable nature of the fish and

the small and traditional scale of production of the catch and the limited financial position of fishermen.

Based on the results of the analysis above, it is known that there are only 2 marketing channels for fresh julung-julung fish caught by fishermen that is :




| | |
|---|---|
| Cost/tail | 50 |
| Selling Price/tail | 500 |
| Value Added/tail | 450 |
| Margin | 0 |

*Fig.1. Marketing Margin Analysis of Fresh Julung-Julung Fish*

In Figure 1 there are 2 marketing channels for fresh julung-julung fish caught by fishermen 1, namely from fishermen to final consumers (housewives) or channel 2, namely from fishermen to UPI (Fish Processing Unit). The selling price of the fishermen is the same, which is Rp. 500, - per fish. There are no marketing costs because they are directly sold on the beach when the boat is docked. Thus, it can be seen in Figure 1 that the added value or profit obtained by fishermen per fresh julung-julung fish is the same, namely Rp. 450, -. While the margin is 0 because the price paid by consumers is the same as that received by producers, namely Rp. 500, - This is a very efficient marketing channel because it is the shortest channel and the margin is 0.

**Marketing Margin at the Smoked Julung-Julung Processor level**

The costs incurred by the Smoked Julung-Julung Fish Processor consist of fixed costs and variable costs. Fixed costs are only in the form of depreciation of the smoking room measuring 6m x 10 m, which costs Rp. 10,000,000 to manufacture, which can be used for up to 20 years so that the amount of depreciation per year is Rp. 500,000,- and the depreciation per month is Rp. 41,667, - in a month. The production process is carried out 24 times so that the amount of depreciation per production is Rp. 1.750, -. For more clarity, it can be seen in table 4

*Table. 4. Costs incurred in the Processing Business of Smoked Julung-Julung Fish per production with an average production of 150 pins*

| No | Description | Variable Costs (Rp) |
|---|---|---|
| | **Fixed Cost (Depreciation)** | **1.750** |
| | **Variable Cost** | |
| 1 | Raw Material (Rp.500,-./head) | **1.500.000** |
| 2 | Wage clamp (Rp.500,-/pin) | **75.000** |
| 3 | Smoker wages (Rp.750,-/pin) | **112.500** |
| 4 | Bamboo tongs (Rp.500,-/pin) | **75.000** |
| 5 | Firewood | **25.000** |
| | **Total Cost/Production** | **1.789.250** |
| | **Total Cost/Pinch** | **12.000** |

Source: Primary data, 2020

In table 4 it can be seen that the costs incurred in the Smoked Julung-Julung Fish Processing Business per production with an average production of 150 flops is Rp. 1.789.250, -. Thus, the production cost of smoked julung-julung fish per pin is Rp. 12,000,-. The production results in the form of smoked julung-julung fish are sold for Rp. 20,000, - per pin and marketing costs in the form of sea transportation to Likupang are Rp. 100,000, - and eating and drinking coffee and cakes are Rp. 30,000, - so that the total marketing costs incurred producer as much as Rp. 130.000,-. In one marketing, an average of 1000 pins of smoked julung-julung fish are brought in. Thus, the marketing cost per tweezers incurred by the smoked julung-julung producer is Rp. 130, - so that the profit or margin obtained by the smoked julung-julung producer is Rp. 7,870, - per flop. For more details, the production costs of smoked julung-julung fish per pin and their marketing costs can be seen in table 5.

*Table. 5. Production and marketing costs of smoked julung-julung per pinch*

| No | Description | Cost (Rp) |
|---|---|---|
| 1 | Production Cost/clamp | **12.000** |
| 2 | Marketing Fee/pinch | **130** |
| 3 | Modal / clamp | **12.130** |
| 4 | Price/clamp | **20.000** |
| 5 | Manufacturer profit | **7.870** |

Source: Primary data, 2020

**Marketing Margin at Brokerage level**

The costs incurred at the intermediary level vary depending on the marketing area, in general the brokerage fees incurred are only for vehicle rental costs and meals. \Based on the results of interviews with respondents from intermediary traders from Bitung and Manado, the cost for renting a pick-up vehicle is the same, namely Rp. 250,000 and a meal of Rp. 25,000, with a load of 300 flops for those in Bitung and 500 flops for those in Manado. Thus the cost at the intermediary level per pin for the Bitung marketing area is Rp. 915, -, while for the Manado marketing area it is Rp. 550, -. For intermediary traders in Airmadidi only use 2-wheeled vehicles so that the costs incurred are only for gasoline costs of Rp. 25,000, - and only drinking coffee and cakes for Rp. 10,000, - so a total of Rp. 35,000, -. Not much smoked Julung-Julung fish are transported, only 100 pins, so the cost per pin is Rp. 350,-. Finally, for middlemen in the marketing area of Tomohon, the cost of renting a vehicle is up to Rp. 400,000, - and eating 2 people is Rp. 50,000, - so the total cost is Rp. 450,000, - while the smoked Julung-Julung fish that are transported reach 500 pins. Thus the cost per pin is Rp.900,-. For more details can be seen in table 6.

*Table 6: Marketing costs per pinch at the intermediary level per marketing area*

| No. | Information | Bitung | Airmadidi | Manado | Tomohon |
|---|---|---|---|---|---|
| 1 | Vehicle Rental (Rp) | 250.000 | 25.000 | 250.000 | 400.000 |
| 2 | Meal/ coffee+cake (Rp) | 25.000 | 10.000 | 25.000 | 50.000 |
| 3 | Total (Rp) | 275.000 | 35.000 | 275.000 | 450.000 |
| 4 | Transported goods (Clamp) | 300 | 100 | 500 | 500 |
| 5 | Cost per clip (Rp) | 915 | 350 | 550 | 900 |
| 6 | Purchase price per clip(Rp) | 20,000 | 20,000 | 20,000 | 20,000 |
| 7 | Capital per pinch | 20,915 | 20,350 | 20,550 | 20,900 |
| 8 | Selling price per clip (Rp) | 26,000 | 25,000 | 26,000 | 27,000 |
| 9 | Margin at brokerage level (Rp) | **5.085** | **4.650** | **5.450** | **6.100** |

Source: Primary Data Processed, 2020

**Marketing Margin at Merchant Retailer level**

Retailers who are used as respondents are retailers who are marketed in their marketing areas. The costs incurred by retailers who are in the market are generally only costs for eating and drinking because smoked julung-julung fish are delivered by intermediary traders directly based on orders. The cost for eating and drinking coffee and cake per day for retailers in the market is the same in all marketing areas, which is Rp. 30,000, - because that is the general standard in North Sulawesi. However, the price at each retailer varies according to the marketing area. The average smoked julung-julung retailer in the market not only sells smoked julung-julung but also sells almost all kinds of salted fish so that the marketing costs cannot be charged to the sale of smoked julung-julung only but to share with other kinds of processed fish. other. The retailer of smoked julung-julung fish sells about 20 types of salted fish from various types of anchovies to various types of salted reef fish with various levels of selling prices. Therefore, in the analysis of marketing costs by retailers per type of fish, it is obtained that Rp. 30,000, - is divided by 20 types of fish sold so that per type is charged a fee of Rp. 1,500, - Likewise, Smoked Julung-Julung Fish which is successfully sold by each trader. retailers are not the same, this will affect the marketing costs per pin. For more details on marketing costs per pin and margin at the retailer level per marketing area can be seen in table 7.

*Table 7: Marketing costs per pinch at the retailer level per marketing area*

| No. | Information | Bitung | Airmadidi | Manado | Tomohon |
|---|---|---|---|---|---|
| 1 | Marketing cost/day (Rp) | 1.500 | 1.500 | 1.500 | 1.500 |
| 2 | Average sold/day (Pinch) | 20 | 10 | 20 | 15 |
| 3 | Marketing fee/pin (Rp) | 75 | 150 | 75 | 100 |
| 4 | Purchase price per clip (Rp) | 26,000 | 25,000 | 26,000 | 27,000 |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Capital per pin (Rp) | 26,075 | 25,150 | 26,075 | 27,100 |
| 6 | Selling price per clip(Rp) | 30.000 | 28,500 | 30,000 | 32,000 |
| 7 | Margin at Brokerage level (Rp) | **3.925** | **3.350** | **3.925** | **4.900** |

Source: Primary Data Processed, 2020

**Smoked Scallops Marketing Channel**

There are 4 marketing channels for smoked julung-julung fish from Kinabuhutan Village, namely

**a. Marketing Channel 1**

**Channel Marketing 1 Smoked Julung fish**


| | | | |
|---|---|---|---|
| **Charges/pins** | **12.130** | **20,915** | **26,075** |
| **price/clamp** | **20.000** | **26.000** | **30.000** |
| **Value Added/clamp** | **7.870** | **5.085** | **3.925** |
| **Margin** | **10.000** | | |

**BITUNG**

| | | | |
|---|---|---|---|
| **Charges/pins** | **12.130** | **20,350** | **25,150** |
| **price/clamp** | **20.000** | **25.000** | **28.500** |
| **Value Added/clamp** | **7.870** | **4.650** | **3.350** |
| **Margin** | **8.500** | | |

**AIRMADIDI**

| | | | |
|---|---|---|---|
| **Charges/pins** | **12.130** | **20,550** | **26,075** |
| **price/clamp** | **20.000** | **26.000** | **30.000** |
| **Value Added/clamp** | **7.870** | **5.450** | **3.925** |
| **Margin** | **10.000** | | |

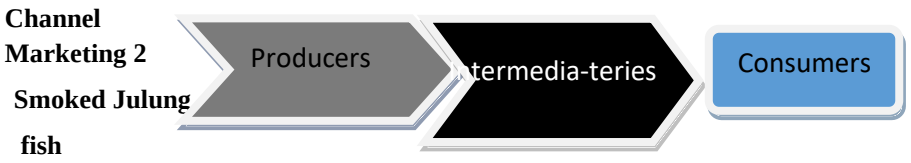
**MANADO**

| | | | |
|---|---|---|---|
| **Charges/pins** | **12.130** | **20,900** | **27,100** |
| **price/clamp** | **20.000** | **27.000** | **32.000** |
| **Value Added/clamp** | **7.870** | **6.100** | **4.900** |
| **Margin** | **12.000** | | |

**TOMOHON**

*Fig.2. Margin Analysis on Marketing Channels 1 Smoked Julung-Julung Fish in Each Marketing Area*

**b. Marketing Channel 2**




| | | |
|---|---|---|
| Charges/pins | 12.130 | 20,915 |
| price/clamp | 20.000 | 26.000 |
| Value Added/clamp | 7.870 | 5.085 |
| Margin | 6.000 | |

