# Financialization of Commodity : the Role of Financial Investors in Commodity Markets

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# Financialization of Commodity: the Role of Financial Investors in Commodity Markets

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September, 14 2017

*To my family*

*To Ivar Ekeland & Nesim Fintz*

*To my supervisors*

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# Résumé

Une commodité est définie comme "un bien intermédiaire ayant une qualité standard, qui peut être échangée sur des marchés internationaux compétitifs et liquides de biens physiques"(Clark et al. (2001)). Cette définition est plus large que celle des matières premières. Ces dernières sont des biens intermédiaires issus des ressources naturelles ayant subis une ou deux étapes de transformation. La précédente définition indique que le marché des commodités doit être compétitif et liquide. La liquidité nécessite que le marché s'équilibre à tout instant (avec l'offre globale égale à la demande globale) comme une résultante de l'interaction entre plusieurs vendeurs et acheteurs sur un marché global (compétitif). Conformément à cette définition, il existe différentes catégories de commodités : les commodités énergétiques (e.g. pétrole brut, gaz naturel, produits dérivés du pétrole raffiné, charbon, biocarburant) métaux (précieux (e.g. or, cuivre, argent, platine, palladium) et ferreux (e.g. fer)) et toutes les commodités agricoles (e.g. céréales (blé, maïs, soja, etc.) huiles (huile de soja, etc.), produits doux (cacao, café, coton, etc.)) et le bétail). D'autres marchés complexes, qui deviennent plus compatibles avec la définition, se commoditisent, comme l'électricité, les services (e.g. fret), les devises et les actifs financiers. Les marchés des commodités sont innovants, par conséquent, il apparentera certainement de nouveaux types de commodités.

Les prix des commodités sont fixés par la confrontation de l'offre et de la demande. Les prix évoluent dans le temps, ce qui représente un risque pour les acheteurs comme pour les vendeurs des marchés au comptant[1]. Le vendeur se préoccupe de la baisse des prix alors que l'acheteur se préoccupe de sa hausse. Par exemple, les agriculteurs qui cultivent l'avoine ou le blé ne peuvent savoir à quel niveau leur prix s'établira après quatre mois de leur plantation. Une compagnie aérienne ayant besoin de carburant pour ses avions, et vu ses capacités limitées de stockage, voudra se prémunir contre tout hausse des prix des carburants. Par conséquent, les opérateurs des marchés au comptant ont recours aux marchés dérivés. Un contrat dérivé est un arrangement entre les parties pour échanger un actif sous-jacent à une date future; ces

[1]Dans ce contexte, il existe des marchés de commodités au comptant et des marchés de commodités tangibles. Sur le marché au comptant, la commodité est payée et livrée immédiatement. Sur les marchés tangibles ou ceux forward, la commodité est payée et est livrée à une date ultérieure.

actifs sous-jacents peuvent être des actions, des obligations, des commodités, des devises ou des indices (Whaley (2012)). Dans cette thèse, je m'intéresse aux marchés des commodités. Ainsi, nous définissons le marché des dérivés des commodités comme un marché financier dans lequel les instruments financiers, représentant certains commodités physiques sous-jacentes disponibles pour être livrées à une date future donnée, sont échangés sous plusieurs conditions (Clark et al. (2001)). Il existe différents types de contrats dérivés, qui sont échangés sur les marchés organisés comme les contrats à terme et les options ou sur les marchés de gré-à-gré (OTC) comme les contrats forward et les swaps. Les contrats futurs sont largement plus utilisés que les autres instruments dérivés pour différentes raisons: la livraison de l'actif tangible sur les marchés à terme n'est pas une obligation; seuls 1 à 2% du total des positions à terme sont livrées physiquement; c'est-à-dire atteignant la date de maturité. Si un hedger a besoin de couvrir ses positions à terme, il n'a qu'à prendre des positions opposées sur le marché à terme. Lorsque le contrat futur n'est pas soldé avant maturité, l'agent devra payer le solde pour équilibrer le marché. Aussi, les marchés à terme sont organisés, ils sont contrôlés par des chambres de compensations (plus sécurisés).

Le marché des dérivés est le lieu où des positions physiques sont couvertes. Dans le but de se prémunir contre les variations des prix, et en se basant sur la théorie traditionnelle de couverture, les hedgers prennent des positions de la même ampleur que sur le marché physique mais dans le sens opposé (Johnson (1960) and Ederington (1979)). Par exemple, un agent qui stocke des commodités en vue de les vendre ultérieurement (spéculation physique) se préoccupe de la baisse de leur prix. Par conséquent, il vend des positions futures (appelées positions courtes). De l'autre côté, si un autre agent (un producteur par exemple) a besoin d'acheter une commodité, il achète des positions futures (prend des positions longues) par crainte de la hausse des prix. Dans le cas idéal, les positions futures prises par les agents exerçant des activités commerciales sur les marchés physiques (les hedgers) doivent se compenser mutuellement. Cependant, dans les faits, le total des positions futures courtes des hedgers est différent du total des positions longues. Ainsi, aux côtés des hedgers existent les spéculateurs. La spéculation des commodités vise à obtenir un profit en réalisant des transactions dont le but exclusif est l'obtention de ce profit et non la production, la commercialisation ou le développement des commodités (Working (1960)). Les spéculateurs compensent les positions des hedgers et sont rémunérés par ces derniers pour les risques qu'ils supportent sous forme de prime de risque des contrats à terme (Keynes (1930)).

## Les investisseurs financiers sur les marchés à terme des commodités

Les deux dernières décennies, notamment depuis le début du troisième millénaire, ont connu une hausse des contrats futurs échangés sur les marchés des commodités. Le tableau 2 montre les positions d'intérêts ouvertes des contrats futurs pour dix commodités échangées sur différents marchés: énergie (pétrole brut, fioul domestique et gaz naturel) commodités agricoles (blé, maïs, soja et huile de soja) produits doux (coton) et métaux (cuivre et or). Les commodités sont présentées dans le tableau 1. Pour montrer l'évolution sur le marché des futurs, j'utilise des données publiées par Commodity Futures Trading Committee (CFTC). Cette instance publie régulièrement des rapports fournissant chaque mardi les positions d'intérêts ouvertes (ces données sont fournies hebdomadairement depuis septembre 1992 et deux fois par mois avant cette date). Ces positions sont agrégées pour toutes les maturités. Les rapports du CFTC fournissent les positions de court et de long terme. Le volume agrégé des positions de long terme est égal à celui des positions de court terme. Les positions d'intérêts ouvertes sont composées des positions signalées et non-signalées. Les traders signalés se subdivisent en traders commerciaux et non-commerciaux. Le commercial est un trader qui utilise les contrats à terme pour des finalités de couverture, lié aux marchés des commodités physiques. Dans les autres cas le trader est non-commercial. Dans ce contexte, l'usage de positions commerciales renvoie aux activités de couverture alors que l'usage de positions non-commerciales renvoie aux activités spéculatives. Le Tableau 2 montre que la croissance des positions d'intérêts ouvertes/encours, entre 2000 et 2015, a doublé dans les marchés futurs du maïs et de l'huile de soja, comparée à leur évolution entre 1990 et 2000. Dans les marchés du fioul domestique et du coton, la croissance des positions d'intérêts ouvertes pendant la période 2000-2015 représente trois fois leur croissance pendant la période 1990-2000. En outre, la croissance sur la période 2000-2015 est 4 fois supérieure à celle du marché du pétrole brut, 1,4 fois dans le blé, 6,5 fois dans le marché du soja et 9 fois dans le marché de l'or de la période 1990-2000. Le marché du cuivre a connu une croissance régulière au même rythme.

Table 1: Aperçu des marchés à terme de matières premières

| Commodité | Exchange | taille du contrat | Prix quatation | Livraison |
|---|---|---|---|---|
| Pétrole brut (WTI) | NYMEX | 1,000 Barils | U.S. $ Par baril | Mensuel |
| Gaz naturel | NYMEX | 10,000 mmBtu | U.S. $ par mmBtu | Mensuel |
| Fioul domestique | NYMEX | 42,000 gallons | U.S. $ par gallon | Mensuel |
| Blé | CBOT | 5,000 boisseaux | Cents per bushel | Mar, May, Jul, Sept and Dec |
| Mais | CBOT | 5,000 boisseaux | Cents per bushel | Mar, May, Jul, Sept and Dec |
| Soja | CBOT | 5,000 boisseaux | Cents per bushel | Jan, Mar, May, Jul, Aug, Sept and Nov |
| Huile de soja | CBOT | 60,000 pounds | Cents per pound | Jan, Mar, May, Jul, Aug, Sept, Oct and Dec |
| Coton | NYMEX | 50,000 pounds | U.S. $ per pound | Mar, May, Jul, Oct, and Dec |
| Cuivre | COMEX | 25,000 pounds | U.S. $ per pound | Mar, May, Jul, Sept and Dec |
| Or | COMEX | 100 troy ounces | U.S. $ per ounce | Feb, Apr, Jun, Aug, Oct and Dec |

- NYMEX est New York Mercantile Exchange; CBOT est Chicago Board of Trade; COMEX est Commodity Exchange (une division en NYMEX)
- **Note**: Pour les commodités agricoles (blé, maïs et soja), la taille du contrat avant janvier 1998 est de 1000 boisseaux. Mais, il est de 5000 boisseaux après janvier 1998. Dans les graphiques, j'ai unifié ces contrats à 1000 boisseaux par contrat.

Table 2: Taux de croissance des contrats à terme sur les positions ouvertes de matières premières

| Commodity | 1990 | 2000 | 2015 | Growth rate 90-00 | Growth rate 00-15 |
|---|---|---|---|---|---|
| Pétrole brut (WTI) | 272,262 | 464,369 | 1,678,012 | 71% | 261% |
| Fioul domestique | 88,912 | 140,650 | 376,758 | 58% | 168% |
| Gaz naturel | 8,180 | 333,874 | 991,540 | 3982% | 197% |
| Blé | 283,154 | 683,987 | 2,013,454 | 142% | 194% |
| Mais | 1,094,145 | 2,172,483 | 6,665,012 | 99% | 207% |
| Soja | 557,624 | 830,915 | 3,447,435 | 49% | 315% |
| Huile de soja | 72,125 | 143,733 | 380,204 | 99% | 165% |
| Coton | 38,149 | 62,079 | 185,401 | 63% | 199% |
| Cuivre | 33,535 | 73,423 | 170,499 | 119% | 132% |
| Or | 117,763 | 142,078 | 418,942 | 21% | 195% |

Ce tableau montre le taux de croissance des contrats à terme sur commodités. Les données sont obtenues auprès de la CFTC. J'utilise les positions moyennes ouvertes sur les années 1990, 2000 et 2015 (deuxième, troisième et quatrième colonnes).

La croissance des positions d'intérêts ouvertes a été accompagnée d'une augmentation significative de la participation des investisseurs aux marchés des futurs. La présence de ces investis-

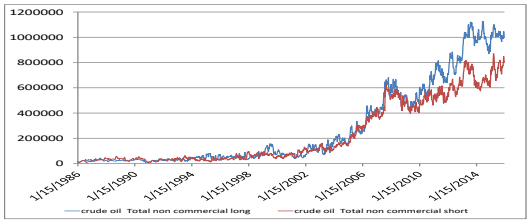
seurs, qui ne sont pas commercialement liés aux marchés des commodités physiques, a connu une rupture structurelle sur les marchés futurs au début du troisième millénaire, notamment autour de 2002/2003; chose qui a été stimulée par l'usage répandu de l'internet et le développement des moyens de communication. Ce phénomène est appelé : financiarisation des commodités[2]. La Figure 1 montre les contrats futurs détenus par les agents non-commerciaux sur les marchés suivants : pétrole brut, fioul domestique, gaz naturel, blé, maïs, soja, huile de soja, coton, cuivre et or.

Selon Masters (2008), les indices d'investissement des commodités ont augmenté de 13 milliards de dollars en 2003 à 260 milliards en mars 2008. Aussi, Carpenter (2011) estime l'encours total des actifs de commodités à 412 milliards de dollars en mars 2011 (Belousova and Dorfleitner (2012)). Pourquoi ces agents participent activement aux marchés des commodités? En s'appuyant sur une base de données couvrant la période 1959-2005, Gorton and Rouwenhorst (2006) montrent que les futurs de commodités offrent les mêmes rendements moyens que les actions américains mais avec des corrélations négatives entre les marchés des commodités et ceux des actions et obligations. Erb and Harvey (2006) montrent que la corrélation entre les rendements des commodités est nulle, pour la période entre 1982 et 2004. Dans ce contexte, l'introduction des commodités aux portefeuilles d'actions et d'obligations réduit le risque global. Ainsi, le fait de considérer les commodités comme des actifs et les intégrer aux portefeuilles est bénéfique pour les investisseurs du point de vue de la diversification. L'intérêt de la diversification a été montré également par Cheung and Miu (2010). Toutefois, les commodités ne sont des actifs comme les autres. Selon Geman (2005), elles se distinguent des actifs ordinaires par différentes propriétés. Premièrement, elles offrent une couverture contre l'inflation. La valeur des commodités traduit la variation du niveau des prix. En effet, toute augmentation de la demande des biens et services provoque une hausse de la demande des commodités qui sont utilisées dans la production de ces biens et services. Deuxièmement, les commodités offrent une couverture contre les variations du cours du dollar. De manière générale, les commodités sont cotées en dollar. Ainsi, une dépréciation du dollar provoque une hausse des prix des commodités. Enfin, les prix des commodités sont déterminés par l'interaction entre l'offre et la demande, alors elles ne peuvent être évaluées comme des actifs ordinaires (Belousova and Dorfleitner (2012) ).

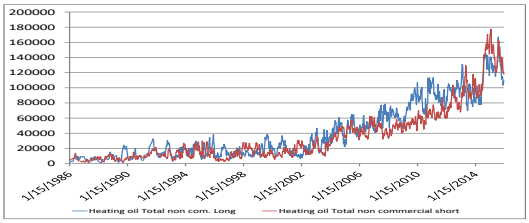
[2]Greta Krippner définit la financiarisation comme un modèle d'accumulation dans lequel le profit est réalisé principalement par le biais des canaux financiers plutôt que par la production des commodités (Krippner (2005)). Epstein (2005) considère la financiarisation comme la hausse de l'importance des marchés financiers, des acteurs financiers et des institutions financières dans le fonctionnement de l'économie aux niveaux local et international. La financiarisation transforme le fonctionnement du système économique, du point de vue de l'économie réelle, aux niveaux micro et macro. Les impacts de la financiarisation sont les suivants: l'augmentation de l'importance du secteur financier par rapport à l'économie réelle ; le transfert du revenu de la sphère réelle vers le secteur financier ; la contribution à l'augmentation des inégalités et de la stagnation des salaires (Palley (2007))).

L'investissement dans les commodités peut se faire par l'achat des commodités physiques sur le marché au comptant, l'achat des actions des entreprises liées à ces commodités, l'achat des futurs de commodités et des options, des indices des commodités ou des notes liées aux commodités(Geman (2005)). La dernière méthode est facile et préférable comparée à l'exposition aux marchés des commodités. Selon Stoll and Whaley (2010) et Irwin and Sanders (2011), les investisseurs financiers, qu'ils soient individuels ou institutionnels, ont tendance à investir dans les futurs des commodités en utilisant des indices de commodités comme benchmarks, à l'instar de Standard and Poor's-Goldman Sachs Commodity Index (S&P GSCI) and Dow Jones-UBS Commodity Index (DJ-UBSCI). Ils considèrent ces indices comme étant bien diversifiés. Par conséquent, ils constituent des portefeuilles qui répliquent ces indices. Ils peuvent également constituer un portefeuille de contrats futurs, de sorte à répliquer l'un de ces indices. Toutefois, étant donné le manque d'expérience des investisseurs en matière de gestion des portefeuilles de commodités, ils ont recours aux véhicules d'investissement à l'instar des fonds d'indices de commodités et des swaps des rendements des commodités. Dans la période récente, les produits échangés en bourse (Exchange-traded funds (ETFs) and Exchange-traded notes (ETNs)) ont été largement sollicités. Les ETFs sont des parts de fonds mutuels échangés sur une bourse/un marché de capitaux dans lequel les prix de ces parts sont fonction d'un indice de commodités. Les ETNs sont des titres de dette remboursés par l'émetteur sur la base de la valeur de l'indice de commodités sous-jacent. Il est encore plus probable que les investisseurs diversifient leurs portefeuilles en combinant des commodités. Ainsi, la financiarisation des commodités renvoie à deux importantes considérations. Premièrement, la relation entre les marchés des actions et ceux des commodités. Deuxièmement, la relation entre les marchés des commodités eux-mêmes.

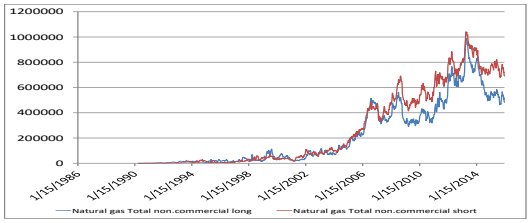
Figure 1: Positions à terme non commerciales sur matières premières



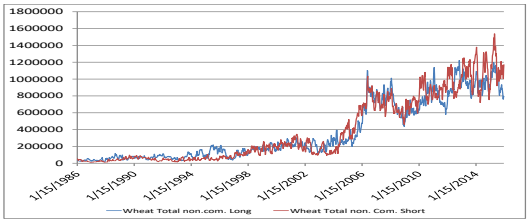

(a) Pétrole brut



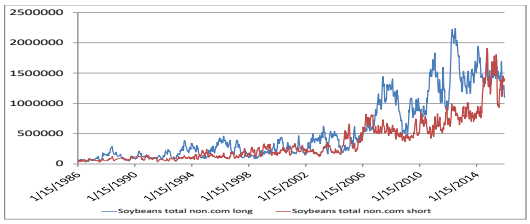

(b) Fioul domestique



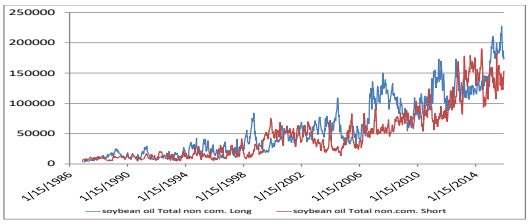

(c) Gaz naturel



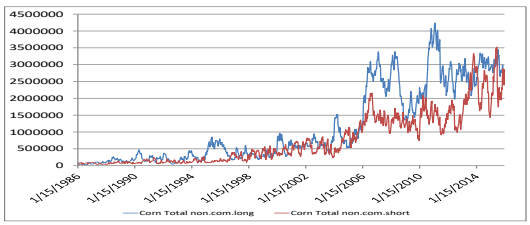

(d) Blé



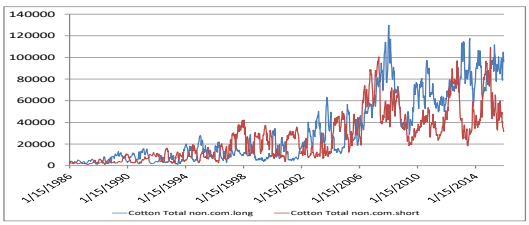

(e) Soja



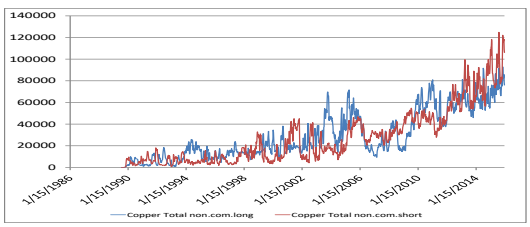

(f) Huile de soja



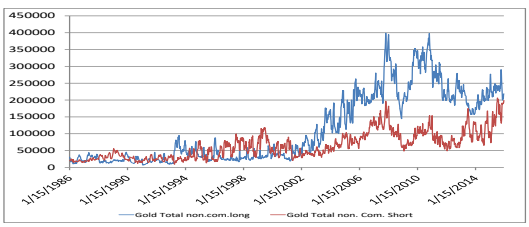

(g) mais




(h) Coton

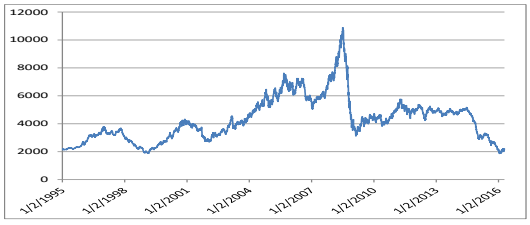



(i) Cuivre



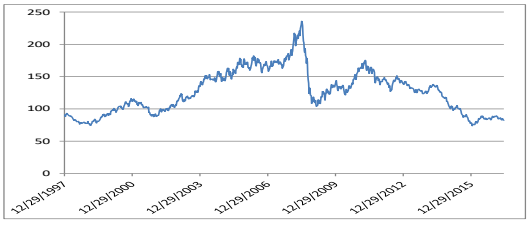

(j) Or

Figure 2: Les indices S&P GSCI et DJ-UBSCI




(a) S&P GSCI

source: Datastream




(b) DJ-UBSCI

source: www.mrci.com/client/djubs.php

## Spéculation sur indices

Dans la précédente section, je me suis intéressé à la question de l'augmentation de la participation des investisseurs aux marchés à terme des commodités. Toutefois, comme le montrent les données du CFTC, les positions futures d'intérêts ouvertes augmentent dans les niveaux commerciaux et non-commerciaux. Alors, pourquoi ne nous poserons pas la question de savoir si la hausse du rôle des investisseurs financiers n'est pas une réponse normale aux activités de couverture. Pour vérifier le rôle des activités spéculatives, je vais montrer deux cas qui encouragent la hausse de la spéculation. D'abord, je vais montrer le pourcentage des positions d'intérêts ouvertes non-commerciales dans total de ces positions. Ensuite, je simulerai l'indice de Working (1960).

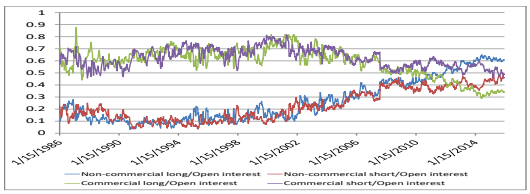
### Le non-commercial dans le total des positions d'intérêts ouvertes

La Figure 3 montre les poids respectifs des positions d'intérêts ouvertes des futurs commerciaux et non-commerciaux concernant : le pétrole brut, le fioul domestique, le gaz naturel, le blé, le maïs, le soja, l'huile de soja, l'or, le cuivre et le coton pour la période 1986-2015. Cette figure montre la hausse nette de la part des positions d'intérêts ouvertes non-commerciales sur le marché de l'énergie plus que tout autre marché. Jusqu'en 2002, les positions futures commerciales d'intérêts ouvertes dominaient de manière claire les positions non-commerciales courtes et longues, avec un poids presque stable. Par exemple, les positions non-commerciales longues (courtes) pour le pétrole brut représentaient 13% (12%) du total des positions futures d'intérêts ouvertes, alors que les positions commerciales longues (courtes) représentaient 67% (67%) du total des positions. La situation est similaire sur les marchés du fioul domestique et du gaz naturel. Les positions non-commerciales longues (courtes) du fioul domestique représentaient 11% (10%) du total des positions futures d'intérêts ouvertes, alors que les positions commerciales longues (courtes) représentaient 55% (66%) du total des positions. Sur le marché futur du gaz naturel, les positions non-commerciales longues (courtes) du fioul domestique représentaient

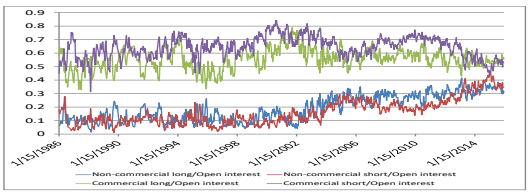
11% (9%) du total des positions futures d'intérêts ouvertes, alors que les positions commerciales longues (courtes) représentaient 69% (78%) du total des positions. Après 2002, le poids des positions non-commerciales a commencé à augmenter par rapport aux positions commerciales. A la fin de l'année 2015, les positions courtes commerciales et non-commerciales ont convergé pour représenter respectivement 46% et 49% du total des positions d'intérêts ouvertes. A l'opposé, les poids des positions non-commerciales et commerciales longues sont différents, les premières sont surreprésentées avec 60,5% contre 34,6% pour les positions longues commerciales. Entre 2002 et 2015, le volume des positions non-commerciales, pour fioul domestique, a augmenté mais sans dépasser celui des positions commerciales; les positions non-commerciales longues (courtes) à la fin 2005 représentaient 31,8% (34,3%) contre 55,3% (53,5%) pour les positions commerciales longues (courtes). Le constat est plus évident pour le marché du gaz naturel sur lequel la dominance est passée des positions commerciales à celles non-commerciales, après 2006. A la fin 2006, les positions non-commerciales longues (courtes) représentaient 49% (70%) du total des positions d'intérêts ouvertes, alors que les positions commerciales représentaient 44,7% (25%) du total des positions d'intérêts ouvertes.

La hausse des positions non-commerciales sur les marchés agricoles ne peut être observable, à l'instar du marché de l'énergie (voir les figures 3d, 3e, 3f and 3g). Ceci peut être dû à la saisonnalité des marchés agricoles. Toutefois, le poids des positions non-commerciales augmente avec le temps. Par exemple, les positions non-commerciales sur le marché du blé dominaient fortement les positions commerciales autour de 2013, représentant 44,1% du total des positions longues et 65% des positions courtes à la fin de 2015. Sur le marché du maïs, les positions non-commerciales et commerciales sont presque équivalentes. Pour les marchés futurs de l'or, après 2002, les positions longues étaient dominées par les opérateurs non-commerciaux alors que les positions courtes étaient dominées par les agents commerciaux. Cependant, les positions commerciales et non-commerciales semblent être proches les unes des autres, avec 54% (49,5%) pour les positions non-commerciales longues (courtes) contres 36,6% (40,4%) pour les positions commerciales longues (courtes). Le Tableau 7 montre l'évolution du poids des positions commerciales et non-commerciales dans le total des positions d'intérêt ouvertes.

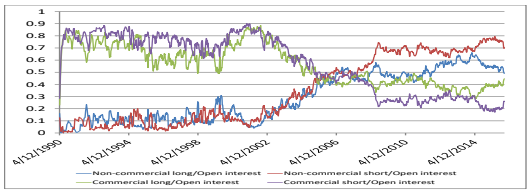
Figure 3: La part des positions non-commerciales et commerciales par rapport au total des positions ouvertes



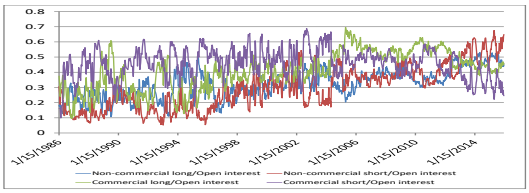

(a) Pétrole brut



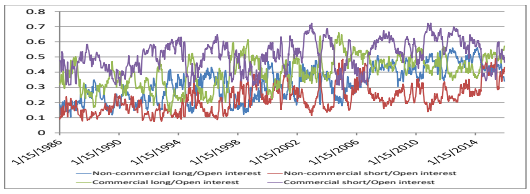

(b) Fioul domestique



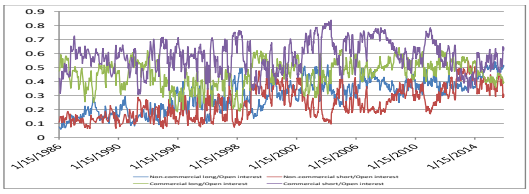

(c) Gaz naturel



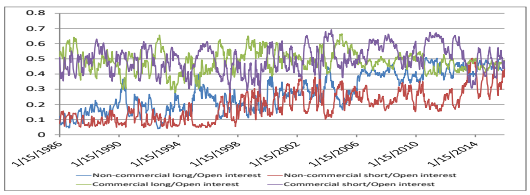

(d) Blé



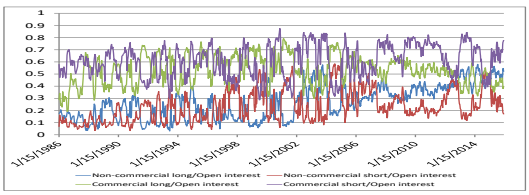

(e) Soja



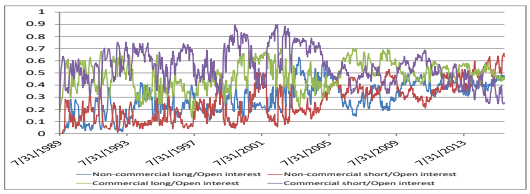

(f) Huile de soja



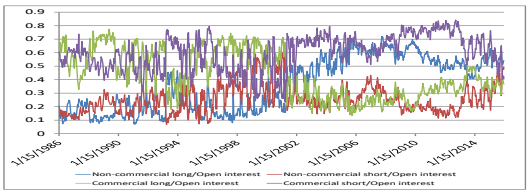

(g) Mais




(h) Coton




(i) Cuivre




(j) Or

### L'indice "$T$" de Working (1960)

La hausse des positions non-commerciales (des spéculateurs) a été accompagnée par une hausse des positions commerciales. Par conséquent, afin d'être précis sur la hausse de la spéculation, j'utilise l'indice de Working (1960) pour mesurer les activités spéculatives sur les marchés futurs des commodités. L'indice "$T$" de Working mesure le rapport entre les activités non-commerciales et les activités commerciales (spéculation par rapport au activités de couverture). Le concept de cet indice dépend de la relation entre les spéculateurs et les hedgeurs. Il est basé sur l'argument selon lequel les spéculateurs sont nécessaires pour compenser les positions nettes des hedgeurs. Cet indice considère les spéculateurs comme inutiles lorsque les positions longues nettes des hedgeurs sont égales à leurs positions nettes courtes (les hedgeurs se compensent mutuellement). Toutefois, la réalité est différente, les positions futures longues et courtes ne se compensent pas. Ainsi, l'indice de Working (1960) évalue les activités spéculatives excédant celles nécessaires à la compensation des positions de courveture[3].

L'indice "T" de Working (1960) est:

$$T_t^i = \begin{cases} 1 + \frac{NS_t^i}{CS_t^i + CL_t^i}, \text{ lorsque } CS_t^i \geq CL_t^i \\ \\ 1 + \frac{NL_t^i}{CS_t^i + CL_t^i}, \text{ lorsque } CS_t^i \leq CL_t^i \end{cases}, \text{lorsque } i\text{indique la commodité}$$

Où, NS les positions non-commerciales courtes (les positions courtes des spéculateurs) ; NL les positions non-commerciales longues (les positions longues des spéculateurs) ; CS les positions commerciales futures courtes; CL les positions commerciales futures longues.

Pour estimer l'indice sur les marchés futurs du pétrole brut, du fioul domestique, du gaz naturel, du blé, du maïs, du soja, de l'huile de soja, du cuivre, de l'or et du coton, j'utilise les données concernant les positions non-commerciales fournies par le CFTC pour la période allant de janvier 1986 à décembre 2015, à l'exception du gaz naturel (1990-2015) et du cuivre (1989-2015).

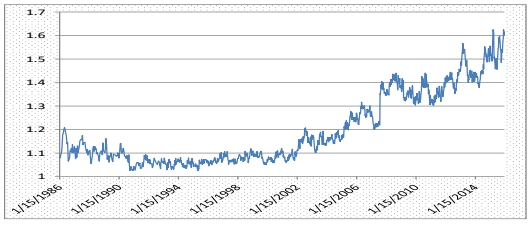
La Figure 4 smontre les variations de l'indice T de Working pour les commodités choisies. Les figures 4a, 4b and 4c illustrent la hausse des activités spéculatives après 2002 respectivement sur les marchés futurs du pétrole brut, du fioul domestique et du gaz naturel. Durant la période 1986-2002, l'indice de Working pour le pétrole brut varie autour de 1,076, alors qu'au début de l'année 2002 il était de 1,11 pour grimper à 1,62 en fin 2015 (i.e. les activités spéculatives, celles excédent les volumes nécessaires à la compensation des activités de courveture, ont augmenté de

[3]Cet indice est utilisé également dans Buyukşahin and Robe (2014b).

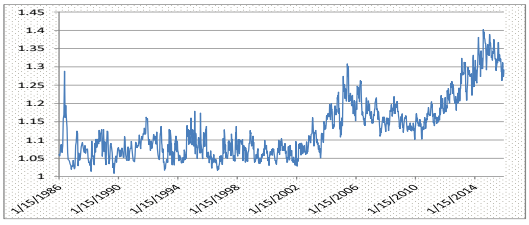
11% à 62% durant la période 2002-2015). Pour le gaz naturel, les activités spéculatives passent de 1,056 en 2002 à 2,06 en 2015 (i.e. 5,6% en 2002 à 106% en 2015). Le marché du fioul domestique a connu une évolution moins accentuée, les activités spéculatives sont passées de 1,05 au début de 2002 à 1,37 en début 2015, pour baisser à 1,29 en fin 2015 (l'excès des activités spéculatives est passé de 5% en début 2002 à 37% au début 2015).

Le marché du cuivre représente un autre exemple éclairant sur la hausse des activités spéculatives. L'excès de spéculation sur ce marché a augmenté continuellement à partir de 2006. A la fin 2015, l'indice de Working se situait au alentour de 1,7 (soit 70% d'excès de spéculation). Pour le marché de l'or, l'excès de spéculation a été en hausse jusqu'au début de l'année 2007, enregistrant 50% à ce moment. Toutefois, il a baissé ensuite pour enregistrer ses plus bas niveau depuis 1986 ; en 2012, l'excès de spéculation a été seulement de 14%. Il a néanmoins grimpé à 61% en 2015. Sur le marché du blé, l'excès de spéculation variait autour de 28% jusqu'en 2010, pour passer à 61% en 2015. Sur les autres marchés comme le soja, l'huile de soja, le coton et le cuivre, l'excès de spéculation évoluait selon un rythme constant (on ne constate pas de rupture structurelle). Leurs excès de spéculation ont été respectivement de: 40%, 39%, 39% et 26,5%.

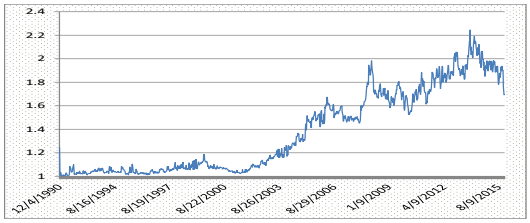
Figure 4: Working (1960) "T" index



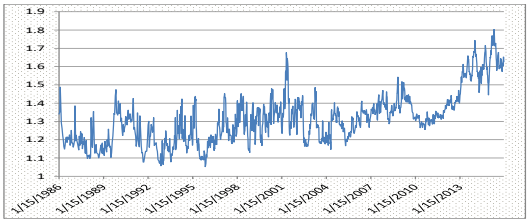
(a) Pétrole brut



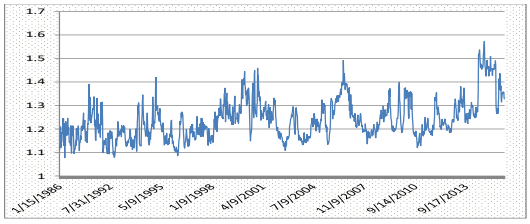
(b) Fioul domestique



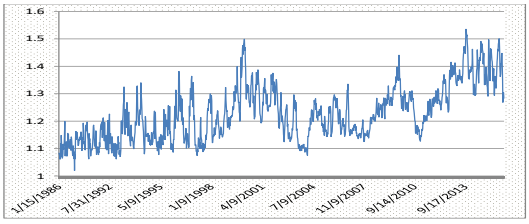
(c) Gaz naturel



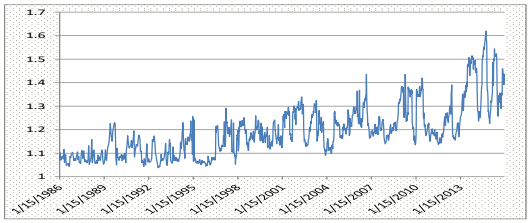
(d) Blé



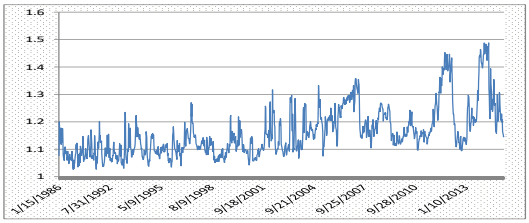
(e) Soja



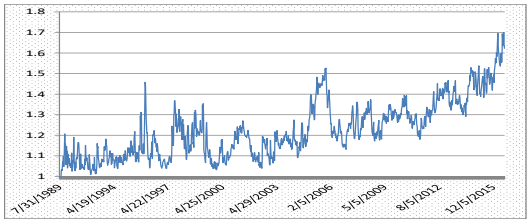
(f) Huile de soja



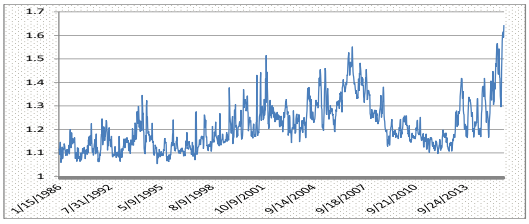
(g) Mais



(h) Coton



(i) Cuivre



(j) Or

## Le rôle des investisseurs financiers sur les marchés des commodités

Comme expliqué précédemment, les investisseurs financiers détenant des portefeuilles d'actions, ont intensifié leur participation sur les marchés à terme à partir de 2002. Ils investissent dans des paniers de commodités, ce qui leur impose de s'intéresser à deux questions. D'abord, l'interaction entre les marchés des actions et ceux des commodités; ensuite, l'intégration des marchés futurs des commodités entre eux. Même si ces deux questions sont étudiées dans plusieurs articles, dont la majeure partie est de nature empirique, le débat les concernant reste ouvert. Par conséquent, il est indispensable de proposer des travaux théoriques supplémentaires pour clarifier davantage le débat actuel sur les effets de la financiarisation. Ainsi, cette thèse étudie dans un premier temps l'afflux de l'investissement sur les marchés des commodités et son impact sur les prix de celles-ci. Dans un second temps, elle s'intéresse à l'intégration entre les différents marchés des commodités, dans des perspectives théorique et empirique.

J'inscris ma recherche dans la continuité du modèle développé par Ekeland et al. (2015). Ces auteurs proposent un modèle qui étudie l'interaction entre les marchés des commodités physiques et à terme. Il s'agit d'un modèle statique dans lequel l'équilibre est obtenu de l'interaction entre quatre types d'agents: les détenteurs des inventaires, les processeurs, les spéculateurs et les traders au comptant. Ces agents s'intéressent à une seule commodité. Le détenteur des inventaires (appelé aussi stockeur) a la capacité de stocker les commodités; il est un spéculateur physique. Il achète la commodité à une date $t$, la stocke, et la revend à une date ultérieure $T$. Le processeur utilise la commodité pour produire un bien final. Ces deux premiers agents, stockeur et processeur, couvrent leurs positions physiques sur les marchés à terme. L'stockeur fait face à un risque de baisse des prix des commodités. Par conséquent, il vend des contrats à terme (prend des positions courtes) pour ses besoins de couverture. A l'opposé, le processeur achète des contrats à terme (prend des positions longues). Cependant, pour des finalités spéculatives, l'agent des stocks peut prendre des positions longues et le processeur des positions courtes. Le spéculateur agit sur les marchés à terme seulement. Il compense les positions nettes prises par les hedgers. Les traders au comptant interviennent sur le marché physique des commodités seulement. Ils agissent à la fois sur les côtés de l'offre et de la demande du marché au comptant. Le modèle de Ekeland et al. (2015) focalise son analyse sur la question de savoir si la financiarisation contribue à la stabilisation ou à la déstabilisation des prix des commodités.

J'estime que le modèle de Ekeland et al. (2015) est approprié à l'expérimentation de mes idées. Les auteurs établissent plusieurs hypothèses, deux d'entre elles sont particulièrement importantes pour mon étude. Selon la première hypothèse, les spéculateurs interviennent uniquement sur

les marchés à terme. La seconde hypothèse prévoit que l'étude se limite à un seul marché de commodité. Par conséquent, le modèle de Ekeland et al. (2015) représente la pierre angulaire de cette thèse, qui s'articulera sur trois chapitres. Deux de ces chapitres sont théoriques et le troisième empirique. Ces chapitres étudient l'interaction entre les marchés d'actions et de commodités, l'intégration croisée des commodités et l'impact des investisseurs financiers sur la prime de risque à terme des commodités. Dans le premier chapitre, je suppose que les investisseurs financiers diversifient leurs portefeuilles sur les marchés à terme. Ainsi, je remplace les spéculateurs, pris en compte dans Ekeland et al. (2015), par des investisseurs financiers; autrement dit, dans cette thèse les spéculateurs n'interviennent pas uniquement sur les marchés à terme. Dans le deuxième chapitre, j'étudie empiriquement l'effet du marché d'actions sur les marchés à terme des commodités. Dans le troisième chapitre, je suppose que les spéculateurs interviennent sur deux marchés à terme de commodités, i.e. j'établie le lien entre deux formes isolées de Ekeland et al. (2015). Je résume ces trois chapitres dans ce qui suit.

### Chapitre I: l'intégration des marchés des actions et des commodités, un modèle d'équilibre

Dans ce chapitre, j'essaye d'étudier l'influence du marché des actions sur celui des commodités. J'ai été motivé par le débat actuel concernant l'impact des investisseurs sur les marchés à termes des commodités, que ces investisseurs soient des hudge funds, des index funds, des négociants de swaps ou encore négociants de produits de commerce. Je ferai cela en proposant un modèle dans le même esprit que celui de Ekeland et al. (2015). Le modèle étudie les interactions entre les marchés physiques des commodités, les marchés à terme des commodités et les marchés d'actions. Une seule commodité est échangée sur les marchés physique et à terme. Les échanges sur les marchés se font à $t$ et $T$. Nous avons par conséquent un modèle à deux périodes. Il existe quatre types d'agents : les détenteurs des inventaires (inventory holders), les processeurs (processors), les investisseurs financiers et les traders au comptant. Les détenteurs des inventaires a la capacité de stocker les commodités, il achète la commodité, la détient, et la revend (spéculation physique). Le processeur utilise la commodité pour produire un bien final. Ces deux agents opèrent sur les marchés à terme pour des raisons de couverture. Le stockeur couvre ses positions contre le risque de baisse des prix en prenant des positions courtes, alors que le processeur prend des positions à terme longues pour couvrir ses positions physiques contre une hausse des prix des commodités. L'investisseur financier inclut les contrats à terme dans son portefeuille d'actions pour des raisons de diversification. Les traders au comptant se positionnent sur les côtés de l'offre et de la demande du marché au comptant des commodités. Dans ce modèle, il existe plusieurs marchés et plusieurs canaux de transmission. Le stockeur établit le lien entre les deux périodes; lui et le processeur relient les marchés physiques aux marchés à terme, quant à l'investisseur financier, il relie le marché d'actions aux marchés à terme.

Lors de la première période, le stockeur se positionne sur le côté de la demande du marché physique et achète la commodité pour la stocker. Le trader au comptant agit sur les côtés de l'offre et de la demande du marché physique. Le processeur décide du volume de commodités dont il aura besoin pour sa production durant la seconde période. Le stockeur et le processeur couvrent leurs positions physiques en faisant recours aux marchés à terme. Pour leurs besoins de couverture, le stockeur vend des positions à terme (prend des positions courtes) alors que le processeur achète des positions à terme (prend des positions longues). Les positions à terme de ces deux agents sont composées de leurs positions prises pour des raisons de couverture en plus d'autres positions prises à des fins de spéculation. Les investisseurs financiers prennent, quant à eux, leurs positions sur les marchés à terme des commodités en fonction d'information provenant des marchés d'actions et de commodités comme les rendements de ces deux marchés et la corrélation entre eux. Les décisions des investisseurs financiers sur les marchés à terme montrent clairement le concept de diversification. Lors de la seconde période, les stockeurs vendent sur le marché physique les quantités qu'ils ont détenues depuis la première période. Le processeur se positionne sur le côté de la demande et livre la commodité qu'il avait demandé. Le trader au comptant apparaît sur les côtés de l'offre et de la demande du marché au comptant. Les contrats à terme sont établis sur la base d'un profit financier obtenu des marchés à terme, mesuré par la différence entre les prix au comptant anticipés et les prix à terme (primes de risque à terme). Le dénouement des contrats à terme s'effectue par règlement cash (les agents prennent des positions opposées à leurs positions à terme) ou éventuellement par un règlement physique.

Le chapitre étudie deux questions. La première concerne l'effet de la corrélation entre commodités et fond propres sur les prix des commodités. La seconde porte sur l'impact de l'investissement financier sur les marchés des commodités. La première question est motivée par le renforcement du lien entre les marchés d'actions et des commodités, étant donné que la corrélation entre les deux a significativement augmenté depuis la crise financière de 2008 pour plusieurs marchés de commodités, comme le montre la figure 10 (e.g. Buyukşahin and Robe (2014a)). En posant la seconde question, je cherche à apporter une réponse théorique au débat sur l'existence de l'impact les investisseurs financiers sur les marchés des commodités ou non.

Cette question a été motivée par le travail de Basak and Pavlova (2016) qui trouvent que la financiarisation engendre une hausse de la corrélation entre actions et commodités. Une hausse de la corrélation commodité-action, si les anticipations des rendements des actions sont positives, provoque une baisse des positions à terme longues (hausse des positions courtes) des investisseurs financiers. La baisse de l'achat des contrats à terme provoque la baisse des prix à

terme. Par conséquent, les stockeurs réduisent leurs stocks physiques, à cause des coûts élevés de couverture. La baisse de la demande des stockeurs sur le marché physique provoque une baisse des prix au comptant. La baisse des prix à terme offre des conditions favorables aux processeurs pour augmenter leurs positions physiques, i.e. ils bénéficient du couverture. La baisse des stocks et la hausse de la demande des processeurs provoquent une hausse des prix au comptant à terme.

Les résultats du modèle montrent la raison pour laquelle il existe une ambigüité sur l'effet de l'investissement sur les marchés à terme des commodités. Les pressions du couverture, la corrélation commodité-actions et les rendements anticipés des actions déterminent l'effet de l'investissement sur les prix des commodités. Partant d'une situation de non-diversification, l'effet de la spéculation est déterminé par le signe de la pression de couverture. Ce résultat correspond à celui de Ekeland et al. (2015). Cependant, en permettant aux investisseurs financiers de diversifier leurs portefeuilles sur les marchés à terme des commodités, la corrélation commodité-actions et les rendements à terme anticipés participent à la détermination de l'effet de la financiarisation. Dans certains scénarios l'effet est clair. Par exemple, une pression nette de couverture court et une corrélation commodité-actions négative associées à un choc positif de rendement provoque la hausse à la fois du prix au comptant, du prix futur et des stocks ainsi qu'une baisse du prix au comptant futur et de la demande physique pour production. Un autre scénario clair concerne le cas où la pression nette de couverture est longue et la corrélation commodité-actions et la prime de risque du marché d'actions sont positives. Dans ce cas, le prix au comptant de la commodité, le prix futur et le niveau des stocks baissent, alors que le prix au comptant futur et la demande de production augmentent. Cependant, l'effet de la financiarisation pourrait être déterminé pour toute situation, connaissant les caractéristiques des marchés à terme et ceux des actions.

### Chapitre II : le rôle des investisseurs financiers dans la prime de risque à terme des commodités

Dans ce chapitre, je mène une étude empirique sur l'impact des investisseurs financiers sur la prime de risque à terme des commodités. Cette recherche s'inscrit dans la continuité du débat empirique sur le rôle des investisseurs financiers dans les marchés des commodités. L'une des contributions du chapitre précédent (Isleimeyyeh et al. (2017)) montre que la prime de risque à terme est déterminée par deux termes. Le premier terme est les fondamentaux économiques de la commodité, qui sont exprimés par le stock physique total et la demande pour la production. Ce terme peut également être considéré comme la pression nette de couverture courte. Le second terme est le marché des actions. Ce déterminant est exprimé via le rendement anticipé des actions associé à la corrélation fonds propres-commodité. Econométriquement, je régresse la

prime de risque des contrats à terme sur deux variables explicatives: la première est la pression nette de couverture qui est définie comme la différence entre le total des positions des contrats à terme courtes et longues des agentes commerciaux divisé par le total des positions de couverture; la seconde variable est le rendement ajusté des actions qui est défini par la multiplication entre le rendement du marché des actions et la corrélation entre actions et commodité à chaque instant. Le fait de choisir une corrélation variable entre actions et commodité est motivé par les résultats de Basak and Pavlova (2016) qui ont montré théoriquement que la financiarisation des commodités augmente la corrélation entre actions et commodité. Empiriquement, Buyukşahin and Robe (2014a,b) and Creti et al. (2013) ont constaté une hausse significative de cette corrélation après la crise de 2008.

Ce chapitre se focalise sur le marché des commodités énergétiques, constitué lui-même par trois sous-marchés : le pétrole brut (WTI), le gaz naturel et le fioul domestique. J'ai choisi ces commodités pour différentes raisons : le marché de l'énergie représente une part importante du panier des commodités, il représente par exemple 63% du S&PGSCI. Aussi, l'excès de spéculation apparaît clairement sur ces marchés, comme le montrent les figures 4a, 4b and 4c. Pour chaque commodité, j'ai sélectionné une série de données allant de 1995 à la fin 2015. J'ai divisé la période étudiée en 3 sous-périodes: 1995-2002, 2003-2008 et 2008-2015. Cette division temporelle a été choisie pour exprimer les phases pré et post-financiarisation, où la post-financiarisation est subdivisée en deux périodes séparées par le début de la crise financière de 2008. Je teste l'effet du marché d'actions et de la pression de couverture sur la prime de risque des contrats à terme pour différentes maturités. Ceci diffère de ce qui est fait dans la plupart de la littérature, qui s'intéresse principalement au premier et/ou second le plus proche des maturités. Les investisseurs visant la diversification de portefeuille sont des investisseurs passifs. Par conséquent, ils achètent et conservent leurs actifs, bénéficiant des rendements de long terme. Logiquement, ils achètent des contrats à termede longues maturités et les conservent. Par la suite, ils les compensent lorsque leurs dates de maturité approchent. En outre, Buyukşahin and Robe (2014b) ont montré que l'excès de spéculation augmentait à la fois dans les maturités courtes et longues.

Par conséquent, je constate que la pression de couverture est une variable explicative de la prime de risque sur les contrats à terme. Une nette et courte pression de couverture augmente la prime de risque sur les contrats à terme, tandis que l'impact se reflète lorsque la pression nette de couverture est longue. Je constate également que l'impact de la pression de couverture sur la prime de risque sur les contrats à terme décroît lorsque l'échéance du contrat à terme augmente. Les résultats montrent l'importance de rentabilité des actions pour expliquer la prime de risque sur les contrats à terme, qui est devenue significativement influente dans la période de

la crise financière postérieure à 2008. En outre, l'impact de rentabilité des actions sur les longues échéances dépasse l'impact de la pression de couverture. Cela ne contredit pas la conclusion de Boons et al. (2014), qui constatent que 70% de la prime de risque sur les contrats à terme sont expliqués par une pression de couverture et que les 30% qui restent sont attribués aux rentabilité des actions Pour les courtes échéances (la première et la seconde comme testées par Boons et al. (2014), je constate que la variation de la prime de risque sur les contrats à terme est principalement attribuable à la pression de couverture et deuxièmement aux rentabilité des actions. Cependant, l'interprétation est l'inverse pour les maturités longues.

### Chapitre III, Intégration des marchés des Commodités, un modèle d'équilibre

Dans ce chapitre, je développe un modèle dans l'esprit d'Ekeland et al. (2015). Ce modèle étudie l'interaction entre les différents marchés à terme des commodités. Ce travail est motivé par l'augmentation significative de l'indice de l'investissement sur les marchés à terme des commodités. Les investisseurs financiers détiennent un portefeuille de produits qui imite des indices bien diversifiés, tel l'indice de commodité de Goldman Sachs (S&P GCSI) ou l'indice de commodité de Dow Jones-UBS (DJ-UBSCI). Par conséquent, plusieurs études empiriques montrent que la corrélation entre les commodités a augmenté au cours de la période suivant la financiarisation, comme Tang and Xiong (2012), Natanelov et al. (2011) et Bruno et al. (2013). Cependant, le travail théorique en est encore rare. Le modèle étudie l'interaction entre deux marchés de commodités. Pour chaque marché de commodité, il y a quatre types de participants: le détenteur de l'inventaire (stockeur), le producteur, le spéculateur (investisseurs financiers) et les commerçants au comptant. Logiquement, toutes les marchandises n'ont pas les mêmes conditions de stockage et, bien sûr, différentes commodités sont utilisées pour produire des produits différents. Intuitivement, chaque commodité différents types de stockages, de transformateurs et de commerçants au comptant que les autres. Les investisseurs sont les seuls opérateurs qui négocient sur les deux marchés.

Dans chaque marché de commodité, les stockeurs achètent la marchandise pour la stocker. Les commerçants au comptant (spot) répondent à la demande des stockeurs sur le marché physique. Les transformateurs décident du volume de la marchandise nécessaire à leur production dans la seconde période. A des fins de couverture, les stockeurs et les transformateurs prennent des positions sur le marché à terme à certains prix à terme. Enfin, les investisseurs financiers se positionnent sur le marché à terme des commodités en fonction des informations provenant des deux marchés de commodités. Selon le modèle, il existe trois facteurs déterminants pour les positions à terme, courtes ou longues: les rendements attendus sur les marchés des commodités et la corrélation entre ces dernières. Dans un temps futur, les stockeurs vendront leurs stocks détenus depuis la période précédente sur le marché physique. Les transformateurs se

situent du côté de la demande et livrent le produit qu'ils avaient commandé. Les commerçants au comptant apparaissent du côté de la demande et de l'offre sur le marché au comptant. Les contrats à terme sont dénoués, ce qui implique un bénéfice financier des marchés à terme, mesuré par la différence entre le prix attendu et les prix à terme (prime de risque sur les contrats à terme).

Le modèle étudie de nombreuses statistiques comparatives. Cependant, je me concentre principalement sur l'étude de trois questions. Premièrement, l'impact des chocs d'offre et de la demande sur les prix des commodités. Deuxièmement, l'impact des chocs futurs prévus de l'offre et de demande sur les prix des commodités. J'étudie l'impact de ces chocs sur les prix du marché des commodités subissant le choc et comment il se propage à l'autre marché. Troisièmement, j'étudie l'impact de la spéculation sur les prix des commodités. Ces trois questions ont été choisies afin de clarifier le vague débat sur l'impact de l'investissement indiciel sur les prix des commodités. Aussi, je vise à montrer l'intégration entre les différents commodités.

Avant de résumer les résultats, je voudrais rappeler les canaux de transmission suivants qui sont responsables de la circulation de l'information entre les différents marchés. Premièrement, les couvreurs de risques (hedgers) sont responsables de la transmission d'informations entre les marchés physiques et à terme. Deuxièmement, les stockeurs font la liaison entre deux périodes de temps. Troisièmement, l'investisseur financier est considéré comme le canal de transmission responsable du flux d'information entre les deux marchés. La corrélation croisée des commodités joue un rôle crucial dans la détermination de la direction de l'intégration entre les marchés. Par conséquent, tout changement sur un marché pourrait se refléter en deux impacts opposés sur d'autres marchés, en fonction du signe de la corrélation croisée des commodités. Cependant, j'introduis le cas de corrélations positives entre commodités (voir par exemple Tang and Xiong (2012)). Mais il faut garder à l'esprit que dans toute situation où la corrélation entre commodités est négative, les résultats seront affectés. L'abondance de toute marchandise pousse l'investisseur à avoir des positions longues sur ce marché. Au contraire, les positions longues (courtes) prises par les investisseurs dans l'autre marché diminuent (augmentent). Ces changements dans les positions à terme entraîne une baisse du prix à terme. Par conséquent, la couverture pour les détenteurs de inventaire, qui vendent des contrats à terme, est moins rentable. Ainsi, ils vont réduire leurs niveaux d'inventaire, ce qui entraine une baisse du prix au compte actuel. A l'inverse, la demande de production, le futur prix au comptant et les futures primes de risque augmentent. Les transformateurs bénéficient de baisses de prix à terme et sont capables de couvrir leurs positions physiques. Ainsi, ils sont en sécurité en ce qui concerne l'achat de plus de commodités sur les marchés physiques. Ainsi, l'augmentation de la demande future conduit à augmenter le prix au comptant futur. Enfin, le bénéfice du marché financier devient plus élevé; les primes de risque sur les contrats à terme augmentent.

Le fait de s'attendre à un choc futur dans n'importe quel marché provoque une récession sur ce marché; pendant ce temps l'autre marché devient plus actif. Un tel choc positif d'offre conduit les investisseurs à prendre des positions courtes sur le marché qui a subi le choc. Au contraire, les investisseurs ont tendance à avoir des positions à terme plus longues sur le marché stable. Cela est considéré comme la clé des changements de prix des commodités. Une demande accrue sur des positions longues à terme entraîne une augmentation des prix à terme. Les prix à terme élevés sont motivés par le fait que les stockeurs augmentent leur stock (offrent un abri aux stockeurs). Par conséquent, la forte demande de stocks dans les situations physiques entraîne une augmentation du prix au comptant. Les prix à terme élevés entraînent des coûts de couverture élevés pour les transformateurs. Par conséquent, ces derniers réduisent leur demande sur le marché physique. En conséquence pour des stocks élevés, l'offre future sera élevée. Ensuite, le prix au comptant futur devrait diminuer.

Enfin, l'impact de la financiarisation est déterminé par un équilibre de la pression de couverture. Prendre des positions longues (courtes) sur le marché à terme augmente (diminue) le prix au comptant, le prix à terme et les niveaux de stocks, alors qu'il diminue (augmente) la demande de production et le prix au comptant futur. De plus, l'importance de l'impact des investisseurs financiers sur les prix des commodités a une relation inverse avec la taille du marché.

# Introduction

A commodity is defined as "an intermediate good with a standard quality, which can be traded on competitive and liquid global international physical markets" (Clark et al. (2001)). This definition is more generalized than raw materials (primary commodities). Raw materials are intermediate goods that are produced from natural resources after one or two transformation steps. The definition says that the commodity market must be competitive and liquid. Liquidity requires that the market must be cleared at any time (with total supply equals total demand) as a result of interactions between many suppliers and buyers in the global market (competitive market). Given this definition, there are different categories of commodities: energy commodities (e.g. crude oil, natural gas, refined oil products, coal, biofuel), metals (precious (e.g. gold, copper, silver, platinum, palladium), and ferrous (e.g. iron)), and all agricultural commodities (e.g. grains (wheat, corn, soybean, etc.), oils (soybean oil, etc.), soft (cocoa, coffee, cotton, etc.), and livestock). Other complex markets, which became more compatible with the definition, are commoditized such as electricity, services (e.g. freight), currency, and financial assets. Commodity markets are innovative, and surely there will be new types of commodities.

Commodity prices are settled by meeting supply with demand. Prices change through time, which generate a risk for both buyers and sellers in the spot markets[4]. The seller is worried about decreases in the prices, while buyers are scared from increases in the prices. For instance, farmers who cultivate oat or wheat are not sure about how much the prices will become after four months from their planting. An airline company that needs fuel for its planes, and with it's limited capacity for storage, seeks for security against any increase in the fuel prices. Consequently, the operators in spot markets resort to the derivatives markets. A derivative contract is an agreement between parties to exchange an underlying asset at some future date, where these underlying assets could be stocks, bonds, commodities, currency or indices (Whaley (2012)). In this dissertation, I will focus on the commodity markets. Therefore, we induce that the definition of the commodity derivative market as a "financial market on which financial instruments are

[4]In this context, there are spot and physical commodity markets. In the spot market, the commodity is paid and delivered immediately. In the physical markets or forward markets, the commodity is paid and the physical delivery is at future date.

representing some underlying physical commodities available for delivery at some future date are traded under various conditions" (Clark et al. (2001)). There are several common types of derivatives that are traded either in organized markets such as futures contracts, options or in Over-the-Counter (OTC) markets such as forward contracts and swaps. Futures contracts are highly used compared to the other derivative instruments for several reasons: the physical delivery in the futures markets is not an obligation; $1-2\%$ of the total of the futures positions are delivered physically; i.e. reach to the maturity date. If any hedger needs to offset his futures positions, he just needs to close them by taking the opposite direction in the futures market. Even if the futures contract is not closed before the maturity, the agent needs to balance the market by paying cash balance against the settlement. Also, the futures markets are organized; they are controlled by clearing houses (more securitized).

Derivatives markets are considered a place for hedging physical positions. Based on the traditional hedging theory, in order to avoid the risk of prices changing, hedgers take futures positions in the same magnitude as physical markets but in the opposite (Johnson (1960) and Ederington (1979)). For example, an inventory holder, who stores the commodity to sell it in the future (physical speculation), worries about prices falling. Hence, he sells futures positions (called short positions). On the other side, if an operator needs to buy the commodity (a producer for instance), to avoid the risk of the commodity price increase, he buys futures positions (takes long positions). Ideally, the futures positions taken by the operators who are linked to commercial activities in physical markets (the hedgers) should offset each other. But, in reality, total hedger's short futures positions are not equal to hedger's long futures positions. Therefore, on the opposite side of the hedgers, there are speculators. Speculation in commodities means seeking profit from undertaken transactions especially for that purpose, and not in the normal course of conducting a business of producing, merchandising, or processing a commodity (Working (1960)). Speculators are offsetting the hedgers' positions, and they are remunerated by hedgers for their risk borne by receiving margins that called futures risk premium (Keynes (1930)).

## Financial investors in commodity futures markets

The last two decades, the beginning of the third millennium particularly, witnessed a surge in the futures contracts traded in commodity markets. Table 4 shows open interests futures contracts for ten commodities traded in different markets: energy (crude oil, heating oil and natural gas), agricultural (wheat, corn, soybean and soybean oil), soft (cotton), and metals (copper and gold). The commodities are overviewed in table 3. For showing the changes in the futures markets, I use data published by Commodity Futures Trading Committee (CFTC).

CFTC publishes regular reports entitled Commitments of Traders (COT) that provide each Tuesday's open interests positions (CFTC data is weekly after September 1992, but it is semi-monthly before that time). These positions are aggregated for all maturities. The CFTC reports show both short and long open interest positions. The aggregate of long open interest is equal to the aggregate of short open interest. The open interest positions are comprised of reportable and non-reportable positions. The reportable traders are classified to commercials and non-commercials traders. The commercial is the trader who uses the futures contracts for hedging purposes, who is commercially linked to the commodity physical markets. Otherwise, the trader is a non-commercial. In this context, I employee the commercial positions to indicate to the hedging activities, and the non-commercial positions to the speculation activities. Table 4 shows that the growth rate in open interest futures positions, between 2000 and 2015, is doubled in corn and soybean oil futures markets comparing to the growth in the period between 1990 and 2000. In heating oil and cotton markets, the growth in open interest positions in 2000-2015 is three times of the growth in 1990-2000. Furthermore, the growth in the period 2000-2015 is 4 times that in crude oil market, 1.4 times in wheat, 6.5 times in soybean market and 9 times in gold market of the growth in period 1990-2000. In copper market. the growth increased steadily at the same pace.

Table 3: Overview of commodity futures markets

| Commodity | Exchange | Contract size | Prices quatation | Delivery |
|---|---|---|---|---|
| Crude oil (WTI) | NYMEX | 1,000 barrels | U.S. $ per barrel | Monthly |
| Natural gas | NYMEX | 10,000 mmBtu | U.S. $ per mmBtu | Monthly |
| Heating oil | NYMEX | 42,000 gallons | U.S. $ per gallon | Monthly |
| Wheat | CBOT | 5,000 bushels | Cents per bushel | Mar, May, Jul, Sept and Dec |
| Corn | CBOT | 5,000 bushels | Cents per bushel | Mar, May, Jul, Sept and Dec |
| Soybean | CBOT | 5,000 bushels | Cents per bushel | Jan, Mar, May, Jul, Aug, Sept and Nov |
| Soybean oil | CBOT | 60,000 pounds | Cents per pound | Jan, Mar, May, Jul, Aug, Sept, Oct and Dec |
| Cotton | NYMEX | 50,000 pound | U.S. $ per pound | Mar, May, Jul, Oct, and Dec |
| Copper | COMEX | 25,000 pounds | U.S. $ per pound | Mar, May, Jul, Sept and Dec |
| Gold | COMEX | 100 troy ounces | U.S. $ per ounce | Feb, Apr, Jun, Aug, Oct and Dec |

- NYMEX is New York Mercantile Exchange; CBOT is Chicago Board of Trade; COMEX is Commodity Exchange (a division in NYMEX)
- **Note**: For agriculture commodities (wheat, corn and soybean), the contract size before January 1998 is 1000 bushels. But, it is 5000 bushels after January 1998. In drawing charts, I unified these contracts to be 1000 bushels per contracts.

Table 4: The growth rate of commodity futures open interest

| Commodity | 1990 | 2000 | 2015 | Growth rate 90-00 | Growth rate 00-15 |
|---|---|---|---|---|---|
| Crude oil (WTI) | 272,262 | 464,369 | 1,678,012 | 71% | 261% |
| Heating oil | 88,912 | 140,650 | 376,758 | 58% | 168% |
| Natural gas | 8,180 | 333,874 | 991,540 | 3982% | 197% |
| Wheat | 283,154 | 683,987 | 2,013,454 | 142% | 194% |
| Corn | 1,094,145 | 2,172,483 | 6,665,012 | 99% | 207% |
| Soybean | 557,624 | 830,915 | 3,447,435 | 49% | 315% |
| Soybean oil | 72,125 | 143,733 | 380,204 | 99% | 165% |
| Cotton | 38,149 | 62,079 | 185,401 | 63% | 199% |
| Copper | 33,535 | 73,423 | 170,499 | 119% | 132% |
| Gold | 117,763 | 142,078 | 418,942 | 21% | 195% |

This table shows the growth rate of the commodity futures open interests positions. The data is obtained from CFTC. I use the average open interest positions in the years 1990, 2000 and 2015 (the second, third and fourth columns).

The growth in the open interest futures positions was accompanied by significant increase in the financial investors' participation in the futures markets. Those investors, who are non-commercially linked with the commodity physical markets, show a structural break in their appearance in the futures markets by the beginning of the third millennium, and especially around 2002/2003, which is boosted by the revolution of the wide use of internet and the development of telecommunication means. This phenomenon is referred by Financialization of commodity[5]. Figure 5 shows the futures contracts held by non-commercial operators in each of crude oil, heating oil, natural gas, wheat, corn, soybean, soybean oil, cotton, copper and gold markets.

According to Masters (2008), commodity index investments have risen from $13 billion at 2003 to $260 billion at March 2008. Also, according to Carpenter (2011), the total amount of commodity assets recorded $412 billion in March 2011 (Belousova and Dorfleitner (2012)). Why did those participants intensively operate in commodity markets? Gorton and Rouwenhorst (2006) document, based on a dataset covered the period between 1959 and 2004, that the

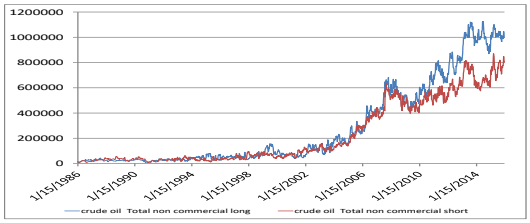
[5]**Financialization:** Greta Krippner defined the term of financialization as a pattern of accumulation in which profit mainly achieved through financial channels rather than through trade commodity production (Krippner (2005)). Whereas, Epstein (2005) points the term as the rising function of financial markets, financial actors and financial institutions in the operation of the economy, in domestic and international levels (Epstein (2005)). Financialization transforms the functioning of the economic system at both micro and macro(associated with the era of real economic growth) levels. Financialization impact are: to elevate the significance of financial sector relative to the real sector, to transfer income from the real sector to the financial one, and to contribute to increased income inequality and wage stagnation(Palley (2007)).

commodity futures returns offer the same mean returns as US equity returns, but with negative correlations between commodity and stock and bonds markets. Erb and Harvey (2006) document that the cross commodity returns correlations are around zero by studying the period between 1982 and 2004. In such circumstances, adding commodity to stocks and bonds portfolio leads to decrease the overall risk. That ensures considering commodities as assets and including them in the portfolio is beneficial for investors from the diversification perspective. The benefits from diversification have been shown also by Cheung and Miu (2010). However, commodities are not like any normal asset. Because, based on Geman (2005), commodities have several properties distinguishing them than any other normal asset: first, commodities offer hedging against inflation. Commodities have a value and reflect the changes in the price level. So, any increase in the demand on goods and services cause an increase in the demand on commodities, which are used in the production process of those goods and services. Second, commodities offer a hedging against U.S. dollar. Predominantly, commodities are priced in US dollars. Hence, a depreciation in the US dollar increases the commodity prices. On the contrary, an appreciation in the US dollars leads to decrease in the commodity prices. Lastly, commodity prices are determined by the interaction between supply and demand. Therefore, they cannot be evaluated like the normal assets (Belousova and Dorfleitner (2012)).

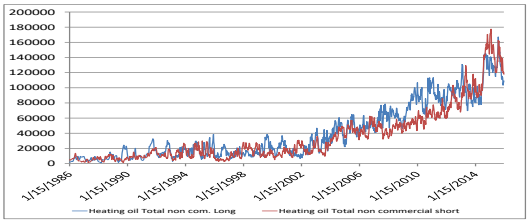
Investments in commodity could be by purchasing of the physical commodity in the cash market, purchase of the stock of the commodity-related companies, purchase of commodity futures and options, or investing in commodity indices and commodity-related notes (Geman (2005)). The latter method is an easy one, and preferable of getting exposure of commodity markets. Based on Stoll and Whaley (2010) and Irwin and Sanders (2011), financial investors, whether they are institutions or individuals, tend to invest in commodity futures by using commodity indices as benchmarks such as the standard and Poor's-Goldman Sachs Commodity Index (S&P GSCI) and Dow Jones-UBS Commodity Index (DJ-UBSCI). They believe that these indices are well-diversified. Therefore, they build a portfolio that mimics one of these indices. Investors may directly build a futures contracts portfolio in a way that mimics one of the commodity indices. However, due to the shortage in investors' experience in managing commodity index portfolio, they resort to commodity investments vehicles such as commodity index funds and commodity returns swap. In general, using any vehicle ended to futures markets. Recently, Exchange-traded products (Exchange-traded funds (ETFs) and Exchange-traded notes (ETNs)) have been demanded heavily. ETFs are a mutual fund shares that trade on a stock exchange where the prices of these shares tracks (follows) a commodity index. ETNs are debt securities where the issuer commits to pay-out based on the value of the underlying commodity index. More importantly, financial investors diversify their stock portfolios by including a combination of commodities. Therefore, financialization of commodity highlights two interesting issues: first,

the relationship between stock and commodity markets. Second, the relationship between commodity markets themselves.