BITUNG

| | | |
|---|---|---|
| Charges/pins | 12.130 | 20,350 |
| price/clamp | 20.000 | 25.000 |
| Value Added/clamp | 7.870 | 4.650 |
| Margin | 5.000 | |

AIRMADIDI

| | | |
|---|---|---|
| Charges/pins | 12.130 | 20,550 |
| price/clamp | 20.000 | 26.000 |
| Value Added/clamp | 7.870 | 5.450 |
| Margin | 6.000 | |

MANADO

| | | |
|---|---|---|
| Charges/pins | 12.130 | 20,900 |
| price/clamp | 20.000 | 27.000 |
| Value Added/clamp | 7.870 | 6.100 |
| Margin | 7.000 | |

TOMOHON

*Figure 3. Margin Analysis on Marketing Channels 2 Smoked Julung-Julung Fish in each marketing area*

**c. Marketing Channel 3**


| | | |
|---|---|---|
| Charges/pins | 12.130 | 20.150 |
| price/clamp | 20.000 | 25.000 |
| Value Added/clamp | 7.870 | 4.850 |
| Margin | 5.000 | |

LIKUPANG

*Fig.4. Margin Analysis on Marketing Channels 3 Smoked Julung-Julung Fish that only exist in the Likupang marketing area*

**d. Marketing Channel 4**


| | |
|---|---|
| **Charges/pins** | **12.000** |
| **price/clamp** | **20.000** |
| **Value Added/clamp** | **8.000** |
| **Margin** | **0** |

*Fig.5. Margin Analysis on Marketing Channels 4 Smoked Julung-Julung Fish that only exist in the Kinabuhutan marketing area*

The results of the marketing margin analysis of smoked julung-julung fish show that channel 4 is the most efficient channel because what consumers pay is the same as what the producer receives, which means the marketer's margin is 0. The 2nd and 3rd marketing channels are the next efficient marketing channels and the one that is the most efficient. The least efficient is marketing channel 1 because the marketing channel is long so the marketing margin is big. Based on the marketing area, the most efficient marketing area is the one in Kinabuhutan because it is in the production area while the least efficient is the marketing area of Tomohon City because the largest marketing margin is Rp. 12,000,

**Fisherman's Share**

Fisherman's Share Analysis This analysis is used to compare the price received by fishermen with the price paid by the final consumer (Limbong and Sitorus 1987). According to Kohls and Uhl (1990) if the share received by fishermen is less than 50 percent, it can be said that the marketing system is not efficient, and Azzaino (1983) suggests that the longer the marketing chain or the number of traders, the greater the marketing costs. This results in a larger marketing margin so that the price received by fishermen is getting smaller.

*Table 8. Marketing Margin of Fresh Julung-Julung Fish and Fisherman's share in Kinabuhutan Marketing Area*

| **Description** | **KINABUHUTAN** | | | |
|---|---|---|---|---|
| | **Selling price of fishermen/20 fish (Rp)** | **Consumer buying price(Rp)** | **Marketing Margin (Rp)** | **Fisherman's share (%)** |
| **Channel 1** | **10.000** | **10.000** | **0** | **100** |
| **Channel 2** | **10.000** | **10.000** | **0** | **100** |

Source: Primary Data Processed, 2020

Table 8 shows that the marketing margin is 0 on all channels, because the price paid by consumers is the same as that received by fishermen. Thus the Fisherman's share becomes 100%, it can be concluded that the marketing of Fresh Julung-Julung Fish is very efficient.

Margin and Fisherman's share in the marketing of smoked julung-julung fish as shown in table 9.

*Table 9. Marketing Margin of Smoked Crayfish and Fisherman's share in Each Marketing Area*

| **Description** | **BITUNG** | | | |
|---|---|---|---|---|
| | **Selling price of fishermen /20 fish (Rp)** | **Consumer buying price (Rp)** | **Marketing Margin (Rp)** | **Fisherman's share (%)** |
| Channel 1 | 10.000 | 30.000 | 20.000 | 33 |
| Channel 2 | 10.000 | 26.000 | 16.000 | 38,5 |
| | AIRMADIDI | | | |
| Description | Selling price of fishermen /20 fish (Rp) | Consumer buying price (Rp) | Marketing Margin (Rp) | Fisherman's share (%) |

| | | | | |
|---|---|---|---|---|
| Channel 1 | 10.000 | 28.500 | 18.500 | 35 |
| Channel 2 | 10.000 | 26.000 | 16.000 | 38,5 |
| | | MANADO | | |
| Description | Selling price of fishermen /20 fish (Rp) | Consumer buying price (Rp) | Marketing Margin (Rp) | Fisherman's share (%) |
| Channel 1 | 10.000 | 30.000 | 20.000 | 33 |
| Channel 2 | 10.000 | 26.000 | 16.000 | 38,5 |
| | | TOMOHON | | |
| Description | Selling price of fishermen /20 fish (Rp) | Consumer buying price (Rp) | Marketing Margin (Rp) | Fisherman's share (%) |
| Channel 1 | 10.000 | 32.000 | 22.000 | 31 |
| Channel 2 | 10.000 | 27.000 | 17.000 | 37 |
| | | LIKUPANG | | |
| Description | Selling price of fishermen /20 fish (Rp) | Consumer buying price (Rp) | Marketing Margin (Rp) | Fisherman's share (%) |
| Channel 3 | 10.000 | 25.000 | 20.000 | 40 |
| | | KINABUHUTAN | | |
| Description | Selling price of fishermen /20 fish (Rp) | Consumer buying price (Rp) | Marketing Margin (Rp) | Fisherman's share (%) |
| Channel 4 | 10.000 | 20.000 | 10.000 | 50 |

Source: Primary Data Processed, 2020

Table 9 shows that in all channels the margins are very large and Fisherman's share is all <50%, which means that the Julung-Julung Asap fish marketing channel is not efficient, this is because it has gone through the processing process so that the prices received by fishermen and those paid by consumers are very large. the difference, or the marketing margin will be big.

## IV. CONCLUSION

From the results of the analysis, the following conclusions can be drawn:

(1). There are 2 marketing channels for fresh julung-julung fish, but both are very efficient because the marketing margin is 0. There are 4 marketing channels for smoked julung-julung fish, the first from producers to middlemen then to retailers in the market directly to consumers. The second channel is from producers to middlemen and directly to consumers. The third channel is from producers to retailers and then directly to consumers. The fourth channel is from producers directly to consumers.

(2). The result of marketing margin analysis of smoked julung-julung fish is that the farther the distance between producers and consumers, the longer the marketing channel and the larger the marketing margin, making it more inefficient. In this study, the marketing channel no. 1 with the marketing area to Tomohon is inefficient because the price paid by the final consumer is the most expensive so that the largest marketing margin is Rp. 12,000,-. While the most efficient which is marketed in the production area is channel 4 because the margin is 0.

(3). The added value or share received by fishermen is Rp.4,500,- per 20 fish, fish processing producers are Rp.7,850,- per pin, while intermediary traders and retailers vary according to the marketing area.

(4). Marketing margins on all marketing channels of Fresh Julung-Julung Fish are very efficient, because the price paid by consumers is the same as that received by fishermen. Thus the margin is 0 and Fisherman's share is 100%. On the other hand, in all marketing channels of Smoked Julung-Julung fish, the margin is very large and all Fisherman's shares are <50%, which means that Smoked Julung-Julung fish marketing channels are inefficient,

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# The role of sophisticated accounting system in organizational planning

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***Abstract*** *— The aim of the current study is to analyze the relationship between accounting system and organizational planning. Managers are aware of their own requirements as well as the resources that their organizations would require to support the activities that have been recommended. We believe that the findings of this study will assist managers in better understanding different personality profiles and making decisions on which profile is most appropriate for their needs. The finding revealed that there is a positive relationship between accounting system and organizational planning. The study was carried out among car dealerships in Erbil, Kurdistan. Total of 53 participants involved in this study. Five point likert scales was used in this study ranging from not important at all to very important. However, despite the fact that this study regards organizational planning and accounting system as two distinct problems, the cluster analysis takes these two aspects into account at the same time. While the effect of organizational planning on the accounting system, and vice versa, was not specifically addressed in the current study, it is a relationship that should be explored in greater detail in future research.*

***Keywords*** *— **Accounting System, Strategy, Organizational Planning, Erbil.***

## I. INTRODUCTION

Recent decades have seen an increase in the volatility and unpredictability of the economic environment, and the complexity of company management has increased in tandem (Gardi, 2021). Increased competition, in particular, has posed a danger to the long-term viability of firms in particularly susceptible industries (Qader et al. 2021). When operating in this business environment, organizational planning with an eye on attaining organizational efficacy is very essential (Ismael et al. 2021). Although the formulation of successful strategies is important, it will not guarantee that an entity will attain organizational effectiveness unless and until the entity has put such plans into action (Ali et al. 2021). According to Hamad et al. (2021), this implementation necessitates the interposition of a specific form of organizational planning between the formulation of policies and their implementation (Fatah et al. 2021); furthermore, the effective implementation of the formulated strategies necessitates the use of instruments that facilitate and control the effective implementation of the formulated strategies (Ali & Hamad, 2021). To effectively manage the business and achieve organizational efficacy, the organization takes a number of factors into consideration, including organizational structure, management style (Hamad, 2018), and the management control system, which includes the management accounting system (Ali & Anwar, 2021). Among the main mechanisms responsible for the creation and execution of strategies is the management control system, which is particularly essential (Anwar & Shukur,2015). The supply of management information that feeds the planning and control processes is essential in terms of breadth and dependability of the information (Hamza et al. 2021). There are two dimensions to such a management control system: I information selection; and, (ii) information

display. (Sabir et al. 2021). In the first instance, it is necessary to pick the most relevant management accounting information (Aziz et al. 2021). The second refers to the management control techniques that organizations have adopted, including traditional ones such as organizational planning and accounting system (Sorguli et al. 2021). The design of the management control system is determined by the connection between these two aspects of the management control system (Ahmed et al. 2021).

The purpose of this study is to investigate how the characteristics of the information provided by the management accounting system influence the selection of management control procedures (Anwar & Abdullah, 2021). Premise of this investigation is that the planning process, which encompasses both organizational planning and accounting system, differs depending on the accounting profile tools that a company chooses to use (Abdullah & Anwar, 2021). Some firms implement all of the tools in accordance with the conceptual framework, whilst others have less-developed profiles in terms of the tools implemented by them (Anwar & Shukur, 2015).