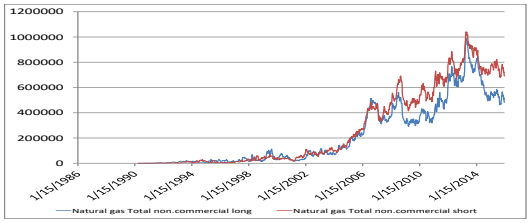
Figure 5: Commodities non commercials futures positions



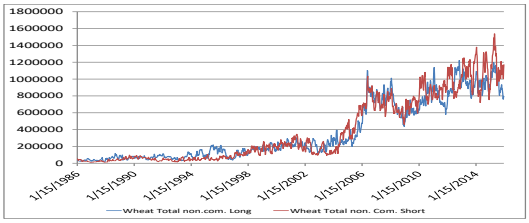

(a) Crude oil



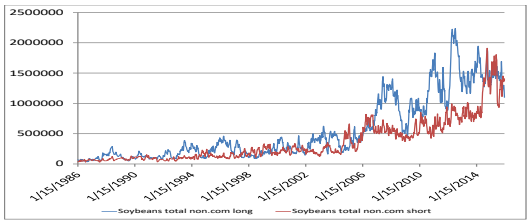

(b) Heating oil



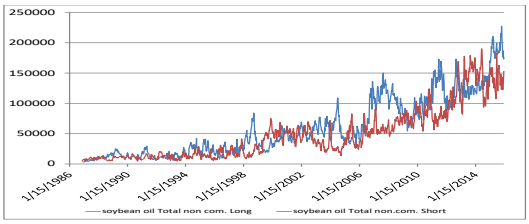

(c) Natural gas



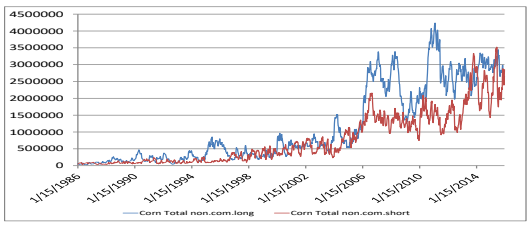

(d) Wheat



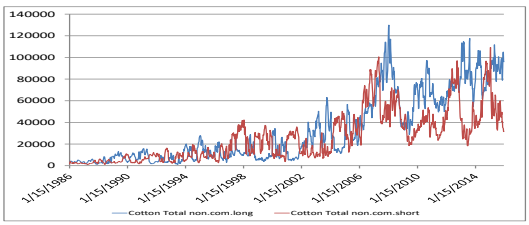

(e) Soybean



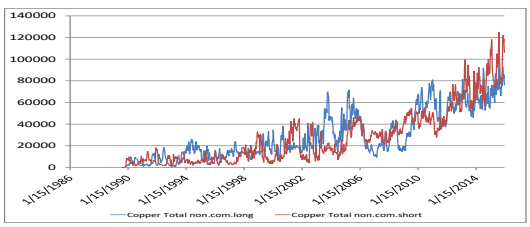

(f) Soybean oil



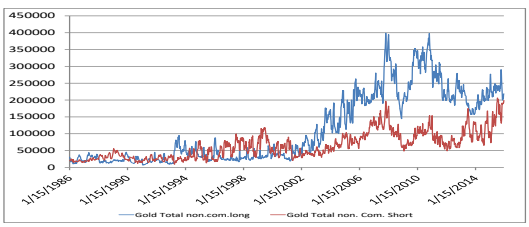

(g) Corn




(h) Cotton



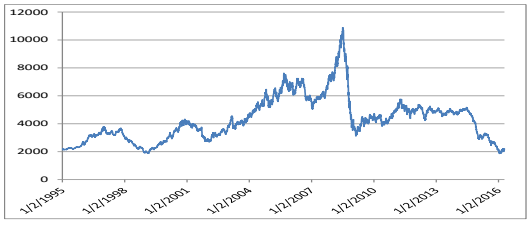

(i) Copper




(j) Gold

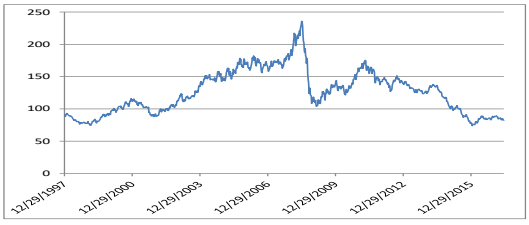
Source: CFTC. Blue line indicates to commodity non-commercial long positions. Red line indicates to commodity non-commercial short positions.

Figure 6: S&P GSCI and DJ-UBSCI indices




(a) S&P GSCI

source: Datastream




(b) DJ-UBSCI

source: www.mrci.com/client/djubs.php

## Speculation indices

In the previous section, I discussed the increase in the financial investors' participation in the commodity futures markets. However, as shown in the data of CFTC, futures open interests increased in both commercial and non-commercial levels. So, why do not we ask ourselves that the increase in the financial investors is normal responses to the hedging activities? To make sure about the increase in the speculation activities, I will be showing two cases as motivations of the speculation increases. First, I will be showing the percentage of the non-commercial to the total open interest positions. Second, I will compute Working's (1960) index (Working (1960)).

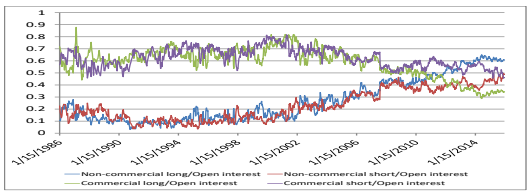
### Non-commercial to the total open interests positions

Figure 7 shows the commercials and non-commercials weights from the total futures open interests for each of crude oil, heating oil, natural gas, wheat, corn, soybean, soybean oil, gold, copper, and cotton in the period between 1986 and 2015. The figure shows the clear increase in the non-commercials portion from the total open interest positions in energy market than any other market. In the period till 2002, commercials futures positions obviously dominated the non-commercials positions in both short and long terms, with almost fixed weight. For instance, the non-commercials long (short) positions of crude oil formed 13% (12%) from the total futures open interests, while the commercials long (short) positions formed 67% (67%) from the total open interests. The situation is similar in heating oil and natural gas markets. The non-commercials long (short) positions of heating oil formed 11% (10%) from the total futures open interests, while the commercials long (short) positions formed 55% (66%) from the total open interests. In natural gas futures market, the non-commercials long (short) positions formed 11% (9%) from the total futures open interests, while the commercials long (short) positions formed 69% (78%) from the total open interests. Post 2002, the weight of non-commercial started to increase compared with the commercial positions. By the end of 2015, the commercial and

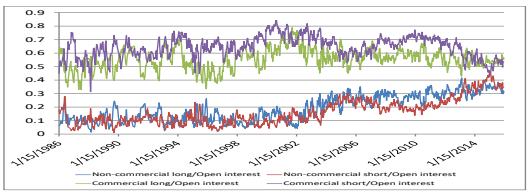
non-commercial short positions in crude oil markets have converged weights from the total open interests with weight formed 49% for non-commercial positions and 46% to commercial positions. On the contrary, the non-commercials and commercials long positions weights are differentiated, where the non-commercial long positions are overwhelming, with 60.5% the commercials long positions that records 34.6%. For heating oil, between 2002 and 2015, the non-commercials presence increased, but still did not surpass the commercials positions, where the long (short) positions of non-commercials, at the end of 2015, recorded 31.8% (34.3%) versus 55.3% (53.5%) for the commercials long (short) positions. The situation is more obvious in natural gas market, where dominance was switched from commercials positions to non-commercials positions after 2006. At the end of 2015, the non-commercial long (short) positions formed 49% (70%) from the total open interests positions, while the commercial long (short) positions recorded 44.7% (25%) from the total open interests.

The increase in the non-commercials positions in agricultural markets may not be observable, as same as energy market (e.g. see figures 7d, 7e, 7f and 7g). It might be because of the seasonality in the agricultural markets. But generally, the non-commercials weight increase over the time. For example, the non-commercials positions in wheat market overwhelmed the commercials positions around 2013, where they represent 44.1% of the total long positions, and 65% of total short positions at the end of 2015. In corn market, the non-commercials and commercials positions are mostly matched. For gold futures market, after 2002, the long futures positions were dominated by non-commercials operators, while the short positions were dominated by commercials agents. However, by the end of 2015, the commercials and non-commercials positions seem to be close to each other, where the non-commercial positions advanced with a step, where the futures positions marked 54% (49.5%) for non-commercials long (short) positions versus 36.6% (40.4%) for commercials long (short) positions. Table 7 exposures the changes in the weights of commercials and non-commercials positions from the total open interest positions.

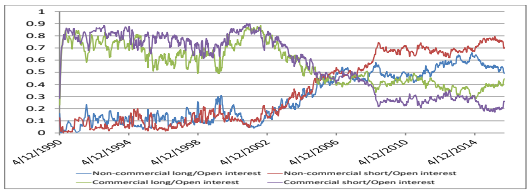
Figure 7: The weight of non-commercials and commercials positions to the total open interest positions



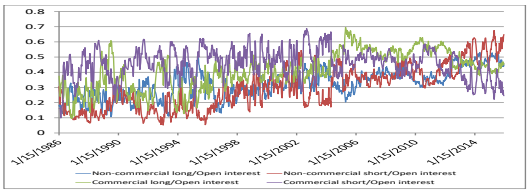

(a) Crude oil



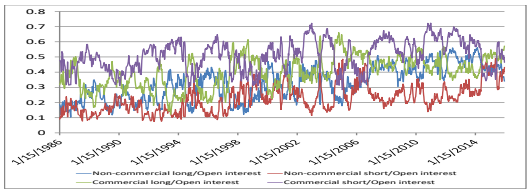

(b) Heating oil



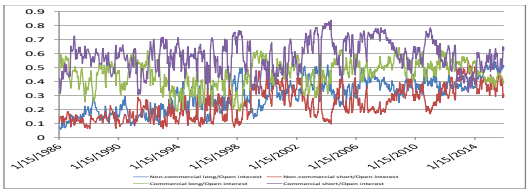

(c) Natural gas



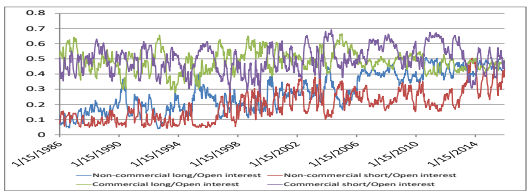

(d) Wheat



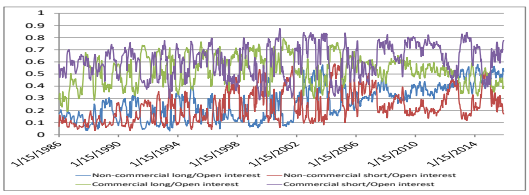

(e) Soybean



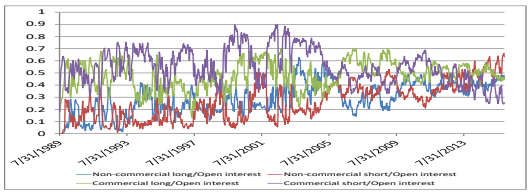

(f) Soybean oil



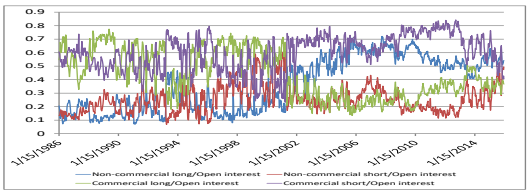

(g) Corn




(h) Cotton




(i) Copper




(j) Gold

Note: Blue line is the weight of non-commercial long to open interest positions. Red line is the non commercial short to open interest positions.Green line is the weight of commercial long to open interest. Indigo line is the commercial short to open interest.

### Working (1960) "T" index

The increases in non-commercial positions (speculators) were accompanied by increases in the commercial positions. Therefore, to be more precise about the increase in the speculation I measure the speculative activities in the commodity futures markets by using the speculative index of Working (1960). Working (1960) "T" index measures the ratio between non-commercials agents' activities to the commercials activities (speculation to hedging). The concept of this index depends on the relation between hedgers and speculators. It follows the argument that says the speculators are needed to offset the hedger's net positions. He predicts that there is no need for speculators when hedgers' long positions equal to hedger's short positions (hedgers offset each other). But, the reality is different. In reality, long and short futures positions are not matching. Thus, Working's (1960) index evaluates the speculation activities that exceed what are needed to meet hedgers' positions[6].

Working (1960) "T" index is:

$$T_t^i = \begin{cases} 1 + \frac{NS_t^i}{CS_t^i + CL_t^i}, \text{ when } CS_t^i \geq CL_t^i \\ \\ 1 + \frac{NL_t^i}{CS_t^i + CL_t^i}, \text{ when } CS_t^i \leq CL_t^i \end{cases}, \text{where } i \text{ indicates the commodity}$$

Where, $NS$ is the Non-commercials Short positions (speculators short positions); $NL$ is the Non-commercial Long futures positions (speculators long positions); $CS$ is the Commercials Short futures positions; $CL$ is the Commercials Long futures positions.

To compute the index for each of crude oil, heating oil, natural gas, wheat, corn, soybean, soybean oil, copper, gold and cotton futures markets, I use (non)commercials futures positions from CFTC in the period between January 1986 and December 2015 except for natural gas (1990 - 2015) and copper (1989 - 2015).

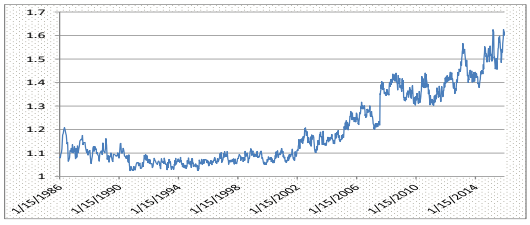
Figure 8 shows Working "$T$" index movements of the selected commodities. Figures 8a, 8b and 8c illustrate the obvious increases in the speculative activities after 2002 in crude oil, heating oil and natural gas futures markets respectively. In the period 1986-2002, Working index of crude oil was moving around average 1.076, while at the beginning of 2002, the index was 1.11, and then it jumped to 1.62 at the end of 2015 (i.e. the speculative activities, which are greater than what were needed to meet hedging activities, increase from 11% to 62% in the period 2002-2015). For natural gas, the speculative activities increase from 1.056 in 2002 to 2.06 in 2015 (i.e. 5.6% in 2002 to 106% in 2015). Heating oil market was less sour, the speculative

[6]This index is also used in Buyukşahin and Robe (2014b)

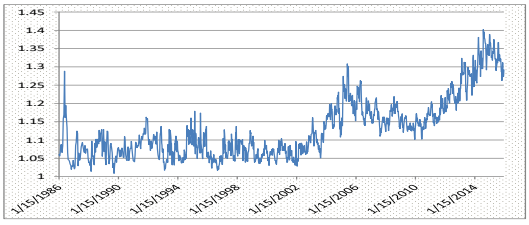
activities increase from 1.05, at the beginning of 2002, to 1.37 at the beginning of 2015. But, it decreased to 1.29 at the end December 2015 (the excess speculation increase from 5% at the beginning of 2002 to 37% at the beginning of 2015).

Another clear example about the increase in the speculation is the copper market. The excess speculation started increasing continuously after 2006. At the end of 2015, Working (1960) index marked approximately 1.7 (the excess speculation was around 70%). For gold market, the excess speculation increased till the beginning of 2007, when it registered 50%. However, it decreased again to mark one of the lowest levels since 1986; in 2012, the excess speculation was around 14%. But, it rose again to register 61% at the end of 2015. In wheat market, the excess speculation moved around 28% till 2010. After then, it increased to 66% in 2015. The excess speculation in other markets such as soybean, soybean oil, cotton and corn moved in steady rhythm (there were no structural breaks). The excess speculation activities for each of soybean, soybean oil, corn and cotton in 2015 registered in average $40\%, 39\%, 39\%$ and $26.5\%$ respectively.

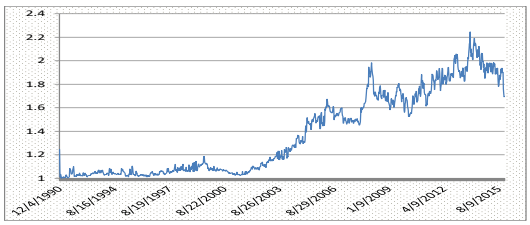
Figure 8: Working (1960) "T" index



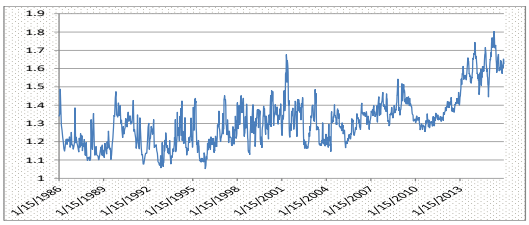
(a) Crude oil



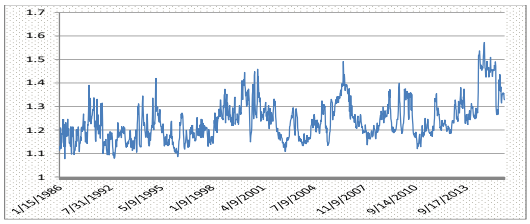
(b) Heating oil



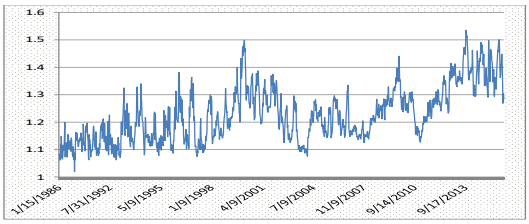
(c) Natural gas



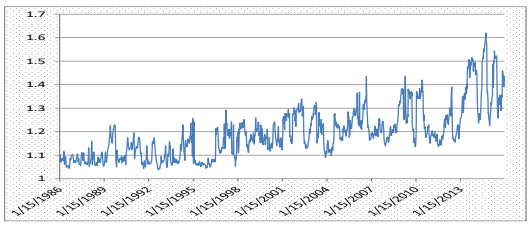
(d) Wheat



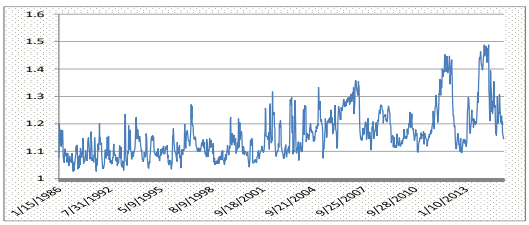
(e) Soybean



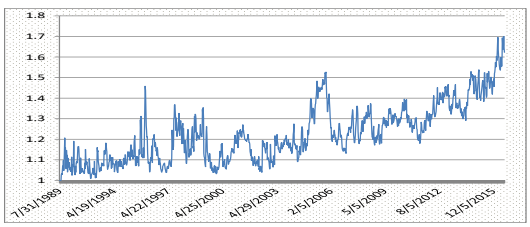
(f) Soybean oil



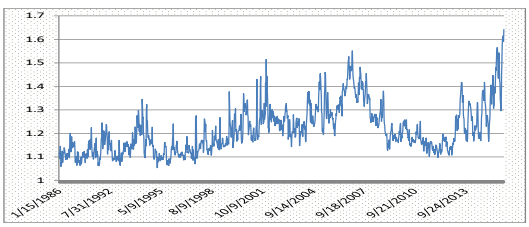
(g) Corn



(h) Cotton



(i) Copper



(j) Gold

## What has been learned so far?

In the previous section, I explained the increase of the speculation in some commodity markets. Synchronizing with these increases, several changes have appeared in the commodity markets especially the surge in most of commodities prices between 2003 and 2008. For instance, crude oil (WTI) futures prices witnessed dramatically increases; from 30$ per barrel in 2003 to 140$ per barrel in July 2008, and then a sharp decrease to around 50$ per barrel in February 2009. After that date, the futures prices recovered and increase next two years. Between 2011 and 2014, the prices were moving around 100 $ per barrel. Then, they started declining again by the second half of 2014 to reach almost to 30$ per barrel by the beginning of 2016 (see figure 9a). As we see from figure 9, there are other commodities that witnessed surges in prices between 2003 and 2008 such as heating oil, wheat, corn, soybean and soybean oil. On the contrary, cotton prices increase significantly between 2008 and 2010. The important question is whether there is a link between the speculation and the commodity prices, or not. Keeping in mind that the speculation kept increasing, but the commodities prices are not, for example the drop in the prices after Lehman's Brothers crisis.

There is a group of papers that attributes the surge in commodity prices between 2003 and 2008 to the supply and demand in commodity markets. Hamilton (2009) explains the crude oil prices by the growing demand from China, the Middle East and the industrialized economies, and the low oil production, and the low price elasticity of demand. In the same line, Kilian and Murphy (2014) explain crude oil prices by the increase in the global demand. Sockin and Xiong (2015) demonstrate that producers' commodity demand can increase with the price, and supply shocks can have an amplified effect on the price and an undetermined effect on producers' demand. On the contrary, they are not sure whether the inflow of the investments to commodity futures markets has amplified the commodity prices prior to 2008.

Another group went in different track and claim that surge in the commodity prices could not be only explained by the economic fundamentals of supply and demand. They tend to adapt the idea of the responsibility of the speculation and commodity investments on deriving the commodity prices[7]. Most of researches were motivated by the Masters (2008), who addresses that commodity index investments have risen from $13 billion at 2003 to $260 billion at March 2008. Brunetti and Buyukşahin (2009) find no evidence that the speculations causes price movements when they study futures markets of crude oil, natural gas, corn, Eurodollars and mini-dow by using a unique data from CFTC. Buyukşahin and Harris (2011) find that the speculators and the index investors positions do not lead crude oil futures prices. Fattouh et al. (2013) summarize an

[7] Irwin and Sanders (2011) reviews the debate about the impact of index funds in commodity futures markets.

overview about the role of speculation in oil market. They reached to several conclusions: first, there is a clear evidence of the increased financialization of oil markets. But, its responsibility of the asset prices co-movement is still debated. Second, they did not find any evidence that the positions of financial traders foresee the changes in oil futures. Third, they find no evidences that oil futures prices forecasts the spot prices. Forth, structural VAR models do not support that the speculations is a determinant of of the 2003-2008 surge. Knittel and Pindyck (2016) demonstrate that speculation has no effects on crude oil prices. Singleton (2014) find significant influence of investors flow on oil futures prices. Kyrtsou et al. (2016) find a persistent lead-lag relationship between the S&P 500 index and the market participants expectations for crude oil, from 2004 to 2009. Henderson et al. (2015), for several commodities, provide evidence by using data on Commodity-Linked Notes (CLNs). Hamilton and Wu (2015) find little evidence of index fund on commodity prices. They find no relations between 12 different agricultural commodity futures returns and the index fund positions, while they find evidence about crude oil futures returns. Du et al. (2011) demonstrate that crude oil price volatility is explained by scalping, speculation, and petroleum inventories. Also, they find that oil price shocks appear to have triggered sharp price changes in agricultural commodity markets, especially in the corn and wheat markets. The vast majority of studies, to our knowledge, is about energy market and particularly crude oil. Other markets such as agriculture and precious metals have less attention. Bosch and Pradkhan (2015) find no evidence of speculative activities on precious metals. Bruno et al. (2013) study what drives the linkages between grain, livestock and equity markets. They find, in the period 2000-2008, a causal relationship from speculative activity to the strength equity-commodity linkage, but in the post 2008 crisis, the speculative activities are weaker. Silvennoinen and Thorp (2014) do not show weakening in the correlation between commodities and stock returns.

Other papers tended to compute and analyze the variation in the linkage between commodity and equity markets such as Buyukşahin et al. (2010), Creti et al. (2013), Buyukşahin and Robe (2014a) and Buyukşahin and Robe (2014b). These papers used Dynamic Conditional Correlation (DCC) that has been addressed by Engle (2002) (the methodology is explained in the appendix ). Buyukşahin et al. (2010) did not find a significant change between commodity and equity returns, when their sample was ended on November 2008. Buyukşahin and Robe (2014a) address that speculative activity in energy futures markets, especially for hedge funds, has explanatory power for commodity-equity correlations. Buyukşahin and Robe (2014b) find the linkage between commodity and equity markets for 17 commodity futures markets over the period 2000 and 2010. They conclude that the commodity-equity correlation increased significantly after 2008 crisis. They also find that hedge funds (beside macroeconomic fundamentals and financial market stress) have predictive power on the commodity-equity correlation more

than other participants such as swap dealers, index fund, traditional commercial traders, floor brokers and traders. They find that a 1% increase in hedge funds' share of the commodity futures open interest is associated with, about, 4% increase in equity–commodity return correlations. Creti et al. (2013) investigate the correlation between 25 commodities and stocks over the period from 2001 to 2011. They find that commodity-equity correlations evolve through time being highly volatile, particularly since the 2007–2008 financial crisis.

Going in the line with the previous literature, I find the dynamic conditional correlation (DCC) between commodity and equity returns. I use daily datasets over the period between 1995 and 2015 to compute the dynamic conditional correlation between commodity and equity returns. I represent the commodity return by computing the return of the first futures nearest-to maturity returns. For equity returns, I represent them by finding the return of S&P 500.

Figure 10 shows the dynamic conditional correlation between equity returns represented by S&P 500 returns and the commodity futures returns for each of crude oil (WTI), heating oil, natural gas, wheat, soybean, soybean oil, corn, cotton, copper and gold over the period 1995 and 2015. The commodity-equity correlations of crude oil (WTI) and heating oil was not stable (The DCC of both commodities have almost the same movements). For crude oil (WTI), the correlation moved in the range between 0.34 and -0.30 till September 2008. For the same period, the correlation in heating oil market was fluctuated between 0.29 and -0.32. After 2008 financial crisis, the commodity-equity correlation of both markets jumped noticeably to reach the highest level on July 2012, when the commodity-equity correlation marked 0.65 and 0.61 for crude oil and heating oil respectively. On the other hand, the commodity-equity correlation of natural gas was stable, and it did not change widely; the commodity-equity correlation is 0.012 in average.

In agricultural market, especially wheat, soybean and corn, the correlation with $S\&P500$ changes in the same range before 2008, sometimes it is positive and sometimes it is negative. However, after 2008 financial crisis, the correlation increased above the historical average, but for short period. For wheat, the correlation increased its historical ranges between 2009 and 2010, while it was a little longer in soybean and corn markets, when it extend for 2009 and 2012. However, after this short period of comparative high correlation, it decreases to the pre-financial crisis situation. To notice that clearly, see figures 10d, 10f and 10g for wheat, soybean and corn markets respectively. In the same scenario, the linkage between copper futures and $S\&P500$ increased after 2008 crisis to reach the peak on April 2012, when the correlation marked 0.62. Then, it decreased gradually to reach its normal situation before 2008 crisis on Mid-2015. On the contrary, the correlation between cotton futures and $S\&P500$ increased after 2008 crisis and is still high comparing to its historical average. The commodity-equity correlation before

2008 shows the low (or negative) correlation that has been addressed in Gorton and Rouwenhorst (2006), when it was appealing for financial investor to diversify their portfolios. However, the increase in the commodity-equity correlation makes a lot of researchers to doubt about the diversification. However, I confirm Bhardwaj et al. (2015) who debated that the increase in the commodity-equity correlation is temporarily, and it will return to its historical average. As shown in figure 10, some of commodity-equity correlation is returning to normal historical levels. Except, we need to wait and see what is going to happen in other markets such as crude oil, heating oil, and cotton.

Tang and Xiong (2012) investigate the impact of financialization on cross commodity markets. They ensure that the determinations of commodity prices are not limited only to the macroeconomic variables (supply and demand). But, the commodity index investors are also important in determining the prices. They find that futures prices of non-energy commodities became increasingly correlated with oil after 2004. Furthermore, they find that the correlation between indexed commodities increased more than the non-indexed commodities. Cheng et al. (2015) find that, after the 2008 crisis, financial traders reduce their long positions due to their smaller risk absorption capacity, while hedgers take the other side. The hedgers increased their risk holding than they did previously; i.e. a portion of the risk that was previously held by financial traders will be taken back on by hedgers. This risk flow reallocates risk from the groups less able to bear the risk to the groups more able to bear risk. Therefore, demand liquidity from commercial hedgers rather than provide liquidity to commercial hedgers.

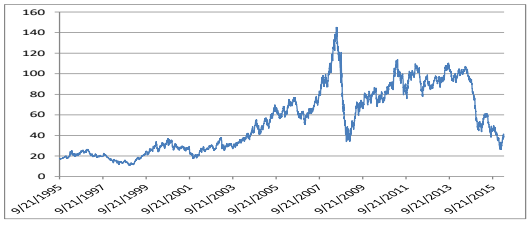
Theoretically, the work that has been done about this phenomenon "financialization of commodity" is limited. Boons et al. (2014) develop a model that studies the interaction between commodity and stock markets. They find that about 70% of the commodity futures returns can be attributed to traditional hedging pressure and the remaining 30% to stock market risk. Ekeland et al. (2015) develop a model that studies the interaction between spot and futures commodity markets. They find that the impact of speculation splits to two scenarios depending whether the futures market is in normal backwardation or contango. In normal backwardation state, speculation increase causes an increase in the spot price, futures price and inventory levels. On the contrary, the spot price, futures price and inventory levels are decreasing in contango state.

On the other side, there are some dynamic models that investigate the financialization such as Basak and Pavlova (2016) and Baker (2016). Basak and Pavlova (2016) develop a multi-goods and multi assets model with institutional investors and futures market participants. They find that commodity futures, commodity-equity correlation and volatility of futures returns increase

with the financialization. They explain the cross commodity spillovers, and find that the abundance in any commodity decreases the price and the inventory of the other commodity. Baker (2016) builds a dynamic equilibrium model to study the impact of financialization on spot and futures prices. He finds, for crude oil market, that financialization increases the standard deviation of spot and futures prices, and the futures open interest becomes more correlated with the spot price. Also, it does not have an impact in the mean spot price.

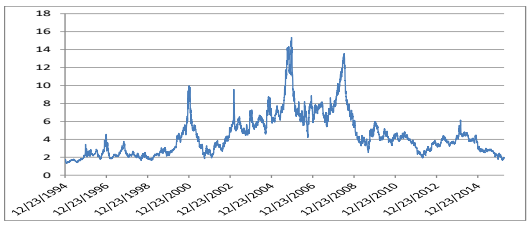
There are other models that focus on studying the futures risk premium, which some of them reviewed by Baumeister and Kilian (2015). Acharya et al. (2013) build a model to study the interaction between the spot and futures commodity markets. Their model is built on the idea where speculators are capital constrained, and commodity producers have hedging demands for commodity futures. Hence, their point is that when speculators are constrained in their ability to provide capital in the commodity futures market, commodity producers experience limits to hedging. Consequently, futures prices decline. The decision of decreasing hedging activity leads to a decrease in the inventory levels of the producers. In turn, it decreases spot prices. Acharya et al. (2013) predict an increase in the futures risk premium and the change in spot price when the risk aversion of hedgers increase. Also, both futures risk premium and the changes in spot prices are predicted to increase when the risk aversion of speculators increase. Etula (2013) derives an asset pricing model that studies the influential of the brokers on the commodities futures risk premium. He predicts that the risk premium is determined by marketable and non-marketable risks. Ekeland et al. (2015) find that the futures risk premium is determined by the sign and the magnitude of hedging pressure, which is defined as the difference between the inventory holders and processors physical positions. Hamilton and Wu (2014) create a model that is studying the interaction between hedging demands from commercial producers or financial investors and arbitrageurs on the counter side. As a result they find that, prior to 2005, agents who take long position of oil futures contracts received positive compensation on average. They show significant changes in the risk premium after 2005, which they attribute it to the increase in the financial investors participation in the futures market (the compensation from long position is lower, often significantly negative when the futures curve slopes upward).

Figure 9: Commodity futures prices

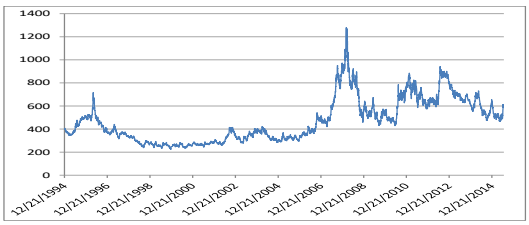


(a) Crude oil

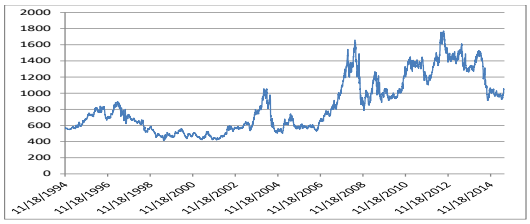
(b) Heating oil



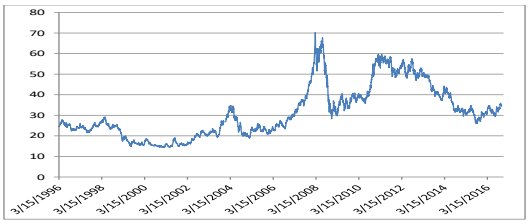
(c) Natural gas



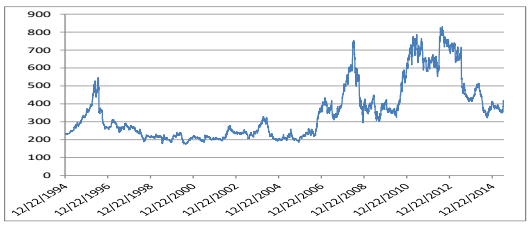
(d) Wheat



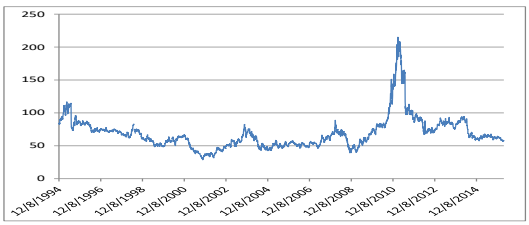
(e) Soybean



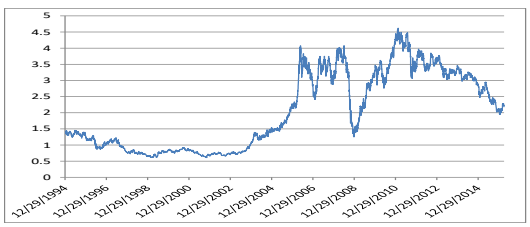
(f) Soybean oil



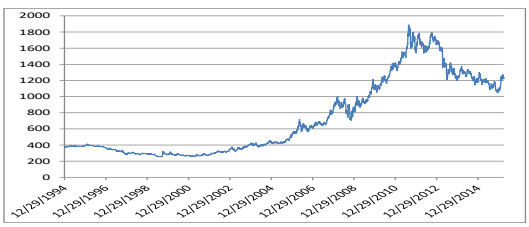
(g) Corn



(h) Cotton



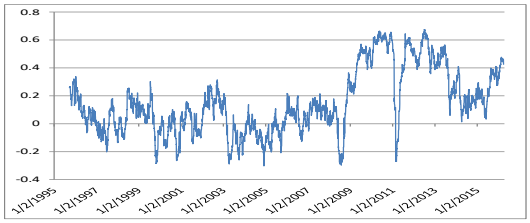
(i) Copper



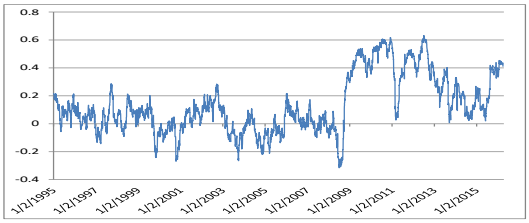
(j) Gold

Source: Datastream

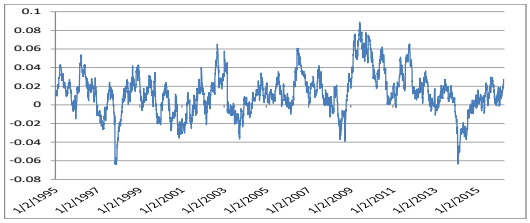
Figure 10: Dynamic conditional correlation between S&P 500 returns and the first nearest-to-maturity returns



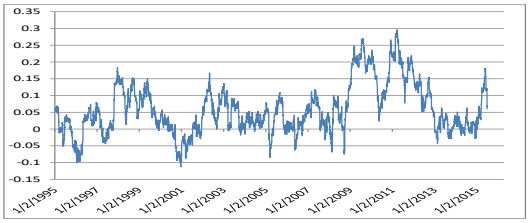
(a) Crude oil & S&P 500



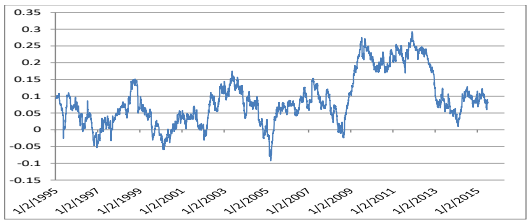
(b) Heating oil & S&P 500



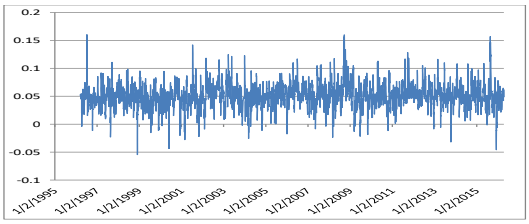
(c) Natural gas & S&P 500



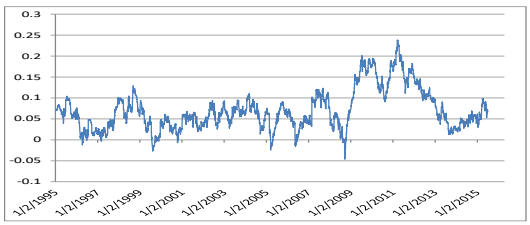
(d) Wheat & S&P 500



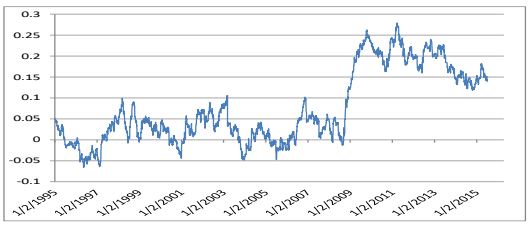
(e) Soybean & S&P 500



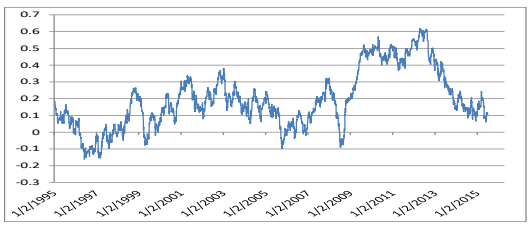
(f) Soybean oil & S&P 500



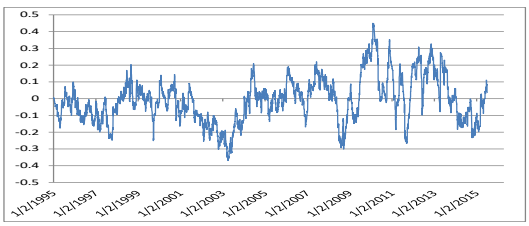
(g) Corn & S&P 500



(h) Cotton & S&P 500



(i) Copper & S&P 500



(j) Gold & S&P 500

## The role of financial investors in commodity markets

As it has been explained previously, the financial investors, who have stock portfolios, intensified their participation in the futures markets after 2002. Furthermore, those investors invest in a basket of commodities. That raises two important questions to investigate: first, the interaction between stock and commodity markets, and second, the integration between commodity futures markets. Despite these two questions were debated in several articles, which most of them are empirical, but the debate is still on. Therefore, it is necessary to have more theoretical researches to clarify the ongoing debate about the impact of financialization. Consequently, in this dissertation, I will be studying the impact of the investment inflow in commodity markets on commodity prices in the first place, and the integration between different commodity markets in the second place, in both theoretical and empirical perspectives.

I build my research lines on a model that has been developed by Ekeland et al. (2015). Ekeland et al. (2015) build a model that studies the interaction between the physical and futures commodity markets. They construct a simple static model, where the equilibrium is based on the interaction between four types of agents: inventory holders, processors, speculators and spot traders. Hence, they represent the basic economic functions. Those agents are interested in one commodity. The inventory holder (also named storer) has the capacity to store the commodity. He is a physical speculator. He buys the commodity (say at time $t$), stores it for sometimes, and then sells it at future time (say at time $T$). The processor uses the commodity to produce final products. Both storer and processor hedge their physical positions in the futures market. The inventory holder faces a risk of declining in the commodity prices. Therefore, he sells futures contracts (takes short positions) for his hedging purpose. On the contrary, the processor buys futures contracts (takes long positions). However, the storer may take long positions and the processors may take short positions, but that is considered for speculation purposes. The speculator operates in commodity futures market only. He offsets the net futures positions taken by hedgers. The spot traders operate in the commodity physical market only. They locate on the supply and demand sides at any time. In their model, they concentrate on studying the question whether the speculation stabilize or destabilize the commodity prices.

I find that the model of Ekeland et al. (2015) is appealing to apply our ideas. In their model, they assume several assumptions. Two of these assumptions are of particular interest for my study. First, they model the speculator to operate only in the futures market. Second, the model is studying one commodity market. Consequently, I use Ekeland et al. (2015) as a cornerstone in writing this thesis. So, I construct a thesis that contains three chapters. Two of these chapters are theoretical, and the third is empirical. These chapters investigate the interaction between stock and commodity markets by building a theoretical model, cross commodity integration, and

the impact of financial investor on commodity futures risk premium. In the first chapter, I allow to financial investors to diversify their portfolios in the futures market. Hence, I replace the speculators (in Ekeland et al. (2015)) by financial investors; in other words, the speculators are not operate only in the futures markets. In the second chapter, I study empirically the impact of stock market on the commodity futures markets. Finally, in the third chapter, I allow to the speculators to operate in two different commodities markets; i.e. I link between two isolated forms of Ekeland et al. (2015). Next is a summary for the three chapters.

### Chapter I, Commodity and Stock Market Integration, An Equilibrium Model

In this chapter, I aim to study the influential power of stock market on commodity one. I was motivated by the ongoing debate about whether the financial investors, no matter if they are hedge funds, index fund, swap dealers or exchange trade products holders, have an impact on commodity futures markets, or not. I do so by introducing a model in the spirit of Ekeland et al. (2015). The model studies the interaction between commodity physical, commodity futures and stock markets. There is a single commodity that is traded in the physical and the futures markets. The markets are interacting at $t$ and $T$. Hence, we have a two periods model. There are four types of traders: Inventory holder (storer), processor, financial investor and spot traders. The inventory holder has the capacity to store the commodity; they buy, hold and then sell the commodity (physical speculation). The processor uses the commodity as an input to produce final products. Both of them, the storer and processor, operate in the futures market for hedging reasons. The storer hedge his physical position against any decrease in the prices by taking short futures positions, while the processor take long futures positions to hedge his physical positions from any increase in the commodity price. The financial investor includes futures contracts in his stock portfolio for diversification reasons. Spot traders are located on the demand and supply sides in commodity spot markets. In the model, there are several markets and several transmission channels; the storer links between the two periods, the storer and processor link between the physical and the futures markets and the financial investor links between the stock and futures markets.

At the first period, the storers locate on the demand side in the physical market, and buy the commodity, to store it. The spot traders appear in both demand and supply sides in the physical market. The processors decide the volume of the commodity that is needed for their production in the second period. The storers and processors hedge their physical positions in the futures market at certain futures price. For their hedging purposes, the storers sell futures position (take short positions), while the processors buy futures positions (takes long positions). The futures positions of the storers and processors comprised of positions for hedging and others for speculation purposes. Finally, the financial investors position themselves in the commodity

futures market depending on information from the commodity and stock markets such as the expected returns in both markets and the commodity-equity correlation. The decisions of financial investors in futures market show highly the diversification concept. At the second period, the storers sell the inventories that they have been holding from the first period in the physical market. The processors locate on the demand side and deliver the commodity that they had asked for. The spot traders appear on the demand and supply sides of the spot market. The futures contracts are settled implying a financial profit from the futures market, which is measured by the difference between the expected spot and the futures prices (futures risk premium). The futures contracts are offset either by cash settlement (agents take the opposite direction of their futures positions), or possibly by physical settlement.

The chapter focuses on studying two questions: first, the impact of commodity-equity correlation on the commodity prices, and second, the impact of financial investment on commodity markets. Positing the first question is motivated by the increase in the linkage between equity and commodity markets, where the commodity-equity correlation jumped significantly after the 2008 financial crisis for several commodity markets as shown in figure 10 (e.g. Buyukşahin and Robe (2014a)). In the second question, I aim to provide a theoretical answer to the debate whether there is an impact of the financial investors on commodity markets, or not.

Motivated by Basak and Pavlova (2016), who find that the financialization increase the commodity-equity correlation, an increase in the commodity-equity correlation, subjected to positive expected stock returns, causes a decrease in long (or increase short) futures positions of financial investors. Purchasing less futures contracts decreases the futures prices. Consequently, the storers reduce their physical inventory, because of the expensive cost of hedging. The declining in the storers' demand in the physical market causes a decrease in the spot price. Low futures price offers a suitable atmosphere for the processors to increase their physical positions; i.e. they benefit from hedging. Low inventory and the increase in the processors' demand cause an increase in the future spot price.

The model's findings show why there is ambiguity in the evidences about the impact of investment in commodity futures markets. Hedging pressure, commodity-equity correlation and expected stock returns are responsible on determining the impact of the investment on the commodity prices. Starting from no diversification point, the impact of speculation is determined by the sign of hedging pressure. This finding corresponds with the finding of Ekeland et al. (2015). However, by allowing financial investors to diversify their portfolios in commodity futures markets, commodity-equity correlation and expected futures returns also share in determining the impact of financialization. In some scenarios, the impact is clear. For example, a net short hedg-

ing pressure and negative commodity-equity correlation accompanied by a positive stock return causes an increase in each of spot price, futures price and the inventory level, and a decrease in the future spot price and the physical demand for production. Another clear scenario is when the net hedging pressure is long and both commodity-equity correlation and the stock market risk premium are positive. In this situation, commodity spot price, futures price and inventory levels decrease, while the future spot price and the physical demand for production increase. However, the impact of financialization could be determined at any situation by knowing the characteristics of both stock and futures markets.

### Chapter II, The Role of Financial Investors on Commodity Futures Risk Premium

In this chapter, I implement an empirical study about the impact of the financial investors on commodity futures risk premium. This research question is a continuation to the empirical debate about finding evidences of the influence of financial investors in commodity markets. One of the previous chapter's contributions (Isleimeyyeh et al. (2017)) is that the futures risk premium is determined by two basic terms. The first term is the economic fundamentals of commodity that are represented by the total physical inventory and the demand for production. This term also can be introduced as the net short hedging pressure. The second term is the stock market factor. This factor is represented by the expected stock return accompanied by the commodity-equity correlation. Econometrically, I will be regressing the commodity futures risk premium on two explanatory variables: first, the net short hedging pressure which is defined as the difference between the total short and total long futures positions of the commercial agents divided by the total hedging positions. The second variable is the adjusted stock returns that are defined by the multiplication between stock market returns and the commodity-equity correlation at any given time. Chosen the commodity-equity correlation to be variable is motivated by the finding of Basak and Pavlova (2016), who find, theoretically, that the financialization of commodity increases the commodity-equity correlation. Empirically, Buyukşahin and Robe (2014a,b) and Creti et al. (2013) experienced a significant increase in the commodity equity correlation after 2008 financial crisis.

In this chapter, I concentrate on testing energy commodity markets that is represented by three commodity markets: crude oil (WTI), natural gas and heating oil. I select these commodities for several reasons: energy market represents an important share in the commodity basket, for example, it represents 63% of the $S\&PGSCI$. Also, the excess speculation appeared clearly in these markets as shown in figures 8a, 8b and 8c. For each commodity, I select a dataset that covers the period between 1995 and end of 2015. I divide the tested period into

three sub-periods, namely: 1995-2002, 2003-2008 and 2008-2015. These time divisions have been chosen to represent the pre-financialization and post-financialization periods, where the post-financialization splits to two periods that are distinguished by 2008 financial crisis. I test the impact of the stock market and the hedging pressure on the futures risk premium for several maturities. This step is different from most of the literature, which focus on the first and/or the second nearest-to-maturities. The investors who are looking for portfolios diversifying are passive investors. Therefore, they buy and hold benefiting from long run returns. Logically, they buy long maturity futures contracts and hold them. After then, they offset these contracts when they are close to maturity. Furthermore, Buyukşahin and Robe (2014b) showed that the excess speculation increased in both short and long maturities.

As a result, I find that the hedging pressure is a strong explanatory variable of the futures risk premium. A net short hedging pressure increase the futures risk premium, while the impact is mirrored when the net hedging pressure is long. I find also that the impact of hedging pressure on the futures risk premium decreases when the futures contract maturity increases. The results show the importance of the stock returns in explaining the futures risk premium, which become significantly influential in the period post 2008 financial crisis. Furthermore, the impact of stock returns for longer maturities overwhelms the impact of the hedging pressure. That does do not contradict the finding of Boons et al. (2014), where they find that 70% of futures risk premium is interpreted by hedging pressure and the 30% rest is attributed to stock market returns. For short maturities (the first and the second as tested in Boons et al. (2014)), I find that the variation of the futures risk premium is mostly attributable to hedging pressure and secondarily by stock market returns. But, the interpretation is the inverse for long maturities.

### Chapter III, Cross Commodity Markets Integration, An Equilibrium Model

In this chapter, I develop a model in the spirit of Ekeland et al. (2015). This model is investigating the interaction between different commodity futures markets. This work is motivated by the significant increase of index investment in the commodity futures markets. Financial investors hold a portfolio of commodities that imitates a well-diversified index such as Goldman Sachs Commodity Index (S&P GCSI), or Dow Jones-UBS Commodity Index (DJ-UBSCI). Consequently, several empirical papers find that the linkage between commodities increased in the period post financialization such as Tang and Xiong (2012), Natanelov et al. (2011) and Bruno et al. (2013). However, the theoretical work on that is still scanty. The model studies the interaction between two commodity markets. For each commodity market, there are four types of participants: inventory holder (storer), producer, speculator (financial investors) and spot traders. Logically, not all commodities have the same condition of storing, and of course different commodities are used to produce different products. Intuitively, each commodity has

different types of storers, processors and spot traders than the other. The investors are the only operators who trade in both markets.

In each commodity market, the storers buy the commodity, to store it. The spot traders meet the storers' demand in the physical market. The processors decide the volume of the commodity that is needed for their production in the second period. For hedging purposes, the storers and processors take positions in futures market at certain futures price. Finally, the financial investors position themselves in the commodity futures market depending on information from both commodity markets. Based on the model, there are three determinants of having short or long futures positions: the expected returns in both commodity markets and the cross commodity correlation. At future time, the storers sell their inventory that have been held from the previous period in the physical market. The processors locate on the demand side and deliver the commodity that they had asked for. The spot traders appear on the demand and supply side of the spot market. The futures contracts are settled implying a financial profit from the futures markets, which is measured by the difference between the expected spot and the futures prices (futures risk premium).

The model offers to study many comparative statics. However, I focus on studying three questions. First, the impact of the supply/demand shocks on the commodity prices. Second, the impact of expected future shocks in the supply/demand on the commodity prices. I study the impact of these shocks on the prices of the shocked commodity market, and how it spreads to the other market. Third, I investigate the impact of speculation on the commodity prices. These three questions have been chosen in order to clarify the vague debate about the impact of index investing on commodity prices. Also, I aim to show the integration between the different commodities.

Before summarizing the results, I would like to remind with following transmission channels that are responsible on information flow between the different markets. First, the hedgers are responsible in transmitting information between physical and futures markets. Second, storers are connecting two time periods. Third, financial investor is considered the transmission channel that is responsible for information flow between both markets. Cross commodity correlation plays a crucial role in determining the integration's direction between markets. Therefore, Any change in one market could be reflected in two opposite impacts in other markets, of course depending on the sign of cross commodity correlation. However, I introduce the positive cross commodity correlation case (e.g. see Tang and Xiong (2012)). But, keep in mind that in any situation where the cross commodity correlation is negative, then the following results are mirrored. Abundance in any commodity pushes the investor to have long positions in that market.

On the contrary, the long (short) positions taken by investors in the other market decrease (increase). That changes in the futures positions leads to a decrease in the futures price. Therefore, the hedging for inventory holders, who sell futures contracts, is less profitable. Hence, they will reduce their inventory levels. Consequently, current spot price declines. On the contrary, the demand for production, the future spot price and futures risk premium rise. The processors are benefiting from futures price declines, and are able to hedge their physical positions. So, they are safe for buying more commodity in physical markets. Thus, more future demand leads to increase the future spot price. Finally, the profit from financial market becomes higher; the futures risk premium increase.

Expecting a future shock in any market causes a recession in that market, meanwhile the other market is more active. Such a positive supply shock leads investors to take short positions in the shocked market. On the contrary, investors tend toward having more long futures positions in the stable market. That is considered the key in the commodity price changes. More demand on long futures positions causes an increase in futures prices. Higher futures prices are motivated for storers to increase their inventory (offer a shelter to storers). Hence, high inventory demand in the physical positions causes an increase in the spot price. High futures prices cause a high hedging cost for processors. Therefore, they reduce their demand in physical market. As a result to high inventory, the future supply will be high. Then, future spot price is expected to decrease.

Finally, the impact of financialization is determined by a balance of hedging pressure. Taking long (short) positions in the futures market raises (declines) the spot price, the futures price and the inventory levels, while it decreases (increases) the demand for production and the future spot price. Moreover, the size of the impact of financial investors on commodity prices has an inverse relationship with the size of the market.

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# Tables

Table 5: S&P GSCI and DJ-UBSCI 2016 weights

| Commodity | S&P GSCI | DJ-UBSCI |
|---|---|---|
| Energy | 63.05% | 33.33% |
| Agriculture | 15.76% | 28.80% |
| Livestock | 8.64% | 4.53% |
| Industrial metals | 8.91% | 21.15% |
| Precious metals | 3.65% | 12.89% |

Source: https://us.spindices.com, 2016 weights

Table 6: Dynamic conditional correlation (DCC) between stock and commodity markets

| | Crude oil | | Heating oil | | Natural gas | | Wheat | | Corn | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | P-value | Coefficient | P-value | Coefficient | P-value | Coefficient | P-value | Coefficient | P-value |
| $\rho$ | 0.258956 | 0.0739 | 0.230754 | 0.0857 | 0.010242 | 0.5827 | 0.05621 | 0.1025 | 0.071021 | 0.0102 |
| $\alpha$ | 0.021814 | 0.0047 | 0.018538 | 0.0003 | 0.003295 | 0.2335 | 0.007981 | 0.0553 | 0.004826 | 0.0530 |
| $\beta$ | 0.97552 | 0.0000 | 0.979389 | 0.0000 | 0.986331 | 0.0000 | 0.986057 | 0.0000 | 0.990639 | 0.0000 |
| $\alpha+\beta$ | 0.997334 | | 0.997927 | | 0.989626 | | 0.994038 | | 0.995465 | |

| | Soybean | | Soybean oil | | Cotton | | Copper | | Gold | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | P-value | Coefficient | P-value | Coefficient | P-value | Coefficient | P-value | Coefficient | P-value |
| $\rho$ | 0.092558 | 0.0382 | 0.050636 | 0.0008 | -0.02326 | 0.8182 | 0.209822 | 0.0500 | -0.0001 | 0.9982 |
| $\alpha$ | 0.005925 | 0.0021 | 0.012517 | 0.2359 | 0.0032 | 0.0239 | 0.012429 | 0.0000 | 0.017388 | 0.0202 |
| $\beta$ | 0.991388 | 0.0000 | 0.796253 | 0.0000 | 0.996768 | 0.0000 | 0.98588 | 0.0000 | 0.97309 | 0.0000 |
| $\alpha+\beta$ | 0.997313 | | 0.80877 | | 0.999968 | | 0.998309 | | 0.990478 | |

Table 7: Commercials and non-commercials weight to the total open interest positions

| Commodity | 1986 | | | | Average 1986-2002 | | | | 2002 | | | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non-commercial | | Commercial | | Non-commercial | | Commercial | | Non-commercial | | Commercial | | Non-commercial | | Commercial | |
| | long | short | long | short | long | short | long | short | long | short | long | short | long | short | long | short |
| crude oil (WTI) | 10.6% | 22.8% | 71.9% | 56.6% | 12.8% | 12.3% | 66.7% | 67.0% | 12.7% | 27.8% | 76.1% | 66.4% | 60.5% | 48.6% | 34.6% | 46.3% |
| Heating oil | 6.2% | 18.0% | 58.1% | 44.9% | 11.3% | 9.6% | 55.0% | 65.5% | 6.9% | 15.0% | 71.4% | 68.2% | 31.8% | 34.3% | 55.3% | 53.5% |
| Natural gas | 16.1% | 12.6% | 23.0% | 28.3% | 11.0% | 9.0% | 69.4% | 78.0% | 8.2% | 16.5% | 84.1% | 77.3% | 49.0% | 70.2% | 44.7% | 25.9% |
| Wheat | 18.2% | 30.6% | 37.5% | 16.2% | 27.6% | 21.6% | 34.5% | 47.0% | 31.8% | 33.5% | 43.4% | 48.3% | 44.1% | 65.0% | 46.0% | 24.4% |
| Corn | 12.2% | 7.4% | 51.1% | 51.1% | 20.0% | 14.1% | 48.4% | 46.9% | 27.6% | 29.2% | 52.5% | 44.7% | 40.4% | 43.4% | 49.1% | 43.4% |
| Soybean | 18.7% | 8.9% | 31.6% | 47.5% | 26.8% | 20.0% | 35.3% | 48.3% | 18.2% | 29.7% | 50.9% | 51.7% | 33.9% | 43.3% | 57.3% | 46.3% |
| Soybean oil | 7.5% | 10.7% | 47.3% | 42.3% | 24.4% | 20.9% | 42.4% | 55.0% | 26.9% | 34.6% | 58.8% | 52.4% | 51.3% | 29.2% | 39.1% | 64.1% |
| Cotton | 17.5% | 6.7% | 28.9% | 58.0% | 17.2% | 21.8% | 56.4% | 57.3% | 26.3% | 19.1% | 53.3% | 69.1% | 52.3% | 17.1% | 39.7% | 77.8% |
| Copper | 8.9% | 21.2% | 53.7% | 38.1% | 21.4% | 17.0% | 45.2% | 58.6% | 18.2% | 15.8% | 66.1% | 71.7% | 45.3% | 63.3% | 47.0% | 25.8% |
| Gold | 20.7% | 13.3% | 54.6% | 60.7% | 21.1% | 27.7% | 55.2% | 52.7% | 34.8% | 35.4% | 42.2% | 55.0% | 54.3% | 49.5% | 36.6% | 40.4% |

This table expresses the weights of commercials and non-commercials to the total open interest positions. The percentages are obtained in 1986, the average between 1986 and 2002, 2002 and 2015. For each year, there are weights for the non-commercials and commercials in both short and long aspects.

**Note:** For copper and natural gas, the weights that are recorded for 1986 are for the year 1990 (The datasets starts from January 1990 and April 1990 for copper and natural gas respectively).

# Appendix

## Dynamic conditional correlation (DCC)

The dynamic conditional correlation (DCC) is a class of multivariate GARCH estimations. It concerns in estimating relationships between two random variables (time series) overtime. It is based on a two steps model: first by estimating time varying variances using GARCH model. Second, estimating the time varying conditional correlation by using the standardized residuals from the first the step.

Assume $r_t$ is a $n \times 1$ vector of different asset (in our case $n = 2$). $r_t$ is normally distributed, where

$$\begin{aligned} r_t &\sim N(0, H_t) \\ H_t &= D_t R_t D_t \end{aligned}$$

Where,

- $H_t$ is conditional covariance.
- $R_t$ is time varying conditional correlation matrix.
- $D_t$ is the diagonal matrix of the standard deviation, which is given by

$$\begin{aligned} D_t &= diag\sqrt{E_{t-1}\left(r_{it}^2\right)} = diag\sqrt{h_{it}} \\ D_t &= \begin{pmatrix} \sqrt{h_{1t}} & 0 \\ 0 & \sqrt{h_{2t}} \end{pmatrix} \end{aligned}$$

$D_t$ is issued from the estimation of univariate GARCH(1,1)

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 h_{t-1}$$

So, the standardized disturbances can be written as $\epsilon_t = D^{-1} r_t \left(\epsilon_t = \frac{r_t}{\sqrt{h_t}}\right)$
The conditional correlation between two returns is:

$$\rho_{ij,t} = \frac{E_{t-1}\left(r_{i,t} r_{j,t}\right)}{\sqrt{E_{t-1}\left(r_{i,t}^2 r_{j,t}^2\right)}}$$

That implies,

$$\rho_{ij,t} = E_{t-1}\left(\epsilon_{it}\epsilon_{jt}\right)$$

i.e. the conditional correlation between returns is equal to the conditional correlation between standardized disturbance.

Engle (2002) addresses the following dynamic of correlation

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1}$$

where,

$$Q_t = (1 - \alpha - \beta)\,\overline{Q} + \alpha\left(\epsilon_{it-1}\epsilon_{jt-1}\right) + \beta Q_{t-1}$$

$\overline{Q}$ is unconditional correlation matrix of the standard residuals

$Q_t^*$ is the diagonal squared roots components of the matrix $Q_t$.*i.e.* $\begin{pmatrix} \sqrt{q_{iit}} & 0 \\ 0 & \sqrt{q_{jjt}} \end{pmatrix}$.

Thus, $Q_t^{*-1} = \begin{pmatrix} \frac{1}{\sqrt{q_{iit}}} & 0 \\ 0 & \frac{1}{\sqrt{q_{jjt}}} \end{pmatrix}$.

The dynamic conditional correlation is given by

$$\rho_{ijt} = \frac{q_{ijt}}{\sqrt{q_{iit} q_{jjt}}}$$

Finally, the of dynamic conditional correlation in Engle (2002) is estimated by maximium likelihood method:

$$L = -\frac{1}{2}\sum_{t=1}^{T}\left(n\log\left(2\pi\right) + 2\log\left(|D_t|\right) + \log\left(|R_t|\right) + \epsilon R_t^{-1}\epsilon\right)$$

# Chapter 1

# Commodity and Stock Markets Integration: An Equilibrium Model

We construct an equilibrium model regarding the participation of financial investors in the commodity futures markets namely financialization of commodities. We extend the model of Ekeland et al. (2015) by allowing financial investors to include a commodity in their baskets. The study is motivated by the synchronization between the sharp increases in the futures positions taken by those investors and the structural changes in the commodity markets. Hence, we study the interaction between commodity and stock markets by combining the functions of different types of agents: inventory holder, processor and financial investor. In equilibrium, first, we find that a positive stocks returns accompanied by positive (negative) equity-commodity correlation increase (decrease) the commodity futures risk premium. Second, an increase in the commodity-equity correlation decreases the current spot price, the futures price and the storage, while it raises the quantity demanded for production, the future spot price and the futures risk premium. That happens if the stock returns are positive, while the impact is mirrored if we expect a negative stock return. Third, we find also that financialization increases the spot prices, the futures prices and inventory levels.

**Keywords** Commodity market, stock market, commodity-equity correlation, speculation, inventory, hedgers, equilibrium prices/quantities, financialization.

## 1.1 Introduction

Last fifteen years witnessed a noticeable increase in the financial investors' participation in the futures market. A quick review in the Commodity Futures Trade Commission (CFTC) public data, we see structural breaks in the both short and long non-commercials positions around 2002 for different commodities[1]. For instance, the slope of non-commercials long positions in the period 2002-2016 is 20,009 and 34,109 times of the slope in the period 1990-2002 for crude oil (WTI) and Heating oil respectively (e.g. see figures 1.7a and 1.7b in appendix 1.A). These enormous increases hit most of the commodities in both long and short positions (e.g. see figure 1.7). By the beginning of third millennium, financial investor started looking at the commodity futures as assets that are needed to be included in his basket to reduce his stock portfolio's risk (e.g see Gorton and Rouwenhorst (2006)). Based on Stoll and Whaley (2010) and Irwin and Sanders (2011), financial investors, whether they are institutions or individuals, tend to invest in commodity futures by using commodity indices as benchmarks such as the standard and Poor's-Goldman Sachs Commodity Index (S&P GSCI) and Dow Jones-UBS Commodity Index (DJ-UBSCI). They believe that these indices are well-diversified. Therefore, they build a portfolio that mimics one of these indices. Investors may directly build a futures contracts portfolio in a way that mimics one the commodity indices. However, due to the shortage in investors' experience in managing commodity index portfolio, they resort to commodity investments vehicles such as commodity index funds and commodity returns swap. In general, using any vehicle ended to futures markets. Recently, Exchange-traded products (Exchange-traded funds (ETFs) and Exchange-traded notes (ETNs)) have been demanded heavily[2].

Synchronizing with these increases, several changes hit the commodity markets. For instance, the surge in most of commodities prices between 2004 and 2008 (for example crude oil jumped from 30$ in 2003/2004 to 140$ in mid-2008), to Lehman Brothers crisis in 2008, to the decrease in the commodity prices again after 2014, and Amaranths collapse, and the prices are expected to keep moving. However, a lot of ink has been consumed to prove or disapprove the impact of the financial investors on commodity prices; i.e. the impact of financialization. Researchers' contributions were varying. Some of them found no evidence of that impact such as the review of Fattouh et al. (2013) (for oil market), Buyukşahin and Harris (2011), Brunetti and Buyukşahin (2009) and Knittel and Pindyck (2016). On the contrary, other contributions confirm the impact

[1]Commodity Futures Trade Commission (CFTC) publishes regular weekly reports entitled Commitments of Traders (COT). These reports contain the futures positions. They provide data about short (selling futures) and long (buying futures) positions. They specify whether the trader is commercials (operate in the futures market for Hedging reasons) or non-commercial (speculators).

[2]ETFs are a mutual fund shares that trade on a stock exchange where the prices of these shares follows a commodity index. ETNs are debt securities where the issuer commits to pay-out based on the value of the underlying commodity index.

of financialzation on commodity markets such as Masters (2008), Singleton (2014), Henderson et al. (2015), Kyrtsou et al. (2016). Also, Hamilton and Wu (2015) find little evidence of index fund on commodity prices; they find no relations between 12 agricultural commodities and the index fund positions, while they find evidences for crude oil futures. Generally, literatures concentrate on energy markets and specifically on crude oil, and with less attention in agricultural and metals markets, where Bosch and Pradkhan (2015) find no evidence of speculative activities on precious metals. Bruno et al. (2013) study the linkage between grains, livestock and stock markets. They find a relationship between speculative activities and the strength commodity-equity linkage before 2008 financial crisis. But, in the period post 2008 crisis, the speculative activities are weaker.

Despite all the studies related to the financailization of commodity, which are mostly empirical, the impact of financial investor is still debated. Therefore, there is a need for more theoretical studies to study this phenomenon. In this paper, we aim to study the influential power of the stock market on the commodity one. We do so by extending a model introduced by Ekeland et al. (2015). Our model is studying the interaction between commodity (physical & futures) and stock markets. There is a single commodity that is traded in the physical and the futures markets. The model is a two periods model; the markets are interacting at $t$ and $T$. There are four types of traders: Inventory holder (storer), processor, financial investor and spot traders. The inventory holder has the capacity to store the commodity; they buy, hold and then sell the commodity (physical speculation). The processor uses the commodity as an input to produce final products. Both of them, the storer and processor, operate in the futures market for hedging reasons. The storer hedge his physical position against any decrease in the prices by taking short futures positions, while the processor take long futures positions to hedge his physical positions from any increase in the commodity price. The financial investor includes futures contracts in his stock portfolio for diversification reasons. Spot traders are located on the demand and supply sides in commodity spot markets. In the model, the storer link between the two periods, the storer and processor link between the physical and the futures markets and the financial investors link between the stock and futures markets. The agents are mean variance utility maximizers. Uncertainty is sourced from the demand of the spot traders and the stock prices at $T$. But, the distribution functions are common knowledge for all agents.

The positions taken by hedgers (storer and processor) in the physical market is determined by futures and spot prices. The storer hold inventory when he believes that the futures price is higher than the spot price. On the contrary, The processor buys the commodity when he believes that the price of the final product is higher than the futures price. But, their futures positions are determined by the physical positions (hedge term) and the speculation term, which

means that the hedgers can speculate after hedging their physical positions totally. The futures positions of the financial investors are determined by the bias in the futures prices, the stock market return and the correlation between both markets. That combination shows the diversification impact in the financial investor's decisions, especially when we look to the impact of commodity-equity correlation. Thus, when the commodity-equity correlation is negative (or low), the financial investor takes more long (less short) futures positions if the stock returns are positive, and he takes more short (less long) futures positions if the stock returns are negative.

We find that the futures risk premium is determined by two terms. First, the hedging pressure, which is defined by the difference between storer's and processor's positions. Second, the stock market term, which is a result of the combination between the stock returns and the commodity-equity correlation. We find that the net short hedging pressure increases the futures risk premium. Also, a positive stock returns accompanied by positive commodity equity correlation increases the futures risk premium. The previous scenario is more likely to happen in the current situations of stock and futures markets.

Despite the large possibilities of studying different comparative statics in the model, we focus on two questions: first, the impact of commodity-equity correlation on the commodity prices, and second, the impact of financialization. We are motivated, in the first question, by the increase in the linkage between equity and commodity markets, where the commodity-equity correlation shifted from a reason to a result (from the low commodity-equity correlation (e.g. Gorton and Rouwenhorst (2006)) to the significant increase after 2008 financial crisis (e.g. Buyukşahin and Robe (2014b))). In the second question, we aim to provide a theoretical answer to the debate about the impact of the financial investors on the commodity markets.

In our model, and because of the network between different markets, we have several transmission channels that are responsible on information transference between markets. The storer is the transmit channel between the period $t$ and $T$ in the physical market. The hedgers (processor and storer) are the carriers between the futures and the physical markets. Finally, the financial investor is the information transformer between stock and futures markets. These channels are the keys of our contributions interpretations. The story of prices changes is linked to the demand on the futures positions taken by the financial investors. Hence, the increase in long futures positions lead to increase the futures prices. That declines the cost of hedging, and the storers increase their inventory levels physically. Consequently, the spot prices increases. Holding more inventories causes high supply in the future, and then future spot prices will decrease. After then, the processor decreases their demand from the commodity. The analysis is mirrored when the financial investors increase their short positions. This effects track shows co-movement

between futures price, spot price and inventory level. Inversely, it shows a co-movement between demand for production and the future spot price.

The impact of commodity-equity correlation is linked to the expected stock returns. Consequently, the increase in commodity-equity correlation could lead to two opposite impacts depending on whether the stock markets provide gains or losses. However, we focus, by considering the index $S\&P500$ as a representative of the stock market performance, on the common case when the expected stocks returns are positive. Also, our model is capturing the losses in the stock market around the financial crisis 2008 (see figure 1.8). In general, we find that an increase in the commodity-equity correlation accompanied by a positive expected return causes a decrease in the long positions (increase short positions) taken by financial investors. Consequently, the futures price, spot price and inventory levels decrease. On the other hand, it increases the quantity demanded for by processors, the future spot price and the futures risk premium.

Our findings show plausible debate about the impact of financialization, where it is not easy to find a direct answer in each scenario. In some circumstances, the futures positions taken by pure speculators are different than those taken because of the diversification. The aggregated positions are observed only by real dataset. However, we find that the impact of financialization depends on the financial investors' situation themselves. When the net positions taken by financial investors are net long, then the intense in the financial investor participation causes a high demand on futures positions. Hence, the futures prices increase. Consequently, inventory levels increase due the ability to hedge the physical commodity in futures market. That raises the spot price. On the contrary, it decreases the physical demand of the processors, because of high futures price. Also, the future spot price decreases, because of the high future supply, which results from the high current inventory. For net short futures positions, the impact is inverted.

The rest of the paper includes the literature reviews in section 1.2. Section 1.3 introduces the model. In section 1.4, we solve the model and find the equilibrium. Section 1.5 analyses the equilibrium. Section 1.6 shows the comparative statics of the equilibrium prices and quantities with respect the commodity-equity correlation. Section 1.7 shows the impact of the speculation. Finally, section 1.8 is the conclusion.

## 1.2 Literature reviews

This research is positioned between the studies that highlight the interaction between stock and commodity markets. In building our model, we are motivated by the growing belief about considering the commodity as an asset class. This belief was interpreted by Gorton and Rouwenhorst (2006) who address that the financial investor benefits from the low correlation between commodity, and bond and stock markets (the tested sample from 1959 to 2004). Also, Erb and Harvey (2006) find a low correlation between different commodities returns. Cheung and Miu (2010) confirm that the benefits from the claimed diversification are existed, especially for conservative investors. On the other hand, Galvani and Plourde (2010) assess the value of the portfolio diversification within energy asset and commodity markets, and they find that holding futures contract is insurance policies rather than as profitable investments. Furthermore, Daskalaki and Skiadopoulos (2011) challenge the common belief that commodities should be included in investors' portfolios, when they find that commodities are beneficial for non-mean variance investors. Recently, Bhardwaj et al. (2015) update the paper that was addressed by Gorton and Rouwenhorst (2006). Hence, they state that the correlation among commodities and the co-movement of commodities with other asset classes has varied, and increased after the financial crisis, but they claim that the correlation increases tend to be temporary in nature. However, whether the diversification reasons still applicable or not, the financial investors participation in futures market is still increasing.

Our model exceeds those theoretical frameworks that study spot-futures commodity markets interaction, such as Anderson and Danthine (1983a,b), Hirshleifer (1988b), Hirshleifer (1989b), Acharya et al. (2013) and Ekeland et al. (2015), to study the interaction between stock and commodity markets (physical and futures). Some equilibrium models focus on our research line, such as Hirshleifer (1988a), Hirshleifer (1989a) and, recently, Boons et al. (2014). Boons et al. (2014) follow Hirshleifer (1988a, 1989a) by including multi-assets in their model. However, there are several differences between our work and what they have done. They do not model storage, while we do. We separate inventory from production in the hedging side, following Ekeland et al. (2015), which simplifies the model and give the opportunity to have final equilibrium prices. That provides an opportunity to study different comparative statics in both commodity and stock markets, and the impact of any market on the other. As a result, we have current and future spot price, futures price, inventory, and the input of production for any commodity, in addition to the ability to address futures risk premium. On the contrary, Hirshleifer (1988a, 1989a) and Boons et al. (2014) have terminated to study the futures risk premium only.

There are also dynamic models that investigate the financialization such as Basak and Pavlova (2016) and Baker (2016). Basak and Pavlova (2016) develop a multi-goods and multi-

assets model with institutional investors and futures market participants. They find that commodity futures, commodity-equity correlation and volatilities of futures returns increase with the financialization. We take their result about commodity-equity correlation as a motivation to study the impact of that correlation on the equilibrium prices. Baker (2016) builds a dynamic model about the interaction between spot and futures prices, which does not investigate the interaction between commodity and stock markets.

Our paper also contributes to the done work about the consequences of commodity financialization, where the vast majority of them are empirically. Irwin and Sanders (2011) reviews the debate about the impact of index funds in commodity futures markets. Buyukşahin et al. (2010) did not find a significant change in the relation between commodity and equity returns. Tang and Xiong (2012) find that futures prices of non-energy commodities became increasingly correlated with oil after 2004. Creti et al. (2013) find that commodity-equity correlations evolve through time being highly volatile, particularly since the 2007–2008 financial crisis. The same finding has been adressed by Buyukşahin and Robe (2014a,b) who find that hedge funds have predictive power on the commodity-equity correlation more than other participants such as swap dealers, index funds and traditional commercial traders[3]. Consistent with the previous studies, Silvennoinen and Thorp (2014) do not show weakening in the correlation between commodities and stock returns. Bruno et al. (2013) study what drives the linkages between grain, livestock and equity markets. They find, in the period 2000-2008, a causal relationship from speculative activity to the strength equity-commodity linkage, but in the post 2008 crisis, the speculative activities are weaker. Hamilton and Wu (2015) conclude that index-fund have had little impact on commodity futures prices. They find no relations between 12 different agricultural commodity futures returns and the index fund positions, while they find evidence about crude oil futures returns. Henderson et al. (2015) bring new evidence on the financialization of commodity, which say that the financial investments have impacts on commodity prices, by using data on Commodity-Linked Notes (CLNs). Kyrtsou et al. (2016) find a persistent lead-lag relationship between the $S\&P500$ index and the market participants expectations for crude oil, from 2004 to 2009. Du et al. (2011) demonstrate that crude oil price volatility is explained by scalping, speculation, and petroleum inventories. Soucek and Todorova (2013) show that the equity market is leading the volatility of crude oil (by using the heterogeneous autoregressive (HAR) model). Bosch and Pradkhan (2015) find no evidence of speculative positions on the precious metals futures prices. Despite all studies about financialization, researchers did not confirm and did not reject the impact of financialization on commodity markets, and the subject is still debated.

[3] Buyukşahin and Robe (2014b) study 17 US commodity futures markets, and Buyukşahin and Robe (2014a) the energy markets only in the second paper. Creti et al. (2013) investigate 25 commodities and stocks by paying attention to energy raw materials.

Generally, the empirical literatures focus, in the first place, on energy market, and agricultural commodities in the second place.

Finally, our paper also contributes to the articles that investigate the futures risk premium, especially those recent papers in the era of financialization, which some of them are reviewed in Baumeister and Kilian (2015) such as De Roon et al. (2000), Acharya et al. (2013), Etula (2013), Hamilton and Wu (2014), Gorton et al. (2013), Szymanowska et al. (2014), and others.

## 1.3 The model

We develop a model in the spirit of Ekeland et al. (2015). Our model studies the interaction between commodity, both physical and futures, and the stock markets. The model investigates the integration between four types of agents: inventory holder (storer), processor, financial investor and spot traders. Those agents are interested in one commodity. The storer (physical speculator) has the capacity to store the commodity. He aims to gain profit from the changes in the commodity spot prices. He buys the commodity, stores it, and then he sells his inventory at future time. The processor uses the commodity to produce final goods; he uses the commodity in his production process (raw materials). Both of them (storer and processor) operate in both physical and futures markets. They participate in the futures market for hedging reasons. The financial investor holds a stock portfolio and futures contracts, which is differentiate our model from the model of Ekeland et al. (2015). The spot traders operate only in the physical market to meet the immediate demand and supply in the commodity physical market. The model is constructed on two time periods, $t$ and $T$. The operation in physical market is at $t$ and $T$. Meanwhile, The futures contracts are traded at $t$ and be offset at $T$. We assume that the risk free rate is neglected.

At time $t$, the storer locates on the demand side in the physical market, and buys $x$ quantity of the commodity at spot price $P_t$, to store it. The spot traders appear in both demand and supply sides in the physical market. They supply $\omega_t$ of the commodity, and ask for quantity $\mu_t - mP_t$; the demand curve. The processor decides the volume of the commodity quantity $(y)$ that he wants to buy at the future $(T)$ at future spot price $\tilde{P}_T$. The storer and processor hedge their physical positions in the futures market at futures price $F_{t,T}$. The storer sells futures position (take short positions), while the processor buys futures positions (takes long positions), they take $f_I$ and $f_P$ futures positions respectively. The financial investor takes $(f_S)$ positions in the futures market. At time $T$, the storer sits on the supply side and sells his inventory in the physical market. The processor locates on the demand side and delivers the commodity that he had asked for. The spot traders appear on the demand and supply side of the spot market.

They supply $\tilde{\omega}_T$, and demand $\tilde{\mu_T} - m\tilde{P}_T$. $\sim$ indicates to the variables randomness. The futures contracts are settled implying a financial profit $\tilde{P}_T - F_{t,T}$. The futures contracts are offset either by cash settlement (agents take the opposite direction of their futures positions), or possibly by physical settlement (by delivery the commodity at the maturity date[4]).

### 1.3.1 Agents' profit

The storer holds a non-negative quantity $x$ of inventory. He buys $x$ at $t$ at spot price $P_t$ and sells it at $T$ at future spot price $\tilde{P}_T$. Holding the commodity from $t$ to $T$ costs $\frac{1}{2}Cx^2$, where $C$ is the cost of storage. He holds $f_I$ futures positions at futures price $F_{t,T}$. His profit from operating in both physical and futures markets is:

$$\tilde{\pi}(x, f_I) = x(\tilde{P}_T - P_t) + f_I(\tilde{P}_T - F_{t,T}) - \frac{1}{2}Cx^2 \tag{1.1}$$

Where $x$ is the inventory that held by the storer. $P_t$ and $\tilde{P}_T$ is the commodity spot price at time $t$ and $T$ respectively. $f_I$ is the storer's futures positions. $F_{t,T}$ is the futures price. $C$ is the cost of storage.

The processor buys the commodity to use it in the production process, and then produce other final goods. He buys a quantity $y$ at $T$. His revenue from selling the final output is $\left(y - \frac{\beta}{2}y^2\right)Z$, where $Z$ is the price of the final product. He holds $f_P$ futures positions with profit $\tilde{P}_T - F_{t,T}$. The profit of processor from operating in physical and futures markets is:

$$\tilde{\pi}(y, f_P) = (y - \frac{\beta}{2}y^2)Z - y\tilde{P}_T + f_P(\tilde{P}_T - F_{t,T}) \tag{1.2}$$

Where $y$ is the demanded quantity of the commodity. $\beta$ is the cost of the production. $\tilde{P}_T$ is the future spot price of the commodity. $F_{t,T}$ is the futures price. $Z$ is the price of the final good. $f_P$ is the processor's futures positions.

Finally, financial investor operates in stock and futures markets. He takes $f_S$ futures positions, in addition to his portfolio in the stock market. The profit is derived from the profit in the futures and stock markets. First, the profit from futures market is $(\tilde{P}_T - F_{t,T})$. Second, the profit from stock market in the period $T - t$ is given by the difference in the total value of his portfolio between time $t$ and $T$ $(\tilde{V_T} - V_t)$.

$$V_t = \Sigma_i^n \theta^i S_t^i$$

Where $S_t^i$ is the price of the asset $i$ at time $t$. $\theta^i$ is the total number of the asset $i$ in the portfolio.

[4] 1-2% of the futures contracts reach to maturity date.

Thus, the total profit is given by:

$$\pi(k, f_S) = k(\tilde{V_T} - V_t) + f_S(\tilde{P_T} - F_{t,T}), k \geq 0 \tag{1.3}$$

Where $V_i$ is the value of the financial investor's portfolio in the stock market, $i = t, T$. $f_S$ is the financial investor's in the futures market. $k$ shows the positions taken in the stock market.

### 1.3.2 Profit optimization

Agents are profit maximizers. Their problems are to find the optimal positions in the physical, the futures and the stock markets. They apply their profits to the mean-variance utility, in the line with Anderson and Danthine (1983b), Ekeland et al. (2015), and others.

$$E(\tilde{\pi_j}) - \frac{1}{2}\alpha_j Var(\tilde{\pi_j}) \tag{1.4}$$

Where $\pi_j$ is the profit of the agent $j$, and $\alpha_j$ is the risk aversion of agent $j$, $j$ is financial investor, storer or processor. We assume different risk aversions for the different agents. The risk aversion ranges between *zero* to $\infty$ $(0 < \alpha_j < \infty)$.

Next, we will be finding the agents' optimal positions by applying the mean-variance utility on the agents' profits that were introduced in section 1.3.1. Appendix 1.B exposures the computations of the agents' optimal positions.

#### Storer

Storer has positions in both physical and futures markets. His optimal positions are $x^*$ and $f_I^*$ in the physical and the futures market respectively.

$$x^* = \frac{1}{C} max\left\{F_{t,T} - P_t, 0\right\}, \tag{1.5}$$

$$f_I^* = \frac{E[\tilde{P_T}] - F_{t,T}}{\alpha_I Var[\tilde{P_T}]} - x^* \tag{1.6}$$

The storer holds the commodity in the physical market when he believes that the futures prices is higher than the current spot price. As shown in equation (1.6), the optimal futures positions is consisting of hedging term $(-x^*)$ and a pure speculative term $\left(\frac{E[\tilde{P_T}]-F_{t,T}}{\alpha_I Var[\tilde{P_T}]}\right)$. If $f_I > 0$, then the storer takes long futures positions, otherwise he takes short futures positions. His positions in the futures market demonstrates that he hedges the commodity physical positions by having positions equal to the negative physical position $(-x^*)$. The negative sign indicates that he takes short positions for his hedging purposes. Meanwhile, the pure speculative term shows that the storer can speculate in the futures market after hedging 100% of his physical position. Based on

the pure speculative term, the storer takes long positions whenever he believes that the expected future spot price is higher than the futures price. Otherwise, he takes short positions.

### Processor

The optimal positions of the processor are $y^*$ and $f_P^*$ in the physical and the futures markets respectively.

$$y^* = \frac{1}{\beta Z} \max\left\{Z - F_{t,T}, 0\right\}, \tag{1.7}$$

$$f_P^* = \frac{E[\tilde{P}_T] - F_{t,T}}{\alpha_P Var[\tilde{P}_T]} + y^* \tag{1.8}$$

Equation (1.7) shows that the processor buys the commodity physically when he believes that the price of the final good is higher than the futures price. As same as storer, his optimal futures positions are consisted of the hedging term $y^*$ and the speculative term $\left(\frac{E[\tilde{P}_T]-F_{t,T}}{\alpha_P Var[\tilde{P}_T]}\right)$. He hedges his physical positions from the prices increases. For his hedging purposes, he takes long positions in the futures markets. However, for his speculative purposes, he may take short or long futures positions. That is determined by the difference between the expected future spot price and the futures prices, as described previously in the storer optimal positions explanation. Both storer's and processor's positions correspond with the finding of Ekeland et al. (2015).

### Financial investor

Equations (1.9) and (1.10) express the optimal positions of the financial investor in the futures and the stock markets respectively. The equations are highly symmetric. The positions are comprised of the expected return of futures, the stock market expected return, the commodity-equity correlation, financial investor's risk aversion, and the variance of both stock and physical markets prices. The terms between brackets appears like a sum of two sharpe ratios weighted by the correlation between the markets.

$$f_S^* = \left(\frac{1}{1-\rho^2}\right) \frac{1}{\alpha_S \sigma_P} \left[\frac{E[\tilde{P}_T] - F_{t,T}}{\sigma_P} - \rho \frac{E[\tilde{V}_T] - V_t}{\sigma_V}\right], \rho \neq \pm 1 \tag{1.9}$$

$$k^* = \left(\frac{1}{1-\rho^2}\right) \frac{1}{\alpha_S \sigma_V} \left[\frac{E[\tilde{V}_T] - V_t}{\sigma_V} - \rho \frac{E[\tilde{P}_T] - F_{t,T}}{\sigma_P}\right], \rho \neq \pm 1 \tag{1.10}$$

When $f_S^* > 0$, the financial investor goes long. Otherwise, he goes short. Unlike Ekeland et al. (2015), the sign and the level of the futures positions are not determined only by the bias in the futures prices. The determinants are extended to have the combination of the stock

risk premium and the commodity-equity correlation[5]. Regarding the pure speculative term, the financial investor goes long in the futures market when he believes that the expected spot price is higher than the futures price, otherwise he goes short. The combination of the stock risk premium (stock return) and the commodity-equity correlation affect the taken positions in the futures market in a way shows the diversification. A positive stock risk premium accompanied with positive commodity-equity correlation decrease (increase) the long (short) positions of the financial investors. On the other hand, a positive stock risk premium accompanied by negative commodity-equity correlation increase (decrease) the long (short) positions for financial investors. From equation (1.9), we notice that high risk aversions decrease the taken positions in the futures market. Also, the variance of the commodity price has a negative relationship with the futures positions. On the contrary, the financial investor's futures position has a positive relationship with variance of stock market.

### 1.3.3 Market clearings

Up to now, the optimal positions were standard for one storer, processor and financial investor. In our model, we have $N_I$, $N_P$, and $N_S$ number of the storers, processors and financial investors respectively. Consequently, the total positions taken by agents are aggregated. Hence, the total inventory in the physical market that are held by storers is given by $N_I x^*$, and the total futures positions is given by $N_I f_I^*$, and so on.

| | |
|---|---|
| Total inventory | $= N_I x^*$ |
| Quantity demanded for production | $= N_P y^*$ |
| Storers' futures positions | $= N_I f_I^*$ |
| Processors' futures positions | $= N_P f_P^*$ |
| Finanical investors' futures positions | $= N_S f_S^*$ |

At any time, the physical market is clear when total supply corresponds with total demand. In the futures market, the market is clear by having a zero summation for futures contracts. Thus, at time $t$ in the physical market, spot traders supply a total quantity of commodity, $\omega_t$. On the demand side, there is spot traders and inventory holders (storers). Spot traders demand $\mu_t - mP_t$ of the commodity. Storers buy a quantity $N_I x^*$ of the commodity. As a result, the market clearing of the physical market at $t$ is:

[5] Anderson and Danthine (1983b) states that the pure speculative is not generalized in determining whether the speculators trade in several assets, and this what we confirmed in our findings

$$\omega_t = n_I X + \mu_t - mP_t,$$

Subsequently,

$$P_t = \frac{1}{m}\left(\mu_t - \omega_t + N_I x^*\right) \tag{1.11}$$

At time $T$, both storers and spot traders exist on the supply side. Spot traders supply $\tilde{\omega}_T$, while storers supply all their inventory, $N_I x^*$. On the demand side, there are processor and spot traders. Spot traders demand a quantity represented by $\tilde{\mu}_T - m\tilde{P}_T$, and processors ask for a quantity equal to $N_P y^*$. Consequently, the market clearing in the physical market at time $T$ is:

$$\tilde{\omega}_T + N_I x^* = N_P y^* + \tilde{\mu}_T - m\tilde{P}_T,$$

Thus,

$$\tilde{P}_T = \frac{1}{m}\left(\tilde{\mu}_T - \tilde{\omega}_T - N_I x^* + N_P y^*\right). \tag{1.12}$$

In commodity futures markets, the market is clear when the total short and long futures positions is zero.

$$N_S f_S^\star + N_P f_P^\star + N_I f_I^\star = 0.$$

By substituting the values of $f_j^*$, we obtain ,

$$\mathrm{E}[\tilde{P}_T] - F_{t,T} = \frac{\mathrm{Var}[\tilde{P}_T]}{\frac{N_P}{\alpha_P} + \frac{N_I}{\alpha_I} + \frac{N_S}{\alpha_S}\left(\frac{1}{1-\rho^2}\right)}\left(N_I x^* - N_P y^* + \frac{N_S}{\alpha_S}\rho\frac{E[\tilde{V}_T] - V_t}{\sigma_P \sigma_V (1-\rho^2)}\right) \tag{1.13}$$

Equation 1.13 shows the futures risk premium, which is defined here as the difference between expected future spot and the futures prices. The futures risk premium is determined first by the fundamental economic structures represented by the difference between the physical positions of the storers and the processors, which is referred by the hedging pressure. Second, expected stock returns. Third, commodity-equity correlation. Fourth, the number of agents $(I, P, S)$ restricted to their risk aversion. Fifth, the volatility for each of the underlying asset (futures contract) and the stock portfolio. The sign of the futures risk premium depends on the aggregated sign of the hedging pressure, expected stock returns and the commodity-equity correlation.

Our finding extends the finding of Ekeland et al. (2015) who find that the futures risk premium is determined only by the hedging pressure. It shows the significance of the stock market on the futures risk premium. The direction of this impact is determined by the combination

between the expected stock market returns and the commodity-equity correlation. An increase in the positive stock risk premium accompanied by positive (negative) commodity-equity correlation cause an increase (decrease) in the futures risk premium. On the contrary, an increase in the negative stock risk premium accompanied by positive (negative) correlation decrease (increase) the futures risk premium.

Before finishing this section, the physical quantities of the storers and the processors are,

$$\begin{aligned} N_I x^* &= \frac{N_I}{C}\max\{F_{t,T}-P_t,0\} \\ N_P y^* &= \frac{N_P}{\beta Z}\max\{Z-F_{t,T},0\} \end{aligned}$$

Let us note

$$\begin{aligned} N_I x^* &= n_I X \\ N_P y^* &= n_P Y \end{aligned}$$

Where,

$$\begin{aligned} n_I &= \tfrac{N_I}{C}, \quad X = \max\{F_{t,T}-P_t,0\} \\ n_P &= \tfrac{N_P}{\beta Z}, \quad Y = \max\{Z-F_{t,T},0\} \end{aligned}$$

To sum up, the physical and futures markets clearings are:

$$\begin{cases} P_t &= \frac{1}{m}(\mu_t-\omega_t+n_I X) & (1.11)\\ \tilde{P}_T &= \frac{1}{m}(\tilde{\mu}_T-\tilde{\omega}_T-n_I X+n_P Y) & (1.12)\\ \mathrm{E}[\tilde{P}_T]-F_{t,T} &= \frac{\mathrm{Var}[\tilde{P}_T]}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}+\frac{N_S}{\alpha_S}\left(\frac{1}{1-\rho^2}\right)}\left(HP+\frac{N_S}{\alpha_S}\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V(1-\rho^2)}\right) & (1.13) \end{cases}$$

Where,

$$HP := n_I X - n_P Y \tag{1.14}$$

$$\begin{aligned} X &= \max\{F_{t,T}-P_t,0\} \quad (1.5)\\ Y &= \max\{Z-F_{t,T},0\} \quad (1.7) \end{aligned}$$

## 1.4 The equilibrium

**Definition**: An equilibrium is a family ($X, Y, P_t, F_{t,T}$ , and $\tilde{P}_T$) such that all prices except possibly $\tilde{P}_T$ are non-negative, processors, storers and speculators act as price-takers and all markets

clear.

Before proceeding in finding the equilibrium prices, we will set some notations. First, we start with the physical market, and note that:

$$\begin{aligned} \xi_t &:= \mu_t - \omega_t, \\ \tilde{\xi}_T &:= \tilde{\mu}_T \text{ -}\tilde{\omega}_T \\ \xi_T &:= \mathrm{E}[\tilde{\mu}_T - \tilde{\omega}_T] \end{aligned}$$

Where $\xi$ indicates to the scarcity; the failure of the suppliers to meet the highest level of the demand in the spot market.

Second, consequently to the previous notations, from equation (1.12), $\mathrm{E}[\tilde{P}_T]$ and $\mathrm{Var}[\tilde{P}_T]$ are:

$$\mathrm{E}[\tilde{P}_T] = \frac{1}{m}(\xi_2 - n_I X + n_P Y), \tag{1.12A}$$

$$\mathrm{Var}[\tilde{P}_T] = \frac{\mathrm{Var}[\tilde{\xi}_T]}{m^2}. \tag{1.12B}$$

Third, let us introduce the following notations:

$$\gamma := 1 + \frac{1}{m} \frac{Var[\tilde{\xi}_T]}{\frac{N_P}{\alpha_P} + \frac{N_I}{\alpha_I} + \frac{N_S}{\alpha_S}\left(\frac{1}{1-\rho^2}\right)} \tag{1.15}$$

$$R := (\gamma - 1)\,\frac{N_S}{\alpha_S}\rho \frac{E[\tilde{V}_T] - V_t}{\sigma_P \sigma_V (1-\rho^2)} \tag{1.16}$$

Note that the latter condition depends on the realization of the random variables $\tilde{P}_T$ and $\tilde{V}_T$, which can be observed only at T, while the others are known at t. However, the distributions of the random variables are common knowledge.

By substituting the notations that were introduced above, equation (1.11) becomes:

$$\xi_t = mP_t - n_I X \tag{1.17}$$

By substituting ((1.12)A) in (1.13), we obtain:

$$\xi_T = mF_{t,T} + \gamma(n_I X - n_P Y) + R \tag{1.18}$$

Also, by substituting (1.5) and (1.7) in (1.17) and (1.18), we get a system of two equations with two unknowns $(P_t, F_{t,T})$:

$$\xi_t = mP_t - n_I \max\{F_{t,T} - P_t, 0\} \tag{1.19}$$

$$\xi_T = mF_{t,T} + \gamma\left(n_I \max\{F_{t,T} - P_t, 0\} - n_P \max\{Z - F_{t,T}, 0\}\right) + R \tag{1.20}$$

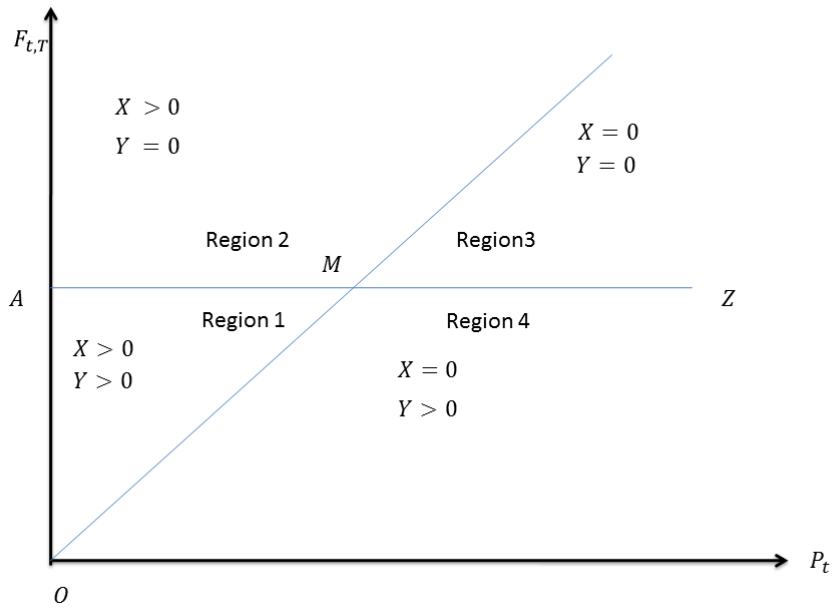
Consider the new mapping $\kappa : R^2_+ \to R^2$, which is defined by:

$$\kappa(P_t, F_{t,T}) = \begin{pmatrix} mP_t - n_I \max\{F_{t,T} - P_t, 0\} \\ mF_{t,T} + \gamma\left(n_I \max\{F_{t,T} - P_t, 0\} - n_P \max\{Z - F_{t,T}, 0\}\right) + R \end{pmatrix} \tag{1.21}$$

This system can be solved in four ways. These ways are summarized by the combination of solving $max\{F_{t,T} - P_t, 0\}$ and $\max\{Z - F_{t,T}, 0\}$. Therefore, we divide $(P_t, F_{t,T})$ space to four regions. These regions are determined by the relationships between $P_t$, $F_{t,T}$ and $Z$. these regions are bounded by a horizontal coordinate $(P_t)$ and a vertical coordinate $(F_{t,T})$. They are separated by two lines: first the line $F_{t,T} = P_t$ (the $45^o$ line). Second, the line $F_{t,T} = Z$. Figure 1.1 shows these four regions, which are summarized as follow:

- Region 1, where $F > P_1$ and $F < Z$. In this region, $X > 0$ and $Y > 0$.
- Region 2, where $F > P_1$ and $F > Z$. In this region, $X > 0$ and $Y = 0$.
- Region 3, where $F < P_1$ and $F > Z$. In this region, $X = 0$ and $Y = 0$.
- Region 4, where $F < P_1$ and $F < Z$. In this region, $X = 0$ and $Y > 0$

Figure 1.1: Phase diagram of physical and financial decision on space $(P_t, F_{t,T})$



The regions showed in figure 1.1 are represented by the existence of the storers or the processor in the market. Region 1 is the comprehensive region where both storers and processors are active in the market, where most of commodities are located in this frame. In Region 2, there is storage but no production, for instance gold could be considered in this region. In Region 3, there is neither storage nor production in the market, where it is impossible to find a commodity that exist under this category. In region 4, there is a production, but no storage, which electricity is the example that correspond with this region. Accordingly, we aim to study the general region (Region 1).

Considering the general case, where $X > 0$ and $Y > 0$. Then , the system $\kappa$ is

$$\kappa(P_t, F_{t,T}) = \begin{pmatrix} (m + n_I) P_t - n_I F_{t,T} \\ -\gamma n_I P_t + (m + \gamma (n_I + n_P)) F_{t,T} - \gamma n_P Z + R \end{pmatrix}$$

We can rewrite the system as follow,

$$\begin{pmatrix} \xi_t \\ \xi_T \end{pmatrix} = \begin{pmatrix} m + n_I & -n_I \\ -\gamma n_I & m + \gamma (n_I + n_P) \end{pmatrix} \begin{pmatrix} P_t \\ F_{t,T} \end{pmatrix} + \begin{pmatrix} 0 \\ -\gamma n_P Z + R \end{pmatrix}$$

It implies,

$$\begin{pmatrix} \xi_t \\ \xi_T + \gamma n_P Z - R \end{pmatrix} = \begin{pmatrix} m + n_I & -n_I \\ -\gamma n_I & m + \gamma (n_I + n_P) \end{pmatrix} \begin{pmatrix} P_t \\ F_{t,T} \end{pmatrix}$$

By computing the determinant

$$\begin{vmatrix} m + n_I & -n_I \\ -\gamma n_I & m + \gamma (n_I + n_P) \end{vmatrix} = m (m + \gamma (n_I + n_P)) + n_I m + \gamma n_I n_P > 0$$

It implies that the system $\kappa$ has a unique solution (the determinant is greater than zero in the four regions) .

By finding the image of $(P_t, F_{t,T})$ space in $(\xi_t, \xi_T)$,

$$\begin{aligned} \kappa(O) &= (0, -\gamma n_P Z + R) \\ \kappa(A) &= (-n_I Z, (m + \gamma n_I) Z + R) \\ \kappa(M) &= (mZ, mZ + R) \end{aligned}$$

The triangle $\kappa(O)\kappa(A)\kappa(M)$ represents the region 1 in the space $(\xi_t, \xi_T)$. Region 2 is bounded by the image of the segment $\kappa(A)\kappa(M)$ and the line $\{F_{t,T} = P_t \,,\ F_{t,T} \geq Z\}$ and the line $\{P_t = 0,\ F_{t,T} \geq Z\}$ . The line $\{F_{t,T} = P_t$ and $F_{t,T} \geq Z\}$ emits from $\kappa(A)$ and is bounded by the vector $(-n_I F_{t,T}, (m + \gamma n_I) F_{t,T} + R)$, where it extending to pass by the point $(0, R)$. The image

of the line $\{P_t = 0,\ F_{t,T} \geq Z\}$ emits from $\kappa(M)$ and is bounded by the vector $(mP_t, mP_t + R)$, which (if we extend it) pass by the point $(0, R)$. Region 4 is bounded by the segment $\kappa(O)\kappa(M)$ and two lines: $\{F_{t,T} = 0\}$ and $\{F_{t,T} = Z,\ F_{t,T} \leq P_t\}$. As a result, the image of the line $\{F_{t,T} = 0\}$ emits from $\kappa(O)$ and the line$\{F_{t,T} = Z,\ F_{t,T} \leq P_t\}$ emits from $\kappa(M)$, and both of them are parallel to the x-axis. There are two possibilities of the images regarding the sign of the $R$. Figures 1.2 and 1.3 show the the image of $(P_t, F_{t,T})$ space in $(\xi_t, \xi_T)$ space when the $R$ is positive and negative respectively. Those figures are similar to the finding of Ekeland et al. (2015), but our work explain the impact of the stock market. The stock market impact appears on $\xi_T$ axis, where the graph moves upward (downward) when the sign of $R$ is positive (negative).

Figure 1.2: Physical and financial decisions in space $(\xi_t, \xi_T)$ when R is positive

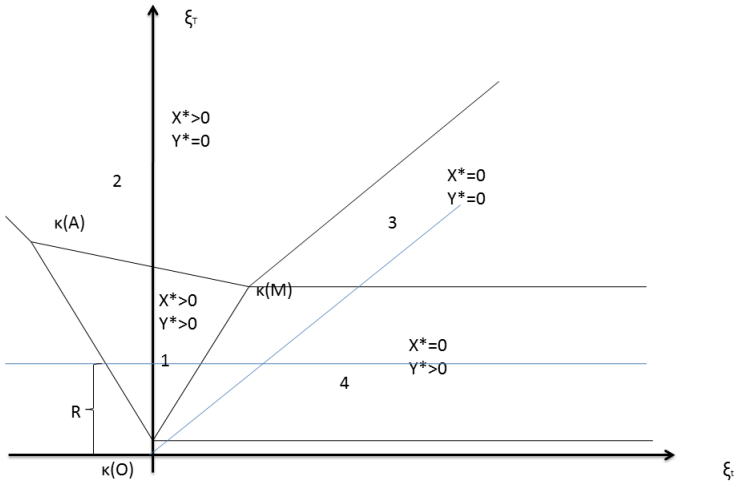
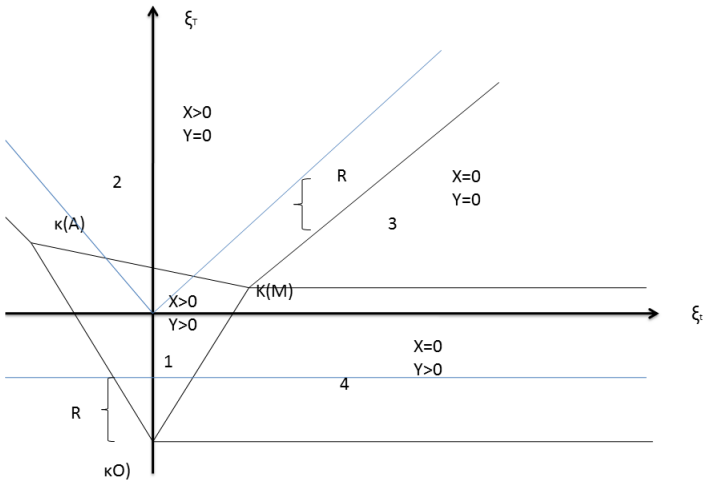


Figure 1.3: Physical and financial decisions in space $(\xi_t, \xi_T)$ when R is negative




That leads us to introduce the following theorem.

**Theorem** There is a equilibrium if and only if $(\xi_t, \xi_T)$ belongs to the region:

$$\xi_T \geq -\gamma n_P Z + R \qquad \text{if } \xi_t \geq 0 \tag{1.22}$$

$$\xi_T \geq -\gamma n_P Z - \frac{(m + (n_P + n_I)\gamma}{n_I}\xi_t + R \qquad \text{if } -n_I Z \leq \xi_t \leq 0 \tag{1.23}$$

$$\xi_T \geq -\frac{m + n_I\gamma}{n_I}\xi_t + R \qquad \text{if } \xi_t \leq -n_I Z \tag{1.24}$$

and then it is unique.

## 1.5 The equilibrium analysis

In this section, we will be analyzing the equilibrium into several steps. First, we will be explaining the normal backwardation and contango in the model, as a result to the interaction between commodity physical, commodity futures and stock markets. Second, we will describe the equilibrium prices.

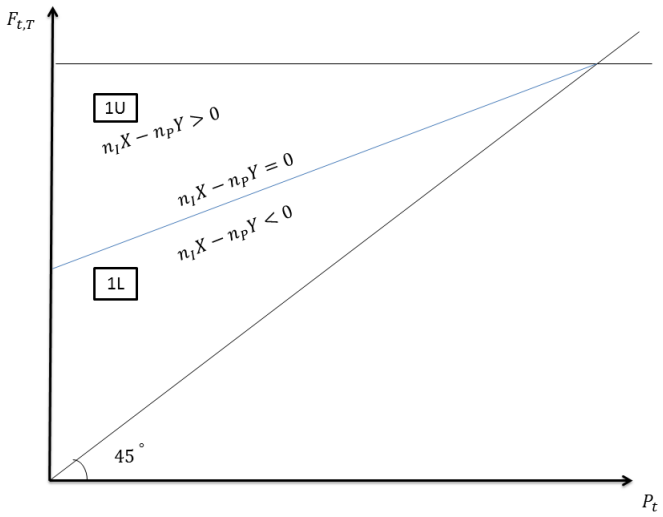
### 1.5.1 Normal backwardation and contango

Figure 1.1 shows that the futures market in region 1 and 2 is contangoed $(F_{t,T} > P_t)$, while it is backwardated in region 3 and 4 $(F_{t,T} < P_t)$. This result is accompanied by the existence of the inventory in the market; when there is inventory, the market is contango, while the market

is in backwardation when there is no inventory.

More importantly, in our model, is the comparison between the expected spot price and the futures price ($E[P_T] - F_{t,T}$), which we define as the futures risk premium. Let us start from assuming that the financial investors do not diversify in the futures market. Consequently, the futures risk premium is determined by whether the storers activities overwhelm the processors ones, or the opposite. This special case is identical to the finding Ekeland et al. (2015). So, the sign and the magnitude of hedging pressure determine the sign of the futures risk premium. When the hedging pressure is net short ($HP > 0$), the speculators go long, which requires futures prices be lower than the expected spot price ($E[\tilde{P}_T] > F_{t,T}$), which shows that the futures market is in normal backwardation. Conversely, when hedging pressure is net long ($HP < 0$), the speculator go short. So, the futures price must be higher than the expected spot price ($E[\tilde{P}_T] - F < 0$), which means that the futures market is in contango. In region 1, both cases are available. As shown in figure 1.4, it could be divided to sub-regions: one when the hedging pressure is net short (1U) and the other when it is long (1L) .

Figure 1.4: Physical and financial decisions in space $(P_t, F_{t,T})$ by assuming the financial investor do not operate in the stock market (zoom in region 1)




By allowing the financial investors to diversify their portfolios and consider the commodity as an asset, the determinants of the futures risk premium are extended to include the stock market impact (beside the hedging pressure). The stock impact is represented by the term $R$ in equation (1.13). $R$ might be positive or negative depending on commodity-equity correlation

$(\rho)$ and expected stock returns $\left(E[\tilde{V}_T] - V_t\right)$ signs.

$$R = \frac{\rho}{1-\rho^2}(\gamma - 1)\frac{N_S}{\alpha_S}\frac{E[\tilde{V}_T] - V_t}{\sigma_P \sigma_V}$$

- Positive (negative) expected stock returns accompanied by positive (negative) commodity-equity correlation results positive $R$.
- Positive (negative) expected stock returns accompanied by negative (positive) commodity-equity correlation results negative $R$.

However, positive R is more likely to happen. We address that depending on two clues: first, by considering the index standard and poor 500 ($S\&P500$) as a representative to the stock market, we find it moves increasingly. Therefore, we expect a positive stock returns most of the time. Second, despite of the financial investors' participation in the futures market is due to small, or negative, commodity-equity correlation. But, the commodity-equity correlation increased and became positive especially after the financial crises 2008 (e.g. see Buyukşahin and Robe (2014b) and Buyukşahin and Robe (2014a)). However, our model is still able to explain the past cases, or possibly the future cases, when the equity-commodity correlation is negative.

To explain the impact of financial investor, let us define:

$$\aleph : \quad n_I X - n_P Y + R = 0$$

$$n_I (F_{t,T} - P_t) - n_P (Z - F_{t,T}) + R = 0$$

$$F_{t,T} = \frac{n_I}{n_I + n_P} P_t + \frac{n_P}{n_I + n_P} Z - \frac{R}{n_I + n_P}$$

When $\aleph > 0$, then $F_{t,T} < E[\tilde{P}_T]$, which refers that the futures market is backwardated. This result extends the normal backwardation theory founded by Keynes (1930). Inversely, when $\aleph < 0$, then $F_{t,T} > E[\tilde{P}_T]$, which means that the futures market is contangoed. Table 1.1 shows the relationships between physical positions and prices in region 1.

By allowing the financial investor to participate in the futures market, the stock market shares in determining the taken positions in the futures market. Under certain conditions, the financial investor's stock portfolio affects the decisions that are taken in the futures market. When $R$ is positive, the financial investor takes less long or more short positions in the commodity futures market. Oppositely, when $R$ is negative. As a result, positive $R$ enlarge normal

backwardation possibility in Region 1. On the contrary, negative $R$ enlarge contango possibility in Region 1. Figures 1.5 and 1.6 show the normal backwardation and contango in $(P_t, F_{t,T})$ space.

Table 1.1: Relationships between physical positions and prices

| | | | | |
|---|---|---|---|---|
| $\aleph > 0$ | $X > 0$ | $Y > 0$ | $F_{t,T} > P_t$ | $F_{t,T} < E[\tilde{P}_T]$ |
| $\aleph = 0$ | $X > 0$ | $Y > 0$ | $F_{t,T} > P_t$ | $F_{t,T} = E[\tilde{P}_T]$ |
| $\aleph < 0$ | $X > 0$ | $Y > 0$ | $F_{t,T} > P_t$ | $F_{t,T} > E[\tilde{P}_T]$ |

Figure 1.5: Normal backwardation and contango states in Region 1 in $(P_t, F_{t,T})$ space, when R is positive.

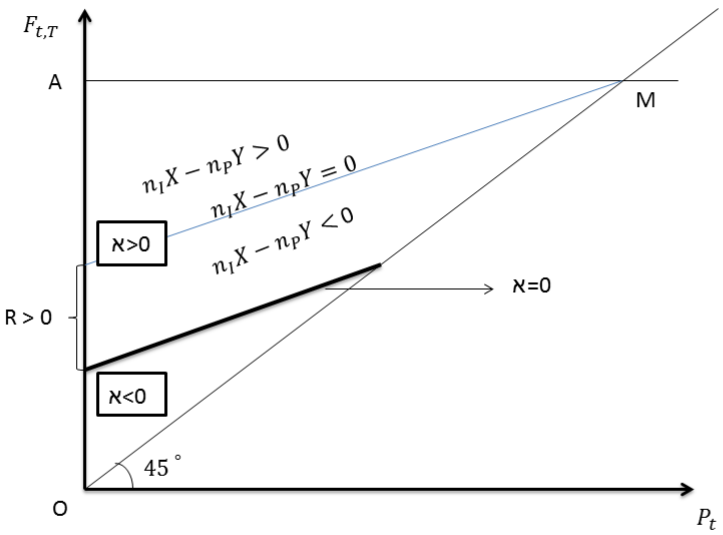
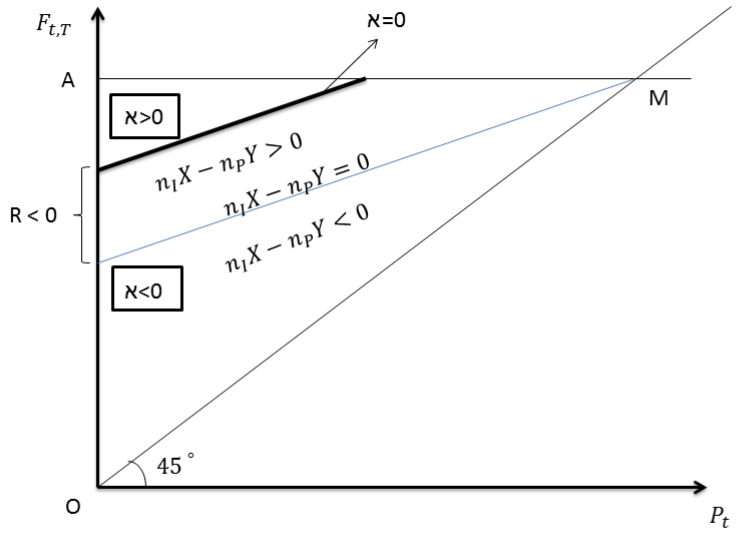


Figure 1.6: Normal backwardation and contango states in Region 1 in $(P_t, F_{t,T})$ space, when R is negative.




### 1.5.2 Prices and quantities description

In appendix 1.C, we list the prices and quantities of the equilibrium. The prices are: the spot price at t $(P_t)$, the (random) spot price at T $(\tilde{P}_T)$ and the futures price $(F_{t,T})$. The quantities are: the per unit inventories $(X)$ and per unit demand $(Y)$. These prices and quantities are obtained by solving the system (1.21). The prices and quantities comprise of the scarcity factors $(\xi_t, \xi_T)$, the slope of the demand curve of the commodity $(m)$, number of agents constrained to their risk aversions $(N_S, N_P, N_I, \alpha_S, \alpha_I, \alpha_P)$, the forward price for the output $(Z)$, the stock risk premium $(E[\tilde{V}_T] - V_t)$ and the commodity-equity correlation $(\rho)$. We can study the impact of any factor on the prices and quantities by fixing the rest of factors and derive the prices with respect to that factor.

The prices and quantities in region 1 are comprehensive. We discussed that there are four regions that are determined by the activeness of the storers and the processors in the physical market. In order to have the prices for region 2, we eliminate the impact of the processor on the prices by fixing $n_P = 0$. To have the prices in region 3, we set $n_P = 0$ and $n_I = 0$. To find the prices in region 4, we set $n_I = 0$.

## 1.6 The impact of the commodity-equity correlation

The surge in the financial investors' participation in the futures market was attributed to the low correlation between commodity and equity markets (Gorton and Rouwenhorst (2006), Erb and Harvey (2006)). However, the linkage between commodity and equity markets increased as a consequence of the financialization, which has been found theoretically in Basak and Pavlova (2016) and empirically in some papers such as Buyukşahin and Robe (2014a), Buyukşahin and Robe (2014b). Hence, the correlation moves from a reason to a result. Therefore, it is quite interesting to address the impact of the commodity-equity correlation increases on the prices.

For simplistic reasons, we estimate the equilibrium prices by using Taylor's theorem around $\rho = 0$ (see appendix 1.D).

$$\psi(\rho) = \psi \restriction_{\rho=0} + \rho \frac{d\psi}{d\rho} \restriction_{\rho=0}$$

Where $\psi := \{P_t, F_{t,T}, X, Y, \tilde{P}_T\}$.

Each estimated price is comprised of two terms. The first term is identical to the prices found by Ekeland et al. (2015) ($\phi_{\rho=0}$). The second term is the stock market impact.

$$\psi = \psi_{\rho=0} + \rho \ C$$

It implies,

$$\frac{d\phi}{d\rho} = C$$

Where $C$ represents the impact of stock market on the equilibrium prices.

As a result, when the commodity-equity correlation ($\rho$) increases, spot price ($P_t$), futures price ($F_{t,T}$) and the inventory levels ($X$) decrease. On the other hand, the quantity demanded by processors ($Y$), future spot price ($\tilde{P}_T$) and futures risk premium ($E[\tilde{P}_T] - F_{t,T}$) increase. This is, of course, when we expect a positive stock returns. The prices changes oppositely when the expected stock market returns are negative.

The reason behind that is represented by the taken futures position from the financial investors' side. The increase in the commodity-equity correlation accompanied by positive stock returns (positive $R$) causes a decrease (increase) long (short) positions. Positive $R$ means that the long positions are less attractive for the financial investors to diversify their portfolios.

Therefore, they move toward having short positions. Selling more (buying less) futures contracts decreases the futures price ($F_{t,T}$). This makes the hedging is more expensive. As a result, the storers hold less inventories. This low demand on the commodity decreases the spot prices at period $t$ ($P_t$). Less inventories held from period $t$ causes an increase in the spot prices at period $T$ ($P_T$). Even more, a decrease in the futures prices motivates the processor to buy more quantity from the physical market and hedge these quantities in the futures market. Inversely, when $R$ is negative. Table 1.2 shows the impact of the commodity-equity correlation on the prices and quantities at the equilibrium state.

Table 1.2: The impact of the commodity-equity correlation on the equilibrium prices

| | $P_t$ | $F_{t,T}$ | X | Y | $\tilde{P}_T$ | $E[\tilde{P}_T] - F_{t,T}$ |
|---|---|---|---|---|---|---|
| Stock risk premium is positive | ↘ | ↘ | ↘ | ↗ | ↗ | ↗ |
| Stock risk premium is negative | ↗ | ↗ | ↗ | ↘ | ↘ | ↘ |

## 1.7 The impact of financialization

In this section, we aim to study the impact of financial investors' inflow on commodity prices. The impact of speculation could be studied by two approaches. The first is by investigating the impact of the existence and the non-existence of financial investors (speculators) in the market (e.g. Newbery (1987)). The second approach studies the increase in the speculation (e.g. Ekeland et al. (2015)). In this paper, we go in the line with the second approach, while we study the first approach in appendix 1.E. The increase in the speculation can be observed from the easy access to futures market, and/or from the decrease in the investors' risk aversion. That is represented by $\frac{N_s}{\alpha_S}$, which appears in $\gamma$ and $R$ in the equilibrium prices.

In the following, and for simplistic reasons, we resort to the estimated equilibrium prices by using Taylor's theorem around $\rho = 0$. As explained in the previous section, the estimated prices are comprised of two terms: first, a zero correlation term, which corresponds with the finding of Ekeland et al. (2015) prices. The second term shows the stock market share in determining the prices. The estimated prices seem as follow (see appendix 1.D):

$$\begin{aligned} P_t &= P_t^{ELV} && -n_I \Upsilon \\ F_{t,T} &= F_{t,T}^{ELV} && -(m+n_I)\,\Upsilon \\ \tilde{P}_T &= \tilde{P}_T^{ELV} && +\left((m+n_I)\,n_P m^{-1}+n_I\right)\Upsilon \\ X &= X^{ELV} && -m\Upsilon \\ Y &= Y^{ELV} && +(m+n_I)\,\Upsilon \end{aligned}$$

Where,

$$\Upsilon := \frac{(\gamma'-1)N_S\rho(E[\tilde{V}_T]-V_t)}{\alpha_S\sigma_P\sigma_V\left(m(m+n_I+(n_I+n_P)\gamma')+\gamma' n_I n_P\right)}$$

$$\gamma^{'} := \gamma(\rho=0) = 1+\frac{1}{m}\frac{Var[\tilde{\xi}_T]}{\frac{N_I}{\alpha_I}+\frac{N_P}{\alpha_P}+\frac{N_S}{\alpha_S}}$$

In what follows, we will be studying the impact of speculation on the prices. We will start by finding the impact when there is no diversification. After then, we will step forward to find the impact of stock share. Finally, we will be combining the whole effects together.

Let us note that each price is given by the next notation,

$$\psi = \psi^{ELV} + c\Upsilon$$

Hence, the change in any price with respect to speculation is given by:

$$\frac{d\psi}{d\frac{N_S}{\alpha_S}} = \frac{d\psi^{ELV}}{d\frac{N_S}{\alpha_S}} + c\frac{d\Upsilon}{d\frac{N_S}{\alpha_S}}$$

The impact of the first term "no diversification" is separated to two opposite scenarios. These scenarios are distinguished by net hedging pressure. When the net hedging pressure is short (storers activities overwhelm the processors activities), then the increase in the speculation causes an increase in futures prices ($F_{t,T}$), spot price ($P_t$) and inventory levels ($X$). Regarding the relations between prices, that causes a decrease in the futures spot price ($\tilde{P}_T$) and the physical demand for production ($Y$). In the situation of short hedging pressure, speculators taker long positions for offsetting the hedgers' futures positions. Hence, the changes in the prices are interpreted by the increase in long positions taken by speculators. High demand on long positions increases the futures price. Consequently, the inventory levels increases, which leads the spot price to increase. The processors decrease their demand from the physical market. The increase in the inventory and the decrease in the future demand from the processors' side causes a decrease in the future spot price. On the contrary, when the hedging pressure is net long, then speculators ask for more short positions. Consequently, the prices changes in the opposite directions to the first scenario. Table 1.3 shows the impact of the speculation on the prices and the quantities considering the pure speculation effect.

Table 1.3: The impact of the speculation on the prices and quantities, the pure speculation effect

| | $P_t$ | $F_{t,T}$ | X | Y | $\tilde{P}_T$ | $E[\tilde{P}_T] - F_{t,T}$ |
|---|---|---|---|---|---|---|
| $HP > 0$ | ↗ | ↗ | ↗ | ↘ | ↘ | ↘ |
| $HP < 0$ | ↘ | ↘ | ↘ | ↗ | ↗ | ↘ |

The impact of second term "stock market share", which is represented by $c\frac{d\Upsilon}{d\frac{N_S}{\alpha_S}}$, are determined by two components: commodity-equity correlation and expected stock market share.

$$\frac{d\Upsilon}{d\frac{N_S}{\alpha_S}} = \frac{\rho\left(E[\tilde{V}_T] - V_t\right)}{\sigma_P \sigma_V} \frac{(\gamma' - 1)}{\frac{N_I}{\alpha_I} + \frac{N_P}{\alpha_P} + \frac{N_S}{\alpha_S}} \upsilon$$

$$\upsilon = \left[ \frac{\left(\frac{N_I}{\alpha_I} + \frac{N_P}{\alpha_P}\right) m\,(m + n_I) + (m\,(n_I + n_P) + n_I n_P)\left(\frac{N_I}{\alpha_I} + \frac{N_P}{\alpha_P} + \frac{Var[\xi_T]}{m}\right)}{\left[m\,(m + n_I) + (m\,(n_I + n_P) + n_I n_P)\,\gamma'\right]^2} \right], \upsilon > 0$$

Consequently, there are two scenarios for the sign of $\frac{d\Upsilon}{d\frac{N_S}{\alpha_S}}$. These scenarios are settled by the signs of the commodity-equity correlation and stock market returns; i.e when both factors have similar signs or different signs. Positive R (the situation when commodity-equity correlation and stocks returns are similar), as explained previously, motivates the financial investors to have lower long or more short futures positions. Therefore, an increase in the number of financial investors under these conditions raises the demand toward the short positions. As a result, increasing in selling futures contract will increase the cost of hedging. Futures prices decreases, which leads to a decrease in the inventory levels. Consequently, the spot price decreases. On the other hand, low inventory levels results predicts a low supply in the future, which means higher future spot price. Low futures price motivates the processors to buy more quantities from the commodity. Opposite impact appears when the commodity-equity correlation and stock risk premium have different signs. Table 1.4 shows the impact of the speculation on the prices and the quantities considering the stock market share only.

Table 1.4: The impact of speculation on the prices and the quantities considering the stock market effect only

| | $P_t$ | $F_{t,T}$ | X | Y | $\tilde{P}_T$ | $E[\tilde{P}_T] - F_{t,T}$ |
|---|---|---|---|---|---|---|
| $\rho$ and $E[\tilde{V}_T] - V_t$ have the same signs | ↘ | ↘ | ↘ | ↗ | ↗ | ↗ |
| $\rho$ and $E[\tilde{V}_T] - V_t$ have different signs | ↗ | ↗ | ↗ | ↘ | ↘ | ↘ |

The aggregated impact is a linear combination between the impacts of pure speculation and stock market share. The aggregated impact of the speculation is not clear for all cases, which gives plausible reasons why the question of the impact of financialization is still debated until now. In general, the final impact of the financial investors on the commodity prices is determined by the combination between hedging pressure, commodity-equity correlation and the expected stocks returns. However, the pure speculation and the impact of stock market share show opposite impacts in some cases. Consequently, the final impacts cannot be determined easily. This hesitating in determining the final impact of the financial investors is attributed to the taken futures positions. Sometimes, the increase in the financial investors cause an increase in the long futures positions taken from pure speculation point of view, and at the same time it is preferred to have short positions from diversification point of view. The final results could be determined by knowing the net position taken by the financial investors. In certain cases, when the hedging pressure of futures commodity markets is net long, and the commodity-equity correlation and the expected stocks return are positive, then the increase in financialization causes a decrease in the futures price, spot price and inventory levels. As a result, the future demand for production and the future spot price increase. Another clear case when the commodity-equity correlation and stocks returns have different signs and the hedging pressure is net short, then the increase in financialization increases each of spot price, futures price and inventory levels. Furthermore, continuing to the prices relations, it decreases the physical demand of the processors and the future spot price decrease. Table 1.5 shows the different scenarios of the impact of financialization.

Table 1.5: The impact of the speculation on the prices and quantities

| Region 1 | $P_t$ | $F_{t,T}$ | X | Y | $\tilde{P}_T$ | $E[\tilde{P}_T] - F_{t,T}$ |
|---|---|---|---|---|---|---|
| $HP > 0$ and $\rho$ & $E[\tilde{V}_T] - V_t$ have same signs | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown |
| $HP < 0$ and $\rho$ & $E[\tilde{[}V_T] - V_t$ have same signs | ↘ | ↘ | ↘ | ↗ | ↗ | Unknown |
| $HP > 0$ and $\rho$ & $E[\tilde{V}_T] - V_t$ have different signs | ↗ | ↗ | ↗ | ↘ | ↘ | ↘ |
| $HP < 0$ and $\rho$ & $E[\tilde{V}_T] - V_t$ have different signs | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown |

## 1.8 Conclusion

In this chapter, we develop a theoretical model that investigates the interaction between commodity and stock markets. This work is motivated by ongoing and unresolved debate about the impact of financialization of commodity. From the theoretical point of view, we find that the impact of the financial investors on commodity markets is linked to their positions taken in the futures markets. In the period when they have net long positions, then the financialization of commodity increases the futures price, the spot price and the inventory levels. On the contrary, the prices relationships show a decrease in the physical demand for processors and the future spot prices. The results are reflected when the financial investors positions are net short. Generally, our results show co-movements between futures price, spot price and inventory levels. On opposite side, there is a co-movement between the physical demand for production and the future spot price.

Basak and Pavlova (2016) (theoretically), Buyukşahin and Robe (2014a,b) and Creti et al. (2013) (empirically) show an increase in the linkage between commodity and stock markets. These literature motivate us to study the impact of the commodity-equity correlation on the commodity markets. We find that the impact of the commodity-equity correlation is related to the expected stocks return. However, by considering the index $S\&P500$ a representative to the situation of the stock market, we notice that, in general, the stocks returns are positive except for a short period after the financial crisis. Generally, an increase in the commodity-equity correlation causes a decrease in spot price, futures price and inventory levels, while it raises the processors physical demand, the future spot price and the futures risk premium. These prices movements are interpreted by the increase in the financial investors' demand on short futures positions.

We find that the debate about the impact of financialization is plausible. We find that this impact is determined by the net futures positions taken by financial investors. If their aggregated futures positions are long, then the increase in the financial investors leads to raise the futures prices, and motivate the inventory holders to have more physical commodities regarding the securitization from the futures market. Then, that causes an increase in the spot price. Based on our equilibrium prices relations, the demand for the production decrease, which leads to a decline in the future spot prices. On the contrary, that impacts is totally reflected when the aggregated futures are short.

Finally, the futures risk premium is determined by two components: first the hedging pressure, which goes in the line with the literature that have addressed the relationship between hedging pressure and the futures risk premium such as De Roon et al. (2000) and Boons et al.

(2014). The second component is the stock market returns and commodity equity correlation. We find that the net short hedging pressure increase the futures risk premium. We find also, by noticing the increase in the commodity-equity correlation and the phase of $S\&P500$ equity index, that the flow of financial investors in the commodity market increases the futures risk premium.

This paper contributes to the growing literature about the financialization of commodity markets. This is a further proof to the previous work, which the vast majority is empirical, that address the effect of financial investors on commodity markets, such as Henderson et al. (2015), Hamilton and Wu (2015), Singleton (2014) and others.

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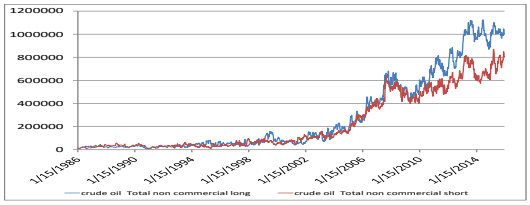
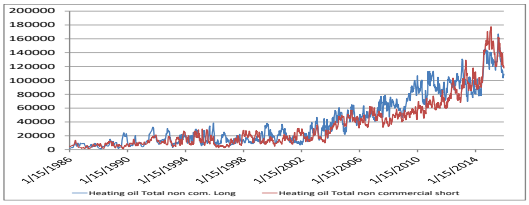
# Appendix

## 1.A Commodity positions

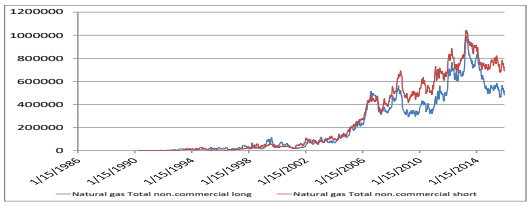
Figure 1.7: Commodities non commercials futures positions



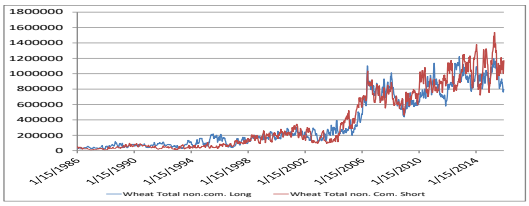

(a) Crude oil



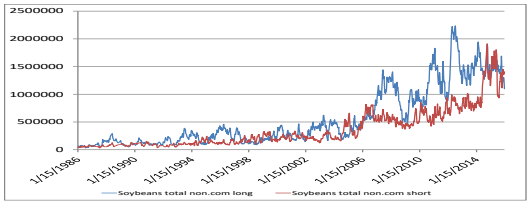

(b) Heating oil



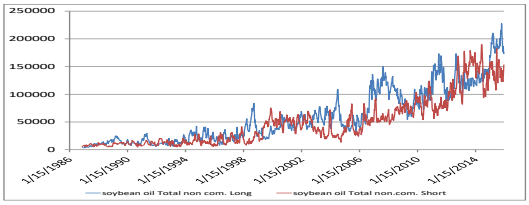

(c) Natural gas



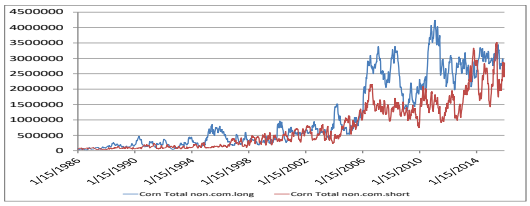

(d) Wheat



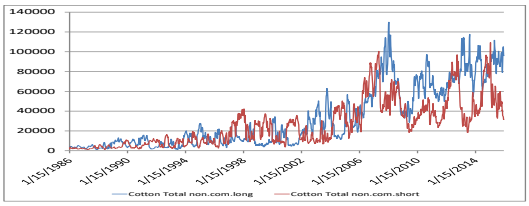

(e) Soybean



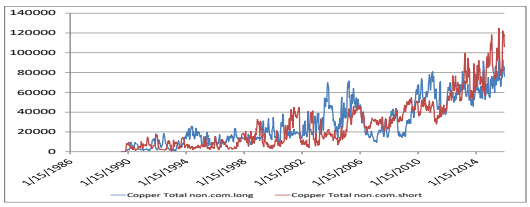

(f) Soybean oil



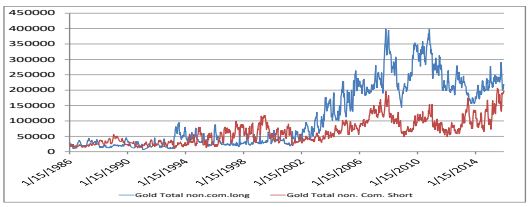

(g) Corn




(h) Cotton

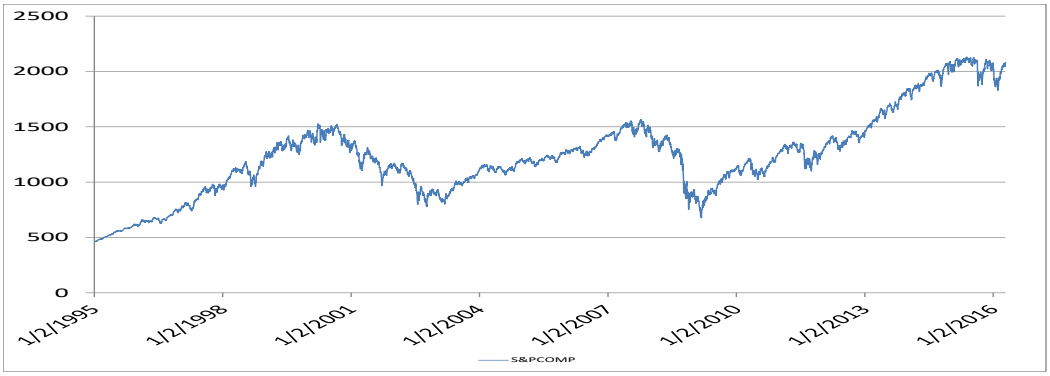



(i) Copper




(j) Gold

Figure 1.8: S&P 500, 1995-2016




## 1.B Agents optimal positions

In this section, we introduce the computations of the optimal positions for each of the storer, processor and the financial investors. We have explained that the agents are mean-variance utility maximizers. Therefore, each agent needs to maximize

$$E(\tilde{\pi}^i) - \frac{1}{2}\alpha_j^i Var(\tilde{\pi}^i)$$

Where, $\pi$ is the agents profit. $\alpha_j^i$ is the agent's $j$ risk aversion in commodity market $i$. $\sim$ indicates that the variable is random.

### 1.B.1 Storer

The profit of the storer from operating in the physical and futures markets is represented by

$$\tilde{\pi}(x, f_I) = x(\tilde{P}_T - P_t) + f_I(\tilde{P}_T - F_{t,T}) - \frac{1}{2}Cx^2 \tag{1.1}$$

To obtain the storers' optimal positions in the physical and the futures markets, we need to solve the first order conditions of the next expression.

$$\max_{x,f_I} \left\{ E[\tilde{\pi}] - \frac{1}{2}\alpha_I Var(\tilde{\pi}) \right\}$$

$$\max_{x,f_I} \left\{ (x + f_I)E\left(\tilde{P}_T\right) - xP_t - f_I F_{t,T} - \frac{1}{2}Cx^2 - \frac{1}{2}\alpha_I (x + f_I)^2 Var\left(\tilde{P}_T\right) \right\}$$

Hence, the storer's optimal positions in the physical and futures markets respectively are:

$$x^* = \frac{1}{C} max\left\{F_{t,T} - P_t, 0\right\} \tag{1.5}$$

$$f_I^* = \frac{E[\tilde{P}_T] - F_{t,T}}{\alpha_I Var[\tilde{P}_T]} - x^* \tag{1.6}$$

### 1.B.2 Processor

The profit of the processor in physical and futures markets is represented by:

$$\tilde{\pi}(y, f_P) = (y - \frac{\beta}{2}(y)^2)Z - y\tilde{P}_T + f_P(\tilde{P}_T - F_{t,T}) \tag{1.2}$$

By solving

$$\max_{y,f_P} \left\{ E(\tilde{\pi}) - \frac{1}{2}\alpha_P Var[\tilde{\pi}] \right\},$$

$$\max_{y,f_P} \left\{ (f_P - y)E\left(\tilde{P}_T\right) + \left(y - \frac{\beta}{2}(y)^2\right)Z - f_P F_{t,T} - \frac{1}{2}\alpha_P (f_P - y)^2 Var\left(\tilde{P}_T\right) \right\},$$

By finding the first order conditions, the processor's optimal positions in the physical and the futures markets are:

$$y^* = \frac{1}{\beta Z} \max\{Z - F_{t,T}, 0\}, \tag{1.7}$$

$$f_P^* = \frac{E[\tilde{P}_T] - F_{t,T}}{\alpha_P Var[\tilde{P}_T]} + y^* \tag{1.8}$$

### 1.B.3 financial investor

The profit of the investors by operating in the commodity and stock markets are:

$$\tilde{\pi}(f_S, k) = f_S(\tilde{P}_T - F_{t,T}) + k(\tilde{V}_T - V_t) \tag{1.3}$$

By solving the following problem,

$$\max_{f_S^a,k} \left\{ E[\tilde{\pi}] - \frac{1}{2}\alpha_S Var(\tilde{\pi}) \right\}$$

$$\max_{f_S,k} \left\{ f_S\left(E\left(\tilde{P}_T\right) - F_{t,T}\right) + k\left(E\left(\tilde{V}_T\right) - V_t\right) - \frac{1}{2}\alpha_S \left[ (f_S)^2 Var\left(\tilde{P}_T\right) + (k)^2 Var\left(\tilde{V}_T\right) + 2 f_S k cov\left(\tilde{P}_T, \tilde{V}_T\right) \right] \right\}$$

After finding the first order conditions, the optimal positions of the investor in commodity and stock markets are:

$$f_S^* = \left(\frac{1}{1-\rho^2}\right) \frac{1}{\alpha_S \sigma_P} \left[ \frac{E[\tilde{P}_T] - F_{t,T}}{\sigma_P} - \rho \frac{E[\tilde{V}_T] - V_t}{\sigma_V} \right], \rho \neq \pm 1$$

$$k^* = \left(\frac{1}{1-\rho^2}\right) \frac{1}{\alpha_S \sigma_V} \left[ \frac{E[\tilde{V}_T] - V_t}{\sigma_V} - \rho \frac{E[\tilde{P}_T] - F_{t,T}}{\sigma_P} \right], \rho \neq \pm 1$$

## 1.C Prices

This section shows the equilibrium prices in the four regions.