Anwar & Abd Zebari, (2015) found that companies utilize more recently created accounting tools less frequently than they do older accounting tools. In this study, neither organizational planning nor accounting system are considered to be newly produced instruments for the sake of this investigation (Anwar & Surarchith, 2015). The investigation is not only concerned with whether or whether they exist in a certain organization, but also with the extent to which they do so (in terms of complexity and usage profiles) (Anwar, 2017). Anwar & Louis, (2017) argue that it is necessary to examine the reciprocal implications of the dimensions of the management control system in order to have an understanding of the relationship between them. In certain cases, the identification of the characteristics' profile can explain significant variations between entities in terms of the planning process (Anwar, 2015), the degree of usage, and even their level of pleasure with the use of the artifact (Hameed & Anwar, 2018). The purpose of this study is to contribute to the literature by conducting a qualitative discussion of the planning process in a more ambitious dimension than simply determining whether the process exists or not, and by determining whether different planning process profiles necessitate different characteristics of the management accounting system (Abdullah et al. 2017). As a result of this associative analysis, the evolution of management accounting as well as the need for management accounting may be understood in a more comprehensive manner (Anwar & Balcioglu, 2016). The following research topic is intended to be addressed in light of the fact that management accounting may have varied profiles of level of structuring and that, depending on these profiles, management accounting may have varying implications on the strategic plan and accounting system (Anwar, 2016).

## II. LITERATURE REVIEW

### Organizational planning process

According to organizational planning literature, the use of a organizational planning process has a beneficial impact on profitability, and this has been the primary goal of organizational planning since at least the 1960s (Anwar, 2017). Although several studies have looked at the link between organizational planning and performance, they have come up with a variety of different findings (Anwar & Ghafoor, 2017). These differences, according to Anwar & Qadir, (2017), are the consequence of a combination of factors, including I inconsistent planning, (ii) disregarding environmental impacts, and (iv) faulty measurement methodologies. The final point to mention is the inadequacies of accounting data. Anwar & Climis, (2017) argue that one explanation for the disparity is the use of accounting-based metrics, such as revenue, which they believe are a contributing factor. According to Anwar & Louis, (2017), this lack of convergence is caused by two intrinsic flaws in accounting-based performance measures: I a lack of uniformity in accounting data; and (ii) a lack of availability of data for small businesses (Anwar, 2015). For example, in their study, Gardi, (2021) identified many hurdles to the implementation of formal organizational planning, including a lack of relevant and appropriate information, which is critical to the organizational planning process for firms that officially implement this approach. In this context, Qader et al. (2021) state that information management will be the most important organizational issue in the future, and that the organizational planning process must highlight the sorts of information that will support the company's strategic direction in order to be effective (Ismael et al. 2021). No process needs more coordination and information input than the planning process of a company or organization (Ali et al. 2021). The management team, it appears, need a significant amount of internal information to support its decision-making process, and it appears that each organization has its own configuration of requirements, timeliness, and specifics (Hamad et al. 2021). When selecting information, care must be taken to ensure that it meets the unique needs of the business, rather than being dictated by a mandate from outside the institution (Fatah et al. 2021). The majority of objections leveled at accounting information stem from a failure to design the information structure in accordance with the unique requirements or demands of the company. Rather than looking at probable causes for this, such as life cycle and

cost–benefit analysis, the authors' primary focus is on ensuring that the information structure is readily available (Ali & Hamad, 2021).

**Management accounting systems**

Accounting information systems are divided into two primary subsystems, according to Hamad, (2018): the financial subsystem and the management subsystem. These subsystems are not necessary independent of one another, and in an ideal case, integration and a linked database would exist between the two subsystems, according to them (Ali & Anwar, 2021). There is the option of using the outputs of one subsystem as inputs for the other component. In a nutshell, these writers are in favor of the integration of financial accounting databases. Management accounting systems are a subset of a company's overall management control systems, which include financial accounting systems (Anwar & Shukur,2015). Overall, management control is in place to guarantee that internal agents operate in line with the objectives of the company (Hamza et al. 2021). Management accounting information systems, in this context, are one of the most important control methods for determining if diverse operations are generating advantages for the business as a whole (Sabir et al. 2021). According to Aziz et al. (2021), stated that the accounting exists in administration primarily to support the creation and implementation of corporate strategy. Administrative processes, according to them, are cyclical in nature and consist of four phases: I the formulation of strategies; (ii) the communication of these strategies throughout the organization; (iv) the development of tactics and the implementation of these tactics in order to implement the strategies throughout the entire organization; and (v) the development of controls to monitor the implementation steps and to assess the success in achieving strategic objectives (Sorguli et al. 2021). The authors (Ahmed et al. 2021) also point out that accounting has a function to play in each of these stages. In the first step, accounting information serves as the foundation for financial analysis by assisting in the development of plans that are financially feasible for the organization (Anwar & Abdullah, 2021). During the second phase, accounting reports are a key instrument for communicating the fundamental components of the strategy, and they should be reviewed regularly. After that, accounting information is used to help determine which tactical program will be most effective in helping the organization accomplish its goals in the third phase (Abdullah & Anwar, 2021). The accounting department also has a significant impact on analyzing and reporting on management and business unit performance, particularly when it comes to determining standard expenses, expenditure accounting systems, and yearly profit goals (Anwar & Shukur, 2015). Management accounting systems, as a result, have the potential to provide financial information related to costing products, services, and other items of interest to management in terms of planning, control, assignment, continuous improvement, and decision-making. Management accounting systems are used to cost products, services, and other items of interest to management (Anwar & Abd Zebari, 2015). As a result, management accounting can provide the information necessary for both goal formulation during the strategy design phase and performance assignment throughout the performance evaluation process (Anwar & Surarchith, 2015). The planning and control process, on the other hand, must take into account both financial and nonfinancial information (Anwar, 2017).

**Relationship between organizational planning and accounting system**

According to Anwar & Louis, (2017), the organizational planning concept possesses the following characteristics: The term "organizational planning" refers to the process of developing long-term organizational objectives, medium-term programs to achieve those objectives, short-term accounting systems and operational plans to ensure that the strategies are implemented (Anwar, 2015). The term "organizational planning" refers to the future consequences of current decisions; it is also a process that begins with setting organizational objectives, then defines the strategies and policies to achieve those objectives, and finally develops detailed plans to ensure that the strategies are implemented (Hameed & Anwar, 2018). The accounting system is the mechanism that makes it possible for the strategic plan to achieve its goals (Abdullah et al. 2017). It is important to note that when establishing links, particularly the connection between long term plans and short-term accounting systems, the association between strategic issues and tactical issues becomes particularly relevant to the overall development of the planning system, avoiding either an ethereal approach (which lacks contact with business reality) (Anwar & Balcioglu, 2016)or an exclusively tactical process (which lacks consideration of the overall strategic objectives of the company) (Anwar, 2016). Neither of these extremes gives the process with the balance it need to function properly (Anwar, 2017). It is generally accepted that a relationship exists between inability to demonstrate a positive link between organizational planning and performance and "a propensity not to highlight the importance of organizational planning," according to Anwar & Ghafoor, (2017). Management accounting can therefore contribute to poor organizational planning, either as a result of insufficient or absent information, or as a result of inefficient use of information

(Anwar & Qadir, 2017). Anwar & Climis, (2017) divides the most frequent organizational planning faults into three categories: I those that occur before the commencement of the elaboration (Anwar & Louis, 2017); (ii) those that occur during the elaboration; and (iii) those that occur during the implementation. Anwar, (2015) lists among the errors in the first category the failure to prepare the ground for organizational planning inside the organization as well as the failure to schedule the system for the management and assessment of organizational planning. Defining the criteria and implementing them (Ismael et al. 2021). For the executive, it is critical to have the parameters, as well as the information system, in place to ensure that organizational planning is controlled and evaluated effectively (Ali et al. 2021). Success in organizational planning is therefore dependent on the ability to control and evaluate operations on the basis of management accounting techniques (which include accounting system and accounting systemary control) (Hamad et al. 2021). Management accounting may provide the essential assistance to the planning process as a whole if it is done properly. However, according to Ali & Anwar, (2021), the accounting system (which serves as the managers' tactical instrument) must include all relevant assumptions, marketing plans, production plans, supplies and inventories (Anwar & Shukur,2015), human resource plans, investment plans, and financial statement projections in addition to other information (Hamza et al. 2021).

**Relationship between management accounting and the planning process**

The management system's profile is determined by the approaches of management control that are chosen and implemented (Sabir et al. 2021). The characteristics of the information provided by the system are influenced by the methodologies used for organizational planning and accounting system, among other things. Using traditional management control information, Aziz et al. (2021) establish the existence of a link between conventional management control approaches, such as organizational planning and accounting system, and traditional management control data. Strategic planners, according to Sorguli et al. (2021), are disengaged from the day-to-day specifics of operations while creating strategy, presumably because they believe that information systems can provide them with all of the information they need. It becomes much more relevant if the company does not take steps to guarantee that managers receive the daily accurate information that only management accounting is capable of providing. As a result, even authors who are critical of organizational planning, such as Ahmed et al. (2021), acknowledge the importance of information in the formulation of strategies and the evaluation of their feasibility after execution. Opponents of the use of accounting data as a source of such information, whether to assist strategy formulation (Anwar & Abdullah, 2021) or to assess business performance (Abdullah & Anwar, 2021), do exist (Anwar & Shukur, 2015). Facsimile information (including managerial information), according to Anwar & Abd Zebari, (2015), is frequently constrained in the following ways:

- It often has a restricted scope and frequently misses out crucial non-economic and non-quantitative elements that are significant;
- This makes it difficult to make effective use of factual knowledge in the creation of strategies.
- This causes factual information to be used in strategy creation to be reduced because it is frequently received late.
- An unexpectedly large amount of factual information cannot be relied upon.

Having a sufficient supply of information becomes a matter of importance in the decision-making process in this environment; thus, changes in the type of information that management accounting has provided in recent years have resulted from this priority (Anwar & Surarchith, 2015). According to Anwar, (2017), management accounting is critical because: the organizational planning exercise is expanded in order to establish strategies that would allow the firm to achieve its goals (Anwar & Louis, 2017). These strategies frequently necessitate the use of critical information from management accounting (Anwar, 2015). Furthermore, Hameed & Anwar, (2018) state that accounting supports planning, management, and decision-making through accounting systems and other financial criteria, but does not record current outcomes in a systematic manner or play a role in performance evaluation." In addition, these writers have said that a management accounting system can only be efficient if it is compatible with the aims and strategies of the business (Abdullah et al. 2017). The present study which draws on the research of Anwar & Balcioglu, (2016) as a theoretical foundation places a strong emphasis on the categorization of management accounting in terms of its characteristics. On the basis of Statement of Accounting Concept, these writers grouped the important qualities of management accounting into two areas: information selection and information presentation which they proposed should be divided into two divisions (Anwar, 2016). The first, information selection, is comprised of the content dimensions or tools that accounting systems employ to assist managers in their decision-making processes (Hamza et al. 2021). However, in light of the fact that organizations can differ in terms of strategies, structures, and styles, information presentation includes other attributes of accounting, such as the level of aggregation, the integration

of information, the scope of the information, and the timeliness of information (Sabir et al. 2021).