Note that,

$$\gamma = 1 + \frac{1}{m} \frac{Var[\tilde{\xi}_T]}{\frac{N_P}{\alpha_P} + \frac{N_I}{\alpha_I} + \frac{N_S}{\alpha_S}\left(\frac{1}{1-\rho^2}\right)} \tag{1.25}$$

$$R = (\gamma - 1)\frac{N_S}{\alpha_S}\rho\frac{E[\tilde{V}_T] - V_t}{\sigma_P \sigma_V (1-\rho^2)} \tag{1.26}$$

The equilibrium prices are:

### 1.C.1 Regime 1

$$P_t = \frac{(m + (n_I + n_P)\gamma)\xi_t + n_I(\xi_T - R) + n_I n_P \gamma Z}{m(m + n_I + (n_I + n_P)\gamma) + \gamma n_I n_P} \tag{1.27}$$

$$F_{t,T} = \frac{n_I\gamma\xi_t + (m + n_I)(\xi_T - R) + (m + n_I)n_P\gamma Z}{m(m + n_I + (n_I + n_P)\gamma) + \gamma n_I n_P} \tag{1.28}$$

$$\tilde{P}_T = \frac{\tilde{\xi}_T}{m} + \frac{n_I\xi_t - ((m + n_I)n_P m^{-1} + n_I)(\xi_T - R) + (m + n_I)n_P Z}{m(m + n_I + (n_I + n_P)\gamma) + \gamma n_I n_P} \tag{1.29}$$

$$X^\star = \frac{-(m + n_P\gamma)\xi_t + m(\xi_T - R) + n_P\gamma m Z}{m(m + n_I + (n_I + n_P)\gamma) + \gamma n_I n_P} \tag{1.30}$$

$$Y^\star = \frac{-n_I\gamma\xi_t - (m + n_I)(\xi_T - R) + m(m + (1+\gamma)n_I)Z}{m(m + n_I + (n_I + n_P)\gamma) + \gamma n_I n_P} \tag{1.31}$$

### 1.C.2 Regime 2

$$P_t = \frac{(m + n_I\gamma)\xi_t + n_I(\xi_T - R)}{m(m + n_I(1+\gamma))}\ ;\ F_{t,T} = \frac{n_I\gamma\xi_t + (m + n_I)(\xi_T - R)}{m(m + n_I(1+\gamma))}\ ;$$
$$\tilde{P}_T = \frac{\tilde{\xi}_T}{m} + \frac{n_I\xi_t - n_I(\xi_T - R)}{m(m + n_I(1+\gamma))}\ ;\ X^\star = \frac{-\xi_t + \xi_T - R}{m + n_I(1+\gamma)}\ ;\ Y^\star = 0.$$

### 1.C.3 Regime 3

$$P_t = \frac{\xi_t}{m}\ ;\ F_{t,T} = \frac{\xi_T - R}{m}\ ;\ \tilde{P}_T = \frac{\tilde{\xi}_T}{m}\ ;\ X^\star = 0\ ;\ Y^\star = 0.$$

### 1.C.4 Regime 4

$$P_t = \frac{\xi_t}{m}\ ;\ F_{t,T} = \frac{\xi_T - R + n_P\gamma Z}{m + n_P\gamma}\ ;\ \tilde{P}_T = \frac{\tilde{\xi}_T}{m} + \frac{n_P Z - n_P\frac{\xi_T - R}{m}}{m + n_P\gamma}\ ;\ X^\star = 0\ ;\ Y^\star = \frac{mZ - (\xi_T - R)}{m + n_P\gamma}.$$

## 1.D Price estimation

Note that,

$$\gamma' = 1 + \frac{1}{m}\frac{Var[\tilde{\xi}_T]}{\frac{N_P}{\alpha_P} + \frac{N_I}{\alpha_I} + \frac{N_S}{\alpha_S}}$$

The estimated prices are:

### 1.D.1 Regime 1

$$\begin{aligned}
P_t &= \frac{(m + (n_I + n_P)\gamma')\xi_t + n_I\xi_T + n_I n_P\gamma' Z}{m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P} - \frac{n_I(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V\,(m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P)} \\
F_{t,T} &= \frac{n_I\gamma'\xi_t + (m + n_I)\xi_T + (m + n_I)n_P\gamma' Z}{m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P} - \frac{(m + n_I)(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V\,(m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P)} \\
\tilde{P}_T &= \frac{\tilde{\xi_T}}{m} + \frac{n_I\xi_t - ((m + n_I)n_P m^{-1} + n_I)\xi_T + (m + n_I)n_P Z}{m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P} + \frac{((m + n_I)n_P m^{-1} + n_I)(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V\,(m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P)} \\
X &= \frac{-(m + n_P\gamma')\xi_t + m\xi_T + n_P\gamma' mZ}{m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P} - \frac{m(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V\,(m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P)} \\
Y &= \frac{-n_I\gamma'\xi_t - (m + n_I)\xi_T + m(m + (1 + \gamma')n_I)Z}{m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P} + \frac{(m + n_I)(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V\,(m(m + n_I + (n_I + n_P)\gamma') + \gamma' n_I n_P)}
\end{aligned}$$

### 1.D.2 Regime 2

$$\begin{aligned}
P_t &= \frac{(m + n_I\gamma')\xi_t + n_I\xi_T}{m(m + n_I(1 + \gamma'))} - \frac{n_I(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V m(m + n_I(1 + \gamma'))} \\
F_{t,T} &= \frac{n_I\gamma'\xi_t + (m + n_I)\xi_T}{m(m + n_I(1 + \gamma'))} - \frac{(m + n_I)(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V m(m + n_I(1 + \gamma'))} \\
\tilde{P}_T &= \frac{\tilde{\xi}_T}{m} + \frac{n_I\xi_1 - n_I\xi_T}{m(m + n_I(1 + \gamma'))} + \frac{n_I(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V m(m + n_I(1 + \gamma'))} \\
X &= \frac{-\xi_t + \xi_T}{m + n_I(1 + \gamma')} - \frac{(\gamma' - 1)N_S\rho(E[\tilde{V}_T] - V_t)}{\alpha_S\sigma_P\sigma_V m(m + n_I(1 + \gamma'))} \\
Y &= 0
\end{aligned}$$

### 1.D.3 Regime 3

$$P_t = \frac{\xi_t}{m}, \qquad F_{t,T} = \frac{\xi_T}{m} - \frac{(\gamma'-1)N_S\rho(E[\tilde{V}_T]-V_t)}{m\alpha_S\sigma_P\sigma_V}, \qquad \tilde{P}_T = \frac{\tilde{\xi}_T}{m}, \qquad X = 0, \qquad Y = 0$$

### 1.D.4 Regime 4

$$\begin{aligned}
P_t &= \frac{\xi_t}{m} \\
F_{t,T} &= \frac{\xi_T + n_P\gamma' Z}{m + n_P\gamma'} - \frac{(\gamma'-1)N_S\rho(E[\tilde{V}_T]-V_t)}{\alpha_S\sigma_P\sigma_V(m+\gamma' n_P)} \\
\tilde{P}_T &= \frac{\tilde{\xi}_T}{m} + \frac{n_P m Z - n_P\xi_T}{m(m+n_P\gamma')} + \frac{n_P(\gamma'-1)N_S\rho(E[\tilde{V}_T]-V_t)}{\alpha_S\sigma_P\sigma_V(m+\gamma' n_P)} \\
X &= 0 \\
Y &= \frac{mZ-\xi_T}{m+n_P\gamma'} + \frac{(\gamma'-1)N_S\rho(E[\tilde{V}_T]-V_t)}{\alpha_S\sigma_P\sigma_V(m+\gamma' n_P)}
\end{aligned}$$

## 1.E The impact of financialization

In this section, we will be investigating the impact of the financialization on commodity prices. We aim to study the difference between the existence and non-existence of the investment in commodity futures market.

$$\Phi\left(\frac{N_S}{\alpha_S}\right) - \Phi(0)$$

To do so, we recompute the equilibrium and use Taylor's theorem.

$$\Delta\Phi = \frac{N_S}{\alpha_S}\frac{\partial\Phi}{\partial\frac{N_S}{\alpha_S}}\Big|_{\frac{N_S}{\alpha_S}=0}$$

Note that,

$$\gamma = 1 + \frac{1}{m}\frac{Var[\tilde{\xi}_T]}{\frac{N_P}{\alpha_P} + \frac{N_I}{\alpha_I} + \frac{N_S}{\alpha_S}\left(\frac{1}{1-\rho^2}\right)} \tag{1.32}$$

$$R = (\gamma-1)\frac{N_S}{\alpha_S}\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V(1-\rho^2)} \tag{1.33}$$

First, the system (1.21) , in Region 1, where $X > 0$ and $Y > 0$, can be written as follow,

$$\begin{pmatrix} \xi_t \\ \xi_T \end{pmatrix} = \begin{pmatrix} m+n_I & -n_I \\ -\gamma n_I & m+\gamma\left(n_I+n_P\right) \end{pmatrix} \begin{pmatrix} P_t \\ F_{t,T} \end{pmatrix} + \begin{pmatrix} 0 \\ -\gamma n_P Z + R \end{pmatrix}$$

It implies,

$$\begin{pmatrix} \xi_t \\ \xi_T + \gamma n_P Z - R \end{pmatrix} = \begin{pmatrix} m+n_I & -n_I \\ -\gamma n_I & m+\gamma\left(n_I+n_P\right) \end{pmatrix} \begin{pmatrix} P_t \\ F_{t,T} \end{pmatrix}$$

i.e.

$$A = B\Phi$$

Where,

$$A = \begin{pmatrix} \xi_t \\ \xi_T + \gamma n_P Z - R \end{pmatrix}, \quad B = \begin{pmatrix} m+n_I & -n_I \\ -\gamma n_I & m+\gamma\left(n_I+n_P\right) \end{pmatrix}, \text{ and } \Phi = \begin{pmatrix} P_t \\ F_{t,T} \end{pmatrix}$$

We can solve the system by finding the inverse of the matrix $B$.

$$\Phi = B^{-1}A$$

By computing the determinant of matrix $B$,

$$l := \begin{vmatrix} m+n_I & -n_I \\ -\gamma n_I & m+\gamma\left(n_I+n_P\right) \end{vmatrix} = m\left(m+\gamma\left(n_I+n_P\right)\right) + n_I m + \gamma n_I n_P > 0$$

It implies that the system (1.21) is solvable, and has a unique solution.

Thus, the inverse of matrix $B$ is:

$$B^{-1} = \begin{pmatrix} \frac{m+\gamma(n_I+n_P)}{l} & \frac{n_I}{l} \\ \frac{\gamma n_I}{l} & \frac{m+n_I}{l} \end{pmatrix}$$

Second, to find the prices difference when there is investment in commodity futures market and when there is not, we aim to apply Taylor's theorem.

$$\Phi(\frac{N_S}{\alpha_S}) = \Phi(0) + \frac{N_S}{\alpha_S}\frac{\partial\Phi}{\partial\frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0}$$

Where, $\Phi = \{P, F\}$.

It implies,

$$\Delta\Phi = \frac{N_S}{\alpha_S}\frac{\partial\Phi}{\partial\frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0}$$

Next, we will be computing $\frac{\partial\Phi}{\partial\frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0}$,

$$\Phi = B^{-1}A \tag{1.34}$$

Then, $\frac{\partial\Phi}{\partial\frac{N_S}{\alpha_S}}$ is

$$\frac{\partial\Phi}{\partial\frac{N_S}{\alpha_S}} = -B^{-1}\frac{\partial B}{\partial\frac{N_S}{\alpha_S}}B^{-1}A + B^{-1}\frac{\partial A}{\partial\frac{N_S}{\alpha_S}}$$

From (1.34) , $\Phi = B^{-1}A$. Thus,

$$\frac{\partial\Phi}{\partial\frac{N_S}{\alpha_S}} = -B^{-1}\frac{\partial B}{\partial\frac{N_S}{\alpha_S}}\Phi + B^{-1}\frac{\partial A}{\partial\frac{N_S}{\alpha_S}}$$

Next, we are introducing $\frac{\partial B}{\partial\frac{N_S}{\alpha_S}}$ and $\frac{\partial A}{\partial\frac{N_S}{\alpha_S}}$

$$\frac{\partial B}{\partial\frac{N_S}{\alpha_S}} = \begin{pmatrix} 0 & 0 \\ -n_I\frac{\partial\gamma}{\partial\frac{N_S}{\alpha_S}} & (n_I+n_P)\frac{\partial\gamma}{\partial\frac{N_S}{\alpha_S}} \end{pmatrix}, \quad \frac{\partial A}{\partial\frac{N_S}{\alpha_S}} = \begin{pmatrix} 0 \\ n_P Z\frac{\partial\gamma}{\partial\frac{N_S}{\alpha_S}} - \frac{\partial R}{\partial\frac{N_S}{\alpha_S}} \end{pmatrix}$$

Where,

$$\begin{aligned}
\frac{\partial\gamma}{\partial\frac{N_S}{\alpha_S}} &= -\frac{Var[\tilde{\xi}_T]}{m}\frac{\frac{1}{1-\rho^2}}{\left(\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}+\frac{N_S}{\alpha_S}\left(\frac{1}{1-\rho^2}\right)\right)^2} \\
\frac{\partial R}{\partial\frac{N_S}{\alpha_S}} &= (\gamma-1)\,\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V(1-\rho^2)} + \frac{N_S}{\alpha_S}\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V(1-\rho^2)}\frac{\partial\gamma}{\partial\frac{N_S}{\alpha_S}}
\end{aligned}$$

By setting $\frac{N_S}{\alpha_S} = 0$ , we have

$$\overline{\gamma} = 1 + \frac{1}{m}\frac{Var[\tilde{\xi}_T]}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}} \tag{1.35}$$

$$\overline{l} = m\left(m + \overline{\gamma}\left(n_I+n_P\right)\right) + n_I m + \overline{\gamma}n_I n_P$$

$$\begin{aligned}
\frac{\partial\gamma}{\partial\frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} &= -\frac{(\overline{\gamma}-1)}{1-\rho^2}\frac{1}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}} \\
\frac{\partial R}{\partial\frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} &= (\overline{\gamma}-1)\,\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V(1-\rho^2)}
\end{aligned}$$

$$\overline{B}^{-1} = \begin{pmatrix} \frac{m+\overline{\gamma}(n_I+n_P)}{\bar{l}} & \frac{n_I}{\bar{l}} \\ \frac{\gamma n_I}{\bar{l}} & \frac{m+n_I}{\bar{l}} \end{pmatrix}$$

Hence,

$$\frac{\partial \Phi}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} = -\overline{B}^{-1} \frac{\partial B}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \overline{\Phi} + \overline{B}^{-1} \frac{\partial A}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0}$$

By substituting $\overline{B}^{-1}$, $\frac{\partial B}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0}$, and $\frac{\partial A}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0}$, we have

$$\frac{\partial \Phi}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} = -\begin{pmatrix} \frac{m+\overline{\gamma}(n_I+n_P)}{\bar{l}} & \frac{n_I}{\bar{l}} \\ \frac{\gamma n_I}{\bar{l}} & \frac{m+n_I}{\bar{l}} \end{pmatrix} \begin{pmatrix} 0 & 0 \\ -n_I \frac{\partial \gamma}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} & (n_I+n_P) \frac{\partial \gamma}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \end{pmatrix} \begin{pmatrix} \overline{P_t} \\ \overline{F}_{t,T} \end{pmatrix} + \begin{pmatrix} \frac{m+\overline{\gamma}(n_I+n_P)}{\bar{l}} & \frac{n_I}{\bar{l}} \\ \frac{\gamma n_I}{\bar{l}} & \frac{m+n_I}{\bar{l}} \end{pmatrix} \begin{pmatrix} 0 \\ n_P Z \frac{\partial \gamma}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} - \frac{\partial R}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \end{pmatrix}$$

It implies,

$$\frac{\partial \Phi}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} = \begin{pmatrix} \frac{n_I}{\bar{l}} \frac{\partial \gamma}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \left( n_I \overline{P_t} - (n_I+n_P) \overline{F}_{t,T} + n_P Z \right) - \frac{n_I}{\bar{l}} \left( \frac{\partial R}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \right) \\ \frac{n_I+m}{\bar{l}} \frac{\partial \gamma}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \left( n_I \overline{P_t} - (n_I+n_P) \overline{F}_{t,T} + n_P Z \right) - \frac{n_I+m}{\bar{l}} \left( \frac{\partial R}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \right) \end{pmatrix}$$

By rearranging the system, we have

$$\frac{\partial \Phi}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} = \begin{pmatrix} -\frac{n_I}{\bar{l}} \frac{(\overline{\gamma}-1)}{1-\rho^2} \frac{1}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}} \left( -n_I \left( \overline{F}_{t,T} - \overline{P}_t \right) + n_P \left( Z - \overline{F}_{t,T} \right) \right) - \frac{n_I}{\bar{l}} \left( (\overline{\gamma}-1) \rho \frac{E[\tilde{V}_T]-V_t}{\sigma_P \sigma_V (1-\rho^2)} \right) \\ \frac{n_I+m}{\bar{l}} \frac{\partial \gamma}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \left( -n_I \left( \overline{F}_{t,T} - \overline{P}_t \right) + n_P \left( Z - \overline{F}_{t,T} \right) \right) - \frac{n_I+m}{\bar{l}} \left( (\overline{\gamma}-1) \rho \frac{E[\tilde{V}_T]-V_t}{\sigma_P \sigma_V (1-\rho^2)} \right) \end{pmatrix}$$

It implies,

$$\frac{\partial \Phi}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} = \begin{pmatrix} \frac{n_I}{\bar{l}} \frac{(\overline{\gamma}-1)}{1-\rho^2} \frac{1}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}} \left( \overline{HP} \right) - \frac{n_I}{\bar{l}} \left( (\overline{\gamma}-1) \rho \frac{E[\tilde{V}_T]-V_t}{\sigma_P \sigma_V (1-\rho^2)} \right) \\ \frac{n_I+m}{\bar{l}} \frac{(\overline{\gamma}-1)}{1-\rho^2} \frac{1}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}} \left( \overline{HP} \right) - \frac{n_I+m}{\bar{l}} \left( (\overline{\gamma}-1) \rho \frac{E[\tilde{V}_T]-V_t}{\sigma_P \sigma_V (1-\rho^2)} \right) \end{pmatrix}$$

Where, $\overline{HP} = n_I \left( \overline{F}_{t,T} - \overline{P}_t \right) - n_P \left( Z - \overline{F}_{t,T} \right)$.

Finally, the derivative of the prices when $\frac{N_S}{\alpha_S} = 0$ takes the following form.

$$\frac{\partial \Phi}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} := \begin{pmatrix} \frac{\partial P_t}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \\ \frac{\partial F_{t,T}}{\partial \frac{N_S}{\alpha_S}}|_{\frac{N_S}{\alpha_S}=0} \end{pmatrix} = \begin{pmatrix} \frac{n_I}{\bar{l}} \frac{(\overline{\gamma}-1)}{1-\rho^2} \left( \frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}} - \rho \frac{E[\tilde{V}_T]-V_t}{\sigma_P \sigma_V} \right) \\ \frac{n_I+m}{\bar{l}} \frac{(\overline{\gamma}-1)}{1-\rho^2} \left( \frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}} - \rho \frac{E[\tilde{V}_T]-V_t}{\sigma_P \sigma_V} \right) \end{pmatrix}$$

Third, the changes in the prices are

$$\begin{aligned}
\Delta P_t &= \frac{N_S}{\alpha_S}\frac{n_I}{\bar{l}}\frac{(\overline{\gamma}-1)}{1-\rho^2}\left(\frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}-\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V}\right)\\
\Delta F_{t,T} &= \frac{N_S}{\alpha_S}\frac{n_I+m}{\bar{l}}\frac{(\overline{\gamma}-1)}{1-\rho^2}\left(\frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}-\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V}\right)\\
\Delta X &= \frac{N_S}{\alpha_S}\frac{m}{\bar{l}}\frac{(\overline{\gamma}-1)}{1-\rho^2}\left(\frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}-\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V}\right)\\
\Delta Y &= -\frac{N_S}{\alpha_S}\frac{n_I+m}{\bar{l}}\frac{(\overline{\gamma}-1)}{1-\rho^2}\left(\frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}-\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V}\right)\\
\Delta P_T &= -\frac{N_S}{\alpha_S}\frac{\frac{1}{m}\left(n_P m+n_P\left(n_I+m\right)\right)}{\bar{l}}\frac{(\overline{\gamma}-1)}{1-\rho^2}\left(\frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}-\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V}\right)
\end{aligned}$$

There is a common factor between prices changes which is represented by (let us call it $\Pi$)

$$\Pi = \frac{N_S}{\alpha_S}\frac{n_I}{\bar{l}}\frac{(\overline{\gamma}-1)}{1-\rho^2}\left(\frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}-\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V}\right)$$

By substituting $\overline{\gamma}-1$, $\Pi$ becomes,

$$\Pi = \frac{\frac{N_S}{\alpha_S}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}\frac{n_I}{\bar{l}}\frac{Var[\tilde{\xi}_T]}{1-\rho^2}\frac{1}{m}\left(\frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}-\rho\frac{E[\tilde{V}_T]-V_t}{\sigma_P\sigma_V}\right)$$

When $\frac{N_S}{\alpha_S}=0$,, then the futures risk premium as given in (**??**) is given as

$$E[\widetilde{P}_T]-F_{t,T}=\frac{1}{(m)^2}\frac{Var[\tilde{\xi}_T]\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}$$

Consequently,

$$\Pi = \frac{\frac{N_S}{\alpha_S}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}\frac{n_I}{\bar{l}}\frac{Var[\tilde{\xi}_T]}{1-\rho^2}\frac{1}{m}\left(\frac{Var[\tilde{\xi}_T]}{Var[\tilde{\xi}_T]}\frac{\overline{HP}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}-\frac{\rho}{\sigma_P\sigma_V}E[\tilde{V}_T]-V_t\right)$$

i.e.

$$\Pi = \frac{\frac{N_S}{\alpha_S}}{\frac{N_P}{\alpha_P}+\frac{N_I}{\alpha_I}}\frac{n_I}{\bar{l}}\frac{Var[\tilde{\xi}_T]m}{1-\rho^2}\left(\frac{E[\widetilde{P}_T]-F_{t,T}}{Var[\tilde{\xi}_T]}-\rho\frac{E[\tilde{V}_T]-V_t}{m\sigma_P\sigma_V}\right)$$

By comparing the previous equation with the optimal positions of the financial investor (see equation (1.9)), we obtain

$$\Pi = \frac{N_S}{\frac{N_P}{\alpha_P} + \frac{N_I}{\alpha_I}} \frac{Var[\tilde{\xi}_T]m}{\bar{l}} f_S$$

That means that the impact of the financial investors on commodity prices depends on their net taken position in the futures markets. If financial investors take long positions, then $\Delta P_t$, $\Delta F_{t,T}$ and $\Delta X$ have positive signs. On the contrary, $\Delta Y$ and $\Delta P_T$ have negative signs. The impact is inverted when the net positions are short.

# Chapter 2

# The Role of Financial Investors in Commodity Futures Risk Premium

In this paper, I study the impact of financial investors on the commodities futures risk premium, that is the financialization of commodity markets. I implement my tests based on the theoretical model of Isleimeyyeh et al. (2017), which demonstrates that the futures risk premium is determined by the hedging pressure and the stock market returns accompanied by commodity-equity correlation. I build regressions that mimic the theoretical result. I investigate three commodities: crude oil (WTI), natural gas and heating oil. The dataset covers the period between 1995 and 2015. First, I find that the hedging pressure is an important determinant of the futures risk premium. Second, I show that the stock returns becomes significant effective determinant of the futures risk premium after 2008 crisis.

**Keywords**: Futures risk premium, financialization, stock risk premium, financial investor, diversification, commodity (crude oil, natural gas, heating oil), DCC.

## 2.1 Introduction

Commodity futures markets are considered a shelter for commercial traders to hedge their physical positions. Based on the traditional hedging theory, in order to avoid the risk of prices changing, hedgers take futures positions in the same magnitude as physical markets but in the opposite (Johnson (1960) and Ederington (1979)). On the counter side, there are non-commercial agents (speculators), who are offsetting the hedgers' net futures positions and they are remunerated by hedgers for their borne risk by receiving margins that called futures risk premium (Keynes (1930))[1]. Hence, the interactions between those two types of participants are responsible of determining the risk premium from the information that hedgers bring from physical and futures markets, and of course the information that speculators bring from the futures market (e.g. Ekeland et al. (2015)). In the last two decades, especially after 2002/2003, excess speculative activities increased in the futures markets. These increases are attributed to the increase in the financial investors particpation in the futures markts (e.g. Masters (2008)). Those are investors who own a stock portfolio, but seek to diversify into the commodity markets. This is usually referred as the financialization of commodity. The diversification reasons was rationalized by the small correlation between futures and stock returns and commodity futures returns as found in Gorton and Rouwenhorst (2006) and Erb and Harvey (2006)[2]. Financial institutions and individual investors trade commodity futures in several forms such as: hedge fund, commodity index funds, commodity returns swaper, exchange traded funds (ETFs) and exchange traded note (ETNs) (e.g. see Stoll and Whaley (2010)).

Since financial investor operate in two different markets, the positions taken in futures market is restricted to the information from the stock market, and vice versa (Isleimeyyeh et al. (2017)). They also create information channels between markets. Therefore, theoretically and logically, stock market do matter in determining the commodity futures risk premium. Several papers are debating the consequences of financialization on commodity markets[3]. Especially, the period of financialization was synchronized with several changes in commodity markets; more importantly, the surge in crude oil prices between the period 2003 and 2008. Researchers were motivated to study whether financial investors are responsible on the changes, or not. Some of them find evidences about the impact of investors on commodity markets such as Masters (2008), Tang

[1]Speculation in commodities means seeking profit from undertaken transactions especially for that purpose, and not in the normal course of conducting a business of producing, merchandising, or processing a commodity (Working (1960)).

[2]Although commodity equity linkage increased after the financialization, there are some papers confirm the diversification purpose of the financial investor such as Bhardwaj et al. (2015), Galvani and Plourde (2010) and Cheung and Miu (2010). On the contrary, some papers challenge that hypothesis such as Belousova and Dorfleitner (2012) and Daskalaki et al. (2014).

[3]See the review of Irwin and Sanders (2011) and Cheng and Xiong (2014).

and Xiong (2012) and Singleton (2014) and Henderson et al. (2015). On the contrary, others reject that hypothesis such as Hamilton (2009), Brunetti and Buyukşahin (2009), Buyukşahin and Harris (2011), Sockin and Xiong (2015) and Knittel and Pindyck (2016). However, empirical studies still did not solve the debate of whether financial investors and stock market affect on commodity futures markets. Moreover, the futures risk premium has less attention in the literature. In this paper, we will be looking at the effect of financial investors on the commodity futures risk premium.

In this paper, I am testing a theoretical model developed by Isleimeyyeh et al. (2017)). This model is a developed version of Ekeland et al. (2015). In Isleimeyyeh et al. (2017), financial investors are allowed to participate in the futures market in addition to their participation in the stock market, which is not the case in Ekeland et al. (2015). The model studies the interaction between commodity and stock markets. There are four types of agents: inventory holder (storer), processor, financial investor and spot traders. The agents trade a single commodity. The storer and the processor operate in the physical and the futures markets of this commodity. The financial investors operate in the commodity futures and the stock markets. The storer buys the commodity in the physical market to sell it in the future. He also hedges his physical positions in the futures market; he usually goes short in the futures market (sells futures). The processor decides the quantity needed of the commodity to buy it at the future. He hedges his physical positions in the futures market; usually by going long (buys futures). The financial investor has his own portfolio in the stock market and he needs to diversify that portfolio by operating in the commodity futures market. Pure speculator, who operates in the futures market only, is included in the financial investor category.

As a result of the equilibrium in the physical, futures and stock markets, the commodity futures risk premium is determined by the signs and the magnitudes of: the physical positions of the hedgers that are referred by the hedging pressure, the financial investor's profit which is referred by the expected stock returns, and the commodity-equity correlation. Also, it is affected by the magnitudes of other factors comprised of the number of agents restricted to their risk aversions, and the variances of the spot and stock prices.

As mentioned, the commodity-equity correlation is an important determinant of the futures risk premium. Many papers addressed that the correlation between the stock and the futures returns witnessed changes over time. Buyukşahin et al. (2010) found that the commodity-equity correlation increased sharply in the fall of 2008, but it was still less than its previous peaks. After then, the vision became clearer when Creti et al. (2013) and Buyukşahin and Robe (2014a,b) explained that the linkage between commodity and stock markets increased after 2008 financial

crisis. Basak and Pavlova (2016) also conclude that financialization raises correlation between commodity and equity markets. Consequently, I am convinced enough to consider the correlation between equity and futures markets is variable. Therefore, I resort to compute the dynamic conditional correlation (DCC) addressed by Engle (2002) in order to have variable correlation (time series of commodity-equity correlation).

In this paper, I study the interaction between the futures and the stock markets. I do so by regressing the futures risk premium on both the hedging pressure and the adjusted stock returns, which is defined as the expected stock returns multiplied by commodity-equity correlation. I choose datasets that cover the period between 1995 and 2015. I divide the tested period into three sub-periods, namely: 1995-2002, 2003-2008 and 2008-2015. These sub-periods represent the pre-financialization and post-financialization periods. I test three commodities: crude oil (WTI), natural gas and heating oil, where are traded in New York Mercantile Exchange (NYMEX). For selected commodities, I construct weekly futures returns datasets for several maturities. These maturities reach to 18, 18 and 16 series for crude oil (WTI), natural gas and heating oil respectively. This step is different from most of the literature, which focus on the first and/or the second nearest-to-maturities. The investors who are looking for portfolios diversifying are passive investors. Therefore, they buy and hold benefiting from long run returns. Logically, they buy long maturity futures contracts and hold them. After then, they offset these contracts when they are close to maturity. Furthermore, Buyukşahin and Robe (2014b) show that the excess speculation increased in both short and long maturities. I also collect the hedgers' positions published by CFTC, which are used to compute the net short hedging pressure. Finally, I collect weekly S&P500 composite in order to compute the expected stock returns. By finding the dynamic conditional correlation (DCC) between commodity and equity markets, I observe that the commodity-equity correlation increase dramatically after 2008 to reach 0.6 in sometimes for crude oil (WTI) and heating oil, which boosts my hypothesis of considering the commodity-equity correlation is variable.

Empirically, for tested commodities, I find that the hedging pressure is a strong explanatory variable of the futures risk premium in different circumstances. My results go in the line with the traditional price pressure hypothesis and show that net short (long) hedging positions are related with positive (negative) futures risk premium, which also corresponds with Ekeland et al. (2015). Hedging pressure effect decreases when the maturity increases. That leads to induce that hedging activities are intensive in short maturities more than in long ones. However, the vision would be more specified if there is a data about hedging position for each maturity and not aggregated ones as published by CFTC. Second, I find that the stock market effect on the futures risk premium appeared virtually after 2008 financial crisis. This result is interpreted by

the dramatically increase in commodity-equity correlation for most commodities, which makes the diversification in commodity is doubtable. In such circumstances, financial investors should be remunerated for the borne risk from commodity futures markets. Moreover, the results show the importance of having several maturities in our tests. The effect of stock market overwhelms the impact of hedging pressure for longer maturities, especially for crude oil and heating oil. That, of course, does not contradict the finding of Boons et al. (2014) who find the opposite. For shorter maturities, the result is inverted. Investors in commodity markets are passive; they buy and hold the futures contracts. They are interested in longer maturities and offset their futures positions before maturity dates.

That leads us to address the main results: first, based on the data collected from CFTC that shows the net hedging pressures for crude oil (WTI) and heating oil are short, the hedging pressure increases the futures risk premium. For natural gas, the net hedging pressure is short till the financial crises 2008. After then, it becomes net long. Therefore, the hedging pressure of the natural gas decreases the futures risk premium after 2008. Second and after 2008 crisis, the positive stock returns are accompanied by positive commodity-equity correlation. That increases the futures risk premium for crude oil (WTI) and heating oil. Totally, the futures risk premium of crude oil (WTI) and heating oil have increased after 2008 crisis. These previous results confirm the theoretical finding of Isleimeyyeh et al. (2017).

I implement several robustness checks. First, I test the theoretical givings by replacing the weekly datasets by monthly ones. Second, I substitute the maturities by S&P GSCI total return for the tested commodities. Third, I divide the tested periods to shorter sub-periods. Each sub-period is represented by 175 weeks. Fourth, I replace the net short hedging pressure by the net long speculative pressure. I use this test based on the fact that the speculators sit on the opposite direction of the hedgers to offset their net positions. These checks boost my results, and show qualitatively the same result as I found in the original regressions.

The rest of the paper is organized as follow: Section 2.2 expresses the literature reviews. Section 2.3 introduces the theoretical background. Section 2.4 demonstrates the data sets and their summary statistics. Section 2.5 presents the empirical results. Section 2.6 retests the regressions using different methodologies. Section 2.7 concludes the results.

## 2.2 Literature reviews

The question that I state is positioned in the literature that study the financialization of commodity generally, and the risk premium in commodity market particularly. Speaking about the

risk premium goes with us to Keynes (1930) and Kaldor (1940). The classic view of Keynes (1930) states that speculators must be remunerated for their risk bearing in the futures market from the classic hedgers (producers), which is referred to the theory of normal backwardation. On the other hand, the theory of storage that was developed by Kaldor (1940), Working (1949) and Brennan (1958) state that the risk premium is determined by the inventory levels, where backwardation depends on the size of convenience yield.

Theoretically, Hirshleifer (1988a, 1989a, 1990) addressed that the risk premium is determined by the hedging pressure beside the systematic risk. On the one hand, Bessembinder (1992), De Roon et al. (2000) and Basu and Miffre (2013) verify empirically the significant impact of the hedging pressure on the futures risk premium. On the other hand, Daskalaki et al. (2014) find that the hedging pressure is not informative about risk premium. However, Our findings confirm the impact of the hedging pressure in both theoretical and empirical levels. After the growing linkage between commodity and equity markets, the studies about the futures risk premium are included under the rapid growing literature that studies the financialization of commodity markets. Some of these papers were covered in the review of Fattouh et al. (2013) and Baumeister and Kilian (2015) (for oil market). Hamilton and Wu (2014) show significant changes in the risk premium after 2005. They show that the compensation of taking long positions became lower after 2005. Acharya et al. (2013) attribute that the speculators capital constrained can have impacts through limits to hedging (Limit risk sharing has strong implications for risk premium). They associated the increase in the commodity futures risk premium with the default risk increase. They predict an increase in the futures risk premium when the risk aversion of hedgers increase. Also, both futures risk premium and the changes in spot prices are predicted to increase when the risk aversion of speculators increase. Etula (2013) links between the broker-dealer risk and the commodity risk premium, and finds that time-variation in effective risk aversion has the highest impact on expected risk premium. A closer work to what I do is introduced by Boons et al. (2014). They find that about 70% of the cross spread in average returns can be attributed to traditional hedging pressure and the remaining 30% to stock market risk. I confirm that hedging pressure impact is overwhelming the stock market for short maturities. But, for longer maturities the stock market has the major influence on the futures risk premium. However, in their paper there is no storage, but, in our paper, the inventory is a determinant of the futures risk premium. Studying the storage separated from production was boosted by the theories that consider the commodity physical inventory is a fundamental determinant of the the commodity prices generally and commodity futures risk premium especially (e.g. Ekeland et al. (2015), Kaldor (1940)). That is confirmed by Gorton et al. (2013), who show a relation between the inventory levels and the risk premium.

Haase and Zimmermann (2013) studies risk premium for crude oil for several maturities as same as we do. However, their study proposed a decomposition of spot and futures prices that separate a scarcity price component from a quasi-asset price component.

This work also contributes to the papers that address evidences of the impact of financialization on commodity markets such as Tang and Xiong (2012), Buyukşahin and Robe (2014a,b), Singleton (2014), Henderson et al. (2015), Hamilton and Wu (2015), Basak and Pavlova (2016) and Baker (2016).

## 2.3 Theoretical Motivation

Isleimeyyeh et al. (2017) (chapter 1) construct an equilibrium model that investigates the interaction between commodity and stock markets. In the model, there is one commodity that is traded in two markets: spot (physical) and futures (paper) markets. There are four types of agents: inventory holder (storer) has the capacity to store the commodity. The processor uses the commodity to produce a final good. The financial investor speculates in the commodity futures market. The storer and the processor operate in the physical and the futures market for hedging purposes. The financial investor, beside his stock portfolio, operates in the futures market for diversification reasons[4]. Finally, spot trader operates in the physical market only.

At time $t$, the storer sits on the demand side in the physical market, and buys the commodity at spot price $P_t$, to store it. The spot traders' effect appear in both demand and supply side in the physical market. The processor decides the size of the commodity quantity that he wants to buy at $T$ at future spot price $\tilde{P}_T$ [5]. The storer and processor hedge their physical positions in the futures market. The financial investor takes their futures positions at futures price $F_{t,T}$.

At time $T$, the storer sits on the supply side and sells his inventory in the physical market. The processor sits on the demand side and delivers quantity from the commodity. The spot traders appear on the demand and supply side of the physical market. The futures contracts are settled implying a financial profit $\tilde{P}_T - F_{t,T}$.

Isleimeyyeh et al. (2017) (i.e. chapter 1) find that the futures risk premium is determined by the signs and the magnitudes of the hedging pressure, the stock market returns and the commodity-equity correlation. The futures risk premium is interpreted in appendix 2.A, where the final image for the futures risk premium is:

[4]The pure speculator ,who operates in the futures market only, is enrolled in the financial investors category.
[5]$\sim$ shows the randomness; that means $\tilde{P}_T$ is a random variable

$$\mathrm{E}[\tilde{P}_T] - F_{t,T} = \beta_1 HP + \beta_2 \rho \left( E[\tilde{V}_T] - V_t \right) \tag{2.1}$$

$$\beta_1 = \frac{\mathrm{Var}[\tilde{P}_T]}{\frac{N_S}{\alpha_S}}, \quad \beta_2 = \frac{\mathrm{Var}[\tilde{P}_T]}{\sigma_P \sigma_V}$$

Where, $\mathrm{E}[\tilde{P}_T] - F_{t,T}$ is the profit from operating in the futures market (i.e. the futures risk premium).

Theoretically, equation 2.2 shows that an increase in the positive expected stocks returns accompanied by positive (negative) commodity-equity correlation increases (decreases) the futures risk premium. A decrease in the negative stock risk premium accompanied by positive (negative) correlation decreases (increases) the futures risk premium[6]. Also, the net short hedging pressure cause an increase in the futures risk premium, while the net long hedging pressure decreases the futures risk premium.

To sum up, my objective is to test the impact of different factors on the futures risk premium following the theoretical finding on of Isleimeyyeh et al. (2017). Based on them, the futures risk premium for any commodity is determined by the hedging pressure of that commodity and stocks returns accompanied by commodity equity correlation. I will be building regressions mimicking that theoretical giving. I will focus on the stocks return term and its impact on the futures risk premium, which became quite important as a consequence of the financialization.

## 2.4 Data

In this section, I firstly introduce datasets that are required to estimate the determinants of the futures risk premium. I need data to estimate the futures returns, hedging pressure and expected stock returns. Secondly, I show a summary statistics for these datasets.

### 2.4.1 Data description

I use weekly datasets for last two decades from 1995 to 2015 concerning three commodities in the energy market: crude oil (WTI), heating oil and natural gas. These datasets contain futures prices for different maturities, open interest positions for each commodity (long and short open interest positions) and composite S&P 500 index. The selected commodities are traded in New York Mercantile Exchange (NYMEX). The data are gotten form Thomson Reuters datastream

[6] When we assume that the financial investors do not participate in the futures market, or even when the commodity-equity correlation is zero, the futures risk premium is:

$$\mathrm{E}[\tilde{P}_T] - F_{t,T} = \frac{\mathrm{Var}[\tilde{P}_T]}{\frac{N_P}{\alpha_P} + \frac{N_I}{\alpha_I} + \frac{N_S}{\alpha_S}} (HP)$$

The previous formula is familiar; it addresses the futures risk premium in Ekeland et al. (2015).

and from Commodity Futures Trading Commission (CFTC). Table 2.1 shows some information about the selected commodities.

Table 2.1: Commodities contracts description

| Commodity | Sample period | Exchange | Contract size | Prices quotation | Delivery |
|---|---|---|---|---|---|
| Crude oil (WTI) | 10/3/1995 - 1/5/2016 | NYMEX | 1,000 barrels | U.S. $ per barrel | Monthly |
| Natural gas | 1/3/1995 - 1/5/2016 | NYMEX | 10,000 mmBtu | U.S. $ per mmBtu | Monthly |
| Heating oil | 1/10/1995 - 1/5/2016 | NYMEX | 42,000 gallons | U.S. $ gallon | Monthly |

- This table shows a description for the commodity futures contracts. I mention the sample period, the exchanges, contract size, price quotation and delivery time.
- NYMEX is New York Mercantile Exchange.
- mmBtu means million British thermal units.

### Hedging pressure (HP)

To determine the Hedging Pressure, I resort to the public data of Commodity Futures Trading Commission (CFTC). CFTC publishes regular reports entitled Commitments of Traders (COT) that provide each Tuesday's open interests positions[7]. These positions are aggregated for all maturities. The CFTC reports show both short and long open interest positions. The aggregate of long open interest is equal to the aggregate of short open interest. The open interest positions are comprised of reportable and non-reportable positions[8]. The reportable traders are classified to commercials and non-commercials traders. The commercial is the trader who uses the futures contracts for hedging reasons. Otherwise, the trader is a non-commercial. In this context, I employee the commercials data to indicate to the hedgers, and the non-commercials to the financial investors (speculators). However, the number of commercials and non-commercials are unknown in the non-reportable category[9]. Therefore, I depend on the commercials reportable positions to indicate the hedgers positions. In the model of Isleimeyyeh et al. (2017), storers take short positions, and processors take long positions in the futures market for their hedging purposes. Therefore, I measure the hedging pressure by computing the difference between reportable short and long positions for the commercials traders divided by the total reportable hedging positions for the commercials traders. This methodology goes in the line with De Roon et al. (2000), Boons et al. (2014), Szymanowska et al. (2014), Daskalaki et al. (2014), Haase and

[7]Open interest is the total of all futures contracts entered into and not yet offset by a transaction, by delivery, by exercise... etc.

[8]Reportable positions are the positions of traders that hold positions above specific reporting levels set by CFTC regulations. Non-reportable short (long) positions are derived by subtracting total Reportable short (long) positions from the total open interest. In this category, the number of commercials/ non-commercials is unknown.

[9]Reportable positions represent 70 to 90% of the total open interest.

Zimmermann (2013), Etula (2013), Acharya et al. (2013) and Zhang (2013).

$$\textbf{The net short hedging pressure}_t = \frac{\textbf{Reportable commercial Short}_t - \textbf{Reportable commercial long}_t}{\textbf{Reportable commercial Short}_t + \textbf{Reportable commercial long}_t}$$

### Commodity expected futures returns

I construct weekly futures prices for the selected commodities from datastream. I use the available dead and live futures contracts to form the time series of futures prices for different maturities. For each commodity, there are several deliveries for futures contract during the year (for example, there is monthly delivery for energy futures as shown in table 2.1). With the passage of time, the futures contract becomes closer to the maturity. Before the delivery, there is a termination of trading for each commodity futures. For instance, the termination of trading for crude oil is the third business day prior to twenty fifth of the month preceding the delivery month. For natural gas, the termination of trading is the third business day prior to the first day of the delivery month. For heating oil, the termination of trading is the last business day of the month preceding the delivery month. I consider the termination of trading date to roll over the futures contract and buy longer futures contract (to switch from a nearest-to-maturity to the second one). At the termination of trading, the first nearest-to-maturity disappears. On the next day, the second nearest-to-maturity is switched to the first nearest-to-maturity. As a result, I construct 18, 18 and 16 maturities for crude oil (WTI), natural gas and heating oil respectively. For a selected date, the first futures price represents the futures price to the closest delivery at that date. The second futures prices series represents the second closest delivery at that given date, and so on. Choosing several maturities is motivated by the Buyukşahin and Robe (2014b) who showed that excess speculation increased in both short and long maturities. Furthermore, the investors who are looking for portfolios diversifying are passive investors. Therefore, they buy and hold benefiting from long run returns.

For each maturity, I go in the line with Gorton and Rouwenhorst (2006) and compute the futures returns as follow,

$$RFUT_t = \frac{F_{t,T} - F_{t-1,T}}{F_{t-1,T}}$$

Where, $RFUT$ is the futures risk premium. $F_{t,T}$ is the futures price at week $t$ on the contract whose expiration at time $T$[10].

[10] Fama and French (1987) mentioned that predictable variation in realized premiums is evidence of time-varying expected premiums $\tilde{P}_T - F_{t,T}$ implies $\mathrm{E}_t[\tilde{P}_T] - F_{t,T}$. Accordingly, I replace the expected future spot price by the future spot price. The futures price is considered the best estimators for the future spot price. This could be

**Expected stock returns**

To estimate the stock returns, I compute the growth return of the index S&P 500. Therefore, I collect weekly dataset of the index S&P 500 composite that obtained from Datastream.

$$RSP500_t = \frac{SP500_t - SP500_{t-1}}{SP500_{t-1}}$$

Where $SP500_t$ is the $S\&P500$ composite at time $t$.

The theoretical results show that the stock returns are engaged to the commodity-equity correlation in determining the impact of the stock market on the futures risk premium. Furthermore, it has been found that the financialization increased the linkage between commodity and equity markets (Basak and Pavlova (2016)), which also has been confirmed empirically in different articles such as Creti et al. (2013) and Buyukşahin and Robe (2014a,b). Therefore, I construct a new index that is named adjusted stock returns. The adjusted stock returns are a result of the multiplication between the stock returns and the commodity-equity correlation at week $t$.

$$RPSP500adj_t := \rho_t \times RPSP500_t$$

I collect further datasets for implementing the robustness checks in section 2.6. I collect the S&P GSCI from Datastream. I have also used noncommercial positions for the tested commodities from CFTC, which will be used to compute the speculative pressure.

For the rest of the paper, I note the variables as follow: first, hedging pressure by $HP$. Second, the futures returns by $RFUTXM$, where X indicates to the maturity. Third, the stock returns by $RPSP500$. Fourth, commodity-equity correlation by $\rho$. Fifth, the adjusted stock returns by $RPSP500adj$.

confirmed by the convergence of the futures prices to the spot prices at the expiration time ($P_t = F_{t,t}$), otherwise, an arbitrage opportunity exists. As a result, the final estimation of the futures return is $F_{T,T} - F_{t,T}$, i.e. the growth return is $\frac{F_{T,T}-F_{t,T}}{F_{t,T}}$. This methodology befits to the mechanism of the theoretical framework. However, the financial investors do not wait until the expiration of the futures contract, in order to avoid the physical settlements. They roll over their contracts before the expiration. Therefore, I go in the line with Gorton and Rouwenhorst (2006) and compute the futures returns as follow,

$$RFUT_t = \frac{F_{t,T} - F_{t-1,T}}{F_{t-1,T}}$$

Where, $RFUT$ is the futures risk premium. $F_{t,T}$ is the futures price at week $t$ on the contract whose expiration at time $T$.

### 2.4.2 Summary statistics

Before proceeding in implementing the regressions, I begin with showing some statistics of the selected datasets. As mentioned, I study three commodities: crude oil (WTI), heating oil and natural gas. I study, based on the data availability, the commodity futures risk premium for 18 maturities for crude oil (WTI) and natural gas, and 16 maturities for heating oil[11]. Table 2.2 exhibits a statistic summary of the selected datasets for each of crude oil (WTI)(panel A), heating oil (panel B) and natural gas (panel C) in the period between 1995 and 2015 (1057 week for crude oil, 1096 weeks for heating oil and natural gas). The statistics display that the mean of the commodity futures returns is positive for the selected commodities last two decades. It shows that the mean of the futures return and the standard deviation decrease when the maturity increases. In appendix 2.B.3, figures 2.7, 2.8 and 2.9 present the futures returns of crude oil (WTI), heating oil and natural gas respectively. The figures display the futures returns of the $1^{st}$ and the $18^{th}$ maturities for crude oil and natural gas, and the futures returns of $1^{st}$ and $16^{th}$ for heating oil. Crude oil returns for the first maturity is higher than $18^{th}$ maturity till 2003/2004. After then, the $18^{th}$ maturity increase to be almost in the same level of the $1^{st}$ maturity return. Heating oil has the same movements. On the contrary, natural gas futures returns for longer maturity stay less than shorter maturity. Following the theoretical results, I expect to have bigger impact on futures risk premium for short maturities than long term ones. I also expect that the financial investor impact will be higher for crude oil (WTI) and heating oil case, and specially after 2003/2004. The hedging pressure of the crude oil (WTI) and the heating oil is net short, while it is net long for the natural gas. Finally, the stock market return is positive. Based on theoretical results, I expect to have positive relationship between hedging pressure and futures risk premium for crude oil and heating oil cases. The statistics show also that the futures returns of crude oil (WTI) have negative skew, while the futures returns of heating oil have positive skew. The futures return of natural gas has positive skew till the $8^{th}$ maturity, after then it converts to negative skew. The net short hedging pressure of crude oil and heating oil have positive skew. On the contrary, the net short hedging pressure of natural gas has negative skew. The stock return has negative skew. All variable that are displayed in the table have positive kurtosis.

Table 2.3 shows the results of the unit root test for all the time series for each commodity. From statistic point of view, I do so to verify that each time series has the same distribution function. I conclude that all the time series of the futures returns and stock returns are stationary at 1% level of confidence except the hedging pressure. To solve the stationary problem of the hedging pressure, I compute the first difference of the net short hedging pressure (CHP), where CHP refers to Change in Hedging Pressure.

[11]For the $17^{th}$ and $18^{th}$ maturities, there are many missing values. Therefore, I preferred to eliminate them.

Table 2.2: Summary statistics

| Variable | Panel A Crude oil (WTI) | | | | | Panel B Heating oil | | | | | Panel C Natural gas | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Mean | Std. Dev. | Skewness | Kurtosis | Obs | Mean | Std. Dev. | Skewness | Kurtosis | Obs | Mean | Std. Dev. | Skewness | Kurtosis |
| RFUT1M | 1057 | 0.0021 | 0.0512 | -0.008 | 4.5746 | 1095 | 0.0019 | 0.0485 | 0.1617 | 4.36888 | 1096 | 0.0031 | 0.07578 | 0.80531 | 8.1082 |
| RFUT2M | 1057 | 0.0019 | 0.0473 | -0.042 | 4.4784 | 1095 | 0.0018 | 0.0449 | 0.1506 | 4.30792 | 1096 | 0.0026 | 0.06773 | 0.30019 | 4.5064 |
| RFUT3M | 1057 | 0.0018 | 0.0447 | -0.076 | 4.6365 | 1095 | 0.0017 | 0.0427 | 0.1151 | 4.33751 | 1096 | 0.0023 | 0.06241 | 0.2969 | 5.617 |
| RFUT4M | 1057 | 0.0017 | 0.0426 | -0.084 | 4.7464 | 1095 | 0.0017 | 0.0409 | 0.0613 | 4.56326 | 1096 | 0.0019 | 0.05504 | 0.27684 | 4.692 |
| RFUT5M | 1057 | 0.0017 | 0.0409 | -0.089 | 4.7872 | 1095 | 0.0016 | 0.0393 | 0.0613 | 4.64568 | 1096 | 0.0016 | 0.0502 | 0.10307 | 5.2802 |
| RFUT6M | 1057 | 0.0016 | 0.0396 | -0.098 | 4.8001 | 1095 | 0.0016 | 0.0379 | 0.1054 | 4.6581 | 1096 | 0.0014 | 0.04613 | 0.32398 | 4.9688 |
| RFUT7M | 1057 | 0.0016 | 0.0382 | -0.097 | 4.9172 | 1095 | 0.0015 | 0.0365 | 0.1413 | 4.69917 | 1096 | 0.0013 | 0.04346 | 0.15266 | 5.3037 |
| RFUT8M | 1057 | 0.0016 | 0.0372 | -0.097 | 5.0034 | 1095 | 0.0015 | 0.0353 | 0.1568 | 4.79809 | 1096 | 0.0012 | 0.04051 | 0.10133 | 4.1774 |
| RFUT9M | 1057 | 0.0015 | 0.0363 | -0.098 | 5.0558 | 1095 | 0.0015 | 0.0342 | 0.1598 | 4.75357 | 1096 | 0.0011 | 0.03977 | -0.1473 | 4.7424 |
| RFUT10M | 1057 | 0.0015 | 0.0355 | -0.097 | 5.1006 | 1095 | 0.0014 | 0.0333 | 0.1704 | 4.81363 | 1096 | 0.001 | 0.03797 | -0.2216 | 5.1986 |
| RFUT11M | 1057 | 0.0015 | 0.0348 | -0.095 | 5.1657 | 1095 | 0.0014 | 0.0326 | 0.1591 | 4.78332 | 1096 | 0.001 | 0.03663 | -0.3582 | 5.8306 |
| RFUT12M | 1057 | 0.0015 | 0.0341 | -0.094 | 5.2426 | 1095 | 0.0014 | 0.0318 | 0.1856 | 4.83278 | 1096 | 0.0009 | 0.03509 | -0.1584 | 5.5152 |
| RFUT13M | 1057 | 0.0015 | 0.0335 | -0.088 | 5.3136 | 1090 | 0.0014 | 0.0315 | 0.1912 | 4.81289 | 1096 | 0.001 | 0.03423 | -0.1618 | 6.2424 |
| RFUT14M | 1057 | 0.0015 | 0.033 | -0.08 | 5.3796 | 1086 | 0.0014 | 0.0312 | 0.1509 | 4.71347 | 1096 | 0.001 | 0.03316 | -0.0257 | 5.0507 |
| RFUT15M | 1057 | 0.0015 | 0.0325 | -0.076 | 5.4326 | 1082 | 0.0013 | 0.031 | 0.1084 | 4.6703 | 1096 | 0.001 | 0.03299 | -0.0992 | 5.286 |
| RFUT16M | 1057 | 0.0015 | 0.032 | -0.075 | 5.4937 | 1073 | 0.0013 | 0.0311 | 0.0849 | 4.65007 | 1096 | 0.0009 | 0.03231 | -0.3419 | 6.5052 |
| RFUT17M | 1057 | 0.0014 | 0.0315 | -0.072 | 5.5593 | | | | | | 1096 | 0.0009 | 0.03173 | -0.5062 | 8.2397 |
| RFUT18M | 1057 | 0.0014 | 0.0311 | -0.066 | 5.6146 | | | | | | 1096 | 0.0009 | 0.03076 | -0.2321 | 6.3381 |
| TOI | 1057 | 969134 | 486821 | 0.207 | 1.4677 | 1096 | 213675 | 80041 | 0.5569 | 2.17173 | 1097 | 617839 | 355881 | 0.40205 | 2.0663 |
| TL | 1057 | 492960 | 166250 | 0.1502 | 1.9595 | 1096 | 120985 | 45889 | 0.3364 | 2.13723 | 1097 | 286434 | 116033 | -0.2065 | 1.9144 |
| TS | 1057 | 574897 | 242021 | 0.1835 | 1.6258 | 1096 | 138332 | 48333 | 0.4448 | 2.11869 | 1097 | 253500 | 92753.5 | 0.36505 | 2.2497 |
| HP | 1057 | 0.0581 | 0.0888 | 0.5961 | 3.1352 | 1096 | 0.074 | 0.0773 | 0.2368 | 2.90191 | 1097 | -0.042 | 0.14191 | -0.5866 | 2.3817 |
| CHP | 1056 | 0.0001 | 0.019 | 0.2714 | 7.9618 | 1095 | -1E-04 | 0.0286 | -0.099 | 6.3219 | 1096 | -2E-04 | 0.02128 | 0.67054 | 7.8415 |
| SP500 | 1057 | 1254.2 | 343.91 | 0.5958 | 3.3016 | 1096 | 1228.2 | 364.02 | 0.4079 | 3.21392 | 1096 | 1228.2 | 364.017 | 0.40787 | 3.2139 |
| RPSP500 | 1056 | 0.0015 | 0.0243 | -0.438 | 6.8263 | 1095 | 0.0017 | 0.0239 | -0.459 | 7.00575 | 1095 | 0.0017 | 0.02395 | -0.4595 | 7.0057 |
| RPSP500adj | 1056 | 0.0004 | 0.0071 | -0.085 | 8.9199 | 1095 | 0.0004 | 0.0074 | 0.0775 | 8.59973 | 1095 | 0.0001 | 0.00145 | -0.4599 | 7.009 |

The table shows a summary statistics of the datasets. The data covers the period between 1995-2015. Panels A, B and C exhibit the statistics of crude oil (WTI), heating oil and natural gas respectively. In each panel, there are five columns: number of observations, mean, standard deviation, skewness and kurtosis. The variables are: the futures returns of the first 18 maturities for crude oil (WTI) and natural gas, and 16 maturities for heating oil (RFUT1M ... RFUT18M), open interests positions (TOI), commercials long positions (TL), commercials short positions (TS), hedging pressure (HP), change in hedging pressure (CHP), S&P 500 composite (SP500), the stock returns (RPSP500), the adjusted stock returns, and the commodity equity correlation (DCC).

Table 2.3: Unit root test (Dickey-fuller test)

| Variable | Crude oil | | | Heating oil | | | Natural gas | | |
|---|---|---|---|---|---|---|---|---|---|
| | Obs | Test statistic | P-value | Obs | Test statistic | P-value | Obs | Test statistic | P-value |
| RFUT1M | 1056 | -35.969 | 0.0000 | 1094 | -34.809 | 0.0000 | 1095 | 34.795 | 0.0000 |
| RFUT2M | 1056 | -35.166 | 0.0000 | 1094 | -34.112 | 0.0000 | 1095 | -34.365 | 0.0000 |
| RFUT3M | 1056 | -34.968 | 0.0000 | 1094 | -33.744 | 0.0000 | 1095 | -34.328 | 0.0000 |
| RFUT4M | 1056 | -34.859 | 0.0000 | 1094 | -33.552 | 0.0000 | 1095 | -35.395 | 0.0000 |
| RFUT5M | 1056 | -34.796 | 0.0000 | 1094 | -33.723 | 0.0000 | 1095 | -34.971 | 0.0000 |
| RFUT6M | 1056 | -34.842 | 0.0000 | 1094 | -34.121 | 0.0000 | 1095 | -34.032 | 0.0000 |
| RFUT7M | 1056 | -34.756 | 0.0000 | 1094 | -34.260 | 0.0000 | 1095 | -33.153 | 0.0000 |
| RFUT8M | 1056 | -34.761 | 0.0000 | 1094 | -34.358 | 0.0000 | 1095 | -33.137 | 0.0000 |
| RFUT9M | 1056 | -34.811 | 0.0000 | 1094 | -34.454 | 0.0000 | 1095 | -33.652 | 0.0000 |
| RFUT10M | 1056 | -34.863 | 0.0000 | 1094 | -34.420 | 0.0000 | 1095 | -34.881 | 0.0000 |
| RFUT11M | 1056 | -34.900 | 0.0000 | 1094 | -34.448 | 0.0000 | 1095 | -35.775 | 0.0000 |
| RFUT12M | 1056 | -34.900 | 0.0000 | 1094 | -34.521 | 0.0000 | 1095 | -35.418 | 0.0000 |
| RFUT13M | 1056 | -34.876 | 0.0000 | 1088 | -34.582 | 0.0000 | 1095 | -35.168 | 0.0000 |
| RFUT14M | 1056 | -34.925 | 0.0000 | 1084 | -34.511 | 0.0000 | 1095 | -34.217 | 0.0000 |
| RFUT15M | 1056 | -34.990 | 0.0000 | 1080 | -34.243 | 0.0000 | 1095 | -34.17 | 0.0000 |
| RFUT16M | 1056 | -34.982 | 0.0000 | 1070 | -34.014 | 0.0000 | 1095 | -34.787 | 0.0000 |
| RFUT17M | 1056 | -35.002 | 0.0000 | | | | 1095 | -33.856 | 0.0000 |
| RFUT18M | 1056 | -35.013 | 0.0000 | | | | 1095 | -33.250 | 0.0000 |
| HP | 1056 | -3.426 | 0.0101 | 1095 | -6.192 | 0.0000 | 1096 | -2.236 | 0.1933 |
| CHP | 1055 | -27.542 | 0.0000 | 1094 | -28.24 | 0.0000 | 1095 | -27.441 | 0.0000 |
| SP500 | 1056 | -1.032 | 0.7416 | 1095 | -1.115 | 0.7089 | 1095 | -1.115 | 0.7089 |
| RPSP500 | 1055 | -36.208 | 0.0000 | 1094 | -36.849 | 0.0000 | 1094 | 36.849 | 0.0000 |
| RPSP500adj | 1057 | -35.618 | 0.0000 | 1094 | -36.824 | 0.0000 | 1094 | -36.849 | 0.0000 |

This table shows the unit root test. The tested variables are: the futures returns of the first 18 maturities for crude oil (WTI) and natural gas, and 16 maturities for heating oil (RFUT1M, RFUT2M ...), the hedging pressure (HP), the change in hedging pressure (CHP), the stock returns (RPSP500), and the adjusted stocks returns (RPSP500adj). For each commodity, there are three columns: number of observation, Dickey-Fuller test and p-value for each variable. Dickey-Fuller test is a test where the null hypothesis assumes the existence of the unit root in an autoregressive model. The alternative hypothesis assume that the time series is stationary.

## 2.5 Empirical implementation

### 2.5.1 Commodity-equity correlation

After collecting and explaining the datasets in the previous section, there is one step left to start implementing our regressions. It was explained the significance of the commodity-equity correlation in determining the commodity futures risk premium. The theoretical finding of Isleimeyyeh et al. (2017) shows the linkage between the expected stock returns and the commodity-equity correlation in determining the impact of stock market on futures risk premium. Thus, I construct an index that represents the impact of stock market. The index is named by adjusted stock returns. The index is obtained by multiplying the expected stock returns by commodity-equity correlation at each week.

$$RPSP500adj_t := \rho_t \times RPSP500_t$$

Where $\rho_t$ is the commodity-equity correlation, $RPSP500_t$ is the stock returns.

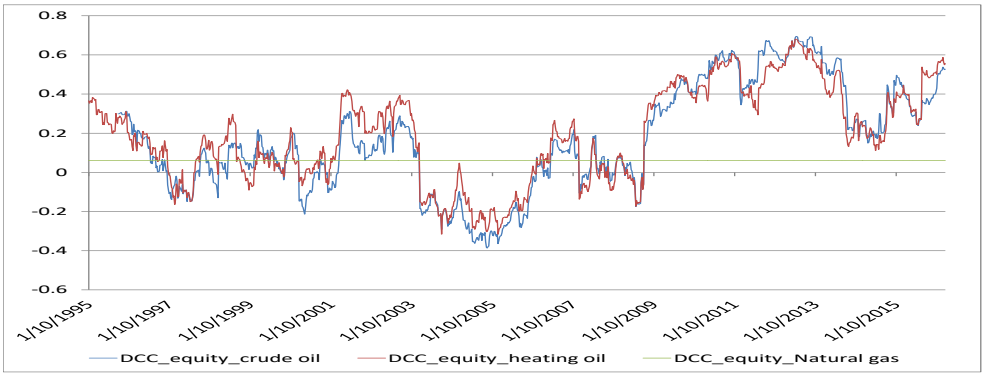
Theoretically, as introduced in Isleimeyyeh et al. (2017), the commodity-equity correlation is actually the correlation between future spot price and the stock market. Because futures prices are considered the best estimation for the future spot price, I use the first neareast-to-maturity (which is one month maturity for the tested commodities) to approximate the future spot prices. Hence, the correlation was computed between the first nearest-to-maturity futures contract returns and S&P 500 returns. I resort to compute the dynamic conditional correlation (DCC) introduced by Engle (2002) in order to have variable correlation (time series of commodity-equity correlation). Engel's model is implemented into two steps: by estimating a time varying variances GARCH(1,1) model, and then by estimating a time varying correlation by using the residual from the first step. Several papers used this methodology to study the linkage between commodity and stock markets, such as Buyukşahin et al. (2010) and Creti et al. (2013)[12].

Figure 2.1 shows the commodity-equity returns dynamic conditional correlation (DCC) of crude oil (WTI), heating oil and natural gas respectively. The commodity-equity correlations of crude oil (WTI) and heating oil was not stable (The DCC of both commodities have almost the same movements). The correlation has changed widely during different periods last two decades. For crude oil (WTI), the correlation moved between 0.3 and $-0.2$ till 2002. From 2002 to 2006, the correlation was completely negative, and it reached to $-0.38$ by the end of 2004. After 2008, the correlation increased sharply to exceed 0.6. Till 2008, the finding of DCC for crude oil corresponds with Buyukşahin et al. (2010) when their sample ended at 2008. The

[12]For the methodology of computing the DCC, you can see the papers of Buyukşahin et al. (2010) and Creti et al. (2013). They explained well the linkage increase between commodity futures and stock returns

commodity-equity correlation of heating oil have the same track as crude oil (WTI). In the period 1995-2002, the correlation moved between 0.37 and −0.164 (in average, the correlation was positive). From March 2003 to February 2006, the correlation was negative, and the lowest value was −0.32 which is marked in March 2005. After October 2008, the correlation became positive and jump significantly to reach the peak 0.68 in July 2012. Then, the correlation decreased in 2013 and reached to around 0.2 at the beginning of 2014. After then, the correlation started increasing again. On the other hand, the correlation of natural gas was stable, and it did not change wildly; the commodity-equity correlation is 0.06 in average. Therefore, we expect the commodity-equity correlation of natural gas will have stable and negligible effect on the futures risk premium through time.

Figure 2.1: Dynamic conditional correlation (DCC) between commodity and equity markets of crude oil, heating oil and natural gas, 1995-2016




Note: this figure shows the correlation between S&P 500 returns and the spot returns of crude oil (blue), heating oil (red) and natural gas (green) in the period between 1995 and 2015. The original datasets (S&P 500, the nearest-to-maturity futures prices) are obtained from Datastream.

### 2.5.2 Regressions results

In this section, I regress the futures risk premium on its determinants as explained in the theoretical motivation. I aim to test the hypothesis whether there is an impact of the financial investors on the futures risk premium. I testify the impact of the financial investors participation on the futures risk premium on three periods: 1995-2002, 2003-2008 and 2008-2015. Why do we choose this timing? I aim to study the futures risk premium on pre-financialization

and post-financialization periods. The financialisation phenomenon has appeared by the beginning of the third millennium. The aggregated non-commercials positions, which is published by CFTC, show that non-commercials long and short positions have started increasing sharply since 2002, as shown in figure 2.2. That is boosted by Masters (2008) who said that commodity index investments have risen from $ 13 billion at 2003 to $ 260 billion at March 2008. The first period, 1995-2002, refers to the pre-financialization period. The second period, 2003-2008, is ended by 2008 crisis. The third period, 2008-2016 represents post 2008-crisis. Both second and third periods refer to the post-financialization period. Furthermore, we choose these divisions to equalize the periods length.

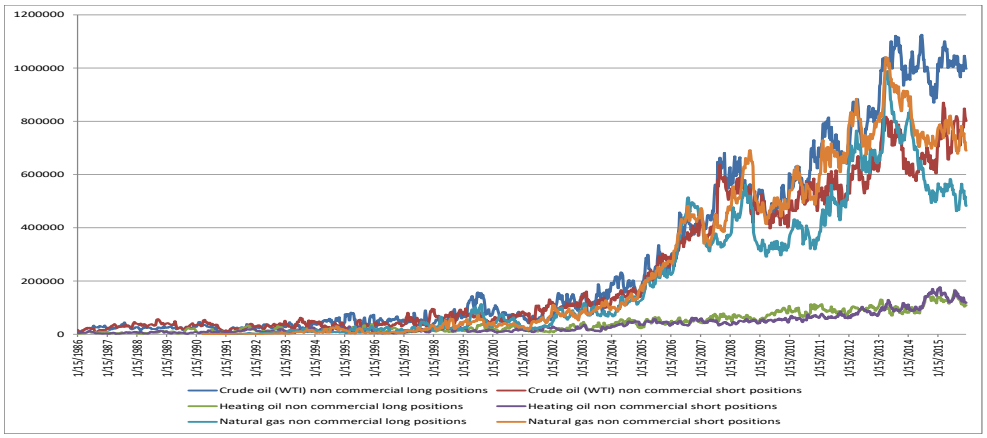
The regression equation is:

$$RFUTXM_t = \beta_1 CHP_t + \beta_2 RPSP500adj_t + \epsilon_t$$

$$RPSP500adj_t := \rho_t RPSP500_t$$

Where $RFUTXM$ is the futures risk premium of $XM$ maturity, $CHP$ is the change in net short hedging pressure, $RPSP500$ is the stock returns, $\rho$ is the commodity-equity correlation and $RPSP500adj$ is the adjusted stock returns. Finally, $\beta_1$ and $\beta_2$ are the coefficients of the net hedging pressure and the adjusted stock returns respectively.

Figure 2.2: Long and short futures positions for crude oil (WTI), Heating oil and natural gas




Source: Commodity Futures Trading Commission (CFTC)

Table 2.4 explains the regression estimation of crude oil (WTI) for the first 18 maturities. The table contains three panels: Panel A shows the estimated coefficients on the period October

1995- December 2002. Panel B shows the estimated coefficients on the period December 2002- October 2008. Panel C shows the estimated coefficients on the period October 2008- January 2016. The coefficient of the net short hedging pressure ($CHP$), in the three periods, is positive and strongly significant for each maturity. It also decreases when the maturity increases. In the period October 1995-December 2002, the coefficient decreases from 0.946 to 0.298 when the maturity increases from the $1^{st}$ to the $18^{th}$. In the period December 2002- October 2008, the coefficient decreases from 1.343 for the $1^{st}$ maturity to 0.586 for the $18^{th}$ maturity. In the period October 2008- January 2016, the coefficient decreases from 0.829 for the $1^{st}$ maturity to 0.369 for the $18^{th}$ maturity. The impact of the net hedging pressure on the futures risk premium between 2002 and 2008 is slightly higher than the other two periods. On the contrary, the coefficient of the adjusted stock returns is not significant in all periods. In the first two periods (1995-2002 and 2003-2008), the coefficient is not significant except the $1^{st}$ maturity in the period 2003-2008. But, the coefficient is positive and strongly significant in the period between 2008 and 2015. It decreases very slightly when the maturity increases (after the second maturity), where the average of the adjusted stock returns coefficient is 2.010. R-squared has inverse relationship with the increase in the maturity on the periods 1995-2002 (after the $3^{rd}$ maturity) and 2003-2008. Oppositely, R-squared has a positive relationship with the increase in the maturity. In period 1995-2002, R-squared decreases from 0.0.267 for the $3^{rd}$ maturity to 0.114 for the $18^{th}$ maturity. In the period 2003-2008, R-squared decreases from 0.2 for the $1^{st}$ maturity to 0.078 for the $18^{th}$ maturity. In post-crisis period (2008-2015), R-squared increases from 0.269 for the $1^{st}$ maturity to around 0.34 for the $18^{th}$ maturity.

Table 2.5 expresses the regression estimation of natural gas for the first 18 maturities. The table contains three panels: Panel $A$ explains the regression estimation on the period January 1995- December 2002, Panel $B$ shows the regression estimation on the period December 2002- October 2008, and Panel $C$ shows the regression estimation on the period October 2008- January 2016. The three panels show that the coefficient of the net hedging pressure is positive, significant and decreasing when the maturity increases. In Panel $A$, the coefficient of the net hedging pressure decreases from 1.329 for the $1^{st}$ maturity to 0.207 for the $18^{th}$ maturity. In Panel $B$, the coefficient decreases from 1.864 for $1^{st}$ maturity to 0.330 for $18^{th}$ maturity. In Panel $C$, it decreases from 0.791 for $1^{st}$ maturity to 0.143 for $18^{th}$ maturity. The coefficient of the adjusted stock returns is varied in the three periods. In the period January 1995- December 2002, the coefficient of stock returns is significant only for $1^{st}$ , $5^{th}$, $6^{th}$ and $7^{th}$ maturity at 10% level of confidence. In the period December 2002- October 2008, the coefficient is also significant for few maturities ($2^{nd}$, $5^{th}$, $6^{th}$, $8^{th}$, $14^{th}$ and $15^{th}$ at 10% level of confidence, and $13^{th}$ at 5% level of confidence). However, in the period October 2008- January 2016, the coefficient of the adjusted stock returns is positive and significant. R-squared dropped significantly in the

period 2008-2015. Even it is negligible; it is between 0.049 and 0.082 for the available maturities.

Table 2.6 demonstrates the regression estimation of heating oil for the first 16 maturities on the periods: January 1995- December 2002, December 2002- October 2008 and October 2008- January 2016. Panel $A$, $B$ and $C$ show the regression estimation on the periods January 1995- December 2002, December 2002- October 2008 and October 2008- January 2016 respectively. As same as crude oil (WTI) and natural gas, the coefficient of the net short hedging pressure is positive and significant, at 1% level of confidence, on all periods. Also, it decreases when the maturity increases. In the period January 1995- December 2002, the coefficient of the net hedging pressure decreases from 0.818 for the $1^{st}$ maturity to 0.276 for the $16^{th}$ maturity. In the period December 2002- October 2008, the coefficient decreases from 0.898 for the $1^{st}$ maturity to 0.532 for the $16^{th}$ maturity. In the period October 2008- January 2016, the coefficient decreases from 0.729 for the $1^{st}$ maturity to 0.510 for the $16^{th}$ maturity. The coefficient of the adjusted stock returns is not significant in all time. In the period January 1995- December 2002, there is eleven from sixteen maturities that the coefficient is significant at 5% or 10% level of confidence. In the period December 2002- October 2008, the coefficient is not significant for any maturity. Inversely, in the period October 2008- January 2016, the coefficient of the adjusted stock returns is positive and strongly significant for all the maturities. It does not decrease widely when the maturity increases; the average of the stock returns coefficient is 1.629. R-squared generally decreases when the maturity increases on the periods 1995-2002 and 2003-2008. On the contrary, R-squared is almost stable when the maturity increases (around 0.4).

Before finish speaking about the regressions, I implemented some further regressions to test the heteroskedasticity and the autocorrelation. I test the autocorrelation by testing the autoregressive model AR(1) for the residual term as shown in table 2.9. By using the previous test, autocorrelation has appeared in the period 1995-2002. Inversely, the residual is not correlated in the periods 2003-2008 and 2008-2015. Furthermore, I also find the results of Durban Watson test, where it is explained in table 2.10. It shows to us that for each regression, there is no autocorrelation problem. To test the heteroskedasticity, I test Autoregressive Conditional Heteroskedasticity model ARCH(1). The results as shown in table 2.7 and 2.8, show that there is a heteroskedasticity. However, heteroskedasticity does not cause bias or inconsistency in the estimated parameters.

### 2.5.3 Economic interpretation

The coefficient of the net short hedging pressure ($CHP$) for the tested commodities (crude oil (WTI), heating oil and natural gas) is positive and significant. It also decreases when the maturity increases. First, I conclude that hedging pressure is an important determinant of the

futures risk premium during different periods and different circumstances. This finding corresponds with Bessembinder (1992), Hirshleifer (1990), De Roon et al. (2000), Basu and Miffre (2013), Boons et al. (2014) and others. Second, the positive coefficient of the net short hedging pressure is interpreted by the traditional price pressure hypothesis. This hypothesis states that a net short (long) futures positions related with positive (negative) bias in the futures prices. This hypothesis corresponds with the theoretical findings of Ekeland et al. (2015) who find that the sign and the magnitude of the hedging pressure determine the sign of the bias in the futures price (when the hedging pressure is short (long), the futures market is in backwardation (contango)). Third, my results show that the coefficient of the net short hedging pressure decreases when the maturity increases. Therefore, I may induce that the hedging pressure is strong explanatory variable for the short maturities. The data collected by CFTC is aggregated, so we can not have specific futures positions for each maturity. However, based on the avialable data, I say that the hedging activities are greater in the short maturities. This finding corresponds with Haase and Zimmermann (2013) who study the risk premium of crude oil for different maturities.

My results show the virtual impact of the stock market appeared after 2008 financial crisis. Thus, I expect that the stock market became a strong explanatory variable after 2008. This result is might be interpreted by the dramatically increase in the commodity-equity correlation especially for crude oil and heating oil. The increase in the commodity-equity correlation makes the diversification in commodity markets doubtable. The latter argument is boosted by Daskalaki and Skiadopoulos (2011) and Belousova and Dorfleitner (2012). Therefore, the financial investors must be remunerated to their risk bearing in the futures market, (Keynes (1930)). Also, the positive sign of the coefficient corresponds with the theoretical finding of Isleimeyyeh et al. (2017), which states that an expected positive stocks returns accompanied by a positive commodity-equity correlation increase the futures risk premium.

The results also show that the impact of stock market overwhelms the impact of hedging pressure for longer maturities of crude oil (WTI) and heating oil. For short maturities, the result corresponds with Boons et al. (2014) who find that the majority of futures returns is attributed to the traditional hedging pressure. However, they study only the first two nearest-to-maturities. My result is quite plausible. As I explained before, the hedgers are more active in short maturities, and their effect decrease when the maturity increases. On the contrary, the financial investors are passive investors, who are interested in holding the futures contracts to secure their portfolios. When the contracts become closer to the delivery, they roll over the futures contract and buy other futures contracts with longer maturities. Logically, they are active in trading long maturities.

Table 2.4: Regression estimation for crude oil (WTI) on the periods 1995-2002, 2003-2008 and 2008-2015

| | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | CHP | RPSP500adj | Obs | R-squared | CHP | RPSP500adj | Obs | R-squared | CHP | RPSP500adj | Obs | R-squared |
| RFUT1M | 0.946*** | -0.0827 | 376 | 0.200 | 1.343*** | 1.483* | 307 | 0.200 | 0.829*** | 2.097*** | 375 | 0.269 |
| | (0.0981) | (0.574) | | | (0.156) | (0.860) | | | (0.185) | (0.213) | | |
| RFUT2M | 0.927*** | -0.0915 | 376 | 0.258 | 1.276*** | 0.998 | 307 | 0.195 | 0.758*** | 2.172*** | 375 | 0.295 |
| | (0.0817) | (0.477) | | | (0.149) | (0.823) | | | (0.175) | (0.201) | | |
| RFUT3M | 0.863*** | -0.0320 | 376 | 0.267 | 1.212*** | 0.838 | 307 | 0.192 | 0.719*** | 2.163*** | 375 | 0.311 |
| | (0.0743) | (0.434) | | | (0.143) | (0.790) | | | (0.166) | (0.192) | | |
| RFUT4M | 0.784*** | 0.0246 | 376 | 0.261 | 1.144*** | 0.714 | 307 | 0.184 | 0.686*** | 2.145*** | 375 | 0.319 |
| | (0.0686) | (0.401) | | | (0.138) | (0.763) | | | (0.161) | (0.185) | | |
| RFUT5M | 0.714*** | 0.0718 | 376 | 0.251 | 1.079*** | 0.628 | 307 | 0.174 | 0.651*** | 2.120*** | 375 | 0.324 |
| | (0.0642) | (0.375) | | | (0.135) | (0.744) | | | (0.156) | (0.180) | | |
| RFUT6M | 0.650*** | 0.0936 | 376 | 0.229 | 1.018*** | 0.547 | 307 | 0.164 | 0.620*** | 2.093*** | 375 | 0.327 |
| | (0.0621) | (0.363) | | | (0.132) | (0.728) | | | (0.152) | (0.176) | | |
| RFUT7M | 0.603*** | 0.136 | 376 | 0.229 | 0.961*** | 0.496 | 307 | 0.154 | 0.592*** | 2.074*** | 375 | 0.330 |
| | (0.0577) | (0.337) | | | (0.129) | (0.715) | | | (0.149) | (0.172) | | |
| RFUT8M | 0.558*** | 0.146 | 376 | 0.218 | 0.910*** | 0.44 | 307 | 0.144 | 0.566*** | 2.053*** | 375 | 0.333 |
| | (0.0552) | (0.323) | | | (0.127) | (0.704) | | | (0.146) | (0.168) | | |
| RFUT9M | 0.518*** | 0.180 | 376 | 0.206 | 0.867*** | 0.384 | 307 | 0.135 | 0.543*** | 2.031*** | 375 | 0.336 |
| | (0.0533) | (0.311) | | | (0.126) | (0.695) | | | (0.143) | (0.165) | | |
| RFUT10M | 0.485*** | 0.201 | 376 | 0.194 | 0.826*** | 0.353 | 307 | 0.127 | 0.517*** | 2.009*** | 375 | 0.337 |
| | (0.0519) | (0.303) | | | (0.124) | (0.687 | | | (0.140) | (0.162) | | |
| RFUT11M | 0.453*** | 0.229 | 376 | 0.182 | 0.790*** | 0.343 | 307 | 0.120 | 0.491*** | 1.985*** | 375 | 0.338 |
| | (0.0505) | (0.295) | | | (0.123) | (0.678) | | | (0.138) | (0.159) | | |
| RFUT12M | 0.425*** | 0.246 | 376 | 0.171 | 0.754*** | 0.342 | 307 | 0.113 | 0.467*** | 1.960*** | 375 | 0.338 |
| | (0.0493) | (0.288) | | | (0.121) | (0.671) | | | (0.136) | (0.156) | | |
| RFUT13M | 0.398*** | 0.254 | 376 | 0.160 | 0.720*** | 0.332 | 307 | 0.105 | 0.445*** | 1.938*** | 375 | 0.338 |
| | (0.0482) | (0.282) | | | (0.120) | (0.665) | | | (0.133) | (0.154) | | |
| RFUT14M | 0.372*** | 0.251 | 376 | 0.148 | 0.688*** | 0.323 | 307 | 0.099 | 0.427*** | 1.914*** | 375 | 0.338 |
| | (0.0472) | (0.276) | | | (0.119) | (0.659) | | | (0.131) | (0.151) | | |
| RFUT15M | 0.351*** | 0.247 | 376 | 0.138 | 0.659*** | 0.321 | 307 | 0.092 | 0.412*** | 1.892*** | 375 | 0.339 |
| | (0.0464) | (0.271) | | | (0.118) | (0.654) | | | (0.130) | (0.149) | | |
| RFUT16M | 0.331*** | 0.261 | 376 | 0.129 | 0.634*** | 0.272 | 307 | 0.088 | 0.396*** | 1.868*** | 375 | 0.338 |
| | (0.0458) | (0.268) | | | (0.117) | (0.648) | | | (0.128) | (0.147) | | |
| RFUT17M | 0.314*** | 0.263 | 376 | 0.121 | 0.608*** | 0.250 | 307 | 0.082 | 0.382*** | 1.842*** | 375 | 0.337 |
| | (0.0451) | (0.263) | | | (0.116) | (0.644) | | | (0.126) | (0.145) | | |
| RFUT18M | 0.298*** | 0.275 | 376 | 0.114 | 0.586*** | 0.250 | 307 | 0.078 | 0.369*** | 1.818*** | 375 | 0.336 |
| | (0.0443) | (0.259) | | | (0.116) | (0.640) | | | (0.124) | (0.143) | | |

This table shows the regression results of crude oil (WTI) for 18 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2015 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; $Obs$ indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.5: Regression estimation for Natural gas on the periods 1995-2002, 2003-2008 and 2008-2015

| | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | CHP | RPSP500adj | Obs | R-squared | CHP | RPSP500adj | Obs | R-squared | CHP | RPSP500adj | Obs | R-squared |
| RFUT1M | 1.329*** | 4.262* | 417 | 0.190 | 1.864*** | 4.339 | 302 | 0.160 | 0.791*** | 4.503** | 378 | 0.064 |
| | (0.139) | (2.243) | | | (0.248) | (3.646) | | | (0.175) | (2.069) | | |
| RFUT2M | 1.292*** | 2.594 | 417 | 0.211 | 1.810*** | 5.344* | 302 | 0.213 | 0.827*** | 4.308** | 378 | 0.078 |
| | (0.125) | (2.012) | | | (0.203) | (2.990) | | | (0.161) | (1.906) | | |
| RFUT3M | 1.164*** | 2.208 | 417 | 0.209 | 1.664*** | 4.161 | 302 | 0.199 | 0.716*** | 4.627*** | 378 | 0.075 |
| | (0.113) | (1.821) | | | (0.194) | (2.860) | | | (0.149) | (1.759) | | |
| RFUT4M | 0.976*** | 1.919 | 417 | 0.200 | 1.359*** | 4.121 | 302 | 0.175 | 0.617*** | 4.955*** | 378 | 0.074 |
| | (0.0973) | (1.572) | | | (0.172) | (2.535) | | | (0.138) | (1.626) | | |
| RFUT5M | 0.769*** | 2.438* | 417 | 0.170 | 1.259*** | 3.961* | 302 | 0.170 | 0.499*** | 4.940*** | 378 | 0.064 |
| | (0.0859) | (1.387) | | | (0.163) | (2.395) | | | (0.130) | (1.540) | | |
| RFUT6M | 0.644*** | 2.239* | 417 | 0.143 | 0.946*** | 3.697* | 302 | 0.125 | 0.471*** | 5.285*** | 378 | 0.069 |
| | (0.0800) | (1.292) | | | (0.148) | (2.174) | | | (0.124) | (1.467) | | |
| RFUT7M | 0.568*** | 2.220* | 417 | 0.124 | 1.013*** | 3.320 | 302 | 0.157 | 0.495*** | 4.685*** | 378 | 0.078 |
| | (0.0773) | (1.248) | | | (0.138) | (2.025) | | | (0.114) | (1.345) | | |
| RFUT8M | 0.517*** | 1.520 | 417 | 0.107 | 1.036*** | 3.182* | 302 | 0.196 | 0.498*** | 3.744*** | 378 | 0.080 |
| | (0.0751) | (1.213) | | | (0.123) | (1.804) | | | (0.104) | (1.229) | | |
| RFUT9M | 0.483*** | 1.199 | 417 | 0.097 | 1.098*** | 2.082 | 302 | 0.206 | 0.452*** | 3.507*** | 378 | 0.075 |
| | (0.0736) | (1.189) | | | (0.125) | (1.836) | | | (0.0990) | (1.171) | | |
| RFUT10M | 0.417*** | 0.955 | 417 | 0.082 | 0.828*** | 1.730 | 302 | 0.121 | 0.409*** | 3.513*** | 378 | 0.073 |
| | (0.0696) | (1.124) | | | (0.129) | (1.900) | | | (0.0938) | (1.109) | | |
| RFUT11M | 0.348*** | 0.922 | 417 | 0.062 | 0.753*** | 2.280 | 302 | 0.106 | 0.365*** | 3.752*** | 378 | 0.074 |
| | (0.0677) | (1.094) | | | (0.128) | (1.879) | | | (0.0889) | (1.052) | | |
| RFUT12M | 0.270*** | 1.348 | 417 | 0.044 | 0.487*** | 2.161 | 302 | 0.054 | 0.342*** | 3.983*** | 378 | 0.074 |
| | (0.0655) | (1.057) | | | (0.122) | (1.794) | | | (0.0884) | (1.045) | | |
| RFUT13M | 0.264*** | 1.184 | 417 | 0.044 | 0.286** | 4.339** | 302 | 0.036 | 0.377*** | 3.745*** | 378 | 0.082 |
| | (0.0637) | (1.029) | | | (0.120) | (1.770) | | | (0.0859) | (1.016) | | |
| RFUT14M | 0.276*** | 0.253 | 417 | 0.045 | 0.407*** | 3.174* | 302 | 0.050 | 0.369*** | 3.399*** | 378 | 0.080 |
| | (0.0627) | (1.013) | | | (0.114) | (1.682) | | | (0.0828) | (0.979) | | |
| RFUT15M | 0.321*** | -0.0936 | 417 | 0.061 | 0.549*** | 2.996* | 302 | 0.078 | 0.278*** | 3.143*** | 378 | 0.058 |
| | (0.0622) | (1.004) | | | (0.115) | (1.688) | | | (0.0809) | (0.956) | | |
| RFUT16M | 0.300*** | -0.126 | 417 | 0.056 | 0.481*** | 2.111 | 302 | 0.057 | 0.219*** | 3.347*** | 378 | 0.055 |
| | (0.0604) | (0.975) | | | (0.117) | (1.716) | | | (0.0775) | (0.916) | | |
| RFUT17M | 0.252*** | 0.536 | 417 | 0.042 | 0.491*** | 1.704 | 302 | 0.059 | 0.177** | 3.231*** | 378 | 0.049 |
| | (0.0605) | (0.977) | | | (0.115) | (1.689) | | | (0.0746) | (0.882) | | |
| RFUT18M | 0.207*** | 0.720 | 417 | 0.030 | 0.330*** | 1.774 | 302 | 0.032 | 0.143** | 3.823*** | 378 | 0.060 |
| | (0.0600) | (0.968) | | | (0.110) | (1.618) | | | (0.0726) | (0.859) | | |

This table shows the regression results of Natural for 18 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2016 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; *Obs* indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.6: Regression estimation for Heating oil on the periods 1995-2002, 2003-2008 and 2008-2015

| | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | CHP | RPSP500adj | Obs | R-squared | CHP | RPSP500adj | Obs | R-squared | CHP | RPSP500adj | Obs | R-squared |
| RFUT1M | 0.818*** | 0.625* | 418 | 0.292 | 0.898*** | -0.175 | 302 | 0.259 | 0.729*** | 1.745*** | 377 | 0.392 |
| | (0.0641) | (0.348) | | | (0.0877) | (0.877) | | | (0.0804) | (0.175) | | |
| RFUT2M | 0.748*** | 0.524* | 418 | 0.329 | 0.867*** | -0.488 | 302 | 0.262 | 0.701*** | 1.773*** | 377 | 0.399 |
| | (0.0537) | (0.291) | | | (0.0844) | (0.843) | | | (0.0785) | (0.171) | | |
| RFUT3M | 0.677*** | 0.429 | 418 | 0.317 | 0.839*** | -0.533 | 302 | 0.269 | 0.697*** | 1.715*** | 377 | 0.397 |
| | (0.0498) | (0.270) | | | (0.0803) | (0.802) | | | (0.0771) | (0.167) | | |
| RFUT4M | 0.615*** | 0.336 | 418 | 0.299 | 0.824*** | -0.398 | 302 | 0.279 | 0.677*** | 1.676*** | 377 | 0.396 |
| | (0.0470) | (0.255) | | | (0.0767) | (0.766) | | | (0.0754) | (0.164) | | |
| RFUT5M | 0.553*** | 0.349 | 418 | 0.280 | 0.799*** | -0.0177 | 302 | 0.279 | 0.653*** | 1.657*** | 377 | 0.396 |
| | (0.0445) | (0.241) | | | (0.0743) | (0.742) | | | (0.0737) | (0.160) | | |
| RFUT6M | 0.487*** | 0.408* | 418 | 0.255 | 0.764*** | 0.209 | 302 | 0.269 | 0.632*** | 1.645*** | 377 | 0.396 |
| | (0.0421) | (0.229) | | | (0.0728) | (0.727) | | | (0.0723) | (0.157) | | |
| RFUT7M | 0.433*** | 0.457** | 418 | 0.238 | 0.704*** | 0.173 | 302 | 0.245 | 0.622*** | 1.630*** | 377 | 0.399 |
| | (0.0396) | (0.215) | | | (0.0714) | (0.713) | | | (0.0710) | (0.154) | | |
| RFUT8M | 0.389*** | 0.516** | 418 | 0.221 | 0.643*** | -0.00343 | 302 | 0.221 | 0.607*** | 1.615*** | 377 | 0.399 |
| | (0.0379) | (0.206) | | | (0.0698) | (0.697) | | | (0.0700) | (0.152) | | |
| RFUT9M | 0.359*** | 0.478** | 418 | 0.205 | 0.586*** | -0.216 | 302 | 0.200 | 0.599*** | 1.596*** | 377 | 0.403 |
| | (0.0367) | (0.199) | | | (0.0679) | (0.679) | | | (0.0685) | (0.149) | | |
| RFUT10M | 0.342*** | 0.455** | 418 | 0.201 | 0.553*** | -0.281 | 302 | 0.190 | 0.584*** | 1.589*** | 377 | 0.407 |
| | (0.0353) | (0.192) | | | (0.0662) | (0.661) | | | (0.0671) | (0.146) | | |
| RFUT11M | 0.329*** | 0.377** | 418 | 0.187 | 0.541*** | -0.169 | 302 | 0.189 | 0.572*** | 1.561*** | 377 | 0.409 |
| | (0.0353) | (0.191) | | | (0.0648) | (0.648) | | | (0.0655) | (0.142) | | |
| RFUT12M | 0.312*** | 0.347* | 418 | 0.188 | 0.522*** | -0.0167 | 302 | 0.180 | 0.557*** | 1.570*** | 377 | 0.417 |
| | (0.0332) | (0.180) | | | (0.0643) | (0.642) | | | (0.0640) | (0.139) | | |
| RFUT13M | 0.299*** | 0.326* | 418 | 0.181 | 0.516*** | 0.0149 | 302 | 0.177 | 0.546*** | 1.577*** | 372 | 0.417 |
| | (0.0325) | (0.176) | | | (0.0642) | (0.642) | | | (0.0637) | (0.139) | | |
| RFUT14M | 0.288*** | 0.302* | 418 | 0.169 | 0.511*** | -0.157 | 302 | 0.176 | 0.533*** | 1.561*** | 368 | 0.413 |
| | (0.0326) | (0.177) | | | (0.0639) | (0.638) | | | (0.0633) | (0.139) | | |
| RFUT15M | 0.278*** | 0.266 | 418 | 0.157 | 0.521*** | -0.170 | 302 | 0.184 | 0.524*** | 1.538*** | 364 | 0.410 |
| | (0.0327) | (0.177) | | | (0.0635) | (0.634) | | | (0.0631) | (0.139) | | |
| RFUT16M | 0.276*** | 0.203 | 414 | 0.146 | 0.532*** | -0.102 | 302 | 0.192 | 0.510*** | 1.519*** | 359 | 0.404 |
| | (0.0338) | (0.183) | | | (0.0632) | (0.632) | | | (0.0632) | (0.138) | | |

This table shows the regression results of heating oil for 16 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2016 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; $Obs$ indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.7: Autoregressive Conditional Heteroskedasticity ARCH(1)(a)

| | Crude oil | | | | | | | | | Heating oil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables | 1995-2002 Obs=375 | | | 2003-2008 Obs=307 | | | 2008-2016 Obs=375 | | | 1995-2002 Obs=417 (412 for M16) | | | 2003-2008 Obs=302 | | |
| | $\gamma_1$ | $\gamma_0$ | R-squared | $\gamma_1$ | $\gamma_0$ | R-squared | $\gamma_1$ | $\gamma_0$ | R-squared | $\gamma_1$ | $\gamma_0$ | R-squared | $\gamma_1$ | $\gamma_0$ | R-squared |
| $1^{st}$ maturity | 0.180*** | 0.00188*** | 0.033 | 0.289*** | 0.00139*** | 0.082 | 0.351*** | 0.00122*** | 0.124 | 0.348*** | 0.00119*** | 0.121 | 0.0762 | 0.00173*** | 0.006 |
| | (0.0509) | (0.000259) | | (0.0553) | (0.000208) | | (0.0483) | (0.000229) | | (0.0460) | (0.000174) | | (0.0576) | (0.000221) | |
| $2^{nd}$ maturity | 0.128** | 0.00139*** | 0.016 | 0.320*** | 0.00122*** | 0.099 | 0.234*** | 0.00129*** | 0.055 | 0.0599 | 0.00121*** | 0.004 | 0.0447 | 0.00166*** | 0.002 |
| | (0.0513) | (0.000169) | | (0.0552) | (0.000197) | | (0.0503) | (0.000206) | | (0.0490) | (0.000111) | | (0.0578) | (0.000201) | |
| $3^{rd}$ maturity | 0.137*** | 0.00113*** | 0.019 | 0.313*** | 0.00114*** | 0.095 | 0.170*** | 0.00127*** | 0.029 | 0.0708 | 0.00102*** | 0.005 | 0.0337 | 0.00152*** | 0.001 |
| | (0.0513) | (0.000142) | | (0.0555) | (0.000182) | | (0.0509) | (0.000190) | | (0.0492) | (9.91e-05) | | (0.0578) | (0.000177) | |
| $4^{th}$ maturity | 0.150*** | 0.000953*** | 0.022 | 0.339*** | 0.00102*** | 0.110 | 0.151*** | 0.00121*** | 0.023 | 0.0858* | 0.000901*** | 0.007 | 0.0387 | 0.00138*** | 0.001 |
| | (0.0512) | (0.000122) | | (0.0552) | (0.000168) | | (0.0511) | (0.000178) | | (0.0491) | (9.37e-05) | | (0.0578) | (0.000162) | |
| $5^{th}$ maturity | 0.162*** | 0.000822*** | 0.026 | 0.356*** | 0.000949*** | 0.121 | 0.151*** | 0.00114*** | 0.023 | 0.0969** | 0.000794*** | 0.009 | 0.0591 | 0.00126*** | 0.003 |
| | (0.0511) | (0.000106) | | (0.0550) | (0.000159) | | (0.0511) | (0.000167) | | (0.0489) | (8.60e-05) | | (0.0578) | (0.000153) | |
| $6^{th}$ maturity | 0.238*** | 0.000701*** | 0.056 | 0.369*** | 0.000892*** | 0.129 | 0.163*** | 0.00107*** | 0.027 | 0.153*** | 0.000669*** | 0.023 | 0.0931 | 0.00117*** | 0.009 |
| | (0.0503) | (9.87e-05) | | (0.0550) | (0.000152) | | (0.0510) | (0.000157) | | (0.0485) | (7.36e-05) | | (0.0576) | (0.000147) | |
| $7^{th}$ maturity | 0.184*** | 0.000646*** | 0.034 | 0.376*** | 0.000851*** | 0.133 | 0.181*** | 0.00100*** | 0.033 | 0.168*** | 0.000582*** | 0.028 | 0.142** | 0.00106*** | 0.020 |
| | (0.0509) | (8.45e-05) | | (0.0550) | (0.000148) | | (0.0508) | (0.000150) | | (0.0484) | (6.40e-05) | | (0.0573) | (0.000139) | |
| $8^{th}$ maturity | 0.200*** | 0.000580*** | 0.040 | 0.383*** | 0.000818*** | 0.137 | 0.203*** | 0.000936*** | 0.042 | 0.179*** | 0.000525*** | 0.032 | 0.172*** | 0.000983*** | 0.030 |
| | (0.0507) | (7.69e-05) | | (0.0551) | (0.000144) | | (0.0506) | (0.000143) | | (0.0483) | (5.86e-05) | | (0.0570) | (0.000133) | |
| $9^{th}$ maturity | 0.204*** | 0.000538*** | 0.042 | 0.389*** | 0.000790*** | 0.141 | 0.227*** | 0.000872*** | 0.052 | 0.186*** | 0.000488*** | 0.035 | 0.190*** | 0.000911*** | 0.036 |
| | (0.0507) | (7.08e-05) | | (0.0551) | (0.000140) | | (0.0503) | (0.000136) | | (0.0482) | (5.47e-05) | | (0.0568) | (0.000125) | |
| $10^{th}$ maturity | 0.219*** | 0.000501*** | 0.048 | 0.393*** | 0.000768*** | 0.142 | 0.251*** | 0.000814*** | 0.063 | 0.219*** | 0.000433*** | 0.048 | 0.183*** | 0.000872*** | 0.033 |
| | (0.0505) | (6.69e-05) | | (0.0553) | (0.000137) | | (0.0500) | (0.000130) | | (0.0479) | (4.95e-05) | | (0.0569) | (0.000117) | |
| $11^{th}$ maturity | 0.227*** | 0.000470*** | 0.052 | 0.395*** | 0.000747*** | 0.143 | 0.268*** | 0.000767*** | 0.072 | 0.256*** | 0.000411*** | 0.066 | 0.163*** | 0.000857*** | 0.027 |
| | (0.0504) | (6.36e-05) | | (0.0554) | (0.000134) | | (0.0498) | (0.000125) | | (0.0474) | (4.99e-05) | | (0.0571) | (0.000112) | |
| $12^{th}$ maturity | 0.238*** | 0.000441*** | 0.057 | 0.393*** | 0.000733*** | 0.141 | 0.284*** | 0.000726*** | 0.081 | 0.229*** | 0.000379*** | 0.053 | 0.152*** | 0.000854*** | 0.023 |
| | (0.0503) | (6.10e-05) | | (0.0557) | (0.000132) | | (0.0495) | (0.000121) | | (0.0478) | (4.34e-05) | | (0.0572) | (0.000108) | |
| $13^{th}$ maturity | 0.246*** | 0.000417*** | 0.060 | 0.389*** | 0.000725*** | 0.137 | 0.295*** | 0.000691*** | 0.087 | 0.223*** | 0.000366*** | 0.050 | 0.142** | 0.000863*** | 0.020 |
| | (0.0502) | (5.85e-05) | | (0.0560) | (0.000129) | | (0.0494) | (0.000117) | | (0.0478) | (4.19e-05) | | (0.0573) | (0.000107) | |
| $14^{th}$ maturity | 0.251*** | 0.000399*** | 0.063 | 0.385*** | 0.000718*** | 0.133 | 0.307*** | 0.000659*** | 0.094 | 0.203*** | 0.000377*** | 0.041 | 0.140** | 0.000854*** | 0.019 |
| | (0.0501) | (5.64e-05) | | (0.0563) | (0.000128) | | (0.0492) | (0.000114) | | (0.0481) | (4.23e-05) | | (0.0573) | (0.000106) | |
| $15^{th}$ maturity | 0.256*** | 0.000382*** | 0.066 | 0.380*** | 0.000712*** | 0.129 | 0.319*** | 0.000629*** | 0.102 | 0.188*** | 0.000387*** | 0.035 | 0.135** | 0.000849*** | 0.018 |
| | (0.0501) | (5.44e-05) | | (0.0566) | (0.000126) | | (0.0490) | (0.000111) | | (0.0483) | (4.39e-05) | | (0.0573) | (0.000105) | |
| $16^{th}$ maturity | 0.258*** | 0.000372*** | 0.066 | 0.381*** | 0.000698*** | 0.129 | 0.330*** | 0.000603*** | 0.109 | 0.209*** | 0.000402*** | 0.044 | 0.135** | 0.000842*** | 0.018 |
| | (0.0500) | (5.33e-05) | | (0.0568) | (0.000124) | | (0.0488) | (0.000108) | | (0.0484) | (4.73e-05) | | (0.0573) | (0.000106) | |
| $17^{th}$ maturity | 0.258*** | 0.000360*** | 0.067 | 0.378*** | 0.000692*** | 0.126 | 0.338*** | 0.000579*** | 0.115 | | | | | | |
| | (0.0500) | (5.21e-05) | | (0.0570) | (0.000123) | | (0.0487) | (0.000105) | | | | | | | |
| $18^{th}$ maturity | 0.253*** | 0.000351*** | 0.064 | 0.375*** | 0.000688*** | 0.123 | 0.347*** | 0.000556*** | 0.120 | | | | | | |
| | (0.0501) | (5.07e-05) | | (0.0573) | (0.000122) | | (0.0485) | (0.000103) | | | | | | | |
| | | | | ) | | | | | | | | | | | |

Continue ...

This table shows the Autoregressive Conditional Heteroskedasticity model ARCH(1) of the implemented regressions. For each maturity,

1. I implement the following regression

$$RFUTXM_t = \beta_1 CHP_t + \beta_2 RPSP500adj_t + \epsilon_t$$

2. Then, I regress

$$\epsilon_t^2 = \gamma_0 + \gamma_1 \epsilon_{t-1}^2 + u_t$$

I implement the previous process for the tested commodity: crude oil, heating oil and natural gas. For each commodity, I do the regressions for three sub-periods: 1995-2002, 2003-2008 and 2008-2015. Obs means the number of observations. $\gamma_0$ is the constant. $\gamma_1$ is the coefficient of the squared residual lag. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively.

Table 2.8: Autoregressive Conditional Heteroskedasticity ARCH(1) (b)

| | Heating oil | | | | | | Natural gas | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables | 2008-2016 Obs=377[13] | | | 1995-2002 Obs=416 | | | 2003-2008 Obs=302 | | | 2008-2015 Obs=378 | | |
| | $\gamma_1$ | $\gamma_0$ | R-squared | $\gamma_1$ | $\gamma_0$ | R-squared | $\gamma_1$ | $\gamma_0$ | R-squared | $\gamma_1$ | $\gamma_0$ | R-squared |
| $1^{st}$ maturity | 0.0979** | 0.00108*** | 0.010 | 0.170*** | 0.00429*** | 0.029 | 0.131** | 0.00497*** | 0.017 | 0.0633 | 0.00363*** | 0.003 |
| | (0.0497) | (0.000179) | | (0.0482) | (0.000580) | | (0.0572) | (0.00143) | | (0.0554) | (0.000502) | |
| $2^{nd}$ maturity | 0.111** | 0.00101*** | 0.013 | 0.286*** | 0.00298*** | 0.082 | 0.0793 | 0.00354*** | 0.006 | 0.0401 | 0.00316*** | 0.001 |
| | (0.0494) | (0.000168) | | (0.0469) | (0.000422) | | (0.0575) | (0.000508) | | (0.0547) | (0.000384) | |
| $3^{rd}$ maturity | 0.114** | 0.000974*** | 0.014 | 0.237*** | 0.00262*** | 0.056 | 0.0777 | 0.00325*** | 0.006 | 0.0551 | 0.00264*** | 0.003 |
| | (0.0492) | (0.000152) | | (0.0477) | (0.000384) | | (0.0576) | (0.000596) | | (0.0534) | (0.000334) | |
| $4^{th}$ maturity | 0.106** | 0.000940*** | 0.012 | 0.173*** | 0.00211*** | 0.030 | 0.0625 | 0.00259*** | 0.004 | 0.0731 | 0.00222*** | 0.005 |
| | (0.0490) | (0.000142) | | (0.0483) | (0.000255) | | (0.0576) | (0.000432) | | (0.0524) | (0.000271) | |
| $5^{th}$ maturity | 0.0973** | 0.000905*** | 0.011 | 0.151*** | 0.00169*** | 0.023 | 0.0860 | 0.00226*** | 0.007 | 0.0808 | 0.00197*** | 0.006 |
| | (0.0487) | (0.000135) | | (0.0485) | (0.000205) | | (0.0575) | (0.000356) | | (0.0518) | (0.000285) | |
| $6^{th}$ maturity | 0.0931* | 0.000877*** | 0.010 | 0.136*** | 0.00149*** | 0.019 | 0.0902 | 0.00185*** | 0.008 | 0.0852* | 0.00178*** | 0.007 |
| | (0.0485) | (0.000130) | | (0.0487) | (0.000184) | | (0.0575) | (0.000251) | | (0.0516) | (0.000266) | |
| $7^{th}$ maturity | 0.0934* | 0.000845*** | 0.010 | 0.122** | 0.00142*** | 0.015 | 0.0693 | 0.00164*** | 0.005 | 0.0279 | 0.00159*** | 0.001 |
| | (0.0484) | (0.000125) | | (0.0488) | (0.000183) | | (0.0576) | (0.000241) | | (0.0519) | (0.000209) | |
| $8^{th}$ maturity | 0.0972** | 0.000816*** | 0.011 | 0.164*** | 0.00127*** | 0.027 | 0.0323 | 0.00136*** | 0.001 | 0.0439 | 0.00131*** | 0.002 |
| | (0.0484) | (0.000120) | | (0.0485) | (0.000167) | | (0.0577) | (0.000166) | | (0.0522) | (0.000140) | |
| $9^{th}$ maturity | 0.104** | 0.000778*** | 0.012 | 0.181*** | 0.00120*** | 0.033 | 0.0231 | 0.00142*** | 0.001 | 0.0293 | 0.00120*** | 0.001 |
| | (0.0485) | (0.000112) | | (0.0483) | (0.000157) | | (0.0577) | (0.000206) | | (0.0522) | (0.000128) | |
| $10^{th}$ maturity | 0.110** | 0.000739*** | 0.014 | 0.195*** | 0.00106*** | 0.038 | -0.00740 | 0.00157*** | 0.000 | 0.00373 | 0.00111*** | 0.000 |
| | (0.0485) | (0.000107) | | (0.0482) | (0.000141) | | (0.0577) | (0.000261) | | (0.0525) | (0.000111) | |
| $11^{th}$ maturity | 0.118** | 0.000699*** | 0.016 | 0.171*** | 0.00103*** | 0.029 | -0.0308 | 0.00157*** | 0.001 | 0.0156 | 0.000983*** | 0.000 |
| | (0.0485) | (0.000102) | | (0.0484) | (0.000143) | | (0.0577) | (0.000223) | | (0.0521) | (9.81e-05) | |
| $12^{th}$ maturity | 0.125*** | 0.000661*** | 0.018 | 0.137*** | 0.00100*** | 0.019 | -0.0222 | 0.00142*** | 0.000 | 0.0511 | 0.000937*** | 0.003 |
| | (0.0482) | (9.63e-05) | | (0.0487) | (0.000142) | | (0.0577) | (0.000199) | | (0.0517) | (0.000103) | |
| $13^{th}$ maturity | 0.137*** | 0.000642*** | 0.021 | 0.172*** | 0.000911*** | 0.030 | 0.0460 | 0.00129*** | 0.002 | 0.00730 | 0.000926*** | 0.000 |
| | (0.0482) | (9.29e-05) | | (0.0484) | (0.000126) | | (0.0577) | (0.000227) | | (0.0516) | (0.000102) | |
| $14^{th}$ maturity | 0.148*** | 0.000626*** | 0.025 | 0.272*** | 0.000776*** | 0.074 | 0.0101 | 0.00120*** | 0.000 | -0.0325 | 0.000895*** | 0.001 |
| | (0.0482) | (8.92e-05) | | (0.0473) | (0.000115) | | (0.0577) | (0.000180) | | (0.0516) | (8.80e-05) | |
| $15^{th}$ maturity | 0.145*** | 0.000618*** | 0.024 | 0.320*** | 0.000713*** | 0.102 | 0.0213 | 0.00120*** | 0.000 | -0.0419 | 0.000860*** | 0.002 |
| | (0.0483) | (8.69e-05) | | (0.0466) | (0.000112) | | (0.0577) | (0.000174) | | (0.0516) | (8.72e-05) | |
| $16^{th}$ maturity | 0.133*** | 0.000623*** | 0.021 | 0.321*** | 0.000669*** | 0.103 | -0.0123 | 0.00128*** | 0.000 | -0.0244 | 0.000777*** | 0.001 |
| | (0.0486) | (8.80e-05) | | (0.0466) | (0.000106) | | (0.0577) | (0.000218) | | (0.0516) | (7.92e-05) | |
| $17^{th}$ maturity | | | | 0.336*** | 0.000657*** | 0.113 | 0.0198 | 0.00120*** | 0.000 | 0.0404 | 0.000674*** | 0.002 |
| | | | | (0.0463) | (0.000108) | | (0.0577) | (0.000238) | | (0.0513) | (7.40e-05) | |
| $18^{th}$ maturity | | | | 0.262*** | 0.000718*** | 0.069 | 0.0500 | 0.00107*** | 0.002 | -0.00480 | 0.000670*** | 0.000 |
| | | | | (0.0474) | (0.000108) | | (0.0577) | (0.000187) | | (0.0452) | (6.99e-05) | |

This table shows the Autoregressive Conditional Heteroskedasticity model ARCH(1) of the implemented regressions. For each maturity,

1. I implement the following regression

$$RFUTXM_t = \beta_1 CHP_t + \beta_2 RPSP500adj_t + \epsilon_t$$

2. Then, I regress

$$\epsilon_t^2 = \gamma_0 + \gamma_1 \epsilon_{t-1}^2 + u_t$$

I implement the previous process for the tested commodity: crude oil, heating oil and natural gas. For each commodity, I do the regressions for three sub-periods: 1995-2002, 2003-2008 and 2008-2015. Obs means the number of observations. $\gamma_0$ is the constant. $\gamma_1$ is the coefficient of the squared residual lag. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively.

Table 2.9: Auto-regressive model AR(1)

| VARIABLES | Crude oil (WTI) | | | | | | Heating oil | | | | | | Natural gas | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1995-2002 Obs = 375 | | 2003-2008 Obs = 307 | | 2008-2016 Obs=375 | | 1995-2002 Obs=417 (412 for M16) | | 2003-2008 Obs=302 | | 2008-2016 Obs=377 [14] | | 1995-2002 Obs = 416 | | 2003-2008 Obs=302 | | 2008-2015 Obs=378 | |
| | $\alpha_0$ | R-squared | $\alpha_0$ | R-squared | $\alpha_0$ | R-squared | $\alpha_0$ | R-squared | $\alpha_0$ | R-squared | $\alpha_0$ | R-squared | $\alpha_0$ | R-squared | $\alpha_0$ | R-squared | $\alpha_0$ | R-squared |
| $1^{st}$ maturity | -0.193*** | 0.037 | -0.0687 | 0.005 | -0.0459 | 0.002 | -0.165*** | 0.027 | -0.0134 | 0.000 | 0.0238 | 0.001 | -0.107** | 0.011 | -0.120** | 0.014 | -0.0898* | 0.008 |
| | (0.0507) | | (0.0575) | | (0.0514) | | (0.0484) | | (0.0577) | | (0.0506) | | (0.0485) | | (0.0573) | | (0.0525) | |
| $2^{nd}$ maturity | -0.150*** | 0.022 | -0.0701 | 0.005 | -0.0419 | 0.002 | -0.136*** | 0.018 | -0.0357 | 0.001 | 0.0312 | 0.001 | -0.103** | 0.011 | -0.0982* | 0.010 | -0.113** | 0.012 |
| | (0.0511) | | (0.0576) | | (0.0515) | | (0.0487) | | (0.0577) | | (0.0505) | | (0.0487) | | (0.0574) | | (0.0522) | |
| $3^{rd}$ maturity | -0.148*** | 0.022 | -0.0613 | 0.004 | -0.0416 | 0.002 | -0.139*** | 0.019 | -0.0355 | 0.001 | 0.0358 | 0.001 | -0.118** | 0.014 | -0.0676 | 0.005 | -0.114** | 0.013 |
| | (0.0510) | | (0.0577) | | (0.0515) | | (0.0488) | | (0.0578) | | (0.0505) | | (0.0487) | | (0.0575) | | (0.0520) | |
| $4^{th}$ maturity | -0.151*** | 0.023 | -0.0514 | 0.003 | -0.0391 | 0.002 | -0.154*** | 0.023 | -0.0263 | 0.001 | 0.0454 | 0.002 | -0.130*** | 0.017 | -0.103* | 0.011 | -0.132** | 0.017 |
| | (0.0510) | | (0.0578) | | (0.0515) | | (0.0487) | | (0.0579) | | (0.0505) | | (0.0485) | | (0.0573) | | (0.0515) | |
| $5^{th}$ maturity | -0.153*** | 0.023 | -0.0441 | 0.002 | -0.0360 | 0.001 | -0.174*** | 0.030 | -0.0287 | 0.001 | 0.0473 | 0.002 | -0.0723 | 0.005 | -0.106* | 0.011 | -0.121** | 0.015 |
| | (0.0510) | | (0.0579) | | (0.0515) | | (0.0484) | | (0.0579) | | (0.0504) | | (0.0488) | | (0.0572) | | (0.0514) | |
| $6^{th}$ maturity | -0.155*** | 0.024 | -0.0367 | 0.001 | -0.0335 | 0.001 | -0.204*** | 0.041 | -0.0316 | 0.001 | 0.0457 | 0.002 | -0.0368 | 0.001 | -0.0896 | 0.008 | -0.0662 | 0.004 |
| | (0.0510) | | (0.0579) | | (0.0515) | | (0.0480) | | (0.0579) | | (0.0504) | | (0.0489) | | (0.0573) | | (0.0516) | |
| $7^{th}$ maturity | -0.160*** | 0.026 | -0.0294 | 0.001 | -0.0335 | 0.001 | -0.214*** | 0.046 | -0.0250 | 0.001 | 0.0376 | 0.001 | -0.0362 | 0.001 | -0.0252 | 0.001 | -0.0514 | 0.003 |
| | (0.0509) | | (0.0580) | | (0.0515) | | (0.0479) | | (0.0579) | | (0.0504) | | (0.0489) | | (0.0575) | | (0.0518) | |
| $8^{th}$ maturity | -0.161*** | 0.026 | -0.0228 | 0.001 | -0.0349 | 0.001 | -0.215*** | 0.046 | -0.0206 | 0.000 | 0.0294 | 0.001 | -0.0440 | 0.002 | 0.00185 | 0.000 | -0.0767 | 0.006 |
| | (0.0509) | | (0.0580) | | (0.0515) | | (0.0479) | | (0.0579) | | (0.0504) | | (0.0489) | | (0.0575) | | (0.0518) | |
| $9^{th}$ maturity | -0.166*** | 0.028 | -0.0164 | 0.000 | -0.0363 | 0.001 | -0.215*** | 0.046 | -0.0157 | 0.000 | 0.0245 | 0.001 | -0.0650 | 0.004 | -0.0221 | 0.000 | -0.0815 | 0.007 |
| | (0.0508) | | (0.0581) | | (0.0515) | | (0.0479) | | (0.0579) | | (0.0505) | | (0.0489) | | (0.0575) | | (0.0517) | |
| $10^{th}$ maturity | -0.169*** | 0.029 | -0.0120 | 0.000 | -0.0376 | 0.001 | -0.202*** | 0.041 | -0.00567 | 0.000 | 0.0225 | 0.001 | -0.0857* | 0.007 | -0.0600 | 0.004 | -0.0881* | 0.008 |
| | (0.0508) | | (0.0581) | | (0.0515) | | (0.0480) | | (0.0579) | | (0.0505) | | (0.0489) | | (0.0575) | | (0.0517) | |
| $11^{th}$ maturity | -0.171*** | 0.029 | -0.00714 | 0.000 | -0.0385 | 0.001 | -0.199*** | 0.040 | 0.00155 | 0.000 | 0.0218 | 0.000 | -0.0837* | 0.007 | -0.103* | 0.011 | -0.0870* | 0.007 |
| | (0.0508) | | (0.0582) | | (0.0515) | | (0.0480) | | (0.0579) | | (0.0505) | | (0.0489) | | (0.0572) | | (0.0516) | |
| $12^{th}$ maturity | -0.171*** | 0.029 | -0.00325 | 0.000 | -0.0382 | 0.001 | -0.204*** | 0.041 | -0.00663 | 0.000 | 0.0332 | 0.001 | -0.0618 | 0.004 | -0.104* | 0.011 | -0.0765 | 0.006 |
| | (0.0508) | | (0.0582) | | (0.0515) | | (0.0480) | | (0.0579) | | (0.0504) | | (0.0490) | | (0.0572) | | (0.0515) | |
| $13^{th}$ maturity | -0.173*** | 0.030 | -2.16e-05 | 0.000 | -0.0370 | 0.001 | -0.208*** | 0.043 | -0.0178 | 0.000 | 0.0364 | 0.001 | -0.0655 | 0.004 | -0.119** | 0.014 | -0.0350 | 0.001 |
| | (0.0508) | | (0.0582) | | (0.0515) | | (0.0480) | | (0.0579) | | (0.0508) | | (0.0489) | | (0.0571) | | (0.0517) | |
| $14^{th}$ maturity | -0.180*** | 0.032 | 0.00251 | 0.000 | -0.0381 | 0.001 | -0.222*** | 0.049 | -0.0115 | 0.000 | 0.0359 | 0.001 | -0.0461 | 0.002 | -0.0420 | 0.002 | -0.0609 | 0.004 |
| | (0.0508) | | (0.0583) | | (0.0515) | | (0.0480) | | (0.0579) | | (0.0511) | | (0.0490) | | (0.0574) | | (0.0516) | |
| $15^{th}$ maturity | -0.185*** | 0.034 | 0.00336 | 0.000 | -0.0402 | 0.002 | -0.220*** | 0.048 | -0.00351 | 0.000 | 0.0456 | 0.002 | -0.0905* | 0.008 | -0.0118 | 0.000 | -0.0651 | 0.004 |
| | (0.0508) | | (0.0583) | | (0.0515) | | (0.0480) | | (0.0579) | | (0.0513) | | (0.0490) | | (0.0575) | | (0.0516) | |
| $16^{th}$ maturity | -0.187*** | 0.035 | 0.00965 | 0.000 | -0.0430 | 0.002 | -0.227*** | 0.051 | 0.00549 | 0.000 | 0.0555 | 0.003 | -0.0653 | 0.004 | -0.0497 | 0.002 | -0.0745 | 0.006 |
| | (0.0508) | | (0.0583) | | (0.0515) | | (0.0483) | | (0.0579) | | (0.0516) | | (0.0489) | | (0.0575) | | (0.0514) | |
| $17^{th}$ maturity | -0.186*** | 0.035 | 0.0112 | 0.000 | -0.0465 | 0.002 | | | | | | | -0.0409 | 0.002 | -0.0367 | 0.001 | -0.0187 | 0.000 |
| | (0.0508) | | (0.0583) | | (0.0515) | | | | | | | | (0.0490) | | (0.0575) | | (0.0513) | |
| $18^{th}$ maturity | -0.185*** | 0.034 | 0.0112 | 0.000 | -0.0486 | 0.002 | | | | | | | -0.0186 | 0.000 | 0.00405 | 0.000 | -0.0255 | 0.001 |
| | (0.0508) | | (0.0584) | | (0.0515) | | | | | | | | (0.0490) | | (0.0576) | | (0.0503) | |

This table shows the auto-regressive model AR(1) for the residuals term of the implemented regressions. For each maturity,

1. I implement the following regression

$$RFUTXM_t = \beta_1 CHP_t + \beta_2 RPSP500adj_t + \epsilon_t$$

2. I regress

$$\epsilon_t = \alpha_0 \epsilon_{t-1} + u_t$$

I implement the previous process for the tested commodity: crude oil, heating oil and natural gas. For each commodity, I do the regressions for three sub-periods: 1995-2002, 2003-2008 and 2008-2015. Obs means the number of observations. $\alpha_0$ is the coefficient of the lagged residual (the correlation between the residual and its lagged). */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively.

Table 2.10: Durban Watson test

| | Crude oil (WTI) | | | Heating oil | | | Natrural gas | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1995-2002 | 2003-2008 | 2008-2016 | 1995-2002 | 2002-2008 | 2008-2016 | 1995-2002 | 2003-2008 | 2008-2016 |
| $1^{st}$ maturity | 2.376652 | 2.116816 | 2.102477 | 2.32936 | 2.021174 | 1.982078 | 2.199114 | 2.235542 | 2.126554 |
| $2^{nd}$ maturity | 2.28857 | 2.114276 | 2.08994 | 2.264343 | 2.066763 | 1.968208 | 2.188812 | 2.184299 | 2.179365 |
| $3^{rd}$ maturity | 2.28696 | 2.096041 | 2.089355 | 2.266249 | 2.062831 | 1.957837 | 2.22056 | 2.116216 | 2.19056 |
| $4^{th}$ maturity | 2.293734 | 2.075286 | 2.084506 | 2.293155 | 2.04174 | 1.938929 | 2.250742 | 2.200818 | 2.23938 |
| $5^{th}$ maturity | 2.297043 | 2.060126 | 2.078356 | 2.341233 | 2.046973 | 1.93598 | 2.136923 | 2.211361 | 2.225934 |
| $6^{th}$ maturity | 2.303837 | 2.04446 | 2.073149 | 2.404779 | 2.053477 | 1.939892 | 2.067006 | 2.179762 | 2.119348 |
| $7^{th}$ maturity | 2.313237 | 2.028659 | 2.072797 | 2.426229 | 2.040114 | 1.956189 | 2.066949 | 2.050104 | 2.088111 |
| $8^{th}$ maturity | 2.315227 | 2.013947 | 2.074884 | 2.429599 | 2.031061 | 1.9722 | 2.083361 | 1.993927 | 2.135736 |
| $9^{th}$ maturity | 2.32669 | 1.999851 | 2.077398 | 2.428935 | 2.020487 | 1.981002 | 2.126082 | 2.042344 | 2.144837 |
| $10^{th}$ maturity | 2.332106 | 1.989765 | 2.079216 | 2.403149 | 2.000243 | 1.984877 | 2.164376 | 2.12226 | 2.157152 |
| $11^{th}$ maturity | 2.337397 | 1.978811 | 2.079876 | 2.398153 | 1.98618 | 1.986172 | 2.161324 | 2.209987 | 2.16077 |
| $12^{th}$ maturity | 2.337706 | 1.969834 | 2.07803 | 2.406884 | 2.002997 | 1.963259 | 2.120068 | 2.210318 | 2.144574 |
| $13^{th}$ maturity | 2.341776 | 1.962404 | 2.074266 | 2.413778 | 2.025469 | 1.956683 | 2.127636 | 2.235909 | 2.060872 |
| $14^{th}$ maturity | 2.356085 | 1.956131 | 2.074767 | 2.432915 | 2.010799 | 1.956286 | 2.086542 | 2.07263 | 2.111038 |
| $15^{th}$ maturity | 2.36549 | 1.953346 | 2.07705 | 2.426958 | 1.993753 | 1.938175 | 2.167372 | 1.998834 | 2.121277 |
| $16^{th}$ maturity | 2.369964 | 1.94004 | 2.081152 | 2.43909 | 1.975687 | 1.918116 | 2.126694 | 2.096987 | 2.145744 |
| $17^{th}$ maturity | 2.368146 | 1.936016 | 2.086333 | | | | 2.078182 | 2.073697 | 2.038004 |
| $18^{th}$ maturity | 2.366956 | 1.93572 | 2.088667 | | | | 2.032976 | 1.994204 | 2.051504 |

This table shows Durban Watson test for the implemented regressions (in tables 2.4, 2.6 and 2.5). The values that have been shown in the table is Durbin-Watson d-statistic( 2, Obs).

## 2.6 Robustness check

I perform several robustness tests. First, I re-estimate the regressions coefficients by using monthly data sets instead of weekly on the period between 1995 and 2015, in order to check the impact of the data frequency. Second, I replace the futures returns for the available maturities by the S&P GSCI total return index for each commodity on the same period. Financial investors prefer to invest in a basket of commodities. They build a portfolio that mimics an existing index returns such as S&P GSCI, which is considered well diversified index. Third, I implement the regression estimation on shorter sub-periods. I divide the tested period (1995 to 2015) to six sub-periods that each sub-period is represented by 175 weeks. This test is made to emphasize that the three periods that I tested is divided correctly. Another reason is to emphasize that the impact of the stock market has truly appeared after 2008 crisis. Four, I replace the net short hedging pressure by the net long speculative pressure. This test is boosted by the fact that the speculators offset the hedgers positions. This test should verify that there is no impact for the non-reportable (speculative) futures positions. I use the non-commercials positions that are published by CFTC[15].

Firstly, using monthly datasets show the same results qualitatively as the results obtained from the weekly datasets for each of crude oil (WTI) and heating oil. For natural gas, the monthly results boost the weekly ones on the period between 1995 and 2008. However, after 2008 crisis, the monthly data expresses a non-significant coefficient of the adjusted stock returns. This result is not a surprise, because even I find a significant result by using weekly data, R-squared has dropped suddenly comparing to the previous periods, which ensure our thoughts that there is a problem in the natural gas market after the financial crisis in 2008. Tables 2.13, 2.14 and 2.15 show the regressions estimations for crude oil (WTI), heating oil and natural gas respectively on the periods 1995-2002, 2003-2008 and 2008-2015 by using monthly data.

Secondly, the results of using the index S&P GSCI, instead of the maturities returns, show that adjusted stock returns is significant after 2008, which is the same finding that we have for the tested commodities. Table 2.12 shows the regression estimation of crude oil (WTI), heating oil and natural gas by using S&P GSCI index.

[15] The net long speculative pressure is defined as:

$$NLCP = \frac{\textbf{Non commercials Long} - \textbf{non commercials short}}{\textbf{Non commercials long} + \textbf{non commercials short} + 2 * \textbf{positions spread}}$$

Thirdly, by dividing the whole sample, 1995-2015, to shorter sub-periods, I found that the hedging pressure has an explanatory power in all the periods for all commodities. However, the adjusted stock returns impact is different from a commodity to another. Tables 2.16, 2.17 and 2.18 express the regression estimation for crude oil (WTI), heating oil and natural gas respectively for six sub-periods that cover the period between 1995 and 2015. For heating oil, the coefficient of the adjusted stock returns is significant in the last two sub-periods, which are May-2008-September 2011 and September 2011- March 2015 (Panels $E$ & $F$ in table 2.17). The results of these two periods correspond with the results in the post-crisis period (2008-2015). For crude oil, the coefficient of the adjusted stock returns witnesses some changes during the different periods.

- From October 1995 to January 1999 (Panel $A$ in table 2.16), the coefficient of the adjusted stock returns is negative, and significant at level of confidence 5% or 10% for most of maturities.

- From January 1999 to June 2002 (Panel $B$ in table 2.16), the coefficient of the adjusted stock returns is not significant.

- From June 2002 to October 2005 (Panel $C$ in table 2.16), the coefficient of the adjusted stock returns is positive significant at 5% level of confidence for all maturities.

- From October 2005 to February 2009 (Panel $D$ in table 2.16), the coefficient is positive and strongly significant at 1% level of confidence.

- For the remaining periods (February 2009 to June 2012 and From June 2012 to December 2015; Panels $E$&$F$ in table 2.16), the adjusted stock returns is positive and significant at high levels of confidence.

The previous check confirms our results, except for the period between 2002 and 2008. Directly speaking about the significance of the coefficient of adjusted stock returns, I can induce that the aggregation of the first two sup-periods (October 1995 to January 1999 and January 1999 to June 2002) becomes insignificant. But, for the next two sup-periods (June 2002 to October 2005 and October 2005 to February 2009), I find the coefficient of adjusted stock returns is significant in both periods which appears, at first, inconsistent with my results when I found the coefficient of adjusted stock returns is not significant in the period 2003-2008. The reason is that the new division is inconsistent with the primary one. In the paper, post 2008 crisis period starts at October 2008. But, the new division extends that to 2009 which is probably cause the coefficient significance. I rechecked this issue again by dividing 2002-2008 into two sup-periods: January 2002- November 2005 and November 2005-September 2008. I find that the coefficient of the adjusted stock returns is positive and significant at 5% or 10% levels of confidence on the

period 2002-2005. On the contrary, the coefficient is not significant on the period 2005-2008.

For natural gas as shown in table 2.18, the coefficient of the adjusted stock returns is significant for some maturities on January 1995- June 1998 (from $3^{rd}$ to $10^{th}$ maturity). On June 1999- May 2008, the coefficient of the adjusted stock returns is not significant. On the contrary, the coefficient of the adjusted stock returns is strongly significant on May 2008 - September 2011. However, on September 2011- March 2015, the coefficient is not significant and R-squared dropped sharply for all the maturities. These results enhance what I have obtained from the regressions in table 2.5.

Fourthly, by replacing the hedging pressure with the speculative pressure, I have results mimicking the original tests. For the tested commodities, the coefficient of net long speculative pressure is positive and strongly significant. It also decreases when the maturity increases. For crude oil (WTI), the coefficient of the speculative pressure in 2008-2015 is higher than 2003-2008, which is higher than the coefficient in 1995-2002. Heating oil has the same results as crude oil (WTI) but with lower jumps in the coefficient value. For natural gas, the coefficient of the speculative pressure in 2003-2008 and 2008-2015 is higher than the period 1995-2002, but R-squared decreases through time. The coefficient of the adjusted stock returns corresponds with the results obtained from the original regressions for all commodities. Tables 2.19, 2.20 and 2.21 demonstrate the regression estimation for crude oil (WTI), heating oil and natural gas respectively, and by replacing the hedging pressure with speculative pressure.

## 2.7 Conclusion

In this chapter, I test the future risk premium in the era of financialization. My empirical tests depend on a theoretical model introduced by Isleimeyyeh et al. (2017). The model studies the interaction between the commodity and stock markets. The theoretical base addresses that the futures risk premium is determined by the commodity hedging pressure and the stock returns accompanied by the commodity-equity correlation.

I test the theoretical predictions for three commodities in the energy market: crude oil (WTI), natural gas and heating oil. The sample covers the last two decades, from 1995 to the end of 2015. I regress the futures risk premium on the change in net short hedging pressure and the adjusted stock returns. I estimate the regression on three sub-periods: 1995-2002, 2003-October 2008 and October 2008-2015. These regressions are tested for several maturities.

First, I confirm that the hedging pressure is a strong explanatory variable for the futures risk premium. I find that the net short hedging pressure is positively correlated with the futures risk premium for all tested commodities. Also, there is a negative relationship between the impact of the hedging pressure and the futures maturity. Second, the impact of stock market became significantly effective on the futures risk premium in the period post-2008 financial crisis. By that time, the futures risk premium and the adjusted stock returns are positively correlated. This finding confirm the theoretical finding of the Isleimeyyeh et al. (2017), who stated that a positive stock returns accompanied by positive commodity-equity correlation increases the futures risk premium[16]. For Crude oil (WTI) and heating oil, the significant impact is accompanied by increases in commodity-equity correlation. That leads us to go in the line with Daskalaki and Skiadopoulos (2011) and Belousova and Dorfleitner (2012) conclude that the diversification is in doubt. Consequently, financial investors are asking for liquidity instead of providing liquidity to the hedgers (e.g. Cheng et al. (2015)[17]). When the maturity increases, the adjusted stock market returns becomes stronger explanatory than the hedging pressure. This finding confirms Boons et al. (2014) who study the first two maturities. But, it is the opposite for longer maturities. In natural gas case, although the explanatory variables are significant in the period 2008-2015, the futures risk premium should be determined by extra explanatory variables, which is a motivation for further studies to find explanation for this issue.

As a result, the futures risk premium increased significantly after the financial crisis in 2008. Also, this paper contributes to previous literature that emphasizes the impact of financialization on commodity markets.

[16] I was also able to test the opposite case, when the correlation is negative. For instance, the period between 1995 and 1999 for crude oil (Panel A in table 2.16), the impact of the adjusted stock risk premium on the futures risk premium is significantly negative.

[17] Cheng et al. (2015) find that, after the 2008 crisis, (Because of distress in financial markets financial traders) financial traders reduce their long positions due to their smaller risk absorption capacity, while hedgers take the other side. The hedgers become holding more risk than they did previously; i.e. a portion of the risk that was previously held by financial traders will be taken back on by hedgers. This risk flow reallocates risk from the groups less able to bear the risk to the groups more able to bear risk. Therefore, demand liquidity from commercial hedgers rather than provide liquidity to commercial hedgers.

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# Appendix

## 2.A Theoretical adaption to the reality

The futures risk premium as defined by Isleimeyyeh et al. (2017) is determined by the hedging pressure and the stock market factor, which is defined as the combination between stocks returns and commodity-equity correlation.

$$\mathrm{E}[\tilde{P}_T] - F_{t,T} = \frac{\mathrm{Var}[\tilde{P}_T]}{\frac{N_P}{\alpha_P} + \frac{N_I}{\alpha_I} + \frac{N_S}{\alpha_S}\left(\frac{1}{1-\rho^2}\right)} \left( n_I X - n_P Y + \frac{N_S}{\alpha_S} \rho \frac{E[\tilde{V}_t] - V_t}{\sigma_P \sigma_V (1-\rho^2)} \right) \tag{2.2}$$

Where $P_T$ is the commodity spot price at $T$. $F_{t,T}$ is the futures price at $t$ when the maturity is at $T$. $\mathrm{E}[\tilde{P}_T] - F_{t,T}$ is the futures risk premium. $\frac{N_i}{\alpha_i}$ is the number of agent $i$ restricted to his risk aversion, and $i := P, I, S$. P: processor, I: storer and S: financial investor. $\rho$ is the commodity-equity correlation. $V_j$ is the value of the financial investor's portfolio in the stock market at time $j$, $j := t, T$. $\mathrm{E}[\tilde{\mathrm{V}}_t] - V_t$ is the stock market profit. $\mathrm{Var}[\tilde{P}_T]$ is the variance of the commodity prices. $\sigma_P$ and $\sigma_V$ are the standard deviation of commodity spot price and stock prices respectively. Finally, $HP$ is the hedging pressure

$$HP' := N_I x^\star - N_P y^\star$$

Where $N_I x^\star$ is the total inventory of the commodity which is held by the storers in the physical market. $N_P y^\star$ is the total quantity demanded by the processor in the physical market.

In equation (**??**) the hedging pressure is defined as the difference between the physical positions of the storers and the processors ($N_I x^\star - N_P y^\star$). It shows only the futures positions that are taken for hedging the physical positions. However, the optimal positions of the hedgers has speculative positions after hedging 100% of their physical positions (Isleimeyyeh et al. (2017)). CFTC publishes does not distinguish whether the hedgers' positions are for hedging or for speculation; they publish aggregated commercial positions. Therefore, it is necessary to match the theoretical base with the reality (available data). To do so, I will rearrange the risk premium to adapt with the practical definition.

First, let us introduce the agents optimal positions as obtained by Isleimeyyeh et al. (2017), keeping in mind the following notations: $C$ is the cost of storage, $\beta$ is the cost of production, $F_{t,T}$ is the futures price, $P_t$, is the spot price at time $t$, $E[\tilde{P}_T]$ is the expected spot price at time $T$, $\alpha_I$, $\alpha_P$ and $\alpha_S$ is the risk aversion for storer, processor and financial investors respectively. $Var[\tilde{P}_T]$ is the variance of commodity spot price, $\rho$ is the commodity-equity correlation.