**Research Methodology**

The purpose of this research is to examine the relationship between accounting system and organizational planning. The study was carried out among car dealerships in Erbil, Kurdistan. Total of 53 participants involved in this study. Five point likert scales was used in this study ranging from not important at all to very important.

*Research Hypothesis*

Research Hypothesis: Accounting system management has a significant influence on organizational planning.

## III. DATA ANALYSIS

*Table 1- Demographic Analysis*

| Items | Scales | Frequency | Percent |
|---|---|---|---|
| **Gender** | **Male** | 30 | 55.6 |
| | **Female** | 24 | 44.4 |
| **Age** | 20-29 | 18 | 33.3 |
| | 30-39 | 17 | 31.5 |
| | 40-49 | 13 | 24.1 |
| | 50-59 | 6 | 11.1 |
| **Education** | Bachelor | 45 | 83.3 |
| | Master | 9 | 16.7 |
| **Experience** | Less than one | 9 | 16.7 |
| | 1-5 | 26 | 48.1 |
| | 6-10 | 17 | 31.5 |
| | 11 and over | 2 | 3.7 |

The above table (1) demonstrates the participants' demographic analysis participated in this research. In regard of the participants' gender; 55.6% of the participants were male while 44.4% of the participants were female. In regard of the participants' age; 33.3% of the participants were from 20-29 years old, 31.5% of the participants were 30-39 years old, 24.1% of the participants were 30-39 years old, 11.1% of the participants were from 50-59 years old. In regard of the participants' level of education; 83% of the participants had bachelor degree and only 16.7% of the participants had Master degree. In regard of the participants' experience(s) 16.7% of the participants had less than one year of experience, 48.1% of the participants had 1-5 years of the experiences, 31.5% of the participants had 6-10 years of the experiences and only 3.7% of the participants had 11 years and over of the experiences.

*Table 2- Reliability Tests*

| Items | Cronbach's Alpha | Number of Items |
|---|---|---|
| Accounting system | .849 | 10 |
| Organizational Planning | .775 | 10 |

The above table (2) shows the reliability test of 10 items for accounting systemand 10 items for organizational planning. The Cronbach's Alpha for ten Accounting system‘s ten items = .849 which is greater than .6 this means that ten items used for accounting systemfactor were reliable for this study and the Cronbach's Alpha for ten organizational planning‘s ten items = .775 which is greater than .6 this means that ten items used for organizational planning factor were reliable for this study.

*Table 3-Correlations Analysis*

| Factors | Pearson Correlation | Accounting system | Organizational Planning |
|---|---|---|---|
| Accounting system | Pearson Correlation | 1 | .858** |
| | Sig. (2-tailed) | | .000 |
| | N | 54 | 54 |
| Organizational Planning | Pearson Correlation | .858** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 54 | 54 |

**. Correlation is significant at the 0.01 level (2-tailed).

The above table (3) shows the correlation analysis between accounting systemand organizational planning. The value of Pearson Correlation = .858** which is greater than 0.01 this means that there is a positive and strong correlation between accounting system and organizational planning.

*Table 4- Model Summary*

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .858[a] | .736 | .731 | .39631 |
| a. Predictors: (Constant), Accounting system | | | | |

The above table (4) shows the value of R Square =.736 which means that 73% of the variables are explained in this study.

*Table 5- ANOVA*

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 22.808 | 1 | 22.808 | 145.220 | .000[b] |
| | Residual | 8.167 | 52 | .157 | | |
| | Total | 30.975 | 53 | | | |

a. Dependent Variable: Organizational Planning

b. Predictors: (Constant), Accounting system

The above table (5) shows the value of F for both variables (accounting system and organizational planning) is 145.220>1 which indicates there is a significant association between both variables.

*Table 6- Coefficients*

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| (Constant) | .278 | .250 | | 1.115 | .270 |
| 1 | | | | | |
| Accounting system | .963 | .080 | .858 | 12.051 | .000 |

a. Dependent Variable: Organizational Planning

The above table (6) shows the value of Beta=.858 which is greater than 0.01 this indicates that there is a positive relationship between accounting system and organizational planning.

## IV. CONCLUSION

Despite the fact that the management literature regularly alludes to an anticipated link between the planning process (planning and accounting) and management accounting features, few (if any) studies have produced real data to support or refute this assumption. When it came to creating their organizational planning, the researchers investigated the hypothesis that there is a link between the management accounting systems employed by these firms and their conceptual adherence. It has been determined by this investigation that one of the most important conclusions to be drawn is that improper configuration of the planning process is caused by improper configuration of the management accounting attributes. Managers are aware of their own requirements as well as the resources that their organizations would require to support the activities that have been recommended. We believe that the findings of this study will assist managers in better understanding different personality profiles and making decisions on which profile is most appropriate for their needs. The finding revealed that there is a positive relationship between accounting system and organizational planning. However, despite the fact that this study regards organizational planning and accounting system as two distinct problems, the cluster analysis takes these two aspects into account at the same time. While the effect of organizational planning on the accounting system, and vice versa, was not specifically addressed in the current study, it is a relationship that should be explored in greater detail in future research.

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# Hedgers Competition in Financial Market

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***Abstract*****—** *We analyze a two-period model with two kinds of hedgers who have different kinds of non-tradable risky asset to hedge. For holding the asset whose payoff is related to a tradable risky asset, they can derive some different private information about this tradable risky asset. Both hedgers have demand to buy risky asset for the purpose of speculating and hedging. In date 1, they get the information about their non-tradable asset position, private signal of tradable risky asset' payoff and decide how much tradable risky asset they want to hold. They can estimate each other's private information through equilibrium price. We also measure the information passing effect of price.*

***Keywords*****— Hedgers Competition, Private Information, Equilibrium Price.**

## I. INTRODUCTION

In financial market, we can always see different investors trade in a kind of tradable risky asset to hedging the risk exposure which brought by holding the illiquid asset. For instance, in future market, different participants have different hedging demand. They use future to hedge the loss that price volatility of their position leads. Such as farmers enter the crops future market and short it to avoid the loss that crops price decreases. Meanwhile, big restaurants and food manufacturers enter the crops future market and long it to avoid the loss that crops price increases. They may also have speculation demand to take more risk through future market if they can accurately estimate the changing of future price. Because of holding different illiquid asset, they can gain some private information that counterparts do not know. To illustrate, farmers can better understand the weather, fertilize, and some other factors which can influence the supply of crops and influence the future price further. As for those who long crops future, they may have more insight into the demand of crops which influence crops future price. Thus, the hedgers may have different private information according to the payoff of tradable risky asset. Hedgers do not know each other's private information about risky asset's payoff, they also do not know how many non-tradable assets their counterparts need to hedge. Through market clearing, they can gain some information about counterparts' private signal and their personal holding from equilibrium price. The relativity between tradable risky asset and non-tradable asset can either be positive and negative. We not only analyze hedgers' hedging demands, we also analyze their speculation demands. And we study the price informativeness and what factors influence the information learning accuracy.

In our paper, we analyze a two-period model with two kinds of hedgers who have different kinds of non-tradable risky asset to hedge. For holding the asset whose payoff is related to a tradable risky asset, they can derive some

different private information about this tradable risky asset. Both hedgers have demand to buy risky asset for the purpose of speculating and hedging. In date 1, they get the information about their non-tradable asset position, private signal of tradable risky asset' payoff and decide how much tradable risky asset they want to hold. They can estimate each other's private information through equilibrium price. We also study what factor influence the information passing effect of price and risk premium.

This paper is organized as follow. In section 2, literature review is given. In section 3, we introduce the model setting and assumption. In section 4, we define the market equilibrium and analyze how hedgers learn from market price and make their decision. In section 5, we study how equilibrium price is determined and the factors that influence the price. In section 6 and 7, we consider price informativeness and risk premium respectively. In section 8, we give our conclusion.

## II. LITERATURE REVIEW

Liu and Wang (2019) use a random holding non-tradable asset position and analyze a model with hedgers, speculators and market maker. The hedgers are endowed with a random position on a non-tradable risky asset which is corelated with a tradable asset. They have both hedging demand speculation demand and speculators only have speculation demand. Liu and Wang (2016) analyze the market trading under asymmetric information incurred by holding a kind of non-tradable asset. Goldstein, Li and Yang (2014) study a model that different traders have different investment opportunity. That leads to different trading purpose in same financial market, some traders trade for speculation and others trade for hedging. We use same measure to analyze price informativeness and risk premium as Goldstein, Li and Yang. Easley, O'Hara and Yang (2014) study the ambiguity effect of hedging fund investment strategies on asset price and aggregate welfare by letting correlation between asset be unknown to opaque traders. Grossman and Stiglitz (1980) give a fundamental framework of the CARA-normal REE model. Admati (1985) study multiple risk asset and their interaction and analyze a noisy expectation equilibrium. Huand Qin (2013) analyze welfare effect of information acquisition in a competitive financial market with diverse information and rational expectation. Bessembinder (1992) studies the relation between agricultural future return and hedgers' holding.Biais, Bossaerts and Spatt (2010) study the implications of information asymmetric for equilibrium asset pricing and portfolio choice both theoretically and empirically. Easley and O'hara (2004) analyze the influence of information on cost of capital.

We introduce a model that both participants have hedging demand, and there exists asymmetric information but no one have an information advantage. Investors use their own private information and equilibrium price to estimate other information in competitive market.

## III. MODEL

We analyze a two discreet periods (date 1 and date 2) economy and a continuum of hedgers indexed by the unit interval [0,1]. There exist two kinds of hedgers labeled type 1 and type 2, which are endowed with different kind of non-tradable risky asset 1 and asset 2 respectively. The fraction of type 1 hedgers is $\mu$ and thus the fraction of type 2 hedgers is $1-\mu$.They all have CARA utility function with risk aversion coefficient $\gamma$.There is only one kind of tradable risky asset (We call it asset $m$) or may be optimal market portfolio in financial market.

### 3.1 Asset

*3.1.1 Tradable Asset*

Risky asset $m$is the only tradable asset in the market. And its payoff $\tilde{v}$ is constituted by five parts: prior belief mean payoff of asset m $\bar{v}$, private information for type 1 hedgers $\tilde{\theta}_1$, private information for type 2 hedgers $\tilde{\theta}_2$, disruption corelated with asset 1 $\tilde{\varepsilon}_1$, disruption corelated with asset 2 $\tilde{\varepsilon}_2$, that is

$$\tilde{v} = \bar{v} + \tilde{\theta}_1 + \tilde{\theta}_2 + \tilde{\varepsilon}_1 + \tilde{\varepsilon}_2.$$

where $\bar{v} > 0$, $\tilde{\theta}_1 \sim N(0, \sigma_{\theta 1}^2), \tilde{\theta}_2 \sim N(0, \sigma_{\theta 2}^2), \tilde{\varepsilon}_1 \sim N(0, \sigma_{\varepsilon 1}^2), \tilde{\varepsilon}_2 \sim N(0, \sigma_{\varepsilon 2}^2)$. And they are all independent.