The optimal positions of the storer are $x^*$ and $f_I^*$ in the physical and the futures market respectively.

$$N_I x^* = \frac{N_I}{C} max\left\{F_{t,T} - P_t, 0\right\}, \tag{2.3}$$

$$N_I f_I^* = N_I \left[\frac{E[\tilde{P}_T] - F_{t,T}}{\alpha_I Var[\tilde{P}_T]} - x^*\right] \tag{2.4}$$

The optimal positions of the processor are $y^*$ and $f_P^*$ in the physical and the futures market respectively.

$$N_P y^* = \frac{N_P}{\beta Z} \max\left\{Z - F, 0\right\}, \tag{2.5}$$

$$N_P f_P^* = N_P \left[\frac{E[\tilde{P}_T] - F}{\alpha_P Var[\tilde{P}_T]} + y^*\right] \tag{2.6}$$

The optimal positions of the financial investor are $f_S^*$ is:

$$N_S f_S^* = \left(\frac{1}{1-\rho^2}\right) \frac{N_S}{\alpha_S \sigma_P} \left[\frac{E[\tilde{P}_T] - F_{t,T}}{\sigma_P} - \rho \frac{E[\tilde{V}_T] - V_t}{\sigma_V}\right], \rho \neq \pm 1 \tag{2.7}$$

The futures market clearing requires a zero summation of the taken futures positions:

$$N_S f_S^\star + N_P f_P^\star + N_I f_I^\star = 0.$$

By substituting the optimal positions $f_P^*$, $f_S^*$ and $f_I^*$, we get:

$$\mathrm{E}[\tilde{P}_T] - F_{t,T} = \frac{\sigma_P^2\left(1-\rho^2\right)}{\frac{N_S}{\alpha_S}} \left[-N_I\left(\frac{E(\tilde{P}_T) - F_{t,T}}{\alpha_I Var(\tilde{P}_2)} - x^*\right) - N_P\left(\frac{E[\tilde{P}_T] - F_{t,T}}{\alpha_P Var[\tilde{P}_T]} + y^*\right) + N_S\left(\rho \frac{E[\tilde{V}_T] - V_t}{\sigma_P \sigma_V \alpha_S (1-\rho^2)}\right)\right]$$

Let us define the hedging pressure as follow:

$$HP =: -N_I\left(\frac{E[\tilde{P}_T] - F_{t,T}}{\alpha_I Var[\tilde{P}_2]} - x^*\right) - N_P\left(\frac{E[\tilde{P}_T] - F_{t,T}}{\alpha_P Var[\tilde{P}_T]} + y^*\right)$$

It implies,

$$E[\tilde{P}_T] - F_{t,T} = \frac{\sigma_P^2\left(1-\rho^2\right)}{\frac{N_S}{\alpha_S}} \left[HP + N_S\left(\rho \frac{E[\tilde{V}_T] - V_t}{\sigma_P \sigma_V \alpha_S (1-\rho^2)}\right)\right]$$

I considered the commodity-equity correlation as variable. But, the correlation exists in the coefficient terms. Therefore, I apply Taylor theorem around $\rho = 0$ in order to eliminate the correlation from the coefficients.

$$E[\tilde{P}_T] - F_{t,T} = \left(E[\tilde{P}_T] - F_{t,T}\right)|_{\rho=0} + \rho \frac{d\left(E[\tilde{P}_T] - F_{t,T}\right)}{d\rho}|_{\rho=0}$$

It implies,

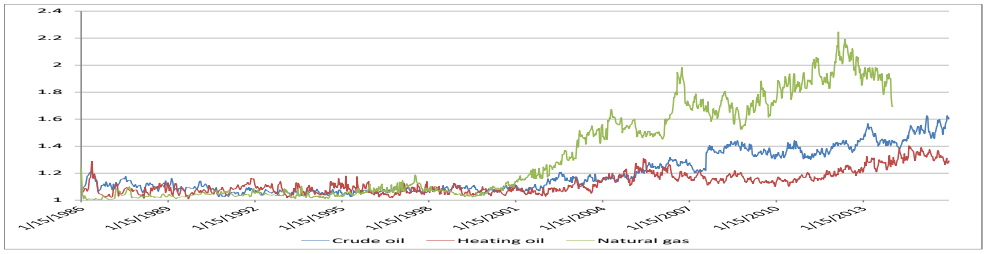
$$\mathrm{E}[\tilde{P}_T] - F_{t,T} = \beta_1 HP + \beta_2 \rho\left(E[\tilde{V}_T] - V_t\right)$$

$$\beta_1 = \frac{\text{Var}[\tilde{P}_T]}{\frac{N_S}{\alpha_S}}, \quad \beta_2 = \frac{\text{Var}[\tilde{P}_T]}{\sigma_P \sigma_V}$$

## 2.B Commodity price and commodity returns

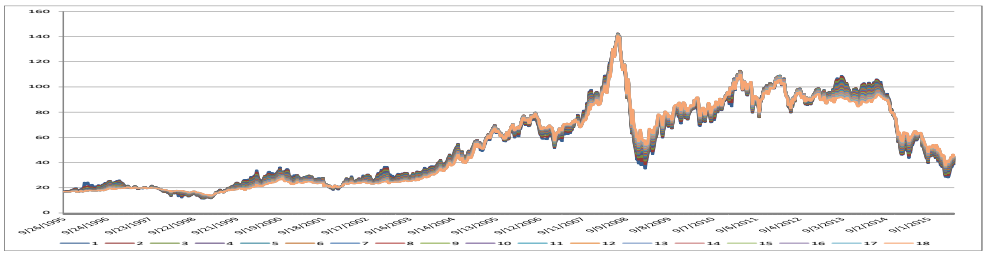
### 2.B.1 Working (1960) "T" test

Figure 2.3: Working index for crude oil (WTI), heating oil and natural gas, 1986-2016



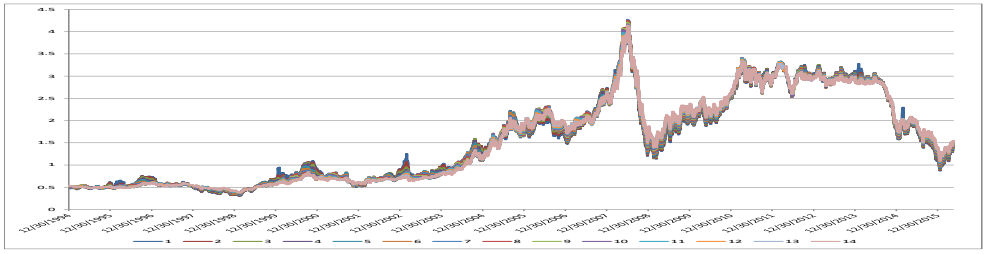

### 2.B.2 Commodity prices

Figure 2.4: Crude oil futures prices for the first 18th maturities, 1995-2016



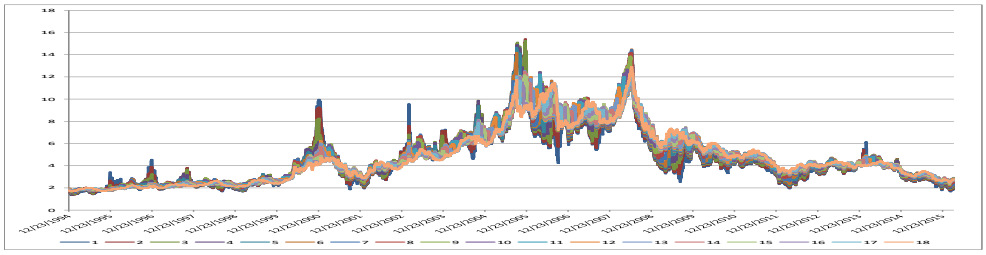

Source: Datastream

Figure 2.5: Heating oil futures prices for the first 14th maturities, 1995-2016



Source: Datastream

Figure 2.6: Natural gas futures prices for the first 18th maturities, 1995-2016



Source: Datastream

### 2.B.3 Commodity returns

Figure 2.7: Crude oil weekly futures returns for the $1^{st}$ and $18^{th}$ maturities, 1995-2016

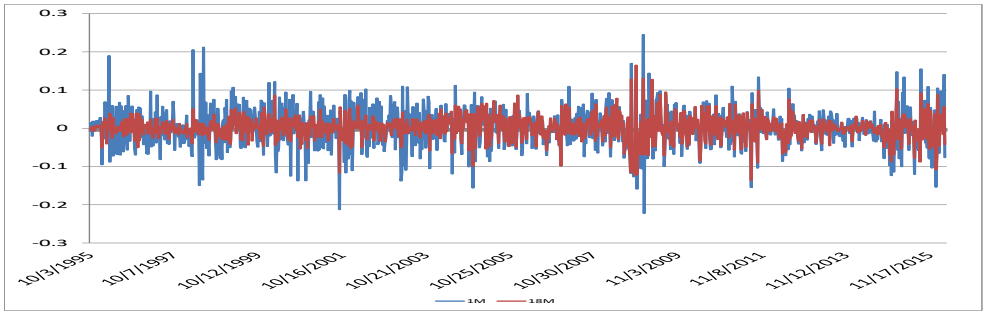


Figure 2.8: Heating oil weekly futures return ffor the $1^{st}$ and $16^{th}$ maturities, 1995-2016

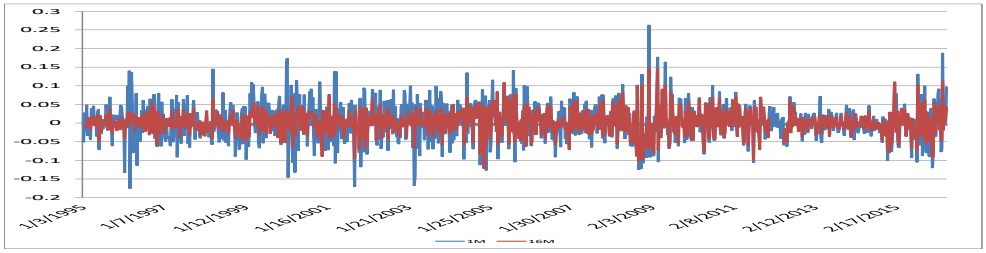



Figure 2.9: Natural gas weekly futures return for the $1^{st}$ and $18^{th}$ maturities, 1995-2016

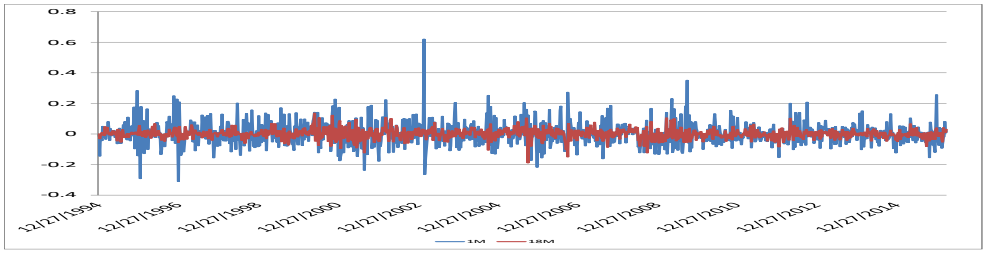



Table 2.11: Dynamic conditional correlation (DCC) for crude oil, and heating oil and natural gas

| | Crude oil | | Heating oil | | Natural gas | |
|---|---|---|---|---|---|---|
| | Coefficient | P-value | Coefficient | P-value | Coefficient | P-value |
| $\rho$ | 0.275245 | 0.5371 | 0.273804 | 0.1555 | 0.063734 | 0.0276 |
| $\alpha$ | 0.034513 | 0.0085 | 0.039093 | 0.0018 | 1.28E-05 | 0.8831 |
| $\beta$ | 0.963604 | 0.0000 | 0.956083 | 0.0000 | 0.856538 | 0.0298 |
| $\alpha + \beta$ | 0.998117 | | 0.995176 | | 0.856551 | |

## 2.C Robustness check tables

Table 2.12: Regression estimation for crude oil (WTI), heating oil and natural gas by replacing futures returns with S&P GSCI returns

| | Crude oil | | | Heating oil | | | Natural gas | | |
|---|---|---|---|---|---|---|---|---|---|
| VARIABLES | 1995-2002 | 2003-2008 | 2008-2015 | 1995-2002 | 2003-2008 | 2008-2015 | 1995-2002 | 2003-2008 | 2008-2015 |
| CHP | 0.000722 | 0.00173* | 0.00834** | 8.38e-06 | 0.000105 | 0.00256** | 0.00196 | 0.000420 | -0.00336 |
| | (0.000849) | (0.00105) | (0.00389) | (0.000205) | (0.000775) | (0.00117) | (0.00144) | (0.000400) | (0.00350) |
| RPSP500adj | 0.583 | 0.977 | 2.321*** | 1.043** | 0.741 | 2.015*** | 3.342 | 4.034 | 3.784** |
| | (0.562) | (0.898) | (0.209) | (0.519) | (0.468) | (0.189) | (2.669) | (2.866) | (1.800) |
| Observations | 378 | 301 | 379 | 378 | 301 | 401 | 377 | 301 | 401 |
| R-squared | 0.005 | 0.012 | 0.257 | 0.011 | 0.008 | 0.233 | 0.010 | 0.010 | 0.013 |

This table shows the regression results for crude oil, heating oil and natural gas by using the returns of S&P GSCI. Panel *A* shows the regressions for crude oil on the periods 1995-2002, 2003-2008 and 2008-2016. Panel *B* shows the regressions for heating oil on the periods 1995-2002, 2003-2008 and 2008-2016.Panel *C* shows the regressions for crude oil on the periods 1995-2002, 2003-2008 and 2008-2016. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; *Obs* indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.13: Regression estimation for crude oil on the periods 1995-2002, 2003-2008 and 2008-2015 by using monthly data

| Variables | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHP | RPSP500adj | Obs. | R-squared | CHP | RPSP500adj | Obs. | R-squared | CHP | RPSP500adj | Obs. | R-squared |
| RFUT1M | 1.070*** | 0.575 | 86 | 0.382 | 1.395*** | 3.219** | 71 | 0.321 | 1.490*** | 1.283** | 87 | 0.272 |
| | (0.149) | (1.217) | | | (0.273) | (1.577) | | | (0.396) | (0.587) | | |
| RFUT2M | 1.041*** | 0.324 | 86 | 0.413 | 1.390*** | 2.991* | 71 | 0.327 | 1.425*** | 1.396** | 87 | 0.313 |
| | (0.136) | (1.110) | | | (0.265) | (1.533) | | | (0.358) | (0.531) | | |
| RFUT3M | 0.961*** | 0.284 | 86 | 0.411 | 1.328*** | 2.828* | 71 | 0.313 | 1.333*** | 1.475*** | 87 | 0.329 |
| | (0.126) | (1.029) | | | (0.261) | (1.509) | | | (0.338) | (0.501) | | |
| RFUT4M | 0.871*** | 0.243 | 86 | 0.395 | 1.255*** | 2.729* | 71 | 0.295 | 1.256*** | 1.513*** | 87 | 0.336 |
| | (0.118) | (0.964) | | | (0.258) | (1.492) | | | (0.325) | (0.481) | | |
| RFUT5M | 0.788*** | 0.240 | 86 | 0.375 | 1.180*** | 2.643* | 71 | 0.275 | 1.194*** | 1.531*** | 87 | 0.339 |
| | (0.111) | (0.910) | | | (0.256) | (1.481) | | | (0.315) | (0.467) | | |
| RFUT6M | 0.715*** | 0.242 | 86 | 0.353 | 1.108*** | 2.581* | 71 | 0.255 | 1.143*** | 1.534*** | 87 | 0.341 |
| | (0.106) | (0.865) | | | (0.254) | (1.473) | | | (0.307) | (0.455) | | |
| RFUT7M | 0.651*** | 0.261 | 86 | 0.335 | 1.041*** | 2.542* | 71 | 0.237 | 1.096*** | 1.535*** | 87 | 0.341 |
| | (0.100) | (0.820) | | | (0.253) | (1.465) | | | (0.300) | (0.445) | | |
| RFUT8M | 0.596*** | 0.296 | 86 | 0.316 | 0.982*** | 2.479* | 71 | 0.220 | 1.050*** | 1.533*** | 87 | 0.342 |
| | (0.0959) | (0.785) | | | (0.252) | (1.458) | | | (0.293) | (0.434) | | |
| RFUT9M | 0.546*** | 0.340 | 86 | 0.297 | 0.934*** | 2.418 | 71 | 0.206 | 1.005*** | 1.531*** | 87 | 0.342 |
| | (0.0920) | (0.753) | | | (0.251) | (1.451) | | | (0.286) | (0.424) | | |
| RFUT10M | 0.497*** | 0.370 | 86 | 0.274 | 0.893*** | 2.354 | 71 | 0.195 | 0.960*** | 1.529*** | 87 | 0.342 |
| | (0.0886) | (0.725) | | | (0.249) | (1.442) | | | (0.280) | (0.415) | | |
| RFUT11M | 0.452*** | 0.407 | 86 | 0.252 | 0.857*** | 2.300 | 71 | 0.186 | 0.917*** | 1.526*** | 87 | 0.340 |
| | (0.0856) | (0.701) | | | (0.247) | (1.432) | | | (0.275) | (0.407) | | |
| RFUT12M | 0.410*** | 0.426 | 86 | 0.229 | 0.825*** | 2.246 | 71 | 0.177 | 0.874*** | 1.521*** | 87 | 0.338 |
| | (0.0828) | (0.678) | | | (0.246) | (1.423) | | | (0.270) | (0.400) | | |
| RFUT13M | 0.373*** | 0.451 | 86 | 0.209 | 0.796*** | 2.185 | 71 | 0.169 | 0.832*** | 1.519*** | 87 | 0.336 |
| | (0.0801) | (0.656) | | | (0.245) | (1.416) | | | (0.265) | (0.393) | | |
| RFUT14M | 0.340*** | 0.459 | 86 | 0.190 | 0.769*** | 2.134 | 71 | 0.161 | 0.794*** | 1.514*** | 87 | 0.334 |
| | (0.0778) | (0.637) | | | (0.244) | (1.411) | | | (0.260) | (0.386) | | |

This table shows the regression results of crude oil for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2016 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; *Obs* indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.14: Regression estimation for heating oil on the periods 1995-2002, 2003-2008 and 2008-2015 by using monthly data

| Variables | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHP | RPSP500adj | Obs. | R-squared | CHP | RPSP500adj | Obs. | R-squared | CHP | RPSP500adj | Obs. | R-squared |
| RFUT1M | 0.658*** | 0.239 | 95 | 0.363 | 0.906*** | 2.313 | 70 | 0.288 | 0.571*** | 1.744*** | 86 | 0.314 |
| | (0.0904) | (0.756) | | | (0.192) | (1.502) | | | (0.174) | (0.445) | | |
| RFUT2M | 0.670*** | 0.234 | 95 | 0.411 | 0.891*** | 2.450* | 70 | 0.314 | 0.564*** | 1.708*** | 86 | 0.319 |
| | (0.0831) | (0.695) | | | (0.179) | (1.401) | | | (0.169) | (0.432) | | |
| RFUT3M | 0.643*** | 0.0844 | 95 | 0.416 | 0.879*** | 2.651* | 70 | 0.335 | 0.586*** | 1.659*** | 86 | 0.321 |
| | (0.0790) | (0.660) | | | (0.171) | (1.336) | | | (0.168) | (0.431) | | |
| RFUT4M | 0.606*** | -0.0204 | 95 | 0.408 | 0.885*** | 2.777** | 70 | 0.351 | 0.567*** | 1.631*** | 86 | 0.314 |
| | (0.0757) | (0.633) | | | (0.167) | (1.307) | | | (0.167) | (0.427) | | |
| RFUT5M | 0.554*** | 0.0953 | 95 | 0.387 | 0.888*** | 2.735** | 70 | 0.358 | 0.544*** | 1.600*** | 86 | 0.311 |
| | (0.0722) | (0.604) | | | (0.164) | (1.287) | | | (0.163) | (0.418) | | |
| RFUT6M | 0.479*** | 0.297 | 95 | 0.353 | 0.888*** | 2.583** | 70 | 0.359 | 0.523*** | 1.570*** | 86 | 0.308 |
| | (0.0674) | (0.563) | | | (0.162) | (1.272) | | | (0.160) | (0.409) | | |
| RFUT7M | 0.418*** | 0.601 | 95 | 0.325 | 0.839*** | 2.276* | 70 | 0.328 | 0.516*** | 1.569*** | 86 | 0.318 |
| | (0.0630) | (0.527) | | | (0.163) | (1.275) | | | (0.155) | (0.397) | | |
| RFUT8M | 0.366*** | 0.792 | 95 | 0.299 | 0.777*** | 2.074 | 70 | 0.295 | 0.498*** | 1.579*** | 86 | 0.323 |
| | (0.0597) | (0.499) | | | (0.162) | (1.272) | | | (0.152) | (0.388) | | |
| RFUT9M | 0.327*** | 0.793 | 95 | 0.273 | 0.681*** | 2.072 | 70 | 0.255 | 0.494*** | 1.570*** | 86 | 0.330 |
| | (0.0572) | (0.478) | | | (0.161) | (1.258) | | | (0.148) | (0.379) | | |
| RFUT10M | 0.294*** | 0.596 | 95 | 0.249 | 0.607*** | 2.177* | 70 | 0.230 | 0.474*** | 1.549*** | 86 | 0.331 |
| | (0.0541) | (0.453) | | | (0.158) | (1.237) | | | (0.144) | (0.369) | | |
| RFUT11M | 0.271*** | 0.378 | 95 | 0.230 | 0.569*** | 2.307* | 70 | 0.223 | 0.465*** | 1.500*** | 86 | 0.330 |
| | (0.0519) | (0.434) | | | (0.155) | (1.215) | | | (0.141) | (0.360) | | |
| RFUT12M | 0.258*** | 0.128 | 95 | 0.229 | 0.534*** | 2.358* | 70 | 0.216 | 0.448*** | 1.480*** | 86 | 0.328 |
| | (0.0491) | (0.410) | | | (0.152) | (1.191) | | | (0.138) | (0.354) | | |
| RFUT13M | 0.257*** | 0.0305 | 95 | 0.244 | 0.528*** | 2.352** | 70 | 0.217 | 0.435*** | 1.499*** | 86 | 0.332 |
| | (0.0469) | (0.392) | | | (0.150) | (1.175) | | | (0.136) | (0.349) | | |

This table shows the regression results of heating oil for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2016 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; $Obs$ indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.15: Regression estimation for natural gas on the periods 1995-2002, 2003-2008 and 2008-2015 by using monthly data

| Variables | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHP | RPSP500adj | Obs. | R-squared | CHP | RPSP500 | Obs. | R-squared | CHP | RPSP500adj | Obs. | R-squared |
| RFUT1M | 1.329*** | 5.697 | 96 | 0.246 | 2.304*** | 0.157 | 70 | 0.369 | 1.162*** | 0.482 | 86 | 0.182 |
| | (0.245) | (5.154) | | | (0.366) | (0.353) | | | (0.269) | (4.552) | | |
| RFUT2M | 1.373*** | 1.083 | 96 | 0.298 | 2.285*** | 0.230 | 70 | 0.439 | 1.120*** | 2.787 | 86 | 0.200 |
| | (0.218) | (4.569) | | | (0.314) | (0.303) | | | (0.245) | (4.133) | | |
| RFUT3M | 1.247*** | -1.476 | 96 | 0.323 | 2.178*** | 0.107 | 70 | 0.427 | 0.978*** | 3.431 | 86 | 0.186 |
| | (0.186) | (3.915) | | | (0.306) | (0.295) | | | (0.225) | (3.793) | | |
| RFUT4M | 0.958*** | 0.309 | 96 | 0.303 | 1.808*** | 0.0336 | 70 | 0.382 | 0.906*** | 1.860 | 86 | 0.185 |
| | (0.150) | (3.151) | | | (0.279) | (0.269) | | | (0.208) | (3.509) | | |
| RFUT5M | 0.695*** | 2.554 | 96 | 0.208 | 1.756*** | 0.0337 | 70 | 0.394 | 0.816*** | -0.132 | 86 | 0.163 |
| | (0.142) | (2.989) | | | (0.264) | (0.254) | | | (0.203) | (3.422) | | |
| RFUT6M | 0.554*** | 4.629 | 96 | 0.157 | 1.374*** | 0.226 | 70 | 0.306 | 0.846*** | 0.668 | 86 | 0.170 |
| | (0.143) | (3.002) | | | (0.254) | (0.245) | | | (0.204) | (3.445) | | |
| RFUT7M | 0.570*** | 5.163* | 96 | 0.161 | 1.435*** | 0.249 | 70 | 0.328 | 0.850*** | 3.425 | 86 | 0.199 |
| | (0.146) | (3.072) | | | (0.253) | (0.243) | | | (0.188) | (3.174) | | |
| RFUT8M | 0.580*** | 5.038* | 96 | 0.170 | 1.420*** | 0.265 | 70 | 0.353 | 0.828*** | 3.910 | 86 | 0.237 |
| | (0.143) | (3.009) | | | (0.237) | (0.228) | | | (0.165) | (2.789) | | |
| RFUT9M | 0.519*** | 3.272 | 96 | 0.149 | 1.468*** | 0.244 | 70 | 0.385 | 0.735*** | 2.460 | 86 | 0.223 |
| | (0.134) | (2.811) | | | (0.228) | (0.219) | | | (0.150) | (2.542) | | |
| RFUT10M | 0.315** | 2.044 | 96 | 0.072 | 1.104*** | 0.143 | 70 | 0.276 | 0.637*** | 2.230 | 86 | 0.202 |
| | (0.122) | (2.564) | | | (0.219) | (0.211) | | | (0.139) | (2.349) | | |
| RFUT11M | 0.164 | 1.696 | 96 | 0.027 | 0.945*** | 0.107 | 70 | 0.241 | 0.557*** | 1.627 | 86 | 0.173 |
| | (0.113) | (2.383) | | | (0.205) | (0.197) | | | (0.133) | (2.255) | | |
| RFUT12M | 0.0858 | 3.282 | 96 | 0.027 | 0.712*** | 0.163 | 70 | 0.165 | 0.472*** | 1.475 | 86 | 0.125 |
| | (0.111) | (2.322) | | | (0.200) | (0.192) | | | (0.137) | (2.313) | | |
| RFUT13M | 0.162 | 2.558 | 96 | 0.034 | 0.590*** | 0.332* | 70 | 0.146 | 0.472*** | 2.938 | 86 | 0.119 |
| | (0.112) | (2.348) | | | (0.200) | (0.192) | | | (0.145) | (2.458) | | |
| RFUT14M | 0.260** | 0.259 | 96 | 0.053 | 0.729*** | 0.298 | 70 | 0.181 | 0.440*** | 3.825 | 86 | 0.117 |
| | (0.114) | (2.391) | | | (0.203) | (0.195) | | | (0.143) | (2.416) | | |
| RFUT15M | 0.318*** | -1.923 | 96 | 0.093 | 0.962*** | 0.244 | 70 | 0.271 | 0.340** | 2.549 | 86 | 0.071 |
| | (0.107) | (2.240) | | | (0.197) | (0.190) | | | (0.142) | (2.396) | | |
| RFUT16M | 0.220** | -0.933 | 96 | 0.048 | 0.839*** | 0.137 | 70 | 0.206 | 0.313** | 1.469 | 86 | 0.063 |
| | (0.103) | (2.160) | | | (0.202) | (0.195) | | | (0.134) | (2.260) | | |

This table shows the regression results of natural gas for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2016 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; $Obs$ indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.16: Regression estimation for crude oil on the periods 1995-1999, 1999-2002, 2002-2005, 2005-2009, 2009-2012 and 2012-2015

| Variables | Panel A<br>October 1995 - January 1999<br>No. Observation = 174 | | | Panel B<br>January 1999 - June 2002<br>No. Observation = 176 | | | Panel C<br>June 2002 - October 2005<br>No. Observation = 176 | | | Panel D<br>October 2005 - February 2009<br>No. Observation = 176 | | | Panel E<br>February 2009 - June 2012<br>No. Observation = 176 | | | Panel F<br>June 2012 - December 2015<br>No. Observation = 183 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ |
| RFUT1M | 0.761*** | -1.050 | 0.192 | 1.312*** | -0.620 | 0.215 | 1.296*** | 1.248** | 0.301 | 1.028*** | 3.850*** | 0.130 | 1.213*** | 1.688*** | 0.394 | 0.754*** | 2.182*** | 0.189 |
| | (0.119) | (1.318) | | (0.191) | (0.981) | | (0.157) | (0.584) | | (0.330) | (0.952) | | (0.241) | (0.228) | | (0.246) | (0.379) | |
| RFUT2M | 0.737*** | -1.733* | 0.289 | 1.287*** | -0.393 | 0.249 | 1.249*** | 1.113** | 0.311 | 0.999*** | 4.688*** | 0.182 | 1.134*** | 1.712*** | 0.414 | 0.710*** | 2.160*** | 0.193 |
| | (0.0890) | (0.985) | | (0.170) | (0.875) | | (0.147) | (0.547) | | (0.306) | (0.881) | | (0.228) | (0.216) | | (0.238) | (0.366) | |
| RFUT3M | 0.678*** | -1.717** | 0.311 | 1.211*** | -0.190 | 0.256 | 1.178*** | 1.025** | 0.311 | 0.951*** | 4.403*** | 0.177 | 1.068*** | 1.741*** | 0.436 | 0.697*** | 2.159*** | 0.205 |
| | (0.0780) | (0.864) | | (0.158) | (0.812) | | (0.138) | (0.515) | | (0.293) | (0.845) | | (0.217) | (0.205) | | (0.228) | (0.351) | |
| RFUT4M | 0.614*** | -1.574** | 0.313 | 1.106*** | -0.0772 | 0.247 | 1.097*** | 0.961* | 0.304 | 0.903*** | 4.148*** | 0.168 | 1.019*** | 1.752*** | 0.446 | 0.677*** | 2.146*** | 0.212 |
| | (0.0702) | (0.777) | | (0.148) | (0.761) | | (0.131) | (0.488) | | (0.286) | (0.824) | | (0.210) | (0.199) | | (0.221) | (0.340) | |
| RFUT5M | 0.557*** | -1.505** | 0.310 | 1.009*** | -0.00376 | 0.234 | 1.018*** | 0.942** | 0.290 | 0.860*** | 3.904*** | 0.158 | 0.976*** | 1.750*** | 0.453 | 0.649*** | 2.133*** | 0.217 |
| | (0.0644) | (0.712) | | (0.140) | (0.719) | | (0.126) | (0.470) | | (0.280) | (0.806) | | (0.205) | (0.194) | | (0.215) | (0.331) | |
| RFUT6M | 0.508*** | -1.458** | 0.268 | 0.922*** | 0.000586 | 0.220 | 0.943*** | 0.929** | 0.274 | 0.821*** | 3.701*** | 0.149 | 0.942*** | 1.741*** | 0.456 | 0.621*** | 2.112*** | 0.221 |
| | (0.0651) | (0.720) | | (0.133) | (0.684) | | (0.122) | (0.455) | | (0.275) | (0.793) | | (0.201) | (0.190) | | (0.209) | (0.322) | |
| RFUT7M | 0.477*** | -1.355** | 0.303 | 0.477*** | -1.355** | 0.303 | 0.874*** | 0.915** | 0.257 | 0.789*** | 3.579*** | 0.144 | 0.916*** | 1.732*** | 0.460 | 0.589*** | 2.089*** | 0.224 |
| | (0.0562) | (0.622) | | (0.0562) | (0.622) | | (0.119) | (0.443) | | (0.272) | (0.783) | | (0.197) | (0.186) | | (0.204) | (0.314) | |
| RFUT8M | 0.448*** | -1.295** | 0.299 | 0.778*** | 0.0749 | 0.191 | 0.811*** | 0.903** | 0.240 | 0.756*** | 3.449*** | 0.137 | 0.895*** | 1.722*** | 0.463 | 0.555*** | 2.062*** | 0.227 |
| | (0.0533) | (0.590) | | (0.123) | (0.633) | | (0.116) | (0.432) | | (0.269) | (0.775) | | (0.194) | (0.183) | | (0.198) | (0.305) | |
| RFUT9M | 0.420*** | -1.223** | 0.289 | 0.718*** | 0.141 | 0.177 | 0.758*** | 0.882** | 0.224 | 0.733*** | 3.320*** | 0.130 | 0.874*** | 1.711*** | 0.465 | 0.524*** | 2.032*** | 0.230 |
| | (0.0512) | (0.567) | | (0.119) | (0.614) | | (0.114) | (0.424) | | (0.267) | (0.768) | | (0.191) | (0.180) | | (0.192) | (0.296) | |
| RFUT10M | 0.397*** | -1.185** | 0.281 | 0.665*** | 0.184 | 0.162 | 0.709*** | 0.876** | 0.210 | 0.707*** | 3.191*** | 0.124 | 0.849*** | 1.702*** | 0.466 | 0.490*** | 2.001*** | 0.231 |
| | (0.0494) | (0.546) | | (0.117) | (0.603) | | (0.112) | (0.416) | | (0.264) | (0.761) | | (0.188) | (0.178) | | (0.187) | (0.288) | |
| RFUT11M | 0.375*** | -1.114** | 0.273 | 0.617*** | 0.241 | 0.148 | 0.667*** | 0.873** | 0.199 | 0.684*** | 3.055*** | 0.117 | 0.822*** | 1.693*** | 0.466 | 0.458** | 1.963*** | 0.231 |
| | (0.0475) | (0.526) | | (0.115) | (0.591) | | (0.110) | (0.408) | | (0.262) | (0.754) | | (0.186) | (0.176) | | (0.183) | (0.281) | |
| RFUT12M | 0.356*** | -1.046** | 0.266 | 0.572*** | 0.259 | 0.135 | 0.625*** | 0.881** | 0.187 | 0.663** | 2.934*** | 0.112 | 0.796*** | 1.682*** | 0.466 | 0.428** | 1.922*** | 0.231 |
| | (0.0460) | (0.509) | | (0.112) | (0.579) | | (0.108) | (0.402) | | (0.259) | (0.748) | | (0.184) | (0.174) | | (0.178) | (0.275) | |
| RFUT13M | 0.336*** | -0.952* | 0.253 | 0.531*** | 0.271 | 0.124 | 0.586*** | 0.866** | 0.174 | 0.644** | 2.814*** | 0.106 | 0.771*** | 1.675*** | 0.467 | 0.401** | 1.885*** | 0.231 |
| | (0.0448) | (0.496) | | (0.110) | (0.568) | | (0.106) | (0.396) | | (0.257) | (0.742) | | (0.182) | (0.172) | | (0.174) | (0.268) | |
| RFUT14M | 0.314*** | -0.939* | 0.238 | 0.496*** | 0.303 | 0.114 | 0.551*** | 0.847** | 0.162 | 0.628** | 2.703*** | 0.100 | 0.744*** | 1.666*** | 0.466 | 0.387** | 1.854*** | 0.233 |
| | (0.0437) | (0.484) | | (0.108) | (0.558) | | (0.105) | (0.390) | | (0.256) | (0.737) | | (0.180) | (0.170) | | (0.170) | (0.262) | |

This table shows the regression results of crude oil for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$, $C$, $D$, $E$, $F$ cover the periods 1995-1999, 1999-2002, 2002-2005, 2005-2009, 2009-2012 and 2012-2015 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; $Obs$ indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.17: Regression estimation for heating oil on the periods 1995-1998, 1998-2001, 2001-2005, 2005-2008, 2008-2011 and 2011-2015

| Variables | Panel A<br>January 1995 - April 1998<br>No. observations = 174 | | | Panel B<br>May 1998 - September 2002<br>No. observations = 176 | | | Panel C<br>September 2002 - January 2005<br>No. observations = 176 | | | Panel D<br>January 2005 - May 2008<br>No. observations = 176 | | | Panel E<br>May 2008 - September 2011<br>No. observations = 176 | | | Panel F<br>September 2011 - March 2015<br>No. observations = 183 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ |
| RFUT1M | 0.622*** | 0.201 | 0.312 | 1.195*** | 0.456 | 0.290 | 0.857*** | 0.500 | 0.307 | 1.110*** | 1.642 | 0.316 | 1.041*** | 1.873*** | 0.408 | 0.506*** | 1.150*** | 0.374 |
| | (0.0704) | (1.015) | | (0.144) | (0.701) | | (0.101) | (0.450) | | (0.124) | (1.351) | | (0.158) | (0.289) | | (0.0717) | (0.192) | |
| RFUT2M | 0.534*** | -0.201 | 0.356 | 1.137*** | 0.477 | 0.365 | 0.818*** | 0.390 | 0.302 | 1.100*** | 1.132 | 0.331 | 1.040*** | 1.877*** | 0.414 | 0.466*** | 1.230*** | 0.398 |
| | (0.0547) | (0.790) | | (0.116) | (0.563) | | (0.0968) | (0.433) | | (0.118) | (1.292) | | (0.156) | (0.286) | | (0.0674) | (0.180) | |
| RFUT3M | 0.456*** | -0.193 | 0.335 | 1.059*** | 0.408 | 0.372 | 0.796*** | 0.288 | 0.314 | 1.051*** | 0.829 | 0.331 | 1.022*** | 1.827*** | 0.416 | 0.474*** | 1.189*** | 0.381 |
| | (0.0489) | (0.706) | | (0.106) | (0.516) | | (0.0911) | (0.407) | | (0.113) | (1.238) | | (0.152) | (0.279) | | (0.0691) | (0.185) | |
| RFUT4M | 0.394*** | -0.222 | 0.311 | 0.982*** | 0.397 | 0.362 | 0.782*** | 0.194 | 0.332 | 1.015*** | 0.589 | 0.330 | 0.999*** | 1.785*** | 0.414 | 0.459*** | 1.193*** | 0.374 |
| | (0.0447) | (0.645) | | (0.100) | (0.489) | | (0.0855) | (0.382) | | (0.110) | (1.197) | | (0.149) | (0.273) | | (0.0692) | (0.185) | |
| RFUT5M | 0.339*** | -0.229 | 0.276 | 0.898*** | 0.481 | 0.345 | 0.745*** | 0.233 | 0.340 | 0.989*** | 0.536 | 0.327 | 0.968*** | 1.765*** | 0.413 | 0.439*** | 1.208*** | 0.371 |
| | (0.0419) | (0.604) | | (0.0958) | (0.467) | | (0.0801) | (0.358) | | (0.108) | (1.176) | | (0.146) | (0.268) | | (0.0686) | (0.183) | |
| RFUT6M | 0.288*** | -0.148 | 0.241 | 0.792*** | 0.564 | 0.311 | 0.694*** | 0.302 | 0.335 | 0.964*** | 0.553 | 0.318 | 0.938*** | 1.752*** | 0.408 | 0.423*** | 1.225*** | 0.372 |
| | (0.0390) | (0.563) | | (0.0920) | (0.448) | | (0.0760) | (0.340) | | (0.107) | (1.169) | | (0.145) | (0.266) | | (0.0677) | (0.181) | |
| RFUT7M | 0.252*** | -0.0908 | 0.217 | 0.252*** | -0.0908 | 0.217 | 0.617*** | 0.377 | 0.311 | 0.929*** | 0.526 | 0.306 | 0.922*** | 1.734*** | 0.407 | 0.414*** | 1.217*** | 0.376 |
| | (0.0365) | (0.527) | | (0.0365) | (0.527) | | (0.0719) | (0.321) | | (0.106) | (1.159) | | (0.143) | (0.263) | | (0.0662) | (0.177) | |
| RFUT8M | 0.224*** | -0.136 | 0.193 | 0.645*** | 0.538 | 0.265 | 0.547*** | 0.438 | 0.285 | 0.878*** | 0.353 | 0.290 | 0.906*** | 1.714*** | 0.407 | 0.399*** | 1.198*** | 0.373 |
| | (0.0350) | (0.505) | | (0.0843) | (0.411) | | (0.0686) | (0.307) | | (0.104) | (1.140) | | (0.141) | (0.259) | | (0.0649) | (0.174) | |
| RFUT9M | 0.213*** | -0.106 | 0.178 | 0.585*** | 0.368 | 0.234 | 0.487*** | 0.435 | 0.260 | 0.830*** | 0.153 | 0.277 | 0.901*** | 1.677*** | 0.411 | 0.390*** | 1.194*** | 0.378 |
| | (0.0348) | (0.502) | | (0.0823) | (0.401) | | (0.0654) | (0.293) | | (0.102) | (1.114) | | (0.138) | (0.253) | | (0.0636) | (0.170) | |
| RFUT10M | 0.216*** | -0.116 | 0.183 | 0.538*** | 0.333 | 0.222 | 0.448*** | 0.413 | 0.244 | 0.792*** | 0.150 | 0.267 | 0.885*** | 1.652*** | 0.413 | 0.379*** | 1.206*** | 0.382 |
| | (0.0348) | (0.502) | | (0.0782) | (0.381) | | (0.0629) | (0.281) | | (0.100) | (1.092) | | (0.135) | (0.248) | | (0.0625) | (0.167) | |
| RFUT11M | 0.222*** | -0.266 | 0.191 | 0.496*** | 0.233 | 0.185 | 0.432*** | 0.373 | 0.245 | 0.768*** | 0.418 | 0.257 | 0.871*** | 1.642*** | 0.417 | 0.370*** | 1.147*** | 0.379 |
| | (0.0349) | (0.504) | | (0.0803) | (0.391) | | (0.0603) | (0.270) | | (0.0992) | (1.083) | | (0.133) | (0.243) | | (0.0606) | (0.162) | |
| RFUT12M | 0.224*** | -0.293 | 0.193 | 0.453*** | 0.321 | 0.193 | 0.398*** | 0.328 | 0.223 | 0.758*** | 0.810 | 0.250 | 0.851*** | 1.640*** | 0.422 | 0.359*** | 1.178*** | 0.390 |
| | (0.0351) | (0.506) | | (0.0722) | (0.352) | | (0.0590) | (0.264) | | (0.0994) | (1.085) | | (0.130) | (0.238) | | (0.0593) | (0.159) | |
| RFUT13M | 0.223*** | -0.416 | 0.194 | 0.427*** | 0.430 | 0.190 | 0.379*** | 0.290 | 0.209 | 0.758*** | 1.039 | 0.248 | 0.838*** | 1.630*** | 0.423 | 0.346*** | 1.189*** | 0.384 |
| | (0.0348) | (0.502) | | (0.0700) | (0.341) | | (0.0582) | (0.260) | | (0.100) | (1.092) | | (0.128) | (0.235) | | (0.0592) | (0.162) | |
| RFUT14M | 0.211*** | -0.482 | 0.182 | 0.419*** | 0.517 | 0.188 | 0.368*** | 0.232 | 0.200 | 0.756*** | 0.896 | 0.248 | 0.820*** | 1.610*** | 0.419 | 0.336*** | 1.178*** | 0.373 |
| | (0.0346) | (0.499) | | (0.0699) | (0.340) | | (0.0578) | (0.258) | | (0.1000) | (1.091) | | (0.127) | (0.233) | | (0.0595) | (0.166) | |

This table shows the regression results of heating oil for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$, $C$, $D$, $E$, $F$ cover the periods 1995-1999, 1999-2002, 2002-2005, 2005-2009, 2009-2012 and 2012-2015 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; $Obs$ indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.18: Regression estimation for natural gas on the periods 1995-1998, 1998-2001, 2001-2005, 2005-2008, 2008-2011 and 2011-2015

| Variables | Panel A<br>January 1995 - April 1998<br>No. observation = 173 | | | Panel B<br>May 1998 - September 2001<br>No. observation = 176 | | | Panel C<br>September 2001 - January 2005<br>No. observation = 176 | | | Panel D<br>January 2005 - May 2008<br>No. observation = 176 | | | Panel E<br>May 2008 - September 2011<br>No. observation = 176 | | | Panel F<br>September 2011 - March 2015<br>No. observation = 183 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ | CHP | RPSP500adj | $R^2$ |
| RFUT1M | 1.091*** | 6.959 | 0.172 | 1.399*** | 1.916 | 0.217 | 2.212*** | 5.667 | 0.223 | 1.780*** | 6.346 | 0.124 | 1.359*** | 6.995*** | 0.149 | 0.638*** | -4.063 | 0.049 |
| | (0.197) | (5.298) | | (0.202) | (3.210) | | (0.320) | (3.593) | | (0.365) | (5.269) | | (0.287) | (2.674) | | (0.225) | (3.491) | |
| RFUT2M | 1.088*** | 6.327 | 0.225 | 1.353*** | -0.784 | 0.221 | 2.132*** | 5.097** | 0.346 | 1.647*** | 7.131 | 0.116 | 1.318*** | 6.718*** | 0.166 | 0.722*** | -3.526 | 0.065 |
| | (0.164) | (4.426) | | (0.193) | (3.061) | | (0.227) | (2.543) | | (0.355) | (5.119) | | (0.261) | (2.435) | | (0.211) | (3.281) | |
| RFUT3M | 0.940*** | 6.689* | 0.236 | 1.264*** | -1.819 | 0.217 | 1.883*** | 4.794** | 0.352 | 1.619*** | 5.319 | 0.112 | 1.206*** | 6.903*** | 0.170 | 0.590*** | -2.399 | 0.051 |
| | (0.140) | (3.770) | | (0.183) | (2.901) | | (0.199) | (2.225) | | (0.351) | (5.068) | | (0.243) | (2.261) | | (0.195) | (3.026) | |
| RFUT4M | 0.731*** | 6.554** | 0.230 | 1.129*** | -1.092 | 0.219 | 1.512*** | 3.668* | 0.316 | 1.333*** | 5.901 | 0.101 | 1.092*** | 6.837*** | 0.167 | 0.476*** | -0.766 | 0.037 |
| | (0.114) | (3.061) | | (0.162) | (2.571) | | (0.172) | (1.931) | | (0.312) | (4.501) | | (0.228) | (2.128) | | (0.181) | (2.805) | |
| RFUT5M | 0.543*** | 6.597*** | 0.227 | 0.915*** | 0.846 | 0.182 | 1.359*** | 2.865 | 0.275 | 1.241*** | 6.102 | 0.105 | 0.984*** | 7.163*** | 0.158 | 0.335** | -1.393 | 0.024 |
| | (0.0895) | (2.412) | | (0.147) | (2.339) | | (0.170) | (1.904) | | (0.285) | (4.119) | | (0.224) | (2.086) | | (0.164) | (2.553) | |
| RFUT6M | 0.483*** | 6.102*** | 0.248 | 0.706*** | 1.822 | 0.132 | 1.144*** | 1.714 | 0.234 | 0.789*** | 5.466 | 0.059 | 0.945*** | 7.491*** | 0.173 | 0.313* | -1.571 | 0.022 |
| | (0.0758) | (2.043) | | (0.139) | (2.204) | | (0.158) | (1.773) | | (0.260) | (3.755) | | (0.211) | (1.965) | | (0.162) | (2.520) | |
| RFUT7M | 0.454*** | 5.593*** | 0.241 | 0.454*** | 5.593*** | 0.241 | 1.173*** | 2.005 | 0.251 | 0.942*** | 4.920 | 0.091 | 0.898*** | 6.718*** | 0.187 | 0.359** | -1.516 | 0.030 |
| | (0.0723) | (1.947) | | (0.0723) | (1.947) | | (0.155) | (1.741) | | (0.236) | (3.409) | | (0.186) | (1.737) | | (0.157) | (2.439) | |
| RFUT8M | 0.431*** | 5.586*** | 0.213 | 0.468*** | -0.194 | 0.071 | 1.142*** | 2.199 | 0.264 | 1.044*** | 4.257 | 0.137 | 0.858*** | 4.973*** | 0.170 | 0.392*** | -1.103 | 0.041 |
| | (0.0751) | (2.023) | | (0.128) | (2.039) | | (0.147) | (1.645) | | (0.204) | (2.944) | | (0.173) | (1.612) | | (0.143) | (2.223) | |
| RFUT9M | 0.424*** | 5.023** | 0.205 | 0.417*** | -0.914 | 0.059 | 1.079*** | 2.162 | 0.247 | 1.278*** | 0.726 | 0.180 | 0.823*** | 5.084*** | 0.174 | 0.338** | -1.473 | 0.036 |
| | (0.0742) | (2.000) | | (0.127) | (2.021) | | (0.145) | (1.626) | | (0.207) | (2.990) | | (0.167) | (1.556) | | (0.134) | (2.086) | |
| RFUT10M | 0.359*** | 3.917** | 0.172 | 0.365*** | -0.748 | 0.049 | 0.862*** | 1.595 | 0.185 | 0.979*** | 1.907 | 0.106 | 0.723*** | 4.970*** | 0.161 | 0.268** | -1.477 | 0.026 |
| | (0.0689) | (1.857) | | (0.123) | (1.951) | | (0.139) | (1.556) | | (0.216) | (3.124) | | (0.159) | (1.485) | | (0.129) | (2.009) | |
| RFUT11M | 0.302*** | 2.162 | 0.122 | 0.295** | 0.0787 | 0.032 | 0.725*** | 1.846 | 0.154 | 1.006*** | 2.183 | 0.107 | 0.714*** | 5.282*** | 0.192 | 0.243** | -1.618 | 0.024 |
| | (0.0671) | (1.808) | | (0.122) | (1.935) | | (0.132) | (1.480) | | (0.221) | (3.191) | | (0.146) | (1.357) | | (0.123) | (1.913) | |
| RFUT12M | 0.243*** | 1.251 | 0.086 | 0.203* | 1.277 | 0.020 | 0.606*** | 1.780 | 0.117 | 0.498** | 2.173 | 0.033 | 0.668*** | 5.647*** | 0.189 | 0.201* | -1.664 | 0.019 |
| | (0.0640) | (1.724) | | (0.117) | (1.852) | | (0.130) | (1.456) | | (0.212) | (3.060) | | (0.146) | (1.357) | | (0.121) | (1.873) | |
| RFUT13M | 0.260*** | -0.178 | 0.088 | 0.175 | 1.368 | 0.017 | 0.619*** | 2.330* | 0.137 | -0.0267 | 6.316** | 0.024 | 0.632*** | 5.573*** | 0.188 | 0.288** | -2.383 | 0.038 |
| | (0.0643) | (1.733) | | (0.112) | (1.776) | | (0.124) | (1.389) | | (0.211) | (3.047) | | (0.141) | (1.311) | | (0.120) | (1.865) | |
| RFUT14M | 0.249*** | -0.537 | 0.088 | 0.211* | -0.403 | 0.021 | 0.613*** | 2.381* | 0.142 | 0.291 | 2.784 | 0.016 | 0.596*** | 4.733*** | 0.168 | 0.296** | -1.261 | 0.036 |
| | (0.0614) | (1.655) | | (0.111) | (1.764) | | (0.120) | (1.350) | | (0.203) | (2.935) | | (0.136) | (1.264) | | (0.117) | (1.811) | |

This table shows the regression results of natural gas for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$, $C$, $D$, $E$, $F$ cover the periods 1995-1999, 1999-2002, 2002-2005, 2005-2009, 2009-2012 and 2012-2015 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CHP$ is the coefficient of the first difference of hedging pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; $Obs$ indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.19: Regression estimation for crude oil (WTI) on the periods 1995-2002, 2003-2008 and 2008-2015, by using speculative pressure

| Variables | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CNCP | RPSP500adj | Obs | R-squared | CNCP | RPSP500adj | Obs | R-squared | CNCP | RPSP500adj | Obs | R-squared |
| RFUT1M | 0.237*** | 0.159 | 376 | 0.159 | 0.654*** | 1.016 | 307 | 0.212 | 1.009*** | 1.918*** | 375 | 0.310 |
| | (0.0283) | (0.584) | | | (0.0731) | (0.849) | | | (0.160) | (0.207) | | |
| RFUT2M | 0.227*** | 0.152 | 376 | 0.196 | 0.632*** | 0.596 | 307 | 0.214 | 0.879*** | 2.028*** | 375 | 0.330 |
| | (0.0239) | (0.493) | | | (0.0696) | (0.809) | | | (0.152) | (0.197) | | |
| RFUT3M | 0.212*** | 0.192 | 376 | 0.204 | 0.604*** | 0.461 | 307 | 0.213 | 0.809*** | 2.034*** | 375 | 0.342 |
| | (0.0218) | (0.450) | | | (0.0667) | (0.775) | | | (0.145) | (0.188) | | |
| RFUT4M | 0.191*** | 0.234 | 376 | 0.197 | 0.571*** | 0.373 | 307 | 0.205 | 0.757*** | 2.027*** | 375 | 0.347 |
| | (0.0201) | (0.415) | | | (0.0645) | (0.749) | | | (0.140) | (0.182) | | |
| RFUT5M | 0.173*** | 0.262 | 376 | 0.188 | 0.539*** | 0.317 | 307 | 0.195 | 0.714*** | 2.009*** | 375 | 0.351 |
| | (0.0188) | (0.388) | | | (0.0629) | (0.731) | | | (0.136) | (0.177) | | |
| RFUT6M | 0.159*** | 0.267 | 376 | 0.175 | 0.509*** | 0.269 | 307 | 0.184 | 0.679*** | 1.988*** | 375 | 0.353 |
| | (0.0181) | (0.373) | | | (0.0616) | (0.715) | | | (0.133) | (0.173) | | |
| RFUT7M | 0.145*** | 0.299 | 376 | 0.170 | 0.482*** | 0.248 | 307 | 0.173 | 0.650*** | 1.973*** | 375 | 0.356 |
| | (0.0168) | (0.348) | | | (0.0605) | (0.703) | | | (0.130) | (0.169) | | |
| RFUT8M | 0.135*** | 0.299 | 376 | 0.163 | 0.457*** | 0.219 | 307 | 0.162 | 0.623*** | 1.956*** | 375 | 0.358 |
| | (0.0161) | (0.332) | | | (0.0596) | (0.692) | | | (0.128) | (0.166) | | |
| RFUT9M | 0.126*** | 0.321 | 376 | 0.155 | 0.437*** | 0.188 | 307 | 0.153 | 0.599*** | 1.937*** | 375 | 0.360 |
| | (0.0155) | (0.319) | | | (0.0589) | (0.684) | | | (0.125) | (0.162) | | |
| RFUT10M | 0.117*** | 0.334 | 376 | 0.145 | 0.417*** | 0.182 | 307 | 0.145 | 0.575*** | 1.918*** | 375 | 0.362 |
| | (0.0150) | (0.310) | | | (0.0582) | (0.676) | | | (0.123) | (0.159) | | |
| RFUT11M | 0.109*** | 0.354 | 376 | 0.136 | 0.400*** | 0.188 | 307 | 0.137 | 0.552*** | 1.897*** | 375 | 0.362 |
| | (0.0146) | (0.302) | | | (0.0575) | (0.668) | | | (0.121) | (0.157) | | |
| RFUT12M | 0.102*** | 0.364 | 376 | 0.128 | 0.383*** | 0.199 | 307 | 0.130 | 0.529*** | 1.874*** | 375 | 0.362 |
| | (0.0142) | (0.294) | | | (0.0569) | (0.661) | | | (0.119) | (0.154) | | |
| RFUT13M | 0.0960*** | 0.367 | 376 | 0.121 | 0.366*** | 0.199 | 307 | 0.122 | 0.509*** | 1.854*** | 375 | 0.362 |
| | (0.0139) | (0.286) | | | (0.0564) | (0.655) | | | (0.117) | (0.151) | | |
| RFUT14M | 0.0893*** | 0.359 | 376 | 0.111 | 0.366*** | 0.199 | 307 | 0.122 | 0.492*** | 1.833*** | 375 | 0.362 |
| | (0.0136) | (0.280) | | | (0.0564) | (0.655) | | | (0.115) | (0.149) | | |

This table shows the regression results of crude oil (WTI) for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2016 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CNCP$ is the coefficient of the first difference of speculative pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; $Obs$ indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.20: Regression estimation for heating oil on the periods 1995-2002, 2003-2008 and 2008-2015, by using speculative pressure

| Variables | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CNCP | RPSP500adj | Obs | R-squared | CNCP | RPSP500adj | Obs | R-squared | CNCP | RPSP500adj | Obs | R-squared |
| RFUT1M | 0.206*** | 0.559 | 418 | 0.252 | 0.342*** | -0.419 | 302 | 0.165 | 0.402*** | 1.746*** | 377 | 0.359 |
| | (0.0179) | (0.359) | | | (0.0445) | (0.930) | | | (0.0523) | (0.181) | | |
| RFUT2M | 0.184*** | 0.473 | 418 | 0.272 | 0.331*** | -0.723 | 302 | 0.167 | 0.395*** | 1.767*** | 377 | 0.372 |
| | (0.0152) | (0.304) | | | (0.0428) | (0.895) | | | (0.0509) | (0.176) | | |
| RFUT3M | 0.164*** | 0.389 | 418 | 0.254 | 0.322*** | -0.760 | 302 | 0.175 | 0.390*** | 1.711*** | 377 | 0.368 |
| | (0.0141) | (0.283) | | | (0.0408) | (0.852) | | | (0.0500) | (0.173) | | |
| RFUT4M | 0.147*** | 0.304 | 418 | 0.234 | 0.319*** | -0.621 | 302 | 0.183 | 0.382*** | 1.670*** | 377 | 0.369 |
| | (0.0134) | (0.267) | | | (0.0390) | (0.815) | | | (0.0489) | (0.169) | | |
| RFUT5M | 0.132*** | 0.321 | 418 | 0.218 | 0.308*** | -0.234 | 302 | 0.182 | 0.368*** | 1.650*** | 377 | 0.370 |
| | (0.0126) | (0.252) | | | (0.0378) | (0.790) | | | (0.0477) | (0.165) | | |
| RFUT6M | 0.115*** | 0.385 | 418 | 0.197 | 0.295*** | 0.00238 | 302 | 0.175 | 0.356*** | 1.640*** | 377 | 0.371 |
| | (0.0119) | (0.238) | | | (0.0369) | (0.772) | | | (0.0468) | (0.162) | | |
| RFUT7M | 0.103*** | 0.436* | 418 | 0.185 | 0.271*** | -0.0173 | 302 | 0.159 | 0.349*** | 1.626*** | 377 | 0.373 |
| | (0.0111) | (0.223) | | | (0.0360) | (0.752) | | | (0.0460) | (0.159) | | |
| RFUT8M | 0.0930*** | 0.496** | 418 | 0.175 | 0.245*** | -0.178 | 302 | 0.141 | 0.340*** | 1.612*** | 377 | 0.373 |
| | (0.0106) | (0.212) | | | (0.0350) | (0.732) | | | (0.0453) | (0.157) | | |
| RFUT9M | 0.0868*** | 0.457** | 418 | 0.166 | 0.221*** | -0.375 | 302 | 0.125 | 0.336*** | 1.593*** | 377 | 0.377 |
| | (0.0102) | (0.205) | | | (0.0339) | (0.709) | | | (0.0444) | (0.154) | | |
| RFUT10M | 0.0828*** | 0.434** | 418 | 0.164 | 0.208*** | -0.432 | 302 | 0.119 | 0.328*** | 1.585*** | 377 | 0.382 |
| | (0.00983) | (0.196) | | | (0.0330) | (0.689) | | | (0.0434) | (0.150) | | |
| RFUT11M | 0.0788*** | 0.360* | 418 | 0.148 | 0.205*** | -0.316 | 302 | 0.119 | 0.323*** | 1.555*** | 377 | 0.385 |
| | (0.00981) | (0.196) | | | (0.0323) | (0.675) | | | (0.0424) | (0.147) | | |
| RFUT12M | 0.0764*** | 0.327* | 418 | 0.155 | 0.198*** | -0.159 | 302 | 0.113 | 0.316*** | 1.563*** | 377 | 0.394 |
| | (0.00922) | (0.184) | | | (0.0320) | (0.668) | | | (0.0414) | (0.143) | | |
| RFUT13M | 0.0718*** | 0.310* | 418 | 0.145 | 0.195*** | -0.125 | 302 | 0.111 | 0.311*** | 1.566*** | 372 | 0.395 |
| | (0.00904) | (0.181) | | | (0.0319) | (0.667) | | | (0.0412) | (0.143) | | |
| RFUT14M | 0.0680*** | 0.289 | 418 | 0.131 | 0.193*** | -0.296 | 302 | 0.110 | 0.305*** | 1.552*** | 368 | 0.392 |
| | (0.00906) | (0.181) | | | (0.0317) | (0.663) | | | (0.0409) | (0.143) | | |
| RFUT15M | 0.0643*** | 0.257 | 418 | 0.117 | 0.196*** | -0.312 | 302 | 0.115 | 0.301*** | 1.526*** | 364 | 0.389 |
| | (0.00911) | (0.182) | | | (0.0316) | (0.660) | | | (0.0407) | (0.142) | | |
| RFUT16M | 0.0638*** | 0.192 | 414 | 0.107 | 0.201*** | -0.247 | 302 | 0.120 | 0.296*** | 1.503*** | 359 | 0.387 |
| | (0.00942) | (0.188) | | | (0.0315) | (0.659) | | | (0.0406) | (0.142) | | |

This table shows the regression results of heating oil for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2016 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CNCP$ is the coefficient of the first difference of speculative pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; *Obs* indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

Table 2.21: Regression estimation for natural gas on the periods 1995-2002, 2003-2008 and 2008-2015, by using speculative pressure

| Variables | Panel A 1995-2002 | | | | Panel B 2003-2008 | | | | Panel C 2008-2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CNCP | RPSP500adj | Obs | R-squared | CNCP | RPSP500adj | Obs | R-squared | CNCP | RPSP500adj | Obs | R-squared |
| RFUT1M | 0.284*** | 4.366* | 417 | 0.196 | 1.147*** | 4.979 | 302 | 0.128 | 1.196*** | 4.664** | 378 | 0.041 |
| | (0.0291) | (2.234) | | | (0.175) | (3.724) | | | (0.361) | (2.094) | | |
| RFUT2M | 0.270*** | 2.713 | 417 | 0.209 | 1.228*** | 6.155** | 302 | 0.205 | 1.265*** | 4.477** | 378 | 0.050 |
| | (0.0262) | (2.014) | | | (0.141) | (3.010) | | | (0.334) | (1.935) | | |
| RFUT3M | 0.241*** | 2.326 | 417 | 0.203 | 1.111*** | 4.878* | 302 | 0.186 | 1.061*** | 4.774*** | 378 | 0.049 |
| | (0.0238) | (1.828) | | | (0.135) | (2.889) | | | (0.308) | (1.784) | | |
| RFUT4M | 0.198*** | 2.031 | 417 | 0.187 | 0.886*** | 4.670* | 302 | 0.157 | 0.889*** | 5.083*** | 378 | 0.049 |
| | (0.0206) | (1.584) | | | (0.120) | (2.569) | | | (0.284) | (1.647) | | |
| RFUT5M | 0.153*** | 2.536* | 417 | 0.154 | 0.812*** | 4.454* | 302 | 0.149 | 0.710*** | 5.043*** | 378 | 0.045 |
| | (0.0182) | (1.400) | | | (0.114) | (2.430) | | | (0.268) | (1.555) | | |
| RFUT6M | 0.130*** | 2.315* | 417 | 0.133 | 0.593*** | 4.039* | 302 | 0.104 | 0.634** | 5.384*** | 378 | 0.049 |
| | (0.0169) | (1.299) | | | (0.103) | (2.204) | | | (0.256) | (1.483) | | |
| RFUT7M | 0.116*** | 2.280* | 417 | 0.118 | 0.629*** | 3.677* | 302 | 0.128 | 0.677*** | 4.788*** | 378 | 0.052 |
| | (0.0163) | (1.252) | | | (0.0968) | (2.064) | | | (0.235) | (1.363) | | |
| RFUT8M | 0.108*** | 1.569 | 417 | 0.106 | 0.631*** | 3.526* | 302 | 0.153 | 0.725*** | 3.846*** | 378 | 0.053 |
| | (0.0158) | (1.214) | | | (0.0870) | (1.855) | | | (0.215) | (1.247) | | |
| RFUT9M | 0.101*** | 1.244 | 417 | 0.097 | 0.636*** | 2.393 | 302 | 0.145 | 0.694*** | 3.598*** | 378 | 0.053 |
| | (0.0155) | (1.189) | | | (0.0895) | (1.909) | | | (0.204) | (1.184) | | |
| RFUT10M | 0.0863*** | 0.997 | 417 | 0.080 | 0.469*** | 1.946 | 302 | 0.082 | 0.534*** | 3.600*** | 378 | 0.046 |
| | (0.0146) | (1.126) | | | (0.0913) | (1.947) | | | (0.194) | (1.125) | | |
| RFUT11M | 0.0699*** | 0.964 | 417 | 0.057 | 0.393*** | 2.422 | 302 | 0.062 | 0.432** | 3.831*** | 378 | 0.047 |
| | (0.0143) | (1.096) | | | (0.0904) | (1.929) | | | (0.184) | (1.067) | | |
| RFUT12M | 0.0565*** | 1.372 | 417 | 0.044 | 0.276*** | 2.289 | 302 | 0.037 | 0.350* | 4.059*** | 378 | 0.047 |
| | (0.0137) | (1.057) | | | (0.0850) | (1.813) | | | (0.183) | (1.061) | | |
| RFUT13M | 0.0566*** | 1.204 | 417 | 0.045 | 0.202** | 4.481** | 302 | 0.037 | 0.429** | 3.828*** | 378 | 0.050 |
| | (0.0134) | (1.028) | | | (0.0831) | (1.773) | | | (0.178) | (1.034) | | |
| RFUT14M | 0.0566*** | 0.282 | 417 | 0.043 | 0.242*** | 3.299* | 302 | 0.039 | 0.441** | 3.479*** | 378 | 0.048 |
| | (0.0132) | (1.013) | | | (0.0794) | (1.694) | | | (0.172) | (0.996) | | |
| RFUT15M | 0.0633*** | -0.0501 | 417 | 0.053 | 0.297*** | 3.117* | 302 | 0.051 | 0.307* | 3.204*** | 378 | 0.037 |
| | (0.0131) | (1.008) | | | (0.0804) | (1.716) | | | (0.167) | (0.966) | | |
| RFUT16M | 0.0563*** | -0.0761 | 417 | 0.045 | 0.250*** | 2.200 | 302 | 0.034 | 0.187 | 3.397*** | 378 | 0.038 |
| | (0.0127) | (0.980) | | | (0.0816) | (1.741) | | | (0.159) | (0.924) | | |
| RFUT17M | 0.0469*** | 0.580 | 417 | 0.033 | 0.285*** | 1.844 | 302 | 0.043 | 0.113 | 3.273*** | 378 | 0.036 |
| | (0.0128) | (0.981) | | | (0.0800) | (1.707) | | | (0.153) | (0.888) | | |

This table shows the regression results of natural gas for 14 maturities considering the participation of the financial investor in the futures market. Panels $A$, $B$ and $C$ cover the periods 1995-2002, 2003-2008 and 2008-2016 respectively. The values between brackets shows the standard deviation. */**/*** which marks the coefficient is the level of confidence at 10%, 5% and 1% respectively. $CNCP$ is the coefficient of the first difference of speculative pressure; $RPSP500adj$ is the coefficient of the adjusted stock returns which is defined by the multiplication between stock returns and commodity-equity correlation; *Obs* indicates the number of observations. The last column of each panel shows R-squared for each maturity regression.

# Chapter 3

# Cross Commodity Markets Integration: An Equilibrium Model

We propose a model that investigates cross commodity linkages. The model examines the integration between two commodity markets as a consequence to the operation of financial investors in commodity markets. As a result, we find that the cross-commodity correlation is an important determinant of information flow between both commodity markets. We explain the role of financial investors in transmitting supply/demand shocks (and the expected future shocks) between commodity markets, and demonstrate the shock's impact on the spot prices, futures prices, future spot prices, inventory levels and the demand for production. The abundance in any commodity decreases the spot prices, the futures prices, and the future spot prices, while it increases the inventory levels and the production demand and the futures risk premium. We find also that the increase in the financial investors participation (who take long positions) in commodity markets increases each of spot prices, futures prices and inventory levels, while it decreases the future spot price and the demand for production.

**Keywords:** Commodity markets, financialization, cross commodity correlation, commodity prices, hedgers, investors.

## 3.1 Introduction

Commodity markets are integrated in different levels. In some occasions, the relationship is clear as in production process. For instance, energy is an input for almost every product directly or indirectly by using it as raw materials, for transportation, etc. Therefore, we notice a highly co-integration between energy and non-energy commodity markets. Some commodities are possibly substitutes or complementary to each other (Malliaris and Urrutia (1996), Chevallier and Ielpo (2013) (chapter 5)). For example, wheat can be a substitute for corn in producing bread. Also, coal, crude oil and natural gas are substitutes commodities in producing electricity. Furthermore, similar commodity markets are affected by similar factors. For instance, weather is an important determinant of the agricultural commodity prices (Stevens (1991)). Add to that, macroeconomic shocks increase the interdependency between commodity markets. However, Kat and Oomen (2007) express that commodities in the same group are higher correlated than groups of commodities with each other. Form one side, we may find reasons for the comovement between different markets such as energy and agricultural markets, but how would we interpret the comovement between less integrated markets such as precious metals and agricultural markets? More importantly, is there just comovement between commodity markets as most of the papers addressed, and not the opposite, where the cross commodity correlation is negative?

In their paper, Dornbusch et al. (2000) posit that contagion, which is an example of information transmission, is caused by fundamental reasons: common shocks, trade links and competitive devaluations, and financial links[1]. King and Wadhwani (1990) shows that financial investors access to different markets can transmit information from one market to another. Moreover, Chevallier and Ielpo (2013) (chapter 5) said that investors can determine the correlation between any commodity markets. Consequently, considering financial investors and the investors' behavior as a channel transmits information from one market to another (or from an economy to another) is a quite interesting question to stop on it. Especially, in the last two decades, the appearance of financial investors and financial institutions increased sharply in the futures commodity markets, which is called the financialization of commodity markets. Masters (2008) estimated that investing in commodities jumped from 13 billion at 2003 to 260 billion at March 2008. The literature explained that financial investors are looking for securitization to their portfolios (e.g. Gorton and Rouwenhorst (2006), Erb and Harvey (2006), Galvani and Plourde (2010), and others). The low co-movement between commodity-equity and cross commodities was appealing to diversify their portfolios and consider the commodity as an asset class.

[1] Contagion is defined as a significant increase in cross market linkage after a shock (**?**). Or, it is the spread of market disturbances (Dornbusch et al. (2000)). Therefore, if the comovement is noticeable before and after the crisis, then the situation is not a contagion but interdependency. In our paper, we do not adapt the term conagion. We use it here as an example of information transmission between differet markets.

That was facilitated by the surge in the internet and the telecommunication developments. Usually, financial investor invests in a basket of commodities. They hold a portfolio of commodities that imitates a well-diversified index such as Goldman Sachs Commodity Index ($S\&P$ GSCI), or Dow Jones-UBS Commodity Index (DJ-UBSCI ) (e.g. see Stoll and Whaley (2010), Irwin and Sanders (2011)). Synchronizing with these increases, several changes have been appeared in the commodity markets. More importantly, different commodities prices became more correlated such as between non-energy commodities and oil (Tang and Xiong (2012)), and between crude oil and agricultural commodities (Natanelov et al. (2011)). Bruno et al. (2013) express an increase in the co-movement in cross commodity return after 2008 crisis.

Several studies, mostly empirical, express the integration between commodity markets and explain the linkage between their prices. Although all the studies that have been done, the question of whether the speculation of index investors has an impact on the commodity markets has not been proved yet. It is necessary to have more theoretical studies. Furthermore, is there all the time co-movement between prices and not the opposite? What is the relationship between inventory levels, quantity demanded for production and the prices? And how do index investors play the role in determining the information flow between different markets?

In this paper, we will be studying the information flows between any two commodity markets. We do so by constructing a model, from the spirit of Ekeland et al. (2015), which studies the interaction between physical and futures markets of a commodity market from one side, and how it interacts with another commodity market (physical and futures) from another side. In this paper, we aim to study two questions: first, the interdependence between commodity markets. Second, the impact of financialization on commodity prices.

Our model investigates the interaction between two commodity markets. In each commodity market, there is an interaction between physical and futures markets, which results from the operation of hedgers in both markets. Consequently, the model exceeds studying the linkage between physical and futures markets of the single commodity to include the linkage between the futures markets of both commodities, and the futures market of a commodity with the physical market of the other commodity. In our model, there are two commodities. The model is a two periods model, the markets correspond at $t$ and $T$. For each commodity market, there are four types of participants: inventory holder (storer), producer, speculator (financial investors) and spot traders. The storer has the capacity to hold the commodity from $t$ to $T$. The processor uses the commodity as a raw material to produce other final goods. Both storer and processor operate in the physical and futures markets; they hedge their physical positions. The speculator holds futures positions only. The spot traders meet the immediate demand and supply in the physical

market. Each commodity has different types of storer, processor and spot traders than the other. For instance, gold and wheat have different ways of storage, and they are used differently. In this context, we assume that the commodities are unrelated fundamentally. The speculator operates in both markets. For more simplicity, our model can be interpreted as a combination between two isolated forms of Ekeland et al. (2015) that are linked by the speculators (financial investor). The agents follow the rational expectations theory. They are mean-variance utility maximizers. In our model, the risk free rate equals zero.

In the model, the speculator is considered the transmission channel that is responsible for information flow between both markets. His optimal positions in both commodities are determined by the signs and the magnitudes of the bias in futures prices of both commodities and the cross-commodity correlation. The combination between these factors' signs determine whether speculator takes long or short positions in futures market. Any shock in the economic fundamentals (supply/demand) in commodity market $a$ (for example) destabilizes the positions taken by hedgers, and consequently affect the futures positions taken by speculators. The change in his positions in market $a$ means he will modify his position in market $b$. That is considered the source of information transmission between the two markets. Generally, in any market, if speculator asks for long (short) positions, the futures price is pushed up (pulled down). As a result to the equilibrium, we find the prices of current spot price, futures price, the future spot price, the inventory levels and the quantity demanded for production.

We focus on studying three questions: first, the comparative statics of the supply/demand shocks. Second, we experience the expected future shock on the supply/demand in the physical market. We study the impact of these shocks on the prices of the commodity, and how it spreads to the other market. Third, we investigate the impact of speculation on the commodity prices.

First, we find that an abundance in commodity $a$ at time $t$ decreases the current spot price, the futures price and future spot price of the commodity. On the contrary, it increases the inventory levels, the quantity demanded for production and the futures risk premium of commodity $a$. These changes are caused by the increase in hedger's demand from physical market. After then, the cost of hedging increases. On the other side, the speculator tend to own more long positions in the futures market of commodity[2] $a$. Information flow between markets is determined by cross commodity correlation. By assuming the general situation where the cross commodity is positive (e.g. Tang and Xiong (2012)), when the speculator has more futures positions in commodity $a$, he will reduce his long position in commodity $b$ (or increase short position). That leads to decrease the futures price. Therefore, the hedging for inventory holder, who sells

[2]This result is familiar to finding of Ekeland et al. (2015)

futures contracts, is less profitable. Hence, inventory levels, and current spot price decline. On the contrary, the demand for production, the future spot price and futures risk premium rise. Basak and Pavlova (2016) also found that an increase in the supply in commodity $a$ causes a decrease in the inventory and the spot price of commodity $b$. The changes in commodity $b$ is mirrored when the cross commodity correlation is negative.

Second, expecting a change in some economic fundamentals (future supply and demand shocks) at time $T$ in commodity $a$ shrinks the prices and quantities in commodity market $a$. On the contrary, commodity market $b$ is more active. In this situation, the speculators tend toward having short positions in commodity $a$ and long positions in commodity $b$ (if the cross commodity correlation is positive). The expected abundance in commodity $a$ causes an increase in the current spot price, futures price and the inventory levels in commodity market $b$. Inversely, the quantity demanded for production, the future spot price and the futures risk premium decrease. In the periods when the cross commodity correlation is negative, the scenario is reversed.

Third, the impact of the financialization in any commodity market depends on the balance of hedging pressure. Taking long (short) positions in the futures market raises (declines) the spot price, the futures price and the inventory levels, while it decreases (increases) the demand for production and the future spot price. Moreover, the size of the impact of financial investors on commodity prices has an inverse relationship with the size of the market. Therefore, the prices in small markets will be affected more than large ones.

Fourth, our model introduces the futures commodity risk premium. We define futures risk premium as the difference between the expected spot price and the futures price in commodity markets, which goes in the line with the defintion of Keynes (1930). The futures risk premium of commodity $a$ is determined by the hedging pressure of the commodity $a$ (which is defined by the difference between inventory holders and processors' physical positions) and the futures risk premium of commodity $b$ that is accompanied by cross commodity correlation. In this context, net short futures positions increase the futures risk premium (increases the possibility of having backwardated market). In the other hand, if commodity market $b$ is backwardated (contangoed) and the cross commodity correlation is positive, then commodity market $a$ tend to be in backwardation (contango) state. But, it is the opposite when the cross commodity correlation is negative.

The rest of the paper is organized as follow: section 3.2 introduces the related literature. In section 3.3, we show the construction of the model, the agents' profit, and the agents optimal decisions. Section 3.4 expresses the market clearings in the physical and futures markets. Section

3.5 explains the equilibrium in our model. In section 3.6, we discuss the spillover between commodity markets as a result to the shocks in economics fundamental such as supply/ demand shocks. Section 3.7 exposures the impact of the financial investors speculation on commodity prices. section 3.8 is the conclusion. Sections 3.A, 3.B, 3.C and 3.D are our appendices.

## 3.2 Literature reviews

This paper is linked to different tracks of literature. These tracks are represented by: first the theoretical models that address the interaction between commodity physical and futures markets. Second, the literature that investigates the cross markets interdependence. Third, the papers related to the impact of financialization on commodity prices. Fourth, the literature that addresses the futures risk premium.

The cornerstone of this paper is Ekeland et al. (2015). In their model, they study the interaction between (spot) physical and futures markets in order to answer the question related to the impact of speculation. Back to the past, there are other theoretical models that introduced the equilibrium between physical and futures markets such as Anderson and Danthine (1983a,b) , Hirshleifer (1988b). Other recent models such as Acharya et al. (2013) who build an equilibrium model of commodity market where speculators are capital constrained. Baker (2016) build a dynamic model between commodity spot and futures market. However, the previous models study commodity spot and futures interaction for one commodity, while we generalize that and study interacting markets. In this manner, we extend investigating the interaction between physical and futures markets of a commodity, and we study the information flow between commodity markets. In this domain, Basak and Pavlova (2016) build a dynamic model for multi-commodities.

We are motivated by several empirical studies such as Tang and Xiong (2012) who address the increase in the linkage between commodity markets as a consequence to the financialization of commodity (crude oil and non-energy commodities). These increases are attributed to the low correlation between commodities returns as explained in Erb and Harvey (2006).

Keynes (1930) demonstrates that speculators exist in the futures market for offsetting hedgers' positions. Therefore, they have to be recompensed for their participation in the futures market. The question that persists is whether those speculators have an impact on the commodity prices or not. Houthakker (1957) shows evidence that speculators have forecasting power on prices (he studied for wheat, corn and cotton). Newbery (1987), in his model, concludes that speculation destabilize spot prices. After the remarkable surge in the financial investors' participation in

the futures market last two decades, the question of the impact of speculators (or investors) became more important. Fattouh et al. (2013) introduce a review about the impact of the speculation especially in the oil markets. However, in their review, they could not confirm the impact of speculation on the prices in the era of financialization, and leave that question for further debate. A lot of empirical researches investigated whether commodity index investments affect the commodity prices, where some of them are covered in the review of Irwin and Sanders (2011). There are two opinions about this issue. First, people who address that there is no impact of the index investment on commodity markets such as Brunetti and Buyukşahin (2009) and Buyukşahin and Harris (2011). On the contrary, other studies that are address the impact of the index investment on commodity prices such as Masters (2008), Tang and Xiong (2012), Hamilton and Wu (2015) and Henderson et al. (2015).

Another track of literature is related the information transmission between markets. Pindyck and Rotemberg (1990) explain the co-movements in commodity prices are attributed to the macroeconomic variables. They find the same result in explaining the co-movements in stock prices in Pindyck and Rotemberg (1993). Le Pen and Sevi (2013) explain that the excess co-movement of commodity prices can be linked to hedging pressure and the speculation. Kyle and Xiong (2001) build a theoretical model that explains the contagion between assets. In their model, Basak and Pavlova (2016) explain the cross commodity spillovers. They find that the abundance in any commodity decreases the price and the inventory of the other commodity. We confirm that. But, this is a part from our results. In our model, that appears when cross commodity correlation is positive. Our model shows the opposite result when the cross commodity correlation is negative. Furthermore, we express the impact of that abundance on the futures prices, the processor demand and the future spot price. Natanelov et al. (2011) Show a co-movement between crude oil and agricultural commodities markets.

Hirshleifer (1988a), Hirshleifer (1989a), Boons et al. (2014), Isleimeyyeh et al. (2017), Isleimeyyeh (2017) are contributions that investigate the future risk premium as a result of the interaction between commodity futures and stock market. Acharya et al. (2013) find the risk premium based on the interaction between hedgers and capital constrained speculator. Etula (2013) investigates the commodity risk premium linked to broker-dealers' aggregate risk. Ekeland et al. (2015) find the risk premium as a result to the interaction between hedgers (inventory holders and pure speculators), where they find the futures risk premium is determined by the sign of the hedging pressure. Hamilton and Wu (2014) compute the futures risk premium by building a model that studies the interaction between producers and financial investors. De Roon et al. (2000) find that the futures risk premium determined by the cross hedging pressure. Gorton et al. (2013) show the importance of inventory levels in determining the futures risk premium

and the basis. Our paper is a value added to the previous researches. First, we obtain the risk premium based on the interaction between two commodities markets, and not one commodity as the previous researches have done. Second, we could find the co-integration between both commodities futures risk premiums.

## 3.3 The model

The model studies the integration between two commodity markets. It is represented by two periods. Markets open at $t$ and settle at $T$. There are two commodities[3]: $a$ and $b$. For each commodity, there are two types of markets: physical (spot) and futures (paper). There are four types of agents who are interested in each commodity. The agents are: inventory holders (storers), processors, investors (speculators) and spot traders. The storer has the capacity to store the commodity. He buys it at $t$ and sells it at $T$. He also operate in the futures market in order to hedge his physical position. The processor, who uses the commodity to produce final consumption goods, decides at $t$ the quantity to be purchased at $T$. He takes his decision at $t$ to be settled at $T$, because he does not have the capacity to store the commodity. He can also operate in the futures market to hedge his physical position. The speculator takes his positions in the futures market at $t$ and offset them at $T$. The spot traders operate in the physical markets only to meet the instantaneous demand and supply from the other agents. Finally, we assume that the free-risk rate is zero.

We assume that each commodity is used differently than the other. Therefore, the storage procedure is different, and both commodities may be used in different purposes, and to produce different final goods. For instance, storing crude oil is different than storing wheat, and both commodities are traded in different markets, and they are used to produce different final goods. Consequently, for any commodity, there are storer, processor and spot traders who are specialized in that commodity, and different than those who operate in the other commodity. Only speculator can trade both commodities. As a result, we have storers for commodity $a$ ($N_I^a$), storers for commodity $b$ ($N_I^b$), processors for commodity $a$ ($N_P^a$), processors for commodity $b$ ($N_P^b$) and speculators $N_S$.

To make the view clear, at $t$, the total supply of the commodity $i$ is $\omega_t^i$, which is supplied by spot traders. On the spot market, the spot trader and storer demand the commodity $i$ with quantity $\mu^i - m^i P_t^i$ and $x^i$ respectively with spot price $P_t^i$. The storer hedge the physical position by taking $f_I^i$ futures positions in the commodity market $i$. Meanwhile, processor decide the

[3]When we have symmetry in the mathematical expressions for the commodities $a$ and $b$, to avoid the repetitions, we will use an index $i$, where $i = \{a, b\}$.

quantity that he needs to buy in the future ($y^i$), and hedge his physical positions by taking $f_P^i$ in the futures market of the commodity $i$. Speculator take his futures positions in both commodity markets. Storer, processor and speculator trade the future contracts at futures price $F_{t,T}^i$.

At $T$, spot traders and the storer sit on the supply side with supplied quantity $\tilde{\omega}_T^i$ and $x^i$ respectively. The spot traders and the processor demand for the commodity physically with quantity $\tilde{\mu}^i - m^i \tilde{P}_T^i$ and $y^i$ respectively. The $\sim$ indicates the randomness of the variable. The futures contracts are settled bringing a financial profit $\tilde{P}_T^i - F_{t,T}^i$. $\tilde{\omega}_T^i$ and $\tilde{\mu}^i$ are the source of uncertainty in our model. However, we assume that the distribution function are common knowledge for all agents. Therefore, at $t$, agents do not know what is the real value of $\tilde{\omega}_T^i$ and $\tilde{\mu}^i$, but they can estimate them.

In what follow, we will be introducing the profit of storer, processor and speculator in each commodity market a,b. We also introduce the optimal positions for those agents in both physical and futures markets.

### 3.3.1 Agents' Profits

**Storers**

In each commodity market $i$, the storer holds physical and futures positions. In physical market, he can hold a non-negative quantity of the inventory, $x^i$. The storer buys the commodity physically at time $t$ with price $P_t$ to sell it at time $T$ with price $P_T$. That is issuing a profit $x^i(\tilde{P}_T^i - P_t^i)$. Holding commodity is costly. Thus, storing the quantity $x^i$ from $t$ to $T$ costs $\frac{1}{2}C^i(x^i)^2$, where $C^i$ is the cost of storage of commodity $i$. Meanwhile, the storer's first motive is to hedge his physical positions in the futures market. He takes a futures position $f_I^i$. Normally, he buys the commodity physically and sells futures contract (takes short position) in order to secure himself from any fall in the commodity prices in the future. Hence, the storer's total profit of having $x^i$ in the physical market and $f_I^i$ in the futures market of commodity $i$ is given by:

$$\tilde{\pi}(x^i, f_I^i) = x^i(\tilde{P}_T^i - P_t^i) + f_I^i(\tilde{P}_T^i - F_{t,T}^i) - \frac{1}{2}C^i(x^i)^2 \tag{3.1}$$

Where: $\pi$ is the profit of the storer who trades in commodity $i$. $i = a, b$. $x^i$ is the quantity demanded by the storer who trades in commodity $i$. $F_{t,T}^i$ is the futures price of the commodity $i$. $P_t^i$ is the spot price at time $(t)$, for commodity $i$. $f_I^i$ is the futures position of the storer in commodity $i$.

**Processors**

In each commodity market $i$, the processor decides the quantity $y^i$ that he needs to buy at time $T$ with price $P_T$. The processor uses the commodity to produce final goods. Thus, the total

revenue from selling his output is given by $Z^i(y^i - \frac{\beta^i}{2}(y^i)^2)$, where $Z^i$ is the forward price of the output which is produced using commodity $i$, and $\beta^i$ is the cost of production. The processor hedges his physical positions in the futures market by having $f_P^i$ futures positions to secure himself from any increases in the commodity prices. Normally, he buys futures contract (take long positions). The total profit of the processor from operating in the physical and futures market for the commodity $i$ is:

$$\tilde{\pi}(y^i, f_P^i) = (y^i - \frac{\beta^i}{2}(y^i)^2)Z^i - y^i\tilde{P}_T^i + f_P^i(\tilde{P}_T^i - F_{t,T}^i) \tag{3.2}$$

Where $\pi$ is the profit of the processor who trades in commodity $i$, $y^i$ is the quantity purchased by the processor who trades in commodity $i$, $F_{t,T}^i$ is the futures price of the commodity $i$, $P_t^i$ is the spot price at time $(t)$, for commodity $i$, $f_P^i$ is the futures position of the processor in commodity $i$.

**Investors**

The speculator's position in any futures market $(i)$ generates a profit $\tilde{P}_T^i - F_{t,T}^i$. The speculator diversifies his position by operating in commodity futures markets $a$ and $b$, which differentiates us from Ekeland et al. (2015). Speculator will not have any functional obstacles to trade in both commodities market. On the contrary, holding two assets is less risky than having one asset. Therefore, the speculator gets more security to increase his investments and take risky decisions. The total profit from having $f_S^a$ futures positions in commodity $a$ and futures positions $f_S^b$ in commodity $b$ is given by:

$$\tilde{\pi}(f_S^a, f_S^b) = f_S^a(\tilde{P}_T^a - F_{t,T}^a) + f_S^b(\tilde{P}_T^b - F_{t,T}^b) \tag{3.3}$$

Where $F_{t,T}^i$ is the futures price of the commodity $i$ at time $t$ and the delivery at time $T$. $i = a, b$. $\tilde{P}_T^i$ is the future spot price of commodity $i$ at time $T$, and $f_S^i$ is the futures position of the speculator in commodity $i$.

### 3.3.2 Profit optimization

In the previous section, we introduced the agents' profit. Agents problems are to maximize their profits in the the physical and futures markets. Now, we are moving a step forward and find the optimal positions of the storer, processor and speculator. In our model, we assume that the agents are mean-variance utility maximizers[4].

$$E(\tilde{\pi}^i) - \frac{1}{2}\alpha_j^i Var(\tilde{\pi}^i) \tag{3.4}$$

[4]By using this methodology, we goes in the line with several papers that use the mean-variance utility to optimize the agents profit such as Ekeland et al. (2015), Anderson and Danthine (1983b), Boons et al. (2014), Hirshleifer (1988b), and others.

where $\tilde{\pi}^i$ is the profit of agent $i$, $\alpha_j^i$ is risk aversion parameter of the agent $j$ in commodity market $i$, and $Var[\tilde{\pi}^i]$ is the variance of the profit for agent $i$.

Agents are willing to maximize their expected profit restricted to their risk aversion. Risk aversion is measured by $\alpha_j^i$. When $\alpha_j^i$ is large, the agent is more risk averse. In appendix 3.A, we show the agents' optimal positions computations.

**Storer**

The storer's problem is to maximize his positions in the physical and futures markets. The storer's optimal positions of commodity $i$ are $x^{i*}$ and $f_I^{i*}$, in the physical and the futures market respectively.

$$x^{i*} = \frac{1}{C^i} \max\left\{F_{t,T}^i - P_t^i, 0\right\} \tag{3.5}$$

$$f_I^{i*} = \frac{E[\tilde{P}_T^i] - F_{t,T}^i}{\alpha_I^i Var[\tilde{P}_T^i]} - x^{i*} \tag{3.6}$$

The storer's optimal position in the physical market, as shown in equation 3.5, is determined by futures and spot prices, and the cost of storage. The storer holds inventories when the futures price ($F_{t,T}$) is higher than the current spot price $P_t$. That means when the market is in contango situation, the storer believes he can get profit in the future.

Equation 3.6 shows that the futures optimal position of the storer is comprised of two terms: first, a position $-x^{i*}$ that represents the negative of the optimal physical positions. Second, the pure speculative position, $\frac{E[\tilde{P}_T^i]-F_{t,T}^i}{\alpha_I^i Var[\tilde{P}_T^i]}$. The storer is basically a hedger. So, he takes short positions to reduce the risk in the physical market prices. The pure speculative term, which will be repeated in several occasions in the rest of the paper, is determined by the bias in the futures price. The agent will take long position if he believes that the expected futures price is higher than the futures price (normal backwardation), otherwise he will take short position (contango). This result also was obtained in Anderson and Danthine (1983a,b), Ekeland et al. (2015) and Isleimeyyeh et al. (2017). The optimal futures position for storer shows that he can speculate after hedging his physical position fully. Consequently, the storer takes long position in the futures market $i$ if $f_I^i > 0$. He takes short position if $f_I^i < 0$. By assuming that there is no bias in the futures price ($E[\tilde{P}_T^i] = F_{t,T}^i$), the storer only hedges his physical positions.

**Processor**

The processor's problem is to optimize his profit by choosing the appropriate quantity demanded in the physical market and his futures positions. The processor's optimal positions of commodity $i$ are $y^{i*}$ and $f_P^{i*}$, in the physical and the futures market respectively:

$$y^{i*} = \frac{1}{\beta^i Z^i} \max\left\{Z^i - F^i_{t,T}, 0\right\}, \tag{3.7}$$

$$f^{i*}_P = \frac{E[\tilde{P}^i_T] - F^i_{t,T}}{\alpha^i_P Var[\tilde{P}^i_T]} + y^{i*} \tag{3.8}$$

The processor asks for the commodity physically whenever he believes that the forward price of the output is higher than the futures price. Otherwise, he does not buy the commodity (as shown in equation 3.7). The optimal futures positions, as shown in equation 3.8, comprised of two terms: first, the optimal physical position $y^{i*}$. Second, the pure speculative term (similar to what has been discussed in futures optimal position of the storer). The processor needs to secure himself from any increase in the commodity price. To do so, he takes long position (buys futures contract). The pure speculative term shows that the processor can take long position if the market is in normal backwardation state. Generally, he can take more long positions (part for hedging and part for speculation). He can take short positions as speculation (if the market is in contango), but after hedging his physical positions; he takes long positions to hedge the physical positions ($y^{i*}$), then he can take short positions. Generally, if $f^i_P > 0$, then the processor takes long position. On the other hand, he takes short position if $f^i_P < 0$.

**Speculator**

The speculator problem is to optimize his profit from operating in both commodity futures markets ($a\&b$). He is looking to balance his portfolio by choosing the optimal positions in commodity futures $a$ and $b$. By maximizing his profit, the optimal futures positions for commodity $a$ and commodity $b$ are,

$$f^{a*}_S = \left(\frac{1}{\left(1 - corr^2\left(\tilde{P}^a_T, \tilde{P}^b_T\right)\right)}\right)\left[\frac{E[\tilde{P}^a_T] - F^a_{t,T}}{\alpha_S Var[\tilde{P}^a_T]} - \text{corr}\left(\tilde{P}^a_T, \tilde{P}^b_T\right)\frac{\sigma^b_P}{\sigma^a_P}\frac{E[\tilde{P}^b_T] - F^b_{t,T}}{\alpha_S Var[\tilde{P}^b_T]}\right], corr^2 \neq 1 \tag{3.9}$$

Where, $f^{a*}_S$ is the speculator's optimal futures positions in commodity market $a$. $corr\left(\tilde{P}^a_T, \tilde{P}^b_T\right)$ is the cross commodity correlation. $\sigma^a_P$ and $\sigma^b_P$ are the standard deviation of the prices at time $T$ for commodity $a$ and $b$ respectively. Note that in order to have the speculator's optimal futures positions for commodity $b$, we replace commodity $a$ by commodity $b$.

The optimal positions in the futures markets are highly symmetric in respect to commodity $a$ and $b$. These positions are comprised of a linear combination of a pure speculative terms of commodity futures market $a$ and $b$, that is weighted by cross commodity correlation and the ratio between markets standard deviations. Each pure speculative term is comprised of the bias in the

futures price divided by variance of the prices and the risk aversion of the speculator. Finally, the value of the optimal futures position is affected by a positive factor[5] $\left(\left(\frac{1}{(1-corr^2(\tilde{P}_T^a,\tilde{P}_T^b))}\right) > 1\right)$.

From each speculative term, the speculator takes long positions in any commodity if the expected spot price is higher than the futures price. Oppositely, he takes short positions. By having a portfolio of commodities, our result extends Ekeland et al. (2015) and Anderson and Danthine (1983b). In each market, the optimal futures position is determined by the pure speculative term of that commodity restricted to the pure speculative of the other commodity. That combination shows the portfolio diversification. In this context, it is not enough that the market is backwardated $\left(E[\tilde{P}_T^i] - F_{t,T}^i > 0\right)$ to take long positions. Similarly, if the commodity market is contangoed $\left(E[\tilde{P}_T^i] - F_{t,T}^i < 0\right)$, it is not sure that the speculator will take short positions. In certain cases, the speculator takes opposite positions to utilize the benefit from the other markets.

When $f_S$ is greater than zero, the speculator takes long position. Otherwise, he takes short position. This can happen in different circumstances that depends on the bias in futures prices for both commodities ($a\&b$), and the correlation between both markets.

- When both markets are in normal backwardation and the cross commodity correlation is positive, the speculator takes less long positions in both markets. Even he may take short positions. But, if the markets are in normal backwardation and the cross commodity correlation is negative, the speculator takes long position in both commodity markets ($a\&b$).

- If the markets are in contango state and the cross commodity correlation is positive, the speculator takes less short position. He possibly takes long positions. On the contrary, if the cross commodity correlation is negative, the speculator takes short position in both markets.

- If the market of commodity a is in normal backwardation and the commodity b is in contango state, and the correlation is positive, the speculator takes long positions in com-

[5] In Ekeland et al. (2015), the optimal positions for speculator is given by the pure speculative term $f_{SELV}^{i*}$:

$$f_{SELV}^{i*} = \frac{E[\tilde{P}_T^i] - F_{t,T}^i}{\alpha_S Var[\tilde{P}_T^i]}$$

Then, we obtain

$$f_S^{a*} = \left(\frac{1}{\left(1 - corr^2\left(\tilde{P}_T^a, \tilde{P}_T^b\right)\right)}\right)\left[f_{SELV}^{a*} - corr\left(\tilde{P}_T^a, \tilde{P}_T^b\right)\frac{\sigma_P^b}{\sigma_P^a} f_{SELV}^{b*}\right]$$

Note that $\left(\frac{1}{(1-corr^2(\tilde{P}_T^a,\tilde{P}_T^b))}\right) > 1$

modity a, and short positions in commodity b. On the other hand, if the correlation is negative, the speculator takes less long positions in commodity a, and less short positions in commodity b.

- If the market of commodity a is in contango and the commodity b is in normal backwardation state, and the correlation is positive, the speculator takes short positions in commodity a, and long positions in commodity b. On the other hand, if the correlation is negative, the speculator takes less short positions in commodity a, and less long positions in commodity b.

By assuming that there is no bias in the futures market in any market $\left(E[\tilde{P}_T^i] - F_{t,T}^i = 0\right)$, the speculator still can take positions in the futures market. His positions, in this case, depend on the information from the other market. Another interested case should be mentioned is when the two markets are isolated $\left(corr\left(\tilde{P}_T^a, \tilde{P}_T^b\right) = 0\right)$. In this case, the two markets are independent. Therefore, there is no information flow between commodity markets. As a result, our model will be two isolated forms of Ekeland et al. (2015).

Up to now, we obtained the optimal positions of the hedgers and speculators in the physical and futures markets, which have been taken in commodity markets a and b. The hedgers (storer and processor) take positions in the physical and futures markets. For each commodity, we have a different type of hedgers. Hedgers take their position in the physical markets. They hedge their physical markets' risk by operating in the futures market. Therefore, their futures positions compound from their physical positions in addition to a pure speculative term. Hence, hedgers can speculate in the futures market after hedging their physical positions totally. In the speculator case, who is the only agent operates in the futures markets of both commodities. His positions are determined by the bias in the futures price of both commodities and the cross commodity correlation.

## 3.4 Markets clearing

In the previous section, we introduced the model, the agents profit and their optimal position in the physical and futures in the commodity markets $a$ and $b$. In this section, we will be finding market clearing in both physical and futures markets for both commodity markets. In this context, we will find the market clearing in the physical markets at t and T, and in the futures markets.

In previous computations, the optimal positions were computed per agent. Let us note that there is $N_I^i$ number of storers in commodity $i$, $N_P^i$ number of processors in commodity $i$, where $i = a, b$. The speculators operate in both markets, so there is $N_S$ number of speculators. The

aggregated optimal positions is the multiplication between per agent optimal position and the number of agents.

At t, spot traders, of commodity $i$, supply the commodity in the physical market with a quantity $\omega_t^i$, where $i = a, b$. On the demand side, a storer purchases $x^{i*}$ from commodity market $i$. $N_I^i$ storers purchase $N_I^i x^{i*}$. Also, the demand of spot traders is given by $\mu_t^i - m^i P_t^i$. The market clearing of the physical market at $t$ is:

$$\omega_t^i = N_I^i x^{i*} + \mu_t^i - m^i P_t^i,$$

$$P_t^i = \frac{1}{m^i}\left(\mu_t^i - \omega_t^i + N_I^i x^{i*}\right). \tag{3.10}$$

At T, there are two sources for supply: first, the supply of spot traders in commodity market $i$ is given by $\tilde{\omega}_T^i$. Second, the stored quantity of commodity $i$ by the storer are sold at $T$. The total supply of the storers is $N_I^i x^{i*}$. On the demand side, there are two sources of demand: first, the demand of a processor in the physical market is $y^{i*}$. $N_P^i$ processors purchase an aggregated quantity $N_P^i y^{i*}$. Second, the demand of spot traders is given by $\tilde{\mu}_T^i - m^i \tilde{P}_T^i$

$$\tilde{\omega}_T^i + N_I^i x^{i*} = N_P^i y^{i*} + \tilde{\mu}_T^i - m^i \tilde{P}_T^i,$$

$$\tilde{P}_T^i = \frac{1}{m^i}\left(\tilde{\mu}_T^i - \tilde{\omega}_T^i - N_I^i x^{i*} + N_P^i y^{i*}\right). \tag{3.11}$$

All agents participate in the futures market. Storers and processors take positions in the futures market of commodity $i$, while the speculators participate in both commodity markets. Each storer takes $f_I^i$ futures positions in commodity $i$. The aggregated positions taken by storers in commodity $i$ are $N_I^i f_I^i$. The position taken by a processor in commodity $i$ is $f_P^i$. Hence, the aggregated futures positions taken by processors are $N_P^i f_P^i$. Finally, the speculators take $N_S f_S^i$ futures positions in commodity $i$. The futures market clearing is defined by the zero summation of the futures contracts.

$$N_S f_S^{i\star} + N_P^i f_P^{i\star} + N_I^i f_I^{i\star} = 0.$$

Where $i = a, b$.

By substituting $f_S^{i\star}$, $f_I^{i\star}$ and $f_P^{i\star}$ (3.6, 3.8 and 3.9), futures market clearing for commodity $i$ implies:

$$\left(E[\tilde{P}_T^i] - F_{t,T}^i\right) = \frac{1}{\gamma^i}\left(HP^i + K\left(E[\tilde{P}_T^j] - F_{t,T}^j\right)\right) \tag{3.12}$$

Where $HP^i$ is the hedging pressure for commodity $i$ [6].

$$HP^i := N_I^i x^{i*} - N_P^i y^{i*}$$

$$\gamma^i = \frac{1}{Var[\tilde{P}_T^i]} \left( \frac{N_I^i}{\alpha_I^i} + \frac{N_P^i}{\alpha_P^i} + \frac{N_S}{\alpha_S} \frac{1}{\left(1 - \left(corr\left(\tilde{P}_T^i, \tilde{P}_T^j\right)\right)^2\right)} \right), corr^2 \neq 1$$

$$K = \frac{N_S}{\alpha_S} \frac{corr\left(\tilde{P}_T^i, \tilde{P}_T^j\right)}{\sigma_P^a \sigma_P^b \left(1 - corr\left(\tilde{P}_T^j, \tilde{P}_T^j\right)^2\right)}, corr^2 \neq 1$$

Note that when $i$ is commodity $a$, then $j$ is commodity $b$ and vice versa.

The futures market clearings for commodity $a$ and $b$ are:

$$\left(E[\tilde{P}_T^a] - F_{t,T}^a\right) = \frac{1}{\gamma^a}\left(HP^a + K\left(E[\tilde{P}_T^b] - F_{t,T}^b\right)\right) \tag{3.13}$$

$$\left(E[\tilde{P}_T^b] - F_{t,T}^b\right) = \frac{1}{\gamma^b}\left(HP^b + K\left(E[\tilde{P}_T^a] - F_{t,T}^a\right)\right) \tag{3.14}$$

Where, $0 \leq \gamma^a, \gamma^b \leq +\infty$ , and $-\infty \leq K \leq +\infty$.

The previous equations show the futures risk premium for commodity $a$ and $b$ respectively. The futures risk premium of any commodity is determined by: first, hedging pressure of that commodity, which is defined as the difference between the total quantity owned by storers and the total quantity demanded by processors. Second, the futures risk premium of the other commodity. Third, different items that appears in $\gamma^a, \gamma^b$ and $K$ such as: the number of agents, the agents risk aversions, variances of the future spot prices and the cross commodity correlation.

For each commodity, the sign of the futures risk premium is determined by the combination between the signs and the magnitudes of the commodity hedging pressure, the futures risk premium of the other commodity and cross commodity correlation. This finding extends the finding Ekeland et al. (2015), who find that only the sign of hedging pressure determines the futures risk premium. When $\left(E[\tilde{P}_T^i] - F_{t,T}^i > 0\right)$ is positive, the market is in normal backwardation state. Otherwise, it is in contango. First, the net short hedging pressure increases the futures risk premium, while the net long hedging pressure decreases the futures risk premium, i.e. net short (long) hedging pressure increase the possibility of normal backwardation (contango) state in the market. Second, the impact of futures risk premium of the commodity $b$ on commodity $a$ is linked to cross commodity correlation. If the combination of their signs (commodity $b$ and the

[6] The hedging pressure explains the net hedged positions between the processors and the storers.

cross commodity correlation) is positive, it increases the futures risk premium of commodity $a$. Inversely, the futures risk premium of commodity $a$ decreases if the risk premium of commodity $b$ and cross commodity correlation net sign is negative. Furthermore, the magnitude of the futures risk premium is affected by the risk aversion of the agents ($\alpha_I^i$, $\alpha_P^i$.and $\alpha_S$.). Our result go in the line with Acharya et al. (2013), who find a positive relationship between risk aversion and the futures risk premium[7].

Now, let us present some notations that would facilitate our computations. Let us start with the optimal physical positions of the storers and processors. The total quantity owned by storers in commodity market $i$ is $N_I^i x^{i*}$. By substituting $x^{i*}$ (equation 3.5), we have

$$N_I^i x^{i*} = \frac{N_I^i}{C^i} \max\{F_{t,T}^i - P_t^i, 0\}$$

Let us assume that

$$n_I^i = \frac{N_I^i}{C^i} \ , \qquad X^i = \max\{F_{t,T}^i - P_t^i, 0\}$$

That implies,

$$N_I^i x^{i*} = n_I^i X^i$$

Where $i = \{a, b\}$.

The total demand by processors in commodity market $i$ is $N_P^i y^{i*}$. By substituting $y^{i*}$ (equation 3.7), we have

$$N_P^i y^{i*} = \frac{N_P^i}{\beta^i Z^i} \max\{Z^i - F_{t,T}^i, 0\}$$

By assuming

$$n_P^i = \frac{N_P^i}{\beta^i Z^i} \ , \qquad Y^i = \max\{Z^i - F_{t,T}^i, 0\}$$

It implies,

$$N_P^i y^{i*} = n_P^i Y^i$$

Also, we are focusing on the spot markets and introducing:

$$\xi_t^i = \mu_t^i - \omega_t^i$$
$$\tilde{\xi}_T^i = \tilde{\mu}_T^i - \tilde{\omega}_T^i$$
$$\xi_T^i = E[\tilde{\mu}_T^i - \tilde{\omega}_T^i]$$

[7] Isleimeyyeh et al. (2017) find similar results when they study the interaction between stock and commodity markets. However, they consider the information from stock market is exogenous (the do not model the stock market). That confirms the thought of considering the commodity as an asset class.

$\xi$ represents the scarcity (the failure of spot traders supply to meet the maximum demand), i.e. the excess demand when the spot price equals zero with respect to the supply for commodity $i$ at time $l$ $(i = a, b, l = t, T)$. Note that $\xi_t^i$ and $\xi_T^i$ are independent.

By using (3.11), the variances, the expected values of $\tilde{P}_T^i$ and the covariance between the prices of both commodities at $T$ are:

- $Var\left[\tilde{P}_T^i\right] = \left(\frac{1}{m^i}\right)^2 Var\left[\tilde{\xi}_T^i\right]$
- $E\left[\tilde{P}_T^i\right] = \frac{1}{m^i}\left(\xi_T^i - n_I^i X^i + n_P^i Y^i\right).$
- $cov\left(\tilde{P}_T^a, \tilde{P}_T^b\right) = \frac{1}{m^a m^b} cov\left(\tilde{\xi}_T^a, \tilde{\xi}_T^b\right)$
- $corr\left(\tilde{P}_T^a, \tilde{P}_T^b\right) = corr\left(\tilde{\xi}_T^a, \tilde{\xi}_T^b\right)$

Then, $\gamma^i$ and $K$ become

$$\gamma^i = \frac{(m^i)^2}{Var[\tilde{\xi}_T^i]}\left(\frac{N_I^i}{\alpha_I^i} + \frac{N_P^i}{\alpha_P^i} + \frac{N_S}{\alpha_S}\frac{1}{\left(1 - \left(corr\left(\tilde{\xi}_T^i, \tilde{\xi}_T^j\right)\right)^2\right)}\right), \tilde{\xi}_T^i \neq \tilde{\xi}_T^j$$

$$K = \frac{N_S}{\alpha_S}\frac{(m^i m^i) corr\left(\tilde{\xi}_T^j, \tilde{\xi}_T^j\right)}{\sigma_{\xi_T}^i \sigma_{\xi_T}^j\left(1 - \left(corr\left(\tilde{\xi}_T^i, \tilde{\xi}_T^j\right)\right)^2\right)}, \tilde{\xi}_T^i \neq \tilde{\xi}_T^j$$

To sum up, the market clearings of the physical and futures markets for commodity $i$ give us the following equations system.

$$\begin{cases} X^i = \max\left\{F_{t,T}^i - P_t^i, 0\right\} & (3.5) \\ Y^i = \max\left\{Z^i - F_{t,T}^i, 0\right\} & (3.7) \\ P_t^i = \frac{1}{m^i}\left(\xi_t^i + n_I^i X^i\right) & (3.10) \\ \tilde{P}_T^i = \frac{1}{m^i}\left(\tilde{\xi}_T^i - n_I^i X^i + n_P^i Y^i\right) & (3.11) \\ \left(E[\tilde{P}_T^i] - F_{t,T}^i\right) = \frac{1}{\gamma^i}\left(HP^i + K\left(E[\tilde{P}_T^j] - F_{t,T}^j\right)\right) & (3.12) \end{cases}$$

## 3.5 Equilibrium

**Definition** The equilibrium is a set of prices for commodity i $(X^i, Y^i, P_t^i, F_{t,T}^i, \widetilde{P}_T^i)$ such that all agents are price takers, all markets clear, and all prices, except possibly $\widetilde{P}_2^i$, are non-negative.

$$\left(x^i \geq 0, y^i \geq 0, P_t^i \geq 0, F_{t,T}^i \geq 0\right)$$

To solve the two systems of commodity $a$ and $b$, we begin by reducing them in order to obtain the simplest form of the equations. It is enough to find $P_t^a, P_t^b, F_{t,T}^a$, and $F_{t,T}^b$ to obtain the rest of the prices and quantities. To do so, we are going to use market clearings of the physical and futures markets for both commodities (equations (3.10), (3.11) and (3.12)).

From the market clearing of the spot market at $t$ (3.10), we obtain for commodity $i$

$$\xi_t^i = m^i P_t^i - n_I^i X^i \tag{3.15}$$

Where $i = a, b$

From market clearing of the futures market (3.13), we obtain for commodity $a$,

$$\left(E[\tilde{P}_T^a] - F_{t,T}^a\right) = \frac{1}{\gamma^a}\left(HP^a + K\left(E[\tilde{P}_T^b] - F_{t,T}^b\right)\right) \tag{3.13}$$

Also, the market clearing of the futures market for commodity $b$ is (equation (3.14)),

$$\left(E[\tilde{P}_T^b] - F_{t,T}^b\right) = \frac{1}{\gamma^b}\left(HP^b + K\left(E[\tilde{P}_T^a] - F_{t,T}^a\right)\right) \tag{3.14}$$

By substituting $E\left(\tilde{P}_T^a\right)$ and $E\left(\tilde{P}_T^b\right)$ in the equations (3.13) and (3.14), we have two equations with two unknowns: $\xi_T^a$ and $\xi_T^b$. By solving this system, we obtain:

$$\xi_T^a = m^a F_{t,T}^a + \left(1 + \frac{\gamma^b m^a}{\gamma^a\gamma^b - (K)^2}\right) HP^a + \left(\frac{m^a K}{\gamma^a\gamma^b - (K)^2}\right) HP^b \tag{3.16}$$

$$\xi_T^b = m^b F_{t,T}^b + \left(\frac{m^b K}{\gamma^a\gamma^b - (K)^2}\right) HP^a + \left(1 + \frac{m^b\gamma^a}{\gamma^a\gamma^b - (K)^2}\right) HP^b \tag{3.17}$$

**Define:**

$$\zeta^a = \frac{m^a}{\gamma^a\gamma^b - K^2}\ , \qquad \zeta^b = \frac{m^b}{\gamma^a\gamma^b - K^2}$$

Where $\zeta^a, \zeta^b > 0$.

The new form of equations (3.16) and (3.17) are:

$$\xi_T^a = m^a F_{t,T}^a + \left(1 + \gamma^b\zeta^a\right) HP^a + \left(K\zeta^a\right) HP^b \tag{3.18}$$

$$\xi_T^b = m^b F_{t,T}^b + \left(K\zeta^b\right) HP^a + \left(1 + \gamma^a\zeta^b\right) HP^b \tag{3.19}$$

Remark that we have four equations with four unknowns $(P_t^a, P_t^b, F_{t,T}^a, F_{t,T}^b)$. Consider the map $\phi : R_+^4 \to R^4$ defined by:

$$\phi(P_t^a, P_t^b, F_{t,T}^a, F_{t,T}^b) = \xi \tag{3.20}$$

i.e.

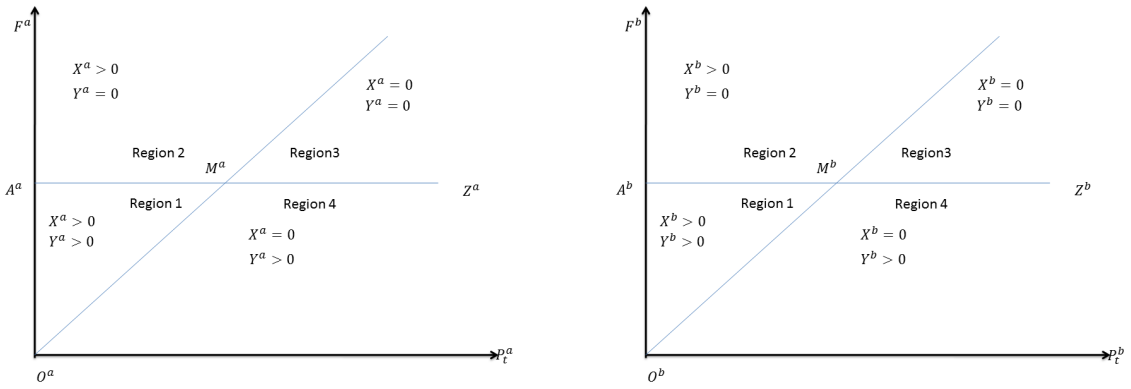
$$\phi(P_t^a, P_t^b, F_{t,T}^a, F_{t,T}^b) = \begin{pmatrix} m^a P_t^a - n_I^a X^a \\ \\ m^b P_t^b - n_I^b X^b \\ \\ m^a F_{t,T}^a + \left(1 + \gamma^b \zeta^a\right) HP^a + \left(K\zeta^a\right) HP^b \\ \\ m^b F_{t,T}^b + \left(K\zeta^b\right) HP^a + \left(1 + \gamma^a \zeta^b\right) HP^b \end{pmatrix}$$

Where,

$$\begin{aligned} HP^i &= n_I^i X^i - n_P^i Y^i \\ X^i &= \max\{F_{t,T}^i - P_t^i, 0\} \\ Y^i &= \max\{Z^i - F_{t,T}^i, 0\} \\ i &= \{a, b\} \end{aligned}$$

Based on the optimal positions of the storers, when $X^i > 0$, then $X^i = F_{t,T}^i - P_t^i$. Otherwise, $X^i = 0$. Also, when $Y^i > 0$, then $Y^i = Z^i - F_{t,T}^i$. For each commodity $i$, the combination of these existence and non-existence of the storers or/and processors introduce different region. Each region is represented by the activeness of the storers and the processors. Figures (3.1a and 3.1b) show the regions in the space $(P_t, F_{t,T})$ for each commodity independently. These regions are formed by the activeness of the storers and the processors in the physical market. Linking two isolated markets together introduces a combination of sixteen regions. Table 3.1 shows these sixteen regions. For instance, Region 11 is a combination of the region 1 in commodity $a$ and the region 1 of commodity $b$; i.e. $X^a > 0, Y^a > 0, X^b > 0$ and $Y^b > 0$. Region 12 is $a$ combination the region 1 in commodity a and the region 2 of commodity $b$; $X^a > 0, Y^a > 0, X^b > 0$ and $Y^b = 0$, an so forth. Those 16 regions can be reduced to 6 regions that are interested to be investigated in this paper. Those 6 regions are $11, 12, 14, 22, 24$ and $44$. The other regions are either treated in Ekeland et al. (2015) such as $13, 23, 33$ and $43$, or repeated such as $21, 31, 32, 41, 42$ and $34$. Region 11 is comprehensive, where all agents are active in both commodity markets. The other regions are sub-regions of the region 11. They are represented by the absence of one or more of the agents. Hence, we will be studying Region 11 as preference, and then we can induce the other sub-regions.

Figure 3.1: Physical and financial decisions in space $\left(F^i_{t,T}, P^i_t\right)$ , $i = a, b$




(a) Commodity $a$

(b) Commodity $b$

Table 3.1: The different regions that represent the activeness of the storers and the processors in the physical markets.

| Region | $X^a$ | $Y^a$ | $X^b$ | $Y^b$ | Region | $X^a$ | $Y^a$ | $X^b$ | $Y^b$ |
|---|---|---|---|---|---|---|---|---|---|
| **11** | $>\mathbf{0}$ | $>\mathbf{0}$ | $>\mathbf{0}$ | $>\mathbf{0}$ | **33** | $=\mathbf{0}$ | $=\mathbf{0}$ | $=\mathbf{0}$ | $=\mathbf{0}$ |
| 12 | $>0$ | $>0$ | $>0$ | $=0$ | 31 | See (13) | | | |
| 13 | $>0$ | $>0$ | $=0$ | $=0$ | 32 | See (23) | | | |
| 14 | $>0$ | $>0$ | $=0$ | $>0$ | 34 | $=0$ | $=0$ | $=0$ | $>0$ |
| **22** | $>\mathbf{0}$ | $=\mathbf{0}$ | $>\mathbf{0}$ | $=\mathbf{0}$ | **44** | $=\mathbf{0}$ | $>\mathbf{0}$ | $=\mathbf{0}$ | $>\mathbf{0}$ |
| 21 | See (12) | | | | 41 | See (14) | | | |
| 23 | $>0$ | $=0$ | $=0$ | $=0$ | 42 | See (24) | | | |
| 24 | $>0$ | $=0$ | $=0$ | $>0$ | 43 | See (34) | | | |

Ekeland et al. (2015), in one commodity case, divides the first region ($X^i > 0, Y^i > 0$) to two sub-regions. These sub-regions are separated by the line $n^i_I X^i - n^i_P Y^i = 0$, which represents a neutral net hedging pressure. When the net hedging pressure is short ($HP^i > 0$), then the market is in normal backwardation state. Oppositely, if the hedging pressure is net long ($HP^i < 0$), the market is in contango. However, this is not the case in our model. As shown in equation (3.12), the market state for any commodity is also determined by the sign and the magnitude of futures risk premium of the other market accompanied by cross commodity correlation. This finding goes in the line with Isleimeyyeh et al. (2017).

If commodity market $b$ is in normal backwardation (contango) state and the cross commodity

correlation is positive, then that would increase (decrease) the opportunity of normal backwardation state in commodity market $a$, or decrease (increase) the opportunity of having contango in commodity market $a$. On the other hand, if commodity $b$ is in normal backwardation (contango) state and the cross commodity correlation is negative, then it decreases (increases) the opportunity of normal backwardation state in commodity market $a$, or increase (decrease) the opportunity of contango in commodity market $a$. That shows the significance of the cross commodity correlation in determining the information flow between different commodity markets.

Coming back to the price computations. We will focus on the Region 11, where $X^a > 0$, $Y^a > 0$, $X^b > 0$, and $Y^b > 0$. The system $\phi$ (3.20) becomes

$$\begin{aligned}
\xi_t^a &= m^a P_t^a - n_I^a X^a \\
\xi_t^b &= m^b P_t^b - n_I^b X^b \\
\xi_T^a &= m^a F_{t,T}^a + \left(1+\gamma^b\zeta^a\right)\left(n_I^a X^a - n_P^a Y^a\right) + \left(K\zeta^a\right)\left(n_I^b X^b - n_P^b Y^b\right) \\
\xi_T^b &= m^b F_{t,T}^b + \left(K\zeta^b\right)\left(n_I^a X^a - n_P^a Y^a\right) + \left(1+\gamma^a\zeta^b\right)\left(n_I^b X^b - n_P^b Y^b\right)
\end{aligned}$$

Where,

$$\begin{aligned}
X^i &= F_{t,T}^i - P_t^i \\
Y^i &= Z^i - F_{t,T}^i \\
i &= \{a,b\}
\end{aligned}$$

That implies,

$$\begin{aligned}
\xi_t^a &= m^a P_t^a - n_I^a\left(F_{t,T}^a - P_t^a\right) \\
\xi_t^b &= m^b P_t^b - n_I^b\left(F_{t,T}^b - P_t^b\right) \\
\xi_T^a &= m^a F_{t,T}^a + \left(1+\gamma^b\zeta^a\right)\left(n_I^a\left(F_{t,T}^a - P_t^a\right) - n_P^a\left(Z^a - F_{t,T}^a\right)\right) + \left(K\zeta^a\right)\left(n_I^b\left(F_{t,T}^b - P_t^b\right) - n_P^b\left(Z^b - F_{t,T}^b\right)\right) \\
\xi_T^b &= m^b F_{t,T}^b + \left(K\zeta^b\right)\left(n_I^a\left(F_{t,T}^a - P_t^a\right) - n_P^a\left(Z^a - F_{t,T}^a\right)\right) + \left(1+\gamma^a\zeta^b\right)\left(n_I^b\left(F_{t,T}^b - P_t^b\right) - n_P^b\left(Z^b - F_{t,T}^b\right)\right)
\end{aligned}$$

We have four equations with four unknowns: $P_t^a$, $F_{t,T}^a$, $P_t^b$, and $F_{t,T}^b$. By rearranging the equations, the result is

$$\begin{aligned}
\xi_t^a &= \left(m^a + n_I^a\right) P_t^a - n_I^a F_{t,T}^a \\
\xi_t^b &= \left(m^b + n_I^b\right) P_t^b - n_I^b F_{t,T}^b \\
\xi_T^a &= \left(m^a + \left(1+\gamma^b\zeta^a\right)\left(n_I^a + n_P^a\right)\right) F_{t,T}^a - n_I^a\left(1+\gamma^b\zeta^a\right) P_t^a - n_P^a\left(1+\gamma^b\zeta^a\right) Z^a \\
&\quad + K\zeta^a\left(n_I^b + n_P^b\right) F_{t,T}^b - n_I^b K\zeta^a P_t^b - n_P^b K\zeta^a Z^b \\
\xi_T^b &= \left(m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right)\right) F_{t,T}^b - n_I^b\left(1+\gamma^a\zeta^b\right) P_t^b - n_P^b\left(1+\gamma^a\zeta^b\right) Z^b \\
&\quad + K\zeta^b\left(n_I^a + n_P^a\right) F_{t,T}^a - n_I^a K\zeta^b P_t^a - n_P^a K\zeta^b Z^a
\end{aligned}$$

Appendix 3.B shows that the previous system has a solution and it is unique.

By solving the previous system, we get four prices ($P_t^a, F_{t,T}^a, P_t^b$, and $F_{t,T}^b$). Consequently, we can find the rest of the prices and quantities ($X^a, Y^a, \tilde{P}_T^a, X^b, Y^b$, and $\tilde{P}_T^b$). Appendix 3.C exposures the computed equilibrium prices and quantities when the sotrers and the processors are active in both commodity markets. In order to have the prices for the other regions, we need to set one of $n_I^a$,, $n_P^a$, $n_I^b$ or/and $n_P^b$ to 0. $n_I^i$ shows that there is storage activities in commodity market $i$. And $n_P^i$ shows that there is storage activities in commodity market $i$.

## 3.6 Comparative statics

Our model shows different prices and quantities at equilibrium state. For each commodity, we have current spot price ($P_t^i$), future spot price ($P_T^i$), futures price ($F_{t,T}^i$), inventory ($X^i$) and processors demand ($Y^i$). Each of these prices is composed of different terms from both commodity markets ($a$&$b$). That offers to study different comparative statics not only in the same market, but even between both markets. In turn, we have a network of relationships between prices and quantities of the commodities. For instance, Let us assume that we have two markets: wheat and crude oil, for instance. A change in any of the wheat market characteristics affects the commodity market prices either positively or negatively depending on the structure of the prices themselves. Our model captures the changes on the current spot price, the future spot price, the futures price, the inventory and the processors demand in wheat market. Furthermore, it captures the changes on the prices and quantities in crude oil market, and vice versa.

Shocks in supply and demand are either positive or negative. The supply might increase (positive shock), or decrease (negative shocks). Negative supply shocks are more common, where the best example is the crude oil that produces heavily from the conflict zones in the Middle East area. Also, negative supply shocks possibly occur because of the weather, especially for agricultural commodities. Positive supply shock could also happen, for example, lifting sanctions on Iran. Oppositely, there are positive and negative demand shocks; i.e increase and decrease in the demand respectively. For example, the immigration wave of people from conflict zones would increase the demand on commodity in the receiving countries (positive demand shock). Consequently, that would affect the commodity prices.

In our mode, $\xi$ expresses the ability of the production to cover the demand of spot traders for a certain commodity i.e. point out the scarcity ($\xi = \mu - \omega$). Low $\xi_t^a(\xi_t^b)$ measures the failure of the current production $\omega_t^a(\omega_t^b)$ to cover the demand of the spot traders for the commodity $a$ ($b$) at time $t$. Moreover, low $\xi_T^a(\xi_T^b)$ measures the failure of the future production, $\omega_T^a(\omega_T^b)$, to

cover the future demand of the spot traders for the commodity $a$ ($b$) at time $T$. Hence, low $\xi^i$ means either decrease in demand or increase in the supply of commodity $i$, while high $\xi$ shows the inverse scenario. In next two subsections, we will be focusing firstly on the impact of the supply/demand shocks on the prices and quantities. Secondly, we introduce the impact of the expected supply/demand on the prices and quantities. We will be studying the impact of supply increase (low $\xi$) on one commodity market and how its effect spreads to the other market. The other scenarios are concluded automatically, such as increase in demand, decrease in supply and decrease in demand.

### 3.6.1 The impact of the change in the supply on the equilibrium prices (Supply/demand shocks)

Imagine an abundance of commodity $a$, or a sharp decrease in the demand of commodity $a$. How does such a change affect the prices in commodity market a? More importantly, are the prices and quantities of commodity b affected by the abundances in commodity $a$?

Intuitively, the abundance of commodity $a$, at time $t$, causes a wane in $P^a_t$. Based on the basic economic principals, the storers are more motivated to buy the commodity and store it. This increases the inventory levels ($X^a$). Thus, the storers need to hedge their positions, and ask for more short positions in the paper markets. Selling more futures contracts decreases the futures price ($F^a_{t,T}$). High inventory levels at $t$ means high supply at $T$. Consequently, the future spot price ($P^a_T$) decreases. Processors are motivated to buy the commodity in the physical market. Thus, their demand increase ($Y^a$). There is one more question. Processors also need to hedge their physical positions in the futures market. So, they ask for more futures contracts. However, we mentioned that futures prices decreases. The answer has been found in our computations, where the quantity demanded by storers is more than what processors ask for. That means the net positions is net short, and then the futures prices decreases. Consequently, hedging becomes more expensive $\left(E\left[\tilde{P}^a_T\right] - F^a_{t,T}\right)$. Finally, speculators will have more long positions in the futures market.

Table 3.2: The impact of the abundance of commodity a on its prices, in regime 11.

| Regime 11 prices | $P^a_t$ | $F^a_{t,T}$ | $X^a$ | $Y^a$ | $P^a_T$ | $E[\tilde{P}^a_T] - F^a_{t,T}$ |
|---|---|---|---|---|---|---|
| Supply shocks impact | $\searrow$ | $\searrow$ | $\nearrow$ | $\nearrow$ | $\searrow$ | $\nearrow$ |

$\searrow$ means decrease, $\nearrow$ means increase

The impact of the abundance in commodity $a$ on commodity $b's$ prices splits into two sce-

narios. Those two scenarios are determined by the cross commodity correlation $\left(corr(\widetilde{\xi}_T^a, \widetilde{\xi}_T^b)\right)$. Our previous interpretation said that speculators will have more long positions in the futures market of commodity $a$. Hence, when the cross commodity correlation is positive, the speculators will have less long (or more short position) positions in the futures market of commodity $b$ (see the speculators' optimal positions (3.9) in section 3.3.2). A decrease in the demand of commodity $b$ futures contracts is followed by a decrease in the futures prices of commodity $b$ ($F_{t,T}^b$). The storers respond to that decrease by lowering their inventory in the physical market ($X^b$). Consequently, the current spot price declines ($P_t^b$). The fall in the futures prices enhances the wishes of the processors to buy more from commodity $b$ ($Y^b$). The future spot price ($\tilde{P}_T^b$) rises for two reasons: first, because the inventory levels of commodity $b$ decreases. Second, the demand of processors increases. Consequently, hedging pressure and the futures risk premium of commodity $a$ increases the futures risk premium in commodity $b$. A positive cross commodity correlation is the common scenario in commodity markets especially after the era of financialization (e.g. see Tang and Xiong (2012)). However, our model is able to interpret the opposite case when the cross commodity correlation is negative, which occasionally happened. When the cross commodity correlation is negative the story is the mirrored. Table 3.3 shows a draw of the prices and quantities changes in commodity $b$, when there is abundance in commodity $a$.

Table 3.3: The impact of the abundance of commodity $a$ on commodity $b$, regime 11

| | $P_t^b$ | $F_{t,T}^b$ | $X^b$ | $Y^b$ | $\tilde{P}_T^b$ | $E[\tilde{P}_T^b] - F_{t,T}^b$ |
|---|---|---|---|---|---|---|
| $\text{corr}(\widetilde{\xi}_T^a, \widetilde{\xi}_T^b) > 0$ | $\searrow$ | $\searrow$ | $\searrow$ | $\nearrow$ | $\nearrow$ | $\nearrow$ |
| $\text{corr}(\widetilde{\xi}_T^a, \widetilde{\xi}_T^b) < 0$ | $\nearrow$ | $\nearrow$ | $\nearrow$ | $\searrow$ | $\searrow$ | $\searrow$ |

To sum up, there are several results that we can settle based on the supply/demand shocks. First, there is a co-movement between current spot price and futures price in both commodity markets. Second, there is a negative relationship between the current spot prices and the futures prices, and the futures risk premium for both commodities $a\&b$. Third, from one hand, our results show a negative relationship between prices and net short hedging pressure for commodity $a$. From the other hand, there is a positive relationship between the prices (current spot and futures) and the net short hedging pressure for commodity $b$. Fourth, by considering the cross commodity correlation is positive, there is a co-movement between the current spot price of commodity $a$ and the current spot price and the futures price of commodity $b$. Fifth, there is a co-movement between the futures risk premium of both commodities when the cross commodity correlation is positive.

### 3.6.2 The impact of the expected change in supply/demand on the equilibrium prices (expected supply/demand shocks)

One of our assumptions that has been established is that the distribution function is a common knowledge for all the operators in the markets. Therefore, all participants have information about the unrealized random variables that take a place at T. In reality, we do not know the future demand and the supply that is represented by $\tilde{\xi}^i_T$, or the future spot price ($\tilde{P}^i_T$). However, we can expect them. Proceeding from that, we are going, in the next section, to investigate the impact of any possible future supply change on the commodity itself, and how it spreads to the other commodity. That is considered very appealing for the agent and the regulators who are worry about the future uncertainty.

In our prices, future supply and demand appear in different places that are represented by $\xi^i_T$ and $\tilde{\xi}^i_T$. $\xi^i_T$ is the expected value of $\tilde{\xi}^i_T$.

$$\begin{aligned}
&\tilde{\xi}^i_T = \tilde{\mu}^i_T - \tilde{\omega}^i_T \\
&\xi^i_T = E\left[\tilde{\mu}^i_T - \tilde{\omega}^i_T\right] \\
&i = a, b
\end{aligned}$$

The listed prices in appendix 3.C show that $\xi^a_T$ and $\xi^b_T$ are exist in all prices. But, $\tilde{\xi}^a_T$ is only exist in $\tilde{P}^a_T$, and $\tilde{\xi}^b_T$ is exist in $\tilde{P}^b_T$. Because we are talking about expectation, we need to consider the expected value for the future spot price. The future spot price as shown in appendix 3.C is:

$$\widetilde{P}^i_T = \frac{\widetilde{\xi}^i_T}{m^i} + \frac{-\left(n^i_I m^i + n^i_P(m^i + n^i_I)\right) D\xi^i_T}{m^i n^i_I (AD - CB)} + \upsilon, \quad \upsilon \text{ is constant}$$

$$E\left(\widetilde{P}^a_T\right) = E\left(\frac{\widetilde{\xi}^i_T}{m^i}\right) + E\left(\frac{-\left(n^i_I m^i + n^i_P(m^i + n^i_I)\right) D\xi^i_T}{m^i n^a_I (AD - CB)} + \upsilon\right)$$

$$E\left(\widetilde{P}^i_T\right) = \frac{n^i_I(AD - CB) - (n^i_I m^i + n^i_P(m^i + n^i_I))D}{m^i n^i_I (AD - CB)} \xi^i_T + \upsilon$$

So, the new factor of $\xi^i_T$ is $\frac{n^i_I(AD-CB)-(n^i_I m^i+n^i_P(m^i+n^i_I))D}{m^i n^i_I(AD-CB)}$ instead of $-\frac{\left(n^i_I m^i+n^i_P(m^i+n^i_I)\right)D}{m^i n^i_I(AD-CB)}$

Where $i = a, b$. $A, B, C$ and $D$ are coefficients that are introduced in the appendix 3.C. We will study the impact of the abundance of commodity $a$ at $T$ on the prices and quantities of commodity $a$, and how it affects on commodity market $b$. The abundance of commodity $a$ is represented by low $\xi^a_T$. Low $\xi^a_T$ is a result of increasing in the supply of commodity $a$ at $T$ ($\omega^a_T$),

or decreasing in the demand on commodity $a$ at $T$ ($\mu^a_T$).

Expecting an abundance in the supply of commodity $a$ at $T$ causes a direct decrease in the expected spot price of commodity $a$ at $T$. It causes a shock for the storers in both the financial and the spot markets. That expected abundance pushes the storers to reduce their inventory levels ($X$). Less demand on the commodity $a$ in the physical market declines the current spot price ($P^a_t$). The storers still need to hedge their positions in the financial markets, which pushes them to propose a lower futures price ($F^a_{t,T}$). The processors are the most beneficiary from this shock, especially as the whole indicators in the futures and the physical markets motivate them to increase their positions in both markets. Thus, the decrease in the expected spot price motivates the processors to buy commodity $a$ in the physical market ($Y^a$). Consequently, they take more long positions in the futures market. The net position of the storers and the processors tends to be more long positions in the futures market, which drives the speculators to take short position. Accordingly, commodity $a$ market tend to be in contango state (the futures risk premium of commodity $a$ decreases).

Table 3.4: The impact of an expected supply change on the commodity $a$ prices in regime 11

| Regime 11 prices | $P^a_t$ | $F^a_{t,T}$ | $X^a$ | $Y^a$ | $\tilde{P}^a_T$ | $E[\tilde{P}^a_T] - F^a_{t,T}$ |
|---|---|---|---|---|---|---|
| Supply shocks impact | $\searrow$ | $\searrow$ | $\searrow$ | $\nearrow$ | $\searrow$ | $\searrow$ |

The next question is how the expected abundance of commodity $a$ derives the market of commodity $b$. We continue with the common case when the cross commodity correlation is positive $\Big(cov(\widetilde{\xi}^a_T, \widetilde{\xi}^b_T) > 0\Big)$. The tendency of the speculators to have short positions on the market of commodity $a$ derives them to have more long positions in commodity $b$ market (more precisely to go toward long, i.e. the speculator reduces the short position in commodity $b$ if he is in situation to take short position (see the optimal positions of the speculators). According to this fact, the interpretations of the changes in the prices and the quantities are straightforward. The increased demand for the futures contracts of commodity $b$ raises the futures prices ($F^b_{t,T}$). Consequently, the storers tend to have higher levels of inventories in their stores ($X^b$). This is based on the realization that they can hedge their physical positions at higher futures prices. Accordingly, the current spot price rises ($P^b_t$). The increase in the futures price causes the processors to be less active in the physical market ($Y^b$ decreases). Hence, the future spot price ($P^b_T$) declines as a result of increasing in the storers' inventory and decreasing of the quantity demanded by the processors. The net futures position between storers and processors are moving toward short. So, the speculators are shifting to have more long positions in the futures market. Eventually, the previous changes decrease the futures risk premium, i.e. commodity $b$ market moves toward

contango. Our model has the possibility to explain the information flow form commodity $a$ to commodity $b$ markets when the cross commodity correlation is negative. Table 3.5 shows a draw of the price movements in commodity $b$ market according to the abundance in commodity market $a$ when the cross commodity correlation is positive and negative.

Table 3.5: The impact of an expected supply change in commodity $a$ on commodity $b$

| | $P_t^b$ | $F_{t,T}^b$ | $X^b$ | $Y^b$ | $\tilde{P}_T^b$ | $E[\tilde{P}_T^b] - F_{t,T}^b$ |
|---|---|---|---|---|---|---|
| $\text{cov}(\widetilde{\xi}_T^a, \widetilde{\xi}_T^b) > 0$ | $\nearrow$ | $\nearrow$ | $\nearrow$ | $\searrow$ | $\searrow$ | $\searrow$ |
| $\text{cov}(\widetilde{\xi}_T^a, \widetilde{\xi}_T^b) < 0$ | $\searrow$ | $\searrow$ | $\searrow$ | $\nearrow$ | $\nearrow$ | $\nearrow$ |

To sum up, an expected future positive supply shock in a specific market shows different results. First, in the market where the shock is existed witness a recession in the market state. It shows a co-movement between the prices themselves, the net short hedging pressure and the futures risk premium. On the contrary, the other market is more active. The speculator wishes to take more long positions in the healthy market. Generally, the results express several co-movements between prices: i) we find a co-movement between the current spot price, futures price and the inventory levels. ii) it shows also a co-movement between futures price and net short hedging pressure. On the contrary, it shows a negative relationship between net short hedging pressure and the futures risk premium. In the same line, there is a negative relationship between futures prices and the futures risk premium. Third, the relationship between both markets is determined mainly by cross commodity correlation. By assuming the cross commodity correlation is positive (often situations), the expected future shock show a negative relationship between commodities spot and futures prices. It shows also, a negative relationship between inventory levels, and quantities demanded for production (it means the commodities net hedging pressure is negatively correlated). It shows a co-movement between future spot prices. On the contrary, that expected future shock expresses a positive relationship between the futures risk premiums of both commodities.

## 3.7 The impact of speculation

We are studying the impact of speculation by following the approach that examines the difference between existence and non-existence of speculators in the market. This approach has been studied before by Newbery (1987). Another approach to study the impact of speculation is by testifying the effect of increasing speculation. This approach has been studied by Ekeland et al. (2015). They define the increase in the speculation either by increasing in the number of speculators, or by decreasing in the speculators' risk aversion. We follow a different track

and investigate the change in the prices and quantities when we have and when we do not have speculators.

The computed prices that are introduced in the appendix 3.C are not helpful in investigating the impact of speculation. Therefore, we approximate the prices by using Taylor theorem. The equilibrium prices have been estimated around the point where there are no speculators ($N_S = 0$). But, that estimation does not mean the number of speculators is small. To make sure that we use Taylor's theorem correctly, we set the following theorem.

**Theorem:** For any market, $\frac{\partial X}{\partial N_S}\frac{1}{X} \to 0$, when $N_I + N_P \to \infty$, where $X$ is any equilibrium price.

The previous theorem says that the relative changes in the prices are neglected when the number of hedgers is large.

**Corollary:** For any $N_S$, we can find $N_I$ and $N_P$ large where $\frac{\Delta X}{X} = \frac{\partial X}{\partial N_S}\frac{1}{X}N_S < \epsilon$.

In appendix 3.D, we introduce a framework of re-computing the equilibrium prices, and applying Taylor's theorem.