Let precision of $\tilde{\theta}_1$be defined as $\tau_{\theta 1} = \frac{1}{\sigma_{\theta 1}^2}$, precision of $\tilde{\theta}_2$ be $\tau_{\theta 2} = \frac{1}{\sigma_{\theta 2}^2}$, precision of $\tilde{\varepsilon}_1$, $\tilde{\varepsilon}_2$ be $\tau_{\varepsilon 1} = \frac{1}{\sigma_{\varepsilon 1}^2}$ and $\tau_{\varepsilon 2} = \frac{1}{\sigma_{\varepsilon 2}^2}$respectively. We let supply of tradable asset be $n$ unit. The price of asset $mp$is determined by demand and supply endogenously.

*3.1.2 Non-tradable Asset*

Asset 1 and asset 2 are non-tradable in the financial market, they can only be held to maturity at date 2 and realize their payoff. The payoff of asset 1 is $\tilde{u}_1$ that follows $N(0,\sigma_{u1}^2)$. The payoff of asset 2 is $\tilde{u}_2$ that follows $N(0,\sigma_{u2}^2)$.

The correlation between asset 1 and asset $m$is $\rho_1$, the correlation between asset 2 and asset $m$ is $\rho_2$. Both $\rho_1$and $\rho_2$belongs to $[-1,1]$.

*3.1.3 Free-risk asset*

The free-risk asset generates no interest.

**3.2 Hedgers**

Type 1 hedgers are endowed with $\tilde{X}_1$units of asset 1at date 1, type 2 hedgers are endowed with $\tilde{X}_2$units of asset 2 . $\tilde{X}_1$ and $\tilde{X}_2$ follow normal distribution $N(0,\sigma_{X1}^2)$ and $N(0,\sigma_{X1}^2)$respectively. And $\tilde{X}_1$and $\tilde{X}_2$are all independent. Let precision of $\tilde{X}_1$ be $\tau_{X1}=\frac{1}{\sigma_{X1}^2}$ and precision of $\tilde{X}_2$be $\tau_{X2}=\frac{1}{\sigma_{X2}^2}$. Both types of hedgers born with currency wealth $W$that can be used to buy asset $m$. And both types of hedgers have utility function $u=-e^{-\gamma W_i^2}$, where $W_i^t$denote the wealth type $i$hedgers have at date $t$. Thus, we have

$$W_i^1 = W = d_{fi} + d_i p \quad (1)$$

$$W_i^2 = d_i\tilde{v} + d_{fi} + \tilde{X}_i\tilde{u}_i \quad (2)$$

Combine (1)and (2), we have

$$W_i^2 = d_i(\tilde{v}-p) + W + \tilde{X}_i\tilde{u}_i, \quad (3)$$

$i \in \{1,2\}$.

**3.3 Information structure**

*3.3.1 Date 1*

Type 1 hedger get a private signal $\tilde{\theta}_1$and their position on non-tradable asset 1 $\tilde{X}_1$. Type 2 hedger get a private signal $\tilde{\theta}_2$and their position on non-tradable asset 2 $\tilde{X}_2$. And they make their decisions on how much asset $m$they want to buy according to the private information on $\tilde{\theta}_i$, $\tilde{X}_i$and information derived from equilibrium price $p$.

*3.3.2 Date 2*

The payoff of non-tradable asset 1, asset 2, and tradable asset $m$is realized.

## IV. LEARNING FROM MARKET AND EQUILIBRIUM

We first analyze the optimal problem of different type of hedgers. Through utility maximization conditional on the information they get, we can get hedgers' demand function. They make their demand decision after observing private signal and their non-tradable asset position. They also get some information about opponents' private information through equilibrium price. We use rational expectation equilibrium (REE) as equilibrium, as in Grossman and Stiglitz (1980). In the equilibrium, every hedger has maximized their expected utility based on their information set, where type 1 hedgers know $\mathcal{F}_1 = \{\tilde{\theta}_1, \tilde{X}_1, \tilde{p}\}$, while type 2 hedgers know$\mathcal{F}_2 = \{\tilde{\theta}_2, \tilde{X}_2, \tilde{p}\}$. The price is set to clear the market. Now we derive the equilibrium in detail.

**4.1 Price function**

Type 1 and type 2 hedgers trade depending on the information set $\mathcal{F}_1$and $\mathcal{F}_2$. Hence, the equilibrium price of asset $m$ is a function of $(\tilde{\theta}_1, \tilde{\theta}_2, \tilde{X}_1, \tilde{X}_2)$ : $\tilde{p} = p(\tilde{\theta}_1, \tilde{\theta}_2, \tilde{X}_1, \tilde{X}_2)$.

As in the case in most of the literature, we analyze linear equilibrium, that is the price $\tilde{p}$is a linear function of $(\tilde{\theta}_1, \tilde{\theta}_2, \tilde{X}_1, \tilde{X}_2)$:

$$\tilde{p} = v + \alpha\tilde{\theta}_1 + \beta\tilde{\theta}_2 + \xi\tilde{X}_1 + \eta\tilde{X}_2$$

where the coefficients are determined endogenously.

We start to examine the decision of hedgers which in turn determine the information determined in the price $\tilde{p}$. And then we solve the market clearing equilibrium to find the equilibrium price and the coefficients in price function.

**4.2 Hedgers' demand**

Type $i$hedgers have information set $\mathcal{F}_i = \{\tilde{\theta}_i, \tilde{X}_i, \tilde{p}\}$. Let $E_i[\cdot\,|\mathcal{F}_i]$denote the conditional expectation operator on their information set. They decide how to allocate their wealth in asset $m$and risk-free asset to maximize their expected utility

$$E_i\left[-e^{-\gamma W_i^2}\middle|\mathcal{F}_i\right],$$

where the wealth of date 2 $W_i^2$is given by (3). Same type of hedgers will choose same risky asset $m$and risk-free asset in their investment because they have same information set. Due to the property of CARA utility function, the initial wealth is irrelevant to allocation decision. Thus, we transfer maximal problem above into

Speculation demand Hedge demand

$$\max d_i[E_i(\tilde{v}|\mathcal{F}_i) - \tilde{p}] - \frac{\gamma}{2}[d_i^2 Var_i(\tilde{v}|\mathcal{F}_i) + 2d_i\tilde{X}_i Cov_i(\tilde{v},\tilde{u}|\mathcal{F}_i)] \quad (4)$$

which equals to

$$d_i\left[\bar{v} + \tilde{\theta}_i + E_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) - \tilde{p}\right] - \frac{\gamma}{2}\left[d_i^2\left(Var_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) + \sigma_{\varepsilon 1}^2 + \sigma_{\varepsilon 2}^2\right) + 2d_i\tilde{X}_i\sigma_{\varepsilon i}\sigma_{ui}\rho_i\right]. \quad (5)$$

The first order condition is

$$\bar{v} + \tilde{\theta}_i + E_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) - \tilde{p} - \gamma\left[d_i\left(Var_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) + \sigma_{\varepsilon 1}^2 + \sigma_{\varepsilon 2}^2\right) + \tilde{X}_i\sigma_{\varepsilon i}\sigma_{ui}\rho_i\right] = 0. \quad (6)$$

where $-i = 2$ if $i = 1$,$-i = 1$ if $i = 2$.

Through F.O.C, we get the demand function of hedgers typed $i$is

$$d_i = \frac{\bar{v} + \tilde{\theta}_i + E_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) - \tilde{p} - \gamma\tilde{X}_i\sigma_{\varepsilon i}\sigma_{ui}\rho_i}{\gamma\left[Var_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) + \sigma_{\varepsilon 1}^2 + \sigma_{\varepsilon 2}^2\right]}$$

$$= \underbrace{\frac{\bar{v} + \tilde{\theta}_i + E_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) - \tilde{p}}{\gamma\left[Var_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) + \sigma_{\varepsilon 1}^2 + \sigma_{\varepsilon 2}^2\right]}}_{} - \underbrace{\frac{\tilde{X}_i\sigma_{\varepsilon i}\sigma_{ui}\rho_i}{Var_i\left(\tilde{\theta}_{-i}\middle|\mathcal{F}_i\right) + \sigma_{\varepsilon 1}^2 + \sigma_{\varepsilon 2}^2}}_{}. \quad (7)$$

Observe that the demand is constituted by two parts. The first part originates from gaining benefit through the payoff taken by asset $m$, we call it speculation demand. And the second part originates from deducing risk exposure of non-tradable asset $i$. Speculate demand depends on the private signal hedgers get, it is always positive because of risk aversion and uncertainty compensation. Hedge demand depends on the position of hedgers on non-tradable asset and correlation ofpayoff between asset $m$ and asset $i$. The signal of hedge demand is determined by position of risk exposure. When $\tilde{X}_i > 0$ and $\rho_i > 0$, there is a long position on the asset $i$and the payoff of asset $i$is positively related to asset $m$, then hedgers will buy less asset $m$to reduce their risk. When $\tilde{X}_i > 0$ and $\rho_i < 0$, there is a long position on the asset $i$and the payoff of asset $i$is negatively related to asset $m$, then hedgers will buy more asset $m$to reduce their risk. When $\tilde{X}_i < 0$ and $\rho_i > 0$, there is a short position on the asset $i$and the payoff of asset $i$is positively related to asset $m$, then hedgers will buy more asset $m$to reduce their risk. When $\tilde{X}_i < 0$ and $\rho_i < 0$, there is a short position on the asset $i$and the payoff of asset $i$is negatively related to asset $m$, then hedgers will buy less asset $m$to reduce their risk. And hedge demand is also influenced by volatility of the payoff of asset $i$and $\varepsilon_i$.

According to market clearing condition, we have

$$\mu\frac{\bar{v} + \tilde{\theta}_1 + E_1\left(\tilde{\theta}_2\middle|\mathcal{F}_1\right) - \tilde{p} - \gamma\tilde{X}_1\sigma_{\varepsilon i}\sigma_{ui}\rho_1}{\gamma\left[Var_1\left(\tilde{\theta}_2\middle|\mathcal{F}_1\right) + \sigma_{\varepsilon 1}^2 + \sigma_{\varepsilon 2}^2\right]}$$

$$+(1-\mu)\frac{\bar{v}+\tilde{\theta}_2+E_2(\tilde{\theta}_1|\mathcal{F}_2)-\tilde{p}-\gamma\tilde{X}_2\sigma_{\varepsilon i}\sigma_{ui}\rho_2}{\gamma\left[Var_2(\tilde{\theta}_1|\mathcal{F}_2)+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}=n \quad (8)$$

For type 1 hedgers, we have

$$\tilde{\theta}_2-\gamma\sigma_{\varepsilon 2}\sigma_{u2}\rho_2\tilde{X}_2=\frac{\gamma\left[Var_2(\tilde{\theta}_1|\mathcal{F}_2)+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}{1-\mu}$$
$$\left[n-\mu\frac{\bar{v}+\tilde{\theta}_1+E_1(\tilde{\theta}_2|\mathcal{F}_1)-\tilde{p}-\gamma\tilde{X}_1\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{\gamma\left[Var_1(\tilde{\theta}_2|\mathcal{F}_2)+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}-(1-\mu)\frac{\bar{v}+E_2(\tilde{\theta}_1|\mathcal{F}_2)-\tilde{p}}{\gamma\left[Var_2(\tilde{\theta}_1|\mathcal{F}_2)+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}\right]. \quad (9)$$

Let $\tilde{S}_1\equiv\tilde{\theta}_2+s_1^{-1}\tilde{X}_2$, where $s_1=-\frac{1}{\gamma\sigma_{\varepsilon 2}\sigma_{u2}\rho_2}<0$. Thus, we have $E_1(\tilde{\theta}_2|\mathcal{F}_1)=\frac{s_1^2\tau_{X2}\tilde{S}_1}{\tau_{\theta 2}+s_1^2\tau_{X2}}$ and $Var_1(\tilde{\theta}_2|\tilde{\theta}_1,\tilde{X}_1,\tilde{p})=\frac{1}{\tau_{\theta 2}+s_1^2\tau_{X2}}$.

For type 2 hedgers, we have

$$\tilde{\theta}_1-\gamma\sigma_{\varepsilon 1}\sigma_{u1}\rho_1\tilde{X}_1=\frac{\gamma\left[Var_1(\tilde{\theta}_2|\tilde{p})+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}{\mu}$$
$$\left[n-(1-\mu)\frac{\bar{v}+\tilde{\theta}_2+E_2(\tilde{\theta}_1|\tilde{p})-\tilde{p}-\gamma\tilde{X}_2\sigma_{\varepsilon i}\sigma_{ui}\rho_2}{\gamma\left[Var_2(\tilde{\theta}_1|\tilde{p})+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}-\mu\frac{\bar{v}+E_1(\tilde{\theta}_2|\tilde{p})-\tilde{p}}{\gamma\left[Var_1(\tilde{\theta}_2|\tilde{p})+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}\right]. \quad (10)$$

Let $\tilde{S}_2\equiv\tilde{\theta}_1+s_2^{-1}\tilde{X}_1$, where $s_2=-\frac{1}{\gamma\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}<0$. Thus, we have $E_2(\tilde{\theta}_1|\mathcal{F}_2)=\frac{s_2^2\tau_{X1}\tilde{S}_2}{\tau_{\theta 1}+s_2^2\tau_{X1}}$ and $Var_2(\tilde{\theta}_1|\mathcal{F}_2)=\frac{1}{\tau_{\theta 1}+s_2^2\tau_{X1}}$.

Through market clearing price, both types hedgers get some information about their counterparts' private signal and non-tradable asset position. Therefore, the demands of type 1 hedgers and type 2 hedgers are respectively

$$d_1=\frac{\bar{v}+\tilde{\theta}_1+\frac{s_1^2\tau_{X2}\tilde{S}_1}{\tau_{\theta 2}+s_1^2\tau_{X2}}-\tilde{p}-\gamma\tilde{X}_1\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{\gamma\left[\frac{1}{\tau_{\theta 2}+s_1^2\tau_{X2}}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}, \quad (11)$$

$$d_2=\frac{\bar{v}+\tilde{\theta}_2+\frac{s_2^2\tau_{X1}\tilde{S}_2}{\tau_{\theta 1}+s_2^2\tau_{X1}}-\tilde{p}-\gamma\tilde{X}_i\sigma_{\varepsilon i}\sigma_{ui}\rho_i}{\gamma\left[\frac{1}{\tau_{\theta 1}+s_2^2\tau_{X1}}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}. \quad (12)$$

### 4.3 Equilibrium

**Definition 1.** Given any hedgers constitution proportion $\mu$ and tradable risky asset supply $n$, an equilibrium $\left(d_1(\tilde{\theta}_1,\tilde{X}_1,\tilde{p}),d_2(\tilde{\theta}_2,\tilde{X}_2,\tilde{p}),\tilde{p}\right)$ is such that

1. Given any $\tilde{\theta}_i,\tilde{X}_i,\tilde{p},d_i$ maximize (4).
2. $\tilde{p}$ makes market clear, that is

$$\mu d_1(\tilde{\theta}_1,\tilde{X}_1,\tilde{p})+(1-\mu)d_2(\tilde{\theta}_2,\tilde{X}_2,\tilde{p})=n. \quad (13)$$

We have mentioned that the sum of demands of hedgers has to be equal to the supply of asset $m$. Substitute demands (11), (12) into (13), we get asset $m$ market clearing condition

$$\mu\frac{\bar{v}+\tilde{\theta}_1+\frac{s_1^2\tau_{X2}\tilde{S}_1}{\tau_{\theta 2}+s_1^2\tau_{X2}}-\tilde{p}-\gamma\tilde{X}_1\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{\gamma\left[\frac{1}{\tau_{\theta 2}+s_1^2\tau_{X2}}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}$$
$$+(1-\mu)\frac{\bar{v}+\tilde{\theta}_2+\frac{s_2^2\tau_{X1}\tilde{S}_2}{\tau_{\theta 1}+s_2^2\tau_{X1}}-\tilde{p}-\gamma\tilde{X}_i\sigma_{\varepsilon i}\sigma_{ui}\rho_i}{\gamma\left[\frac{1}{\tau_{\theta 1}+s_2^2\tau_{X1}}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}=n. \quad (14)$$

Solve this equation, we have followed proposition 1.

**Proposition 1.** For any given $\mu>0$, there exists a unique linear rational expected equilibrium

$$\tilde{p}=\bar{v}-\frac{n}{\Delta}+\frac{\alpha_1+\alpha_2}{\Delta}\tilde{\theta}_1+\frac{\beta_1+\beta_2}{\Delta}\tilde{\theta}_2+\frac{\xi_1+\xi_2}{\Delta}\tilde{X}_1+\frac{\eta_1+\eta_2}{\Delta}\tilde{X}_2,$$

where

$$\Delta=\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2},$$

$$\alpha_1=\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2},$$

$$\alpha_2=\frac{(1-\mu)s_2^2\tau_{X1}}{(\tau_{\theta 1}+s_2^2\tau_{X1})[(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]},$$

$$\beta_1=\frac{\mu s_1^2\tau_{X2}}{(\tau_{\theta 2}+s_1^2\tau_{X2})[(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]},$$

$$\beta_2=\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2},$$

$$\xi_1=-\frac{\mu\gamma\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2},$$

$$\xi_2=\frac{(1-\mu)s_2\tau_{X1}}{(\tau_{\theta 1}+s_2^2\tau_{X1})[(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]},$$

$$\eta_1=\frac{\mu s_1\tau_{X2}}{(\tau_{\theta 2}+s_1^2\tau_{X2})[(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]},$$

$$\eta_2=-\frac{(1-\mu)\gamma\sigma_{\varepsilon 2}\sigma_{u2}\rho_2}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}.$$

## V. PRICE DETERMINATION

The price is determined by demands of different types of hedgers, it depends on the hedgers' private information about private signal $\tilde{\theta}_i$and non-tradable asset position $\tilde{X}_i$. Price also transfer information about counterpart' private information through market equilibrium. We study what factors influence the price and the sensitivity of price, how they act, and their correlation with information transfer effect of price.

Firstly, we analyze the coefficient of $\tilde{\theta}_1$, that is $\frac{\alpha_1+\alpha_2}{\Delta}$.We can see

$$\frac{\alpha_1}{\Delta}=\frac{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}} \tag{15}$$

$$\frac{\alpha_2}{\Delta}=\frac{\frac{(1-\mu)s_2^2\tau_{X1}}{(\tau_{\theta 1}+s_2^2\tau_{X1})\left[(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}$$

$$<\frac{\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}. \tag{16}$$

Sum (15)and (16), we have

$$\frac{\partial\tilde{p}}{\partial\tilde{\theta}_1}=\frac{\alpha_1}{\Delta}+\frac{\alpha_2}{\Delta}<1=\frac{\partial\tilde{v}}{\partial\tilde{\theta}_1}.$$

$\frac{\alpha_1}{\Delta}$ is type 1 hedgers' influence on price, type 1 hedgers have full knowledge of $\tilde{\theta}_1$, thus the change of $\tilde{\theta}_1$can be completely responded in type 1 hedgers' demand function. $\frac{\alpha_2}{\Delta}$ is type 2 hedgers' influence on price, type 2 hedgers do not fully know $\tilde{\theta}_1$, they can only speculate some incomplete information about $\tilde{\theta}_1$through price. Thus, their demands do not

fully respond to the change of $\tilde{\theta}_1$. Finally, even in competitive market, the price can not fully respond to change of payoff because of asymmetric information. The difference between asymmetric information and complete information relies on

$$T_1 \equiv \frac{s_2^2\tau_{X1}}{\tau_{\theta 1}+s_2^2\tau_{X1}} = \frac{\tau_{X1}}{\tau_{\theta 1}(\gamma\sigma_{\varepsilon 1}\sigma_{u1}\rho_1)^2+\tau_{X1}}$$

Higher $T_1$, the market is more complete. As $T_1$increases, $\frac{\alpha_2}{\Delta}$gradually approaches to

$$\frac{\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}.$$

To study what influence the responding of price to $\tilde{\theta}_1$, we try to find the factors influencing $T_1$. At first, $\frac{\partial T_1}{\partial \tau_{X1}} > 0$ means price responds more sensitively to $\tilde{\theta}_1$with the precision of $\tilde{X}_1$increasing. It is because as the precision of $\tilde{X}_1$increases itbecomes more stable, which means through price, type 2 hedgers can estimate $\tilde{\theta}_1$ more accurately. Thus, type 2 hedgers have more information about $\tilde{\theta}_1$which makes price more efficient. Especially, $\tau_{X1}=\infty$, that implies$\tilde{X}_1$becomes constant. Type 2 hedger can perfectly speculate the value of $\tilde{\theta}_1$ through equilibrium price $\lim_{\tau_{X1}\to\infty} T_1 = 1$.Next, we have$\frac{\partial T_1}{\partial \tau_{\theta 1}} < 0$ implying that as precision of prior belief on$\tilde{\theta}_1$decreases, the price responds more sensitively to $\tilde{\theta}_1$. As $\tau_{\theta 1}$decreases, type 2 hedgers rely less on prior belief on $\tilde{\theta}_1$and their speculation about $\tilde{\theta}_1$will rely more on the price signal they get from trading. In reverse, price can fully reflect the change of $\tilde{\theta}_1$. When there is no prior belief on $\tilde{\theta}_1$, type 2 hedgers will fully trust the signal they get from price, and price will fully respond to the change of $\tilde{\theta}_1$, $\lim_{\tau_{\theta 1}\to 0} T_1 = 1$.Then we have $\frac{\partial T_1}{\partial |\rho_1|} < 0$. As the absolute value of correlation between asset $m$and asset 1 decreases, the price is more sensitive to the change of $\tilde{\theta}_1$. That is because type 1 hedgers' demand is less sensitive to $\tilde{X}_1$which makes type 2 hedgers' speculation about $\tilde{\theta}_1$more accurate. The asymmetric information problem weakens, price responds more sensitively to $\tilde{\theta}_1$, $\lim_{|\rho_1|\to 0} T_1 = 1$.