Let us note that

$$\theta = \frac{\frac{N_S}{\alpha_S}}{\left(\frac{N_I^a}{\alpha_I^a} + \frac{N_P^a}{\alpha_P^a}\right)}\left[\frac{1}{\left(1 - corr^2_{\tilde{\xi}_T^a, \tilde{\xi}_T^b}\right)}\right]\left(\frac{Var[\tilde{\xi}_T^a]}{m^a\left(\frac{N_I^a}{\alpha_I^a} + \frac{N_P^a}{\alpha_P^a}\right)}\overline{HP}^a - \frac{\sqrt{Var[\tilde{\xi}_T^b]Var[\tilde{\xi}_T^a]}corr_{\tilde{\xi}_T^a, \tilde{\xi}_T^b}}{m^b\left(\frac{N_I^b}{\alpha_I^b} + \frac{N_P^b}{\alpha_P^b}\right)}\overline{HP}^b\right)$$

As a result, the changes in the prices and the quantities of commodity $a$ are:

$$\begin{aligned}
\Delta P_t^a &= \frac{n_I^a}{J^a}\theta, & \Delta F^a &= \frac{(m^a + n_I^a)}{J^a}\theta, & \Delta X^a &= \frac{m^a}{J^a}\theta \\
\Delta Y^a &= -\frac{(m^a + n_I^a)}{J^a}\theta, & \Delta P_2^a &= -\frac{1}{m^a}\frac{n_I^a m^a + n_P^a\left(m^a + n_I^a\right)}{J^a}\theta
\end{aligned}$$

Where,

$$\begin{aligned}
J^a &= m^a n_I^a\left(1 + \frac{m^a}{\overline{\gamma}^a}\right) + \left(m^a + n_I^a\right)\left(m^a + n_P^a\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)\right) \\
HP^a &= n_I^a\overline{X}^a - n_P^a\overline{Y}^a \\
\overline{\gamma}^a &: = \gamma^a_{N_S=0} = \left(\frac{(m^a)^2}{Var[\tilde{\xi}_T^a]}\right)\left[\frac{N_I^a}{\alpha_I^a} + \frac{N_P^a}{\alpha_P^a}\right] \\
\overline{X}^a &= X^a_{N_S=0}, \qquad \overline{Y}^a = Y^a_{N_S=0}
\end{aligned}$$

We find that the effect of the speculation on the prices is determined by several factors. Most of these factors are common in the prices of the same market, which is represented by $\theta$. We focus in interpreting the common factors. These factors are:

- The weight of speculators to total hedgers $\left( \frac{\frac{N_S}{\alpha_S}}{\left( \frac{N_I^a}{\alpha_I^a} + \frac{N_P^a}{\alpha_P^a} \right)} \right)$.

This factor is represented by the number of speculators divided by the total number of storers and processors. Of course, each of them is divided by their risk aversion. This factor can tell us more. Assume we consider the number of hedgers is a measure of the market size. If the market is large, then the impact of the speculation will be small. On the contrary, the effect of the speculation will be large in small markets.

- The balance of hedging pressure $\left( \frac{Var[\tilde{\xi}_T^a]}{m^a \left( \frac{N_I^a}{\alpha_I^a} + \frac{N_P^a}{\alpha_P^a} \right)} \overline{HP}^a - \frac{\sqrt{Var[\tilde{\xi}_T^b] Var[\tilde{\xi}_T^a]} corr_{\tilde{\xi_T^a}, \tilde{\xi_T^b}}}{m^b \left( \frac{N_I^b}{\alpha_I^b} + \frac{N_P^b}{\alpha_P^b} \right)} \overline{HP}^b \right)$.

This term is represent the by difference between the hedging pressure of both markets weighted to the covariance between markets. The hedging pressure of each commodity is divided by the total number of hedgers. We interpret that as market standardizing, because futures markets are not weighted similarly. In this case, we have different scenarios. However, whenever this term is positive, then the changes in the current spot price, the futures price, and the inventory levels are positive. On the contrary, the changes on the quantity demanded for production, and the future spot prices are negative.

- Other minor terms that control the changes level in the prices and quantities.

These changes depend on the positions taken by speculators in both futures markets. In any market, positive $HP$ means that speculators take long positions, otherwise they take short positions. Positive $\theta$ means that the positions taken by speculators are long. Therefore, an increase in the number of speculators shows increasing in the demand on long futures positions. Hence, the futures price rises. Inventory holders ask for more physical positions, in the time they can hedge them. Consequently, the spot price increases. Conversely, the quantity demanded by processors and future spot price decrease. The increase in the speculation demonstrates a co-movement between current spot price, futures price and the inventory levels. From the other hand, it shows a co-movement between future spot price and the demand for production, but in the opposite side.

## 3.8 Conclusion

In this paper, we introduce a theoretical framework about the existence of the financial investors (index investor) in commodity markets, and their impact in information flow between commodity markets. We build our model from the spirit of Ekeland et al. (2015). In this model, we step forward from studying the interaction between physical and futures markets in the commodity market (like most of the static models in the literature) to study the interaction between two different commodity markets. Those commodities markets are linked by the financial investors (or institutions). We address several questions related to supply/demand shock, expected future supply/demand shock and the impact of speculation.

We show the role of the financial investors in transmitting information between commodity markets. Our results show a big map of relationships between different prices and different markets. A shock in one market affects the prices in that market, and then, it spreads to the other market's prices responding to the investors' decisions in the futures markets. We find that the shocks could be transmitted in two opposite directions based on the cross commodity correlation. Responding to such shocks in supply/demand in a commodity market, we address several co-movements between prices. It shows a co-movement between spot and futures prices in the same commodity market. There is a negative relationship between the prices and quantities demanded for inventory and for production. Also, there is a negative relationship between prices and the futures risk premium. The spread impact on the other market split into two opposite effects, which is determined by the cross commodity correlation. By assuming a positive correlation, our results show co-movement between i) spot and futures prices of both commodities, ii) quantity demanded for production in both markets iii) the futures risk premium in both market. It shows a negative relationship between i) inventory levels in both markets ii) the future spot price in both markets.

Expecting future supply/demand shocks in one market causes a depression in that market, while other markets become more active. In the active market, our results show a comovement between spot price, futures price and inventory level from one side. From the other side, and in the opposite direction, they show a comovement between production demand, future spot price and futures risk premium. Under this situation, and when the cross commodity correlation is positive, the different commodities prices (spot and futures), inventory levels and the demand for production are positively related. On the contrary, there is a negative relationship between futures risk premium and the future spot price.

The impact of the speculation in the presence of the financial investors is determined by the balance of hedging pressures in both markets. If the net taken positions in the futures market

by investors are net long, then that causes increase in the current spot, futures prices and the inventory level. On the contrary, it causes a decrease in the future spot price and the quantity demanded for production. Also, bigger market is less affected by speculation than a smaller one. However, increasing the financial investors' participation shows a co-movement between current spot price, futures price and inventory level. In the opposite side, there is a co-movement in the production demand and the future spot price.

In this paper, we find also the commodity futures risk premium. For any commodity market, the risk premium is determined by the hedging pressure of the commodity and the futures risk premium of the other market restricted to the cross commodity correlation. This result shows that the net short hedging pressure increase the futures risk premium, which goes in the line with De Roon et al. (2000), Ekeland et al. (2015) and others. Also, increasing in normal backwardation (contango) in one market increases the normal backwardation (contango) in the other market. This is a fact by assuming the cross commodity correlation is positive, which goes in the line with Tang and Xiong (2012).

This paper contributes the recent growing literatures that address the significant growing in the financial investors in the commodity futures market generally (where the majority is empirical), and especially to those few papers that study the cross commodity integration such as Basak and Pavlova (2016).

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# Appendix

## 3.A Agents optimal positions

In this section, we introduce the computations of the optimal positions for each of the storer, processor and the investor (speculator) in both markets $a\&b$. We have already explained that the agents are mean-variance utility maximizers. Therefore, each agent is going to maximize

$$E(\tilde{\pi}^i) - \frac{1}{2}\alpha_j^i Var(\tilde{\pi}^i)$$

Where, $\pi$ is the agents profit. $\alpha_j^i$ is the agent's $j$ risk aversion in commodity market $i$. $\sim$ indicates that the variable is random.

### 3.A.1 Storer

The profit of the storer in commodity market $i$ ($i = \{a, b\}$) is represented by

$$\tilde{\pi}(x^i, f_I^i) = x^i(\tilde{P}_T^i - P_t^i) + f_I^i(\tilde{P}_T^i - F_{t,T}^i) - \frac{1}{2}C^i(x^i)^2$$

To obtain the storers' optimal positions in the physical and the futures markets, we need to solve the first order conditions of the next expression.

$$\max_{x^i, f_I^i} \left\{ E(\tilde{\pi}^i) - \frac{1}{2}\alpha_I^i Var[\tilde{\pi}^i] \right\}$$

$$\max_{x^i, f_I^i} \left\{ (x^i + f_I^i) E\left(\tilde{P}_T^i\right) - x^i P_t^i - f_I^i F_{t,T}^i - \frac{1}{2} C^i (x^i)^2) - \frac{1}{2} \alpha_I^i (x^i + f_I^i)^2 Var\left(\tilde{P}_T^i\right) \right\}$$

Hence, the storer's optimal positions in the physical and futures markets respectively are:

$$x^{i*} = \frac{1}{C^i} max\left\{ F_{t,T}^i - P_t^i, 0 \right\} \tag{3.5}$$

$$f_I^{i*} = \frac{E[\tilde{P}_T^i] - F_{t,T}^i}{\alpha_I^i Var[\tilde{P}_T^i]} - x^{i*} \tag{3.6}$$

### 3.A.2 Processor

The profit of the processor in commodity market $i$ ($i = \{a, b\}$) is represnted by:

$$\tilde{\pi}(y^i, f_P^i) = (y^i - \frac{\beta^i}{2}(y^i)^2) Z^i - y^i \tilde{P}_T^i + f_P^i (\tilde{P}_T^i - F_{t,T}^i) \tag{3.2}$$

By solving

$$\max_{y^i, f_P^i} \left\{ E[\tilde{\pi}^i] - \frac{1}{2} \alpha_P^i Var[\tilde{\pi}^i] \right\},$$

$$\max_{y^i, f_P^i} \left\{ (f_P^i - y^i) E\left(\tilde{P}_T^i\right) + \left( y^i - \frac{\beta^i}{2}(y^i)^2 \right) Z^i - f_P^i F_{t,T}^i - \frac{1}{2} \alpha_P^i (f_P^i - y^i)^2 Var\left(\tilde{P}_T^i\right) \right\},$$

By finding the first order conditions, the processor's optimal positions in the physical and the futures markets are:

$$y^{i*} = \frac{1}{\beta^i Z^i} \max\left\{ Z^i - F_{t,T}^i, 0 \right\}, \tag{3.7}$$

$$f_P^{i*} = \frac{E[\tilde{P}_T^i] - F_{t,T}^i}{\alpha_P^i Var[\tilde{P}_T^i]} + y^{i*} \tag{3.8}$$

### 3.A.3 Speculator

The profit of the investors by operating in the two commodities markets is represented by:

$$\tilde{\pi}(f_S^a, f_S^b) = f_S^a (\tilde{P}_T^a - F_{t,T}^a) + f_S^b (\tilde{P}_T^b - F_{t,T}^b) \tag{3.3}$$

By solving the following problem,

$$\max_{f_S^a, f_S^b} \left\{ E(\tilde{\pi}) - \frac{1}{2} \alpha_S Var(\tilde{\pi}) \right\}$$

$$\max_{f_S^a, f_S^b} \left\{ f_S^a \left( E\left(\tilde{P}_T^a\right) - F_{t,T}^a \right) + f_S^b \left( E\left(\tilde{P}_T^b\right) - F_{t,T}^b \right) - \frac{1}{2} \alpha_S \left[ (f_S^a)^2 Var\left(\tilde{P}_T^a\right) + \left(f_S^b\right)^2 Var\left(\tilde{P}_T^b\right) + 2 f_S^a f_S^b cov\left(\tilde{P}_T^a, \tilde{P}_T^b\right) \right] \right\}$$

After finding the first order conditions, the optimal positions of the investor in commodity market $a$ and $b$ are

$$f_S^{a*} = \left(\frac{1}{\left(1 - corr^2\left(\tilde{P}_T^a, \tilde{P}_T^b\right)\right)}\right)\left[\frac{E[\tilde{P}_T^a] - F_{t,T}^a}{\alpha_S Var[\tilde{P}_T^a]} - corr\left(\tilde{P}_T^a, \tilde{P}_T^b\right)\frac{\sigma_P^b}{\sigma_P^a}\frac{\left(E[\tilde{P}_T^b] - F_{t,T}^b\right)}{\alpha_S Var[\tilde{P}_T^b]}\right], corr^2 \neq 1$$

$$f_S^{b*} = \left(\frac{1}{\left(1 - corr^2\left(\tilde{P}_T^a, \tilde{P}_T^b\right)\right)}\right)\left[\frac{E[\tilde{P}_T^b] - F_{t,T}^b}{\alpha_S Var[\tilde{P}_T^b]} - corr\left(\tilde{P}_T^a, \tilde{P}_T^b\right)\frac{\sigma_P^a}{\sigma_P^b}\frac{\left(E[\tilde{P}_T^a] - F_{t,T}^a\right)}{\alpha_S Var[\tilde{P}_T^a]}\right], corr^2 \neq 1$$

## 3.B Equilibrium solution and uniqueness

In this section, we are proving that our model is solvable, and whether there is a unique solution.

The system $\phi$ (3.20) is a system of four linear equations with four unknowns $(P_1^i, F^i)$, $i = a, b$.

$$\phi(P_t^a, P_t^b, F_{t,T}^a, F_{t,T}^b) = \xi$$

We can write the previous system in the following form:

$$Y = AX$$

Where,

$$A = (a_{ij})_{\substack{1\leq i\leq 4\\ 1\leq j\leq 4}} = \begin{pmatrix} m^a + n_I^a & 0 & -n_I^a & 0 \\ 0 & m^b + n_I^b & 0 & -n_I^b \\ -n_I^a\left(1 + \gamma^b\zeta^a\right) & -n_I^b K\zeta^a & m^a + \left(1 + \gamma^b\zeta^a\right)\left(n_I^a + n_P^a\right) & K\zeta^a\left(n_I^b + n_P^b\right) \\ -n_I^a K\zeta^b & -n_I^b\left(1 + \gamma^a\zeta^b\right) & K\zeta^b\left(n_I^a + n_P^a\right) & m^b + \left(1 + \gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right) \end{pmatrix}$$

$$X = \begin{pmatrix} P_t^a \\ P_t^b \\ F_{t,T}^a \\ F_{t,T}^b \end{pmatrix}, \qquad Y = (y_i)_{1\leq i\leq 4} = \begin{pmatrix} \xi_t^a \\ \xi_t^b \\ \xi_T^a + n_P^a\left(1 + \gamma^b\zeta^a\right)Z^a + n_P^b K\zeta^a Z^b \\ \xi_T^b + n_P^a K\zeta^b Z^a + n_P^b\left(1 + \gamma^a\zeta^b\right)Z^b \end{pmatrix}$$

The system is solvable and unique if the $\det(A) \neq 0$.

$$\det(A) = \begin{vmatrix} m^a + n_I^a & 0 & -n_I^a & 0 \\ 0 & m^b + n_I^b & 0 & -n_I^b \\ -n_I^a\left(1+\gamma^b\zeta^a\right) & -n_I^b K\zeta^a & m^a + \left(1+\gamma^b\zeta^a\right)(n_I^a + n_P^a) & K\zeta^a\left(n_I^b + n_P^b\right) \\ -n_I^a K\zeta^b & -n_I^b\left(1+\gamma^a\zeta^b\right) & K\zeta^b(n_I^a + n_P^a) & m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right) \end{vmatrix}$$

$$\det(A) = (m^a + n_I^a)\begin{vmatrix} m^b + n_I^b & 0 & -n_I^b \\ -n_I^b K\zeta^a & m^a + \left(1+\gamma^b\zeta^a\right)(n_I^a + n_P^a) & K\zeta^a\left(n_I^b + n_P^b\right) \\ -n_I^b\left(1+\gamma^a\zeta^b\right) & K\zeta^b(n_I^a + n_P^a) & m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right) \end{vmatrix}$$

$$-n_I^a\begin{vmatrix} 0 & m^b + n_I^b & -n_I^b \\ -n_I^a\left(1+\gamma^b\zeta^a\right) & -n_I^b K\zeta^a & K\zeta^a\left(n_I^b + n_P^b\right) \\ -n_I^a K\zeta^b & -n_I^b\left(1+\gamma^a\zeta^b\right) & m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right) \end{vmatrix}$$

$$\det(A) = (m^a + n_I^a) * \begin{bmatrix} \left(m^b + n_I^b\right)\left[\left(m^a + \left(1+\gamma^b\zeta^a\right)(n_I^a + n_P^a)\right)\left(m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right)\right) - K^2\zeta^b\zeta^a(n_I^a + n_P^a)\left(n_I^b + n_P^b\right)\right] \\ -n_I^b\left[-n_I^b K^2\zeta^a\zeta^b(n_I^a + n_P^a) + n_I^b\left(1+\gamma^a\zeta^b\right)\left(m^a + \left(1+\gamma^b\zeta^a\right)(n_I^a + n_P^a)\right)\right] \end{bmatrix}$$

$$-n_I^a\begin{bmatrix} -\left(m^b + n_I^b\right)\left[-n_I^a\left(1+\gamma^b\zeta^a\right)\left(m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right)\right) + n_I^a K^2\zeta^b\zeta^a\left(n_I^b + n_P^b\right)\right] \\ -n_I^b\left[n_I^a n_I^b\left(1+\gamma^b\zeta^a\right)\left(1+\gamma^a\zeta^b\right) - n_I^a n_I^b K^2\zeta^b\zeta^a\right] \end{bmatrix}$$

$$\det(A) = (m^a + n_I^a) * \begin{bmatrix} \left[\left(m^b\left(m^a + \left(1+\gamma^b\zeta^a\right)(n_I^a + n_P^a)\right)\left(m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right)\right) - K^2\zeta^b\zeta^a(n_I^a + n_P^a)\,n_I^b + n_P^b\left(n_I^b + n_P^b\right)\right)\right] + \\ n_I^b\left[\left(m^a + \left(1+\gamma^b\zeta^a\right)(n_I^a + n_P^a)\right)\left(m^b + n_P^b\left(1+\gamma^a\zeta^b\right)\right) - n_P^b K^2\zeta^b\zeta^a(n_I^a + n_P^a)\right] \end{bmatrix}$$
$$-n_I^a\begin{bmatrix} -m^b\left[-n_I^a\left(1+\gamma^b\zeta^a\right)\left(m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right)\right) + n_I^a K^2\zeta^b\zeta^a\left(n_I^b + n_P^b\right)\right] \\ -n_I^b\left[-n_I^a\left(1+\gamma^b\zeta^a\right)\left(m^b + n_P^b\left(1+\gamma^a\zeta^b\right)\right) + n_I^a n_P^b K^2\zeta^b\zeta^a\right] \end{bmatrix}$$

$$\begin{aligned} \det(A) = {} & m^a\left[\left(m^b\left(m^a + \left(1+\gamma^b\zeta^a\right)(n_I^a + n_P^a)\right)\left(m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right)\right) - K^2\zeta^b\zeta^a(n_I^a + n_P^a)\left(n_I^b + n_P^b\right)\right)\right] \\ & + n_I^a\left[\left(m^b\left(m^a + n_P^a\left(1+\gamma^b\zeta^a\right)\right)\left(m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right)\right) - K^2\zeta^b\zeta^a n_P^a\left(n_I^b + n_P^b\right)\right)\right] \\ & + n_I^b\left[\left(m^a + \left(1+\gamma^b\zeta^a\right)(n_I^a + n_P^a)\right)\left(m^b + n_P^b\left(1+\gamma^a\zeta^b\right)\right) - K^2\zeta^b\zeta^a n_P^b(n_I^a + n_P^a)\right] \\ & + n_I^b\left[n_I^a\left(1+\gamma^b\zeta^a\right)\left(m^b + n_P^b\left(1+\gamma^a\zeta^b\right)\right) - n_I^a n_P^b K^2\zeta^b\zeta^a\right] \end{aligned}$$

Note that $\gamma^a\gamma^b - K^2 > 0$

Then $\det(A) > 0$

We conclude that there is a solution the system $\phi$ and it is unique.

## 3.C Equilibrium prices

This section shows the equilibrium prices of the region 11, where all agents are active.

Note that,

$$\gamma^a = \left(\frac{(m^a)^2}{Var[\tilde{\xi}_T^a]}\right)\left[\frac{N_I^a}{\alpha_I^a} + \frac{N_P^a}{\alpha_P^a} + \frac{N_S}{\alpha_S\left(1-\left(corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)^2\right)}\right], \tilde{\xi}_T^a \neq \tilde{\xi}_T^b$$

$$\gamma^b = \left(\frac{(m^b)^2}{Var[\tilde{\xi}_T^b]}\right)\left[\frac{N_I^b}{\alpha_I^b} + \frac{N_P^b}{\alpha_P^b} + \frac{N_S}{\alpha_S\left(1-\left(corr_{\tilde{\xi}_T^b,\tilde{\xi}_T^a}\right)^2\right)}\right], \tilde{\xi}_T^b \neq \tilde{\xi}_T^a$$

$$K = \frac{N_S(m^a m^b) corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}}{\alpha_S\sqrt{Var[\tilde{\xi}_T^a]Var[\tilde{\xi}_T^b]}\left(1-\left(corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)^2\right)}, \tilde{\xi}_T^a \neq \tilde{\xi}_T^b$$

$$\zeta^a = \frac{m^a}{\gamma^a\gamma^b - K^2}\ , \qquad \zeta^b = \frac{m^b}{\gamma^a\gamma^b - K^2}$$

The prices are:

$$P_t^a = \frac{D\xi_T^a - B\xi_T^b - G\xi_t^a - H\xi_t^b - LZ^b - NZ^a}{AD - CB} \tag{3.23}$$

$$\begin{aligned}
A &= \frac{m^a}{n_I^a}\left(m^a + (n_I^a + n_P^a)(1+\gamma^b\zeta^a)\right) + m^a + n_P^a\left(1+\gamma^b\zeta^a\right)\\
B &= \frac{m^b}{n_I^b}K\zeta^a\left(n_I^b + n_P^b\right) + K\zeta^a n_P^b\\
C &= \frac{m^a}{n_I^a}K\zeta^b\left(n_I^a + n_P^a\right) + K\zeta^b n_P^a\\
D &= \frac{m^b}{n_I^b}\left(m^b + (n_I^b + n_P^b)(1+\gamma^a\zeta^b)\right) + m^b + n_P^b\left(1+\gamma^a\zeta^b\right)\\
G &= \frac{1}{n_I^a}\left[-D\left(m^a + (n_I^a + n_P^a)(1+\gamma^b\zeta^a)\right) + BK\zeta^b(n_I^a + n_P^a)\right]\\
H &= -K\zeta^a m^b\\
L &= -n_P^b DK\rho^a + n_P^b B(1+\gamma^a\zeta^b)\\
N &= -n_P^a D(1+\gamma^b\zeta^a) + n_P^a BK\zeta^b
\end{aligned}$$

$$P_t^b = \frac{\begin{bmatrix} -C\xi_T^a + K\zeta^b m^a\xi_t^a + A\xi_T^b + \frac{1}{n_I^b}\left[A\left((m^b + (n_I^b + n_P^b)(1+\gamma^a\zeta^b)\right)\right.\\ -KC\zeta^a\left(n_I^b + n_P^b\right)\xi_1^b + \frac{1}{n_I^a}\left(K\zeta^b n_P^a(m^a)^2 + K\zeta^b n_P^a n_I^a m^a\right)Z^a + \left(n_P^b(1+\gamma^a\zeta^b)A\right.\\ -K\zeta^a n_P^b CZ^b \end{bmatrix}}{AD - CB} \tag{3.24}$$

$$F^a_{t,T} = \frac{1}{n^a_I} \frac{\begin{bmatrix} (m^a + n^a_I)\left[D\xi^a_T - B\xi^b_T - H\xi^b_t - LZ^b - NZ^a\right] \\ \\ -\left[-Dn^a_I(1+\gamma^b\zeta^a) + BK\zeta^b n^a_I\right]\xi^a_t \end{bmatrix}}{AD - CB} \tag{3.25}$$

$$F^b_{t,T} = \frac{1}{n^b_I} \frac{\begin{bmatrix} \left(m^b + n^b_I\right)\left[-C\xi^a_T + Km^a\zeta^b\xi^t_t + A\xi^b_T \right. \\ \left. + \frac{K\zeta^b m^a n^a_P}{n^a_I}\left(m^a + n^a_I\right)Z^a + \left[An^b_P(1+\gamma^a\zeta^b) - K\zeta^a n^b_P C\right]Z^b\right] \\ + \left[(1+\gamma^a\zeta^b)n^b_I A - Cn^b_I K\zeta^a\right]\xi^b_t \end{bmatrix}}{AD - CB} \tag{3.26}$$

$$E(\widetilde{P}^a_T) - F^a_{t,T} = \frac{\begin{bmatrix} (n^a_I m^a + (m^a + n^a_I)(n^a_P + m^a))\left[H\xi^b_t + B\xi^b_T + LZ^b\right] + \left(n^a_I m^a D\gamma^b\zeta^a + m^a BK\zeta^b n^a_I\right)\xi^a_t \\ \\ +m^a(m^a + n^a_I)\left(n^a_P D + N\right)Z^a - \left(D\gamma^b\zeta^a\left[m^a(n^a_P + n^a_P) + n^a_P n^a_I\right] + n^a_I CB\right)\xi^a_T \end{bmatrix}}{m^a n^a_I(AD - CB)} \tag{3.27}$$

$$E[\widetilde{P}^b_T] - F^b_{t,T} = \frac{\begin{bmatrix} \left(n^b_I m^b + (m^b + n^b_I)(n^b_P + m^b)\right)\left[C\xi^a_T - m^a K\zeta^b\xi^a_t - (m^a + n^a_I)\frac{K\zeta^b m^a n^a_P}{n^a_I}Z^a\right] \\ \\ + \left(n^b_I m^b A\gamma^a\zeta^b + CK\zeta^a n^b_I\right)\xi^b_t + m^b(m^b + n^b_I)\left(\gamma^a\zeta^b A + K\zeta^a n^b_P C\right)Z^b \\ \\ - \left(A\gamma^a\zeta^b\left[m^a(n^b_P + n^b_P) + n^b_P n^b_I\right] + n^b_I CB\right)\xi^b_T \end{bmatrix}}{m^b n^b_I(AD - CB)} \tag{3.28}$$

$$X^a = \frac{m^a[D\xi^a_T - B\xi^b_T - H\xi^b_t - LZ^b - NZ^a] + [-(m^a + n^a_P(1+\gamma^b\zeta^a))D + n^a_P BK\zeta^b]\xi^a_t}{n^a_I(AD - CB)} \tag{3.29}$$

$$Y^a = \frac{\begin{bmatrix} -(m^a + n^a_I)[D\xi^a_T - B\xi^b_T - H\xi^b_t - LZ^b] + [-Dn^a_I(1+\gamma^b\zeta^a) + BK\zeta^b n^a_I]\xi^a_t \\ \\ +[D[m^a(m^a + n^a_I(1+\gamma^b\zeta^a)) + n^a_I m^a] - B(m^a K\zeta^b n^a_I)]Z^a \end{bmatrix}}{n^a_I(AD - CB)} \tag{3.30}$$

$$\widetilde{P}^a_T = \frac{\widetilde{\xi}^a_T}{m^a} + \frac{-\left(n^a_I m^a + n^a_P(m^a + n^a_I)\right)\left[D\xi^a_T - B\xi^b_T - H\xi^b_t - LZ^b\right] + n^a_I m^a D\xi^a_t + n^a_P Dm^a(m^a + n^a_I)Z^a}{m^a n^a_I(AD - CB)} \tag{3.31}$$

$$X^b = \frac{\begin{bmatrix} m^b[-C\xi_T^a + m^a K\zeta^b \xi_t^a + A\xi_T^b + (m^a + n_I^a)\frac{K\zeta^b m^a n_P^a}{n_I^a} Z^a + [n_P^b(1+\gamma^a\zeta^b)A - K\zeta^a n_P^b C]Z^b] \\ -[A(m^b + n_P^b(1+\gamma^a\zeta^b)) - K\zeta^a n_P^b C]\xi_t^b \end{bmatrix}}{n_I^b(AD - CB)} \tag{3.32}$$

$$Y^b = \frac{\begin{bmatrix} -(m^b + n_I^b)[-C\xi_T^a + m^a K\zeta^b \xi_t^a + A\xi_T^b + (m^a + n_I^a)\frac{K\zeta^b m^a n_P^a}{n_I^a} Z^a] \\ -[A(m^b + n_I^b(1+\gamma^a\zeta^b)) - K\zeta^a n_I^b C]\xi_t^b \\ +[A[m^b(m^b + n_I^b(1+\gamma^a\zeta^b)) + n_I^b m^b] - Cm^b K\zeta^a n_I^b]Z^b \end{bmatrix}}{n_I^b(AD - CB)} \tag{3.33}$$

$$\widetilde{P}_T^b = \frac{\widetilde{\xi}_T^b}{m^b} + \frac{\begin{bmatrix} -\left(n_I^b m^b + n_P^b(m^b + n_I^b)\right)[-C\xi_T^a + m^a K\zeta^b \xi_t^a + A\xi_T^b \\ +(m^a + n_I^a)\frac{K\zeta^b m^a n_P^a}{n_I^a} Z^a] + n_I^b m^b A\xi_t^b + n_P^b m^b A(m^b + n_I^b)Z^b \end{bmatrix}}{m^b n_I^b(AD - CB)} \tag{3.34}$$

To obtain the prices and quantities of the other regions, we only need to set $n_I^a$, $n_P^a$, $n_I^b$ or /and $n_P^b$ to *zero*.

## 3.D The impact of speculation

In this section, we introduce the computations related to the investigation of the impact of speculation on the equilibrium prices and quantities. To do so, we study the difference between the existence and the non-existence of the speculation in the markets.
Note that,

$$\gamma^i = \left(\frac{(m^i)^2}{Var[\tilde{\xi}_T^i]}\right)\left[\frac{N_I^i}{\alpha_I^i} + \frac{N_P^i}{\alpha_P^i} + \frac{N_S}{\alpha_S\left(1 - \left(corr_{\tilde{\xi}_T^i, \tilde{\xi}_T^j}\right)^2\right)}\right], \tilde{\xi}_T^i \neq \tilde{\xi}_T^j$$

$$\overline{\gamma}^i := \gamma_{N_S=0}^i = \left(\frac{(m^i)^2}{Var[\tilde{\xi}_T^i]}\right)\left[\frac{N_I^i}{\alpha_I^i} + \frac{N_P^i}{\alpha_P^i}\right]$$

Where $i = a, b$

$$K = \frac{N_S(m^a m^b) corr_{\tilde{\xi}_T^a, \tilde{\xi}_T^b}}{\alpha_S\sqrt{Var[\tilde{\xi}_T^a]Var[\tilde{\xi}_T^b]}\left(1 - \left(corr_{\tilde{\xi}_T^a, \tilde{\xi}_T^b}\right)^2\right)}, \tilde{\xi}_T^a \neq \tilde{\xi}_T^b$$

Where, $0 \leq \gamma^a, \gamma^b \leq +\infty$ , and $-\infty \leq K \leq +\infty$.

The result of the market clearing for physical and futures markets, as explained in section 3.5, is given by (3.20):

$$\phi(P_t^a, P_t^b, F_{t,T}^a, F_{t,T}^b) = \xi$$

$$\begin{pmatrix} \xi_t^a \\ \xi_t^b \\ \xi_T^a \\ \xi_T^b \end{pmatrix} = \begin{pmatrix} m^a P_t^a - n_I^a X^a \\ m^b P_t^b - n_I^b X^b \\ m^a F_{t,T}^a + \left(1+\gamma^b\zeta^a\right)\left(n_I^a X^a - n_P^a Y^a\right) + \left(K\zeta^a\right)\left(n_I^b X^b - n_P^b Y^b\right) \\ m^b F_{t,T}^b + \left(K\zeta^b\right)\left(n_I^a X^a - n_P^a Y^a\right) + \left(1+\gamma^a\zeta^b\right)\left(n_I^b X^b - n_P^b Y^b\right) \end{pmatrix}$$

Where,

$$\begin{aligned} X^i &= F_{t,T}^i - P_t^i \\ Y^i &= Z^i - F_{t,T}^i \\ i &= \{a, b\} \end{aligned}$$

We are interested in the comprehensive case where processors and storers are active, so $X^i > 0$, and $Y^i > 0$. The system becomes:

$$\phi = \begin{pmatrix} \left(m^a + n_I^a\right) P_1^a - n_I^a F^a \\ \left(m^b + n_I^b\right) P_t^b - n_I^b F_{t,T}^b \\ \left(m^a + \left(1+\gamma^b\zeta^a\right)\left(n_I^a + n_P^a\right)\right) F_{t,T}^a - n_I^a\left(1+\gamma^b\zeta^a\right) P_t^a - n_P^a\left(1+\gamma^b\zeta^a\right) Z^a + K\zeta^a\left(n_I^b + n_P^b\right) F_{t,T}^b - n_I^b K\zeta^a P_t^b - n_P^b K\zeta^a Z^b \\ \left(m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right)\right) F_{t,T}^b - n_I^b\left(1+\gamma^a\zeta^b\right) P_t^b - n_P^b\left(1+\gamma^a\zeta^b\right) Z^b + K\zeta^b\left(n_I^a + n_P^a\right) F_{t,T}^a - n_I^a K\zeta^b P_t^a - n_P^a K\zeta^b Z^a \end{pmatrix}$$

$\phi$ is a system of four linear equations with four unknowns $\left(P_1^i, F^i\right)$, $i = a, b$. We can write the previous system in the following form

$$Y = AX \qquad (*)$$

Where,

$$A = (a_{ij})_{\substack{1\leq i\leq 4 \\ 1\leq j\leq 4}} = \begin{pmatrix} m^a + n_I^a & 0 & -n_I^a & 0 \\ 0 & m^b + n_I^b & 0 & -n_I^b \\ -n_I^a\left(1+\gamma^b\zeta^a\right) & -n_I^b K\zeta^a & m^a + \left(1+\gamma^b\zeta^a\right)\left(n_I^a + n_P^a\right) & K\zeta^a\left(n_I^b + n_P^b\right) \\ -n_I^a K\zeta^b & -n_I^b\left(1+\gamma^a\zeta^b\right) & K\zeta^b\left(n_I^a + n_P^a\right) & m^b + \left(1+\gamma^a\zeta^b\right)\left(n_I^b + n_P^b\right) \end{pmatrix}$$

$$X = \begin{pmatrix} P_t^a \\ P_t^b \\ F_{t,T}^a \\ F_{t,T}^b \end{pmatrix}, \qquad Y = (y_i)_{1\le i\le 4} = \begin{pmatrix} \xi_t^a \\ \xi_t^b \\ \xi_T^a + n_P^a \left(1+\gamma^b\zeta^a\right) Z^a + n_P^b K\zeta^a Z^b \\ \xi_T^b + n_P^a K\zeta^b Z^a + n_P^b \left(1+\gamma^a\zeta^b\right) Z^b \end{pmatrix}$$

By setting $N_S = 0$, $A$ becomes

$$\overline{A} = (\overline{a}_{ij})_{\substack{1\le i\le 4\\ 1\le j\le 4}} = \begin{pmatrix} m^a + n_I^a & 0 & -n_I^a & 0 \\ 0 & m^b + n_I^b & 0 & -n_I^b \\ -n_I^a(1+\frac{m^a}{\overline{\gamma}^a}) & 0 & m^a + (n_I^a + n_P^a)(1+\frac{m^a}{\overline{\gamma}^a}) & 0 \\ 0 & -n_I^b(1+\frac{m^b}{\overline{\gamma}^b}) & 0 & m^b + (n_I^b + n_P^b)(1+\frac{m^b}{\overline{\gamma}^b}) \end{pmatrix},$$

Note that the $\det\left(\overline{A}\right) \neq 0$,

$$\begin{aligned}\det(\overline{A}) = &\left(m^a n_I^a \left(1+\tfrac{m^a}{\overline{\gamma}^a}\right) + (m^a + n_I^a)\left(m^a + n_P^a\left(1+\tfrac{m^a}{\overline{\gamma}^a}\right)\right)\right) \\ &* \left(m^b n_I^b \left(1+\tfrac{m^b}{\overline{\gamma}^b}\right) + \left(m^b + n_I^b\right)\left(m^b + n_P^b\left(1+\tfrac{m^b}{\overline{\gamma}^b}\right)\right)\right) \neq 0\end{aligned}$$

So that the matrix $\overline{A}$ is invertible. It follows that $A$ is invertible in some neighborhood $U$ of $\overline{A}$, and the system $(*)$ has a unique solution of all $Y$. Denote this solution by $X(A,Y)$, so that

$$X(A,Y) := A^{-1}Y$$

for all $A \in U$ and $Y \in \mathbb{R}^4$.

It follows from the formula $X(A,Y) := A^{-1}Y$ that $X$ is a $C^\infty$ function of $A$ and $Y$ . By differentiating at $A = \overline{A}$ and $Y = \overline{Y}$.

The derivative of inverse matrix is

$$\frac{\partial X}{\partial a_{ij}}\left(\overline{A}, \overline{Y}\right) = -\overline{A}^{-1} \uparrow\downarrow_{ij} \overline{A}^{-1}\overline{Y}$$

Where $\uparrow\downarrow_{ij}$is the matrix $(b_{kl})$ with $b_{ij} = a_{ij}$ and $b_{kl} = 0$ for $k \neq i$ or $j \neq l$.

The derivative of vector is

$$\tfrac{\partial X}{\partial y_1} = A^{-1}\begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

We aim to compute the derivative of the prices with respect the number of speculator $\left(\frac{\partial X}{\partial N_S}\right)$. $N_S$ is existed in $A$ and $Y$.

Hence the Taylor theorem for the solution:

$$X\left(N_S\right) = X\left(0\right) + N_S \frac{\partial X}{\partial N_S} + o\left(N_S\right)$$

By substituting the $\frac{\partial X}{\partial N_S}$, we have

$$X\left(N_S\right) = X\left(0\right) - N_S \left(\overline{A}^{-1} \frac{\partial A}{\partial N_S} \overline{X} - \overline{A}^{-1} \frac{\partial Y}{\partial N_S}\right) + o\left(N_S\right)$$

$$\Delta X\left(N_S\right) = -\Delta N_S \left(\overline{A}^{-1} \frac{\partial A}{\partial N_S} \overline{X} - \overline{A}^{-1} \frac{\partial Y}{\partial N_S}\right)$$

Let us compute $\frac{\partial A}{\partial N_S}$, $\frac{\partial Y}{\partial N_S}$ , $A^{-1}$ , and $\overline{X}$ at $N_S = 0$.

$A^{-1}$ is

$$A^{-1} = \begin{pmatrix} \frac{m^a + \left(n_I^a + n_P^a\right)\left(1 + \frac{m^a}{\gamma^a}\right)}{J^a} & 0 & \frac{n_I^a}{J^a} & 0 \\ 0 & \frac{m^b + \left(n_I^b + n_P^b\right)\left(1 + \frac{m^b}{\gamma^b}\right)}{J^b} & 0 & \frac{n_I^b}{J^b} \\ \frac{n_I^a\left(1 + \frac{m^a}{\gamma^a}\right)}{J^a} & 0 & \frac{\left(m^a + n_I^a\right)}{J^a} & 0 \\ 0 & \frac{n_I^b\left(1 + \frac{m^b}{\gamma^b}\right)}{J^b} & 0 & \frac{\left(m^b + n_I^b\right)}{J^b} \end{pmatrix}$$

Where,

$J^i = m^i n_I^i \left(1 + \frac{m^i}{\overline{\gamma}^i}\right) + \left(m^i + n_I^i\right)\left(m^i + n_P^i\left(1 + \frac{m^i}{\overline{\gamma}^i}\right)\right)$, where $i = \{a, b\}$.

It follows that the system $(*)$ has the solution when $N_S = 0$. So, $\overline{X} = \overline{A}^{-1}\overline{Y}$.
The result of $\frac{\partial A}{\partial N_S}$ is

$$\frac{\partial A}{\partial N_S} = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ -n_I^a \frac{\partial(1+\gamma^b\zeta^a)}{\partial N_S} & -n_I^b \frac{\partial K\zeta^a}{\partial N_S} & \left(n_I^a + n_P^a\right) \frac{\partial(1+\gamma^b\zeta^a)}{\partial N_S} & \left(n_I^b + n_P^b\right) \frac{\partial K\zeta^a}{\partial N_S} \\ -n_I^a \frac{\partial K\zeta^b}{\partial N_S} & -n_I^b \frac{\partial(1+\gamma^a\zeta^b)}{\partial N_S} & \left(n_I^a + n_P^a\right) \frac{\partial K\zeta^b}{\partial N_S} & \left(n_I^b + n_P^b\right) \frac{\partial(1+\gamma^a\zeta^b)}{\partial N_S} \end{pmatrix}$$

The result of $\frac{\partial Y}{\partial N_S}$ is

$$\frac{\partial Y}{\partial N_S} = \begin{pmatrix} 0 \\ 0 \\ n_P^a Z^a \frac{\partial(1+\gamma^b\zeta^a)}{\partial N_S} + n_P^b Z^b \frac{\partial K\zeta^a}{\partial N_S} \\ n_P^b Z^b \frac{\partial(1+\gamma^a\zeta^b)}{\partial N_S} + n_P^a Z^a \frac{\partial K\zeta^b}{\partial N_S} \end{pmatrix}$$

To simplify the computations, we find $\frac{\partial K\zeta^a}{\partial N_S}$, $\frac{\partial K\zeta^b}{\partial N_S}$, $\frac{\partial(1+\gamma^b\zeta^a)}{\partial N_S}$, and $\frac{\partial(1+\gamma^a\zeta^b)}{\partial N_S}$ :

$$\frac{\partial K\zeta^a}{\partial N_S} \lfloor_{N_S=0} = \frac{\sqrt{Var[\tilde{\xi}_T^b]Var[\tilde{\xi}_T^a]}corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}}{m^b\alpha_S\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)\left(\frac{N_I^b}{\alpha_I^b}+\frac{N_P^b}{\alpha_P^b}\right)\left(1-corr^2_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)}$$

$$\frac{\partial K\zeta^b}{\partial N_S} \lfloor_{N_S=0} = \frac{\sqrt{Var[\tilde{\xi}_T^b]Var[\tilde{\xi}_T^a]}corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}}{m^a\alpha_S\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)\left(\frac{N_I^b}{\alpha_I^b}+\frac{N_P^b}{\alpha_P^b}\right)\left(1-corr^2_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)}$$

$$\frac{\partial(1+\gamma^b\zeta^a)}{\partial N_S} \lfloor_{N_S=0} = \frac{-Var[\tilde{\xi}_T^a]}{m^a\alpha_S\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)^2\left(1-corr^2_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)}$$

$$\frac{\partial(1+\gamma^a\zeta^b)}{\partial N_S} \lfloor_{N_S=0} = \frac{-Var\left(\tilde{\xi}_T^b\right)}{m^b\alpha_S\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)^2\left(1-corr^2_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)}$$

By computing explicitly, we get

$$\Delta P_t^a = \frac{n_I^a}{J^a}\left[\frac{\frac{N_S}{\alpha_S}}{\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)}\frac{1}{\left(1-corr^2_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)}\right]\left(\frac{Var[\tilde{\xi}_T^a]}{m^a\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)}\overline{HP}^a-\frac{\sqrt{Var[\tilde{\xi}_T^b]Var[\tilde{\xi}_T^a]}corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}}{m^b\left(\frac{N_I^b}{\alpha_I^b}+\frac{N_P^b}{\alpha_P^b}\right)}\overline{HP}^b\right)$$

$$\Delta F_{t,T}^a = \frac{\left(m^a+n_I^a\right)}{J^a}\left[\frac{\frac{N_S}{\alpha_S}}{\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)}\frac{1}{\left(1-corr^2_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)}\right]\left(\frac{Var[\tilde{\xi}_T^a]}{m^a\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)}\overline{HP}^a-\frac{\sqrt{Var[\tilde{\xi}_T^b]Var[\tilde{\xi}_T^a]}corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}}{m^b\left(\frac{N_I^2}{\alpha_I^2}+\frac{N_P^2}{\alpha_P^2}\right)}\overline{HP}^b\right)$$

$$\Delta P_t^b = \frac{n_I^b}{J^b}\left[\frac{\frac{N_S}{\alpha_S}}{\left(\frac{N_I^b}{\alpha_I^b}+\frac{N_P^b}{\alpha_P^b}\right)}\frac{1}{\left(1-corr^2_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)}\right]\left(-\frac{\sqrt{Var[\tilde{\xi}_T^b]Var[\tilde{\xi}_T^a]}corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}}{m^a\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)}\overline{HP}^a+\frac{Var[\xi_T^b]}{m^b\left(\frac{N_I^2}{\alpha_I^2}+\frac{N_P^2}{\alpha_P^2}\right)}\overline{HP}^b\right)$$

$$\Delta F_{t,T}^b = \frac{\left(m^b+n_I^b\right)}{J^b}\left[\frac{\frac{N_S}{\alpha_S}}{\left(\frac{N_I^b}{\alpha_I^b}+\frac{N_P^b}{\alpha_P^b}\right)}\frac{1}{\left(1-corr^2_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}\right)}\right]\left(-\frac{\sqrt{Var[\tilde{\xi}_T^b]Var[\tilde{\xi}_T^a]}corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b}}{m^a\left(\frac{N_I^a}{\alpha_I^a}+\frac{N_P^a}{\alpha_P^a}\right)}\overline{HP}^a+\frac{Var[\xi_T^b]}{m^b\left(\frac{N_I^2}{\alpha_I^2}+\frac{N_P^2}{\alpha_P^2}\right)}\overline{HP}^b\right)$$

To find $X^i$, $Y^i$ and $P_T^i$, we use the following relations,

$$\begin{aligned}\Delta X^i &= \Delta F_{t,T}^i - \Delta P_t^i\\ \Delta Y^i &= -\Delta F_{t,T}^i\\ \Delta P_T^i &= \frac{1}{m^i}\left(-n_I^i\Delta X^i + n_P^i\Delta Y^i\right)\end{aligned}$$

Previous changes in prices are determined by mainly by the sign and the magnitude of the combination between hedging pressure in both commodities markets weighted to their covariance. In any commodity market, if the sign of total hedging pressure is positive, then investors takes long positions in the market. Otherwise takes short positions. So, more long positions increase current spot and futures prices and the inventory level, while they decrease the future spot price and the quantity demanded for production.

One last comment, we use Taylor theorem around $N_S = 0$. But, That does not mean the number of speculator is small. To explain that, we introduce the following theorem

**Theorem:** For any market, $\frac{\partial X}{\partial N_S}\frac{1}{X} \to 0$, when $N_I + N_P \to \infty$, where $X$ is any price.
To prove that, let us compute the relative changes on the prices,

$$\overline{P}_t^a = \frac{\xi_T^a + \frac{1}{n_I^a}\left(m^a + (n_I^a + n_P^a)\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)\right)\xi_t^a + n_P^a\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)Z^a}{\frac{m^a}{n_I^a}\left(m^a + (n_I^a + n_P^a)\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)\right) + m^a + n_P^a\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)}$$

$$\overline{P}_t^b = \frac{\xi_T^b + \frac{1}{n_I^b}\left(m^b + (n_I^b + n_P^b)\left(1 + \frac{m^b}{\overline{\gamma}^b}\right)\right)\xi_t^b + n_P^b\left(1 + \frac{m^b}{\overline{\gamma}^b}\right)Z^b}{\frac{m^b}{n_I^b}\left(m^b + (n_I^b + n_P^b)\left(1 + \frac{m^b}{\overline{\gamma}^b}\right)\right) + m^b + n_P^b\left(1 + \frac{m^b}{\overline{\gamma}^b}\right)}$$

$$\overline{F}_{t,T}^a = \frac{1}{n_I^a}\frac{\left(m^a + n_I^a\right)\left[\xi_T^a + n_P^a\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)Z^a\right] + n_I^a\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)\xi_t^a}{\frac{m^a}{n_I^a}\left(m^a + (n_I^a + n_P^a)\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)\right) + m^a + n_P^a\left(1 + \frac{m^a}{\overline{\gamma}^a}\right)}$$

$$\overline{F}_{t,T}^b = \frac{1}{n_I^b}\frac{\left(m^b + n_I^b\right)\left[\xi_2^b + n_P^b\left(1 + \frac{m^b}{\overline{\gamma}^b}\right)Z^b\right] + n_I^b\left(1 + \frac{m^b}{\overline{\gamma}^b}\right)\xi_t^b}{\frac{m^b}{n_I^b}\left(m^b + (n_I^b + n_P^b)\left(1 + \frac{m^b}{\overline{\gamma}^b}\right)\right) + m^b + n_P^b\left(1 + \frac{m^b}{\overline{\gamma}^b}\right)}$$

**Proof:**

$$X\left(N_S\right) = X\left(0\right) + N_S\frac{\partial X}{\partial N_S}$$

$$\frac{\partial X}{\partial N_S}\frac{1}{\overline{X}} = \frac{1}{N_S}\Delta X(N_S)\frac{1}{\overline{X}}$$

Note that:
$\overline{HP}^i = n_I^i\overline{X}^i - n_P^i\overline{Y}^i$, then,

$$\begin{aligned}\overline{HP}^i &= \frac{\left(n_I^i m^i + n_P^i\left(m^i + n_I^i\right)\right)\xi_T^i - n_I^i m^i \xi_t^i - n_P^i m^i\left(m^i + n_I^i\right)Z^i}{m^i\left(m^i + \left(n_I^i + n_P^i\right)\left(1 + \frac{m^i}{\overline{\gamma}^i}\right)\right) + m^i n_I^i + n_P^i n_I^i\left(1 + \frac{m^i}{\overline{\gamma}^i}\right)} \\ \text{where } i &= \{a, b\}\end{aligned}$$

Let us define:

- $T^i := \dfrac{Var[\tilde{\xi}_T^i]}{m^i\left(\frac{N_I{}^i}{\alpha_I^i} + \frac{N_P^i}{\alpha_P^i}\right)}HP^i$

$$T^i = \frac{m^i\left[\left(n_I^i m^i + n_P^i\left(m^i+n_I^i\right)\right)\xi_T^i - n_I^i m^i \xi_t^i - n_P^i m^i\left(m^i+n_I^i\right)Z^i\right]}{m^i\overline{\gamma}^i\left(m^i+(n_I^i+n_P^i)\left(1+\frac{m^i}{\overline{\gamma}^i}\right)\right)+m^i n_I^i\overline{\gamma}^i+n_P^i n_I^i\overline{\gamma}^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)}, \quad \text{where } i=a,b$$

- $V^j := \dfrac{\sqrt{Var[\tilde{\xi}_T^i]Var[\tilde{\xi}_T^j]}corr_{\tilde{\xi}_T^i,\tilde{\xi}_T^j}}{m^j\left(\frac{N_I^j}{\alpha_I^j}+\frac{N_P^j}{\alpha_P^j}\right)}HP^j$

  $V^j = \dfrac{\sqrt{Var[\tilde{\xi}_T^j]}}{\sqrt{Var[\tilde{\xi}_T^i]}}corr_{\tilde{\xi}_T^i,\tilde{\xi}_t^j}\dfrac{m^j\left[\left(n_I^j m^j + n_P^j\left(m^j+n_I^j\right)\right)\xi_2^j - n_I^j m^j \xi_1^j - n_P^j m^j\left(m^j+n_I^j\right)Z^j\right]}{m^j\overline{\gamma}^j\left(m^j+(n_I^j+n_P^j)\left(1+\frac{m^j}{\overline{\gamma}^j}\right)\right)+m^j n_I^j\overline{\gamma}^j+n_P^j n_I^j\overline{\gamma}^j\left(1+\frac{m^j}{\overline{\gamma}^j}\right)}, \quad \text{where } j=a,b.$

  When $i=a$, then $j=b$ and vise versa.

The prices $\overline{P}^i$ and $F_{t,T}^i$

$$\begin{aligned}
\overline{P}_t^i &= \frac{\xi_T^i + \frac{1}{n_I^i}\left(m^i + (n_I^i+n_P^i)\left(1+\frac{m^i}{\overline{\gamma}^i}\right)\right)\xi_t^i + n_P^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)Z^i}{\frac{m^i}{n_I^i}\left(m^i+(n_I^i+n_P^i)\left(1+\frac{m^i}{\overline{\gamma}^i}\right)\right)+m^i+n_P^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)} \\
\overline{F}_{t,T}^i &= \frac{1}{n_I^i}\frac{(m^i+n_I^i)\left[\xi_T^i + n_P^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)Z^i\right] + n_I^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)\xi_t^i}{\frac{m^i}{n_I^i}\left(m^i+(n_I^i+n_P^i)\left(1+\frac{m^i}{\overline{\gamma}^i}\right)\right)+m^i+n_P^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)}
\end{aligned}$$

Then $\frac{n_I^i}{J^i}\frac{1}{P_1^i}$, and $\frac{m^i+n_I^i}{Ji}\frac{1}{F^i}$ are:

- $W^i := \frac{n_I^i}{J^i}\frac{1}{P_1^i} = \dfrac{\overline{\gamma}^i}{\overline{\gamma}^i\xi_2^i+\frac{\overline{\gamma}^i}{n_I^i}\left(m^i+(n_I^i+n_P^i)\left(1+\frac{m^i}{\overline{\gamma}^i}\right)\right)\xi_1^i+n_P^i\overline{\gamma}^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)Z^i}$
- $M^i := \frac{m^i+n_I^i}{Ji}\frac{1}{F^i} = \dfrac{\left(m^i+n_I^i\right)\overline{\gamma}^i}{\left(m^i+n_I^i\right)\overline{\gamma}^i\left[\xi_2^i+n_P^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)Z^i\right]+n_I^i\overline{\gamma}^i\left(1+\frac{m^i}{\overline{\gamma}^i}\right)\xi_1^i}$

Hence, the new forms of the prices relative changes are

$$\frac{\partial P_t^i}{\partial N_S}\frac{1}{\overline{P}_t^i} = \frac{\left(m^i\right)^2}{Var[\tilde{\xi}_T^i]}\frac{1}{\alpha_S\left(1-corr^2_{\tilde{\xi}_T^i,\tilde{\xi}_T^i}\right)}\frac{W^i}{\overline{\gamma}^i}\left(T^i-V^i\right)$$

$$\frac{\partial F^i}{\partial N_S}\frac{1}{\overline{F}_{t,T}^i} = \frac{\left(m^i\right)^2}{Var[\tilde{\xi}_T^i]}\frac{1}{\alpha_S\left(1-corr^2_{\tilde{\xi}_T^i,\tilde{\xi}_T^i}\right)}\frac{M^i}{\overline{\gamma}^i}\left(T^i-V^i\right)$$

We find that

- When $N_I^i$ or $N_P^i \to \infty$.$T^i \to 0$, $\frac{W^i}{\overline{\gamma}^i} \to 0$
- When $N_I^j$ or $N_P^j \to \infty$ , $V^i \to 0$.

As a result, the relative changes of the prices go to zero when the number of hedgers is large. We have the same results for the rest of the prices.

**Corollary:** For any $N_S$, we can find $N_I$ and $N_P$ large where $\frac{\Delta X}{X} = \frac{\partial X}{\partial N_S}\frac{1}{X}N_S < \epsilon$.

## 3.E Special cases: The model when the correlation equal to zero

In this part, we assume that the two commodities are independent i.e. $corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b} = 0$. This assumption indicates that there is no information transferring between the commodity markets. Theoretically, the changes in the structures of any of these commodities do not affect the other commodity. By setting $corr_{\tilde{\xi}_T^a,\tilde{\xi}_T^b} = 0$, we have the two isolated forms as the model of Ekeland et al. (2015).

By monitoring the changes on the structure of our model, we observe that the optimal positions of the speculators is given by:

$$f_S^{i*} = \frac{E[\tilde{P}_T^i] - F_{t,T}^i}{\alpha_S Var[\tilde{P}_T^i]}$$

The result of the commodity futures markets clearing become independent. For each commodity, the bias in futures prices depends on the fundamental economic structure of the commodity itself, which is represented by the net hedge pressure.

$$E(\tilde{P}_T^i) - F_{t,T}^i = \frac{Var[\widetilde{P}_T^i]}{\frac{N_S}{\alpha_S} + \frac{N_I^i}{\alpha_I^i} + \frac{N_P^i}{\alpha_P^i}} \left(n_I^i X^i - n_P^i Y^i\right) \tag{3.35}$$

Consequently, the system of the market clearings and optimal positions for commodity $i$ is,

$$\begin{cases} X^i &= \max\left\{F_{t,T}^i - P_t^i, 0\right\} \\ Y^i &= \max\left\{Z^i - F_{t,T}^i, 0\right\} \\ P_t^i &= \frac{1}{m^i}\left(\xi_t^i + n_I^i X^i\right) \\ \tilde{P}_T^i &= \frac{1}{m^i}\left(\tilde{\xi}_T^i - n_I^i X^i + n_P^i Y^i\right) \\ \left(E[\tilde{P}_T^i] - F_{t,T}^i\right) &= \frac{Var[\widetilde{P}_T^i]}{\frac{N_S}{\alpha_S} + \frac{N_I^i}{\alpha_I^i} + \frac{N_P^i}{\alpha_P^i}} \left(n_I^i X^i - n_P^i Y^i\right) \end{cases}$$

We obtain two uncorrelated groups of prices. Each of these groups represents a commodity. Each of them corresponds with the equilibrium prices of Ekeland et al. (2015). The equilibrium prices of commodity $i$:

$$P_t^i = \frac{\xi_T^i + \frac{1}{n_I^i}\left(m^i + (n_I^i + n_P^i)\left(1 + \frac{m^i}{\gamma^i}\right)\right)\xi_t^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)Z^i}{\frac{m^i}{n_I^i}\left(m^i + (n_I^i + n_P^i)\left(1 + \frac{m^i}{\gamma^i}\right)\right) + m^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)} \tag{3.36}$$

$$F_{t,T}^i = \frac{1}{n_I^i}\frac{(m^i + n_I^i)\left[\xi_T^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)Z^i\right] + n_I^i\left(1 + \frac{m^i}{\gamma^i}\right)\xi_t^i}{\frac{m^i}{n_I^i}\left(m^i + (n_I^i + n_P^i)\left(1 + \frac{m^i}{\gamma^i}\right)\right) + m^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)} \tag{3.37}$$

$$X^i = \frac{m^i[\xi_T^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)Z^i] - (m^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)\xi_t^i}{n_I^i\left(\frac{m^i}{n_I^i}\left(m^i + (n_I^i + n_P^i)\left(1 + \frac{m^i}{\gamma^i}\right)\right) + m^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)\right)} \tag{3.38}$$

$$Y^i = \frac{-(m^i + n_I^i)\xi_T^i + n_I^i\left(1 + \frac{m^i}{\gamma^i}\right)\xi_t^i + \left[m^i\left(m^i + n_I^i\left(1 + \frac{m^i}{\gamma^i}\right)\right) + m^i n_I^i\right]Z^i}{n_I^i\left(\frac{m^i}{n_I^i}\left(m^i + (n_I^i + n_P^i)\left(1 + \frac{m^i}{\gamma^i}\right)\right) + m^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)\right)} \tag{3.39}$$

$$\widetilde{P}_T^i = \frac{\widetilde{\xi}_T^i}{m^i} + \frac{-\left(n_I^i m^i + n_P^i(m^i + n_I^i)\right)\xi_T^i + n_I^i m^i \xi_t^i + n_P^i m^i (m^i + n_I^i)Z^i}{m^i n_I^i\left(\frac{m^i}{n_I^i}\left(m^i + (n_I^i + n_P^i)\left(1 + \frac{m^i}{\gamma^i}\right)\right) + m^i + n_P^i\left(1 + \frac{m^i}{\gamma^i}\right)\right)} \tag{3.40}$$

# General Conclusion

This dissertation investigates the influence of the ongoing increase in the financial investors' inflow in the futures commodity markets; i.e. financialization of commodity. Those investors increase the friction between stock and commodity markets. Therefore, several researchers and financial analysts claim that investments inflow in the commodity markets play a crucial role in determining the changes in commodity markets. Their opinions are split between supporting that claim and refusing it, as explained in the previous literature reviews. However, the vast majority of the implemented researches were empirical. These empirical studies leave the debate on until now. To clarify that ambiguity, theoretical and even empirical researches are required.

Investors, individuals or institutions, diversify their stock positions in the futures markets in different ways: by purchasing the physical commodity in the cash market, purchasing of the stock of the commodity-related companies, purchasing of commodity futures and options, or investing in commodity indices (Geman (2005)). The latter method is preferable of getting exposure of commodity markets (Stoll and Whaley (2010)). Investors invest in commodity futures by using commodity indices as benchmarks, because they believe that these indices are well diversified. Therefore, they build a portfolio that mimics one of the indices (e.g. S&P GSCI or DJ-UBSCI). The participation of financial investors raises two important issues: first, the relation between stock and commodity markets from one aspect, and the relation between commodity markets from another aspect. These issues are raised by the participation of investors in stock and futures markets for their diversification reasons. Also, those investors invest in a basket of commodities. Proceeding from that, I was motivated to study these two issues in both theoretical and empirical levels.

I build this dissertation by developing models in the spirit of Ekeland et al. (2015), who study the interaction between physical and futures commodity markets only. In the first chapter, I develop a model to study the interaction between commodity and stock markets. In the second chapter, I test one of the first chapter contributions empirically, which is related to testifying the impact of stock market on futures risk premium. In the third chapter, I build a model that studies the interaction between different commodity markets in both physical and futures markets in

each commodity. Theoretical models provide to find final expressions for the commodity prices. As a result, that provides an advantage to study the relationships between each of current spot price, futures price, inventory levels, quantity demanded for production and the future spot price.

First, I found that ambiguity in finding evidences about the impact of investment in commodity futures markets is plausible. As a result of operating in different markets, the decisions of the investors are determined based on those markets conditions. Therefore, each market should be treated independently. However, I conclude that the impact of financial investors on commodity markets is linked to their positions taken in the futures markets, which is determined mainly by the expected returns of each market and the cross markets correlation. I find that, as explained in chapter 1 and 3, the financialization of commodity increases the futures price, the spot price and the inventory levels, which is restricted to net long positions. On the contrary, the prices relationships show a decrease in the physical demand for processors and the future spot prices. The results is reflected when the financial investors' futures positions are net short. Furthermore, the results show co-movements between futures price, spot price and inventory levels. On opposite side, there is a co-movement between the physical demand for production and the future spot price. Finally, the impact of financialization is affected by the futures market size; small markets will be less impacted (chapter 3).

Second, I was motivated by theoretical finding of Basak and Pavlova (2016), who find that financialization increase the commodity-equity correlation, and by the empirical findings of each of Buyukşahin and Robe (2014a,b) and Creti et al. (2013) who find that the commodity-equity correlation evolve after 2008 financial crisis. I find, chapter 1, that an increase in the commodity-equity correlation, accompanied by positive expected stock returns, causes a decrease in long (or increase short) futures positions of financial investors. Purchasing less futures contracts decreases the futures prices. Consequently, the storers reduce their physical inventory, because of the expensive cost of hedging. The declining in the storers' demand in the physical market causes a decrease in the spot price. Low futures price offers a suitable atmosphere for the processors to increase their physical positions. Low inventory and the increase in the processors' demand cause an increase in the future spot price.

Third, regarding cross commodity markets integration (as explained in chapter 3), we find that any shock in one market affects the prices in that market, and then, it spreads to the other market's prices responding to the investors' decisions in the futures markets. We find that the shocks could be transmitted in two opposite directions based on the cross commodity correlation. Responding to such shocks in supply/demand in a commodity market, we address several co-movements between prices. It shows a co-movement between spot and futures prices in the

same commodity market. There is a negative relationship between the prices and quantities demanded for inventory and for production. Also, there is a negative relationship between prices and the futures risk premium. The spread impact on the other market split into two opposite effects, which is determined by the cross commodity correlation. By assuming a positive cross commodity correlation, which is the prevailing situation (e.g. Tang and Xiong (2012)), our results show co-movement between, first, spot and futures prices of both commodities, second, quantity demanded for production in both markets, and third, the futures risk premium in both markets. It shows a negative relationship between, first, inventory levels in both markets, and second, the future spot price in both markets.

Fourth, expecting future supply/demand shocks in one market causes a depression in that market, while other markets become more active. In the active market, the results show a co-movement between spot price, futures price and inventory level from one side. From the other side, and in the opposite direction, they show a co-movement between production demand, future spot price and futures risk premium. Under this situation, and when the cross commodity correlation is positive, the different commodities prices (spot and futures), inventory levels and the demand for production are positively related. On the contrary, there is a negative relationship between futures risk premium and the future spot price.

Fifth, from chapter 1 and 3, the futures risk premium is determined by the hedging pressure of the commodity and the futures risk premium (expected returns) of the other market restricted to the cross commodity markets correlation. This result shows that the net short hedging pressure increase the futures risk premium, which goes in the line with De Roon et al. (2000), Ekeland et al. (2015) and others. Also, an increase in expected return in the stock market (chapter 1), or in the futures commodity markets (chapter 3) causes an increase in the futures risk premium of the other market. That is, of course, based on considering the cross markets correlation is positive, following Buyukşahin and Robe (2014a,b) for futures-stock markets and Tang and Xiong (2012) for cross commodity markets. The theoretical result is able to interpret the situation in past periods, when the correlation between markets was negative, or any future change in the cross market correlation. In that case, the influence of the market returns is inverted.

Empirically, as found in chapter 2, I confirm firstly that the hedging pressure is a strong explanatory variable for the futures risk premium. I find that the net short hedging pressure is positively correlated with the futures risk premium for all tested commodities (e.g. energy markets). That goes in the line with several literatures such as De Roon et al. (2000), Boons et al. (2014), etc. Also, there is a negative relationship between the impact of the hedging pressure

and the futures maturity. Secondly, the impact of stock market became significantly effective on the futures risk premium in the period post-2008 financial crisis. By that time, the futures risk premium and the adjusted stock returns are positively correlated. This finding confirms the theoretical finding in chapter 1. For crude oil (WTI) and heating oil, the significant impact is accompanied by increases in commodity-equity correlation. That leads us to go in the line with Daskalaki and Skiadopoulos (2011) and Belousova and Dorfleitner (2012) and conclude that the diversification is in doubt. Consequently, financial investors are asking for liquidity instead of providing liquidity to the hedgers (e.g. Cheng et al. (2015). When the maturity increases, the adjusted stock market returns becomes stronger explanatory than the hedging pressure. This finding does not contradict Boons et al. (2014) who study the first two maturities only. But, it is the opposite for longer maturities. Natural gas market needs further studies. In natural gas case, although the explanatory variables are significant in the period 2008-2015, the futures risk premium should be determined by extra explanatory variables.

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## Résumé

Cette thèse étudie le rôle joué par les investisseurs financiers sur les marchés des matières premières, connu sous le nom de financiarisation des matières premières. Elle est constituée d'une partie théorique et d'une partie empirique. Les recherches menées visent à étudier la participation des investisseurs qui détiennent détenant des portefeuilles d'actions sur les marchés à terme de matières premières, pour des raisons de diversification. De plus, cette diversification peut être obtenue en investissant dans un panier de produits de base. Le premier chapitre analyse théoriquement l'interaction entre le marché des matières premières et celui des actions. Le deuxième chapitre étudie empiriquement l'impact du choix des investisseurs financiers sur la prime de risque des contrats à terme sur les matières premières. Il s'intéresse principalement à trois produits de base : le pétrole brut (WTI), le fioul pour chauffage et le gaz naturel. Le troisième chapitre étudie théoriquement l'intégration de deux marchés de matières premières. Nous clarifions certaines considérations concernant l'effet de la financiarisation sur lesquelles la littérature existante reste hésitante. Nous démontrons le pouvoir d'influence qu'exercent les investisseurs sur le marché des matières premières. Toutefois, ceci dépend de la nature de la position de l'investisseur sur le marché à terme. De manière générale, la financiarisation entraine la hausse des prix spot, des prix des contrats à terme et des niveaux des stocks. Nous montrons aussi que les investisseurs représentent un canal de transmission entre les marchés de matières premières. Leurs effets étendus se limitent à la corrélation croisée des marchés de matières premières. Enfin, nous montrons que les rendements des marchés d'actions sont devenus un déterminant de la prime de risque des contrats à terme après la crise financière de 2008. Cet effet des rendements des actions est indépendant entre les maturités courtes et longues.



## Mots Clés

Financiarisation, marché des matières premières, investisseurs, couverture, corrélation croisée des marchés, équilibre, prix, prime de risque des contrats à termes.



## Abstract

This dissertation studies the role of financial investors on commodity markets, which is referred as financialization of commodity. The content of the dissertation splits to theoretical and empirical work. The implemented researches are motivated by the participation of investors, who own stock portfolios, in commodity futures markets for diversification reasons. Furthermore, that diversification is likely achieved by investing in a basket of commodities. The first chapter investigates, theoretically, the interaction between commodity and stock markets. The second chapter studies, empirically, the impact of financial investors on the commodities futures risk premium. It focuses on studying three commodities: crude oil (WTI), heating oil and natural gas. The third chapter examines, theoretically, the integration between two commodity markets. We clarify the hesitating of the previous literature in finding evidences of the impact of financialization. We confirm the influential power of investment in commodity market. However, that depends on the financial investors positions taken in the futures market. Generally, financialization increases the spot prices, the futures prices and inventory levels. We find, also, that investors are a transmission channel between commodity markets. Their effects spread out restricted to the cross commodity markets correlation. Finally, stock market returns become effective determinant of the futures risk premium after 2008 financial crisis. Also, the effect of the stock returns is indifferent between short and long maturities.



## Keywords

Financialization, commodity market, investors, hedgers, cross markets correlation, equilibrium, prices, futures risk premium.