As for the coefficient of $\tilde{\theta}_2$, that is $\frac{\beta_1+\beta_2}{\Delta}$.We can see

$$\frac{\beta_1}{\Delta} = \frac{\frac{\mu s_1^2\tau_{X2}}{(\tau_{\theta 2}+s_1^2\tau_{X2})[(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}$$

$$< \frac{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}} \quad (17)$$

$$\frac{\beta_2}{\Delta} = \frac{\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}} \quad (18)$$

Sum (15)and (16), we have

$$\frac{\partial \tilde{p}}{\partial \tilde{\theta}_2} = \frac{\beta_1}{\Delta}+\frac{\beta_2}{\Delta} < 1 = \frac{\partial \tilde{v}}{\partial \tilde{\theta}_2}.$$

$\frac{\beta_1}{\Delta}$ is type 1 hedgers' influence on price, type 1 hedgers do not fully know $\tilde{\theta}_2$, they can only speculate some incomplete information about $\tilde{\theta}_2$through price. Thus, their demands do not fully respond to the change of $\tilde{\theta}_2$.$\frac{\beta_2}{\Delta}$ is type 2 hedgers' influence on price, type 2 hedgers have full knowledge of $\tilde{\theta}_2$, thus the change of $\tilde{\theta}_2$can be completely responded in type 2

hedgers' demand function. Finally, even in competitive market, the price cannot fully respond to change of payoff because of asymmetric information.

Similarly, we can define $T_2 = \frac{s_1^2\tau_{X2}}{\tau_{\theta 2}+s_1^2\tau_{X2}} = \frac{\tau_{X2}}{\tau_{\theta 2}(\gamma\sigma_{\varepsilon 2}\sigma_{u2}\rho_2)^2+\tau_{X2}}$and the analysis on the influence of $\tau_{X2}, \tau_{\theta 2}, \rho_2$is similar.

Secondly, we analyze the coefficient of $\tilde{X}_1$:

$$\frac{\xi_1}{\Delta} = \frac{-\frac{\mu\gamma\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}},$$

$$\frac{\xi_2}{\Delta} = \frac{\frac{(1-\mu)s_2\tau_{X1}}{(\tau_{\theta 1}+s_2^2\tau_{X1})\left[(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}},$$

where $\frac{\xi_1}{\Delta}$is type 1 hedgers' influence on price, $\frac{\xi_2}{\Delta}$is type 2 hedgers' influence on price. If correlation of payoff between asset $m$and asset 1 is negative, that is $\rho_1 < 0$, as $\tilde{X}_1$increases, type 1 hedgers need more asset $m$to hedge the risk exposure from asset 1. Thus, the hedge demand increases, which increases the price. And this sensitivity can be enforced by lower $\rho_1$. As $\sigma_{u1}$increases, hedge demand become more sensitive to $\tilde{X}_1$, which makes price more sensitive to $\tilde{X}_1$. And when $\rho_1 < 0, \frac{\xi_2}{\Delta} > 0$, which implies as $\tilde{X}_1$increases type 2 hedgers will have positive influence on price. It can be explained that increasing of $\tilde{X}_1$also increases the signal $\tilde{S}_2$that type 2 hedgers get from the market. This increases the type 2 hedgers' estimation of $\tilde{\theta}_1$, increases the speculation demand by type 2 hedgers, and increases market price.If correlation of payoff between asset $m$and asset 1 is positive, that is $\rho_1 > 0$, as $\tilde{X}_1$increases, type 1 hedgers need less asset $m$to avoid taking too much the risk exposure from asset 1. Thus, the hedge demand decreases, which decreases the price. And this sensitivity can be enforced by higher $\rho_1$. As $\sigma_{u1}$increases, hedge demand become more sensitive to $\tilde{X}_1$, which makes price more sensitive to $\tilde{X}_1$.And when $\rho_1 > 0, \frac{\xi_2}{\Delta} < 0$, which implies as $\tilde{X}_1$increases type 2 hedgers will have negative influence on price. It can be explained that increasing of $\tilde{X}_1$decreases the signal $\tilde{S}_2$that type 2 hedgers get from the market. This decrease the type 2 hedgers' estimation of $\tilde{\theta}_1$,decreases the speculation demand by type 2 hedgers, and decreases market price. The effects of both type hedgers are consistent no matter what sign $\rho_1$has.

As for the coefficient of $\tilde{X}_2$, that is $\frac{\eta_1+\eta_2}{\Delta}$,

$$\frac{\eta_1}{\Delta} = \frac{\frac{\mu s_1\tau_{X2}}{(\tau_{\theta 2}+s_1^2\tau_{X2})[(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}},$$

$$\frac{\eta_2}{\Delta} = \frac{-\frac{(1-\mu)\gamma\sigma_{\varepsilon 2}\sigma_{u2}\rho_2}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}$$

where $\frac{\eta_1}{\Delta}$is type 1 hedgers' influence on price, $\frac{\eta_2}{\Delta}$is type 2 hedgers' influence on price. If correlation of payoff between asset $m$and asset 2 is negative, that is $\rho_2 < 0$, as $\tilde{X}_2$increases, type 2 hedgers need more asset $m$to hedge the risk exposure from asset 2. Thus, the hedge demand of type 2 hedgers increases, which increases the price. And this sensitivity can be enforced by lower $\rho_2$. As $\sigma_{u2}$increases, hedge demand become more sensitive to $\tilde{X}_2$, which makes price more sensitive to $\tilde{X}_2$.And when $\rho_2 < 0, \frac{\eta_1}{\Delta} > 0$, which implies as $\tilde{X}_2$increases type 1 hedgers will have positive influence on price. It can be explained that increasing of $\tilde{X}_2$also increases the signal $\tilde{S}_1$that type 1 hedgers get from the market. This increases the type 1 hedgers'

estimation of $\tilde{\theta}_2$, increases the speculation demand by type 1 hedgers, and increases market price.If correlation of payoff between asset $m$and asset 2 is positive, that is $\rho_2 > 0$, as $\tilde{X}_2$increases, type 1 hedgers need less asset $m$to avoid taking too much the risk exposure from asset 2. Thus, the hedge demand decreases, which decreases the price. And this sensitivity can be enforced by higher $\rho_2$. As $\sigma_{u2}$increases, hedge demand become more sensitive to $\tilde{X}_2$, which makes price more sensitive to $\tilde{X}_2$.And when $\rho_2 > 0$,$\frac{\eta_1}{\Delta} < 0$, which implies as $\tilde{X}_2$increases type 1 hedgers will have negative influence on price. It can be explained that increasing of $\tilde{X}_2$decreases the signal $\tilde{S}_1$that type 1 hedgers get from the market. This decreases the type 1 hedgers' estimation of $\tilde{\theta}_2$, decreases the speculation demand by type 1 hedgers, and decreases market price.The effects of both type hedgers are consistent no matter what sign $\rho_2$has.

To summarize the analysis above, we have proposition 2 and proposition 3.

**Proposition 2.**As volatility of $\tilde{X}_1$decreases, type 2 hedgers can speculate on $\tilde{\theta}_1$more accurately, and increases the sensitivity of price to $\tilde{\theta}_1$. As volatility of prior belief on $\tilde{\theta}_1$increases, type 2 hedgers rely more on price to speculate on $\tilde{\theta}_1$, which makes price more sensitive to $\tilde{\theta}_1$. As the relativity between asset 1 and asset $m$decreases, type 2 hedger can speculate $\tilde{\theta}_1$more accurately, which makes price more sensitive to $\tilde{\theta}_1$. As volatility of $\tilde{X}_2$decreases, type 1 hedgers can speculate on $\tilde{\theta}_2$more accurately, and increases the sensitivity of price to $\tilde{\theta}_2$. As volatility of prior belief on $\tilde{\theta}_2$increases, type 1 hedgers rely more on price to speculate on $\tilde{\theta}_2$, which makes price more sensitive to $\tilde{\theta}_2$. As the relativity between asset 2 and asset $m$decreases, type 1 hedger can speculate $\tilde{\theta}_2$more accurately, which makes price more sensitive to $\tilde{\theta}_2$.

**Proposition 3.** If $\rho_1 > 0$, market price will decrease as $\tilde{X}_1$increases. If $\rho_1 < 0$, market price will increase as $\tilde{X}_1$increases.If $\rho_2 > 0$, market price will decrease as $\tilde{X}_2$increases. If $\rho_2 < 0$, market price will increase as $\tilde{X}_2$increases.

## VI. PRICE INFORMATIVENESS

In measurement of price informativeness, we try to capture the amount of uncertainty about $\tilde{\theta}_{-i}$that is reduced by observing asset $m$price $\tilde{p}$ based on knowingtheir non-tradable asset position $\tilde{X}_i$ , and their private signal $\tilde{\theta}_i$ for $i \in \{1,2\}$. Thus, we define type 1 and type 2hedgers' price informativeness as:

$$I_1 \equiv \frac{Var_1(\tilde{\theta}_2|\tilde{\theta}_1, \tilde{X}_1)}{Var_1(\tilde{\theta}_2|\tilde{\theta}_1, \tilde{X}_1, \tilde{p})} - 1 = s_1^2 \frac{\tau_{X2}}{\tau_{\theta 2}} = \frac{\tau_{X2}}{(\gamma \sigma_{\varepsilon 2} \sigma_{u2} \rho_2)^2 \tau_{\theta 2}}, \quad (19)$$

$$I_2 \equiv \frac{Var_2(\tilde{\theta}_1|\tilde{\theta}_2, \tilde{X}_2)}{Var_2(\tilde{\theta}_1|\tilde{\theta}_2, \tilde{X}_2, \tilde{p})} - 1 = s_2^2 \frac{\tau_{X1}}{\tau_{\theta 1}} = \frac{\tau_{X1}}{(\gamma \sigma_{\varepsilon 1} \sigma_{u1} \rho_1)^2 \tau_{\theta 1}}, \quad (20)$$

where the second equality follows from $Var_i(\tilde{\theta}_{-i}|\tilde{\theta}_i, \tilde{X}_i) = Var(\tilde{\theta}_{-i}) = \frac{1}{\tau_{\theta -i}}$and $Var_i(\tilde{\theta}_{-i}|\tilde{\theta}_i, \tilde{X}_i, \tilde{p}) = \frac{1}{\tau_{\theta -i} + s_i^2 \tau_{X-i}}$, third equality flows from $s_i = -\frac{1}{\gamma \sigma_{\varepsilon -i} \sigma_{u-i} \rho_{-i}}$.

**Proposition 4.** The price informativeness of $\tilde{\theta}_1$increases with precision of $\tilde{X}_2$,$\tilde{\varepsilon}_2$ and decreases with precision of $\tilde{\theta}_2$, volatility of $\tilde{u}_2$, $\rho_2$and risk aversion coefficient$\gamma$. Similarly, price informativeness of $\tilde{\theta}_2$increases with precision of $\tilde{X}_1$,$\tilde{\varepsilon}_1$ and decreases with precision of $\tilde{\theta}_1$, volatility of $\tilde{u}_1$, $\rho_1$and risk aversion coefficient $\gamma$.

**Proof.** It is easy to see from (19) and (20).

The influence of these coefficients comes from two sources. Firstly, they can influence the accuracy of estimation on counterparts' private signal and speculation demand further. Secondly, they can influence the risk exposure of holding non-tradable asset and hedging demand further. Through demand, they influence the competition of the market and price informativeness.

The decreasing of $\gamma, \sigma_{\varepsilon 1}, \sigma_{u1}$,and $\rho_1$increase the estimation accuracy of type 2 hedgers on $\tilde{\theta}_1$, and decrease type 1 hedgers' hedging demand. Both effects are beneficial to increase type 2 hedgers' price informativeness $I_1$. The increasing of $\tau_{X1}$increase the estimation of type 2 hedgers on $\tilde{\theta}_1$which increases the price informativeness $I_1$. The increasing of $\tau_{\theta 1}$decreases the price informativeness $I_1$, because hedgers rely more on their prior belief to decide.

We can see the price informativeness is irrelative to the proportion of different types of hedgers. Minor type hedgers do not have information strength as other models. That is because increasing hedgers number in one type do not expose more information to the other type hedgers.

## VII. COST OF CAPITAL

We examine the implication of price informativeness on asset price and define risk premium as the cost of capital given any non-tradable asset, that is

$$CC \equiv E\left(\tilde{v} - \tilde{p} | \tilde{X}_1, \tilde{X}_2\right).$$

From proposition 1, we know that

$$CC = \frac{n}{\Delta} - \frac{\xi_1 + \xi_2}{\Delta}\tilde{X}_1 - \frac{\eta_1 + \eta_2}{\Delta}\tilde{X}_2$$

$$= \frac{n}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2} + \frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}$$

$$+ \frac{\frac{\mu\gamma\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2} - \frac{(1-\mu)s_2\tau_{X1}}{(\tau_{\theta 1}+s_2^2\tau_{X1})\left[(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2} + \frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}\tilde{X}_1$$

$$+ \frac{\frac{(1-\mu)\gamma\sigma_{\varepsilon 2}\sigma_{u2}\rho_2}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2} - \frac{\mu s_1\tau_{X2}}{(\tau_{\theta 2}+s_1^2\tau_{X2})[(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]}}{\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2} + \frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}}\tilde{X}_2$$

If $\rho_1 > 0$, Cost of capital increases as $\tilde{X}_1$increases because both type 1 hedgers' hedging demand and type 2 hedgers' speculation demand decrease which decreases the price. And risk premium increases.If $\rho_1 < 0$, Cost of capital increases as $\tilde{X}_1$depends because type 1 hedgers' hedging demand increases and type 2 hedgers' speculation demand decrease. We cannot tell which effect is in dominance. The analysis on $\rho_1$and $\tilde{X}_2$is similar.

To further analyze the situation of $\rho_1 < 0$, we can see that the coefficient of $\tilde{X}_1$is positive if $\mu = 0$ and negative if $\mu = 1$. By continuity, there exist a $\bar{\mu} \in (0,1)$rendering

$$\frac{\mu\gamma\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2} - \frac{(1-\mu)s_2\tau_{X1}}{(\tau_{\theta 1}+s_2^2\tau_{X1})[(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]} = 0.$$

For $\mu > \bar{\mu}$, cost of capital decreases as $\tilde{X}_1$ increases, because increasing of hedging demands of type 1 hedgers is greater than decreasing of speculation demands of type 2 hedgers. For $\mu < \bar{\mu}$, cost of capital increases as $\tilde{X}_1$ increases, because increasing of hedging demands of type 1 hedgers is less than decreasing of speculation demands of type 2 hedgers. $\tilde{X}_1$ is similar.

## VIII. CONCLUSION

In our model, we analyze the market with two types of hedgers who own different kinds of non-tradable asset and know different information about the payoff of a tradable asset. Through market clearing, they can estimate counterparts' information about the tradable asset and their position in non-tradable asset by equilibrium price. And make their decision to enter market trading.

We separate hedgers' demands into two parts: speculation demand and hedging demand. Speculation demand derives from hedger's own information about payoff of tradable asset and estimation of counterpart's information. Hedging demand derives from his position on non-tradable asset. All types of hedgers' demand decide the equilibrium price. We conclude that the market price cannot fully reflect the influence of private information because there are always some other type hedgers who do not know accurate information about the payoff. As prior belief of holding position on non-tradable becomes more inaccurate, the market price reacts less to the information because it is more difficult for different type hedgers to estimate others' private information. As prior belief of

private information becomes more inaccurate, the price reacts more to the information because they have to rely more on price to maker estimation on others' private information. More importantly, the increasing of relativity between non-tradable asset and tradable asset decreases the accuracy of others' estimation on their private information because more hedging demand is not benefit for market efficiency but decreases it by reducing speculation demand. Further, we find that tradable asset price is positively related to non-tradable asset position if they have negative correlation. It is because non-tradable asset and tradable asset are complements if their payoff are positively related. And tradable asset price is negatively related to non-tradable asset position if they have positive correlation. It is because non-tradable asset and tradable asset are substitutes if their payoff are negatively related.

Later, we research price informativeness of market clearing. The more accurate estimation is, the more informative price is. And less hedging demands can increase price informativeness. If the correlation between non-tradable asset and tradable asset is positive, risk premium increases with non-tradable position increasing. If the correlation between non-tradable asset and tradable asset is negative, the relation between risk primum and non-tradable asset position is unclear depending on hedgers' proportion.

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## APPENDIX

Proof of proposition 1.

Substitute $\tilde{S}_1 \equiv \tilde{\theta}_2 + s_1^{-1}\tilde{X}_2$and $\tilde{S}_2 \equiv \tilde{\theta}_1 + s_2^{-1}\tilde{X}_1$into (14), we have

$$\frac{1}{\gamma}\left[\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2} + \frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}\right]\tilde{p}$$
$$= \frac{\bar{v}}{\gamma}\left[\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2} + \frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}\right] - n$$
$$+ \mu\frac{\tilde{\theta}_1 + \frac{s_1^2\tau_{X2}(\tilde{\theta}_2+s_1^{-1}\tilde{X}_2)}{\tau_{\theta 2}+s_1^2\tau_{X2}} - \gamma\tilde{X}_1\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{\gamma\left[\frac{1}{\tau_{\theta 2}+s_1^2\tau_{X2}}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}$$
$$+ (1-\mu)\frac{\tilde{\theta}_2 + \frac{s_2^2\tau_{X1}(\tilde{\theta}_1+s_2^{-1}\tilde{X}_1)}{\tau_{\theta 1}+s_2^2\tau_{X1}} - \gamma\tilde{X}_2\sigma_{\varepsilon 2}\sigma_{u2}\rho_2}{\gamma\left[\frac{1}{\tau_{\theta 1}+s_2^2\tau_{X1}}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2\right]}$$

Simplify it, we get

$$\frac{1}{\gamma}\left[\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}\right.$$
$$\left.+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}\right]\tilde{p}$$
$$=\frac{\bar{v}}{\gamma}\left[\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}\right.$$
$$\left.+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}\right]-n$$
$$+\frac{1}{\gamma}\left[\frac{\mu}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}\right.$$
$$\left.+\frac{(1-\mu)s_2^2\tau_{X1}}{(\tau_{\theta 1}+s_2^2\tau_{X1})[(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]}\right]\tilde{\theta}_1$$
$$+\frac{1}{\gamma}[\frac{\mu s_1^2\tau_{X2}}{(\tau_{\theta 2}+s_1^2\tau_{X2})[(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]}$$
$$+\frac{1-\mu}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}]\tilde{\theta}_2$$
$$\frac{1}{\gamma}[-\frac{\mu\gamma\sigma_{\varepsilon 1}\sigma_{u1}\rho_1}{(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}$$
$$+\frac{(1-\mu)s_2\tau_{X1}}{(\tau_{\theta 1}+s_2^2\tau_{X1})[(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]}]\tilde{X}_1$$
$$\frac{1}{\gamma}[\frac{\mu s_1\tau_{X2}}{(\tau_{\theta 2}+s_1^2\tau_{X2})[(\tau_{\theta 2}+s_1^2\tau_{X2})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2]}$$
$$-\frac{(1-\mu)\gamma\sigma_{\varepsilon 2}\sigma_{u2}\rho_2}{(\tau_{\theta 1}+s_2^2\tau_{X1})^{-1}+\sigma_{\varepsilon 1}^2+\sigma_{\varepsilon 2}^2}]\tilde{X}_2$$

Therefore, we have

$$\tilde{p}=\bar{v}-\frac{n}{\Delta}+\frac{\alpha_1+\alpha_2}{\Delta}\tilde{\theta}_1+\frac{\beta_1+\beta_2}{\Delta}\tilde{\theta}_2+\frac{\xi_1+\xi_2}{\Delta}\tilde{X}_1$$
$$+\frac{\eta_1+\eta_2}{\Delta}\tilde{X}_2. \qquad \square$$